Switzerland's Greenhouse Gas Inventory 1990–2003

National Inventory Report
2005

Submission to the United Nations Framework Convention on Climate Change

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Swiss Agency for the Environment, Forests and Landscape SAEFL

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Glossary

Carbura	Schweiz. Zentralstelle für die Einfuhr flüssiger Brenn- und Treibstoffe
Cemsuisse	Verband der Schweizerischenb 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
EMIS	Swiss national air pollution database
FCCC	Framework Convention on Climate Change
FOAG (FAL)	Swiss Federal Office of Agriculture (Swiss Federal Research Station for Agroecology and Agriculture)
FOCA	Federal Office of Civil Aviation
Gg	Giga gramme (10^9 g = 1'000 tons)
GHG	Greenhouse gas
HFC	Hydrofluorocarbons (e.g. HFC-32 difluoromethane)
IDP	Inventory Development Plan
IPCC	Intergovernmental Panel on Climate Change
LUCF	Land-Use Change and Forestry
LULUCF	Land-Use and Land-Use Change and Forestry
MSW	Municipal solid waste
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
SF_6	Sulphur hexafluoride
SFOE	Swiss Federal Office of Energy
SFSO	Swiss Federal Statistical Office
SO_2	Sulphur dioxide
SWISSMEM	Swiss Mechanical and Electrical Engineering Industries
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

Inventory Preparation in Switzerland

On December 10 1993, Switzerland ratified the United Nations Framework Convention on Climate Change (UNFCCC). Since 1996 the submission of its national greenhouse gas inventory is based on IPCC guidelines. From 1998 on, the inventories are submitted in the Common Reporting Format. The present report is Switzerland's second National Inventory Report (NIR 2005) established under the UNFCCC. It includes, as a separate document, Switzerland's 2003 Inventory in the Common Reporting Format.

On July 9 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 under implementation and will be fully operating in 2006.

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 SAEFL, the Swiss Federal Office of Energy, the Swiss Federal Office for Agriculture and the Federal Office for Civil Aviation participate directly in the compilation of the inventory. Several other administrative and research institutions are involved in inventory preparation.

Switzerland's first National Inventory Report was submitted on April 14, 2004, and on September 13-17 2004, an in-country review took place in Berne. The review team stated that “Switzerland has made significant improvements since the last inventory submission” (UNFCCC 2004). The review team also identified a number of issues in the Swiss inventory that should be improved in future submissions. These findings are put together in the Inventory Development Plan (Annex 4).

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: national air pollution database (called EMIS), national energy statistics, data from industry associations, and separate statistics and models for road transportation, agriculture, land-use change and forestry (LUCF) and waste. The data are compiled at the SAEFL in Internal Greenhouse Gas Files, which are set up in line with the FCCC inventory guidelines (FCCC, 2003). 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), IPCC Good Practice Guidance (IPCC 2000). The data from the SAEFL inventory files are pre-processed in order to enable transfer of data to the common reporting format (CRF) required for reporting under the UNFCCC.

All inventory data are assembled and prepared for input in the CRF tables by a specialized task force, the SAEFL Inventory Group. It is responsible for ensuring the conformity of the inventory with UNFCCC guidelines. For the preparation of this report, the Inventory Group was supported by consultants. Their mandate included editing of the NIR, and an analysis of the correspondence between the emission modelling and the recommendations of the IPCC Good Practice Guidance. Furthermore, the consultants carried out the key source analysis, the uncertainty analysis and were responsible for implementation of tasks of the inventory development plan concerning this NIR. An inventory quality assurance and control system is being prepared in the context of the Swiss National Inventory System and is being introduced stepwise up to full implementation in 2006.

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

Chapters 3 to 8 provide principal source and sink category estimates. This NIR 2005 accounts for recommendations of the UNFCCC review team by providing more detailed descriptions of the methodologies and results than the first NIR. A number of methodologies and input data on emission factors and activities are currently being revised and updated. Where new results are not yet available, the chapters contain information on planned improvements.

Chapter 9 explains and justifies recalculations that have been performed since the last inventory submission to the UNFCCC Secretariat in 2004.

Trend Summary: National GHG Emissions and Removals

In 2003, Switzerland released about 52’252 Gg (kilotonnes) CO_2 equivalent, or 7.1 tonnes CO_2 equivalent per capita (CO_2 only: 6.0 tonnes per capita), to the atmosphere not including CO_2 from Land-Use Change and Forestry (LUCF).

For 2003, 34 sources were identified as key sources in level and trend analysis for Switzerland, covering approximately 95% of total greenhouse gas (GHG) emissions (CO_2 equivalent). Approximately 40% of total GHG emissions resulted from the two most important key sources: CO_2 from Fuel Combustion - Transport (source category 1A3) and Fuel Combustion – Other Sectors (source category 1A4 including commercial, institutional and residential sources). Besides Energy (sector 1), other key sources are found in Agriculture (sector 4), Industrial Processes (sector 2) and Waste (sector 6).

Table 1 shows Switzerland's annual GHG emissions by individual GHG from 1990 (base year) to 2003. Total annual GHG emissions show no significant trends. Fluctuations in total GHG emissions over the period 1990-2003 are less than 5%. In 2003, total gross GHG emissions (without LUCF) showed a decrease of -0.4% as compared to the level recorded in 1990 (see also Table 2).

Greenhouse Gas Emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
	CO_2 equivalent (Gg)													
Net CO_2 emissions/removals	43'099	44'683	44'519	40'984	40'245	41'014	41'415	40'476	41'836	42'299	43'806	44'908	43'955	42'957
Gross CO_2 emissions (without LUCF)	44'372	46'022	45'943	43'372	42'636	43'369	43'922	43'150	44'438	44'555	43'656	44'458	43'650	44'724
CH_4	4'451	4'437	4'305	4'244	4'040	4'047	3'974	3'909	3'848	3'836	3'742	3'760	3'683	3'671
N_2O	3'344	3'371	3'370	3'339	3'313	3'248	3'301	3'200	3'193	3'173	3'186	3'156	3'148	3'092
HFCs	0.02	0.4	7.2	14	34	151	185	231	301	349	406	471	483	529
PFCs	100	85	69	30	18	15	17	24	28	31	68	29	36	66
SF_6	179	181	183	148	126	104	98	169	156	143	199	220	187	169
Total (with net CO_2 emissions/removals)	51'173	52'757	52'454	48'759	47'776	48'578	48'991	48'008	49'361	49'830	51'406	52'545	51'492	50'485
Total (without CO_2 from LUCF)	**52'446**	**54'096**	**53'877**	**51'147**	**50'167**	**50'933**	**51'498**	**50'682**	**51'964**	**52'086**	**51'257**	**52'094**	**51'187**	**52'252**

Table 1 Summary of Switzerland’s GHG emissions in CO_2 equivalent (Gg), 1990–2003 (CRF Table 10s5).

As to the distribution of emissions by individual greenhouse gases, CO_2 is the largest single contributor to emissions, accounting for about 85.6% of total gross GHG emissions (without LUCF) in the period from 1990 to 2003. The share of CH_4 decreased from 8.5% (1990) to 7.0% (2003), while the share of N_2O was almost constant at around 6%. The share of synthetic gases increased from 0.5% (1990) to 1.4% (2003).

Greenhouse Gas Emissions	1990		1995		2000		2003	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
Gross CO_2 emissions (without LUCF)	44'372	84.6%	43'369	85.1%	43'656	85.2%	44'724	85.6%
CH_4	4'451	8.5%	4'047	7.9%	3'742	7.3%	3'671	7.0%
N_2O	3'344	6.4%	3'248	6.4%	3'186	6.2%	3'092	5.9%
HFCs	0	0.0%	151	0.3%	406	0.8%	529	1.0%
PFCs	100	0.2%	15	0.0%	68	0.1%	66	0.1%
SF_6	179	0.3%	104	0.2%	199	0.4%	169	0.3%
Total (without CO_2 from LUCF)	**52'446**	**100.0%**	**50'933**	**100.0%**	**51'257**	**100.0%**	**52'252**	**100.0%**

Table 2 Switzerland's total gross GHG emissions (without LUCF) in CO_2 equivalent (Gg), selected years.

Figure 1 shows the share of 2003 emissions contributed by individual greenhouse gases. As the shares of emissions contributed by the gases have remained relatively constant, the diagram is representative for the other years in the period 1990–2003 as well.

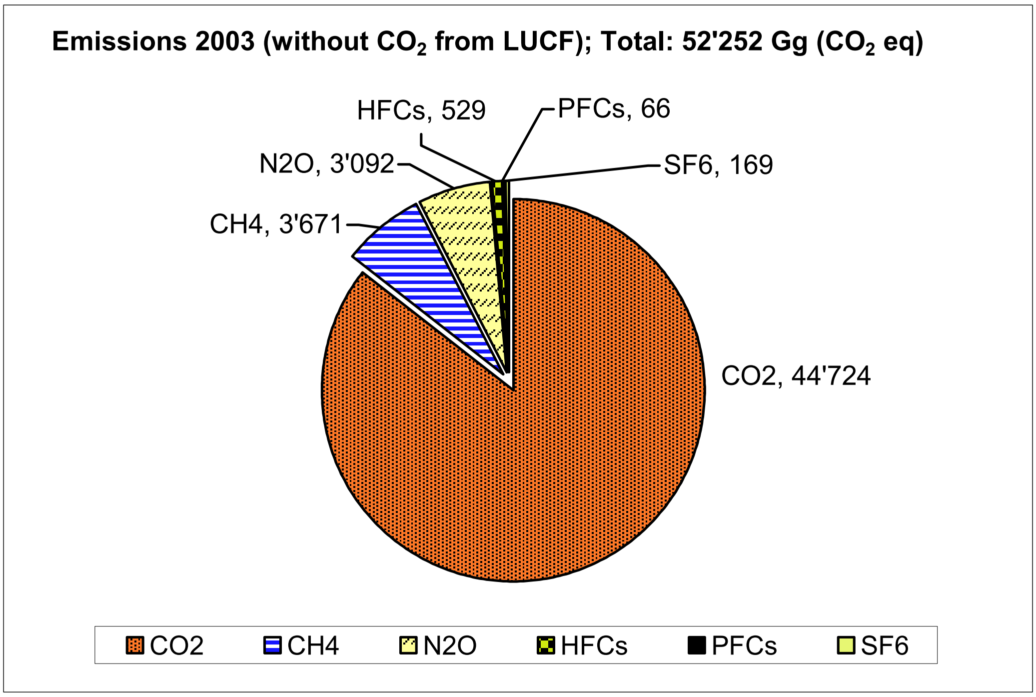

Figure 1 Contribution to Switzerland's GHG emissions by gas (without CO_2 from LUCF), 2003.

Overview of Source and Sink Category Estimates and Trends

Table 3 shows the greenhouse gas emissions and removals by main source categories. The Energy sector (sector 1) is the largest source of national emissions, contributing more than 80% of the emissions. No significant trend is found for the Energy sector for the period 1990–2003. The year to year variations are mainly caused by changing winter temperatures (see Figure 12). The emissions from Industrial Processes (sector 2), Agriculture (sector 4) and Waste (sector 6) all decreased during this period.

Greenhouse Gas Source and	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	*2003/1990*
Sink Categories	CO2 equivalent (Gg)														%
1 Energy	40'968	43'074	43'176	40'893	40'025	40'922	41'680	41'088	42'290	42'370	41'243	42'045	41'252	42'384	*3.5%*
2 Industrial Processes	3'228	2'872	2'708	2'375	2'517	2'476	2'324	2'267	2'339	2'378	2'647	2'730	2'657	2'686	*-16.8%*
3 Solvent and Other Product Use	108	110	112	114	117	119	119	120	120	121	121	121	123	124	*15.3%*
4 Agriculture	6'082	6'090	5'972	5'956	5'801	5'753	5'742	5'585	5'549	5'536	5'498	5'520	5'464	5'372	*-11.7%*
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	*38.7%*
6 Waste	2'061	1'950	1'910	1'808	1'709	1'663	1'634	1'622	1'665	1'682	1'748	1'678	1'691	1'686	*-18.2%*
Total (with net CO_2 emissions/removals)	51'173	52'757	52'454	48'759	47'776	48'578	48'991	48'008	49'361	49'830	51'406	52'545	51'492	50'485	*-1.3%*
Total (without CO_2 from LUCF)	**52'446**	**54'096**	**53'877**	**51'147**	**50'167**	**50'933**	**51'498**	**50'682**	**51'964**	**52'086**	**51'257**	**52'094**	**51'187**	**52'252**	***-0.4%***

Table 3 Summary of Switzerland's GHG emissions by source and sink categories in CO_2 equivalent (Gg), 2003.

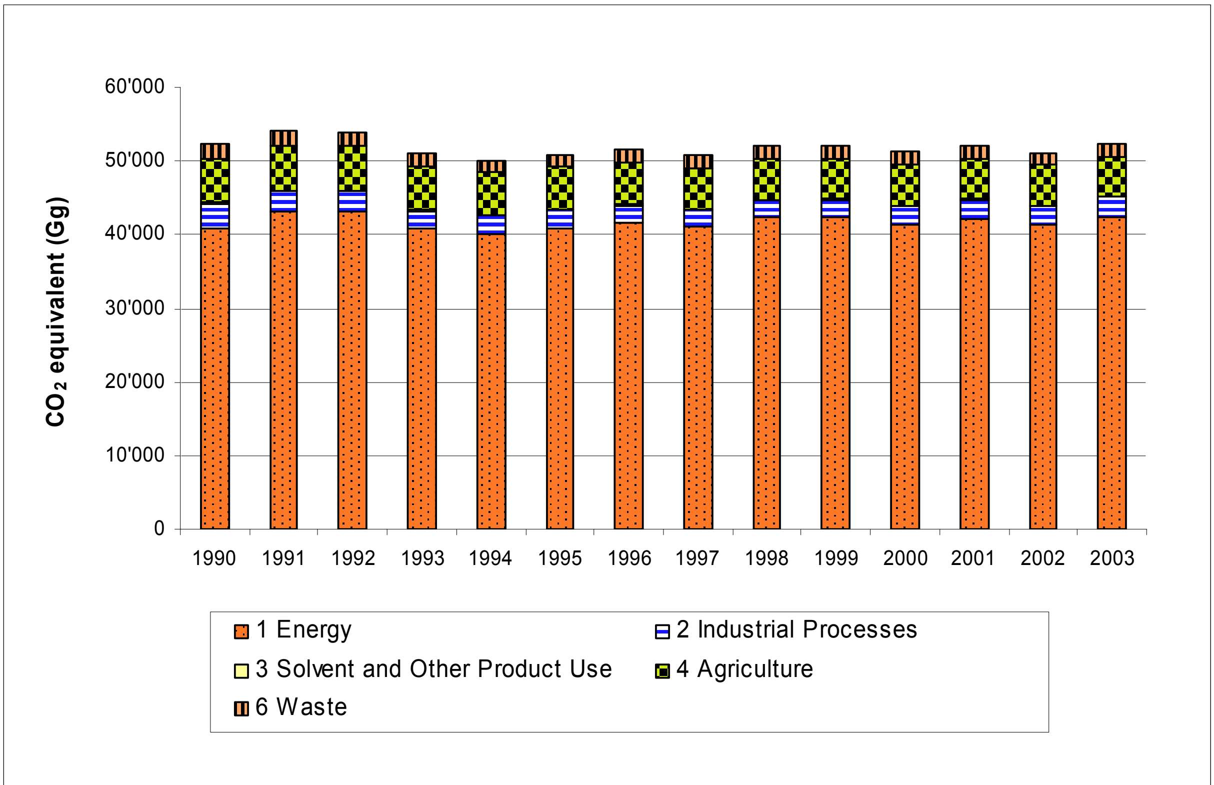

Figure 2 Switzerland's greenhouse gas emissions by main source categories in CO_2 equivalent (Gg), 1990–2003 (without CO_2 from LUCF).

The total gross emissions (without LUCF) remained almost unchanged from 1990 to 2003: -0.4 % in 2003 compared to 1990. (The total emissions with net CO_2 emissions/removals show a decrease of -1.3% in the same period 1990–2003.) After the large losses of biomass due to a heavy storm (winter storm "Lothar") at the end of 1999 which resulted in a major reduction of net removals in the LUCF sector (visible over several years due to 3-year averaging of the storm effects), removals from LUCF are now back at levels prevailing up to 1999.

Table 4 shows sector contributions to total emissions for selected years. Between 1990 and 2003, the relative contribution of source category 1 "Energy" increased from 78.1% to 81.1%, whereas 2 Industrial Processes decreased from 6.2% to 5.1%, 4 Agriculture from 11.6% to 10.3% and 6 Waste from 3.9% to 3.2%, respectively.

Greenhouse Gas Source Categories	1990		1995		2000		2003	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1 Energy	40'968	78.1%	43'176	80.1%	40'025	79.8%	42'384	81.1%
2 Industrial Processes	3'228	6.2%	2'708	5.0%	2'517	5.0%	2'686	5.1%
3 Solvent and Other Product Use	108	0.2%	112	0.2%	117	0.2%	124	0.2%
4 Agriculture	6'082	11.6%	5'972	11.1%	5'801	11.6%	5'372	10.3%
6 Waste	2'061	3.9%	1'910	3.5%	1'709	3.4%	1'686	3.2%
Total (without CO_2 from LUCF)	**52'446**	**100.0%**	**53'877**	**100.0%**	**50'167**	**100.0%**	**52'252**	**100.0%**

Table 4 Switzerland's total gross GHG emissions (without LUCF) by source category in CO_2 equivalent (Gg), selected years.

1. Introduction

1.1. Background Information on Swiss Greenhouse Gas Inventories

On December 10, 1993, Switzerland ratified the United Nations Framework Convention on Climate Change (UNFCCC). Since 1996 the submission of its national greenhouse gas inventory is based on IPCC guidelines. From 1998 on, the inventories are submitted in the Common Reporting Format. The present report is Switzerland's second National Inventory Report established under the UNFCCC. It includes, as a separate document, Switzerland's 2003 Inventory in the Common Reporting Format (SAEFL 2005a).

On July 9, 2003, Switzerland ratified the Kyoto Protocol to the UNFCCC. The national inventory system according to Article 5.1 of the Kyoto Protocol is presently under implementation and will be fully operating in 2006.

Switzerland's first National Inventory Report was submitted on April 14, 2004, and on September 13-17, 2004, an in-country review took place in Berne. The review team, coordinated by Ms. Rocío Lichte (UNFCCC secretariat), stated that “Switzerland has made significant improvements since the last inventory submission” (UNFCCC 2004). The review team also identified a number of issues in the Swiss inventory that should be improved in future submissions. These findings are put together in the Inventory Development Plan which is incorporated in this report in Annex 4.

It is important to note that Switzerland's National Inventory Report also includes the energy-related emissions produced by its neighbouring country, the Principality of Liechtenstein (32,000 inhabitants, corresponding to 0.44% of the Swiss population). Switzerland and the Principality of Liechtenstein form a customs and monetary union leading to unrestricted exchange of goods including e.g. fossil fuels. Liechtenstein's emissions will be excluded from Switzerland's Greenhouse Gas Inventory effective from the next submission in 2006.

1.2. Institutional Arrangements for Inventory Preparation

The Swiss National Inventory System (NIS) is developed and managed under the auspices of the Ministry “Federal Department of Environment, Transport, Energy and Communications”. It is hosted by the Ministry’s Agency for the Environment, Forests and Landscape (SAEFL) which serves as the national entity with overall responsibility for the national GHG inventory.

In the context of a comprehensive project, the SAEFL directorate has mandated its Economics, Research and Monitoring Division in early 2004 to design and establish the NIS in order to ensure full compliance with the reporting requirements of the UNFCCC and its Kyoto Protocol by the end of 2006. With regard to the provisions of Art. 5.1 of the Kyoto Protocol, the project encompasses the following elements:

- Agreements with partner agencies, relating to
  - Roles and responsibilities,
  - Participation in the inventory development process,
  - Data documentation and storage,
  - Data use, communication and publication.
- Inventory Development Plan

- QA/QC System
- Official consideration and approval of data
- Upgrading and updating of central GHG emissions data base

A SAEFL Inventory Group has been formed to implement and run the NIS. Information related to the Swiss GHG Inventory is made publicly accessible through the web site www.climatereporting.ch where detailed contact information is available, too.

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.

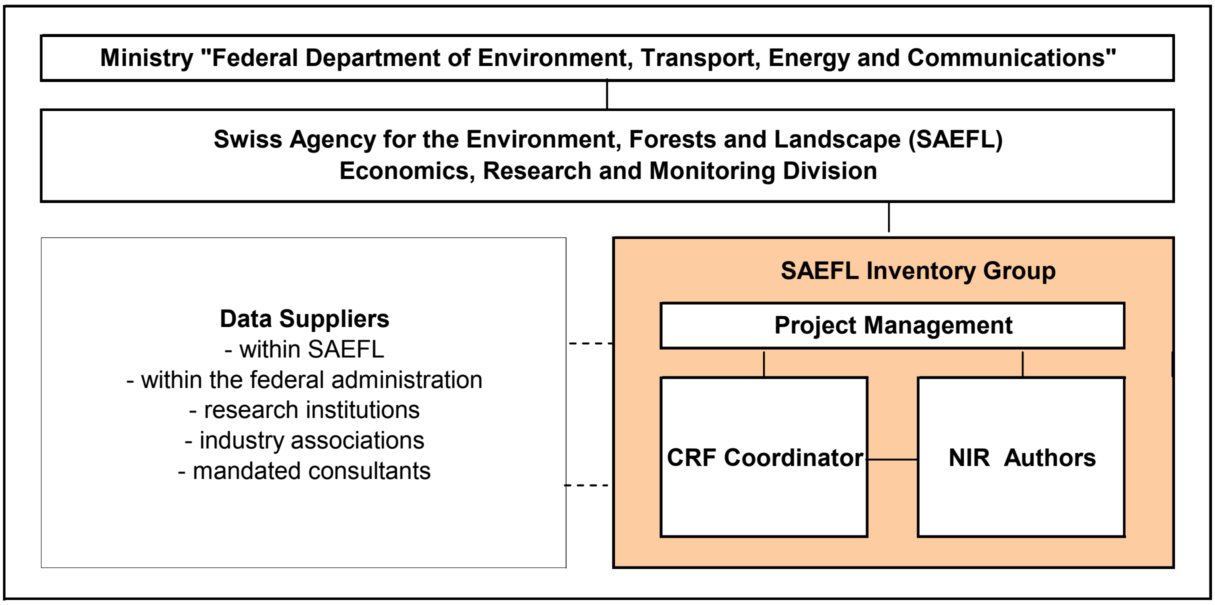

Figure 3 Institutional setting of the process of inventory preparation.

The SAEFL Inventory Group consists of the project team at the agency, including a GHG inventory project leader, a CRF compilation specialist, and data base specialists. It is supported by mandated external experts contributing to the establishment of the yearly inventory submission, in particular the National Inventory Report.

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

The roles and responsibilities of the different contributors are defined through

- Memoranda of understanding within SAEFL,
- Agreements with the other government agencies involved,
- Agreements with research institutions and industry associations,
- Contracts with consultants.

Conclusion of memoranda of understanding, agreements and contracts is under way and is planned to be completed by the end of the year 2005.

SAEFL maintains internal GHG inventory files which contain all basic data needed to set up 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 steps of data collection and processing leading to the CRF tables required for reporting under the UNFCCC.

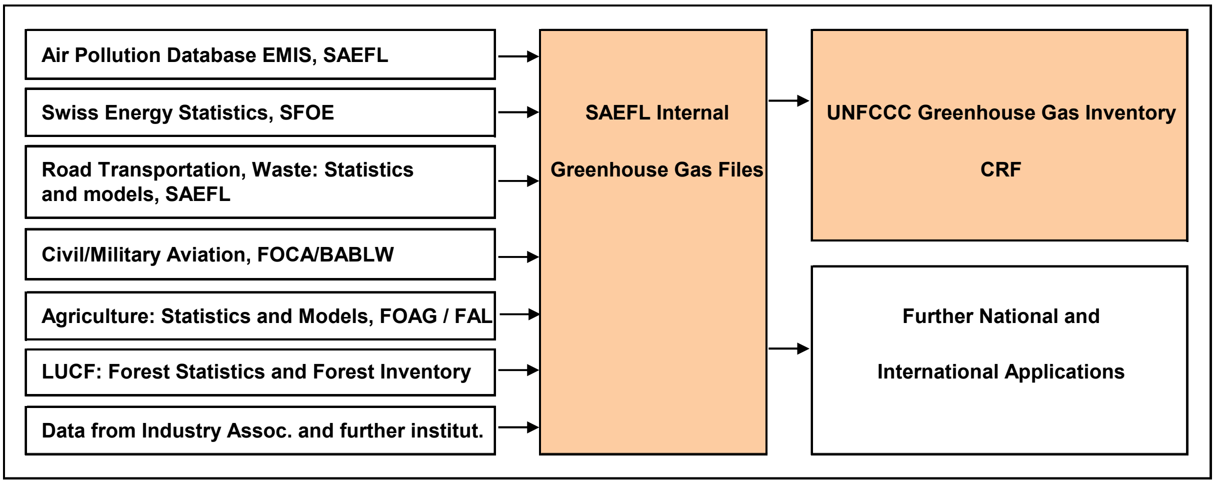

Figure 4 Data collection for SAEFL Internal GHG Files and CRF tables. Shaded boxes: Swiss greenhouse gas data.

Since the individual data suppliers bear the main responsibility for the quality of data they provide, the collection of activity data as well as the selection of emission factors and methods is under their own responsibility, too. However, they are to take the relevant guidelines, including IPCC Good Practice Guidance, into account. Supervision of data suppliers by the SAEFL inventory group, together with QA/QC and review procedures, provide for additional safeguards to maintain or improve consistency, completeness and accuracy of inventory data.

The data suppliers are shown in the following table.

	Institution	Subject	Data supplied for source category...												References in NIR 2005
			1A1	1A2	1A3	1A4	1A5	1B	R.A.	2	3	4	5	6	
	Data suppliers (annual updates)														
1	SAEFL, Air Pollution Control	EMIS 95 database	x	x		x	x	x		x	x	x		x	SAEFL 1995b
2	SAEFL, Air Pollution Control	Off-road database			x		x								SAEFL 1996a, 2000b
3	SAEFL, Waste Management	Waste Statistics	x	x										x	SAEFL 2003a
4	SAEFL, Hazardous Substances	Import Statistics F-gases								x					SAEFL 2004e
5	SAEFL, Forest Agency	Forest Statistics											x		SFSO 2003
6	SFOE	Global Energy Statistics	x	x	x	x		x	x						SFOE 2003
7	FOCA/BAZL	Air traffic			x										FOCA 2004
8	BABLW	Military Aviation			x										BABLW 2003
9	SFSO	Agric. + Land use data										x	x	x	SFSO 2003, 2004, 2004a
10	FAL	Agric. + Land use change										x	x		SBV 2004; SFSO 2003, 2004
11	WSL	National Forest Inventory											x		SFSO 2004a
12	Cepe/Basics	Energy Consumption		x		x									Cepe 2004, Basics 2004
13	Ind. suppliers: SGCI, Swissmem, VSAI etc.	Synthetic gases								x					Carbotech 2005
14	Swiss Petroleum Ass. (Erdölvereinigung)	Oil Statistics							x						EV 2004
15	Cemsuisse	Cement, clinker prod.		x						x					cemsuisse 2004
	Data suppliers (episodic updates)														
16	SVGW	Gas distribution losses						x							GWA 2004
17	EMPA	Various emission factors	x	x	x	x									NIR 2005, Annex 2.1
18	INFRAS	On-road Emission Model			x										SAEFL 2004a
19	Electrowatt	Off-road activity data			x	x	x								SAEFL 1996a, 2000b
20	TTM Meier	Off-road emission factors			x	x	x								SAEFL 1996a, 2000b
21	INFRAS	Off-road emission model			x	x	x								SAEFL 1996a, 2000b
22	Sigmaplan (based on SFSO area statistics)	Land use change											x		SAEFL 2005c

Table 5 Data suppliers 1-15 provide annual updates, suppliers 16-22 provide episodic updates.

1.4. Methodologies

1.4.1. General Description

The emissions in the SAEFL internal GHG inventory files are calculated by multiplying emission factors and activity rates. For a number of source categories, the emissions are calculated by the data suppliers listed in Figure 4, e.g., in EMIS. In those cases, the resulting emission data are inserted directly into the SAEFL internal GHG inventory files. In other cases, data from EMIS are recalculated and interpolated or extrapolated in the SAEFL internal GHG inventory files.

The emissions are calculated based on 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.

The National Approach for source category 1 “Energy” is based on the statistics of fuel sales in Switzerland (see Chapter 1.4.2). The other sectors rest upon national statistics and data surveys as shown in Figure 4. For the different sectors, Tier 1, 2 and 3 methodologies according to IPCC Guidelines (IPCC 1997b) and Good Practice Guidance (IPCC 2000) are used. For key sources, the following methodologies are adopted (source category 3 “Solvent and Other Product Use” does not contain any key sources):

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.
  Emission factors: Country-specific; exception N_2O aviation: IPCC default.

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 and 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 method, 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 the 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 of imported oil and oil products and on data published in the annual report of the Swiss Petroleum Association (Erdöl-Vereinigung/Union pétrolière, EV 2004). The results of the Reference Approach are compared with the results of the National Approach for sector 1 Energy. This comparison is a means to test the quality and completeness of the inventory. For the present inventory, the two approaches show very good correspondence with a difference of CO_2 emissions of only 0.44 % in 2003 (see Chapter 3.6).

1.4.3. Air Pollution Database EMIS

A large body of emission data is adopted from Switzerland's national air pollution database EMIS, which is operated by SAEFL (EMIS 1995). EMIS is designed to estimate not only emissions of greenhouse gases, but all kinds of air pollutants. Its structure corresponds to the European CORINAIR system for classifying emission-generating activities. CORINAIR uses the Selected Nomenclature for Sources of Air Pollution ("SNAP code", CORINAIR 1992). Additionally, a fuel code is defined. Any activity can be identified by SNAP and fuel code. The Revised 1996 IPCC Guidelines provide a correspondence key between IPCC and 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 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), PM10, and more. The input data originate from a variety of different sources, such as production data and emission factors from industry and industry associations or agriculture statistics. EMIS is documented in an internal SAEFL manual for the database (EMIS 1995).

Emissions from EMIS that are relevant for the GHG inventory are imported to the SAEFL internal GHG inventory files. Independently from EMIS, a number of other data sources are relevant for compiling the GHG inventory files: These comprise the SFOE Swiss overall energy statistics, SAEFL statistics and models for emissions from road and off-road transportation, the waste sector as well as the National Forest Inventory and the National Forest Statistics. Data on synthetic GHG emissions stem directly from the relevant industry associations.

The 1995 EMIS database (EMIS 1995) is currently undergoing a full redesign. It is being extended to incorporate more data sources, updated and migrated to a new software platform. At the same time, activity data and emission factors are being checked and updated. The new EMIS database will support completion of the GHG inventory in the CRF and it will help to fulfil various other reporting obligations of Switzerland regarding air pollutants. A beta-version of the new EMIS database is expected to be operational in the first semester 2005.

Where reference to EMIS is made, the present inventory submission still refers to the old EMIS 1995 database (includes several selective updates). From the new EMIS only two technical data sheets on waste and cement production have been used – here explicit reference to the new EMIS is made.

1.5. Key Source Categories

The key source 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%. Compared to the previous submission, a more detailed disaggregation has been realised to identify important sub-sources (see Inventory Development Plan in Annex 4). A more detailed description of the Key Source Analysis and the level of disaggregation is provided in Annex 1.

The category 2F has been separated into four sub-categories:

- Sum of HFC without HFC from 2F1 “2F_o (HFC)” (No. 23 in Table 6)
- Sum of SF_6 without SF_6 from 2F7 “2F_o (SF_6)” (No. 24 in Table 6)
- Sum of PFC (No. 25 in Table 6)
- HFC from 2F1 Refrigeration and Air Conditioning Equipment (No. 26 in Table 6)

Due to the emission dynamics within these groups, they all appear as key sources by trend (Table 6): HFCs were not present at all in 1990 and SF_6 has decreased to half of its value between 1990 and 2003.

For 2003, 34 sources have been identified as key sources:

No.	Code	Source Category	Fuel	Gas	Key Source by	
					level	trend
1	1A1	Energy A. Fuel Combustion 1. Energy Industries	Gaseous Fuels	CO_2	yes	yes
2	1A1	Energy A. Fuel Combustion 1. Energy Industries	Liquid Fuels	CO_2	yes	
3	1A1	Energy A. Fuel Combustion 1. Energy Industries	Other Fuels	CO_2	yes	yes
4	1A2	Energy A. Fuel Combustion 2. Manufacturing Industries and Construction	Gaseous Fuels	CO_2	yes	yes
5	1A2	Energy A. Fuel Combustion 2. Manufacturing Industries and Construction	Liquid Fuels	CO_2	yes	yes
6	1A2	Energy A. Fuel Combustion 2. Manufacturing Industries and Construction	Other Fuels	CO_2		yes
7	1A2	Energy A. Fuel Combustion 2. Manufacturing Industries and Construction	Solid Fuels	CO_2	yes	yes
8	1A3b	Energy A. Fuel Combustion 3. Transport; Road Transportation	Diesel	CO_2	yes	yes
9	1A3b	Energy A. Fuel Combustion 3. Transport; Road Transportation	Gasoline	CO_2	yes	yes
10	1A3b	Energy A. Fuel Combustion 3. Transport; Road Transportation	Gasoline	CH_4		yes
11	1A3b	Energy A. Fuel Combustion 3. Transport; Road Transportation	Gasoline	N_2O		yes
12	1A3e	Energy A. Fuel Combustion 3. Transport; Other Transportation (mil. aviation)	Liquid Fuels	CO_2		yes
13	1A4a	Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO_2	yes	yes
14	1A4a	Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO_2	yes	yes
15	1A4b	Energy A. Fuel Combustion 4. Other Sectors; Residential	Gaseous Fuels	CO_2	yes	yes
16	1A4b	Energy A. Fuel Combustion 4. Other Sectors; Residential	Liquid Fuels	CO_2	yes	yes
17	1A4c	Energy A. Fuel Combustion 4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO_2	yes	yes
18	1A5	Energy A. Fuel Combustion 5. Other	Liquid Fuels	CO_2	yes	yes
19	1B2	Energy B. Fugitive Emissions 2. Oil and Natural Gas		CH_4		yes
20	2A1	Ind. Proc. A. Mineral Products; Cement Production-CO2		CO_2	yes	yes
21	2C3	Ind. Proc. C. Metal Production; Aluminium Production-PFC		PFC		yes
22	2C3	Ind. Proc. C. Metal Production; Aluminium Production-CO2		CO_2		yes
23	2F_o	Ind. Proc. F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC		yes
24	2F_o	Ind. Proc. F. Consumption of Halocarbons and SF6 without 2F7-SF6		SF6		yes
25	2F	Ind. Proc. F. Consumption of Halocarbons and SF6		PFC		yes
26	2F1	Ind. Proc. F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	yes	yes
27	4A	Agriculture A. Enteric Fermentation		CH_4	yes	yes
28	4B	Agriculture B. Manure Management		CH_4	yes	
29	4B	Agriculture B. Manure Management		N_2O	yes	
30	4D1	Agriculture D. Agricultural Soils; Direct Soil Emissions		N_2O	yes	yes
31	4D3	Agriculture D. Agricultural Soils; Indirect Emissions		N_2O	yes	yes
32	6A	Waste A. Solid Waste Disposal on Land		CH_4	yes	yes
33	6A	Waste A. Solid Waste Disposal on Land		CO_2		yes
34	6C	Waste C. Waste Incineration		CO_2	yes	yes

Table 6 List of Switzerland’s Key Sources 2003 sorted by source category codes.

19 of the 34 key sources are in sector 1 Energy contributing 80% to the total CO_2 equivalent in 2003. The other key sources are from sectors 2 Industrial Processes (4.5%), 4 Agriculture (9.9%), and 6 Waste (3.0%). There are two major key sources:

- 1A3b Energy, Fuel Combustion, Road Transportation, gasoline, CO_2, level contribution 22.0%,
- 1A4b Energy, Fuel Combustion, Other Sectors, Residential, liquid fuels, CO_2, level contribution 18.2%.

The following table shows the contributions of the key sources. The complete results of the key source analysis are given in Annex 1.

No.	Code	Sector	Fuel	Gas	1990	2003	Contribution			Key Source by	
					Gg CO_2 eq		level	level cum.	trend	level	trend
9	1A3b	A. Fuel Combustion	Gasoline	CO_2	11'269	11'503	22.01%	22.01%	2.79%	yes	yes
16	1A4b	A. Fuel Combustion	Liquid Fuels	CO_2	10'234	9'522	18.22%	40.24%	6.82%	yes	yes
14	1A4a	A. Fuel Combustion	Liquid Fuels	CO_2	4'448	4'079	7.81%	48.04%	3.57%	yes	yes
8	1A3b	A. Fuel Combustion	Diesel	CO_2	2'493	3'535	6.77%	54.81%	10.62%	yes	yes
5	1A2	A. Fuel Combustion	Liquid Fuels	CO_2	3'383	3'039	5.82%	60.62%	3.35%	yes	yes
27	4A	A. Enteric Fermentation		CH_4	2'767	2'492	4.77%	65.39%	2.67%	yes	yes
15	1A4b	A. Fuel Combustion	Gaseous Fuels	CO_2	1'409	2'218	4.25%	69.64%	8.23%	yes	yes
4	1A2	A. Fuel Combustion	Gaseous Fuels	CO_2	1'131	2'013	3.85%	73.49%	8.95%	yes	yes
20	2A1	A. Mineral Products; Cement Production-CO2		CO_2	2'524	1'618	3.10%	76.59%	9.07%	yes	yes
13	1A4a	A. Fuel Combustion	Gaseous Fuels	CO_2	932	1'396	2.67%	79.26%	4.73%	yes	yes
30	4D1	D. Agricultural Soils; Direct Soil Emissions		N_2O	1'390	1'208	2.31%	81.57%	1.79%	yes	yes
34	6C	C. Waste Incineration		CO_2	1'109	1'186	2.27%	83.84%	0.82%	yes	yes
17	1A4c	A. Fuel Combustion	Liquid Fuels	CO_2	656	735	1.41%	85.25%	0.83%	yes	yes
2	1A1	A. Fuel Combustion	Liquid Fuels	CO_2	691	706	1.35%	86.60%	0.17%	yes	
31	4D3	D. Agricultural Soils; Indirect Emissions		N_2O	819	683	1.31%	87.90%	1.35%	yes	yes
18	1A5	A. Fuel Combustion	Liquid Fuels	CO_2	709	655	1.25%	89.16%	0.52%	yes	yes
3	1A1	A. Fuel Combustion	Other Fuels	CO_2	430	634	1.21%	90.37%	2.08%	yes	yes
7	1A2	A. Fuel Combustion	Solid Fuels	CO_2	1'474	565	1.08%	91.45%	9.13%	yes	yes
26	2F1	F. Consumption of Halocarbons and SF6; Refr		HFC	0.02	471	0.90%	92.35%	4.76%	yes	yes
28	4B	B. Manure Management		CH_4	452	400	0.77%	93.12%	0.51%	yes	
29	4B	B. Manure Management		N_2O	448	397	0.76%	93.88%	0.50%	yes	
32	6A	A. Solid Waste Disposal on Land		CH_4	707	372	0.71%	94.59%	3.37%	yes	yes
1	1A1	A. Fuel Combustion	Gaseous Fuels	CO_2	235	370	0.71%	95.30%	1.38%	yes	yes
6	1A2	A. Fuel Combustion	Other Fuels	CO_2	145	271	0.52%	95.82%	1.27%		yes
19	1B2	B. Fugitive Emissions from Fuels		CH_4	307	251	0.48%	96.30%	0.56%		yes
11	1A3b	A. Fuel Combustion	Gasoline	N_2O	87	143	0.27%	96.93%	0.56%		yes
12	1A3e	A. Fuel Combustion	Liquid Fuels	CO_2	200	135	0.26%	97.45%	0.66%		yes
22	2C3	C. Metal Production; Aluminium Production-CO		CO_2	139	70	0.13%	98.66%	0.69%		yes
23	2F_o	F. Consumption of Halocarbons and SF6 witho		HFC	--	58	0.11%	98.91%	0.59%		yes
24	2F_o	F. Consumption of Halocarbons and SF6 witho		SF6	114	57	0.11%	99.01%	0.58%		yes
25	2F	F. Consumption of Halocarbons and SF6		PFC	0.04	54	0.10%	99.12%	0.55%		yes
10	1A3b	A. Fuel Combustion	Gasoline	CH_4	91	27	0.05%	99.43%	0.64%		yes
21	2C3	C. Metal Production; Aluminium Production-PF		PFC	100	12	0.02%	99.78%	0.89%		yes
33	6A	A. Solid Waste Disposal on Land		CO_2	155	1.5	0.00%	99.97%	1.54%		yes

Table 7 Details to Switzerland's Key Sources: Contributions in level and trend analysis as well as cumulated level contributions ("level cum."). The number (No.) corresponds to the number (No.) in Table 6.

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

1.6.1. Implementation of the QA/QC system

Since autumn 2004, the National System including the QA/QC system is under implementation. A draft of the report "Switzerland's Greenhouse Gas Inventory 1990–2003, Quality Control and Quality Assurance" (SAEFL 2005b) is submitted to the UNFCCC Secretariat together with this National Inventory Report. It contains a description of the actual state of the QA/QC system and planned improvements. The following paragraphs provide a summary.

1.6.2. Current Quality Control Procedures

The following quality control activities have been carried out:

Data suppliers (external and SAEFL-internal)
Up to the present, QC standards have been defined by data suppliers themselves. They carry the responsibility for the quality of their sectoral data: They select appropriate methods, activity data and emission factors, check for correct emission modelling and consistency of time series, compare with previous estimates and document their results.

The **CRF coordinator** (SAEFL-internal)
checks for the correct transcription of data delivered by suppliers and integrated into the SAEFL internal GHG inventory files, checks for consistency of cross-cutting parameters, for correctness of emissions aggregation, for integrity of data structures in the GHG inventory, for completeness of the GHG inventory, for consistency of the time series, for correct transcription of data from internal GHG inventory files into CRF, and for correctness of recalculations. The CRF coordinator is also in charge of the archiving of GHG data.

The **NIR authors** (external)
compare the methods used with IPCC Good Practice Guidance, check the correct recording of the methods in the NIR, check the correct transcription of CRF data into NIR data tables and figures, check for consistency between data tables and text in the NIR, check for completeness of references in the NIR, are responsible for the correctness of the key source and the uncertainty analysis.

The **Project Management**
monitors the GHG emission modelling, the key source analysis, the uncertainty analysis, monitors and reviews the NIR, checks the NIR for correctness, completeness, transparency and quality, checks for the complete archiving of documents, checks for the compliance of QA/QC activities, and checks for the completeness of the CRF submission document.

1.6.3. Current QA Activities

No external review in the formal sense of QA has been carried out so far. However, SAEFL has mandated external consultants to assist in the preparation of the NIR 2004 and 2005. Part of the consultants' work consisted in the assessment of the correspondence of emission calculations with the recommendations of the IPCC Good Practice Guidance.

Additionally, the first in-country review of the Swiss GHG inventory took place in September 2004. The SAEFL Inventory Group analysed the findings of the expert review team in the light of quality improvements. The expert recommendations (UNFCCC 2004) were used to establish a first version of the Inventory Development Plan (SAEFL 2005b, see Annex 4).

1.6.4. Planned QA/QC Activities and Procedures

Establishment of the National Inventory System

- Completion of agreements, memoranda or contracts with all data suppliers,
- Initiation of yearly kick-off meetings with all individuals involved in inventory preparation,
- Detailed QA/QC plan including activities, responsibilities and schedule,
- Centralised database for data and documentation of all QA/QC activities.

These activities will take place in 2005.

Quality Control

For future submissions QC activities and procedures are planned in line with the Good Practice Guidance, particularly as summarised in Table 8.1 of (IPCC 2000). Many of the activities mentioned there have already been accomplished for the previous and the actual submission, but were not documented systematically. Therefore, the list of QC activities will be completed and the systematic documentation of all the activities will be introduced. To that aim, formalised checklists have to be filled in by the suppliers of activity data, emission factors and emissions, by the CRF coordinator, the NIR authors and by the SAEFL Inventory Group. Drafts of the checklists are shown in SAEFL 2005b. Follow-up actions will be defined and controlled as well.

Quality Assurance

Two approaches are selected to carry out future QA activities:

- Episodic domestic in-depth reviews of the complete inventory carried out by independent national experts. The most important source category “1 Energy” will undergo a QA process beginning in late 2005. The review activities will be carried out on an *ex post* basis and cover the complete time-series since 1990.
- Yearly review of the inventory by appointed experts and reviewers before submission: One expert and one reviewer for each sector, mandated by the SAEFL Inventory Group.

QA/QC Plan

The QA/QC activities are to be integrated into the inventory cycle. The following table gives a rough picture of the schedule.

What	Mai	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/GHG inventory												
Data collection			Energy data				Non Energy data					
Emission calculation												
CRF tables												
Key Source Analysis												
Uncertainty analysis												

Table 8 Time schedule inventory preparation.

1.6.5. Treatment of Confidential Data

SAEFL collects the data needed for calculating the emissions of HFCs, PFCs and SF_6 from private companies or branch association. In the National Inventory Report the activity data underlying the emissions of HFCs, PFCs and SF_6 are only partly presented oat the most disaggregated level for reasons of confidentiality. However, the complete emissions are reported in aggregated tables. Confidential data will be made available from SAEFL in line with the procedures agreed under the UNFCCC for in-country review of the inventory.

1.7. Uncertainty Evaluation

With the present NIR, a quantitative uncertainty analysis is presented for the first time. The uncertainty of key sources is assessed following IPCC Good Practice Guidance Tier 1 methodology (IPCC 2000, p. 6.13ff.). For fluorinated gases (F-gases), a Monte Carlo methodology (Tier 2) is used. The quantitative uncertainty data on sources is also used for the key source analysis based on Tier 2 (see Section 1.5). For non-key sources, a qualitative estimate of uncertainties is provided as in earlier NIR submissions.

1.7.1. Data used

Data on uncertainties is not provided explicitly for most key data sources: Neither the Swiss overall energy statistics (SFOE 2003) nor the old EMIS1995 database provide any estimates of uncertainties. In this situation, the authors of the NIR chapters together with the involved experts from SAFEL generated first estimates of uncertainties based on IPCC Good Practice Guidance default values, information on the process of data collection for activity data and emission factors (import or sales statistics, surveys or modelling) and contacted some experts from data suppliers to receive their estimate on some of the uncertainties. Some industry associations/sources provided also published or unpublished uncertainty estimates for their data. Data sources are provided in the relevant sub-sections on "Uncertainties and Time-Series Consistency" in each of the sectoral chapters 3 to 8 below.

All uncertainty figures are to be interpreted as corresponding to one standard deviation. Distributions are assumed to be symmetric.

The present data is still of a somewhat preliminary character. For future submissions, the gradual improvement of the uncertainty analysis is planned. An important step will be to motivate institutions supplying data to provide also estimates of associated uncertainties together with the data.

1.7.2. Results

The results of the Tier 1 uncertainty analysis for GHG emissions from key sources in Switzerland are summarized in Table 9 and Table 10. Details on the uncertainty estimates of 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 emissions in CO_2 equivalents is estimated to be about **3%** for the level. Trend uncertainty is 1.7%

Please note 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 that exist between source categories that have not been considered by the Tier 1 approach (e.g. production data that is used for industry emissions in both 1A2 and 2 or cattle numbers that are used for emissions related to enteric fermentation and to animal manure production),
- Errors due to the assumption of constant parameters, e.g. of constant net calorific values for fuels for the entire period since 1990,
- Errors due to methodological shortcomings,
- Errors due to sources not reported: They are estimated to be very small.

In order to assess the impact of additional sources of errors, a rough sensitivity analysis of the Tier 1 uncertainty calculation has been carried out (see annex 5). The preliminary sensitivity analysis results in a combined uncertainty of 6.6% for level and 5.3% for trend. This may be interpreted as an upper limit of the uncertainty.

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	Gas	Base year emissions 1990	Year 2003 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	3'723.52	6'014.09	5.0	2.3	5.5	0.647	0.0449	0.1170	0.10	0.83	0.83
1A 1. Energy A. Fuel Combustion Liquid fuels	CO2	34'308.73	34'144.52	0.7	0.3	0.8	0.512	0.0002	0.6642	0.00	0.67	0.67
1A 1. Energy A. Fuel Combustion Solid fuels	CO2	1'585.13	577.51	9.5	5.0	10.8	0.121	-0.0194	0.0112	-0.10	0.15	0.18
1A 1. Energy A. Fuel Combustion Other fuels	CO2	575.21	905.01	5.0	30.0	30.4	0.538	0.0065	0.0176	0.19	0.12	0.23
Total CO2 Emissions Fuel Combustion	CO2	40'192.58	41'641.12									

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												
1A3b 1. Energy A. Fuel Combustion 3b. Road Transp. Gasoline	CH4	90.78	27.13	10.0	*28.3*	30.0	0.016	-0.0012	0.0005	-0.03	0.01	0.04
1A3b 1. Energy A. Fuel Combustion 3b. Road Transp. Gasoline	N2O	87.27	142.67	10.0	*299.8*	300.0	0.837	0.0011	0.0028	0.33	0.04	0.33
1B2 1. Energy B. Fugitive Emissions 2. Oil and Natural Gas	CH4	307.34	250.95		50.0	50.0	0.245	-0.0011	0.0049	-0.05	0.00	0.05
2A1 2. Industrial Proc. A. Mineral Products; Cement Production-CO2	CO2	2'524.44	1'617.69	2.0	6.0	6.3	0.200	-0.0174	0.0315	-0.10	0.09	0.14
2C3 2. Industrial Proc. C. Metal Production; Aluminium Production-PFC	PFC	100.17	11.89	3.0	20.0	20.2	0.005	-0.0017	0.0002	-0.03	0.00	0.03
2C3 2. Industrial Proc. C. Metal Production; Aluminium Production-CO2	CO2	139.26	70.24	3.0	20.0	20.2	0.028	-0.0013	0.0014	-0.03	0.01	0.03
2F_o 2. Industrial Proc. F. Consumption of Halocarbons and SF6 without 2F1-HFC	HFC	0.00	58.44		8.4	8.4	0.010	0.0011	0.0011	0.01	0.00	0.01
2F_o 2. Industrial Proc. F. Consumption of Halocarbons and SF6 without 2F7-SF6	SF6	114.45	56.84		8.4	8.4	0.009	-0.0011	0.0011	-0.01	0.00	0.01
2F 2. Industrial Proc. F. Consumption of Halocarbons and SF6	PFC	0.04	54.15		8.4	8.4	0.009	0.0011	0.0011	0.01	0.00	0.01
2F1 2. Industrial Proc. F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	HFC	0.02	470.83		8.4	8.4	0.078	0.0092	0.0092	0.08	0.00	0.08
4A 4. Agriculture A. Enteric Fermentation	CH4	2'766.81	2'492.07	5.0	*12.7*	13.7	0.667	-0.0051	0.0485	-0.06	0.34	0.35
4B 4. Agriculture B. Manure Management	CH4	452.34	399.86	5.0	*36.4*	36.8	0.287	-0.0010	0.0078	-0.04	0.06	0.07
4B 4. Agriculture B. Manure Management	N2O	448.20	396.68	5.0	*71.4*	71.6	0.555	-0.0010	0.0077	-0.07	0.05	0.09
4D1 4. Agriculture D. Agricultural Soils; Direct Soil Emissions	N2O	1'389.82	1'207.74	10.0	*79.8*	80.4	1.899	-0.0034	0.0235	-0.27	0.33	0.43
4D3 4. Agriculture D. Agricultural Soils; Indirect Emissions	N2O	818.89	682.60	50.0	*93.9*	106.4	1.420	-0.0026	0.0133	-0.24	0.94	0.97
6A 6. Waste A. Solid Waste Disposal on Land	CH4	707.42	371.84	10.0	*28.3*	30.0	0.218	-0.0065	0.0072	-0.18	0.10	0.21
6A 6. Waste A. Solid Waste Disposal on Land (Open Burning)	CO2	154.88	1.50	100.0	50.0	111.8	0.003	-0.0030	0.0000	-0.15	0.00	0.15
6C 6. Waste C. Waste Incineration	CO2	1'108.82	1'186.26	5.0	30.0	30.4	0.705	0.0016	0.0231	0.05	0.16	0.17
Total non-CO2 emissions from Fuel Combustion and other Key Sources		11'210.96	9'499.37									

A	B	C	D				H					M
		Gg CO2 equivalent	Gg CO2 equivalent									
3. Total (combined uncertainty of 1. and 2.)												
Total Emissions Uncertainty Analysis (excluding non-key sources)	all gases	51'403.55	51'140.50									
Total Uncertainties						Overall uncertainty in the year (%)	**2.97**				Trend uncertainty (%)	**1.65**

Table 9 Tier 1 Uncertainty Calculation and Reporting for sources in Switzerland (IPCC 2000, Table 6.1).

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	D	R		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		Section 3.2.3
1A	1. Energy	A. Fuel Combustion		Other fuels	CO2	D	D		Section 3.2.3
1A3b	1. Energy	A. Fuel Combustion	3b. Road Transp.	Gasoline	CH4	R	R		Section 3.2.3
1A3b	1. Energy	A. Fuel Combustion	3b. Road Transp.	Gasoline	N2O	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	R	R		Section 4.2.3
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	M	M		Section 4.4.3
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	R	R		Section 4.7.3
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F7-SF6			SF6	R	R		Section 4.7.3
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
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
6A	6. Waste	A. Solid Waste Disposal on Land (Open Burning)			CO2	R	R		Section 8.2.3
6C	6. Waste	C. Waste Incineration			CO2	R	R		Section 8.4.3

Table 10 Tier 1 Uncertainty Calculation and Reporting for sources in Switzerland (Continued).

A				B	C	D	E	F	G	H
IPCC Source category				Gas	Base year emissions 1990	Year 2003 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combinded uncertainty as % of total national emission 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	1.899
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		N2O	818.89	682.60	50.0	93.9	106.4	1.420
1A3b	1. Energy	A. Fuel Combustion 3b. Road Transp.	Gasoline	N2O	87.27	142.67	10.0	299.8	300.0	0.837
6C	6. Waste	C. Waste Incineration		CO2	1'108.82	1'186.26	5.0	30.0	30.4	0.705
4A	4. Agriculture	A. Enteric Fermentation		CH4	2'766.81	2'492.07	5.0	12.7	13.7	0.667
1A	1. Energy	A. Fuel Combustion	Gaseous fuels	CO2	3'723.52	6'014.09	5.0	2.3	5.5	0.647
4B	4. Agriculture	B. Manure Management		N2O	448.20	396.68	5.0	71.4	71.6	0.555
1A	1. Energy	A. Fuel Combustion	Other fuels	CO2	575.21	905.01	5.0	30.0	30.4	0.538
1A	1. Energy	A. Fuel Combustion	Liquid fuels	CO2	34'308.73	34'144.52	0.7	0.3	0.8	0.512
4B	4. Agriculture	B. Manure Management		CH4	452.34	399.86	5.0	36.4	36.8	0.287
1B2	1. Energy	B. Fugitive Emissions 2. Oil and Natural Gas		CH4	307.34	250.95		50.0	50.0	0.245
6A	6. Waste	A. Solid Waste Disposal on Land		CH4	707.42	371.84	10.0	28.3	30.0	0.218
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2		CO2	2'524.44	1'617.69	2.0	6.0	6.3	0.200
1A	1. Energy	A. Fuel Combustion	Solid fuels	CO2	1'585.13	577.51	9.5	5.0	10.8	0.121
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	0.02	470.83		8.4	8.4	0.078
1A3b	1. Energy	A. Fuel Combustion 3b. Road Transp.	Gasoline	CH4	90.78	27.13	10.0	28.3	30.0	0.016
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	0.00	58.44		8.4	8.4	0.010
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F7-SF6		SF6	114.45	56.84		8.4	8.4	0.009
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		PFC	0.04	54.15		8.4	8.4	0.009
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC		PFC	100.17	11.89	3.0	20.0	20.2	0.005
6A	6. Waste	A. Solid Waste Disposal on Land (Open Burning)		CO2	154.88	1.50	100.0	50.0	111.8	0.003

Table 11 Ranked Combined Uncertainties for sources in Switzerland.

If ranked according to their contribution to the uncertainty in total national emissions (using column H in Table 11 above), the N_2O emissions from Agriculture and Road Transport as well as CO_2 from waste incineration and CH_4 from Enteric Fermentation are within the top-five contributors to the uncertainty of the total national emissions. The table serves the identification of future fields for improvement in the context of the Inventory Development Plan (IDP).

1.8. Completeness Assessment

For the key sources, complete estimates of all known sources are accomplished for all gases. For the other sources, the inventory is complete with several marginal exceptions:

- Methane from composting.
- Emissions Industrial waste water treatment plants.
- Emissions from conversion of grassland to settlement.
- Emissions from small marine bunkers.
- Methane from storage lakes.

2. Trends in Greenhouse Gas Emissions and Removals

This chapter gives an overview of Switzerland's GHG emissions and removals as well as their trends in the period 1990–2003.

2.1. Aggregated Greenhouse Gas Emissions 2003

In 2003, Switzerland emitted 52,252 Gg of CO_2 equivalents (without CO_2 from LUCF) to the atmosphere. The largest contributor is CO_2, and the most important sources of emissions are fuel combustion activities in the Energy sector. Table 12 shows the emissions for individual gases and sectors in Switzerland for the year 2003. A breakdown of Switzerland's total emissions by gas is shown in Figure 5 below. Figure 6 is a bar chart of contributions to GHG emissions by gas and sector.

Emissions 2003	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	***Total***
	CO_2 equivalent (Gg)						
1 All Energy	41'721	357	305				***42'384***
2 Industrial Processes	1'815	9	97	529	66	169	***2'686***
3 Solvent Use			124				***124***
4 Agriculture (1 year average)		2'898	2'475				***5'372***
6 Waste	1'188	407	92				***1'686***
Total (without CO_2 from LUCF)	**44'724**	**3'671**	**3'092**	**529**	**66**	**169**	***52'252***
5 Land Use Change/Forestry	-1'766						***-1'766***
Total (with net CO_2 emissions/removals)	42'957	3'671	3'092	529	66	169	***50'485***
International Bunkers	3'672	5	36				***3'713***

Table 12 Summary of Switzerland's GHG emissions by gas and sector in CO_2 equivalent (Gg), 2003.

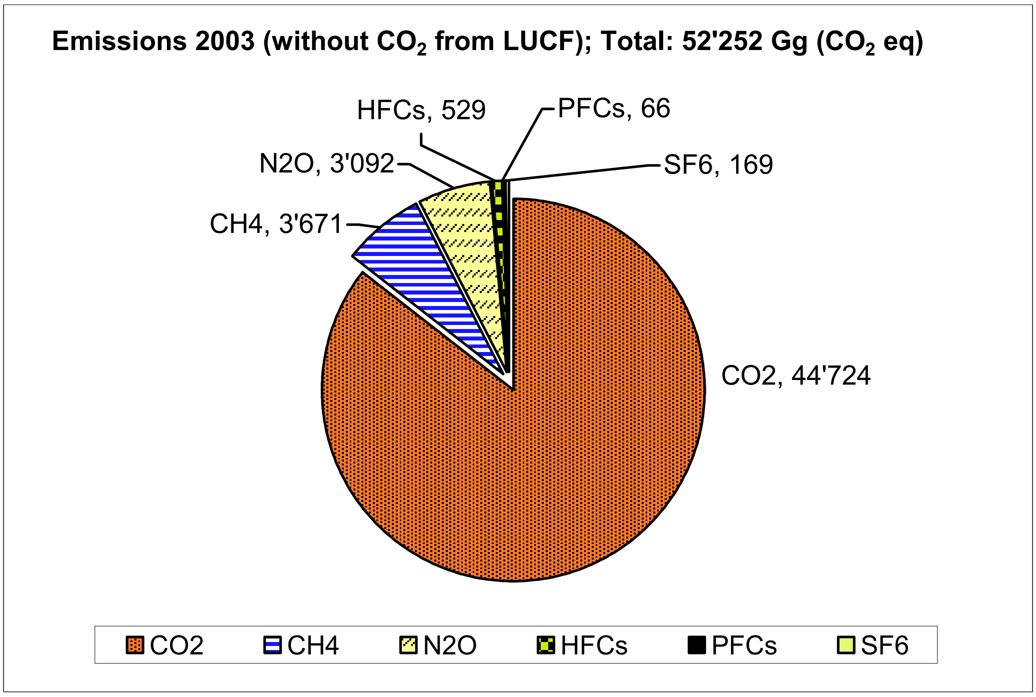

Figure 5 Switzerland's GHG emissions by gas without CO_2 emissions from LUCF, 2003.

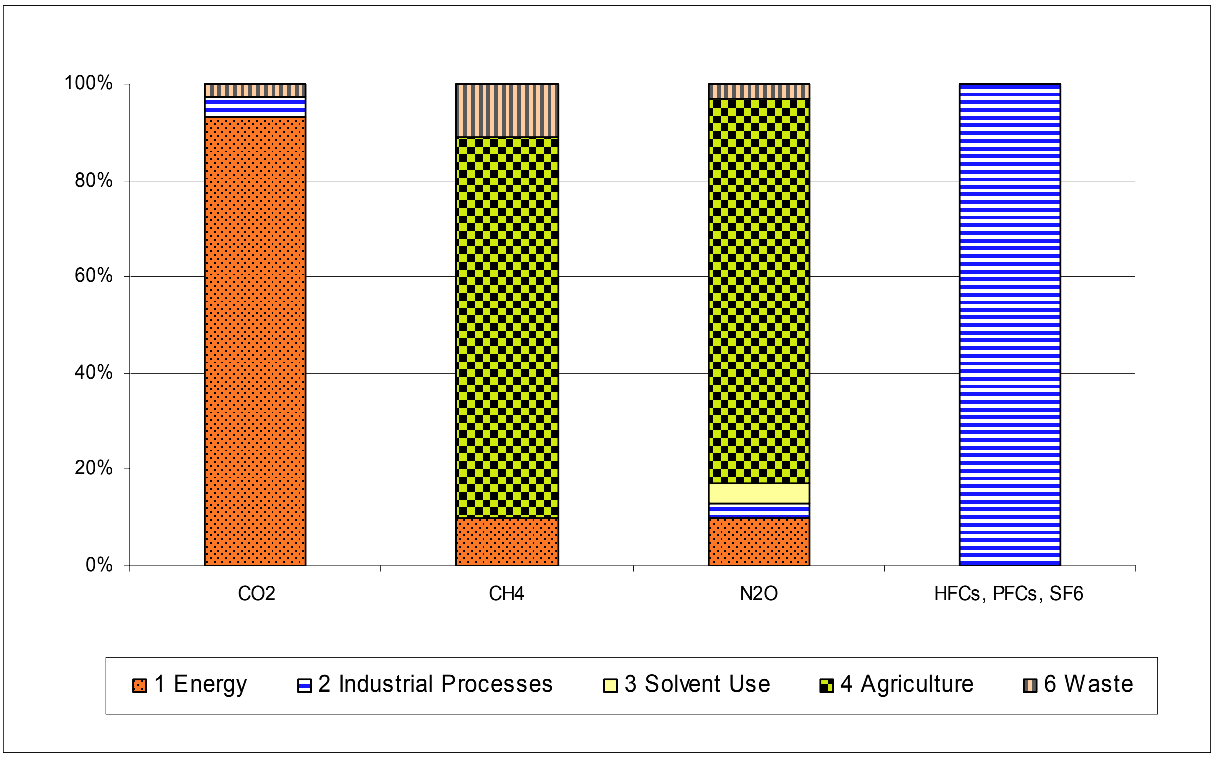

Figure 6 Contribution to GHG emissions by gas and sector, 2003.

Fuel combustion within the Energy sector was by far the largest source of emissions of CO_2 in 2003. 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*

The emission trends by gas are summarised in the upper half of CRF Table 10s5, shown in the table below.

Greenhouse Gas Emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	***2003/1990***
	CO_2 equivalent (Gg)														*%*
Net CO_2 emissions/removals	43'099	44'683	44'519	40'984	40'245	41'014	41'415	40'476	41'836	42'299	43'806	44'908	43'955	42'957	*-0.3%*
Gross CO_2 emissions (without LUCF)	44'372	46'022	45'943	43'372	42'636	43'369	43'922	43'150	44'438	44'555	43'656	44'458	43'650	44'724	*0.8%*
CH_4	4'451	4'437	4'305	4'244	4'040	4'047	3'974	3'909	3'848	3'836	3'742	3'760	3'683	3'671	*-17.5%*
N_2O	3'344	3'371	3'370	3'339	3'313	3'248	3'301	3'200	3'193	3'173	3'186	3'156	3'148	3'092	*-7.5%*
HFCs	0.02	0.4	7.2	14	34	151	185	231	301	349	406	471	483	529	---
PFCs	100	85	69	30	18	15	17	24	28	31	68	29	36	66	*-34.1%*
SF_6	179	181	183	148	126	104	98	169	156	143	199	220	187	169	*-5.3%*
Total (with net CO_2 emissions/removals)	51'173	52'757	52'454	48'759	47'776	48'578	48'991	48'008	49'361	49'830	51'406	52'545	51'492	50'485	*-1.3%*
Total (without CO_2 from LUCF)	**52'446**	**54'096**	**53'877**	**51'147**	**50'167**	**50'933**	**51'498**	**50'682**	**51'964**	**52'086**	**51'257**	**52'094**	**51'187**	**52'252**	***-0.4%***

Table 13 Summary of Switzerland's GHG emissions in CO_2 equivalent (Gg) by gas, 1990–2003 (CRF table 10s5). The column at far right (in italics) shows the percent change in emissions in 2003 as compared to the base year 1990.

The emission trends in individual sectors are as follows (see Table 13 above, Table 14 and Figure 7 below):

- Total gross emissions (without CO_2 from LUCF) were almost constant, with fluctuations within a range of less than 5%. The 2003 total emissions decreased by -0.4% as compared to the emissions recorded in the base year 1990. CO_2 contributed the largest share of emissions, accounting for about 86% of the total in 2003.

- The total with net CO_2 emissions/removals in 2003 show a decrease of -1.3% with reference to the emissions recorded in the base year 1990. After the large losses of biomass due to a heavy storm (winter storm "Lothar") at the end of 1999 which resulted in a major reduction of net removals in the LUCF sector (visible over several years due to 3-year averaging of the storm effects), the total net CO_2 emissions figures are now back at levels prevailing up to 1999.
- A comparison with the number of heating degree days (see further below, Figure 12) indicates that the variation of CO_2 emissions in the period 1990–2003 mainly followed the climatic variations during the same period.
- CH_4 showed a decrease of -17.5% which was mainly the result of two effects: A reduction in the number of animals in agriculture over the period and the corresponding reduction of emissions from enteric fermentation. The CH_4 share of the total GHG emissions decreased from 8.5% in 1990 to 7.0% in 2003.
- HFC emissions increased due to the role of HFCs as substitutes for CFCs. SF_6 emissions have shown relative large fluctuations (ratio max. value / min. value = 2) since 1990. In 2003, SF_6 emissions were reduced by -5.3% with reference to 1990 figures, while PFC emissions declined by -34.1%. The share of all synthetic gases together increased from 0.5% in 1990 to 1.4% in 2003.

Changes due to recalculations

Compared to the NIR 2004, the CH_4 emissions are lower over the entire observation period (1990 to 2003) by -11% to -14%. This change is due to a conversion of the Swiss national model describing CH_4 emissions from solid waste disposal by the methodology recommended by IPCC.

N_2O emissions which in the 2004 NIR were shown to be fairly stable (N_2O emission of 2002 equal to the figures of 1990) have meanwhile been revised and show a reduction. The N_2O emission curve indicates that emissions of 2003 decreased by -7.5% with reference to 1990. This reduction is mainly due to an update of the emission factors of road transportation based on new measurements. Correspondingly, the share of N_2O emissions has been reduced to 5.9% in 2003.

Greenhouse Gas Emissions	**1990**		**1995**		**2000**		**2003**	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
Gross CO_2 emissions (without LUCF)	44'372	84.6%	43'369	85.1%	43'656	85.2%	44'724	85.6%
CH_4	4'451	8.5%	4'047	7.9%	3'742	7.3%	3'671	7.0%
N_2O	3'344	6.4%	3'248	6.4%	3'186	6.2%	3'092	5.9%
HFCs	0	0.0%	151	0.3%	406	0.8%	529	1.0%
PFCs	100	0.2%	15	0.0%	68	0.1%	66	0.1%
SF_6	179	0.3%	104	0.2%	199	0.4%	169	0.3%
Total (without CO_2 from LUCF)	**52'446**	**100.0%**	**50'933**	**100.0%**	**51'257**	**100.0%**	**52'252**	**100.0%**

Table 14 Switzerland's total gross GHG emissions (without LUCF) in CO_2 equivalent (Gg), selected years.

Figure 7 below shows Switzerland's relative GHG emission trend. The base year 1990 is set to 100%.

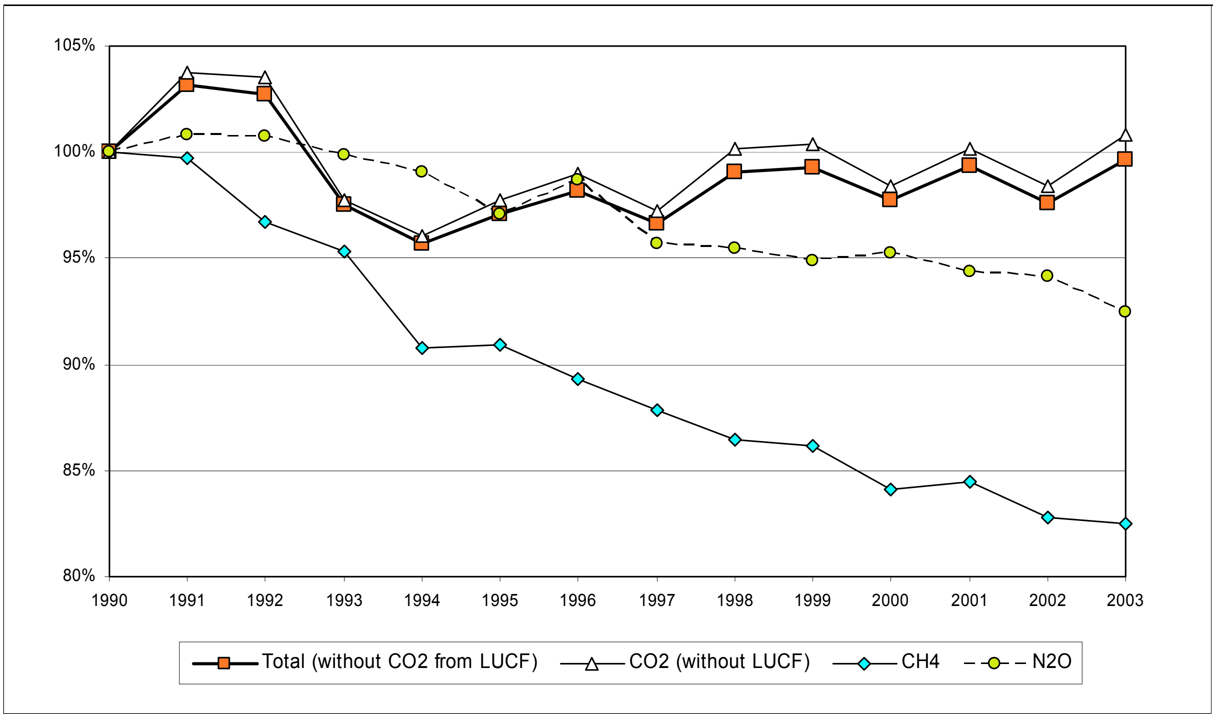

Figure 7 Relative trend of Switzerland's GHG emissions by gas, 1990–2003 (base year 1990 = 100%). The increase of the synthetic gases is not shown (274% in 2003, compared to 1990).

2.3. Emission Trends by Source

Table 15 shows emission trends for all major source categories. As the largest share of emissions originated from the Energy sector, the table also shows 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
	CO_2 equivalent (Gg)													
1 Energy	**40'968**	**43'074**	**43'176**	**40'893**	**40'025**	**40'922**	**41'680**	**41'088**	**42'290**	**42'370**	**41'243**	**42'045**	**41'252**	**42'384**
1A1 Energy Industries	1'425	1'776	1'872	1'562	1'581	1'641	1'821	1'773	2'004	1'799	1'634	1'743	1'762	1'753
1A2 Manufacturing Industries and Construction	6'191	6'109	5'891	5'708	5'786	5'882	5'668	5'624	5'867	5'903	5'897	6'034	5'937	5'936
1A3 Transport	14'382	14'901	15'213	14'153	14'350	14'036	14'094	14'686	14'909	15'523	15'811	15'505	15'406	15'604
1A4 Other Sectors	17'865	19'197	19'121	18'397	17'240	18'308	19'042	17'964	18'478	18'120	16'892	17'748	17'134	18'089
1A5 Other (Offroad)	723	719	715	711	707	703	696	687	679	671	663	666	668	670
1B Fugitive emissions from oil and natrual gas	382	372	364	361	360	351	359	353	353	353	346	348	345	331
2 Industrial Processes	**3'228**	**2'872**	**2'708**	**2'375**	**2'517**	**2'476**	**2'324**	**2'267**	**2'339**	**2'378**	**2'647**	**2'730**	**2'657**	**2'686**
3 Solvent and Other Product Use	**108**	**110**	**112**	**114**	**117**	**119**	**119**	**120**	**120**	**121**	**121**	**121**	**123**	**124**
4 Agriculture	**6'082**	**6'090**	**5'972**	**5'956**	**5'801**	**5'753**	**5'742**	**5'585**	**5'549**	**5'536**	**5'498**	**5'520**	**5'464**	**5'372**
6 Waste	**2'061**	**1'950**	**1'910**	**1'808**	**1'709**	**1'663**	**1'634**	**1'622**	**1'665**	**1'682**	**1'748**	**1'678**	**1'691**	**1'686**
Total (without CO_2 from LUCF)	**52'446**	**54'096**	**53'877**	**51'147**	**50'167**	**50'933**	**51'498**	**50'682**	**51'964**	**52'086**	**51'257**	**52'094**	**51'187**	**52'252**
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
Total (with net CO_2 emissions/removals)	51'173	52'757	52'454	48'759	47'776	48'578	48'991	48'008	49'361	49'830	51'406	52'545	51'492	50'485

Table 15 Summary of Switzerland's GHG emissions by source in CO_2 equivalent (Gg), 1990–2003.

The percentage shares of source categories are shown for selected years in Table 16. Figure 8 through Figure 11 are graphical representations of Table 15 data. For the development of the sub-sectors of source 1 Energy see Chapter 3.

Source and Sink Categories	1990		1995		2000		2003	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1 Energy	40'968	78.1%	40'922	80.3%	41'243	80.5%	42'384	81.1%
1A1 Energy Industries	1'425	2.7%	1'641	3.2%	1'634	3.2%	1'753	3.4%
1A2 Manufacturing Industries and Construction	6'191	11.8%	5'882	11.5%	5'897	11.5%	5'936	11.4%
1A3 Transport	14'382	27.4%	14'036	27.6%	15'811	30.8%	15'604	29.9%
1A4 Other Sectors	17'865	34.1%	18'308	35.9%	16'892	33.0%	18'089	34.6%
1A5 Other (Offroad)	723	1.4%	703	1.4%	663	1.3%	670	1.3%
1B Fugitive emissions from oil and natrual gas	382	0.7%	351	0.7%	346	0.7%	331	0.6%
2 Industrial Processes	3'228	6.2%	2'476	4.9%	2'647	5.2%	2'686	5.1%
3 Solvent and Other Product Use	108	0.2%	119	0.2%	121	0.2%	124	0.2%
4 Agriculture	6'082	11.6%	5'753	11.3%	5'498	10.7%	5'372	10.3%
6 Waste	2'061	3.9%	1'663	3.3%	1'748	3.4%	1'686	3.2%
Total (without CO_2 from LUCF)	**52'446**	**100.0%**	**50'933**	**100.0%**	**51'257**	**100.0%**	**52'252**	**100.0%**

Table 16 Annual share of total gross emissions (without LUCF) by source category in CO_2 equivalent (Gg), selected years.

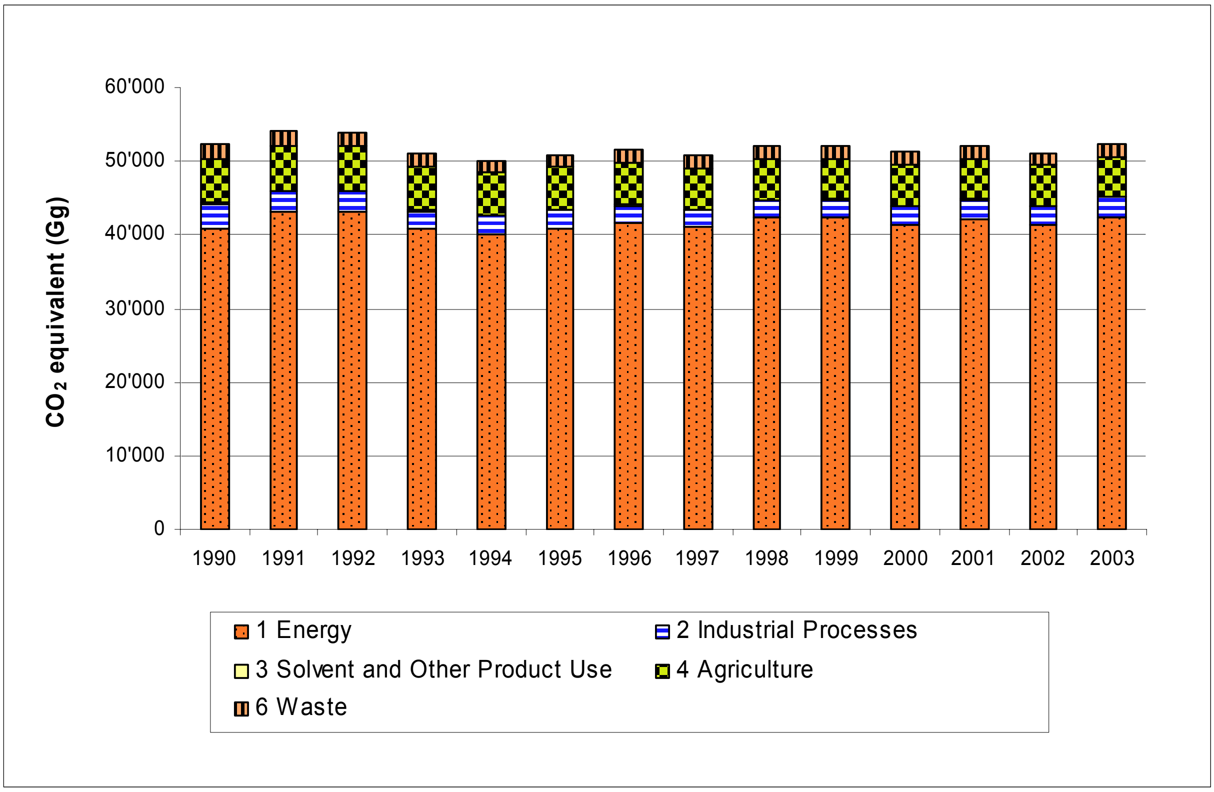

Figure 8 Switzerland's greenhouse gas emissions by main source categories in CO_2 equivalent (Gg), 1990–2003 (without CO_2 from LUCF).

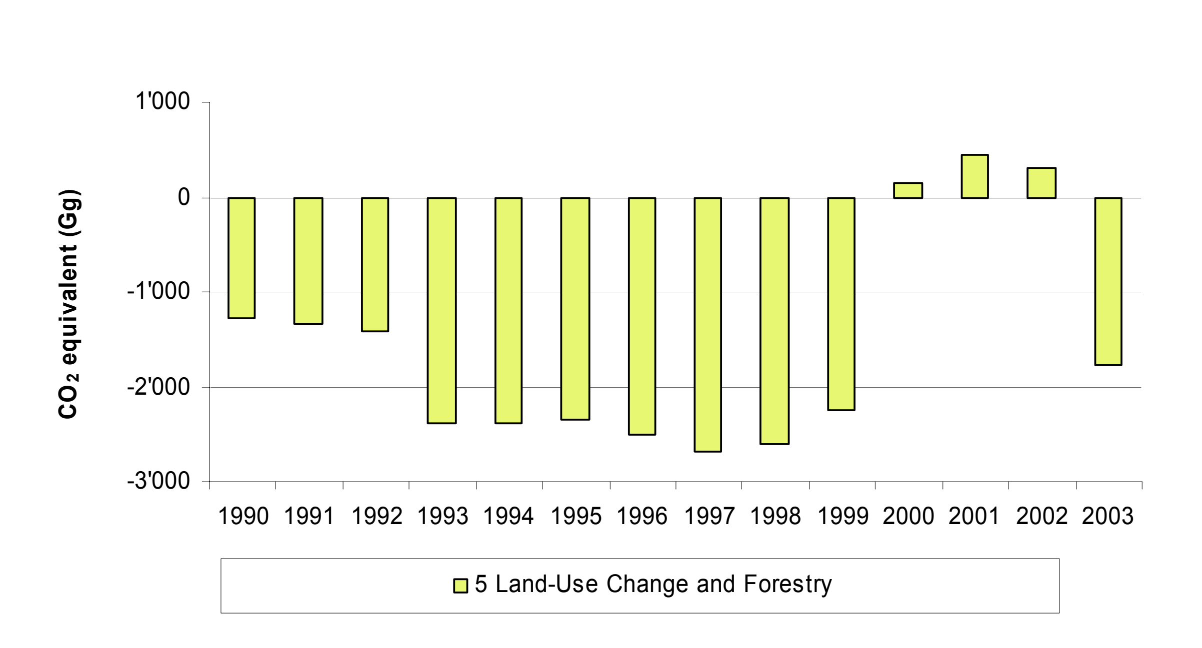

Figure 9 Switzerland's GHG removals (negative emissions) by sinks from LUCF, 1990–2003.

Figure 9 shows the 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 destroyed biomass was nearly three times higher than average annual net growth of Swiss forests). Without the influence of these storms, the removals show only slight variations between, approximately, -2'300 and -2'600 Gg CO_2 eq.

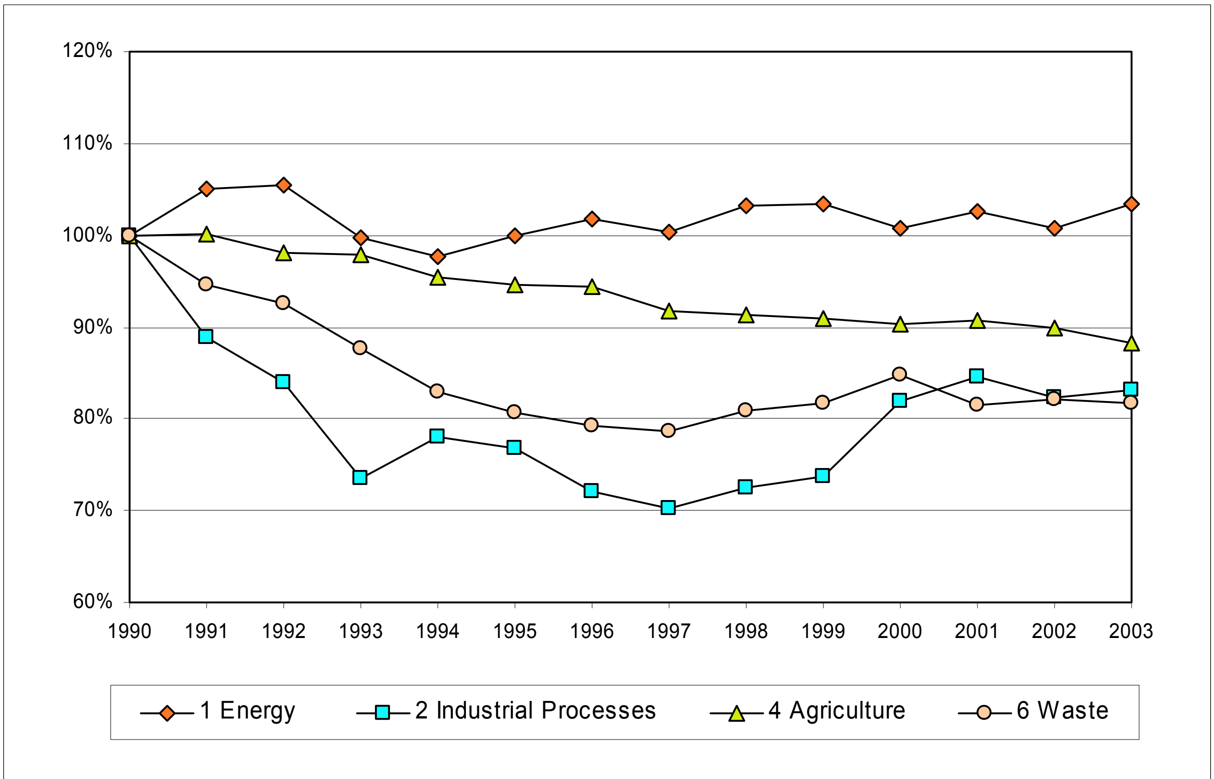

Figure 10 Relative emission trends by main source category (base year 1990 = 100%).

The following emission trends in the sectors are found:

- 1 Energy: The variations can only be understood if the trends within the source sub-categories are considered separately (see Figure 11 and comments below).
- 2 Industrial Processes: In line with the economic development, overall emissions in the Industry sector showed a decreasing trend at the beginning and a slight rebound trend towards the end of the period considered (emissions have fairly stablised since 2000).
- 4 Agriculture: Due to decreasing populations of cattle and swine and reduced fertilizer use, the CO_2 equivalent emissions have decreased.
- 6 Waste: Total emissions from waste decreased steadily from 1990 till 1995. Since 1995, emissions have been fairly stable, with a slight peak in 2000. In essence, this reflects basically the development of waste production over the period.

Changes due to recalculations
Compared to the emissions from waste reported as per NIR 2004, waste emissions have been reduced over the entire observation period by about a factor of two. This is due the change from the Swiss national model describing methane emissions from solid waste disposal by the methodology recommended by IPCC and the resulting recalcuation.

The Energy sector, the major source of Switzerland's GHG emissions, is shown divided into the main Energy sub-sectors in Figure 11.

Figure 11 Emission trends of the three main source sub-categories which account for 94% of emissions in the Energy sector (not shown are the categories of minor importance: 1A1 Energy Industries and 1A5 Other/Off-road and 1B Fugitive Emissions). The bold line "1 Energy" shows the total for the Energy sector.

It is noteworthy that, due to the particular electricity production structure (2003: about 96% of electricity produced in hydro-electrical and nuclear power plants; SFOE 2003, Table 24), the sector 1A1 Energy Industries plays a minor role in the Swiss GHG inventory and is thus not represented in Figure 11.
The following emission trends were observed in the Energy sector:

- 1 Energy: The sub-sectors with their differing trends resulted in a relatively constant overall emission level of the Energy sector (bold line in Figure 11).
- In 1A3 Transport there was a slightly increasing trend in the period 1990–2003 but with significant fluctuations indicating a fairly strong correlation between the transport sector and the economic development: Stagnation periods 1993–1996 and 2001–2003, growth period (gross value added) 1996–2000.
- The trend of 1A4 Other Sectors reflects climatic variations that impact on the heating demand. “Heating degree days” are used as a proxy to characterize conditions of cold weather. In Figure 12, the CO_2 emissions of fuel combustion (without transport and off-road emissions) are depicted, showing the strong correlation with the number of “heating degree days”, which is high in cold winters and low in warm years.
  In the period 1990–2003, the number of buildings and apartments increased as well as the average floor space per person and work place. Both phenomena resulted in an increase of total area heated. Over the same period, however, higher standards for insulation and for efficiency of combustion installation were set for new buildings as well as for renewed old buildings, thereby compensating the emissions from the additional area heated.

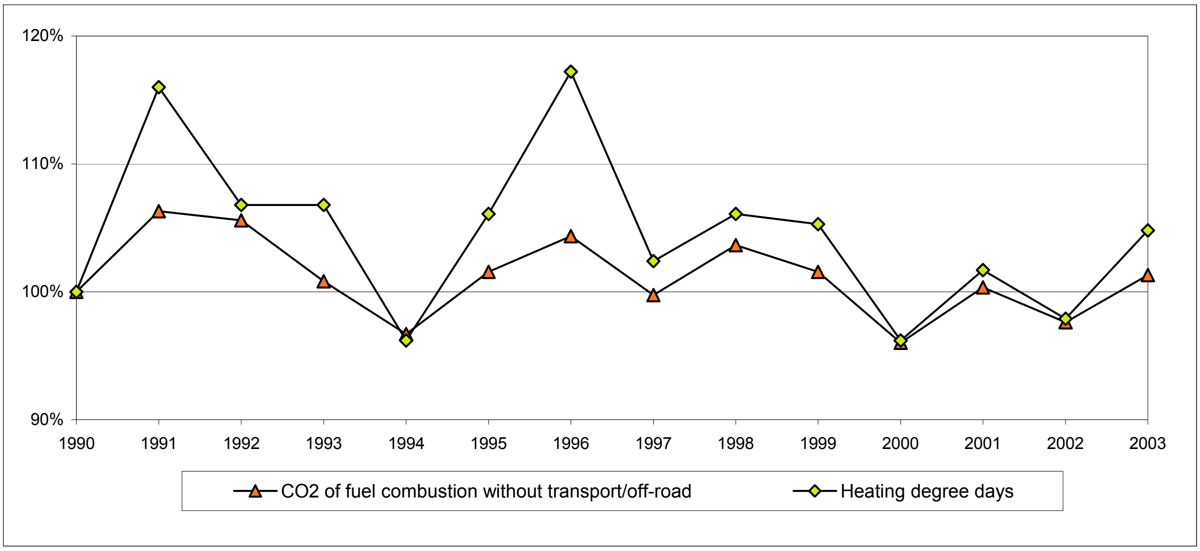

Figure 12 Relative emission trend of CO_2 emissions of fuel combustion (without transport and off-road activities) in comparison with the number of heating degree days (see text above).

2.4. Emission Trends for Indirect Greenhouse Gases and SO_2

The emissions of the indirect greenhouse gases show very pronounced declining trends. Due to a strict air pollution control policy and the implementation of a large number of emission reduction measures, the emission of air pollutants decreased by about 50% in the period from 1990 to 2003. The main reduction measures were abatements of exhaust emissions from road vehicles and stationary combustion, taxation of solvents and sulphured fuels, and voluntary agreements with industry branches.

Indirect Greenhouse Gases and SO_2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	Gg													
NO_x	159	154	144	129	124	118	111	108	106	104	100	96	92	92
CO	741	712	671	595	557	519	507	497	484	480	466	448	429	425
NMVOC	294	275	254	227	209	189	176	163	150	145	137	130	126	125
SO_2	45	40	37	29	30	29	27	27	25	20	18	21	20	19

Table 17 Switzerland's indirect GHG and SO_2 emissions in Gg, 1990–2003.

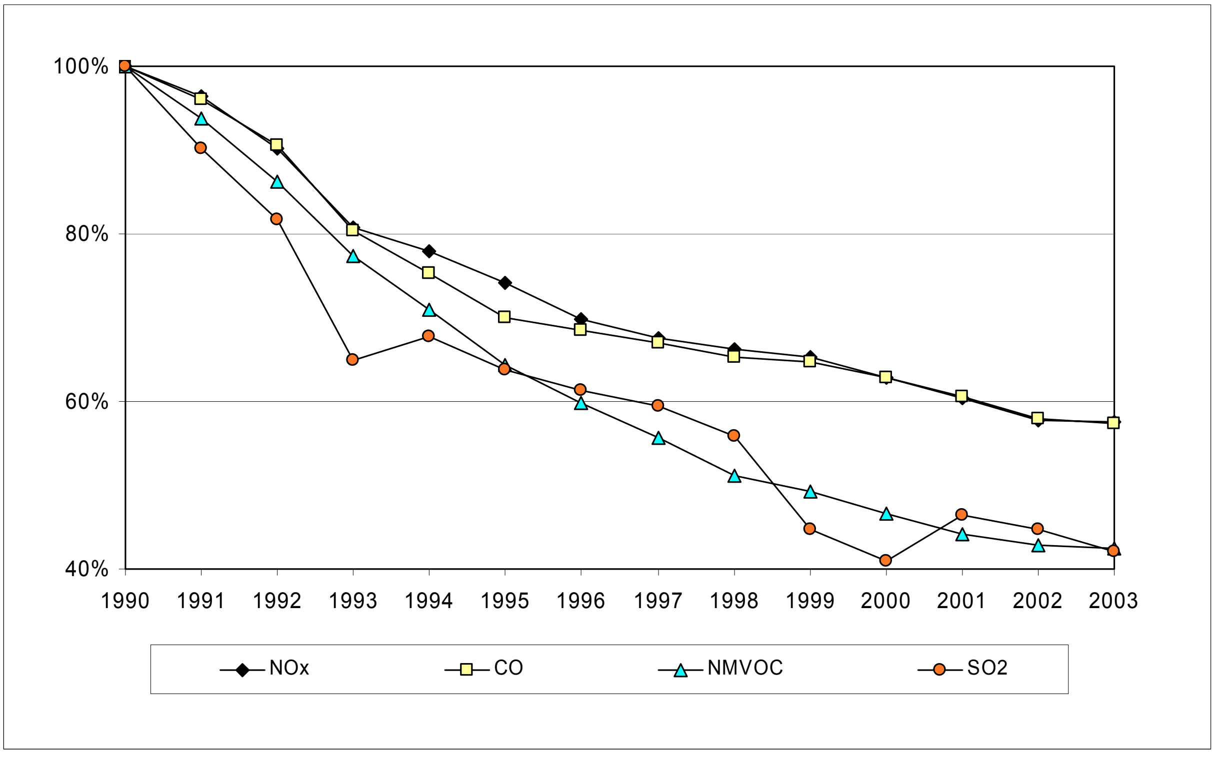

Figure 13 Relative trends of Switzerland's indirect GHG and SO_2 emissions, 1990-2003 (base year 1990 = 100%).

Sector 1 Energy was by far the largest source of the indirect greenhouse gas emissions (see Table 18). The only exception are NMVOCs, where the percentage contribution of category 3 Solvent and Other Product Use covered 54% of the total.

Sources	**NO_x**	**CO**	**NMVOC**	**SO_2**
	Emissions 2003 (Gg)			
1 Energy	84.9	405.2	46.1	13.6
2 Industrial Processes	0.32	12.05	7.31	3.46
3 Solvent and Other Product Use	0.05	0.09	66.82	0.04
4 Agriculture	4.29	5.88	4.22	0.02
6 Waste	2.33	1.72	0.26	1.77
Total	**91.9**	**424.9**	**124.7**	**18.9**

Table 18 Indirect GHG and SO_2 emissions by source in Gg, 2003.

Figure 14 shows the data from Table 18 expressed in percent of the total by individual gas. Sector 1 Energy is clearly visible as the main source of NO_x, CO and SO_2.

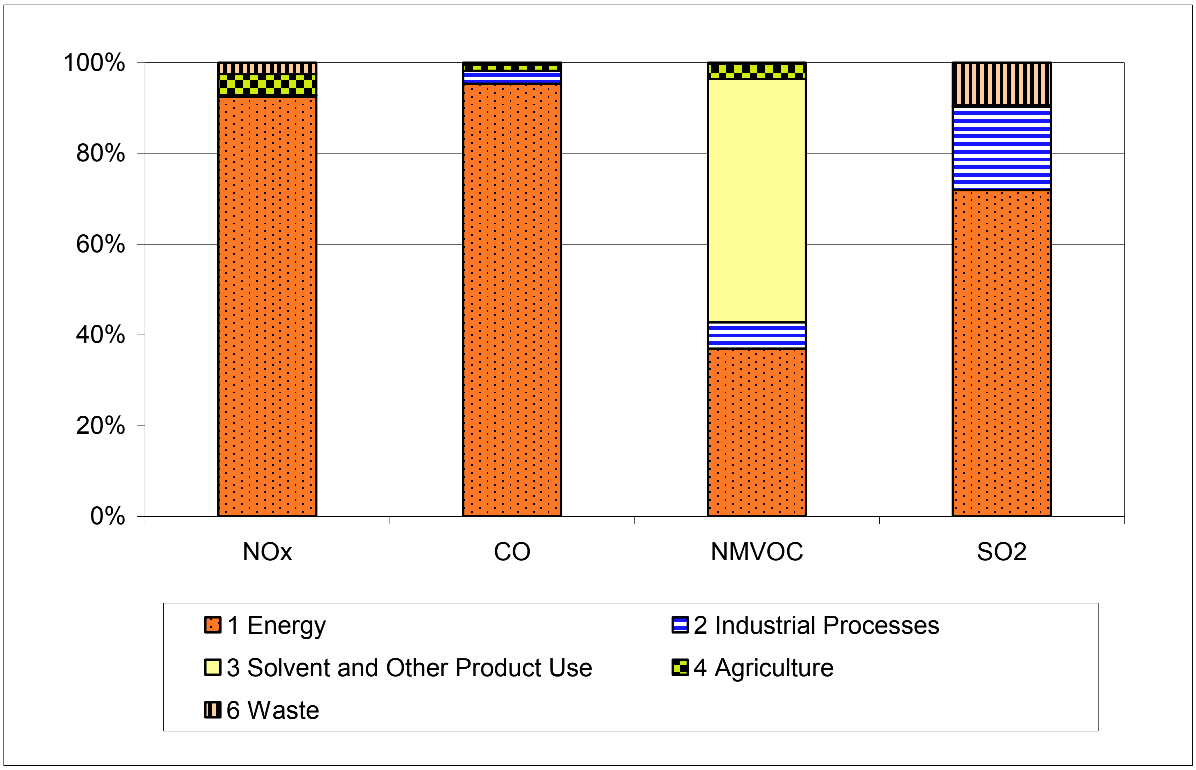

Figure 14 Percentage contributions of indirect GHGs and SO_2 emissions by source, 2003.

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 2003, it emitted 42’384 Gg CO_2 equivalent which correspond to 81.1% of total emissions (52’252 Gg, without CO_2 from LUCF). The emissions of the period 1990–2003 are depicted in Figure 15.

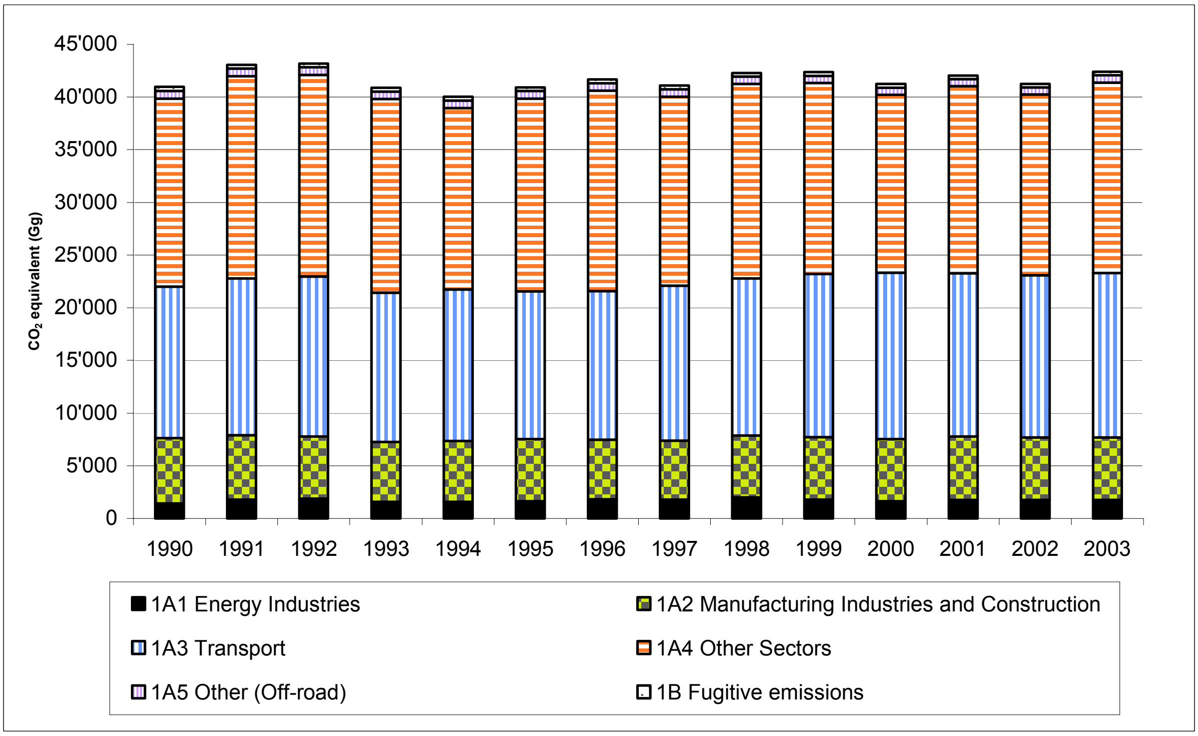

Figure 15 Switzerland’s GHG emissions of source category 1A “Energy” 1990–2003 in CO_2 equivalent (Gg).

For the total emissions of the energy sector, no significant trend may be observed in the period 1990–2003. Three sub-categories dominate the emissions:

- 1A3 Transport and 1A4 Other Sectors are the main sources that cover 36.8% and 42.7%, respectively, of total emissions.
- 1A2 Manufacturing Industries and Construction are of minor importance. They contribute 14.0% to the total emissions.
- 1A1 Energy Industries, 1A5 Other (Off-road) and 1B Fugitive Emissions only play a minor role. In 2003, they cover 4.1%, 1.6% and 0.8%, respectively, of the total emissions of 1 Energy.

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

- The most important gas emitted from source category 1 “Energy” is CO_2. It accounts for 98.4% of the category. Its fluctuations reflect climatic variability in Switzerland (see Figure 12 and related comments).

- In 2003, CH_4 emissions contributed 0.84% 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 0.72% 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
	CO_2 equivalent (Gg)													
CO_2	40'267	42'351	42'449	40'187	39'327	40'229	40'976	40'390	41'594	41'674	40'561	41'371	40'596	41'721
CH_4	473	470	452	431	409	395	394	383	379	374	366	363	357	357
N_2O	227	253	275	275	289	298	310	315	317	321	316	311	299	305
Sum	40'968	43'074	43'176	40'893	40'025	40'922	41'680	41'088	42'290	42'370	41'243	42'045	41'252	42'384

Table 19 GHG emissions of source category 1 “Energy” by gas in CO_2 equivalent (Gg), 1990–2003.

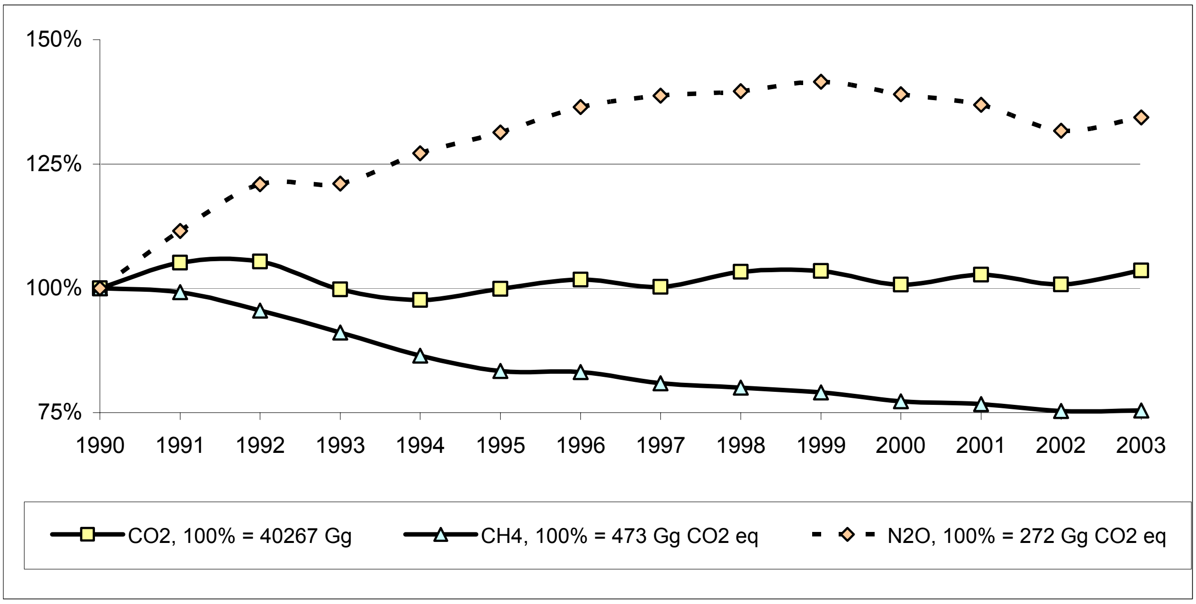

Figure 16 Relative trends of the greenhouse gases of source category 1 “Energy” in the period 1990–2003. The base year 1990 represents 100%.

The following table summarises the emissions of source category 1 “Energy” in 2003. 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 2003	CO_2	CH_4	N_2O	*Total*
	CO_2 equivalent (Gg)			
1 Energy	**41'721**	**357**	**305**	***42'384***
1A Fuel Combustion	**41'641**	**106.4**	**305.0**	***42'053***
1A1 Energy Industries	1'710	1.4	41.4	***1'753***
1A2 Manufacturing Industries and Construction	5'888	8.9	39.5	***5'936***
1A3 Transport	15'409	30.3	164.5	***15'604***
1A4 Other Sectors	17'979	58.5	52.2	***18'089***
1A5 Other	655	7.2	7.4	***670***
1B Fugitive Emissions from Fuels	**80**	**250.9**	**0.0**	***331***

International Bunkers	3'672	5	36	***3'713***
CO_2 Emissions from Biomass	2'077	0	0	***2'077***

Table 20 Summary of source category 1 "Energy", emissions[1] in 2003 in CO_2 equivalent (Gg).

The Swiss greenhouse gas inventory identifies 34 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).

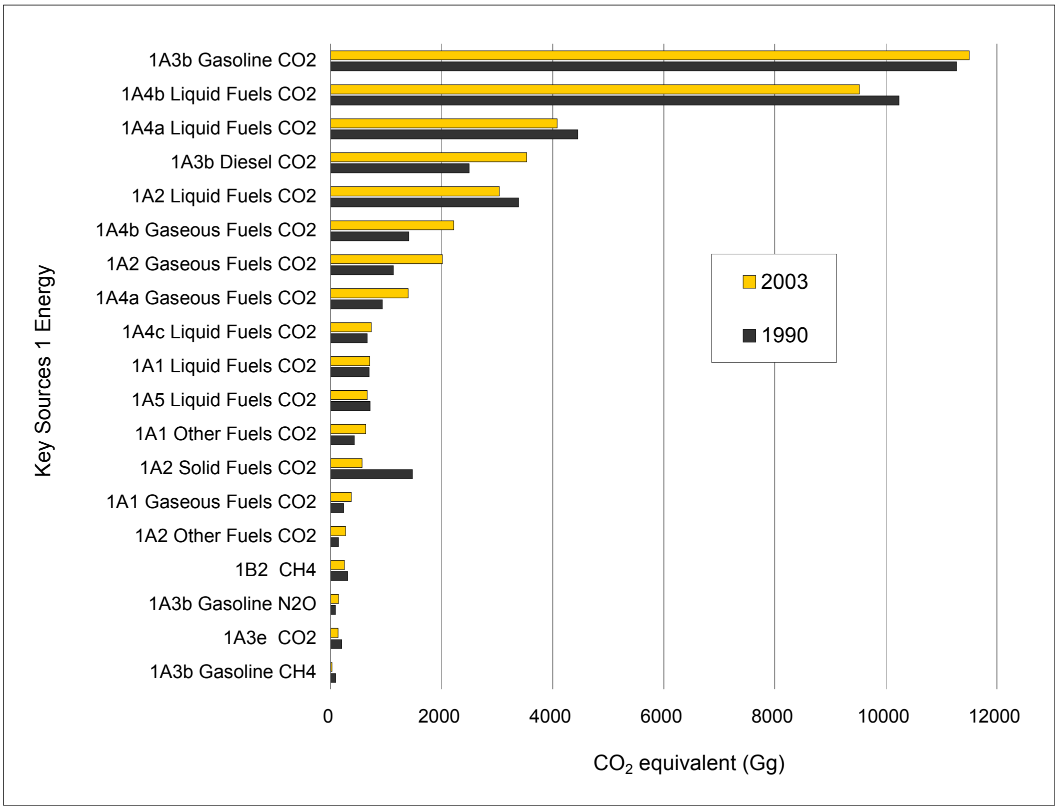

Figure 17 Key sources in the Swiss GHG inventory pertaining to the energy sector.

[1] 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.

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

CO_2 Emission Factors 1990-2003	
Fuel	t CO_2 / TJ
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 21 CO_2 emission factors for fuels. The values are assumed to be constant over the period 1990-2003.

3.1.3. Feedstocks

Energy data are taken from the Swiss overall energy statistics (SFOE 2003). 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 actual CO_2 emissions correctly. Bitumen as refinery product is the only feedstock reported. Other feedstocks are not known. They are assumed to be small.

3.2. Source Category 1A – Fuel Combustion Activities

3.2.1. Source Category Description

a) Energy Industries (1A1)

Key sources 1A1
CO_2 from the combustion of Gaseous Fuels, Liquid Fuels and Other Fuels in Energy Industries (1A1) are key sources regarding level; CO_2 from the combustion of Gaseous Fuels and Other Fuels are also key sources 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 municipal solid waste incineration plants, which is included in 1A1.

In Switzerland, electricity production is dominated by hydroelectric power plants (55.8%) and nuclear power stations (39.7%). Thermal power stations account only for about 4.4% of the electricity generated in Switzerland (SFOE 2003; table 24; data for the year 2003).

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: Activity: SAEFL 2003b EF: CO_2 Fahrni 1999, EMIS 1995 Other sources: Activity: SFOE 2003: EMIS 1995 EF: SAEFL 2000a; SFOE 2000
1A1 b	Petroleum Refining	Combustion activities supporting the refining of petroleum products, excluding evaporative emissions.	Activity: SFOE 2003 EF: Industry data
1A1 c	Manufacture of Solid Fuels and Other Energy Industries	Not occurring in Switzerland	-

Table 22 Specification of source category 1A1 “Energy Industries” (Activity: activity data; EF: emission factors)

b) Manufacturing Industries and Construction (1A2)

Key sources 1A2
CO_2 from the combustion of Gaseous Fuels, Liquid Fuels, and Solid Fuels in Manufacturing Industries and Construction (1A2) is a key source regarding both level and trend. CO_2 from the combustion of Other Fuels in 1A2 is a key source regarding 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 small 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	Activity: SFOE 2003, Basics 2004 and industry data; EMIS 1995 EF: EMIS 1995, 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 mainly Cement, Lime and Glass industries and others.	Same as in 1A2a.

Table 23 Specification of source category 1A2 “Manufacturing Industries and Construction” (Activity: activity data; EF: emission factors)

c) Transport (1A3)

Key sources 1A3b
CO_2 from the combustion of gasoline and of diesel (level and trend)
N_2O and 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 transport, railways, navigation and other transportation. In the last submission, military aviation was included in Aviation (1A3a). For the actual submission military aviation has been separated and is now included in “1A3e 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 2003, FOCA 1999, 2004, SAEFL 1996a, 2000b
1A3 b	Road Transportation	Light and heavy motor vehicles, coaches, two-wheelers	AC: SFOE 2003, EF: SAEFL 2004a-d, RWTÜV 2003 TUG 2002
1A3 c	Railways	Diesel locomotives	SAEFL 1996a, 2000b
1A3 d	Navigation (National)	Passenger ships, motor and sailing boats on the Swiss lakes	SAEFL 1996a, 2000b
1A3 e	Military Aviation		SAEFL 1996a, 2000b, BABLW 2003

Table 24 Specification of Swiss source category 1A3 “Transport”.

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

Key sources 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 sources regarding both level and trend.

Key sources 1A4c
CO_2 from the combustion of Liquid Fuels in Agriculture/Forestry (1A4c) is a key source regarding both level and trend.

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	Activity: SFOE 2003, CEPE 2004 EF: EMIS 1995, SAEFL 2000a; SFOE 2000
1A4 b	Residential	Emissions from fuel combustion in households	Activity: SFOE 2003 EF: EMIS 1995, SAEFL 2000a; SFOE 2000
1A4 c	Agriculture/ Forestry/ Fishing	Comprises fuel combustion for grass drying and off-road machinery in agriculture	Activity: EMIS 1995 and SAEFL 2000b EF: EMIS 1995, SAEFL 2000a; SFOE 2000; SAEFL 1995a, 2000b

Table 25 Specification of source category 1A4 “Other sectors” (Activity: activity data; EF: emission factors).

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.

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 2000. For this 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	SAEFL 1996a, SAEFL 2000b
	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 Transpoortation)	

Table 26 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 2003) and the yearly reports of the Swiss Petroleum Association [Erdöl-Vereinigung/Union pétrolière] (EV 2004). 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 combustion processes and all fuels (including coal). Technical standards for combustion installations in Switzerland are relatively high, therefore oxidation factors close to 100% may be assumed. The following table provides an overview on default oxidation factors provided by IPCC (1997, Vol 3, p. 1.29) and the EU guidelines (EC 2004, Annex II, Section 2.1.1.1 and Annex VII):

Fuel/application	IPCC 1996	EC 2004
Coal	98.0% [2]	99.0% For coal in cement production: 100.0%
Oil and Oil products	99.0%	99.5%
Gas	99.5%	99.5%

Table 27 Default values for oxidation factors from IPCC 1997 and EC 2004. In the Swiss Inventory, 100% is used for all fuels.

As the consumption of liquid fuels roughly stagnated (1990 to 2003: +1% to 464'949 TJ) and gaseous fuels strongly increased (1990 to 2003: +61.5% to 109'347 TJ), overestimating of oxidation factors tends to overestimate emission increase and is therefore conservative.

The consumption of coal plays a minor role in Switzerland. It decreased over the considered period (1990 to 2003: -63.5% to 6'135 TJ). Here, 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 78% of total Swiss coal consumption in 2003. In cement production, an oxidation factor of 100% may be assumed (EC 2004)[3]. With this, the overestimation of emission decrease may become minor.

Oxidation factors will be reconsidered for future submissions.

a) Energy Industries (1A1)

Key sources 1A1
CO_2 from the combustion of Gaseous Fuels, Liquid Fuels and Other Fuels in Energy Industries (1A1) are key sources regarding level; CO_2 from the combustion of Gaseous Fuels and Other Fuels are also key sources regarding trend.

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

- “Public Electricity and Heat Production” including heat and power production in municipal solid waste incineration plants (1A1a) and
- “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. An oxidation factor of 100% is assumed

[2] This figure is a global average but varies for different types of coal, and can be as low as 91%.

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

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

(a) Waste incineration with heat and/or power generation ("Other fuels")
Emission factors for CO_2, N_2O, CO, NMVOC and SO_2 emissons per ton of waste incinerated are country specific based on measurements and expert estimates, documented in the EMIS 1995 database. Emission factors are taking into account flue gas cleaning standards in incineration plants. CH_4 is not occurring because of the high temperatures in waste incineration plants.

A description of emission factors for municipal solid waste incineration plants is provided in Section 8.4.2.

(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 2000, Table 45, p. 51; net calorific values on p. 61. See also Annex 2.1.1).
The activity data on LFO use from the Swiss overall energy statistics (SFOE 2003) includes LPG consumption. 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 considered in the 2004 inventory submission (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	73.50		1	0.6	37	11	2	33
Natural gas	55		6	0.1	28	14	2	0.5
Biomass		92	21	1.6	140	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 (Solid waste)	0.544	0.816		108.0	0.790	0.216	0.020	0.150

Table 28 Emission Factors for 1A1a Public Electricity and Heat Production in Energy Industries in 2003. Emission factors for waste incineration are provided per ton of waste incinerated.

In the table above, the CO_2 emission factor of light fuel oil (73.50 t/TJ) is a weighted average[4] emission factor including both LFO (73.7 t/TJ) and LPG (65.5 t/TJ) emissions.

Activity Data

(a) Municipal solid waste incineration with heat and/or power generation ("Other fuels")

For a detailed description of municipal solid waste incineration activity data see also Section 8.4.2. 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 shared out between categories 1A1a and 6C (Waste Incineration) proportionally to the average waste to energy efficiency[5] of the plants. Activity data for waste incineration is provided in the table below. E.g. in 2003, from the 2'990 Gg of municipal solid waste incinerated, the emissions from the incineration of 1'166 Gg of waste (=2'990 Gg * 0.39) has been accounted for under category 1A1a, whereas 1'824 Gg (=2990 Gg – 1'166 Gg) have been accounted for under category 6C.

Source/fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1A1a Other fuels: Municipal solid waste incinerated with heat and/or power generation															
Total incineration of MSW	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
Waste to energy efficiency	%	32%	34%	36%	36%	37%	40%	40%	42%	41%	41%	40%	40%	39%	39%
Waste accounted for in 1A1a	Gg	790	796	832	832	833	908	916	983	992	1'062	1'120	1'168	1'182	1'166

Table 29 Activity data for 1A1a "Other fuels": municipal solid waste incinerated with heat and/or power generation 1990 to 2003 accounted for in 1A1a.

The table above documents the increase of municipal solid waste incinerated by 47% from 1990 to 2003. 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 Section 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 source 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 2003 correspond to the consumption of LFO, natural gas and biomass in public district heating systems (SFOE 2003; tables 21, 26, and 28). Other fuels is calculated from annual amount of municipal solid waste incinerated with heat and/or electricity generation accounted for under 1A1a (see last line in Table 29).

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[4] Calculation: 73.50 t/TJ = (217'601 TJ * 73.7 t/TJ + 5'336 TJ * 65.5 t/TJ) / (217'601 TJ + 5'336 TJ) for the year 2003.

[5] The waste to energy efficiency is defined in this context as the gross amount of heat and power generated (including auto-consumption by the plant) in TJ devided by the net calorific input of waste in TJ.

Source/fuel	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
1A1a Public Electricity/Heat Fuel Consumption															
Total	TJ	18'029	20'726	22'686	17'885	17'114	18'595	20'814	20'854	23'654	21'001	20'261	21'453	21'138	21'893
Light fuel oil	TJ	980	1'790	1'917	1'662	810	546	806	1'065	865	706	495	554	512	682
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
Natural gas	TJ	4'270	4'709	4'671	4'639	4'729	5'329	6'600	6'960	6'809	6'730	5'830	6'322	6'075	6'736
Coal	TJ	534	112	112	56	84	56	0	0	0	0	0	0	0	0
Other (waste-to-energy)	TJ	9'011	9'070	9'580	9'730	9'890	10'823	10'919	11'715	11'827	12'690	13'866	14'507	14'421	14'315
Biomass	TJ	40	40	70	50	60	50	70	50	60	60	70	70	130	160

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

The table above documents the increase of Gaseous Fuel consumption by 57.8% from 1990 to 2003. This increase is the first reason for category 1A1 Gaseous Fuels being a key source regarding trend.

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 1995 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

Table 31 Emission Factors for 1A1b Petroleum Refining in 2003.

Activity Data

Activity data on fuel combustion (TJ) for Petroleum Refining (1A1b) is extracted from the Annual Reports of the Swiss Petroleum Association (EV 2004, p. 78).

Source/fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
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
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

Table 32 Activity data in 1A1b Petroleum Refining.

The table above documents the increase of gas (refinery LPG) consumption for Petroleum refining by almost 100% from 1990 to 2003. 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 source regarding trend.

b) Manufacturing Industries and Construction (1A2)

Key sources 1A2
CO_2 from the combustion of Gaseous Fuels, Liquid Fuels, and Solid Fuels in Manufacturing Industries and Construction (1A2) is a key source regarding both level and trend. CO_2 from the combustion of Other Fuels in 1A2 is a key source regarding 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 Cement, Lime, Glass, and the Iron and Steel industries. 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 emissions from EMIS 1995		Bottom-up (EMIS1995)
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	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 EMIS1995)
Cement "Other fuels"	Bottom-up	Bottom-up (Industry data and EMIS1995)
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).

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 2000, 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 2003) 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).

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 considered in the 2004 inventory submission (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								
Light fuel oil (LFO)	73.50		1.0	0.6	37	11	2	33
Heavy fuel oil (HFO)	77.00		4.0	0.8	125	15	4	383
Coal (includes hard coal and lignite)	94.13		9.0	1.6	200	100	9	500
Gas	55.00		6.0	0.1	28	14	2	0.5
Biomass		92.0	21.0	1.6	140	500	7	20

Table 34 Emission factors for sources in 1A2a-f that are calculated top-down (see Table 33 further above) for 2003.

Remark: In the table above, the CO_2 emission factor of light fuel oil of 73.46 t/TJ 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 (94.13 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[6].

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 2000, 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 measurements and data from industry and expert estimates, documented in the EMIS 1995 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 1995 database and their relation to CRF categories is provided in Annex A.3.1.2.

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.

[6] Calculation:
94.13t/TJ = (5'845TJ * 94t/TJ + 80TJ * 104t/TJ + 210TJ * 94t/TJ) / (5845TJ + 80TJ + 210TJ) for 2003.

1A2 a Iron and Steel (Koks and gas)	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	t/TJ	kg/TJ		g per ton of iron			kg/TJ
Koks cupolas	94.13	9.0	1.6	48	20	29	500
	t/TJ	kg/TJ		g per ton of steel		kg/TJ	
Gas (steel plants)	55	6.0	0.1	166	11	2.0	0.5

Table 35 Emission factors for sources in Iron and Steel 1A2a that are covered by the EMIS 1995 database in 2003.

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 2002 (NO: not occurring). Source: preliminary new EMIS database. Emission factors for CO_2 are fuel specific; they are the same as in the top-down approach (see Table 34 above).

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 SAEFL internal data sources and the other characteristics of waste derived fuels are from Hackl, A / G. Mauschitz 2003[7]. These emission factors are preliminary and may be revised for future submissions.

[7] As cited in the Draft Technical Commentary "03 03 11 Zementproduktion, Emissionen aus Ofenbetrieb" of the new EMIS data base of 8 February 2005, Table 3 p. 4.

	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 2003) and energy-economic modelling. A detailed description of the modelling work for the desegregation of fuel consumption to the level of 1A2a-f is provided in Annex A.3.1.1.

The resulting disaggregated fuel consumption data for 1990 to 2003 is provided in the table below.

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1A2 Manufacturing Industries and Constr. (Total)	*TJ*	87'367	88'064	86'860	85'632	86'970	89'346	88'417	88'080	91'524	92'446	92'707	95'506	94'865	95'967
Light fuel oil	*TJ*	26'374	29'384	29'667	29'261	28'401	28'966	30'943	33'056	35'673	36'663	34'658	35'485	35'041	35'774
Heavy fuel oil	*TJ*	18'746	17'270	16'743	14'279	14'822	13'594	11'033	9'744	10'082	8'670	6'215	6'685	6'285	5'315
Coal	*TJ*	15'651	12'424	9'070	7'949	8'405	8'801	6'402	4'869	4'277	4'378	6'272	6'476	6'299	6'005
Natural gas	*TJ*	20'571	22'645	24'789	27'033	28'313	29'800	30'656	31'697	32'520	33'985	36'137	36'561	35'647	36'600
Biomass	*TJ*	3'937	4'226	4'432	4'618	4'706	5'213	5'882	5'285	5'391	5'334	5'503	5'571	6'300	6'731
Other Fuels	*TJ*	2'089	2'115	2'158	2'493	2'322	2'971	3'501	3'430	3'580	3'416	3'921	4'727	5'294	5'543
1A2a Iron and Steel	TJ	3'244	3'290	3'627	3'439	3'425	2'914	3'035	3'175	3'307	3'410	3'719	3'876	3'859	3'966
Light fuel oil	TJ	826	830	838	820	799	658	665	708	773	791	820	818	828	814
Heavy fuel oil	TJ	351	347	349	344	346	97	98	100	112	111	122	124	117	121
Coal	TJ	506	543	682	454	488	362	300	298	222	293	235	374	401	484
Natural gas	TJ	1'561	1'569	1'758	1'820	1'793	1'796	1'972	2'068	2'200	2'214	2'543	2'560	2'513	2'547
Biomass	TJ	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
1A2b Non-Ferrous Metals	TJ	525	614	494	504	490	647	704	902	971	1'089	1'092	1'032	1'096	1'148
Light fuel oil	TJ	240	243	229	207	214	227	227	267	286	297	289	271	293	300
Heavy fuel oil	TJ	2	2	2	1	1	3	1	1	1	1	1	1	1	1
Coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	TJ	282	370	263	295	275	418	475	634	683	791	802	760	802	847
Biomass	TJ	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
1A2c Chemicals	TJ	15'414	14'663	14'449	13'836	14'303	15'518	15'462	14'960	15'358	15'373	15'237	15'405	15'356	15'820
Light fuel oil	TJ	3'117	3'196	2'752	2'873	2'731	3'750	3'681	3'335	3'008	2'905	3'078	3'127	3'122	3'213
Heavy fuel oil	TJ	1'720	1'129	779	1'021	788	472	445	402	360	352	274	267	161	196
Coal	TJ	233	221	205	190	195	186	161	141	129	122	116	100	90	83
Natural gas	TJ	10'343	10'116	10'712	9'751	10'590	11'109	11'174	11'082	11'861	11'993	11'769	11'911	11'982	12'328
Biomass	TJ	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
1A2d Pulp, Paper and Print	TJ	9'665	9'443	11'020	10'980	11'880	10'457	9'553	9'774	9'532	9'202	9'430	9'770	9'989	9'668
Light fuel oil	TJ	548	781	991	932	865	959	1'056	995	1'036	1'123	1'084	1'046	1'082	1'022
Heavy fuel oil	TJ	5'228	4'720	4'313	3'678	3'340	3'125	2'983	3'183	3'156	3'001	2'528	2'625	2'472	2'365
Coal	TJ	1'085	662	120	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	TJ	2'804	3'280	5'596	6'370	7'675	6'373	5'513	5'596	5'340	5'077	5'818	6'099	6'436	6'282
Biomass	TJ	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
1A2e Food Processing, Beverages and Tobacco	TJ	7'702	7'892	7'516	7'958	7'676	8'589	9'356	9'466	9'723	9'904	9'588	9'121	9'459	9'094
Light fuel oil	TJ	4'680	4'910	4'901	5'069	5'036	5'143	5'452	5'573	5'835	5'881	5'570	5'342	5'301	5'272
Heavy fuel oil	TJ	1'437	1'060	959	849	830	1'029	625	416	517	291	243	376	407	323
Coal	TJ	456	377	454	390	293	350	485	445	261	302	239	139	395	252
Natural gas	TJ	1'129	1'545	1'201	1'650	1'516	2'066	2'794	3'031	3'110	3'431	3'535	3'264	3'356	3'248
Biomass	TJ	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
1A2f Other	TJ	50'816	52'163	49'753	48'916	49'195	51'221	50'307	49'804	52'633	53'468	53'641	56'302	55'106	56'272
Light fuel oil	TJ	16'962	19'424	19'956	19'359	18'756	18'229	19'861	22'178	24'735	25'665	23'817	24'882	24'416	25'154
Heavy fuel oil	TJ	10'007	10'011	10'340	8'385	9'517	8'868	6'879	5'642	5'935	4'914	3'047	3'293	3'127	2'310
Coal	TJ	13'371	10'621	7'609	6'915	7'429	7'902	5'456	3'984	3'666	3'660	5'682	5'863	5'413	5'187
Natural gas	TJ	4'450	5'766	5'259	7'146	6'465	8'037	8'728	9'285	9'325	10'480	11'671	11'966	10'557	11'348
Biomass	TJ	3'937	4'226	4'432	4'618	4'706	5'213	5'882	5'285	5'391	5'334	5'503	5'571	6'300	6'731
Other Fuels (Waste fuels in Cement)	TJ	2'089	2'115	2'158	2'493	2'322	2'971	3'501	3'430	3'580	3'416	3'921	4'727	5'294	5'543

Table 38 Activity data fuel consumption in 1A2 Manufacturing Industries and Construction 1990 to 2003; 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 78% from 1990 to 2003 as well as the net decrease of liquid fuel consumption by -9% and the decrease of coal consumption by -72% 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 source 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 1995 that has been extrapolated by expert judgement for the years until 2003. (See also planned improvements in Section 3.2.6).

Source/production	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1A2a Iron and Steel															
Iron foundries: cupol ovens	Gg	52	86	83	79	76	72	69	65	61	61	53	53	52	52
Steel plants: reheating furnaces	Gg	780	1'030	955	880	806	730	736	742	748	754	770	770	780	780

Table 39 Activity data: Production in Iron and Steel that is used to calculate bottom-up non-CO_2 emissions from sources in 1A2a that are described by the EMIS 1995 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 2003) (See Table 67 in Section 4.2.2 a).

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[8]: Estimates by SEAFL experts, SAEFL 2003a and Cemsuisse 2003. 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

Table 40 Activity data: Amount of waste derived fuels ("Other fuels") in cement industry. Sources: Estimates by SEAFL experts (in *italics*), SAEFL 2003a and Cemsuisse 2003. Data is preliminary and may be revised for future submissions.

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 2003 (in tons; and by 265% in energy units). This increase is the reason for CO_2 emissions from category 1A2 Other fuels being a key source regarding trend.

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[8] As cited in the *Draft* Technical Commentary "03 03 11 Zementproduktion, Emissionen aus Ofenbetrieb" of the new EMIS data base of 8 February 2005, Table 3 p. 4.

c) Transport (1A3)

Key sources 1A3b
CO_2 from the combustion of gasoline and of diesel (level and trend)
N_2O and 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

To quantify the emissions of civil aviation in Switzerland, Tier 2b method (bottom-up approach based on individual aircraft movements) is used.

The national fuel statistics which is part of the Swiss overall energy statistics (SFOE 2003) provides the annual total of sold fuel including bunkers (sales principle). In addition, the Federal Office of Civil Aviation (FOCA) yearly carries out a detailed modelling (LTO, cruise and overflights) of fuel consumption and of emissions of CO_2, NO_x, VOC and CO due to the territorial principle excluding bunkers (FOCA 2004). Both results, the annual total of sold fuels and the modelled, territorial fuel consumption, are calculated yearly. The bunker fuels are defined as the difference between the fuel consumption (sales principle) and the model results of FOCA.

The calculation of total CO_2 emissions is based on the fuel consumption and on the carbon content of the fuel (see Annex 2). FOCA runs a “reference database” that contains all data needed to calculate the emissions of gases and pollutants. Every individual aircraft movement to and from the three national airports is registered in the reference database. Since the landing taxes on Swiss airports depend on the emission characteristics[9] of the aircraft, the reference database includes the necessary information in order to calculate the emissions for every individual flight.

National and international flights may not be separated for every individual flight. In the reference database, national and international flights of foreign aircrafts are not distinguished at the lowest level of individual movements. The separation must be done in an ex post extension by SAEFL using expert judgment from FOCA about the yearly average split of national and international flights (FOCA 1999, see Table 41 below). Therefore, the bottom-up approach of emission modelling includes a top-down element. At the moment it is not possible to replace this top-down element due to a lack of information about the destination of foreign aircrafts.

Emissions caused by aircraft movements to and from the regional airports (mainly aircraft with piston engines and helicopters are concerned) are integrated in the reference database as well.

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[9] Art. 39 of the Federal Law on Aviation (Luftfahrtgesetz, 22.07.2003)

It may be noted that only one fuel type, jet kerosene, is reported for aviation in the CRF tables since it covers more than 99% of aviation fuel consumption. The other fuel, aviation gasoline, is only used in very small aircraft. Its consumption and emissions are accounted for, but in the CRF aviation gasoline is included under jet kerosene.

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 21). Small yearly variations have been neglected so far but shall be included in future submissions (see planned improvements).
- NO_x, VOC, CO: The factors of the ICAO "Aircraft Engine Exhaust Emissions Data Bank" are used.[10]
- CH_4, NMVOC: For VOC, aircraft-specific emission factors 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 0.0023 t/TJ is used (IPCC 1997b).
- SO_2: The emission factor is derived from the sulphur content of aviation fuel. For 2003 the following values are used: 19.4 kg/TJ for jet kerosene and 15.0 kg/TJ for aviation gasoline with a weighted mean of 19.0 kg/TJ. For bunker emissions, a single emission factor is used (20 kg/TJ).

Activity Data

All activity data on individual aircraft movements originate from the reference database of FOCA. This is a territorial database (includes only consumption of flights within Swiss boundaries). It is used to calculate the consumption of national civil aviation. In this database, the consumption is known for LTO / cruise phase and Airport / airfield types, respectively. The percentage of consumption attributed to national aviation is given in Table 41 (expert judgement by FOCA), the fuel consumption is shown in Table 42.

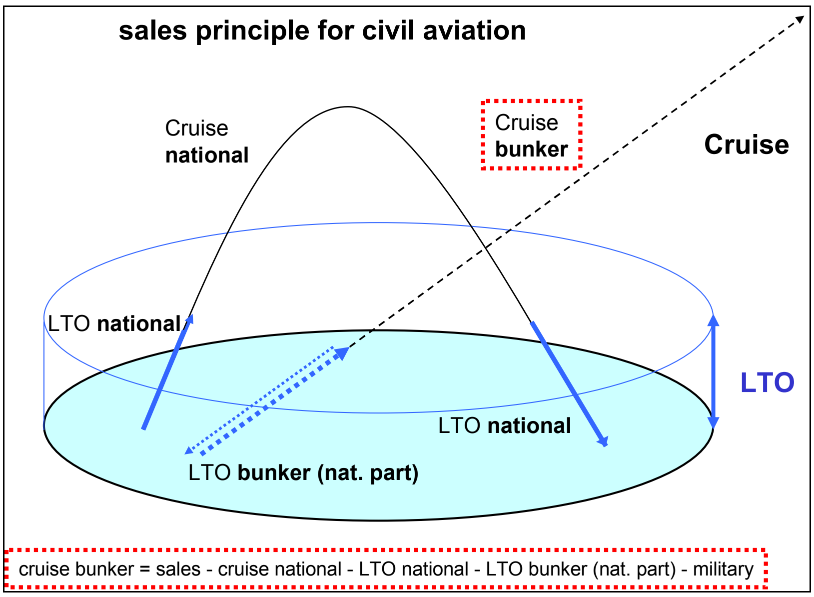

Figure 18 Nomenclature for civil aviation,

[10] ICAO: International Civil Aviation Organization, http://www.qinetiq.com/aircraft.html) as well as factors of the U.S. EPA (http://www.epa.gov/otaq/aviation.htm

	LTO			Cruise	
	Internat. airports	Regional airports	Air fields	Large aircraft	small aircraft, helicopters
National flights	1%	34%	75%	0.25%	100%
International flights	99%	66%	25%	99.75%	0%

Table 41 Shares applied for allocation of fuel consumption (territorial database). Large aircraft include jet and turboprop engines, small aircraft operate with piston engines (expert judgement, FOCA 1999).

Civil Aviation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	Fuel consumption in TJ													
LTO national	183	194	172	170	179	212	180	189	184	186	205	174	246	245
LTO bunker (nat. part)	5'671	6'226	5'270	5'730	5'842	5'934	6'105	6'249	6'447	6'789	7'573	7'170	6'470	6'070
cruise national	1'087	936	706	727	787	764	675	643	625	623	917	908	1'079	1'121
cruise bunker	2'021	2'259	1'968	2'008	2'097	2'563	2'809	3'147	3'251	3'429	3'323	3'308	3'234	3'336
total national (1A3a)	1'270	1'130	878	897	966	975	855	832	809	809	1'122	1'082	1'325	1'366

Table 42 Fuel consumption (jet kerosene) of civil aviation (territorial database). Notation due to Figure 18.

Road Transportation (1A3b)

Key sources 1A3b
CO_2 from the combustion of gasoline and of diesel (level and trend)
N_2O and 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 21). 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 2003).

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. Further details of emission modelling are given in Appendix 3.2.

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 21). 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 3.2.

The following table gives a selection of mean emission factors. The CO_2 factors are constant over the whole period 1990–2003. Changes in the carbon content of the fuels have not been considered so far due to (approximately) constant fuel qualities. For the other gases, more or less pronounced decreases of the emission factors occur due to new emission regulations and subsequent new exhaust technologies (mandatory use of catalytic converters for gasoline cars and lower limits for sulphur content in diesel fuels). Early models of catalytic converters have been substantial sources of N_2O, leading to an emission increase until 1998. Recent converter technologies have overcome this problem resulting in a decrease of the (mean) emission factor. It should be noted that the update of the emission N_2O factors

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[11] The vehicle registration in Switzerland delivers all inputs to build up the fleet composition 1990-2003 which is characterised e.g. by vehicle category, engine capacity, fuel type, total weight, vehicle age and exhaust technology.

(based on new measurements) led to much smaller values. This results in a substantial reduction of the recalculated N_2O emissions of the Road Transportation sector. For the base year 1990, the updated N_2O emissions of 1A3b are a factor of 3.6 lower than in the previous submission. For subsequent years, this factors decreases. In 2003, it is 2.1.

Emission factors per emission concept are given Annex 3.2.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

Table 43 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 160’480 TJ of gasoline and 62’490 TJ of diesel oil (2003). 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 2003	**source cat.**	**Gasoline**	**Diesel**	**Total**
			1000 TJ	
on-road consumption (model)	1A3b	141.5	54.0	195.5
"tank tourism"	1A3b	14.1	-6.0	8.2
off-road consumption (models)	1A3a,c,d;e; 1A4c; 1A5	4.8	14.5	19.3
Gasoline and Diesel sold in Switzerland (CRF)	1A3; 1A4c; 1A5	160.5	62.5	223.0

Table 44 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 45.

Veh. cat.	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
	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
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
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
Coaches	110	110	111	111	112	112	111	110	103	100	101	97	98	96
UBus	175	187	188	191	190	193	189	189	190	193	197	205	208	208
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
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
	100%	102%	101%	99%	101%	104%	106%	108%	110%	113%	117%	119%	122%	123%

Table 45 Mileages in millions of vehicle kilometres. PC passenger cars, LDV light duty vehicles, HDV heavy duty vehicles, UBus urban buses, 2W Two-wheelers.

In 2003, 85.5% of total vehicle kilometres are driven by passenger cars, 6.9% and 3.6% by light and heavy duty vehicles, respectively. The mileages increased for all vehicle categories (except coaches), totalling 23% in the period 1990–2003 or 1.6% per year. In the same period, fuel consumption increased less strongly, 11%, 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 1990-2003; only two-wheelers have enhanced their consumption. On an average over the whole car fleet, a decrease of -10% has been reached.

Veh. Categ.	**1'990**	**1'991**	**1'992**	**1'993**	**1'994**	**1'995**	**1'996**	**1'997**	**1'998**	**1'999**	**2'000**	**2'001**	**2'002**	**2'003**
	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
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
LDT 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
LDT 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
HDT 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
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
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
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
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
	100%	99%	99%	99%	99%	98%	97%	96%	95%	94%	94%	93%	91%	90%

Table 46 Fuel consumption of road transport, not including “tank tourism”(compare with Table 44; G gasoline, D diesel fuel.

For modelling of cold start and evaporative emissions, 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
	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
LDV	221	228	229	228	232	238	241	243	247	254	260	268	274	275
2W	764	747	729	720	708	704	699	709	718	728	731	740	741	746
	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
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
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

Table 47 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. Their emissions are calculated with a tier 2 method based on the fundamental formula for the emission E = EF • AC. The emission modelling, as described below, is carried out for 1990, 1995, 2000, 2005 etc. up to 2030 (SAEFL 1996a and update SAEFL 2000b). For the GHG inventory the missing years 1991, 1992 etc. are interpolated.

Emission Factors (SAEFL 1996a, 2000b)

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 1990-2003 with value 73.6 t/TJ (Diesel oil, see Table 21).
- CH_4 emission factors are assumed to be in a constant proportion (2.4%) of VOC for railway engines. For VOC factors see below.
- For N_2O a constant value of 2.9 kg/TJ is used.
- For SO_2 the emission factors are given in Table 104 in annex 2.
- For the other gases NO_X, CO, and VOC, the emission factors are taken from

$$\boxed{\begin{aligned} &EF = A - B \cdot P^{0.1} \;\; for \; P < 150 \; kW, \\ &EF = C = const. \; for \; P \geq 150 \; kW \end{aligned}}$$

  With EF in g/kWh and P, the motor power in kW, as independent variable. A, B, C are pollutant-specific constants depending on the engine type. For locomotives, the numerical values are given in SAEFL 2000b, appendix A2.1, the motor powers P in annex A4.1a.
  NMVOC is taken to be as a constant fraction (97.6 %) of VOC.

Activity data

For the modelling of CO_2, N_2O and SO_2 emissions, diesel consumption serves as activity data.

Railways	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Diesel (TJ)	415	405	394	384	374	364	362	361	360	359	358	358	358	358
CO2 em. (Gg)	30.5	29.8	29.0	28.3	27.5	26.8	26.7	26.6	26.5	26.4	26.3	26.3	26.3	26.3

Table 48 Activity data (Diesel consumption) and CO_2 emissions for railways.

For the other gases (CH_4, NO_x, CO, NMVOC), first the emission per operation hour is calculated by introducing a representative load factor LF (average power under working condition divided by motor power). The emission per hour Eh (in g/h) is then given by:

$$\boxed{Eh = EF \cdot LF \cdot P}$$

For diesel locomotives, the average value is LF = 0.64 (constant 1990-2003), for smaller tractive vehicles LF = 0.2, for steam engines LF = 0.65. P is again the motor power.

Finally, the emission may be calculated by multiplying Eh with the number of operating hours. Load factors and operating hours for all kind of engines are given in SAEFL 2000b (annex A3.1a).

Navigation (1A3d)

Methodology

There are passenger ships, dredgers, fishing boats, motor and sailing boats on the lakes in Switzerland and on the river Rhine. Every boat is registered at the cantonal authorities. The emissions are calculated with a tier 2 approach according to Box 3 of Figure 2.6 of the IPCC Good Practice Guidance (IPCC 2000, p. 2.52) for the years 1990, 1995, 2000, 2005 etc. up to 2030. For the other years, the emissions are interpolated based on the kilometres travelled.

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 might be estimated (SAEFL 2004d)[12]. By doing so, the emissions of navigation should be recalculated completely for consistency reasons. Since the whole Swiss off-road sector (1A3c, 1A3d, 1A5) is being revised at the moment, one will try to include the bunkers in the new modelling. An additional recalculation of the navigation data just for the actual submission will therefore be cut out. For the next submission the results of the revised off-road modelling will be available (see planned improvements). That means that all emissions from navigation are accounted as national and reported under 1A3c.

Emissions of navigation have been modelled in the same manner as those of railways. They were calculated in a common database and are documented in the same reports (SAEFL 1996a, update SAEFL 2000b).

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

Emission Factors

The emission factors are methodologically derived in the same manner as for railways (see above 1A3c, Emission Factors). In addition to the railways where only diesel is consumed, gasoline is used in navigation too.

- For CO_2 the emission factors are given in Table 16 (diesel and gasoline).

[12] The marine bunker fuels 2003 are estimated between 300 and 400 TJ. The total of the national fuel consumption reported for 1A3d Navigation is 1500 TJ.

- For N_2O the emission factors are 0.18 kg/TJ (gasoline, 4-stroke) and 0.09 kg/TJ (gasoline 2-stoke), 0.60 kg/TJ (gas oil) and 2.9 kg/TJ (diesel).
- For SO_2 the emission factors are given in Table 104 in annex 2.
- CH_4, NO_x, CO, NMVOC are taken from functions (see railways) with pollutant- and fuel-specific constants (for values see SAEFL 2000b, appendix A2.1).

$$\boxed{\begin{array}{l} EF = A - B \cdot P^{0.1} \;\; for \; P < 150 \; kW, \\ EF = C = const. \; for \; P \geq 150 \; kW \end{array}}$$

Activity data

Like for railways, the fuel consumption is the necessary activity data for CO_2, N_2O and SO_2 emission modelling.

Navigation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Diesel (TJ)	512	493	473	454	434	415	420	425	430	435	440	446	453	460
Gasoline (TJ)	519	522	526	529	533	537	563	589	615	641	667	707	747	788
Fuel oil (TJ)	338	329	320	310	301	292	269	249	240	250	261	259	257	254
sum (TJ)	1'369	1'344	1'319	1'293	1'268	1'243	1'251	1'263	1'284	1'326	1'368	1'412	1'457	1'502
CO_2 em. (Gg)	101.3	99.4	97.6	95.7	93.8	91.9	92.4	93.1	94.7	97.7	100.8	104.1	107.4	110.7

Table 49 Activity data and CO_2 emissions for navigation.

For the other gases (CH_4, NO_x, CO, NMVOC), first the emission per operation hour is calculated by introducing a representative load factor LF (average power under working condition divided by motor power). The emission per hour Eh (in g/h) is then given by:

$$\boxed{Eh = EF \cdot LF \cdot P}$$

Finally, the emissions are calculated by multiplying Eh with the number of operating hours. All load factors and operating hours for all kind of engines and fuels are given in SAEFL 2000b (annex A3.3a).

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 1990–2003 is known yearly since it is being copied from the logbooks of the military aircrafts (BABLW 2004). 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 1996-2003, the factors for 1995 are used. The emissions are then calculated yearly by multiplying the average emission factors with the activity data. The extension to CO_2, CH_4, N_2O, NMVOC and SO_2 is also accomplished by SAEFL.

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 21).
- NO_x, VOC, CO: Engine producer information is used (for details see SAEFL 1996a, 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 1996-2003, 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 1990–2003.
- SO_2: The emission factor is derived from the sulphur content of jet kerosene. Between 1990 and 2003, the factor varied between 25 kg/TJ and 32 kg/TJ.

Activity data

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

Military aviation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
av. fuel (million liters)	79.5	72.6	69.3	66.0	63.7	56.8	52.5	56.4	56.0	50.4	52.1	51.0	53.4	53.4
av. fuel (TJ)	2'735	2'497	2'384	2'270	2'193	1'955	1'807	1'941	1'927	1'734	1'793	1'755	1'837	1'837
CO_2 emissions (Gg)	200	183	175	166	161	143	132	142	141	127	131	128	135	135

Table 50 Activity data and CO_2 emissions for military aviation (BABLW 2004). The net calorific value is 34.4 TJ/million litres.

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

Key sources 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 sources regarding both level and trend.

Key sources 1A4c
CO_2 from the combustion of Liquid Fuels in Agriculture/Forestry (1A4c) is a key source regarding both level and trend.

“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 2000, Table 45, p. 51; net calorific values on p. 61. See also Annex 2.1.1).

The activity data on LFO use from the Swiss overall energy statistics (SFOE 2003) also includes LPG consumption. 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.

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 in the 2004 inventory submission (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	73.46		1	0.6	35	13	5	33
Gas	55.00		6	0.1	14	23	2	0.5
Coal	94.13		300	1.6	65	4'600	100	350
Biomass		92	120	1.6	100	2'000	40	20

Table 51 Emission Factors for 1A4a and 1A4b: Commercial/Institutional and Residential in “Other Sectors” for 2002.

Remark: In the table above, the CO_2 emission factor of light fuel oil (73.46 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 (94.1 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 2003; Table 17).

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1A4a Commercial/Institutional	TJ	82'150	91'973	90'436	89'717	81'983	85'570	91'050	86'345	87'979	86'420	81'874	85'882	83'107	88'060
LFO	TJ	60'487	67'117	65'306	63'005	56'763	57'647	61'345	58'564	59'404	57'679	53'465	55'727	53'013	55'489
Gas	TJ	16'940	19'472	19'802	21'100	19'967	22'006	23'277	21'887	22'456	22'615	22'501	23'977	23'424	25'381
Coal	TJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	TJ	4'723	5'384	5'328	5'612	5'254	5'917	6'428	5'895	6'119	6'126	5'907	6'179	6'670	7'189
1A4b Residential	TJ	173'870	185'460	185'970	177'520	168'010	181'570	188'890	176'150	182'400	179'370	165'940	174'920	168'620	178'500
LFO	TJ	139'170	145'730	145'390	136'490	129'120	137'810	140'190	132'140	136'750	132'060	120'960	127'730	122'670	129'540
Gas	TJ	25'620	29'240	30'680	31'090	29'530	33'880	38'000	34'550	36'090	38'040	36'290	38'000	37'790	40'330
Coal	TJ	650	750	520	530	480	460	260	220	140	140	130	130	130	130
Biomass	TJ	8'430	9'740	9'380	9'410	8'880	9'420	10'440	9'240	9'420	9'130	8'560	9'060	8'030	8'500

Table 52 Activity data in 1A4a Commercial/Institutional and 1A4b Residential

The table above documents the increase of Natural Gas consumption by 50% (1A4a) and 57% (1A4b) from 1990 to 2003 as well as the net decrease of liquid fuel consumption by -8.3% (1A4a) and -6.9% (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 sources 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).

An explanation of the method applied for off-road emissions is given in Section 3.2.2 e) Other – Off-road.

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 2000, 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 1995 database (see Section 1.4.3). Some of the emission factors have been updated based on expert judgement.

Off-road machinery: Emission factors are country-specific and documented in SAEFL 2000b.

Activity Data

Drying of grass: Activity data on grass drying (in tons of dried grass) is extracted from the EMIS 1995 database and is assumed to be constant.

Off-road machinery: Activity data is taken from SAEFL 2000b.

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1A4c Agriculture/Forestry	TJ	9'205	9'304	9'402	9'500	9'599	9'697	9'752	9'806	9'860	9'915	9'969	10'075	10'181	10'287
Drying of Grass total	TJ	1'497	1'497	1'497	1'497	1'497	1'497	1'497	1'497	1'497	1'497	1'497	1'497	1'497	1'497
of which light fuel oil	TJ	1'197	1'197	1'197	1'197	1'197	1'197	1'197	1'197	1'197	1'197	1'197	1'197	1'197	1'197
of which natural gas	TJ	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Machinery liquid fuels	TJ	7'708	7'807	7'905	8'003	8'102	8'200	8'254	8'309	8'363	8'418	8'472	8'578	8'684	8'789

Table 53 Activity data in 1A4c Agriculture/Forestry.

Activity data in 1A4c is considered for revision for future submissions.

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

All emissions from off-road activities have been analysed in SAEFL 1996a. The results have been updated in a subsequent study (SAEFL 2000b). Tier 2 methods were applied. For the sections construction, hobby, industry, and military, the emissions were modelled individually.

1A5 emissions have been modelled in the same manner as those of railways and navigation. They were calculated in a common database and are documented in the same reports (SAEFL 1996a, update SAEFL 2000b).

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

Emission Factors

The emission factors are methodologically derived in the same manner as for railways and navigation. Gasoline (4-stroke and 2-stroke) and diesel are consumed in 1A5:

- For CO_2 the emission factors are given in Table 16.
- For N_2O the emission factors are 0.18 kg/TJ (gasoline, 4-stroke) and 0.09 kg/TJ (gasoline 2-stoke) and 2.9 kg/TJ (diesel).
- For SO_2 the emission factors are given in Table 104 in annex 2.
- CH_4, NO_X, CO, NMVOC are taken from functions (see railways, navigation) with pollutant- and fuel-specific constants (for values see SAEFL 2000b, appendix A2.1).

$$EF = A - B \cdot P^{0.1} \;\; for\; P < 150\; kW,$$
$$EF = C = const.\; for\; P \geq 150\; kW$$

Activity Data

For the modelling of CO_2, N_2O and SO_2 emissions, fuel consumption serves as activity data.

Off-road	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
								Fuel consumption in TJ						
Construction	6'295	6'224	6'153	6'082	6'012	5'941	5'788	5'636	5'483	5'331	5'178	5'143	5'108	5'073
Hobby	1'666	1'641	1'615	1'589	1'564	1'538	1'575	1'613	1'650	1'687	1'724	1'780	1'835	1'891
Industry	1'609	1'651	1'692	1'733	1'774	1'815	1'822	1'829	1'837	1'844	1'851	1'862	1'873	1'884
Military	51.4	52.3	53.1	54.0	54.8	55.7	53.2	50.7	48.2	45.8	43.3	43.3	43.4	43.5
sum	9'622	9'567	9'513	9'459	9'404	9'350	9'239	9'128	9'018	8'907	8'796	8'828	8'860	8'891
								CO2 Emissions in Gg						
Construction	463	458	453	448	442	437	426	415	404	392	381	379	376	373
Hobby	123	121	119	117	116	114	116	119	122	125	127	132	136	140
Industry	119	122	125	128	131	134	134	135	135	136	136	137	138	139
Military	3.8	3.8	3.9	4.0	4.0	4.1	3.9	3.7	3.6	3.4	3.2	3.2	3.2	3.2
sum	709	705	701	697	693	689	681	673	664	656	648	650	653	655

Table 54 Activity data (fuel consumption) and CO_2 emissions for off-road activities Construction, Hobby, Industry and Military (without Military Aviation, see 1A3e).

For the other gases (CH_4, NO_x, CO, NMVOC), first the emission per operation hour is calculated by introducing a representative load factor LF (average power under working condition divided by motor power). The emission per hour Eh (in g/h) is then given by:

$$\boxed{Eh = EF \cdot LF \cdot P}$$

Finally, the emissions are calculated by multiplying Eh with the number of operating hours. All load factors and operating hours for all kind of engines and fuels are given in SAEFL 2000b, for:

- Construction in annex A3.4
- Hobby in annex A3.7
- Industry (industrial machinery) in annex A3.8
- Military (mainly tanks) in annex A3.9.

The source of the data is a national database (MOFIS[13]) in which all motor vehicles are recorded that have to be registered (and thus carry a license number). The database also contains information on motor power and fuel type. For small vehicles without license number, the information needed was gathered from the vehicle producers and other professional associations.

3.2.3. Uncertainties and Time-Series Consistency

A quantitative Tier 1 analysis (following Good Practice Guidance; IPCC 2000, p. 6.13ff) is used to estimate uncertainties of key sources 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) Uncertainties

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

The level of disaggregation that has been chosen for the key source analysis provides a rather fine disaggregation of combustion related CO_2 emissions in category 1 Energy. E.g.

[13] MOFIS: Automatisiertes Motorfahrzeug-Informations-System – Swiss automated motor vehicle information system (MOFIS 2003)

the key source 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 3.1.1). In order to avoid errors that are introduced in the process of disaggregation, but that 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 2004	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	507'850	0.5	28'720	10	536'570	0.7	1
Gaseous fuels	Gas	110'010	5	0	0	110'010	5.0	2
Solid fuels	Kohle	3'220	5	2'700	20	5'920	9.5	3
Other fuels	Müll- und Industrieabfälle	45'130	5	0	0	45'130	5.0	4

Comments:

1 Col. D: Expert estimate from carbura (email M. Ruffer 24.1.05). - Col. F: Conservative interpretation of rough expert estimate from carbura ("one-digit uncertainty").

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. F: Rough conservative expert estimate.

4 Col. D: An uncertainty of amount of waste of 5% is assumed (expert judgement), because waste input is reasonably well measured since the nineties.

Table 55 Details of uncertainty analysis of fuels in 1A.

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. 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 0.28% results for the emission factor.

A	B	C	D	E	F	G
	Net calorific value liquid fuels					
	Mean [GJ/t]	Uncertainty [GJ/t]	Uncertainty [%]	=(C*G)^2 [GJ^2/t^2]	No. of samples []	Share 2003 (approx.)
Heavy fuel oil	41.2	0.85	2.06	0.000113	6	1%
Light fuel oil	42.6	0.13	0.31	0.004635	10	52%
Diesel	42.8	0.10	0.23	0.000162	10	13%
Gasoline	42.5	0.29	0.68	0.009312	30	33%
Jet kerosene	43.0	0.25	0.58	0.000001	10	0.3%
Sum	42.6			0.014223	66	100%
Combined Uncertainty		0.119 =SQR(sum(E))	0.28			

Table 56 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 2004 provides a range of -2.9% and +1.7% resulting in an average uncertainty assumed for the emission factor of 2.3%.

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 is the fraction of fossil carbon in the waste. For the fraction of C in incinerated waste an uncertainty of 20% has been estimated, and for the fraction of fossil C in total C an uncertainty of 10% has been estimated, resulting in a preliminary uncertainty estimate of 30% for the waste incineration CO_2 emission factor[14].

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

Table 57 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 2003 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	3'723.52	6'014.09	5.0	2.3	5.5	0.795	0.0536	0.1496	0.12	1.06	1.07
1A Liquid fuels	CO2	34'308.73	34'144.52	0.7	0.28	0.77	0.629	-0.0346	0.8495	-0.01	0.86	0.86
1A Solid fuels	CO2	1'585.13	577.51	9.5	5.0	10.8	0.149	-0.0265	0.0144	-0.13	0.19	0.23
1A Other fuels	CO2	575.21	905.01	5.0	30.0	30.4	0.661	0.0077	0.0225	0.23	0.16	0.28
Total CO2 Emissions Fuel		40'192.58	41'641.12									
		Overall uncertainty CO2 combustion emissions in the year (%):					1.22	CO2 combustion emissions trend uncertainty (%):				1.42

Table 57 Results from Tier 1 uncertainty calculation and reporting for CO2 emissions in 1A Fuel Combustion

The analysis results in an overall uncertainty of the CO_2 emissions from 1A Fuel Combustion of 1.22% for the year 2003 and in a trend uncertainty for the period 1990 to 2003 of 1.42%.

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

Uncertainty in CH_4 and N_2O emissions from Gasoline consumption in 1A3 Road Transportation

The uncertainty for the activity data is 10%, for the emission factor 28% (CH_4) and 300% (N_2O). The combined uncertainty for the emission is 30% (CH_4) and 300% (N_2O). The values for the activity data and for CH_4 emission factor are taken from an extended uncertainty analysis (Kühlwein 2004). The value for N_2O is an expert judgement by an author of the emission modellers. Since only very few measurements are available the uncertainty is classified as high.

Other gases

For SO_2 the quality of estimates is "high" (uncertainty less than 5%) due to the knowledge of fuel consumption and of sulphur contents. For NO_x and NMVOC the detailed analysis by Kühlwein (2004) gives 18% (NO_x) and 24% (NMVOC). No specific analysis has been carried out for CO, but it is expected to be between NO_x and NMVOC. The quality of the emission estimates for these gases may therefore be classified as "medium".

Qualitative estimate of uncertainties of non-key source 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[15].

Aviation (1A3a)
Two levels of uncertainty may be distinguished. The first level contains all – national and bunkers – aviation activities. On this level, the data quality is "high" (fuel consumption, CO_2 and SO_2 emissions) or "medium" (all other gases). On the second level the emissions are split into national aviation (source category 1A3a) and bunker (source category Memo Items International Bunkers). The data quality on this second level is somewhat lower due to the additional uncertainty of the split factors. A sensitivity analysis indicates the dependency on the values of the most relevant splitting factor: The share of the fuel consumption for the LTO phase between national and international flights is 1% : 99%. The share is varied up to 3% : 97%. Within this range, the consumption increases linearly from 100% (1366 TJ) to 114% (1553 TJ). A share of 2% corresponds to a doubling of the original estimation (i.e. an estimation error of 100%!) which results in an increase of national consumption by 7% (1366 TJ -> 1459 TJ; simultaneously, the bunker consumption would decrease by the same amount of 93 TJ, from 50159 TJ to 50066 TJ or -0.2 %). The dependency of the consumption may therefore be considered as quite robust. For that reason, the quality level of the national and the bunker emissions is still considered "high" for CO_2 and SO_2 emissions and "medium" for all other gases.

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

Civil aviation 1A3a	values CRF 2003	sensitivity results			
sensitivity parameter: share dom./internat. (input for calculating activity data)	1:99	1.5:98.5	2.0:98	2.5:97.5	3.0:97
consumption (activity data)					
in TJ	1'366	1'413	1'459	1'506	1'553
in %	100%	103%	107%	110%	114%

Table 58 Sensitivity analysis: The original share of fuel consumption between national and international flights (LTO phase), 1:99, is varied up to 3:97. The resulting consumption of the source category is shifted by 14%.

Other source categories

Uncertainty: No estimates of the uncertainties have been performed.

b) Consistency and Completeness in 1A Fuel Combustion

Consistency:

- The new modelling in the present submission of the disaggregation of fuel consumption in 1A2 Manufacturing Industries and 1A4 Other (See Appendix A3.1.1) removes completely the earlier inconsistencies in time series .
- There exist inconsistencies with the activity data for non-CO_2 emissions in iron and steel 1A2a compared to activity data in iron and steel in Section 4.4 (Source 2C1).
- Time series for 1A1, 1A3, 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 1990–2003 are negligible which marks an excellent agreement.

SAEFL-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 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.

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

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

Transport (1A3)

Aviation (1A3a)

Quality controls are applied to the emissions of the national airports reported in environmental impact assessments. These data are independent from the greenhouse gas inventory and may thus be used to verify inventory data. The Federal Office of Civil Aviation (FOCA) uses the results for comparison with its own modelling results. Occasionally, data from environmental reports of foreign airports are used for plausibility checks. The emissions are compared with Swiss airport emissions on the level of average emissions for an LTO movement of a jet or a turboprop aircraft.

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)

For the off-road emissions, no specific QA/QC activities have been carried out since 2000. A new modelling concept is being developed at the moment (see planned improvements).

3.2.5. Source-Specific Recalculations

All sources 1A1-1A4 have been recalculated for 1990-2003. See Chapter 9.

3.2.6. Source-Specific Planned Improvements

EMIS database

A new EMIS database with updated activity data and emission factors is under construction (see also Section 1.4.3).

Oxidation factors

Oxidation factors have been assumed to be 100% for all combustion processes and fuels (see sub-section on oxidation factors in the beginning of Section 3.2.2). This assumption is to be revisited. In particular, oxidation factors for coal consumption in 1A1, 1A2 and 1A4 (outside of cement production) are to be revised.

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 considered in the inventory submission 2005. 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.

The inconsistencies with the activity data for non-CO_2 emissions in 1A2a Iron and Steel compared to activity data in iron and steel in Source 2C1 in Section 4.4 remains to be resolved for future submissions.

Non-CO2 emisisons are based on old EMIS 1995 data and will be revised and updated for future submissions.

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)

Aviation (1A3a): For a future submission, a new modelling of the aviation emissions according to the IPCC instructions is planned.

The off-road sector, including railways (1A3c) and navigation (1A3d), is undergoing a major revision. A new model with structures similar to the on-road traffic model has been developed in 2004; updated activity data and a common database for the emission factors have been established. A run with the new model for 2000 has just come out. In the next step the time series will be worked out. Results will be available for the next submission 2006.

Other Sectors (1A4)

Activity data in 1A4c is considered for revision for future submissions.

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)

As mentioned in the paragraph above (Transport 1A3), the off-road is undergoing a major revision. It includes all vehicles contained in the source category 1A5.

3.3. Source Category 1B – Fugitive Emissions from Fuels

3.3.1. Source Category Description

Key source 1B2
Fugitive Emissions of CH_4 from Oil and Natural Gas are a key source 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	Activity: SFOE 2003 EF: EMIS 1995
1B2 b	Natural Gas	Emissions from gas pipelines and the compressor station in Ruswil, Lucerne.	Activity: Kilchmann 1995, SFOE 2003 EF: Battelle 1994, Kilchmann 1995
1B2 c	Venting / Flaring	The release/combustion of excess gas at the oil refinery	Activity: SFOE 2003 EF: EMIS 1995

Table 59 Specification of source category 1B2 “Fugitive Emissions from Oil and Natural Gas” (Activity: activity data; EF: emission factors)

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 1B2b Natural Gas, the emissions of CH_4 leakages from gas pipelines are calculated with a country specific Tier 3 method, based on the annual gas consumption and the type and length of the gas pipelines and the pressure. 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. Fugitive emissions arising during normal operations, maintenance and accidents are included. Emissions of greenhouse gases are calculated by multiplying level of activity by emission factor.

Emission factors

The emission factors for CO_2, CH_4 and NMVOC are based on data from the refining and gas industry and expert estimates.

The emission factors for methane (source 1B2b) depend on the type and pressure of the natural gas pipeline. They stem from Battelle 1994 and Kilchmann 1995 and are documented in the EMIS 1995 database.

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.

The activity data for methane of Natural Gas (source 1B2b) are provided by the Swiss gas association. The data on fuel consumption for the operation of the compressor station at Ruswil is based on the Swiss overall energy statistics (SFOE 2003; Table 13).

Fugitive emissions from a high pressure natural gas transfer pipeline, crossing Switzerland from France to Italy, are not yet included in the inventory (see also Section on Planned Improvements below).

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 source 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

No recalculations have been carried out.

3.3.6. Source-Specific Planned Improvements

A new EMIS database with revised activity data and emission factors is under construction (see also Section 1.4.3).

It is planned to update emission factors and activity data regarding the fugitive emissions from gas pipelines based on current data from the Association of the Swiss Gas Industries.

It is planned to include emissions from the high pressure natural gas transfer pipeline crossing Switzerland from France to Italy in future inventories.

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 source** (IPCC 2000).

For Switzerland, the only source of international bunker emissions is aviation. Marine bunker emissions are under revision and are not reported in this submission (see note above in chapter 3.2.2.c), p. 47.

International Bunker Fuels	Specification	Data Source
Aviation	Country-specific model: Emissions Split national / internat. see Table 41	 FOCA 2004 FOCA 1999

Table 60 Specification of Swiss source category International Bunkers for aviation.

3.4.2. Methodological Issues

The methodologies used are described in chapter 3.2.2: See Figure 18 for system boundaries. The emissions from national civil aviation are calculated with a Tier 2b method in combination with a top-down element for splitting national and international flights. International Bunker fuels are determined as the difference between saled fuel and the modelled national consumption.

Bunker fuels of Civil Aviation (TJ)													
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
44'069	42'941	45'844	47'616	48'957	52'024	54'098	56'008	58'539	62'688	65'111	61'319	55'962	50'159

Table 61 International bunker fuels.

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

See Chapter 9.

3.4.6. Source-Specific Planned Improvements

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

International marine bunker is reported as not occurring (see source category description above). In fact, there is a certain, not very large amount of marine bunkers which might be included in the next submission when the Off-road sector has undergone its complete revision (see chapter 3.2.6).

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 biomass in source categories 1A2 (use of waste derived fuels in cement production), 2G (Industrial Processes, Other), 4F(Burning of Agricultural Residues), 6A (Solid Waste Disposal on Land) and 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 on actual 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	**Value 2003 (Gg)**	**Note**
1A1 Energy Industries (without MSW incineration)	15	Included in CRF Source 1A1
1A1 Energy generation from MSW Incineration	952	Not included in CRF
1A2 Manufacturing Ind. and Constr. (excluding waste fuels in cement prod.)	619	Included in CRF Source 1A2
1A2 Use of waste derived fuels in cement production	169	Not included in CRF
1A3 Transport	NO	
1A4 Other Sectors (Commercial/Institutional, Residential)	1'443	Included in CRF Source 1A4
2G Industrial Processes, Other	34	Not included in CRF
4F Agriculture, Burning of Residues	126	Not included in CRF
6A Solid Waste Disposal on Land	63	Not included in CRF
6B Wastewater Handling	298	Not included in CRF
6C Waste Incineration (including non-energy share of MSW incineration)	1'689	Included in CRF Source 6C
Total biomass combustion CO_2 emissions included in CRF	**3'767**	
Total energy related biomass combustion CO_2 emissions included in CRF 1A	**2'077**	see table 20 NIR, Summary2 CRF
Total biomass combustion CO_2 emissions in Switzerland 2003	**5'408**	

Table 62 Actual 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 actual 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 2003) and from the yearly report of the Swiss Petroleum Association [Erdöl-Vereinigung/Union pétrolière] (EV 2004). 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 shows the differences between the Reference and the Sectoral (National) Approaches. The CO_2 emissions agree very well, for all years the differences are between 0.21% and 1.82%. For energy consumption the differences are somewhat larger (between 1.44% and 2.85%) 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), but the charging to account of the corresponding energy consumption of this bitumen feedstock – also reported in table 1A(d) – is not foreseen in table 1A(b); this leads to a somewhat higher difference for energy consumption.

Difference between Reference and Sectoral Approach				
	1990	**1995**	**2000**	**2003**
Energy Consumption	1.44%	2.85%	1.83%	1.50%
CO_2 Emissions	0.21%	1.82%	0.77%	0.44%

Table 63 Differences in energy consumption and CO_2 emissions between the Reference and the Sectoral (National) Approach for selected years. The difference is calculated according to [(RA-NA)/NA] 100% with RA = Reference Approach, NA = National Approach.

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 (cement industry use where petroleum coke is treated as coal).
- The fraction for carbon oxidized 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 fraction factor of 1.0 was chosen. This topic will be analysed for the next submission. In case, the assumption is not sufficiently fulfilled, the fraction will be changed.

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 Energy (category 1).

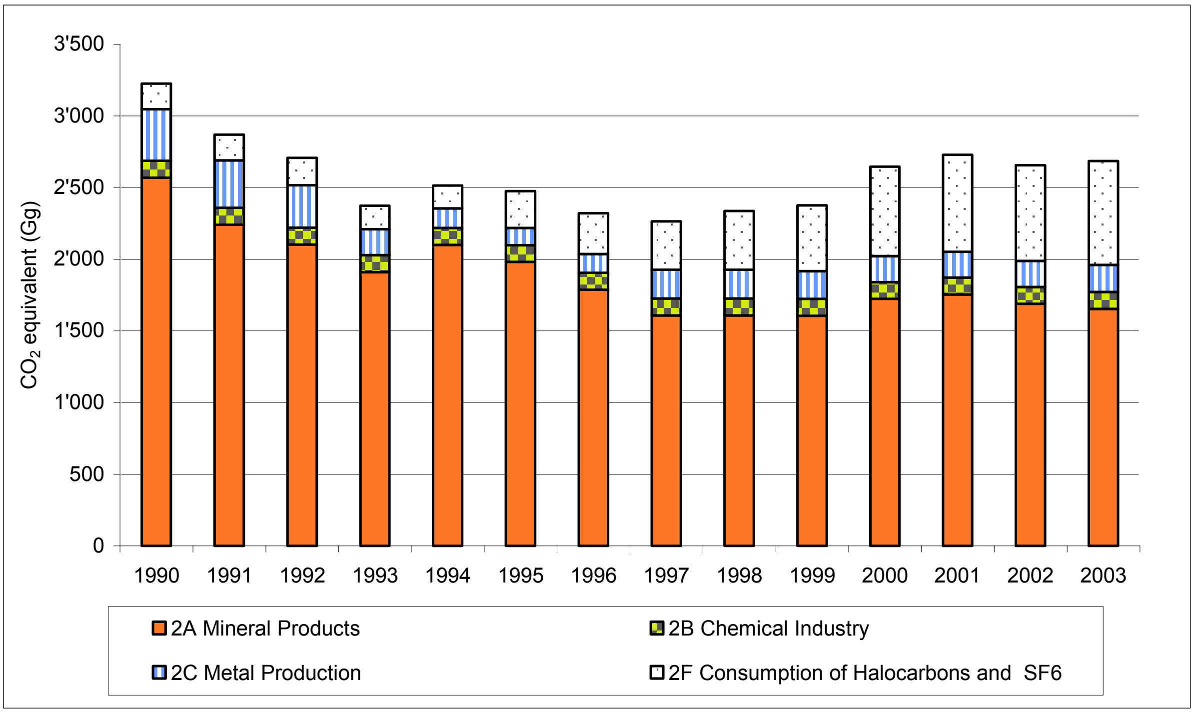

Figure 19 Switzerland's GHG emissions of source category 2 "Industrial Processes" 1990 – 2003. The emissions of the source category 2G "Other" are very small (about 1.4 Gg) and are not shown in the figure.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	CO_2 equivalent (Gg)													
CO_2	2'841	2'498	2'341	2'076	2'234	2'101	1'917	1'738	1'748	1'750	1'869	1'903	1'845	1'815
CH_4	9.1	8.9	8.8	8.7	8.6	8.4	8.5	8.7	8.8	9.0	9.1	9.3	9.4	9.4
N_2O	98.6	98.6	98.6	98.0	96.7	96.7	96.7	96.7	96.7	96.7	96.7	96.7	96.7	96.7
Synthetic gases	279	266	259	192	177	269	301	424	485	522	672	720	706	765
Sum	3'228	2'872	2'708	2'375	2'517	2'476	2'324	2'267	2'339	2'378	2'647	2'730	2'657	2'686

Table 64 GHG emissions of source category 2 "Industrial Processes" 1990-2003 by gases in CO_2 equivalent (Gg).

Although its emissions have decreased by almost -20% in the period 1990-2003, 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. These emissions have grown by a factor of 2.7 in the same period, because of the change from CFC to HFC in a lot of technical applications.

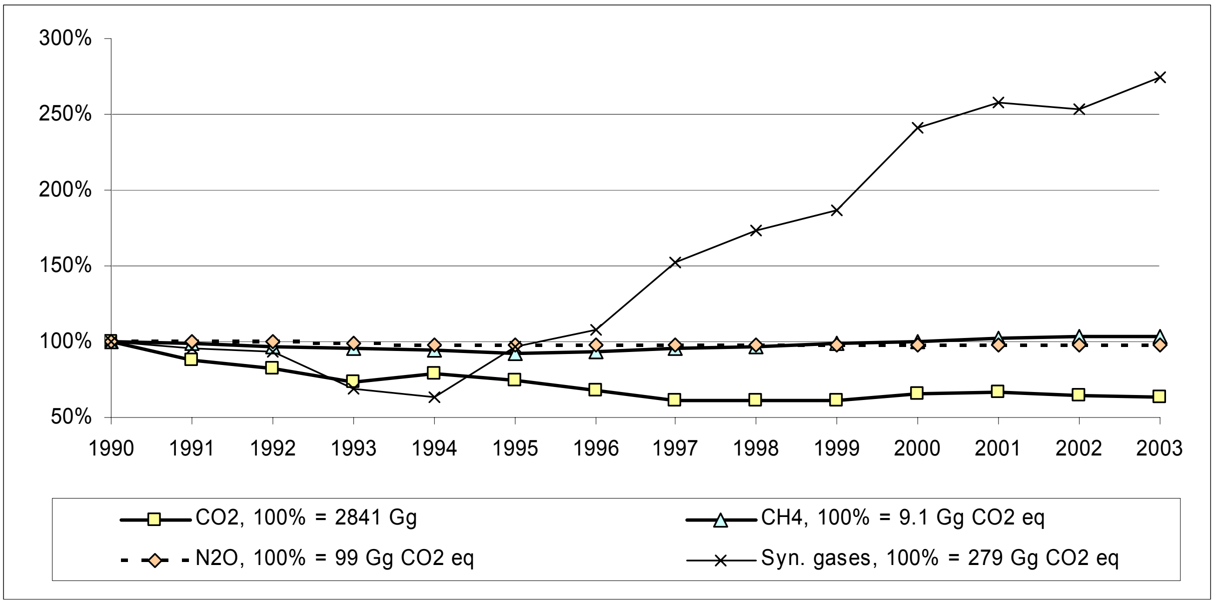

Figure 20 Relative trends of the greenhouse gases of source category 2 "Industrial Processes" in the period 1990-2003. The base year 1990 represents 100%.

The CO_2 emissions have declined to 64% whereas the synthetic gases have increased up to 274% in the period 1990-2003.

4.2. Source Category 2A – Mineral Products

4.2.1. Source Category Description

Key source 2A1
The non-energy CO_2 emissions in Cement Production (2A1) are a key source 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.	Activity: Cemsuisse 2003 EMIS 1995 EF: calcination-CO_2: WBCSD 2001; EF Other gases: EMIS 1995
2A2	Lime Production	Emissions from calcination process in lime production.	Activity: EMIS 1995 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	Activity: EMIS 1995 EF: EMIS 1995
2A7	Other	Not occurring in Switzerland	

Table 65 Specification of source category 2A “Mineral Products” (Activity: activity data; EF: emission factors)

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.

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.

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%. The IPCC default weight fraction of 65% for the CaO content of clinker is used. 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 1995 database (see Section 1.4.3).

Blasting: Emission factors for CO_2, $NO_{x,}$ CO and SO_2 per ton of cement are country specific based on measurements and data from industry and expert estimates, documented in the EMIS 1995 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	0.005			0.60	0.05	0.65
	kg/t cement			g/t cem.	g/t cem.		g/t cem.
Blasting Operations	0.031			3.00	3.00		0.13

Table 66 Emission Factors for 2A1 Cement Production for 2003 (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**	**2000**	**2001**	**2002**	**2003**
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	3'754	3'891	3'771	3'592
Clinker production	Gg	4'808	4'189	3'927	3'564	3'930	3'706	3'337	2'994	2'995	2'992	3'214	3'275	3'150	3'081

Table 67 Activity data in 2A1 Cement Production.

The table above documents the decrease of Swiss cement production by -30% from 1990 to 2003. This decline results in category 2A1 being a key source 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 370 kg/t. It is based on measurements and data from the two existing plants and expert estimates, documented in the EMIS 1995 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 1995 database (see Section 1.4.3). It is assumed that lime production is constant since 1995. Annual lime production is estimated at 94'000 t.

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 0.54 kg/t (2003). 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 1995 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 1995 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 65% is assumed, for which table 3.2 in the GPG provides a default value 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 source emissions in 2A

Time series on production data and emissions factors in the EMIS 1995 database use in many cases expert judgement to estimate data for the period after 1995.

For the most important source, cement production, emissions are based on actual cement and clinker production data provided by the cement industry.

Preliminary expert judgement 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

No recalculations have been carried out.

4.2.6. Source-Specific Planned Improvements

In the calculation of the CO_2 emission factor in 2A Cement production, the IPCC default weight fraction of 65% for the CaO content of clinker is used. 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).

A new EMIS database with revised activity data and emission factors is under construction (see also Section 1.4.3).

4.3. Source Category 2B – Chemical Industry

4.3.1. Source Category Description

Emissions in Chemical Industry (2B) are **not a key source**.

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	Not occurring in Switzerland (only NH_3)	
2B2	Nitric Acid Production	Emissions from the production of Nitric Acid	Activity and EF: EMIS 1995
2B3	Adipic Acid Production	Not occurring in Switzerland	
2B4	Carbide Production	Emissions from the production of Silicon Carbide	Activity and EF: EMIS 1995
2B5	Other	Emissions from the production of Organic Chemicals (Ethylene, PVC, Formaldehyde, Acetic Acid)	Activity and EF: EMIS 1995

Table 68 Specification of source category 1B "Chemical Industry" (Activity: activity data; EF: emission factors)

4.3.2. Methodological Issues

a) 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 1995 database (see Section 1.4.3).

The following table presents the emission factors used in 2B2:

2B2 Nitric Acid Production	**N_2O**	**NO_x**
	kg/t	kg/t
Nitric Acid Production	4.80	0.10

Table 69 Emission Factors for 2B2 Nitric Acid Production.

Activity Data

Activity data on annual production in 1990 has been provided by industry. As the use of fertilisers in agriculture and therefore the production of nitric acid is likely to decrease, the conservative assumption is made that production has been constant since 1990. In 1990, 65’000 tons of nitric acid have been produced in Switzerland.

b) 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 1995.

Activity Data

Activity data on annual production are from industry and are confidential, but available to reviewers.

c) Other (Organic Chemicals; 2B5)

Methodology

For CH_4, CO and NMVOC 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 and NMVOC are country specific based on measurements and data from industry and expert estimates, documented in the EMIS 1995 database (see Section 1.4.3).

Activity Data

Activity data on annual production in the early 90's have been provided by industry as documented in the EMIS 1995 database. Expert judgement and simple extrapolations have been used to estimate trends for the period after 1995.

4.3.3. Uncertainties and Time-Series Consistency

Time series on production data and emission factors in the EMIS 1995 database use in many cases expert judgement to estimate data for the period after 1995.

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

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

No recalculations have been carried out.

4.3.6. Source-Specific Planned Improvements

A new EMIS database with revised activity data and emission factors is under construction (see also Section 1.4.3).

4.4. Source Category 2C – Metal Production

4.4.1. Source Category Description

Key source 2C3
The CO_2 emissions and PFC emissions in Aluminium Production (2C3) are key sources 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.	Activity and EF: EMIS 1995
2C2	Ferroalloys Production	Included in 1C1.	
2C3	Aluminium Production	Emissions from the production of Aluminium	Activity: Industry Data, www.alu.ch EF: EMIS 1995
2C4	Use of SF_6 in Aluminium and Magnesium Foundries	Emissions from use of SF_6 in Aluminium and Magnesium Foundries	Activity and EF: Industry Data, www.alu.ch EF: EMIS 1995
2C5	Other	Not occurring in Switzerland	

Table 70 Specification of source category 2C “Metal Production” (Activity: activity data; EF: emission factors).

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 3a approach. Operating smelter emissions have been monitored continuously 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 for the year 2003 without measured emission data the value of 0.04 $kg_{PFC}/t_{AL}$is used 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.

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 1995 database (see Section 1.4.3). For CO_2 emissions from Aluminium Production (2C3), an emission factor of 1.6 ton CO_2 per ton of aluminium is used.

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 71 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

Table 71 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 1995 database (see Section 1.4.3). Expert judgement and simple extrapolations have been used to estimate trends for the period after 1995.

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. SF_6 Emissions from aluminium foundries are not occurring in Switzerland.

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	2000	2001	2002	2003
2C Metal Production															
2C1 Iron and Steel	Gg	1'288	1'211	1'134	1'056	1'074	902	909	916	924	933	938	950	960	974
2C3 Aluminium	Gg	87.0	81.9	75.4	36.4	24.2	20.7	26.6	27.3	32.3	34.4	35.5	36.3	40.2	43.9

Table 72 Activity data for 2C1 and 2C3 in Metal Production.

The table above documents the decrease of aluminium production by -50 % from 1990 to 2003. This decline results in CO_2 and PFC emissions from category 2C3 being a key source 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 3%). For emission factors of CO_2 and PFC no default values are provided in IPCC 2000. A conservative rough estimate of 20% uncertainty for the CO_2 and PFC emission factors is assumed.

Together, a combined uncertainty of 20.2% for CO_2 and PFC emissions from Aluminium Production in 2C3 results.

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

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

The time series is consistent.

4.4.4. Source-Specific QA/QC and Verification

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

4.4.5. Source-Specific Recalculations

See Chapter 9.

4.4.6. Source-Specific Planned Improvements

A new EMIS database with revised activity data and emission factors is under construction (see also Section 1.4.3).

4.5. Source Category 2D – Other Production

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

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 source 2F
Sum of PFC emissions from the consumption of halocarbons and SF_6 (2F) are a key source regarding trend (no. 25 in Table 6).

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

Key sources 2F_o
Definition: 2F_o (HFC) includes all HFC sources from 2F without 2F1 (no. 23 in Table 6).
Definition: 2F_o (SF_6) includes all SF_6 sources from 2F without 2F7 (no. 24 in Table 6)
Sources 2F_o (HFC) and 2F_o (SF_6) are key sources regarding trend.

See also chapter 1.5 and Annex 1 on key sources.

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	Activity: Various national statistics[16] and industry data EF: Industry data
2F2	Foam Blowing	Emissions from Foam Blowing, incl. Polyurethane Spray	Activity: 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	Activity: Import statistics EF: IPCC default values
2F5	Solvents	Emissions from use as solvents	Activity: Import statistics EF: IPCC default values
2F6	Semiconductor Manufacturing	Emissions from use in semiconductor manufacturing	Activity: Import statistics EF: IPCC default values
2F7	Electrical Equipment	Emissions from use in electrical equipment	Activity: Industry data EF: Industry data
2F8	Other	Emissions of SF_6 which are not yet accounted under 2F7	Activity: Industry data EF: Industry data

Table 73 Specification of source category 2F "Consumption of Halocarbons and SF_6" (Activity: activity data; EF: emission factors).

The following graph shows emissions in source category 2F by sub-sector and by different groups of gases. Refrigeration and air conditioning equipment account for the highest emissions in this source category.

[16] e.g. statistics on registration of cars and trucks, import statistics SAEFL on synthetic gases (SAEFL 2004e)

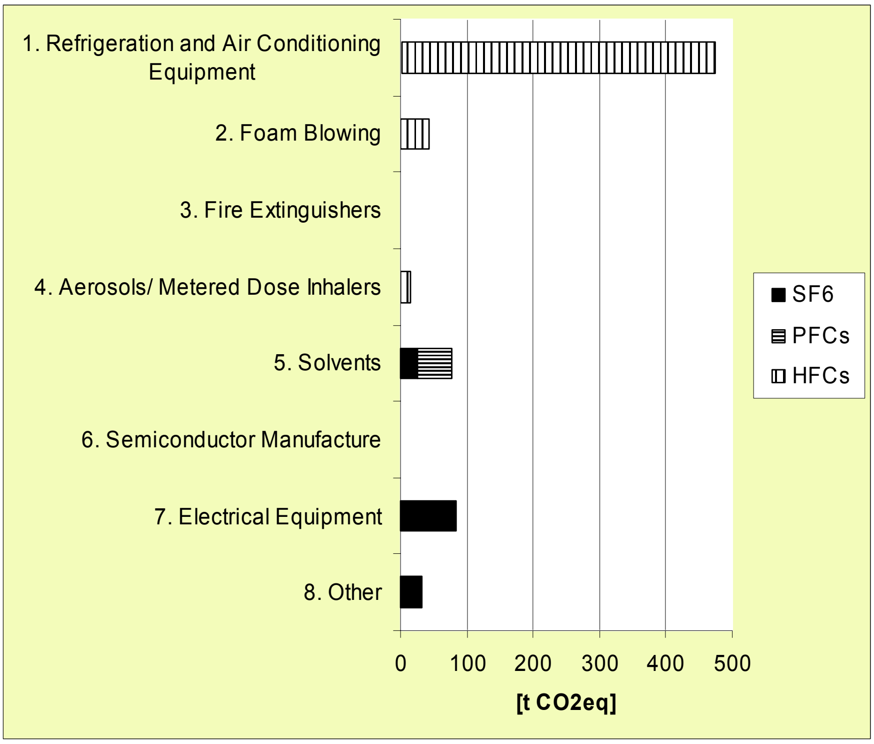

Figure 21 Distribution of emissions under source category 2F “Consumption of Halocarbons and SF_6“ (2003 data).

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 74). Detailed documentation of the individual data models is available from Carbotech 2005 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 74 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	0.2	0.5	94	37
Commercial and Industrial Refrigeration	12	NR	3	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 / 18.5	1	10 (5) / 5 (2.5)	100	10
Heat Pumps	15	2.8 … 7.5	1	0.5	100	10
Mobile Air Conditioning / Cars	12	0.8	NO	8.5 (3)	60	100 (30)
Mobile Air Conditioning / Trucks	10	1.1	NO	10 (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 74 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 submodels 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 source.. For illustration, the detailed calculation model for car air-conditioning including the time series for the activity data for this particular submodel can be seen from Annex 3.3. Car air-conditioning accounts for approx. 30% 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	25 / 0.7** 100 / 0**	0
PU spray		50	10.5 / 4.6 /3.0 *	0.7	95 / 2.5 **	0
Sandwich Elements		50	3	10	0.5	65

* Data for 1990 / 2000 / 2010
** 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 75 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 SAEFL 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 SAEFL 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. Some SF_6 consumption which stems from Aluminium production is reported by the industry as solvent and is therefore also included in 2F5 which is not foreseen by the IPCC GPG.

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 2003. The import of substances by firms delivering to semiconductor industry has mostly been declared as being used for "Snytheses / 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 SAEFL, 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 assumed as 0.5%/a.

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 and only the activity data is reported.

Emission Factors

For windows a production emission factor of 50% 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 2010 due to the long lifetime of the windows of more than 30 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 2003. 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 76 below has been characterised by a statistical distribution. Mostly 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. 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 at SAEFL.

The following table summarises the results for the application-specific emission models. The “value 2003” represents the actual emissions in Gg CO_2 equivalent for the specific application as used for calculating the 2003 CRF tables. The average, median, uncertainty, minimum and maximum values are output values of the Monte Carlo Analysis.

The results for the uncertainties show that the emission model for Commercial/Industrial Refrigeration, Foam Blowing, Stationary Air-Conditioning, Transport Refrigeration, Domestic Refrigeration as well as Mobile Air-Conditioning all have medium quality level (uncertainties between 17% and 31%).

For the model calculations of stocks result some medium and even some high uncertainties (Uncertainty>40%). Due to confidentiality of data the results of model calculation of stocks is not reported in detail here but are documented at SAEFL. High uncertainties result for model values of PU-Sprays, refrigerant R404a in different applications and refrigerant R134a in mobile air conditioning. Medium to high uncertainties are found not only for stocks but also for the amount of refrigerant filled in new equipment. However, high uncertainties for stock and new filled refrigerant related to the split of refrigerant on different applications is of less relevance for the overall emissions, because different applications show similar characteristics for the building of stocks and related emissions.

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 the past years calculation by model calculations 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 2003** 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.	246	257	256	8.5	Medium	200	325
Mobile Air-Conditioning		144	156	155	6	Medium	131	195
Stationary Air-Conditioning		68	77	76	13	Medium	54	113
Foam Blowing		46	49	48	6	Medium	41	57
Transport Refrigeration		14	13	13	15.5	Medium	9	18
Domestic Refrigeration		0.6	0.66	0.65	10.5	Medium	0.47	0.9

Table 76 Summary of results for model parameter “emissions” from Monte Carlo Analysis for 2003 data on selected emission sources.

To estimate an average uncertainty of all applications given in the table above, the uncertainties of every single application are expressed in Gg CO_2 eq, summed up and divided by the sum of emissions of all applications. This yields an average uncertainty of 8.4%.

For other categories under source category 2F no detailed uncertainty assessment has been carried out. A preliminary uncertainty assessment based on expert judgment results in medium confidence in these emissions estimates, which qualitatively corresponds to the applications of Table 76. Therefore, the same value of 8.4% is used for the uncertainty analysis for all 2F applications.

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.

4.7.5. Source-Specific Recalculations

See Chapter 9.

4.7.6. Source-Specific Planned Improvements

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

The SF_6 consumption which stems from Aluminium production and is reported under Solvent (2F5) will be moved to 2C Metal Production to be in compliance with the IPCC GPG.

4.8. Source Category 2G – Other

4.8.1. Source Category Description

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

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 other industry production, including food, drink, pulp and paper industries, and from crematories. In Switzerland, source category 2G includes the sources pertaining to source category 2D.	Activity and EF: EMIS 1995

Table 77 Specification of source category 2G “Other” (Activity: activity data; EF: emission factors).

4.8.2. Methodological Issues

Methodology

In Switzerland source category 2G “Other” represents a comprehensive set of industrial processes (including crematories) that are defined by the EMIS 1995 database. As the output of the EMIS 1995 system provides only aggregated data on the whole set of sources, a disaggregation as required by the IPCC source categories is not possible at the moment. For this reason, emissions related to source category 2D “Other Production” (Pulp and Paper, Food and Drink) are contained in category 2G. (See also Section 4.8.6).

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 1995 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 1995 database (see Section 1.4.3). Expert judgement and simple extrapolations have been used to estimate trends for the period after 1995.

4.8.3. Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgement 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

No recalculations have been carried out.

4.8.6. Source-Specific Planned Improvements

A new EMIS database with revised activity data and emission factors is under construction (see also Section 1.4.3).

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. Also included are evaporative emissions of N_2O, NO_x, CO and SO_2 arising form other types of product use, as N_2O emissions from medical use. The disposal of solvents is reported in 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.

Source category 3 “Solvent and Other Product Use” is not a key source.

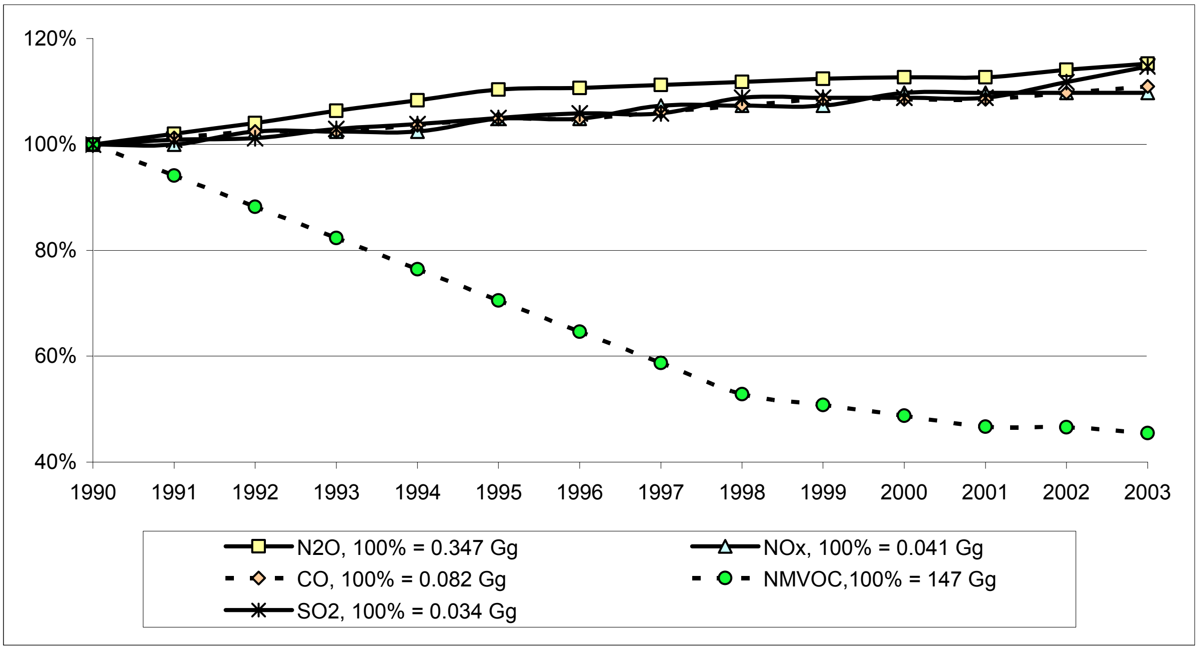

Figure 22 Overview over emissions in category 3 Solvent and Other Product Use in Switzerland.

Gas	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N_2O	t/a	347	354	361	369	376	383	384	386	388	390	391	391	396	400
NO_x	t/a	41	41	42	42	42	43	43	44	44	44	45	45	45	45
CO	t/a	82	83	84	84	85	86	86	87	88	89	89	89	90	91
NMVOC	1'000 t/a	147	138	130	121	112	104	95	86	78	75	72	69	69	67
SO_2	t/a	34	34.3	34.4	35	35.3	35.7	36	36	37	37	37	37	38	39

Table 78 Emissions of source category 3 Solvent and Other Product Use.

NMVOC emissions have diminished since 1990 by - 55% 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). The other emissions have increased since 1990 by 10% to 15%.

5.2. Source Category 3A – Paint Application

5.2.1. Source Category Description

Source category 3A “Paint Application” is **not a key source**.

Source category 3A “Paint Application” comprises NMVOC emissions from paints, lacquers, thinners and related materials used in coatings in industrial, commercial and household applications.

	Source	Specification	Data Source
3A	Paint Application	Paint application in households, industry and construction	Activity: SAEFL 2003, EMIS 1995 EF: SAEFL 2003, EMIS 1995

Table 79 Specification of source category 3A “Paint Application” (Activity: activity data; EF: emission factors)

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.

Emission Factors

Emission factors for NMVOC are country specific based on data from industry, documented in SAEFL 2003 for 1998 and 2001 and the EMIS 1995 database for 1990.

Activity Data

The activity data correspond to the annual consumption of paints. They are based on data from industry, documented in SAEFL 2003 for 1998 and 2001 and the EMIS 1995 database for 1990. The emissions for other years have been interpolated.

5.2.3. Uncertainties and Time-Series Consistency

The uncertainty assessment (SAEFL 2003) results in medium confidence in emissions estimates.

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

No source specific recalculation had to be carried out.

5.2.6. Source-Specific Planned Improvements

A new EMIS database with revised activity data and emission factors is under construction (see also Section 1.4.3).

5.3. *Source Category 3B – Degreasing and Dry Cleaning*

5.3.1. Source Category Description

Source category 3B “Degreasing and Dry Cleaning” is **not a key source**.

Source category 3B “Degreasing and Dry Cleaning” comprises NMVOC emissions from degreasing, dry cleaning and cleaning in electronic industry.

	Source	Specification	Data Source
3B	Degreasing and Dry Cleaning	Degreasing, Dry Cleaning, Electron. Clean.	Activity: industry data, SAEFL 2003, EMIS 1995 EF: industry data, SAEFL 2003, EMIS 1995

Table 80 Specification of source category 3B “Degreasing and Dry Cleaning” (Activity: activity data; EF: emission factors).

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.

Emission Factors

Emission factors for NMVOC are country specific based on data from industry and expert estimates, documented in SAEFL 2003 for 1998 and 2001 and the EMIS 1995 database for 1990.

Activity Data

The activity data are based on data from industry and expert estimates, documented in SAEFL 2003 for 1998 and 2001 and the EMIS 1995 database for 1990. The Emissions for other years have been interpolated.

5.3.3. Uncertainties and Time-Series Consistency

The uncertainty assessment (SAEFL 2003) results in medium confidence in emissions estimates.

The time series is consistent.

5.3.4. Source-Specific QA/QC and Verification

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

5.3.5. Source-Specific Recalculations

No source specific recalculation had to be carried out.

5.3.6. Source-Specific Planned Improvements

A new EMIS database with revised activity data and emission factors is under construction (see also Section 1.4.3).

5.4. Source Category 3C – Chemical Products, Manufacture and Processing

5.4.1. Source Category Description

Source category 3C "Chemical Products, Manufacture and Processing" is **not a key source.**

Source category 3C "Chemical Products, Manufacture and Processing" comprises NMVOC emissions from manufacturing and processing chemical products.

	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.	Activity: industry data, SAEFL 2003, EMIS 1995 EF: industry data, SAEFL 2003, EMIS 1995

Table 81 Specification of source category 3C "Chemical Products, Manufacture and Processing" (Activity: activity data; EF: emission factors).

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.

Emission Factors

Emission factors for NMVOC are country specific based on data from industry and expert estimates and are documented in SAEFL 2003 for 1998 and 2001 and the EMIS 1995 database for 1990. Emission factors for handling and storage of solvents are estimated according to the solvent vapour pressure.

Activity Data

The activity data correspond to the annual consumption of solvents. They are based on data from industry and expert estimates, documented in SAEFL 2003 for 1998 and 2001 and the EMIS 1995 database for 1990. The emissions for other years have been interpolated.

5.4.3. Uncertainties and Time-Series Consistency

The uncertainty assessment (SAEFL 2003) results in medium confidence in emissions estimates.

The 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

No source specific recalculation had to be carried out.

5.4.6. Source-Specific Planned Improvements

A new EMIS database with revised activity data and emission factors is under construction (see also Section 1.4.3).

5.5. Source Category 3D – Other

5.5.1. Source Category Description

Source category 3D “Other” is **not a key source.**

Source category 3D “Other” comprises emissions from many different solvent applications. Besides NMVOC emissions also N_2O, NO_x, CO and SO_2 are relevant. 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;	Activity: industry data, SAEFL 2003, EMIS 1995 EF: industry data, SAEFL 2003, EMIS 1995

Table 82 Specification of source category 3D “Other” (Activity: activity data; EF: emission factors).

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.

Emission Factors

Emission factors for NMVOC are country specific based on data from industry and expert estimates, documented in SAEFL 2003 for 1998 and 2001 and the EMIS 1995 database for 1990. The NMVOC emissions from the production of cosmetics, perfume and aroma are calculated per employee, documented in SAEFL 2003 for 1998 and 2001 and the EMIS 1995 database for 1990.

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 1995 database.

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 SAEFL 2003 for 1998 and 2001 and the EMIS 1995 database for 1990. The emissions for other years have been interpolated.

For other emissions, data from EMIS 1995 is used.

5.5.3. Uncertainties and Time-Series Consistency

The uncertainty assessment (SAEFL 2003) results in medium confidence in emissions estimates.

The 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

No source specific recalculation had to be carried out.

5.5.6. Source-Specific Planned Improvements

A new EMIS database with revised activity data and emission factors is under construction (see also Section 1.4.3).

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, NO_x, CO and NMVOC emissions from field burning of agricultural residues.

Total greenhouse gas emissions from agriculture in 2003 were 5'372 Gg CO_2 equivalents in total which is a contribution of 10.3% to the total of Swiss greenhouse gas emissions. Main agricultural sources of greenhouse gases in 2003 were enteric fermentation emitting 2'492 Gg CO_2 equivalents, followed by agricultural soils with 2'078 Gg CO_2 equivalents. Emissions in all source categories are declining since 1990.

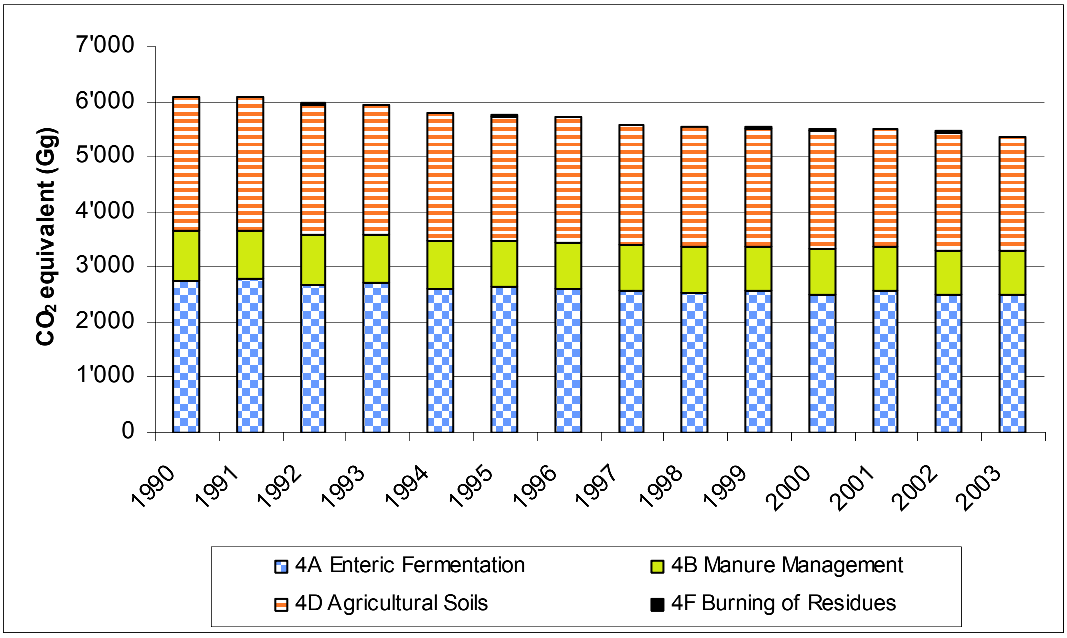

Figure 23 Greenhouse gas emissions in Gg CO_2 equivalents of agriculture1990–2003.

Main greenhouse gases are methane 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
	CO_2 equivalent (Gg)													
CH_4	3'225	3'235	3'142	3'163	3'048	3'080	3'028	2'981	2'959	2'973	2'926	2'975	2'923	2'898
N_2O	2'857	2'855	2'829	2'794	2'752	2'674	2'713	2'605	2'591	2'562	2'572	2'545	2'541	2'475
Sum	6'082	6'090	5'972	5'956	5'801	5'753	5'742	5'585	5'549	5'536	5'498	5'520	5'464	5'372

Table 83 Greenhouse gas emissions in Gg CO_2 equivalents of agriculture1990–2003.

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.

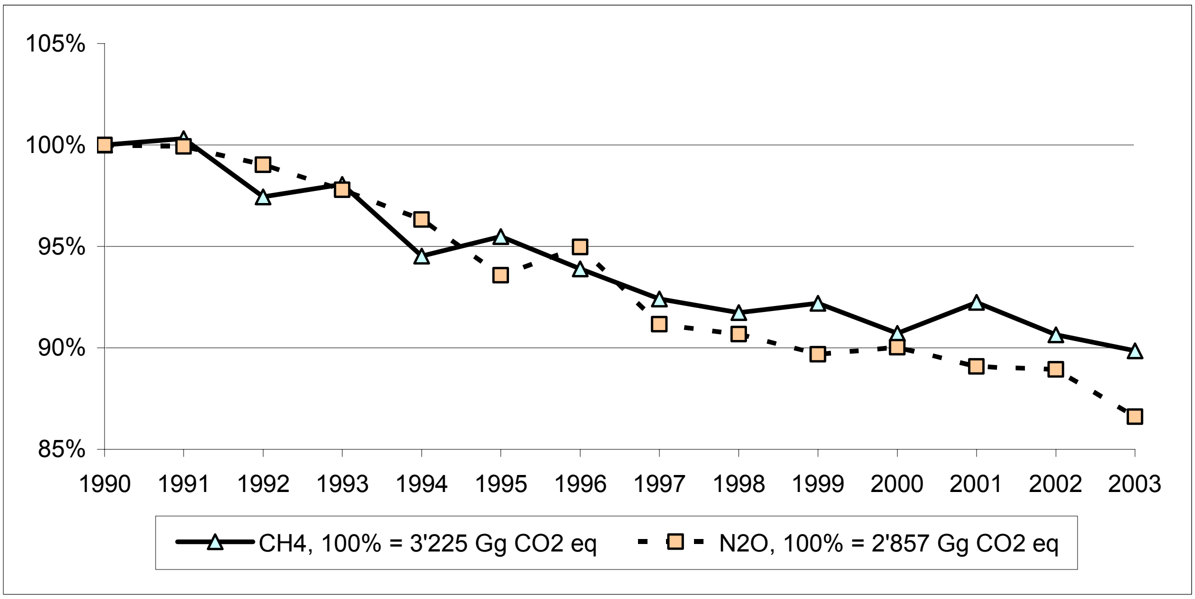

Figure 24 Trend of the greenhouse gases of the agricultural sector 1990-2003. The base year 1990 represents 100%.

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.

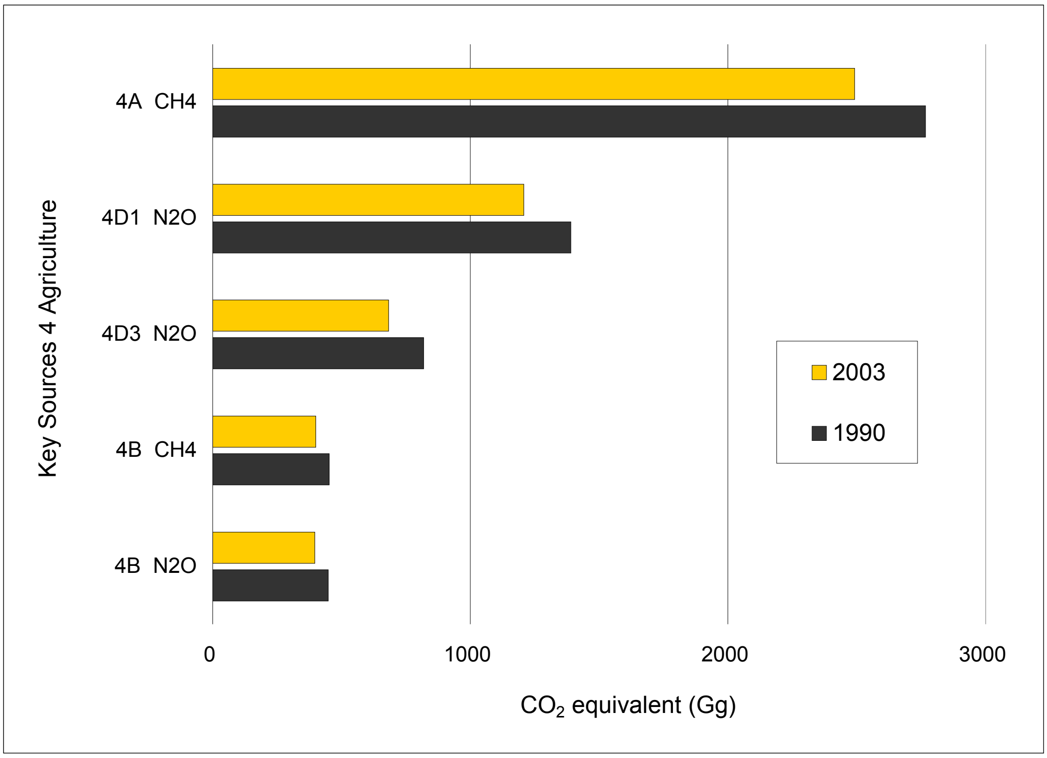

Figure 25 Key sources in Agriculture (emissions in CO_2 equivalents per source category). 4A: Enteric fermentation. 4B: Manure management. 4D: Agricultural soils.

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.

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 approximately 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)	Activity: Livestock data, net energy and feed intake losses from SBV 2004 EF: SAEFL 1998
4A6 4A8	Horses Swine		Activity: Livestock data, digestible energy, feed intake losses from SBV 2004 EF: SAEFL 1998
A47	Mules and asses		Activity: Livestock data from SFSO 2004; digestible energy and feed intake losses from SBV 2004 EF: SAEFL 1998
4A9	Poultry		Activity: Livestock data from SBV 2004 and SFSO 2004; metabolizable energy from SBV 2004, feed intake losses from SBV 2004 EF: SAEFL 1998

Table 84 Specification of source category 4A “Enteric Fermentation”. Activity: activity data; EF: emission factors.

6.2.2. Methodological Issues

Methodology

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

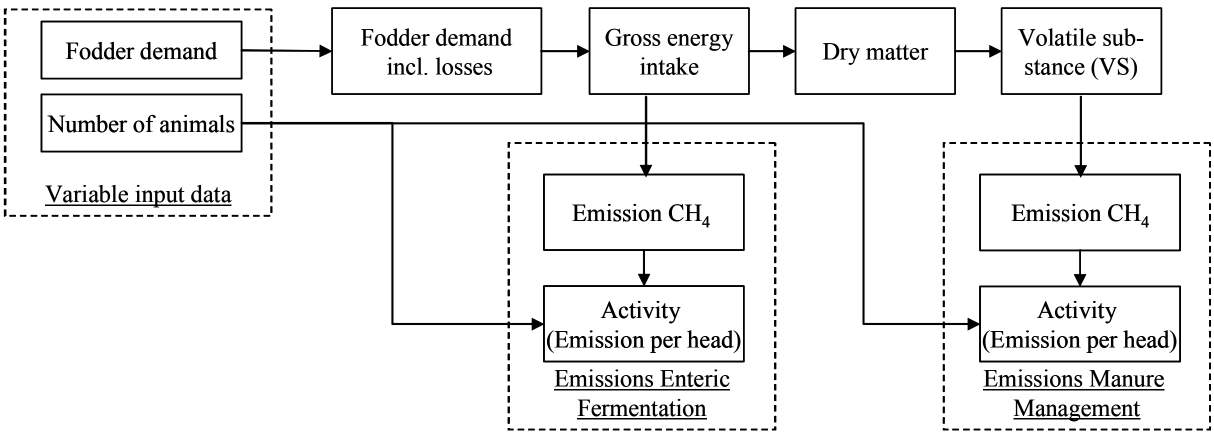

Figure 26 Diagram of the CH_4 Emissions in Agriculture.

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 more disaggregated livestock population categories and emission factors, estimated for each animal category, are used. A further 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 metabolizable 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):

- Metabolizable energy = Gross energy * 0.53
- Net energy lactation = Metabolizable energy * 0.6
- Net energy growth = Metabolizable 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 85 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) = Metabolizable 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
	MJ/head/day													
Cattle														
Dairy cattle	259.2	260.4	255.1	270.5	260.2	261.1	257.7	251.6	252.2	260.2	260.8	263.2	266.9	269.4
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
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
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
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
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
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
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	2.2	2.1

Table 86 Gross energy intake of different livestock groups (SBV 2004).

Activity data

The activity data input has been obtained from statistics published by the Swiss Farmers Association (SBV 2004) and by the Swiss Federal Statistical Office (SFSO 2004).

The activity data are grouped into the livestock categories required for emission calculation.[17]

Population Size	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	(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
Dairy cattle	795	795	781	762	763	763	764	744	737	725	714	720	716	703
Non-Dairy cattle	1'060	1'034	1'002	982	984	986	983	929	904	884	874	891	878	867
Sheep	395	409	415	424	405	387	419	420	422	424	421	420	430	445
Goats	68	65	58	57	55	53	57	58	60	62	62	63	66	67
Horses	45	49	52	54	48	41	43	46	46	49	50	50	51	53
Ponies, Mules and Asses	7	7	8	8	8	8	8	9	10	11	12	12	13	14
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
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	7'206	7'453

Table 87 Activity for calculating methane emissions from enteric fermentation (SBV 2004, SFSO 2004).

The number of cattle, goats and swine was slightly declining during the last 12 years whereas the number of sheep, horses and poultry were increasing.

6.2.3. Uncertainties and Time-Series Consistency

No formal uncertainty assessment has been carried out. Expert judgment assumes that the method as well as the necessary input data are of high quality and allow a reliable estimation of the methane emissions from enteric fermentation (SAEFL 1998, p. 95).

As a first step to a formal uncertainty assessment maximum and minimum emissions based on an estimated uncertainty of activity data and minimum and maximum CH_4 conversion rates were calculated (refer to chapter 1.7).

Uncertainty of activity data is estimated to be 5% which according to expert judgment is a conservative estimate. Livestock data are reliable since subsidies for livestock are paid according to required standard for ecological performance. Furthermore the plausibility of this estimate was substantiated by estimations published in the NIR 2004 of the Netherlands (National Institute for Public Health and the Environment 2004, p.1.26). Minimum and maximum conversion rates are displayed in the following table (SAEFL 1998, p. 65ff.):

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

Livestock Groups	Methane conversion rate		
	Medium	Minimum	Maximum
Cattle			
Dairy cattle	6.00	5.50	6.70
Non-Dairy cattle	6.00	5.50	7.60
Sheep	5.00	4.00	5.80
Goats	5.00	4.00	5.80
Horses	3.50	2.70	4.00
Ponies, Mules and Asses	3.50	2.70	4.00
Swine	0.54	0.40	0.90
Poultry	0.16	n.a	n.a

Table 88 Minimum and maximum methane conversion rates for estimating uncertainty of CH_4 emissions from enteric fermentation (SAEFL 1998, p. 65ff).

Minimum and maximum do not correspond to the effective extreme values. The difference between minimum and maximum emission is interpreted as the double of one standard deviation (the standard deviation is used for the uncertainty analysis in Chapter 1.7).

The time series 1990–2003 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

See Chapter 9.

6.2.6. Source-Specific Planned Improvements

For the next submission the gross energy intake of young cattle is to be estimated. This would allow a further disaggregation of the livestock category dairy and non dairy cattle. Furthermore a better estimation of the uncertainties is planned.

6.3. Source Category 4B – Manure Management

6.3.1. Source Category Description

Key source 4B
Source category 4B Manure Management CH_4 and 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)	Activity: SBV 2004 EF: SAEFL 1998
4B7	Mules and Asses		Activity: SFSO 2004 EF: SAEFL 1998
4B9	Poultry		Activity: SBV 2004 and SFSO 2004 EF: SAEFL 1998

Table 89 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		Activity: SBV 2004, SFSO 2004, FAL/RAC 2001; FAL 1997 EF: IPCC 2000

Table 90 Specification of source category 4B "Manure Management (N_2O)". (Activity: Activity data; EF: Emission factors).

6.3.2. Methodological Issues

For calculation of CH_4 and N_2O emissions different livestock groups are used. 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 (1^{st} year, 2^{nd} year, 3^{rd} 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 2004). 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[18] 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 other parameters regarding the manure systems and the volatile solid excretion VS (SAEFL 1998, p. 75). 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.

Activity data

Activity data on population sizes and feed intake of cattle (dairy cattle, non-dairy cattle), sheep, goats, horses, swine and poultry are taken from SBV 2004. Data on mules and asses as well as data on other poultry are taken from SFSO 2004.

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 emission categories to the particular situation of Switzerland. Further information is provided under the respective chapters. IULIA is described in detail in FAL 2000.

For calculation of emissions from manure management IULIA applies other values for the nitrogen excretion per animal category than IPCC (refer to information about activity data) and differentiates the animal waste management systems Liquid systems and Solid storage. The combined systems (liquid/slurry) are split up into Liquid systems 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.

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

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

Activity data

Input data on cattle, sheep, goats, horses, swine and poultry are taken from the Swiss Farmers Association (SBV 2004), data on mules and asses and other poultry from SFSO 2004. Input data on livestock groups are taken and 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**
	1'000 head													
Dairy cattle	795	795	781	762	763	763	764	744	737	725	714	720	716	703
Non-Dairy cattle	1'060	1'034	1'002	983	984	986	983	929	904	884	874	891	878	867
Rearing cattle 1st year	346	337	324	308	302	295	286	260	254	219	236	238	230	220
Rearing cattle 2nd year	253	252	251	239	239	239	243	233	217	188	222	219	219	213
Rearing cattle 3rd year	151	148	147	142	141	139	140	139	133	118	130	130	126	124
Fattening calves	122	123	123	125	123	120	134	132	137	150	139	155	161	166
Fattening cattle <1/2 year	88	79	71	76	79	82	75	68	66	48	43	40	38	39
Fattening cattle >1/2 year	100	96	87	92	101	111	105	97	97	162	105	109	104	105
Swine	1'195	1'156	1'139	1'110	1'012	914	911	917	983	970	995	1'017	1'022	1'001
Fattening pig places	1'012	977	960	931	844	757	769	769	827	830	851	868	874	857
Breeding pig places	184	179	178	179	168	156	142	148	156	139	145	149	148	144
Sheep (Sheep places) [1]	191	201	201	211	201	191	208	208	209	222	217	217	220	229
Goats (Goats places) 1	40	38	34	33	32	31	33	34	35	37	37	35	36	36
Horses [2]	45	49	52	54	48	41	43	46	46	49	50	50	51	53
Foals (< 1 year)	4	4	5	5	5	5	4	4	4	4	4	4	3	3
Foals (1-2 years)	5	6	6	7	7	6	6	6	6	7	6	6	6	6
Other horses	36	39	41	43	36	30	32	36	36	38	40	40	42	43
Mules and Asses	7	7	8	8	8	8	8	9	10	11	12	12	13	14
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
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
Young hens (< 18 weeks)	719	664	710	719	732	714	732	733	793	761	832	745	754	809
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
Other poultry (turkeys)	110	134	158	183	180	177	174	184	158	155	193	132	132	140

Table 92 Activity data for calculating N_2O emissions from manure management (SBV 2004 and SFSO 2004).
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 Annex 3.5). 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). 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 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 assessment, but a rough estimation of the uncertainty has been done as a first step towards a formal uncertainty assessment (refer to chapter 1.7). Whereas the method is considered appropriate, the estimation of the Volatile Solids excreted is quite uncertain, both methodologically and at the level of the necessary input parameters (SAEFL 1998, p. 97). Maximum and minimum emissions have been estimated (based on uncertainty of the activity data, the maximum and minimum values for the maximum CH_4 producing capacity (Bo), the volatile solids excreted (VS) and the energy content per kg dry matter).

Uncertainty of activity data is estimated to be 5% (for details refer to chapter 6.2.3). Minimum and maximum values for Bo, VS and the energy content per kg dry matter are displayed in the following two tables. From the resulting minimum and maximum emission factor half of their difference corresponds to one standard deviation (refer to chapter 6.2.3).

Minimum and maximum values for calculating uncertainties of manure management CH_4						
	Bo (m^3 CH_4/kg VS)			**VS (kg per kg DM)**		
	Medium	**Minimum**	**Maximum**	**Medium**	**Minimum**	**Maximum**
Cattle						
Dairy cattle	0.24	0.20	0.28	0.25	0.21	0.28
Non-Dairy cattle	0.17	0.14	0.20	0.25	0.21	0.28
Sheep	0.19	0.16	0.22	0.25	0.21	0.28
Goats	0.17	0.14	0.20	0.25	0.21	0.28
Horses	0.33	0.33	0.33	0.45	n.a.	n.a.
Ponies, Mules and Asses	0.33	0.33	0.33	0.45	n.a.	n.a.
Swine	0.45	0.41	0.48	0.20	n.a.	n.a.
Poultry	0.32	0.24	0.39	0.16	n.a.	n.a.

Table 93 Minimum and maximum values for the CH_4 producing capacity (Bo), the volatile solids excreted (VS). All estimations according to SAEFL 1998, p. 65ff and p. 72ff.

	Medium	**Minimum**	**Maximum**
Energy content per kg DM (MJ/kg)	18.45	17.50	19.10

Table 94 Minimum and maximum values for the energy content per kg DM (in MJ/kg). [1] IPCC default value. [2] Estimations according to SAEFL 1998, p. 71.

Time series between 1990 and 2003 are consistent.

b) N_2O Emissions

No formal uncertainty assessment has been carried out. As a first step to a formal uncertainty assessment, minimum and maximum emissions were calculated based on the uncertainty of the activity data and the minimum and maximum emission factors for solid storage and liquid systems (refer to chapter 1.7).

Uncertainty of activity data is estimated to be 5% (for details refer to chapter 6.2.3). Minimum and maximum values for the two relevant emission factors are displayed in the following table.

	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).

Minimum and maximum do not correspond to the effective extreme values. The difference between minimum and maximum emission is interpreted as the double of one standard deviation (the standard deviation is used for the uncertainty analysis in Chapter 1.7). For quantifying the standard deviation, the minimum value for liquid system is set to zero.

Time series between 1990 and 2003 are 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

See Chapter 9.

6.3.6. Source-Specific Planned Improvements

For the next submission a better estimation of the uncertainties is planned.

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	Activity: SBV 2004, FAL/RAC 2001; SFSO 2004; FAL 2003a EF: IPCC 1997b (N_2O) and FAL 2000
4D2	Animal production	Only emissions from pasture range and paddock	Activity: SBV 2004, SFSO 2004, FAL/RAC 2001; FAL 1997 EF: IPCC 1997b
4D3	Indirect emissions	Leaching and run-off, N deposition air to soil	Activity: SBV 2004; FAL/RAC 2001; SFSO 2004; FAC 1994a, FAC 1994b. EF: IPCC 1997b
4D4	Other (sewage sludge and compost used for fertilizing)		Activity: SBV 2004 EF: IPCC 1997b

Table 96 Specification of source category 4D “Agricultural Soils”. (Activity: Activity data; EF: Emission factors).

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 emission categories to the particular situation of Switzerland (FAL 2000). The N_2O emissions, which are considered within the calculation, are displayed in the following figure.

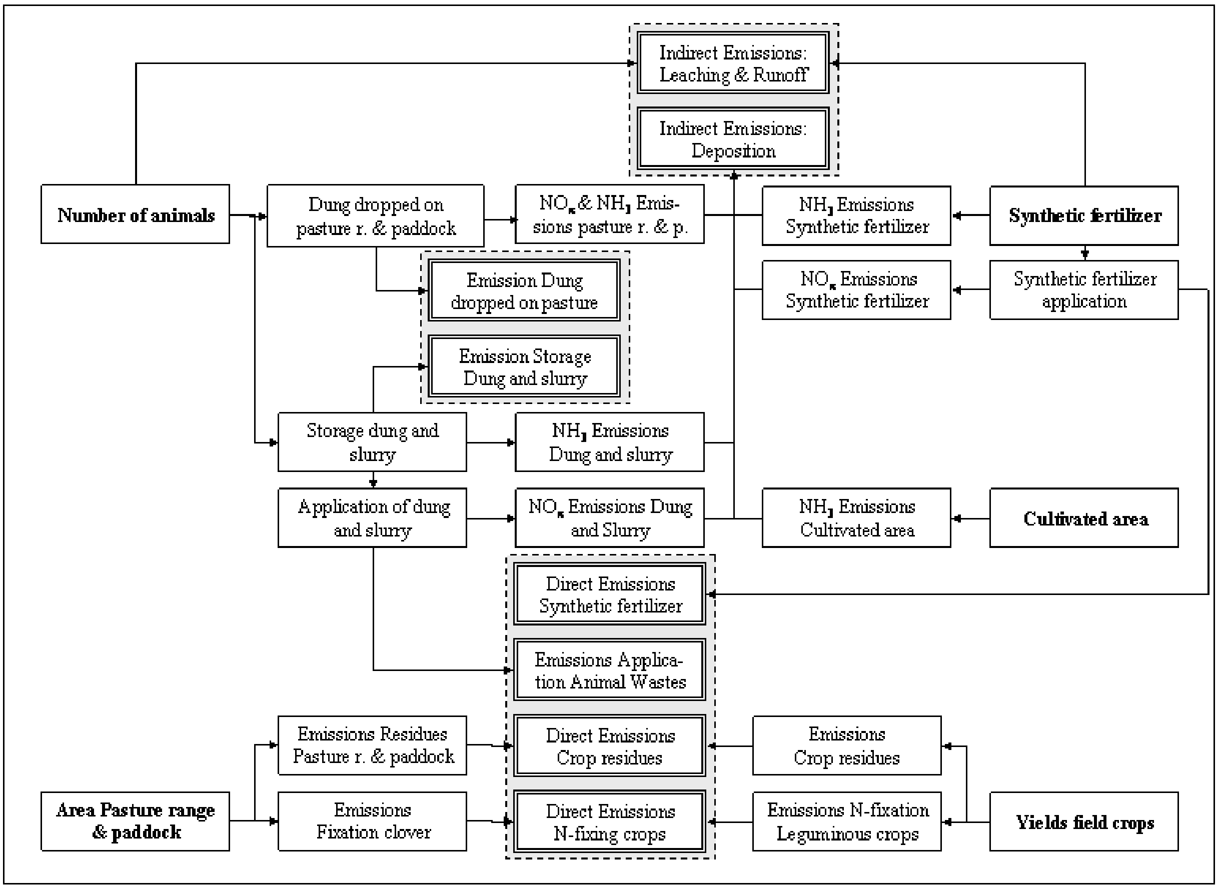

Figure 27 Diagram of the N_2O emissions in Agriculture.

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 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 N_2O 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 2004. From the amount of nitrogen in fertilizer losses to the atmosphere in form of NH_3 and NO_x 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% (NH_3) and 0.7% (NO_x, according to Corinair 2003) instead of the IPCC value of 10% for NH_3 and NO_x. (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 2004), 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 SFSO 2004.

- 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 3.5% of N in the dry matter of clover and 80% of the N in clover stemming from biological nitrogen fixation, and using statistical data for the dry matter production of clover on pastures and meadows (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, SFSO 2004, 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 waterbodies. 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. 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, 1.5 kg NH_3 -N/ha agricultural soil is produced during decomposition of organic material and 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 total (t N)	Losses NH3 (%)	Emissions NH3 (t N)	Losses NOx (%)	Emissions NOx (t N)	Volatized N total (t)
Dairy cattle	74'205	32%	23746	0.7%	519	24'265
Non-Dairy cattle						
Rearing cattle 1st year	5'494	22%	1209	0.7%	38	1'247
Rearing cattle 2nd year	8'508	22%	1'872	0.7%	60	1'931
Rearing cattle 3rd year	6'818	22%	1'500	0.7%	48	1'548
Fattening calves	2'161	37%	799	0.7%	15	815
Fattening cattle <1/2 year	310	37%	115	0.7%	2	117
Fattening cattle >1/2 year	3'475	37%	1'286	0.7%	24	1'310
Swine						
Fattening pig places	11'139	46%	5'124	0.7%	78	5'202
Breeding pig places	5'031	46%	2'314	0.7%	35	2'350
Sheep (Sheep places) [1]	2'743	14%	384	0.7%	19	403
Goats (Goats places) 1	583	29%	169	0.7%	4	173
Horses [2]						
Foals (< 1 year)	57	32%	18	0.7%	0	19
Foals (1-2 years)	253.1	32%	81	0.7%	2	83
Other horses	1'905.6	32%	610	0.7%	13	623
Mules and Asses	367	32%	117	0.7%	3	120
Poultry						
Laying hens	1'409	54%	761	0.7%	10	771
Young hens (< 18 weeks)	275	54%	149	0.7%	2	150
Broilers	1'807	48%	868	0.7%	13	880
Other poultry (turkeys)	196	48%	94	0.7%	1	96
Mineral fertilizer, compost and sewage sludge (t N)	58'300	6%	3'498		408	3'906
NH3 emissions from cropland (ha)	1'063'595	1.5%	1'595			1'595
Total						47'604

Table 98 Overview of the volatized N (NH_3 and NO_x) from animal wastes and fertilizer for 2003. The total amount of volatized N appears under the indirect emissions (atmospheric deposition) in the CRF, table 4D.

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 2004 (use of synthetic fertilizer, crops produced), FAL/RAC 2001, p. 48/49 (nitrogen excretion), SFSO 2004 (area of pasture range and paddock) and FAL 2003a (revised area of cultivated organic soils).

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	Related activity data	Value													
Direct emissions															
Synthetic fertilizer (t/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
	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	53'000
	Sewage sludge (t N/yr)	4'200	n.a.	n.a.	n.a.	n.a.	4'600	4'400	4'200	4'200	4'000	4'000	4'000	4'000	2'000
	Compost (t N/yr)	1'300	n.a.	n.a.	n.a.	n.a.	2'500	2'700	2'900	3'100	3'100	3'100	3'100	3'100	3'100
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	81'387	81'138	79'777	78'839	77'607	76'507	76'518	74'675	74'373	73'479	72'718	71'239	71'065	70'073
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
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
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
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
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
Indirect emissions															
Leaching and run-off	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
Deposition	Volatized N (NH3 and NOx) from fertilizers and animal wastes (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
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

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.

6.5.3. Uncertainties and Time-Series Consistency

No formal uncertainty assessment has been carried out. As a first step uncertainty is estimated based on uncertainties of activity data and maximum and minimum values for the emission factors (refer to chapter 1.7).

Uncertainty of activity data is estimated to be 10% for direct soil emissions (expert judgement) and 50% for indirect soil emissions (IPCC default value). Minimum and maximum values for the related emission factors are displayed in the following table.

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

Table 101 Minimum and maximum values for emission factors related to agricultural soils (IPCC 2000).

Minimum and maximum do not correspond to the effective extreme values. The difference between minimum and maximum emission is interpreted as the double of one standard deviation (the standard deviation is used for the uncertainty analysis in Chapter 1.7).

The time series are 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

See Chapter 9.

6.5.6. Source-Specific Planned Improvements

The Institute for Applied Agriculture in Zollikofen (Schweizerische Hochschule für Landwirtschaft) is implementing a study on nitrogen mass flows in soils. This study will also lead to a better understanding of N_2O emissions. Especially the now applied default emission factors for calculation of emissions from agricultural soils can be adapted to national circumstances.

For the next submission (2006) a better estimation of the uncertainties is planned.

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, NO_x, CO and NMVOC 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 Corinair Default Emission Factors Handbook 1992 and documented in the EMIS (1995) database.

Emissions from burning of branches in agriculture and forestry	**Emission factor** Gg/Gg wood equivalent
CH_4	0.0033
NO_x	0.0004
CO	0.07
NMVOC	0.003
SO_2	0.0002

Table 102 Emission factors for calculating emissions from burning of branches in agriculture and forestry (Corinair Default Emission Factors Handbook 1992).

Activity data

Activity data is based on the EMIS (1995) database.

Amount of Residues burned	**Activity data (in Gg)**
Amount of branches burned in agriculture	21
Amount of branches burned in forestry	63

Table 103 Activity data for calculating emissions from burning of branches in agriculture and forestry (EMIS 1995). 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) since the EMIS (1995) has not been updated since 1995.

The time series are consistent.

6.7.4. Source-Specific QA/QC and Verification

No source-specific activities have been carried out.

6.7.5. Source-Specific Recalculations

See Chapter 9.

6.7.6. Source-Specific Planned Improvements

A new EMIS database is under construction. Within this process a verification of the emission factors and the activity data is foreseen, but not in first priority. N_2O emissions from burning of branches shall be estimated by applying the IPCC default emission factor.

7. Land-Use Change and Forestry

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).

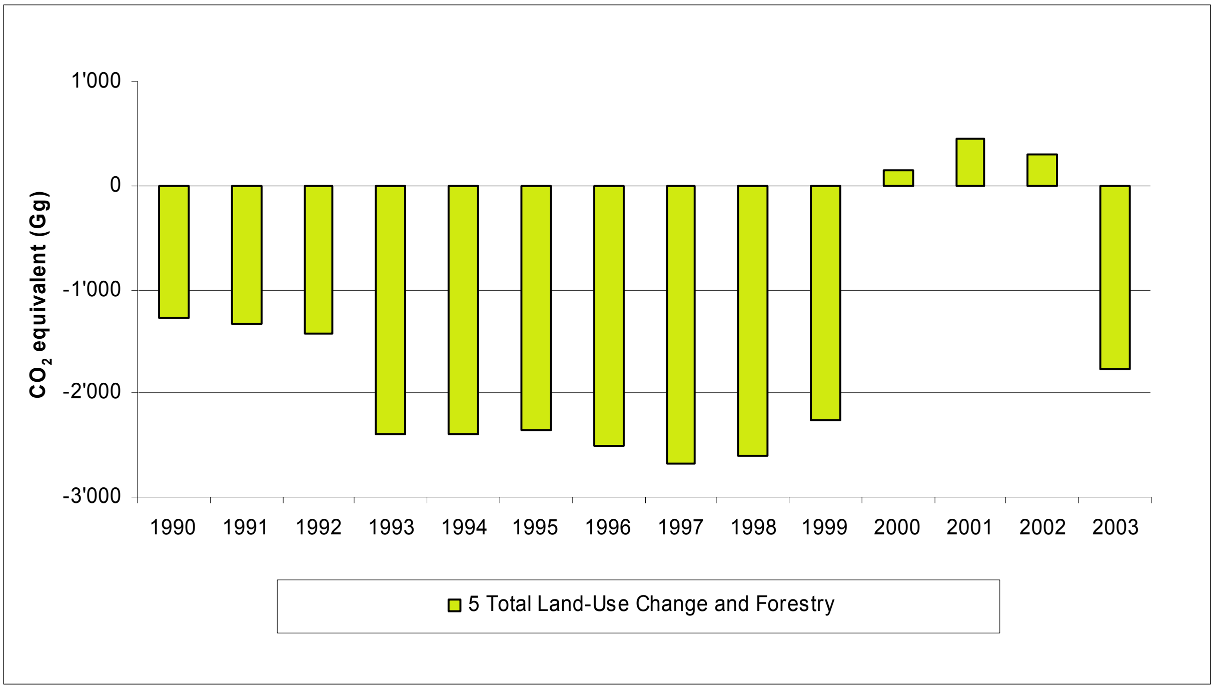

Figure 28 Switzerland's CO_2 emissions/removals of source category 5 "Land-Use Change and Forestry" 1990–2003 in Gg CO_2. Positive values refer to emissions, negative values to removals.

Land-Use Change and Forestry	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	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
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
5D CO2 Emissions and Removals from Soil	613	613	613	613	613	613	613	613	613	613	613	613	613	613

Table 104 CO_2 emissions and removals from Land-Use Change and Forestry (sub-categories and total) in Gg.

Figure 28 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 display the situation with normal harvests without such outstanding events. 2003 was affected by the heat wave, which had supported significant barkbeetle infestations.

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

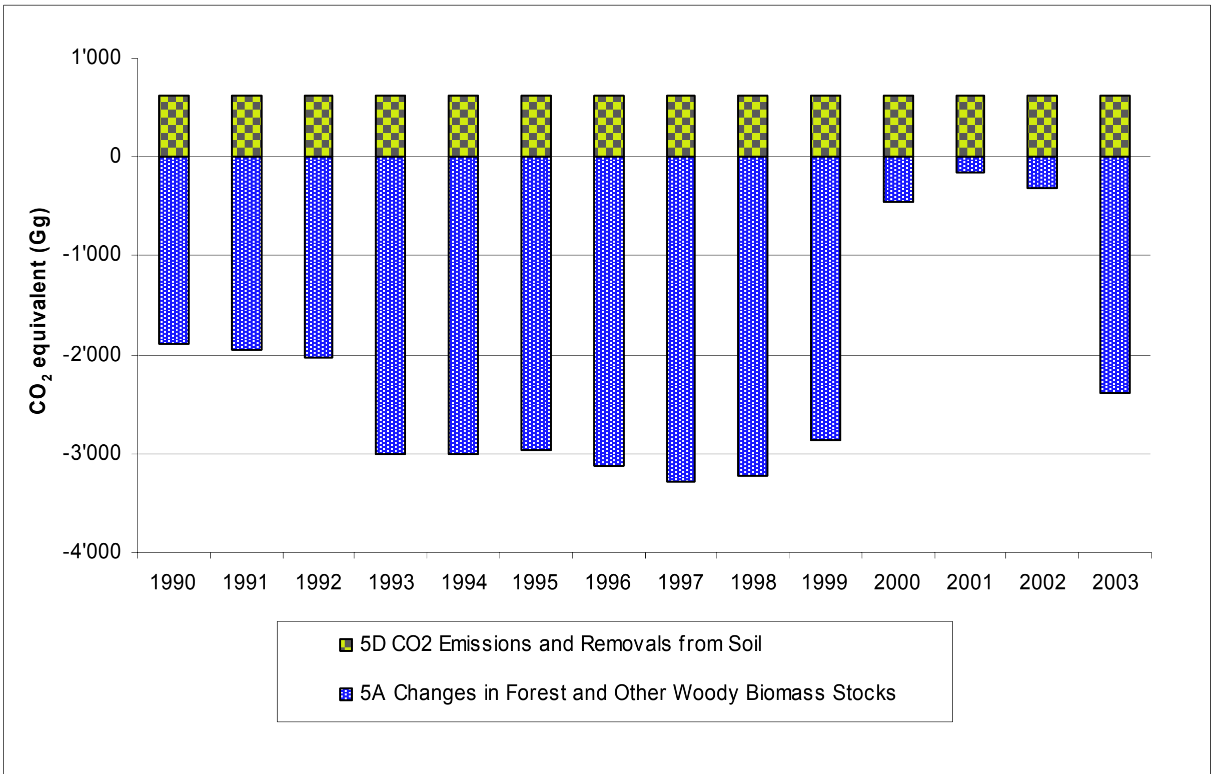

Figure 29 The CO_2 emissions of the sub-categories of Land-Use Change and Forestry 1990–2003.

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 source analysis**.

Only temperate forests are occurring in Switzerland.

5A2	Source/Sink	Specification	Data Source
	Temperate/ Commercial	Growth rate: as shown in Table 107	Brassel P / U.-B. Brändli 1999 (2nd Swiss National Forest Inventory 1995)
		Harvest of evergreen (coniferous) and deciduous are separated	SFSO 2004a: Annual forest statistics

Table 105 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.

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

- A (in hectare) is the total managed forest area equivalent to the productive forest/biomass stocks (according to Table 107).
- AGR (in g dry matter/hectare/a) is the average annual growth rate.
- G (= 8.034 m^3/hectare/year)[19] 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 106 and Table 107):

[19] 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 forst statistics Increase 1995 to 2003 (ha)** SFSO 1996 SFSO 2004a
Total forest area	1'186'300	1'234'000	+ 11'800
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	+ 11'800
Total managed forest area 2003			1'115'000
Evergreen 2003 – 70.0% Deciduous 2003 – 30.0%[20]			781'000 334'000

Table 106 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:

[20] The share of deciduous forest is increasing at a rate of 0.2% per year. The value for 2003 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
Stemwood total on forest area common to both inventories	359	385
Growth of stemwood on new forest area 1995 (afforestation)		2.5
Stemwood on forest area lost (landslides, deforestation)	3.2	
Total stemwood (over bark)	362.2	387.5
Net stock change stemwood 1995–1985		25.3
Total harvest 1985-1995 (incl. mortality)		72.0
Total growth of stemwood 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 107 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 fuelwood consumed	0.5

Table 108 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 109 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 (SFSO 2004a).
- Area of productive forest / biomass stocks A (ha): The annual forest statistics (SFSO 2004a, p 60) provide yearly data on the forested area. In 2003, this area was 1.115 million ha. The share of evergreen forests in 2003 was 70.0%, the share of deciduous forest is 30.0%. 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 2003, this corresponds to an evergreen forest area of 0.781 million ha and deciduous forest area of 0.334 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 (SFSO 2004a, harvest G.4.1 p. 17) 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 (SFSO 2004a).
- 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 110. The result is the total amount of biomass removed.

Wood product groups	Type	Harvested volume 2003 1000 m^3	Density kg/m^3	Removed biomass [1)] kt dm
Commercial harvest (industrial roundwood)	evergreen	3'534	0.384	1968
	deciduous	506	0.556	408
	sub-total	4'040		2'376
Fuel wood	evergreen	473	0.384	263
	deciduous	601	0.556	484
	sub-total	1'073		747
Total		5'113		3'123

Table 110 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 3’123 kt dry matter (Table 110), 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 111). 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, (stemwood, source Brassel P / U.-B. Brändli1999)	72.043 mio m^3 (100%)
Minus stemwood without bark (minus 11%)	64.118 mio m^3 (89%)
Plus timber of branches (3% of stemwood =+ 2.161 mio m3) = a	66.279 mio m^3 (92%)
10 year total of commercially harvested industrial roundwood 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 111 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 112). The forest area since 1995 has been updated on the basis of annual forest statistics (SFSO 2004a), 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 2003 equivalent to 1235 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 112 Statistical differences between the two National Forest Inventories (1985, 1995) and the annual Forest Statistics.

A calibration/recalculation will be done as the 2006 values of the 3rd National Forest Inventory become (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 2006 in response to reporting requirements as adopted at COP9.

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 107, row “Stemwood 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.

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.

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 has been carried out.

7.5.5. Source-Specific Recalculations

See Chapter 9.

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.

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”.

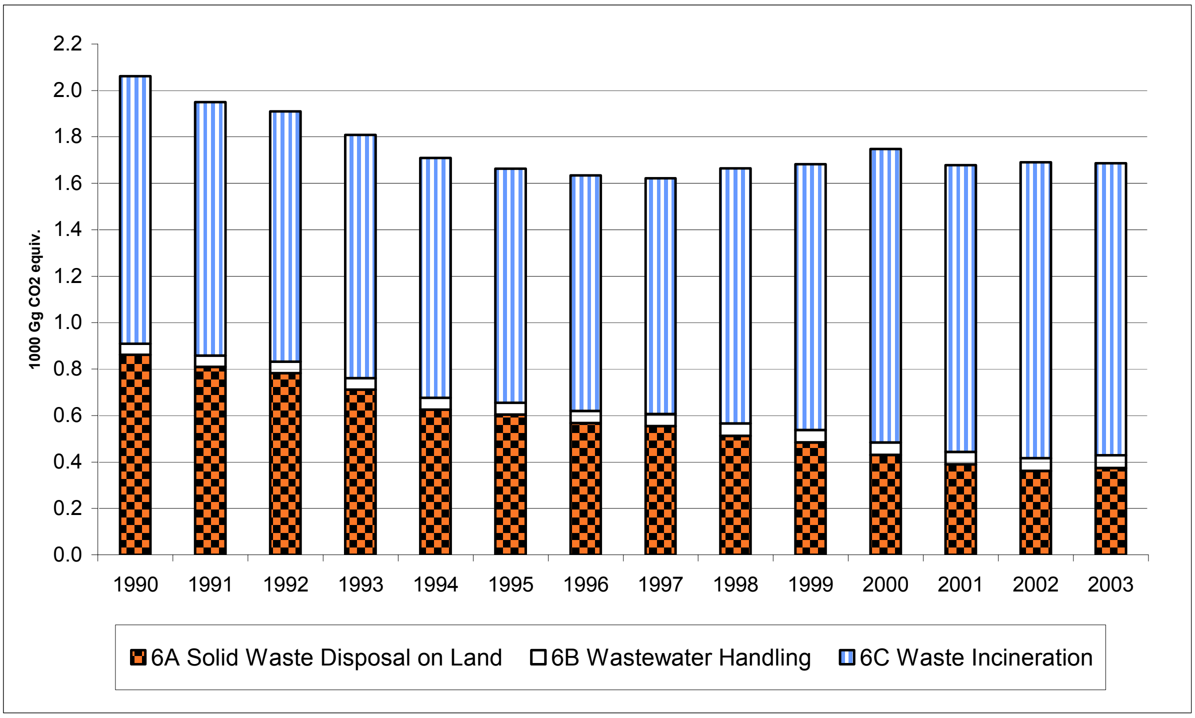

Figure 30 Switzerland’s greenhouse gas emissions in the waste sector 1990–2003.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	CO_2 equivalent (Gg)													
CO_2	1'264	1'173	1'152	1'109	1'076	1'038	1'028	1'023	1'096	1'132	1'226	1'183	1'208	1'188
CH_4	743	723	701	641	574	564	544	536	501	479	441	413	394	407
N_2O	54	54	56	58	59	61	62	64	68	72	81	82	89	92
Sum	2'061	1'950	1'910	1'808	1'709	1'663	1'634	1'622	1'665	1'682	1'748	1'678	1'691	1'686

Table 113 Trend of total GHG emissions from waste management in Switzerland 1990-2003.

In the waste sector a total of 1’686 Gg CO_2 equivalent were emitted in the year 2003. 74.6% of the emissions stem from the sub-category 6C “Waste Incineration”, 22.1% from 6A “Solid Waste Disposal on Land” and 3.3% from 6B “Wastewater Treatment”. The total greenhouse gas emissions show a decrease from 1990 until 1997, followed by an increase until 2000. From 2000 until 2003 roughly a stabilization of the emissions can be observed. The greenhouse gas emissions in source category 6 “Waste” are dominated by the greenhouse gas emissions from source category 6C “Waste Incineration”. In this source category the CO_2 emissions decreased until 1995, followed by a steady increase until 2000. The emissions in source category 6C “Waste Incineration” follow approximately the waste quantity incinerated in the MSW incineration plants. The emissions from 6A “Waste Disposal” decreased constantly from 1990 until 2003. N_2O is of minor importance in the waste sector. The relative trends of the gases can be seen in Figure 31.

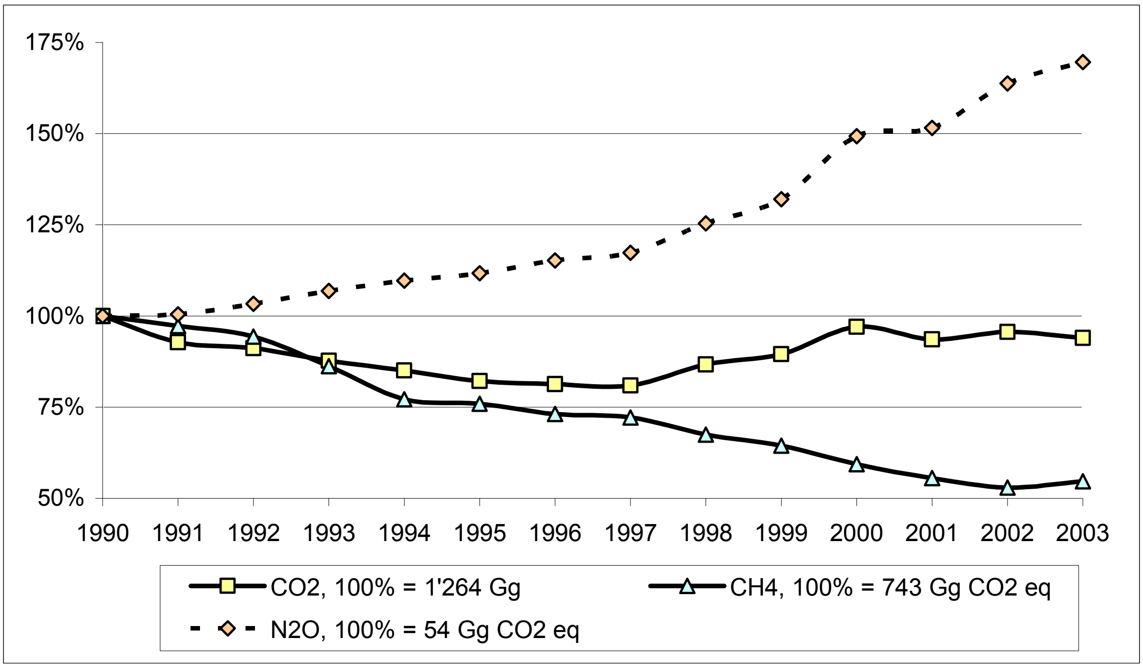

Figure 31 Trend of total GHG emissions from waste management in Switzerland 1990-2003.

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 114 gives an overview on the waste quantities generated in 2003, 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.

Waste Disposal Facilities / Waste Categories	Gg	Landfills (6.A): Inert material landfills	Landfills (6.A): Residue landfills	Landfills (6.A): Reactive landfills 1)	Incineration (6.C.): Mono incineration plants 1)	Incineration (6.C.): MSW incineration plants 1)	Incineration (6.C.): Fuel for energy in industry 3)	Incineration (6.C.): Hospital incinerators 1)	Incineration (6.C.): Hazardous waste incineration plants 1)	Incineration (6.C.): Open burnings	Others (6.D): Car shreddering	Others (6.D): Recycling activities 1) 2)
Municipal solid waste	4'901		577 4)	60	?	2'580				1		2'261
Construction waste	11'000	1'650	74 4)			330				?		9'011
Hazardous waste	1'005			266		415					?	323
Sewage sludge	207				126.7							80.3

Table 114 Overview on waste generation and waste disposal in 2003
1) energy recovery
2) not yet covered in the present National Inventory Report
3) waste as fuel in cement production (refer to source category 1A2). Waste as fuel in paper production (refer to source category 6C).
4) Slag from MSW incineration plants

Table 114 shows that of the 4'901 Gg of municipal solid waste (MSW) generated in 2003, 2'261 Gg or 46% hav been recycled. The main recycled waste types are organic waste (about 740 Gg treated in centralized composting plants, without back-yard composting), paper/cardboard (1’129 Gg) and glass (302 Gg) (SAEFL 2004f). The part of the MSW that has not been recycled has mainly been incinerated (2'580 Gg or 53%) or disposed off on a "ractive" landfill (60 Gg or 1.2%). A small amount went to open burnings and mono incineration plants. 577 Gg of slag has been disposed off on "Residue" landfills. The slag is an output of the MSW incineration plants (and therefore not included in the total of MSW to avoid double counting).

Table 114 shows that about 11'000 Gg construction waste has been generated in Switzerland in the year 2003. From this quantity about 1'650 Gg (15%) were disposed of on landfills and 330 Gg (3%) were incinerated in MSW incineration plants. An unknown smaller quantity was burned at the construction sites and about 9'011 Gg (82%) has been recycled (SAEFL 2004f, SAEFL 2001).

1’005 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.

39% of sewage sludge has been recycled, i.e. this sewage sludge has been used as fertilizer in agriculture. The use of sewage sludge as fertilizer will phase out in the near future since this disposal option won’t be allowed anymore after 2006.

In the present version of the National Inventory greenhouse gas emissions from recycling activities are not estimated yet.

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, and the CO_2 emissions from 6A are a key source regarding 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 2003 11 managed “reactive” landfills have been equipped to recover landfill gas (SFOE 2003a). The landfill gas is used in co-generation plants in order to produce electricity and heat. A small portion of the landfill gas is flared.

6A	Source	Specification	Data Source
6A1	Managed Waste Disposal on Land	Emissions from handling of solid waste on managed landfill sites.	Activity: SAEFL[22] EF: EMIS1995, SAEFL[22]
6A2	Unmanaged Waste Disposal Sites	Emissions from all other waste disposal sites that don’t fall into 6A1. (included in 6A1)	
6A3	Others	Not occurring in Switzerland	

Table 115 Specification of source category 6A “Solid Waste Disposal on Land” (Activity: activity data; EF: emission factors).

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 1997). The subsequent equation is applied to calculate the CH_4 generation in the year t:

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

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 1997)

DOC_F = 0.6 (default value according to IPCC 1997)

F = 0.5 (default value according to IPCC 1997)

The degradable organic carbon also is calculated based on the default values from IPCC 1997.

For the calculation of the 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 subsequent specified parameters are applied for the calculation of the 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 the 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 1995 and in the draft technical commentary[23] 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:

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	2.25	0	1				
	kg / t CH_4 burned						
Co-generation	2’750	0		6	10		1
Flaring	2’750	0		1	17		1
	kg / t waste burned						
Open burning	400	1500		2	60	16	1

Table 116 Emission Factors for 6A1 “Managed Waste Disposal Sites on Land” in 2003.

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[24] to the new EMIS.

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
Construction waste	Gg	147	171	169	122	77	59	41	47	53	53	53	29	5	5
Sewage sludge	Gg (dry)	59	59	59	35	41	30	19	16	13	9	5	5	5	4
Open burned Waste	Gg	121	94	89	79	64	54	42	37	32	27	15	7	2	1
Total waste quantity	**Gg**	**964**	**961**	**954**	**873**	**763**	**675**	**585**	**573**	**561**	**554**	**360**	**225**	**93**	**64**

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
6A1 Managed Waste Disposal on Land															
CH4 as fuel for co-generation 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
CH4 flared	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Table 117 Activity data in 6A1: Waste disposed of on Managed Landfill Sites from 1990 to 2003.

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.

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

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

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
6A1 Managed Waste Disposal on Land															
CH4 as fuel for co-generation 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
CH4 flared	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Table 118 Activity data in 6A1: Share of CH_4 used as fuel in co-generation units and flared from 1990 to 2003.

Table 117 documents the reduction by about 13 times of municipal solid waste, construction waste and sewage sludge disposed of over the period 1990–2003. This is due to changes in the legislative framework, making incineration the mandatory disposal option for municipal solid wastes and banning its disposal on landfills from January 1, 2000.

Together with the relative increase of CH_4 recovery from 1990 until 2003, this is the reason for CH_4 emissions from the source category 6A being a key source regarding trend.

8.2.3. Uncertainties and Time-Series Consistency

Uncertainty in CH_4 emissions from Solid Waste disposal on land in 6A

Uncertainty of direct CH_4 emissions from sanitary landfills is estimated at about 30%[25].

An uncertainty in the amount of waste landfilled of 10% is assumed, because most of the emissions in the nineties results from waste deposed of in the eighties, when waste statistics were less elaborated. From this, an emission factor uncertainty of 28.3% is calculated (resulting in combined uncertainty of 30%).

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.

Completeness: Emissions from composting of organic waste are not estimated and not included in the inventory. (See section 8.2.6 on Planned Improvements.)

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

See Chapter 9.

8.2.6. Source-Specific Planned Improvements

The use of country specific parameters for the CH_4-model.

[25] As cited in the *Draft* Technical Commentary "09 04 00 Kehrichtdeponien" of the new EMIS data base of 21 February 2005, p.9.

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).

There are at present 888 municipal waste water treatment plants in Switzerland. In 2003 293 municipal waste water treatment plants have recovered the biogas in co-generation plants and generate electricity and heat. There are additional waste water treatment plants which use biogas for heat generation only. Their exact number is not known.

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	Activity: SFSO 2003 EF: EMIS 1995
6B3	Others	Not occurring in Switzerland	

Table 119 Specification of source category 6B "Wastewater Handling" (Activity: activity data; EF: emission factors).

8.3.2. Methodological Issues

a) Domestic and Commercial Waste Water (6B2)

Methodology

For domestic and commercial waste water treatment (6B2), a country specific Tier 1 method is used, based on CORINAIR. 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 1995 database.

The following table presents the emission factors used in 6B2:

Source	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	kg/connected inhabitant	g/connected inhabitant					
6B2 Domestic and Commercial Waste Water	0	220	10	70	57	1	180

Table 120 Emission Factors for 6B2 Domestic and Commercial Waste Water in 2003.

Activity data

Activity data for Domestic and Commercial Waste Water (6B2) are extracted from SFSO 2003 for the population and from an unpublished document of SAEFL for the fraction of population connected to waste water treatment plants.

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
6B2 Domestic and Commercial Waste Water															
Population	Inhabitants in 1000	6'796	6'873	6'936	6'997	7'000	7'062	7'128	7'135	7'150	7'172	7'200	7'259	7'349	7'409
Fraction connected to waste water treatment plants	%	90%	91%	92%	93%	94%	95%	96%	97%	97%	97%	97%	97%	97%	97%

Table 121 Activity data in 6B2 Domestic and Commercial Waste Water: Population and fraction connected to waste water treatment plants.

8.3.3. Uncertainties and Time-Series Consistency

Time series on production data and emission factors in the EMIS 1995 database use in many cases expert judgement to estimate data for the period after 1995.

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

Time series is consistent.

8.3.4. Source-Specific QA/QC and Verification

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

8.3.5. Source-Specific Recalculations

No recalculations have been made.

8.3.6. Source-Specific Planned Improvements

In waste water treatment plants, a constant ratio of the biogas recovery rate from 1990 until 2003 between co-generation plants, boilers and flaring has been used. The increased recovery rate of methane has not been updated according to the real development. In future submissions, the effective development of the CH_4 recovery will be used for the calculation of the remaining CH_4 emissions, based on SFOE 2003a.

At present, on site pre-treatment and treatment of industrial waste water and sludge is not estimated. The respective emissions will be taken into account in future submissions, based on SFOE 2003a.

A new EMIS database with revised activity data and emission factors is under construction.

8.4. Source Category 6C – Waste Incineration

8.4.1. Source Category Description

Key source 6C
The CO_2 emissions from Waste Incineration (6C) are a key source regarding level and trend.

In this source category (6C) basically the greenhouse gas emissions from all waste incineration activities are taken into account. In accordance with the IPCC provisions (IPCC 1997c) emissions from the combustion of waste-to-energy fuels in the cement industry are dealt with in 1A "Fuel Combustion Activities" in Energy.

There have been 28 MSW incineration plants in operation in 2003. The MSW incineration plants have to recover the waste heat from the waste incineration process by law. Therefore, all MSW incineration plants are equipped accordingly and in this source category (6C) only a share of the emissions is accounted for. The allocation of the emissions between the two source categories Waste and Energy takes place along the average waste to energy efficiency[26] of all MSW incineration plants. The waste to energy efficiency in 2003 was about 39%.

In contrary to the IPCC provisions (IPCC 1997c) emissions from the combustion of black liquor as fuel for paper/pulp production is taken into account in the present source category 6C "Waste Incineration", and not in 1A "Fuel Combustion Activities" in Energy.

Since 1.1.2000, disposal on landfill sites of waste, which can be burnt, is prohibited by law.

The table below provides an overview on the different waste incineration facilities that contribute emissions to source category 6C "Waste Incineration".

[26] The waste to energy efficiency is defined in this context as the gross amount of heat and power generated (including auto-consumption by the plant) in TJ devided by the net calorific input of waste in TJ.

6C Waste incineration	Specification	Data Source
Municipal solid waste incineration plants	Emissions from waste incineration in municipal solid waste incineration plants	Activity: SAEFL 2004f EF: CO_2 Fahrni 1999, EMIS 1995
Hospital waste incineration	Emissions from incinerating hospital waste in hospital incinerators	Activity: EMIS 1995 EF: EMIS 1995
Households, illegal waste	Emissions from illegal incineration of gardening and household wastes	Activity: EMIS 1995, SAEFL 2003b EF: EMIS 1995
Paper pulp, black liquor	Emissions from incineration of black liquor as fuel for paper/pulp production	Activity: EMIS 1995 EF: EMIS 1995
Paper pulp, other waste	Emission from incineration of residues and sludge from industrial waste water treatment plants as fuel for paper/pulp production	Activity: EMIS 1995, SAEFL 2003b EF: EMIS 1995
Special waste	Emissions from incinerating industrial and hazardous wastes	Activity: SAEFL 1999 Sonderabfallstatistik EF: EMIS 1995
Insulation material from cables	Emissions from incinerating cable insulation materials	Activity: EMIS 1995 EF: EMIS 1995
Sewage sludge	Emissions from sewage sludge incineration plants	Activity: SAEFL 2003b EF: EMIS 1995
Waste at construction sites	Emissions from waste incineration at construction sites (open burning)	Activity: EMIS 1995 EF: EMIS 1995

Table 122 Specification of source category 6C “Waste Incineration” (Activity: activity data; EF: emission factors; most important sources in bold).

In the year 2003 96.5% of the CO_2 emissions from source category 6C stem from two sources: (i) from waste incineration in municipal solid waste incineration plants, and (ii) from incineration of special waste.

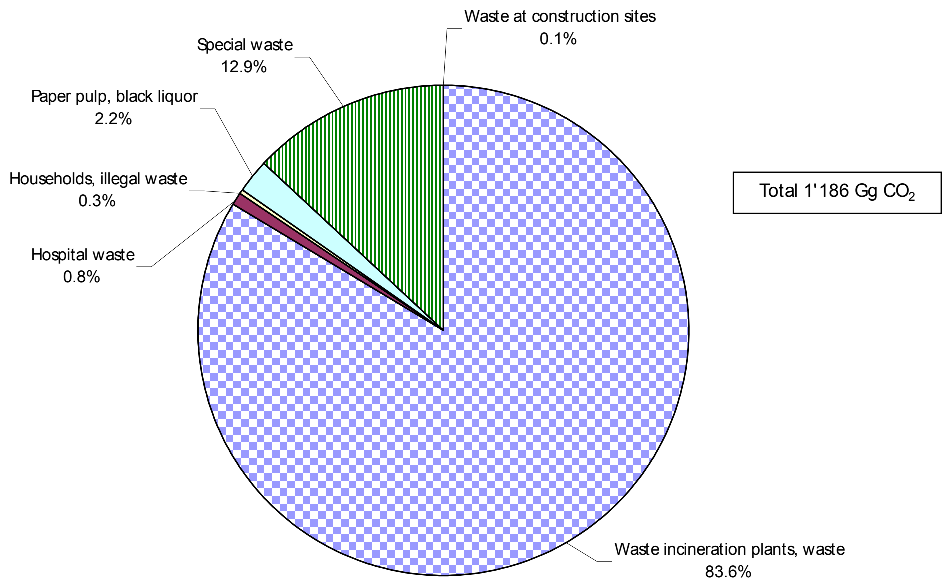

Figure 32 CO_2 emissions of source category 6C "Waste Incineration" in 2003.

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. The GHG emissions are calculated by multiplying the waste quantity incinerated by emission factors.

For municipal solid waste incineration plants, special waste incineration, sewage sludge incineration plants, black liquor and other wastes as fuel in the paper/pulp production, 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 incineration of household waste, incineration of insulation material cables and waste incineration at construction sites, the waste quantities used are based on rough estimations.

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 1995 database.

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

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
6C Waste Incineration							
Municipal Solid Waste Incineration Plants	0.544		108	0.790	0.216	0.020	0.150
Hospital waste incineration	0.9		60	1.5	1.4	0.3	1.3
Households, illegal waste	0.544	6		2	60	16	1
Paper pulp, black liquor	0.213			1.000	0.6	0	1.000
Paper pulp, other waste	0			0.540	1.400		
Special waste	0.900		108	0.720	0.216	0.020	0.15
Insulation material cables	1.300			1.300	2.500	0.500	6.000
Sewage sludge plants	0	0.112	108	0.790	0.216	0.005	0.3
Waste at construction sites	0.544	6		2	60	16	1

Table 123 Emission Factors for 6C “Waste Incineration” in 2003.

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.

Municipal solid waste incineration plants: The main source of fossil CO_2 emissions are plastics. Based on a recent evaluation of the MSW composition the share of non-biogenic waste is considered as 40% (SAEFL 2003).

Hospital waste incineration plants: Mainly waste of fossil origin. Default value for the CO_2 emission factor taken from Corinair 1992.

Households, 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.

Paper pulp, black liquor: Calculated CO_2 emission factor, based on emission data and the quantity and mix of non-biogenic waste incinerated.

Paper pulp, other wastes: Only biodegradable waste is used as fuel. Therefore the CO_2 emission factor is 0.

Special Waste incineration plants: Mainly waste of fossil origin. Default value for the CO_2 emission factor taken from Corinair 1992.

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.

Burning of waste at construction sites: 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.

Activity Data

The activity data for Waste Incineration (6C) are the quantities of waste incinerated and the quantities of waste used as waste-to-energy fuels.

Municipal solid waste incineration: The emissions from heat and/or power generation in municipal solid waste incineration plants are shared out between categories 1A1a (Energy Industries) and 6C (Waste Incineration) proportionally to the average waste to energy efficiency[27] of the plants. Activity data for municipal solid waste incineration is provided in the table below. E.g. in 2003, from the 2'990 Gg of municipal solid waste incinerated, the emissions from the incineration of 1'166 Gg of waste (=2'990 Gg * 0.39) have been accounted for under category 1A1a, whereas 1'824 Gg (=2990 Gg – 1'166 Gg) have been accounted for under category 6C.

Source/fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1A1a Other fuels: Municipal solid waste incinerated with heat and/or power generation															
Total incineration of MSW	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
Waste to energy efficiency	%	32%	34%	36%	36%	37%	40%	40%	42%	41%	41%	40%	40%	39%	39%
Waste accounted for in 1A1a	Gg	790	796	832	832	833	908	916	983	992	1'062	1'120	1'168	1'182	1'166
Waste accounted for in 6C	Gg	1'680	1'544	1'478	1'478	1'418	1'362	1'374	1'357	1'428	1'528	1'680	1'752	1'849	1'824

Table 124 Calcuation of amount of municipal solid waste that is accounted for in source category 6C from 1990 to 2003.

With this, the following activity data table for 6C Waste Incineration results:

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
6C Waste Incineration															
Municipal solid waste incineration plants; waste accounted for in 6C	Gg	1'680	1'544	1'478	1'478	1'418	1'362	1'374	1'357	1'428	1'528	1'680	1'752	1'849	1'824
Hospital waste incineration	Gg	30.0	28.5	27.0	25.5	24.0	22.5	21.0	19.5	18.0	16.5	15.0	13.5	12.0	10.5
Households, illegal waste	Gg	8.3	8.2	7.9	7.8	7.5	7.3	7.0	7.0	7.0	7.4	7.3	7.3	7.4	7.3
Paper pulp, black liquor	Gg	189.0	197.5	190.0	133.2	119.4	151.0	128.0	144.1	149.1	147.2	134.7	122.2	122.2	122.2
Paper pulp, other waste	Gg	14.74	15.44	16.14	16.84	17.31	17.78	18.25	18.72	18.54	17.98	19	19.52	19.52	19.52
Special waste	Gg	125.6	137.2	156.6	130.9	160.5	165.2	174.3	186.4	236.5	227.6	210.0	195.0	174.2	170.0
Insulation material cables	Gg	7.5	6.0	4.5	3.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sewage sludge	Gg dry	57.0	57.5	58.0	58.5	59.0	57.5	56.1	59.6	63.2	63.7	64.3	69.7	75.0	77.8
Waste at construction sites	Gg	50.0	46.4	42.8	39.2	35.6	32.0	26.4	20.8	15.2	9.6	4.0	3.7	3.3	3.0
Total waste in 6C	**Gg**	**2'162**	**2'041**	**1'981**	**1'893**	**1'842**	**1'815**	**1'805**	**1'813**	**1'935**	**2'018**	**2'134**	**2'183**	**2'263**	**2'234**

Table 125 Activity data for the different emission sources within source category 6C “Waste Incineration”.

The table above documents the increase of waste incineration in municipal solid waste incineration plants and in special waste incineration plants. This is the reason for source category 6C “Waste Incineration” being a key source regarding trend.

8.4.3. Uncertainties and Time-Series Consistency

Uncertainty in CO_2 emissions from Waste Incineration in 6C

The dominant factor influencing the uncertainty of CO_2 emissions from municipal solid waste incineration 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[28].

An uncertainty of amount of waste of 5% is assumed (expert judgment), because waste input is reasonably well measured since the nineties. A combined CO_2 emission uncertainty of 30.4% is calculated.

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[27] The waste to energy efficiency is defined in this context as the gross amount of heat and power generated (including auto-consumption by the plant) in TJ devided by the net calorific input of waste in TJ.

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

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

A preliminary uncertainty assessment based on expert judgement 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

No recalculations have been carried out.

8.4.6. Source-Specific Planned Improvements

The CO_2 emissions from waste incineration in municipal solid waste incineration plants are based on the assumption of a constant ratio of 60% biogenic to 40% non-biogenic material. This may be accurate for municipal solid waste, but may be different for the other incinerated waste types like construction waste or sewage sludge. Shares of biogenic materials will be reconsidered.

The data used for special waste are based on expert estimates. It is currently under revision. More accurate data will be available in the year 2006.

The N_2O and NO_x emissions from waste incineration in municipal solid waste incineration plants are based on the fraction of incineration plants that are equipped with DeNOx equipment for flue gas cleaning. The EMIS 1995 data underestimates the real fraction of DeNOx equipment in today's incineration plants.

The emissions from heat and/or power generation in municipal solid waste incineration plants are shared out between categories 1A1a and 6C (Waste Incineration) proportionally to the average waste to energy efficiency[29] of the plants. It is planned for future submissions to reconsider the sharing between the two categories.

A new EMIS database with revised activity data and emission factors is under construction (see also Section 1.3).

The emissions from the combustion of black liquor as fuel for paper/pulp production is presently included in the source category 6C "Waste Incineration", and will be shifted to source category 1A "Fuel Combustion Activities" in Energy in line with IPCC 1997 provisions.

8.5. Source Category 6D – Other

8.5.1. Source Category Description

Source category "Other" (6D) is not a key source.

The source category 6D "Other" comprises all emissions from car shreddering plants.

[29] The waste to energy efficiency is defined in this context as the gross amount of heat and power generated (including auto-consumption by the plant) in TJ devided by the net calorific input of waste in TJ.

6D	Source	Specification	Data Source
	Other	Emissions from car shreddering plants	Activity: EMIS(1995) EF: EMIS 1995

Table 126 Specification of source category 6D “Other” (Shredder) (Activity: activity data; EF: emission factors).

8.5.2. Methodological Issues

Methodology

For emissions under source category “Other” (6D), a country specific Tier 1 method is used, based on CORINAIR. The GHG emissions are calculated by multiplying the quantity of scrap by the emission factors.

Emission Factors

Emission factors for CO and NMVOC are country specific based on measurements and expert estimates, documented in the EMIS 1995 database (see Section 1.3).

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

Source	CO	NMVOC
6D Other (Shredder)	kg/t scrap	
	0.005	0.1

Table 127 Emission Factors for 6D Others (Shredder) in 2002.

Activity data

Activity data for Other (Shredder) (6D) are extracted from EMIS 1995.

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
6D Other (Shredder)															
Scrap	Gg	363	375	387	398	410	422	434	446	458	470	482	421	361	300

Table 128 Activity data in 6D Other (Shredder).

8.5.3. Uncertainties and Time-Series Consistency

Time series on production data and emission factors in the EMIS 1995 database use in many cases expert judgement to estimate data for the period after 1995.

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

The time series is consistent.

8.5.4. Source-Specific QA/QC and Verification

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

8.5.5. Source-Specific Recalculations

No recalculations have been made.

8.5.6. Source-Specific Planned Improvements

The activity data are based on rough estimations. For further submissions more reliable data shall be provided.

A new EMIS database with revised activity data and emission factors is under construction (see also Section 1.3).

In 6D the CO_2 emissions from all waste recycling activities will be estimated. The greenhouse gas emissions from the disposal of organic waste will be added in 2006. Others will follow.

9. Recalculations

9.1. Explanations and Justifications for Recalculation

Several methodological updates required recalculations for the full time period 1990-2002. The reasons for the recalculations are:

1 Energy

- 1A1 Energy Industries: Energy recovery (heat and power) in municipal solid waste incineration plants has been removed from 6C Waste Incineration and transferred to 1A1 Energy Industries (change in allocation of existing emissions). See also below in paragraph 6C
- 1A2 Manufacturing Industries and Construction:
  - The energy consumption of the source categories 1A2 and 1A4a Commercial / Institutional have been disaggregated for the full period 1990-2003. Subsequently, the emissions of the sources concerned has been recalculated. (See Annex A3.1.1)
  - Emissions from the use of waste derived fuels in the cement industry has been removed from 6C and transferred to 1A2.
  - The synthetic gases have been recalculated with updated activity data.
- 1A3b Road Transportation. In the last years, the emission factors of all non-CO_2 gases of road vehicles have been updated in an international project together with Germany, Austria and the Netherlands. Afterwards, the Swiss activity data have been updated too and the road transport emissions were re-modelled for the period 1980-2030. The model results 1990-2003 have been integrated into the GHG Inventory.
- 1A4 Other Sectors: Energy consumption of the source categories 1A2 and 1A4a Commercial/Institutional have been disaggregated for the full time period 1990-2003. Subsequently, the emissions of the sources concerned have been recalculated. (See Annex A3.1.1)

4 Agriculture

A number of corrections were carried out that required a recalculation of the whole time series.

4A Enteric Fermentation

- The Swiss Farmers Association has corrected data for net energy lactation of dairy cattle retroactively until 1997. This leads to slightly increased CH_4 emissions from enteric fermentation from 1997 onwards.

4B Manure Management

- The factor of the N-excretion per sheep place has changed in 2001 from 16 to 12 kg N per sheep place. For the time series, the factor has been smoothed between 1994 and 2001. Before 1994 it is kept at 16 kg, after 2001 at 12 kg. Simultaneously, the N-excretion factor of dairy cattle has changed. Consequently the time series has been smoothed too between 1994 and 2001.
- The NO_x emission factor has been changed from a country-specific (1.5% nitrogen excretion from livestock) to the Corinair default value (0.7%, Corinair 2003).

4D Agricultural Soils

- Activity data N-fertilizer: Emissions from synthetic fertilizers, compost and sewage sludge are newly separated: Fertilisation with compost and sewage sludge is now mentioned under 4D “Other”. The sum of the 4D emissions does not change.
- The change in the factors of the N-excretion of sheep and dairy cattle (see recalculation of 4B Manure Management above) induces changes in the N_2O emissions of 4D.

6 Waste

- 6A Solid Waste Disposal on Land was recalculated for the full time period 1990-2002 with a new methane generation model for waste disposal according to the IPCC guidelines (earlier, a country specific methodology was used)
- 6C Waste Incineration: Energy recovery of waste incineration has been removed from 6C and transferred to 1A1 Energy Industries (change in allocation of existing emissions). See also above in paragraph 1A1.
- 6C Waste Incineration: Emissions from the use of waste derived fuels in the cement industry has been removed from 6C and transferred to 1A2. See also paragraph 1A2 above.

9.2. Implications for Emissions Levels

The effect of recalculations on 2002 data is summarised in the following table. The major difference arises from Waste and Energy where the improvements result in a significant change in the emission level. The other differences are much smaller.

In absolute terms and disregarding the simple reallocation of emissions to other source categories, the largest changes occur due to

- the update of N_2O emission factors in the road transport sector (detailed emission factors, cf. chapter 3.2.2.c), section Road Transportation).
- the CH_4 generation model for solid waste disposal in the waste sector (detailed description of the model, cf. chapter 8.2.2)

The recalculated total of the CO_2 emissions for Switzerland without LUCF is lowered by -1064 Gg of CO_2 equivalent corresponding to a reduction of -2.04% in 2002. If LUCF emissions are included, the recalculated total has decreased by -1045 Gg or -1.99% in 2002.

Recalculation	CO_2			CH_4			N_2O			Sum (CO_2, CH_4 and N_2O)		
Emissions for 2002	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	39'541	40'596	1'055	359	357	-2	644	299	-345	40'545	41'252	707
2 Ind. Processes (without syn. gases)	1'846	1'845	-1	9	9	0	97	97	0	1'952	1'951	0
3 Solvent and Other Product Use	NO	NO	---	0	0	0	123	123	0	123	123	0
4 Agriculture	IE	IE	---	2'856	2'923	67	2'570	2'541	-29	5'425	5'464	39
5 Land-Use Change and Forestry	285	305	20	NO	NO	---	NO	NO	---	285	305	20
6 Waste	2'354	1'208	-1'146	1'033	394	-639	128	89	-39	3'515	1'691	-1'824

Recalculation	HFC			PFC			SF6			Sum (synthetic gases)		
Emissions for 2002	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)	471.4	483.1	11.7	36.3	35.8	-0.5	184.6	187.3	2.7	692.3	706.2	14.0

Recalculation		Sum (all gases)		
Emissions for 2002		Prev.	Latest	Differ.
Source and Sink Categories		CO_2 equivalent (Gg)		
Total CO_2 eq Em. with LUCF		**52'537**	**51'492**	**-1'045**
Total CO_2 eq Em. without LUCF		**52'252**	**51'187**	**-1'064**
		100.00%	97.96%	-2.04%

Table 129 Overview of recalculations. The emissions for 2002 are shown before the recalculation according to the previous submission (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

The latest submission (2005) comprises the full set of CRF tables for all years from 1990 until 2003. The recalculations are complete and all the time series are consistent. Recalculations lead to a general decrease of the total by 2% (without and with LUCF).

Due to recalculations, the emission trend 1990–2003 is changed. Focussing on the year 2002, the emissions showed a decreasing trend of -1.7 % before recalculation. After recalculation, the trend turns out to be somewhat larger, -2.4%.

Recalculation	**1990**		**2002**		**change 1990/2002**	
submission	previous	latest	previous	latest	previous	latest
unit	CO_2 eq (Gg)				%	
gross CO_2 em. (without LUCF)	53'137	52'446	52'254	51'187	-1.7%	-2.4%

Table 130 Change of the emission trend 1990–2003 due to recalculations

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Annexes

Annex 1: Key Sources

Methodology

The key source 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 Source 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*	*52'446.42*	*52'251.73*	*100.00%*		
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'268.92	11'502.92	22.01%	22.01%	KS level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'234.32	9'521.67	18.22%	40.24%	KS level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'448.10	4'078.67	7.81%	48.04%	KS level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'493.41	3'534.85	6.77%	54.81%	KS level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CO2	3'382.87	3'038.79	5.82%	60.62%	KS level
4A	4. Agriculture	A. Enteric Fermentation			CH4	2'766.81	2'492.07	4.77%	65.39%	KS level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'409.10	2'218.15	4.25%	69.64%	KS level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CO2	1'131.39	2'012.99	3.85%	73.49%	KS level
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.44	1'617.69	3.10%	76.59%	KS level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	931.70	1'395.97	2.67%	79.26%	KS level
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.82	1'207.74	2.31%	81.57%	KS level
6C	6. Waste	C. Waste Incineration			CO2	1'108.82	1'186.26	2.27%	83.84%	KS level
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	655.93	735.31	1.41%	85.25%	KS level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	705.59	1.35%	86.60%	KS level
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	682.60	1.31%	87.90%	KS level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	708.89	655.13	1.25%	89.16%	KS level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	429.98	634.36	1.21%	90.37%	KS level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CO2	1'473.66	565.28	1.08%	91.45%	KS level
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	470.83	0.90%	92.35%	KS level
4B	4. Agriculture	B. Manure Management			CH4	452.34	399.86	0.77%	93.12%	KS level
4B	4. Agriculture	B. Manure Management			N2O	448.20	396.68	0.76%	93.88%	KS level
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	707.42	371.84	0.71%	94.59%	KS level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.83	370.48	0.71%	95.30%	KS level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CO2	145.23	270.65	0.52%	95.82%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CH4	307.34	250.95	0.48%	96.30%	-
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	187.63	0.36%	96.66%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	87.27	142.67	0.27%	96.93%	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CO2	131.87	137.08	0.26%	97.19%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.19	134.50	0.26%	97.45%	-
3	3. Solvent and Other Product Use				N2O	107.57	124.00	0.24%	97.69%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	93.00	100.01	0.19%	97.88%	-
2B	2. Industrial Proc.	B. Chemical Industry			N2O	96.72	96.72	0.19%	98.06%	-
2F7	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.45	83.90	0.16%	98.22%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CO2	74.71	80.05	0.15%	98.38%	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	119.97	78.00	0.15%	98.53%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	70.24	0.13%	98.66%	-
6C	6. Waste	C. Waste Incineration			N2O	35.19	69.56	0.13%	98.79%	-
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	58.44	0.11%	98.91%	-
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F7-SF6			SF6	114.45	56.84	0.11%	99.01%	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	0.04	54.15	0.10%	99.12%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	14.70	39.04	0.07%	99.19%	-
2A_o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	43.18	34.89	0.07%	99.26%	-
6B	6. Waste	B. Wastewater Handling			CH4	28.26	33.20	0.06%	99.32%	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF6	0.00	28.68	0.05%	99.38%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	90.78	27.13	0.05%	99.43%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.89	24.09	0.05%	99.48%	-
6B	6. Waste	B. Wastewater Handling			N2O	18.96	22.28	0.04%	99.52%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	21.24	21.42	0.04%	99.56%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	7.92	18.51	0.04%	99.60%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	11.90	18.12	0.03%	99.63%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	16.50	16.50	0.03%	99.66%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	N2O	4.83	13.50	0.03%	99.69%	-
2B	2. Industrial Proc.	B. Chemical Industry			CO2	13.28	13.00	0.02%	99.71%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	29.76	12.31	0.02%	99.74%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	61.20	12.24	0.02%	99.76%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	11.89	0.02%	99.78%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.25	10.32	0.02%	99.80%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	13.44	9.28	0.02%	99.82%	-
2B	2. Industrial Proc.	B. Chemical Industry			CH4	8.17	8.65	0.02%	99.84%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	6.94	7.87	0.02%	99.85%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	7.02	7.36	0.01%	99.87%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	6.97	7.25	0.01%	99.88%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	5.03	6.28	0.01%	99.89%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	5.82	5.82	0.01%	99.90%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.23	5.08	0.01%	99.91%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	2.55	4.61	0.01%	99.92%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	4.18	4.22	0.01%	99.93%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	2.34	3.57	0.01%	99.94%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	N2O	1.95	3.34	0.01%	99.94%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2.13	3.20	0.01%	99.95%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	1.74	2.97	0.01%	99.95%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.85	2.45	0.00%	99.96%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.07	2.08	0.00%	99.96%	-
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	154.88	1.50	0.00%	99.97%	-
6C	6. Waste	C. Waste Incineration			CH4	7.53	1.48	0.00%	99.97%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	1.97	1.32	0.00%	99.97%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.25	0.00%	99.97%	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	1.50	1.17	0.00%	99.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	1.95	1.13	0.00%	99.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	1.45	1.09	0.00%	99.98%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	2.54	1.05	0.00%	99.98%	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N2O	0.98	1.04	0.00%	99.98%	-
2G	2. Industrial Proc.	G. Other			CO2	1.00	1.00	0.00%	99.99%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	0.92	0.98	0.00%	99.99%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.40	0.87	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.85	0.00%	99.99%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	4.10	0.82	0.00%	99.99%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.79	0.00%	99.99%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.84	0.73	0.00%	100.00%	-

Table 131 Key source analysis 2003 regarding level.

Results of Key Source Analysis – Trend

IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Trend Assessment	% Contribution in Trend	Cumulative Total Col. F	Result level assessment	Result trend assessment
						[Gg CO2eq]	[Gg CO2eq]						
TOTAL					*All*	*52'446.42*	*52'251.73*	*100.00%*	*0.1901*	*100.00%*			
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'493.41	3'534.85	6.77%	0.0202	10.6%	10.6%	KS level	KS trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CO2	1'473.66	565.28	1.08%	0.0173	9.1%	19.7%	KS level	KS trend
2A1	2. Ind. Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.44	1'617.69	3.10%	0.0172	9.1%	28.8%	KS level	KS trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CO2	1'131.39	2'012.99	3.85%	0.0170	9.0%	37.8%	KS level	KS trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'409.10	2'218.15	4.25%	0.0156	8.2%	46.0%	KS level	KS trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'234.32	9'521.67	18.22%	0.0130	6.8%	52.8%	KS level	KS trend
2F1	2. Ind. Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	470.83	0.90%	0.0090	4.8%	57.6%	KS level	KS trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	931.70	1'395.97	2.67%	0.0090	4.7%	62.3%	KS level	KS trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'448.10	4'078.67	7.81%	0.0068	3.6%	65.9%	KS level	KS trend
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	707.42	371.84	0.71%	0.0064	3.4%	69.2%	KS level	KS trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CO2	3'382.87	3'038.79	5.82%	0.0064	3.4%	72.6%	KS level	KS trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'268.92	11'502.92	22.01%	0.0053	2.8%	75.4%	KS level	KS trend
4A	4. Agriculture	A. Enteric Fermentation			CH4	2'766.81	2'492.07	4.77%	0.0051	2.7%	78.0%	KS level	KS trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	429.98	634.36	1.21%	0.0040	2.1%	80.1%	KS level	KS trend
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.82	1'207.74	2.31%	0.0034	1.8%	81.9%	KS level	KS trend
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	154.88	1.50	0.00%	0.0029	1.5%	83.5%	-	KS trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.83	370.48	0.71%	0.0026	1.4%	84.8%	KS level	KS trend
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	682.60	1.31%	0.0026	1.3%	86.2%	KS level	KS trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CO2	145.23	270.65	0.52%	0.0024	1.3%	87.5%	-	KS trend
2C3	2. Ind. Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	11.89	0.02%	0.0017	0.9%	88.3%	-	KS trend
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	655.93	735.31	1.41%	0.0016	0.8%	89.2%	KS level	KS trend
6C	6. Waste	C. Waste Incineration			CO2	1'108.82	1'186.26	2.27%	0.0016	0.8%	90.0%	KS level	KS trend
2C3	2. Ind. Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	70.24	0.13%	0.0013	0.7%	90.7%	-	KS trend
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.19	134.50	0.26%	0.0012	0.7%	91.3%	-	KS trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	90.78	27.13	0.05%	0.0012	0.6%	92.0%	-	KS trend
2F_o	2. Ind. Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	58.44	0.11%	0.0011	0.6%	92.6%	-	KS trend
2F_o	2. Ind. Proc.	F. Consumption of Halocarbons and SF6 without 2F7-SF6			SF6	114.45	56.84	0.11%	0.0011	0.6%	93.2%	-	KS trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	87.27	142.67	0.27%	0.0011	0.6%	93.7%	-	KS trend
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CH4	307.34	250.95	0.48%	0.0011	0.6%	94.3%	-	KS trend
2F	2. Ind. Proc.	F. Consumption of Halocarbons and SF6			PFC	0.04	54.15	0.10%	0.0010	0.5%	94.8%	-	KS trend
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	708.89	655.13	1.25%	0.0010	0.5%	95.3%	KS level	KS trend
4B	4. Agriculture	B. Manure Management			CH4	452.34	399.86	0.77%	0.0010	0.5%	95.9%	KS level	-
4B	4. Agriculture	B. Manure Management			N2O	448.20	396.68	0.76%	0.0010	0.5%	96.4%	KS level	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	61.20	12.24	0.02%	0.0009	0.5%	96.8%	-	-
2C_o	2. Ind. Proc.	C. Metal Production without Aluminium Production			CO2	119.97	78.00	0.15%	0.0008	0.4%	97.3%	-	-
6C	6. Waste	C. Waste Incineration			N2O	35.19	69.56	0.13%	0.0007	0.3%	97.6%	-	-
2C_o	2. Ind. Proc.	C. Metal Production without Aluminium Production			SF6	0.00	28.68	0.05%	0.0006	0.3%	97.9%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	14.70	39.04	0.07%	0.0005	0.2%	98.2%	-	-
2F7	2. Ind. Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.45	83.90	0.16%	0.0004	0.2%	98.4%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	29.76	12.31	0.02%	0.0003	0.2%	98.5%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	705.59	1.35%	0.0003	0.2%	98.7%	KS level	-
3	3. Solvent				N2O	107.57	124.00	0.24%	0.0003	0.2%	98.9%	-	-
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	187.63	0.36%	0.0002	0.1%	99.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	7.92	18.51	0.04%	0.0002	0.1%	99.1%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	N2O	4.83	13.50	0.03%	0.0002	0.1%	99.2%	-	-
2A_o	2. Ind. Proc.	A. Mineral Products without Cement Production-CO2			CO2	43.18	34.89	0.07%	0.0002	0.1%	99.3%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	93.00	100.01	0.19%	0.0001	0.1%	99.3%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	11.90	18.12	0.03%	0.0001	0.1%	99.4%	-	-
6C	6. Waste	C. Waste Incineration			CH4	7.53	1.48	0.00%	0.0001	0.1%	99.5%	-	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CO2	131.87	137.08	0.26%	0.0001	0.1%	99.5%	-	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CO2	74.71	80.05	0.15%	0.0001	0.1%	99.6%	-	-
6B	6. Waste	B. Wastewater Handling			CH4	28.26	33.20	0.06%	0.0001	0.1%	99.6%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	13.44	9.28	0.02%	0.0001	0.0%	99.7%	-	-
6B	6. Waste	B. Wastewater Handling			N2O	18.96	22.28	0.04%	0.0001	0.0%	99.7%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.85	2.45	0.00%	0.0001	0.0%	99.7%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	4.10	0.82	0.00%	0.0001	0.0%	99.8%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	2.55	4.61	0.01%	0.0000	0.0%	99.8%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.23	5.08	0.01%	0.0000	0.0%	99.8%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.89	24.09	0.05%	0.0000	0.0%	99.8%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	2.54	1.05	0.00%	0.0000	0.0%	99.8%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	N2O	1.95	3.34	0.01%	0.0000	0.0%	99.9%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	5.03	6.28	0.01%	0.0000	0.0%	99.9%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	1.74	2.97	0.01%	0.0000	0.0%	99.9%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	2.34	3.57	0.01%	0.0000	0.0%	99.9%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2.13	3.20	0.01%	0.0000	0.0%	99.9%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	6.94	7.87	0.02%	0.0000	0.0%	99.9%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.25	10.32	0.02%	0.0000	0.0%	99.9%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	1.95	1.13	0.00%	0.0000	0.0%	99.9%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	1.97	1.32	0.00%	0.0000	0.0%	99.9%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.40	0.87	0.00%	0.0000	0.0%	99.9%	-	-
2B	2. Ind. Proc.	B. Chemical Industry			CH4	8.17	8.65	0.02%	0.0000	0.0%	100.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.25	0.00%	0.0000	0.0%	100.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	0.67	0.23	0.00%	0.0000	0.0%	100.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	7.02	7.36	0.01%	0.0000	0.0%	100.0%	-	-
2B	2. Ind. Proc.	B. Chemical Industry			N2O	96.72	96.72	0.19%	0.0000	0.0%	100.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	1.45	1.09	0.00%	0.0000	0.0%	100.0%	-	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	1.50	1.17	0.00%	0.0000	0.0%	100.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.85	0.00%	0.0000	0.0%	100.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	6.97	7.25	0.01%	0.0000	0.0%	100.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.79	0.00%	0.0000	0.0%	100.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.32	0.06	0.00%	0.0000	0.0%	100.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	21.24	21.42	0.04%	0.0000	0.0%	100.0%	-	-
2B	2. Ind. Proc.	B. Chemical Industry			CO2	13.28	13.00	0.02%	0.0000	0.0%	100.0%	-	-
2A_o	2. Ind. Proc.	A. Mineral Products			CH4	0.54	0.38	0.00%	0.0000	0.0%	100.0%	-	-

Table 132 Key source analysis 2003 regarding trend.

List of Key Sources

IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
						[Gg CO2eq]	[Gg CO2eq]					
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.83	370.48	0.71%	0.002623	1.4%	KS level	KS trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	705.59	1.35%	0.000325	0.2%	KS level	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	429.98	634.36	1.21%	0.003957	2.1%	KS level	KS trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1'131.39	2'012.99	3.85%	0.017016	9.0%	KS level	KS trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3'382.87	3'038.79	5.82%	0.006368	3.4%	KS level	KS trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CO2	145.23	270.65	0.52%	0.002420	1.3%	-	KS trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1'473.66	565.28	1.08%	0.017344	9.1%	KS level	KS trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'493.41	3'534.85	6.77%	0.020183	10.6%	KS level	KS trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'268.92	11'502.92	22.01%	0.005299	2.8%	KS level	KS trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	90.78	27.13	0.05%	0.001216	0.6%	-	KS trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	87.27	142.67	0.27%	0.001070	0.6%	-	KS trend
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.19	134.50	0.26%	0.001247	0.7%	-	KS trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	931.70	1'395.97	2.67%	0.008985	4.7%	KS level	KS trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'448.10	4'078.67	7.81%	0.006779	3.6%	KS level	KS trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'409.10	2'218.15	4.25%	0.015642	8.2%	KS level	KS trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'234.32	9'521.67	18.22%	0.012960	6.8%	KS level	KS trend
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	655.93	735.31	1.41%	0.001572	0.8%	KS level	KS trend
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	708.89	655.13	1.25%	0.000982	0.5%	KS level	KS trend
1B2	1. Energy	B. Fugitive Emissions fı	2. Oil and Natural Gas		CH4	307.34	250.95	0.48%	0.001061	0.6%	-	KS trend
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.44	1'617.69	3.10%	0.017238	9.1%	KS level	KS trend
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	11.89	0.02%	0.001689	0.9%	-	KS trend
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	70.24	0.13%	0.001316	0.7%	-	KS trend
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	58.44	0.11%	0.001123	0.6%	-	KS trend
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F7-SF6			SF6	114.45	56.84	0.11%	0.001098	0.6%	-	KS trend
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	0.04	54.15	0.10%	0.001039	0.5%	-	KS trend
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	470.83	0.90%	0.009044	4.8%	KS level	KS trend
4A	4. Agriculture	A. Enteric Fermentation			CH4	2'766.81	2'492.07	4.77%	0.005080	2.7%	KS level	KS trend
4B	4. Agriculture	B. Manure Management			CH4	452.34	399.86	0.77%	0.000976	0.5%	KS level	-
4B	4. Agriculture	B. Manure Management			N2O	448.20	396.68	0.76%	0.000958	0.5%	KS level	-
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.82	1'207.74	2.31%	0.003399	1.8%	KS level	KS trend
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	682.60	1.31%	0.002560	1.3%	KS level	KS trend
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	707.42	371.84	0.71%	0.006396	3.4%	KS level	KS trend
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	154.88	1.50	0.00%	0.002935	1.5%	-	KS trend
6C	6. Waste	C. Waste Incineration			CO2	1'108.82	1'186.26	2.27%	0.001567	0.8%	KS level	KS trend

Table 133 Key sources in Switzerland 2003. Most of the key sources are identified in both the level and the trend analysis.

Annex 2: Methodology and Input Data for Estimating CO_2 and SO_2 Emissions

Annex 2.1 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 2003 (SFOE 2003).

A2.1.1 Net calorific values (energy content) and density of fossil fuels

Fuel	Net calorific values		Density
	GJ / t	GJ / volume	t / volume
Coal	28.1	---	---
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 134

A2.1.2 CO_2 emission factors of fossil fuels

CO_2 Emission Factor			
Fuel	t CO_2 / TJ	t CO_2 / t	t CO_2 / volume
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 135

A2.1.3 Swiss Energy Flux

The diagram shows a summary of the Swiss energy flux 2003 as published by the Swiss Federal Office of Energy (SFOE). The diagram languages are German and French.

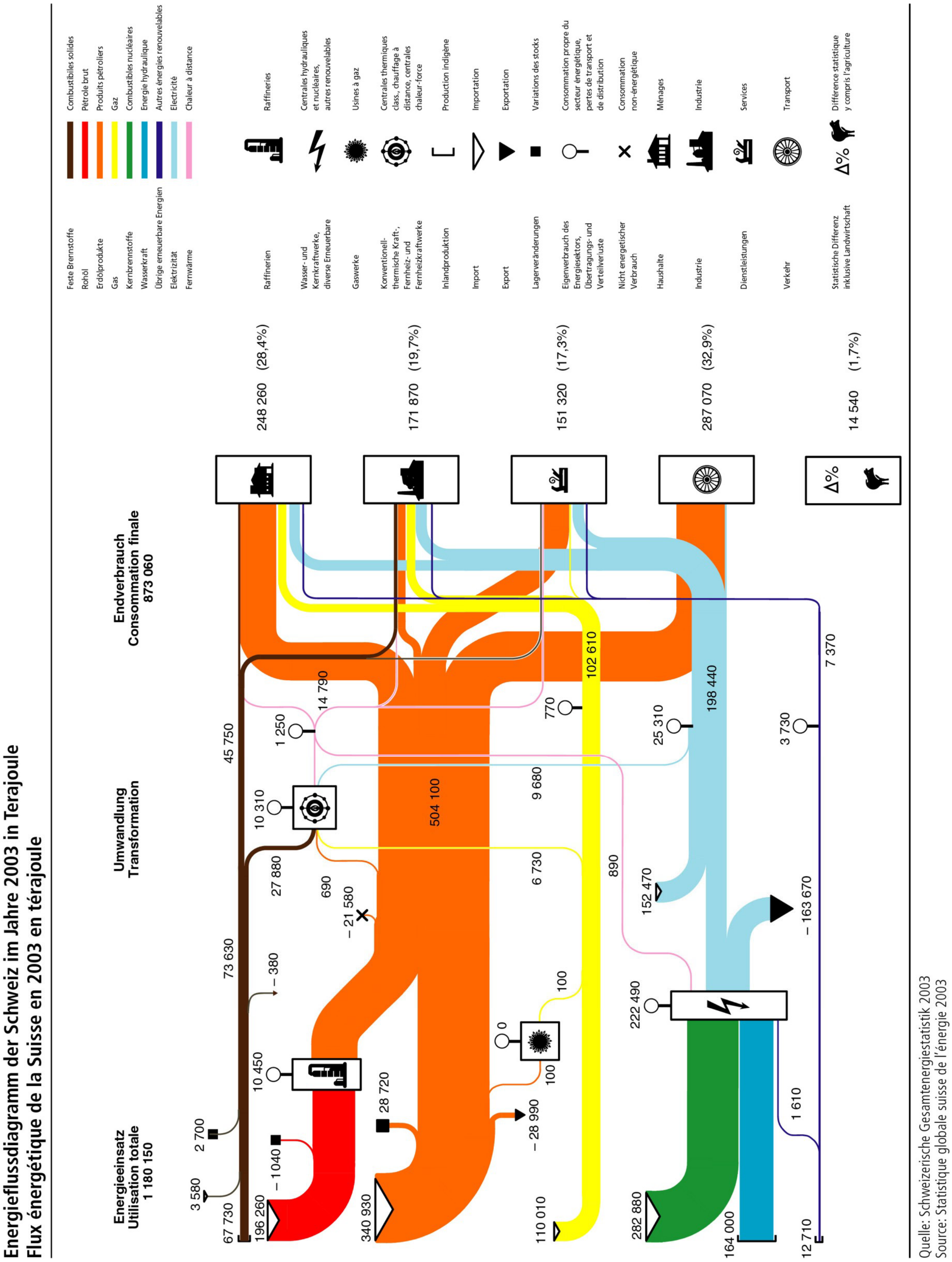

Figure 33 Energy flux in Switzerland 2003 (SFOE 2003)

Annex 2.2 Sulphur Dioxide (SO_2)

year	1						
	Diesel oil ppm	Gasoline ppm	Gas oil ppm	Natural gas ppm	Res. fuel oil %	Coal %	Kerosene ppm
1990	1400	200	2000	19	1.0	1.0	
1991	1300	200	2000	19	1.0	1.0	
1992	1200	200	2000	19	1.0	1.0	
1993	1000	200	2000	19	1.0	1.0	
1994	500	200	500	19	1.0	1.0	
1995	500	200	500	19	1.0	1.0	
1996	500	200	500	19	1.0	1.0	
1997	500	200	500	19	1.0	1.0	
1998	500	200	500	19	1.0	1.0	
1999	500	200	500	19	1.0	1.0	
2000	350	150	200	19	1.0	1.0	
2001	350	150	200	19	1.0	1.0	
2002	350	150	200	19	1.0	1.0	
2003	350	150	200	19	1.0	1.0	
2004	350	150	200	19	1.0	1.0	
2005	50	50	200	19	1.0	1.0	

year	Effective sulphur content						
	Diesel oil ppm	Gasoline ppm	Gas oil ppm	Natural gas ppm	Res. fuel oil %	Coal %	Kerosene ppm
1990	1400	200	1600	11.6	0.97	0.8	837
1991	1300	200	1300	11.6	0.89	0.8	837
1992	1200	200	1200	11.6	0.86	0.8	835
1993	1000	200	1000	11.6	0.87	0.8	831
1994	434	200	1350	11.6	0.77	0.8	832
1995	341	200	1170	11.6	0.78	0.8	839
1996	372	200	1160	11.6	0.78	0.8	841
1997	353	200	1250	11.6	0.70	0.8	841
1998	402	200	926	11.6	0.83	0.8	842
1999	443	200	650	11.6	0.62	0.8	842
2000	272	142	680	11.6	0.66	0.8	713
2001	250	121	830	11.6	0.82	0.8	711
2002	235	101	798	11.6	0.82	0.8	711
2003	200	81	700	11.6	0.79	0.8	711

year	Effective SO_2 emission factor						
	Diesel oil	Gasoline	Gas oil	Natural gas	Res. fuel oil	Coal	Kerosene
	kg/TJ						
1990	65.4	9.4	75.1	0.50	473	350	22.9
1991	60.7	9.4	61.0	0.50	432	350	22.9
1992	56.1	9.4	56.3	0.50	417	350	22.8
1993	46.7	9.4	46.9	0.50	422	350	22.7
1994	20.3	9.4	63.4	0.50	374	350	22.7
1995	15.9	9.4	54.9	0.50	377	350	22.9
1996	17.4	9.4	54.5	0.50	379	350	23.0
1997	16.5	9.4	58.7	0.50	340	350	23.0
1998	18.8	9.4	43.5	0.50	403	350	23.0
1999	20.7	9.4	30.5	0.50	301	350	23.0
2000	12.7	6.7	31.9	0.50	320	350	19.5
2001	11.7	5.7	39.0	0.50	398	350	19.4
2002	11.0	4.8	37.5	0.50	398	350	19.4
2003	9.3	3.8	32.9	0.50	383	350	19.4

Table 136 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

$$\boxed{\frac{M_{SO_2}}{M_S}\frac{S}{NCV} = 2\frac{S}{NCV}}$$

Annex 3: Other Detailed Descriptions and Data for Individual Sources

Annex 3.1: Emissions from Fuel Consumption

A3.1.1 Disaggregation of Fuel Consumption

Swiss global energy statistics 2003

The consumption of Solid, Liquid, Gaseous and Other Fuels in the Swiss global energy statistics 2003 (SFOE 2003) 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 (“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.

Modeling of fuel consumption in Manufacturing Industries and Construction (Basics)

The modelling of fuel consumption in Manufacturing Industries and Construction in Switzerland from 1990 to 2003 of Basics (Basics 2004) 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. (for 1999 to2001), data from the Swiss energy agency for industry (Energieagentur der Wirtschaft ENAW, for 1990 and 2000 to 2002), 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, 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 $F_{1A2}^{Model} = \sum_{i=a}^{f} F_{1A2i}^{Model}$.

Modeling of fuel consumption in services/institutional (CEPE)

Modeling work at the Centre for Energy Policy and Economics in Zürich (CEPE 2004) provided the basis to estimate the fuel consumption of the services and institutional sector in Switzerland from 1990 to 2003. The model calculates heat and electricity demand on the basis of heated building area. Seven fuels/heating systems are distinguished: Light fuel 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 behavior 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 2003, 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 the fuel related emissions from Manufacturing Industries based on the outputs of the Basics-model:

(3) $$F_{1A2a} = F_{1A2a}^{Model}\ ;\quad F_{1A2b} = F_{1A2b}^{Model}\ ;\quad F_{1A2c} = F_{1A2c}^{Model}\ ;\quad F_{1A2d} = F_{1A2d}^{Model}\ ;\quad F_{1A2e} = F_{1A2e}^{Model}$$

(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.

The resulting (top-down) fuel consumptions in 1A2f Others has then be cross-checked with available (bottom-up) data on fuel consumption in the cement, lime and glass industry from cemsuisse and the old EMIS1995 database. In some years and for the fuels heavy fuel oil and hard coal, the bottom-up data resulted in higher fuel consumption than the top-down approach.

In these cases, fuel consumption data for Manufacturing Industries and Construction from the statistics have been modified. The modifications consisted in shifting amounts of heavy fuel oil and hard coal between certain years in such a way that top-down consumption is not smaller than bottom-up data in every year (this could also be interpreted as introducing additional stock changes). The modifications are documented in the table below. Data of the years 1990 and 1993 have not been modified, and cumulative consumption in the period 1991-2002 is not affected by the modifications.

Fuel	1990 TJ	1991 TJ	1992 TJ	1993 TJ	1994 TJ	1995 TJ	1996 TJ	1997 TJ	1998 TJ	1999 TJ	2000 TJ	2001 TJ	2002 TJ	2003 TJ
Heavy fuel oil														
Swiss global energy statistics	18'870	17'386	16'851	14'379	14'914	13'678	11'083	9'764	10'382	8'570	6'015	8'034	4'936	5'315
Modification									*-300*	*100*	*200*	*-1'349*	*1'349*	
Input to CRF	18'870	17'386	16'851	14'379	14'914	13'678	11'083	9'764	*10'082*	*8'670*	*6'215*	*6'685*	*6'285*	5'315
Hard coal														
Swiss global energy statistics	14'640	12'392	8'514	7'137	7'194	7'840	5'861	4'468	3'694	3'877	5'626	6'126	5'648	5'845
Modification		*-500*	*500*				*-450*	*200*	*150*		*100*			
Input to CRF	14'640	*11'892*	*9'014*	7'137	7'194	7'840	*5'411*	*4'668*	*3'844*	3'877	*5'726*	6'126	5'648	5'845

Table 137 Original fuel consumption data from Swiss global energy statistics (SFOE 2003), modifications applied and resulting fuel consumption used as input to CRFs.

A3.1.2 “Industry” in the Old EMIS 1995 Database and CRF Categories

The following table provides an overview on "processes" that are subsumed under the category “industry” in the old EMIS 1995 database and their relation to the CRF categories for bottom up calculations

Industrial process (English)	**Industrial process (German)**	**Included in CRF categorie**
Non-ferrous metals	Buntmetall	Included in source category 2
Foundries	Giessereien	Included in 1A2a Iron and steel
Gas steel plants	Wärmeöfen	Included in 1A2a Iron and steel
Aluminium smelting	Aluminium umschmelzen	Included in 2
Aluminium production (Anodes)	Aluminiumproduktion (Anoden)	Included in 2
Graphite	Graphit	Included in 2
Mineral wool	Steinwolle	Included in 1A2f Cement/lime/Glass
Glass wool	Glaswolle	Included in 1A2f Cement/lime/Glass
Glass	Glas	Included in 1A2f Cement/lime/Glass
Container glass	Hohlglas	Included in 1A2f Cement/lime/Glass
Asphalt concrete plants	Mischgut	Included in 1A2f Cement/lime/Glass
Fine ceramics materials	Feinkeramik	Included in 1A2f Cement/lime/Glass
Brick and tile	Grobkeramik	Included in 1A2f Cement/lime/Glass
Plaster	Gips	Included in 1A2f Cement/lime/Glass
Lime	Kalk	Included in 1A2f Cement/lime/Glass
Cement	Zement	Included in 1A2f Cement/lime/Glass
Cellulose	Zellulose	Included in source category 6
Gras drying	Grastrocknung	Included in 1A4c
Steamboats	Dampfschiffe	Included in 1A3

Table 138 Overview on Processes included in the category “industry” in EMIS 1995 and their link to the CRF categories.

Annex 3.2: Road Transportation

A3.2.1 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 139 Vehicle segmentation of the passenger cars. Each class (segment) is subdivided into three cubic capacities: <1.4 liter, 1.4-2.0 liters, > 2.0 liters (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 140 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 141 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 142 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.

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 143 Mean emission factors of heavy duty vehicles (HDV) and urban busses (U-Bus). SMW: schwere Motorwagen = HDV, D: diesel.

A3.2.2 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.

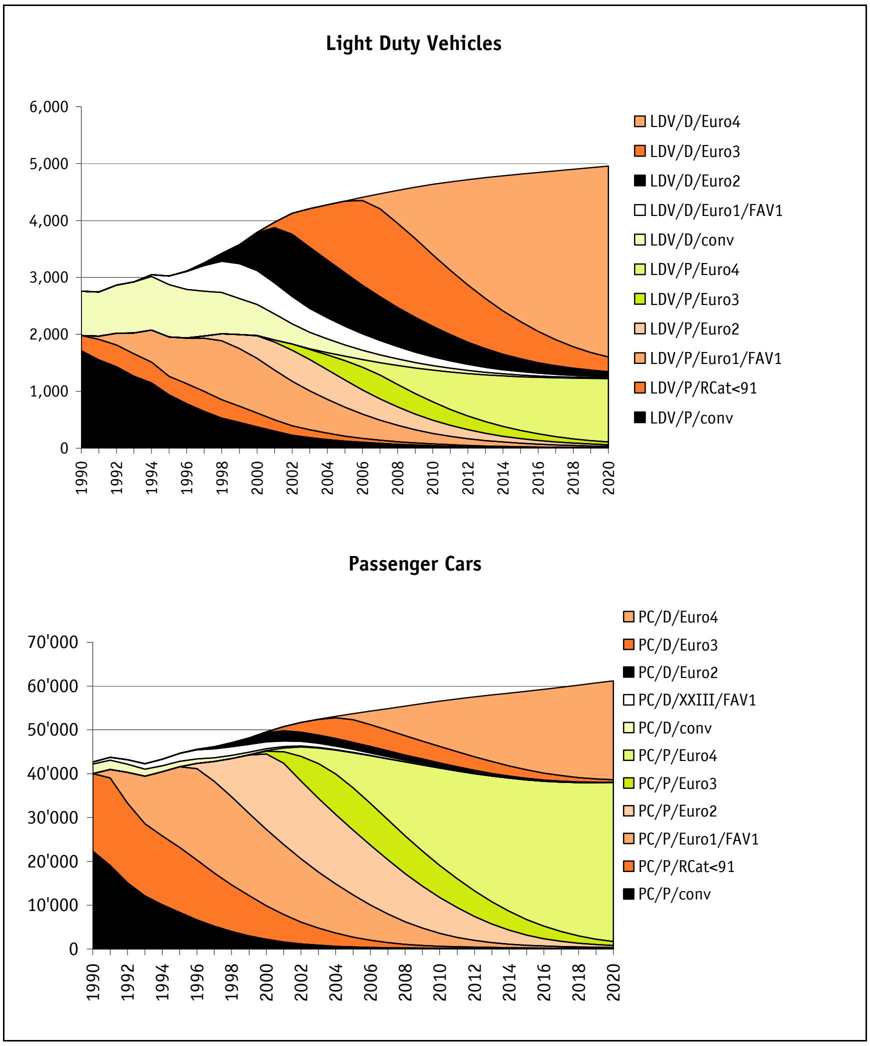

Figure 34 Fleet composition by emission concepts for PC and LDV (SAEFL 2004a).

A3.2.3 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.

A3.2.4 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 nor evaporative emissions are taken into account due to lack of data.

Annex 3.3: 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 144 Model structure and assumptions for calculating emissions from mobile air conditioning in cars

Annex 3.4: New LULUCF Reporting

A3.4.1 Method-Oriented Pilot Study

In the Draft decision -/CP.9 „Good practice guidance for land use, land-use change and forestry in the preparation of national greenhouse gas inventories under the Convention“, it was decided to use, for a trial period covering inventory submission due in 2005, the revised tables of the common reporting format for LULUCF as contained in annex I and III of the decision (FCCC/SBSTA/2003/L.22/add.1). In addition, the decision invites the Parties to submit the Secretariat, by 15 May 2005, their views on the tables and the experiences on their use.

Switzerland has started a pilot study with the aim to investigate the possibilities to fulfill the new LULUCF reporting requirements by using existing land cover data. The pilot study is method-oriented. A check of the proposed method within a test region will be done, too. First results of the check are available but there is not enough information to fill in the new tables at the moment. Therefore, for the latest submission (2005) the reporting is based on the previous LUCF CRF tables. It is planned to use the new tables for the preparation of the 2006 submission.

The information from the pilot study can be summarized as follows:

A3.4.2 Data Sources

Three data sources are available.

- The Swiss Area Statistics makes a sample in a 100x100m grid covering the whole area of Switzerland (4.1 million sampling points). In principle the land cover at the sampling point is interpreted, for surface categories (e.g. forest), an area of 25x25 m around the sampling point is interpreted. The survey is mainly based on aerial photographs. It was updated every 12 years in the past. In future, updates are planned every 6 years. The main advantage is the availability of a great number of land use categories which cover all LULUCF categories. A disadvantage is the relatively bad representation of linear elements (streets, small rivers) due to the sampling grid.
- The full information of the topographic maps (scale 1:25’000) is available in digitized form as vector data. The maps are based on an interpretation of aerial photographs. The updates are made every 6 years. The main advantage of this data source is the very high precision of the information and the full coverage of the area of Switzerland. A disadvantage is the reduced number of categories. Grassland and cropland are in the same category and cannot be distinguished.
- A further data source is the National Forest Inventory. Information about the forest carbon stock changes will be taken from this source. The sampling grid for the fieldwork is 1.4x1.4 km. Due to the course sampling grid this data base will not be used to calculate the forest area changes.

A3.4.3 Land-Use Change

The main task of the pilot study is to define the best combination of the above mentioned data sets in view of the good practice guidance LULUCF. Two possibilities are open: land-use change is taken from the Swiss Area Statistics as single data source or a combination of Area Statistics (area elements) and topographic map (linear elements) is chosen. The selection of the topographic maps as single data source is not possible due to the missing grassland-cropland differentiation. The decision has still to be taken.

A3.4.4 Carbon Stock Change

After defining the land-use changes, the resulting carbon stock changes have to be calculated. This will be the next step of the inquiry starting in spring 2005. For the forest area which is most important in this context, the National Forest Inventory is a good basis for doing these calculations. The calculation of carbon stock changes in non-forest areas will rely mainly on the GPG LULUCF.

A major problem in this context is the distinction of organic and mineral soils. A digitized soil map is available, but the usability of this map has still to be checked.

A3.4.5 Final Cconsideration

For the 2006 submission, Switzerland will be able to fill at least part of the new CRF files for LULUCF by using existing data sets. The reported yearly carbon stock changes will probably be a mean of a 6-year period. The quality of the carbon stock change data has still to be investigated. The quality of the land-use change data should be high.

Annex 3.5: Agriculture

Lifestock Population Data for N_2O Emission Calculation

Livestock population data 2003	Number of animals	kg N/head/year	$Frac_{GASM}$ (6)	N volatilized (kg N)
Cattle	**1'570'178**			
dairy cows (1)	703'432	105	0.327	24'265'049
rearing cattle 1st year	219'768	25	0.227	1'247'183
rearing cattle 2nd year	212'710	40	0.227	1'931'407
rearing cattle 3rd year	123'961	55	0.227	1'547'653
fattening cattle >1/2 hear	105'292	33	0.377	1'309'938
fattening cattle < 1/2 year	38'807	8	0.377	117'042
fattening calves	166'208	13	0.377	814'585
Pigs	**1'528'933**			
fattening pig places (2)	856'822	13	0.467	5'201'768
breeding pig places (3)	143'755	35	0.467	2'349'675
Sheep	**444'811**			
sheep places (4)	228'589	12	0.147	403'231
Goats	**67'412**			
goat places (5)	36'418	16	0.297	173'056
Horses	**52'672**			
foals < 1 year	3'339	17	0.327	18'562
foals 1 - 3 years	6'025	42	0.327	82'747
> 3 years	43'308	44	0.327	623'116
Ponies, Mules and Asses	**14'105**	26	0.327	119'921
Poultry	**7'452'934**			
laying hens	1'985'167	0.71	0.547	770'979
young hens < 18 weeks	808'995	0.34	0.547	150'457
broilers	4'518'416	0.40	0.487	880'187
turkeys	140'356	1.40	0.487	95'695
Total	**11'131'045**			**42'102'252**

(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 145

Additional Data for N_2O Emission Calculation of Agricultural Soils (4D)

	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	2'713	364'055'000	53			
Barley	1'053	185'215'000	21			
Maize	646	77'095'000	13			
Oats	137	18'275'000	3			
Rye	73	8'925'000	1			
Other (please specify)						
Spelt	52	5'780'000	13			
Triticale	679	57'715'000	1			
Mix of fodder cereals	8	1'445'000	0			
Mix of bread cereals	11	1'530'000	0			
2. Pulse						
Dry bean	38	951'150	1	0.0443	49'516	1.0
Eiweisserbsen/peas	350	14'890'300	7	0.0330	578'094	11.4
Soybeans	246	5'938'100	5	0.0571	399'040	7.8
Other (please specify)						
Leguminous vegetables	297	2'894'211	6	0.0177	284'968	5.6
3. Tuber and Root						
Potatoes	438	100'760'000	9			
Other (please specify)						
Fodder beet	210	22'500'000	4			
Sugar beet	2'611	276'584'000	51			
5. Other (please specify)						
Grass	22'321	6'244'930'493	438	0.0050	31'484'952	618.5
Silage corn	225	997'590'000	4			
Green corn	25	169'590'300	0			
Fruit	223	55'724'640	4			
Vine	152	25'403'400	3			
Renewable energy crops	79	5'103'000	2			
Non-leguminous vegetables	955	61'100'000	19			
Sunflowers	322	15'220'950	6			
Tobacco	36	1'400'000	1			
Rape	680	43'714'800	13			
Total Non-leguminous	33'650	8'739'656'583	661	0.0050	31'484'952	618.5
Total Leguminous	931	24'673'761	18	0.1521	1'311'618	25.8
Total	34'581	8'764'330'343	679	0.1571	32'796'571	644.2

Table 146

Annex 4: Inventory Development Plan

Final Version 17 February 2005 (revised 21 Feb 2005)

From 13 to 17 September 2004 an international expert team reviewed the Swiss Greenhouse Gas Inventory (2004 Submission). The results of this in-country review (ICR) are available in the UNFCCC report FCCC/WEB/IRI/2004/CHE[30] of 15 December 2004. The review proposes "the development of a plan for implementing all the improvements identified as needed, setting annual priorities, time frames and resource allocation". The following detailed list of possible improvements is a response to this proposition (see paragraph 35a of in-country report).

Explanation of column "Time schedule":

Sub. 05 means: Improvement realized and documented in submission of 15 April 2005

Sub. 05/06 means: First assessments (drafts) included in submission 15 April 2005, final improvement realized in submission of 15 April 2006

Sub. 06 means: Improvement realized until submission of 15 April 2006

Explanation of column "Responsibility":

If more than one institution is mentioned, the first one has the lead.

Explanation of column "Status":

N: Work not yet started

P: Work in progress

R: Work realized

[30] See http://unfccc.int/national_reports/annex_i_ghg_inventories/inventory_review_reports/items/2767.php

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

BAZL	Federal Office for Civil Aviation
BFE	Swiss Federal Office of Energy
BLW-FAL	Swiss Federal Office for Agriculture – Swiss Federal Research Station for Agroecology and Agriculture
BUWAL	Swiss Agency for the Environment, Forests and Landscape, SAEFL
Carbotech	Private Consultants (Experts synthetic gases)
EBP	Ernst Basler + Partner AG, private consultants (NIR co-authors)
Infras	Infras Forschung und Beratung, private consultants (NIR co-authors)

Persons (from SAEFL)

FP	Filliger Paul
LA	Liechti Andreas
MBU	Müller Beat
NM	Nauser Markus
QR	Quartier Robin

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	Sub. 05/06	BUWAL (NM)	Medium to high	P
2	Redesign of EMIS database including a checking and updating of activity data and emission factors	33, 106	High	2005	BUWAL (MBU)	Very high	P
3	Exclusion of the fossil fuel emissions of Liechtenstein from Swiss GHG inventory for all inventory years	5, 35g	Medium	Sub. 06	BUWAL (FP) / Infras / EBP	Low to me-dium, de-pends on LIE-Inven-tory	N
4	Consistent use of notation keys and extended use of documentation boxes	19, 35c	Medium	Sub. 05/06	BUWAL (LA)	Medium	P
5	Background documentation in English	107	Low	2006	BUWAL (FP)	Medium to high	N

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	Sub. 05/06	Infras / EBP for NIR, BUWAL (LA) for internal files	High	P
7	Data in CRF and NIR not identical, to be corrected in NIR	22	High	Sub. 05	Infras / EBP	Low	R
8	Documentation and verification of the decisions to use country-specific approaches	7	Medium	Sub. 06	Infras / EBP	Medium	P

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	High	Sub. 05	EBP	Medium	R
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. 05, QA/QC driven recalculations from 06 onwards	Decision about recalc. BUWAL (FP, LA), description Infras/EBP	Medium	P

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	High	First draft for Sub. 05, improved analyses for Sub. 06	EBP, Infras, BUWAL (LA, FP) +all data suppliers	Very high	P
12	Development of a formal Quality assurance/quality control plan	9c, 9d, 22, 27, 28, 35f, 48, 116, 142, 156, 167	High	First draft for Sub. 05, final version Sub. 06	Infras, EBP, BUWAL (FP) + all data suppliers	Very high	P
13	Plan for the verification of AD provided by outside agencies	48	Low	2006	BUWAL (FP)	Medium	N

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	2005/06	BUWAL (NM)	Medium to high	P
15	Institutional arrangements and responsibility in LULUCF sector to be defined	137, 158	High	Mid 05	BUWAL (NM, FP)	Medium	P
16	Improving flow of information for CRF and NIR in LUCF sector	158	Medium	2005/06	BUWAL (NM)	Low	P
17	Improving archiving system for documentation (centralized database)	9d, 31, 35b	Medium	Mid 06	BUWAL (FP)	Medium to high	N
18	Improving archiving system for data sets	9d, 31	Low	End 05	BUWAL (MBU)	Low	P

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	High	Sub. 05/06	BUWAL (LA) for data, EBP for documentation, BFE for energy statistics	High	P
20	Industry-data of 1.A.2f Other to be disaggregated into the IPCC categories	60, 71					P
21	More details for emissions from waste fuels in cement industry (AD and EF)	63	High	Sub. 05	BUWAL (QR) for data, EBP for NIR	Medium	P
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	High	Sub. 06	EBP / Infras / BUWAL (LA)	Medium to High	P
23	Revision of oxidation factor (in particular coal), inclusion in uncertainty estimate	73	High	Sub. 06	EBP / BUWAL (LA)	Low	P
24	Emissions arising from electricity generation by waste combustion to be moved from Waste to Energy sector	74, 160	High	Sub. 05	BUWAL (LA) / EBP	Low	R
25	Clear distinction between annually collected and interpolated data	41	Medium to high	Sub. 05/06	EBP / Infras	Medium	P

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
26	Description of interpolation/extrapolation methods	41	Medium to high	Sub. 05/06	EBP/Infras	Medium	P
27	Inclusion of new Off-Road data, better description of off-road data	44, 55, 59, 66, 71	Medium to high	Sub. 06	BUWAL (LA), Infras	Medium	N
28	More precise description of methodologies that differ from IPCC	35e	Medium	Sub. 05/06	Infras / EBP	Medium	P
29	Better Documentation of weighted fuel averages in sector 1.A.1 as well as in general	42, 65	Medium	Sub. 05	EBP / Infras from BUWAL-Input (LA)	Low	R
30	Further details on military and civil aviation (separate reporting)	58	Medium	Sub. 05	BUWAL (LA) / Infras	Low	R
31	New modelling of aviation emis-sions (division national vs. international)	71	Medium	Sub. 06	BUWAL (LA) / BAZL	Medium	N
32	Better documentation for civil aviation	44, 51, 52	Medium	Sub. 05, Sub. 06 (new database)	Infras / BUWAL (LA) / BAZL	Medium	P
33	Further details on estimation of 1990, 91 emissions of cement industry	63	Medium	Sub. 05/06	EBP / BUWAL (LA, QR)	Low	P
34	Table of EFs used in the calculations for cement industry	63	Medium	Sub. 05	EBP	Low	R
35	Inconsistent IEF (1994 CRF) for biomass from commercial/institutional	45	Medium	Sub. 05	BUWAL (LA)	Low	R
36	CO2 emissions from oil refinery fugitives to	39	Low	Sub. 06	BUWAL	Low	N

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
	be included				(LA)		
37	International marine bunker to be included	39, 50	Low	Sub. 06	BUWAL (LA, FP)	Medium	N
38	Inconsistencies of trend shown for iron and steel combustion and process emission	48, 61	Low	Sub. 05/06	BUWAL (LA)	Medium to high	P
39	Improved AD for grass drying (held constant since 1990)	55	Low	Sub. 06	BUWAL (LA)	Low to medium	N
40	Discrepancy with IEA aviation data	58	Low	Sub. 06	BUWAL (FP) / BAZL	Medium	N
41	Different EF for industrial boilers and engines	62, 71	Low	Sub. 06	BUWAL (LA)	Low	N
42	CH4 and N2O emissions from fuel consumption of cement industry to be included	63, 71	Low	Sub. 05/06	BUWAL (LA)	Low	P
43	Details on AD of lime and glass production in NIR	64	Low	Sub. 06	EBP	Low	P
44	Estimation of CO2 emissions from distribution of oil products missing	67	Low	Sub. 06	BUWAL (LA)	Low	N
45	New estimation of emissions from CH4 leaks in gas pipelines (incl. transfer pipeline crossing Switzerland)	68	Low	Sub. 05/06	BUWAL (FP)	Medium	N
46	EF for flaring of oil is outlier and should be checked	69	Low	Sub. 06	BUWAL (LA)	Low	N

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	High	Sub. 05	Carbotech / BUWAL (LA) / Infras	Medium	R
48	Review of emission factor for CO2 from clinker. Measurements of CaO content of clinker and possible non-carbonate feeds to kiln	88	High	Sub. 06	BUWAL (FP) / EBP	Medium	P
49	PFC EF not consistent between CRF and NIR, better description in NIR	98	High	Sub. 05	Infras / Carbotech	Low	R
50	SF6 from magnesium foundries: NIR incorrect for start time (1997), use of notation key “C” in CRF	102	High	Sub. 05	Infras (NIR)/ BUWAL (LA) (CRF)	Low	R
51	CO2 from solvent emission missing (oxidation in atmosphere), to be checked	Not covered in ICR report	High	Sub. 06	BUWAL (FP)	Low	N
52	Consistency of time series of SF6 for 1990-94 to be checked, better documentation of recalculation of 1990 SF6 data	82	Medium	Sub. 06	Carbotech / Infras	Medium	N
53	Difference between CRF and UN statistics for cement production to be explained	90	Medium	Sub. 05/06	BUWAL (FP)	Medium to high	N
54	Move emissions from ferroalloys production to non-ferrous metals	101	Medium	Sub. 05	BUWAL (LA)	Low	R
55	C3F8 ratio of potential to actual emissions	104	Medium	Sub. 05	Carbotech	Low	R

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
	should be checked						
56	SF6 in sub-source 2.F.5. Solvents not covered by IPCC GPG	94	Low	Sub. 05	Carbotech / Infras	Low	R
57	CO2 EF for Iron and Steel and Aluminium Production to be documented	95	Low	Sub. 06	EBP	Low	P
58	Revision of country-specific PFC emission factor	98	Low	Sub. 06	Carbotech	Medium to high	N
59	Review of EF and AD of lime production	99, 100	Low	Sub. 06	BUWAL (MBU-EMIS)	Low	N

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	High	Sub. 05/06	Infras	Medium to high	P
61	Consideration of subcategories of dairy and non-dairy cattle	117	High	Sub. 05/06	BLW-FAL	Medium to high	P
62	Units of EFs of crop residues and N-fixing crops to be checked	120	High	Sub. 05	BLW-FAL	Low	R
63	Information currently given in Table 4.F to be included in a table in NIR	126	High	Sub. 05	Infras / BLW-FAL	Medium	R
64	Explanation of „animal places“, discussion of use in tables 4.A and 4.B	129	High	Sub. 05	BLW-FAL / Infras	Low	R
65	Not enough information in NIR about country-specific methods and EFs	111, 112	Medium	Sub. 05/06	Infras	Medium	P
66	Time series inconsistency in N2O from cattle	Not covered in ICR report	Medium	Sub. 05	BUWAL (FP) / BLW-FAL	Low	R
67	ERT questions low uncertainty for enteric fermentation	115, 25	Medium	Sub. 05/06	BLW-FAL, EBP	Low	P
68	More detailed description of country-specific method for calculating gross energy intake	118	Medium	Sub. 05/06	Infras	Medium	P
69	Emissions from sewage sludge and compost used for fertilizing to be reported in table 4.D. Other (AD in NIR)	119	Medium	Sub. 05/06	BLW-FAL (CRF) / Infras (NIR)	Low	P

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
70	Explanation of choice of $Frac_{Leach}$ of 0.2 instead of 0.3 (IPCC)	122	Medium	Sub. 05	BLW-FAL / Infras	Low	R
71	Documentation of N-input values as AD for indirect emissions of N2O from leaching and run-off	123	Medium	Sub. 05/06	Infras / BLW-FAL	Medium	P
72	Documentation of NH3 input values for calculation of indirect N2O emissions from deposition, more details on losses of NH3 from pasture	124	Medium	Sub. 05/06	Infras / BLW-FAL	Medium	P
73	Create table for N amount that ends up in N2O in NIR	125	Medium	Sub. 05/06	Infras	Medium	P
74	Check table of fractions used for N2O from soils (not filled in properly)	126	Medium	Sub. 05	BLW-FAL	Low	R
75	More information about CS values for volatile solids in manure (CH4)	127	Medium	Sub. 05/06	Infras	Low	P
76	Are all manure management systems covered? NIR should mention on what basis the distribution between the management systems has been made	128	Medium	Sub. 05	BLW-FAL / Infras	Medium	R
77	Description of the method used for CH4 conversion rate of poultry missing	118	Low	Sub. 05/06	Infras	Low	P
78	N2O from burning of agricultural residues missing	111	Low	Sub. 06	BUWAL (LA)	Low	P
79	Notation key NO in 4.C and 4.E	131	Low	Sub. 05	BLW-FAL	Low	R
80	Tables 4.C, 4.E to be completed	19	Low	Sub. 05/06	BLW-FAL	Low	P

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	High	Sub. 05/06	BUWAL (RV) / Infras	Medium	P
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	BUWAL (FP, RV)	High	P
83	CO2 emissions from liming to be estimated	138, 149	Medium	Sub. 05	BLW-FAL	Low	R
84	More detailed information in NIR on how annual changes in forest area from annual forest statistics are combined with NFI data	138	Medium	Sub. 05	Infras / BUWAL (RV)	Low	R
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. 05/06	Infras / BUWAL (RV) / BLW-FAL	Medium	P
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	144, 146, 19	Medium	Sub. 06	BUWAL (RV)	High	P

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
	Managed Land)						
87	Problems of different forest definitions by AD (from NFI, Area statistics, digital maps)	145	Medium to high	Sub. 06	BUWAL (RV)	Low to medium	P
88	Information in table 5.D missing	151	Medium	Sub. 06	BLW-FAL / BUWAL (RV)	Medium	P
89	Estimation of above-ground and below-ground carbon budgets	152	Medium	Sub. 06	BUWAL (RV)	High	N
90	Notation keys and AD for cultivated organic soils to be checked	143	Low	Sub. 05	BLW-FAL / BUWAL (LA)	Low	R
91	Incorporate non-forest trees	148	Low	Sub. 06	BUWAL (FP, RV)	Medium	P

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: - CH_4 from composting - N_2O and CH_4 from on-site waste water treatment for commercial sources and industrial waste water	162, 170	High	Sub. 06	BUWAL (LA, QR)	Medium to high	P
93	Check use of notation keys and give values of methane correction factor and degradable organic carbon in 6.A and 6.C	163	High	Sub. 05	BUWAL (LA, QR)	Low	R
94	Check fractions of waste in additional info to table 6.A	163	High	Sub. 05	BUWAL (LA, QR)	Low	R
95	Inconsistency CRF – NIR (IEF in CRF not given, but EF given in NIR, e.g. 6.A)	163	High	Sub. 05	EBP / BUWAL (LA)	Low to medium	R
96	Not enough information about existing model on CH_4 from solid waste disposal. Country specific model not in line with IPCC (redesign of model)	164, 168	High	Sub. 05	EBP / BUWAL (QR)	High	R
97	More information on activity data in NIR	164	High	Sub. 05	EBP	Medium	R
98	Documentation of recalculations	165	High	Sub. 05	EBP / BUWAL (LA, QR)	Medium	R
99	Improvement of waste database	162	Medium	Sub. 05/06	BUWAL	Medium	P

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
					(Abfall)		
100	N2O from human sewage missing, more information on human sewage in general	163, 175	Medium	Sub. 06	BUWAL (QR) / EBP	Medium	N
101	Better documentation in NIR on CH4 recovered for energy generation	169	Medium	Sub. 05	EBP / BUWAL (LA, QR)	Low	R
102	More information on recycling activities to be provided in the NIR and reflected in CRF table 6.A (other waste)	170	Medium	Sub. 05	EBP / BUWAL (QR, LA)	Medium	R
103	Information on specific EFs on each type of waste incinerated and explanation of selection of 60 % for organic fraction	172	Medium	Sub. 05/06	EBP / BUWAL (QR)	Medium	P
104	Improve transparency for each type of incinerated waste	172	Medium	Sub. 05/06	EBP	Medium	P
105	Emissions from industrial waste-water treatment plants and industrial disposal facilities not covered, to be included	173	Medium	Sub. 06	BUWAL (QR)	Medium	N
106	Improve method for estimating municipal waste water treatment	174	Low to medium	Sub. 06	BUWAL (QR)	Medium to high	N
107	Various burn-out efficiencies for different kinds of waste not taken into account, to be checked	172	Low	Sub. 06	EBP / BUWAL (QR)	Medium	P
108	Better data on clinical and special waste	171	Low	Sub. 05	EBP	Low	R

Annex 5: Preliminary Sensitivity Analysis for Uncertainty Calculation

Source: NIR authors expert estimate for (hypothetical) maximum activity data and emission factor or combined uncertainties.

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	Gas	Base year emissions 1990	Year 2003 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
Sensitivity Analysis: Maximum Uncertainties have been assumed.		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	3'723.52	6'014.09	10.0	5.0	11.2	1.315	0.0449	0.1170	0.22	1.65	1.67
1A 1. Energy A. Fuel Combustion Liquid fuels	CO2	34'308.73	34'144.52	5.0	2.0	5.4	3.595	0.0002	0.6642	0.00	4.70	4.70
1A 1. Energy A. Fuel Combustion Solid fuels	CO2	1'585.13	577.51	20.0	10.0	22.4	0.253	-0.0194	0.0112	-0.19	0.32	0.37
1A 1. Energy A. Fuel Combustion Other fuels	CO2	575.21	905.01	20.0	50.0	53.9	0.953	0.0065	0.0176	0.32	0.50	0.59
Total CO2 Emissions Fuel Combustion	CO2	40'192.58	41'641.12									

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												
1A3b 1. Energy A. Fuel Combustion 3b. Road Transp. Gasoline	CH4	90.78	27.13	15.0	*58.1*	60.0	0.032	-0.0012	0.0005	-0.07	0.01	0.07
1A3b 1. Energy A. Fuel Combustion 3b. Road Transp. Gasoline	N2O	87.27	142.67	15.0	*399.7*	400.0	1.116	0.0011	0.0028	0.43	0.06	0.44
1B2 1. Energy B. Fugitive Emissions 2. Oil and Natural Gas	CH4	307.34	250.95		100.0	100.0	0.491	-0.0011	0.0049	-0.11	0.00	0.11
2A1 2. Industrial Proc. A. Mineral Products; Cement Production-CO2	CO2	2'524.44	1'617.69	10.0	15.0	18.0	0.570	-0.0174	0.0315	-0.26	0.45	0.52
2C3 2. Industrial Proc. C. Metal Production; Aluminium Production-PFC	PFC	100.17	11.89	5.0	30.0	30.4	0.007	-0.0017	0.0002	-0.05	0.00	0.05
2C3 2. Industrial Proc. C. Metal Production; Aluminium Production-CO2	CO2	139.26	70.24	10.0	40.0	41.2	0.057	-0.0013	0.0014	-0.05	0.02	0.06
2F_o 2. Industrial Proc. F. Consumption of Halocarbons and SF6 without 2F1-HFC	HFC	0.00	58.44	5.0	15.0	15.8	0.018	0.0011	0.0011	0.02	0.01	0.02
2F_o 2. Industrial Proc. F. Consumption of Halocarbons and SF6 without 2F7-SF6	SF6	114.45	56.84	5.0	15.0	15.8	0.018	-0.0011	0.0011	-0.02	0.01	0.02
2F 2. Industrial Proc. F. Consumption of Halocarbons and SF6	PFC	0.04	54.15	5.0	15.0	15.8	0.017	0.0011	0.0011	0.02	0.01	0.02
2F1 2. Industrial Proc. F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	HFC	0.02	470.83	5.0	15.0	15.8	0.146	0.0092	0.0092	0.14	0.06	0.15
4A 4. Agriculture A. Enteric Fermentation	CH4	2'766.81	2'492.07	10.0	*22.9*	25.0	1.218	-0.0051	0.0485	-0.12	0.69	0.70
4B 4. Agriculture B. Manure Management	CH4	452.34	399.86	10.0	*69.3*	70.0	0.547	-0.0010	0.0078	-0.07	0.11	0.13
4B 4. Agriculture B. Manure Management	N2O	448.20	396.68	10.0	*139.6*	140.0	1.086	-0.0010	0.0077	-0.13	0.11	0.17
4D1 4. Agriculture D. Agricultural Soils; Direct Soil Emissions	N2O	1'389.82	1'207.74	20.0	*158.7*	160.0	3.779	-0.0034	0.0235	-0.54	0.66	0.86
4D3 4. Agriculture D. Agricultural Soils; Indirect Emissions	N2O	818.89	682.60	50.0	*193.6*	200.0	2.669	-0.0026	0.0133	-0.50	0.94	1.06
6A 6. Waste A. Solid Waste Disposal on Land	CH4	707.42	371.84	20.0	*45.8*	50.0	0.364	-0.0065	0.0072	-0.30	0.20	0.36
6A 6. Waste A. Solid Waste Disposal on Land (Open Burning)	CO2	154.88	1.50	200.0	100.0	223.6	0.007	-0.0030	0.0000	-0.30	0.01	0.30
6C 6. Waste C. Waste Incineration	CO2	1'108.82	1'186.26	10.0	50.0	51.0	1.183	0.0016	0.0231	0.08	0.33	0.34
Total non-CO2 emissions from Fuel Combustion and other Key Sources		11'210.96	9'499.37									

A	B	C	D				H					M
		Gg CO2 equivalent	Gg CO2 equivalent									
3. Total (combined uncertainty of 1. and 2.)												
Total Emissions Uncertainty Analysis	all gases	51'403.55	51'140.50									
Total Uncertainties						Overall uncertainty in the year (%)	**6.59**				Trend uncertainty (%)	**5.34**

Table 147 Sensitivity Analysis of Uncertainty Calculation for sources in Switzerland (maximum uncertainties). Table of actual uncertainties is provided in Section 1.7.