# Switzerland's Greenhouse Gas Inventory 1990–2002

## National Inventory Report 2004

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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## National Inventory Report 2004


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# Table of Contents

# Executive Summary

## *Inventory Preparation in Switzerland*

On December 10, 1993, Switzerland ratified the United Nations Framework Convention on Climate Change (UNFCCC). Since the 1996 submission, its national greenhouse gas inventory has been reported based on IPCC guidelines. From 1998 on, the inventories were submitted in the Common Reporting Format. The present report is Switzerland's first National Inventory Report established under the UNFCCC. It includes, as a separate document, Switzerland's 2002 Inventory in the Common Reporting Format.

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 2005.

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.

**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, 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 1997), IPCC Good Practice Guidance (IPCC 2000) and by country-specific methods. 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 at SAEFL. The task force is responsible for ensuring the conformity of the inventory with UNFCCC guidelines. For the preparation of this report, the task force was supported by consultants. Their mandate included analysis of the correspondence between the emission modelling and the recommendations of the IPCC Good Practice Guidance. A complete inventory quality assurance and control system is being prepared in the context of the national inventory system and will be 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 in the Executive Summary.

**Chapters 3 to 8** provide principal source and sink category estimates. As this is Switzerland's first National Inventory Report, the report provides detailed descriptions of the methodologies used as well as the results. 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 2003.

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

In 2002, Switzerland released about 52’254 Gg (kilotonnes) $CO_2$ equivalent, or 7.2 tonnes $CO_2$ equivalent per capita ($CO_2$ only: 6.1 tonnes per capita), to the atmosphere not including $CO_2$ from Land-Use Change and Forestry (LUCF).

For 2002, nineteen 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 49% of total GHG emissions resulted from the two most important key sources: $CO_2$ from Fuel Combustion – Other Sectors (source category 1A4 including commercial, institutional and residential sources) and Fuel Combustion - Transport (source category 1A3). Besides Energy (sector 1), other key sources are found in Agriculture (sector 4), Waste (sector 6) and Industrial Processes (sector 2).

Table 1 shows Switzerland's annual GHG emissions by individual GHG from 1990 (base year) to 2002. Total annual GHG emissions show no significant trends. Fluctuations in total GHG emissions over the period 1990-2002 are less than 5%. In 2002, total GHG emissions showed a decrease of 1.7% 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | |
| Net $CO_2$ emissions/removals | 43'012 | 44'672 | 44'406 | 40'952 | 40'231 | 41'026 | 41'492 | 40'517 | 41'886 | 42'341 | 43'808 | 45'182 | 44'027 |
| Gross $CO_2$ emissions (without LUCF) | 44'305 | 46'031 | 45'849 | 43'360 | 42'643 | 43'401 | 44'019 | 43'211 | 44'508 | 44'617 | 43'678 | 44'752 | 43'741 |
| $CH_4$ | 4'988 | 4'974 | 4'843 | 4'826 | 4'682 | 4'696 | 4'638 | 4'484 | 4'449 | 4'433 | 4'369 | 4'361 | 4'258 |
| $N_2O$ | 3'565 | 3'635 | 3'682 | 3'655 | 3'653 | 3'633 | 3'682 | 3'622 | 3'642 | 3'649 | 3'668 | 3'567 | 3'561 |
| HFCs | 0.02 | 0.4 | 2.9 | 61 | 80 | 115 | 166 | 206 | 276 | 334 | 376 | 435 | 473 |
| PFCs | 100 | 85 | 69 | 30 | 18 | 15 | 17 | 24 | 28 | 31 | 68 | 30 | 36 |
| $SF_6$ | 178 | 180 | 182 | 148 | 125 | 103 | 97 | 168 | 155 | 143 | 186 | 213 | 185 |
| Total (with net $CO_2$ emissions/removals) | 51'844 | 53'546 | 53'185 | 49'671 | 48'789 | 49'588 | 50'093 | 49'022 | 50'436 | 50'931 | 52'475 | 53'788 | 52'539 |
| **Total (without $CO_2$ from LUCF)** | **53'137** | **54'905** | **54'629** | **52'079** | **51'201** | **51'963** | **52'620** | **51'715** | **53'058** | **53'207** | **52'345** | **53'358** | **52'254** |

Table 1 Summary of Switzerland’s GHG emissions in $CO_2$ equivalent (Gg), 1990–2002 (CRF Table 10s5).

As to the distribution of emissions by individual greenhouse gas, $CO_2$ is the largest single contributor to emissions, at about 83% of total GHG emissions in the period from 1990 to 2002. The contribution of $CH_4$ decreased from 9.5% (1990) to 8.3% (2002), while the share of $N_2O$ was almost constant at 7%. The contribution of synthetic gases increased from 0.4% (1990) to 1.5% (2002).

| Greenhouse Gas Emissions | 1990 | | 1995 | | 2000 | | 2002 | |
|---|---|---|---|---|---|---|---|---|
| | Gg | % | Gg | % | Gg | % | Gg | % |
| Gross $CO_2$ emissions (without LUCF) | 44'305 | 83.4% | 43'401 | 83.5% | 43'678 | 83.4% | 43'741 | 83.7% |
| $CH_4$ | 4'988 | 9.4% | 4'696 | 9.0% | 4'369 | 8.3% | 4'258 | 8.1% |
| $N_2O$ | 3'565 | 6.7% | 3'633 | 7.0% | 3'668 | 7.0% | 3'561 | 6.8% |
| HFCs | 0 | 0.0% | 115 | 0.2% | 376 | 0.7% | 473 | 0.9% |
| PFCs | 100 | 0.2% | 15 | 0.0% | 68 | 0.1% | 36 | 0.1% |
| $SF_6$ | 178 | 0.3% | 103 | 0.2% | 186 | 0.4% | 185 | 0.4% |
| **Total (without $CO_2$ from LUCF)** | **53'137** | **100.0%** | **51'963** | **100.0%** | **52'345** | **100.0%** | **52'254** | **100.0%** |

Table 2 Switzerland's GHG emissions by gas in $CO_2$ equivalent (Gg), selected years.

Figure 1 shows the share of 2002 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 1990–2002 as well.

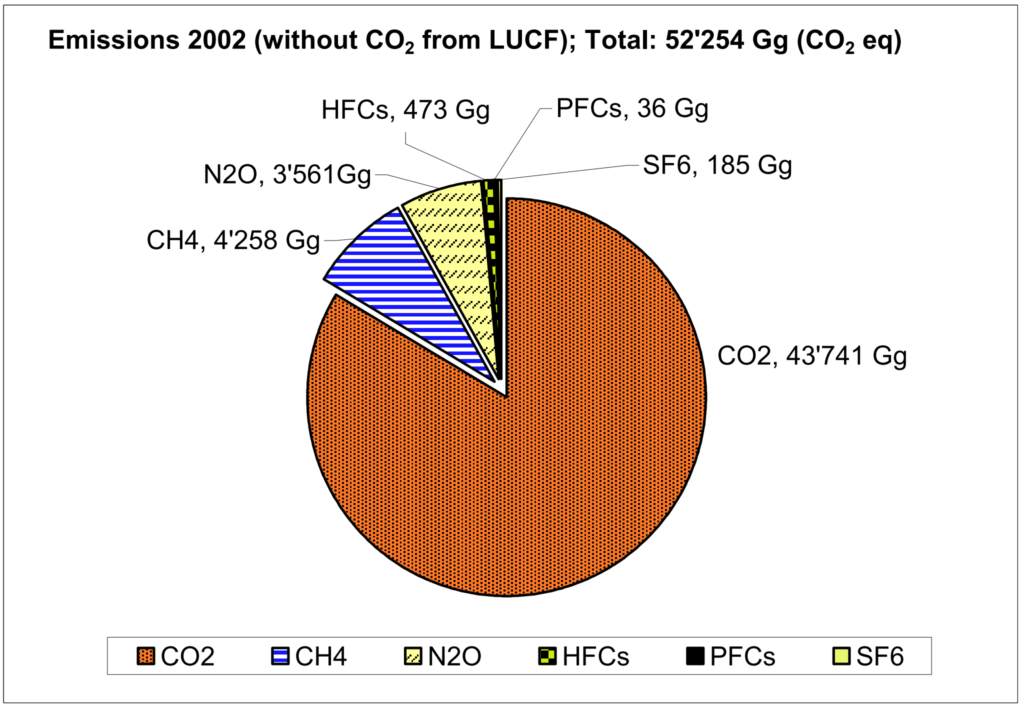


Figure 1 Contribution to Switzerland's GHG emissions by gas (without $CO_2$ from LUCF), 2002.

## *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 nearly 80% of emissions. No significant trend is found for the Energy sector for the period 1990–2002. The emissions from Industrial Processes (sector 2) and Agriculture (sector 4) decreased during the period, while the emissions from Waste (sector 6) increased.

| Greenhouse Gas Source and Sink Categories | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | |
| 1 Energy | 40'571 | 42'764 | 42'797 | 40'544 | 39'717 | 40'552 | 41'346 | 40'698 | 41'906 | 41'962 | 40'758 | 41'630 | 40'545 |
| 2 Industrial Processes | 3'228 | 2'872 | 2'704 | 2'422 | 2'563 | 2'440 | 2'304 | 2'243 | 2'314 | 2'364 | 2'606 | 2'688 | 2'646 |
| 3 Solvent and Other Product Use | 108 | 110 | 112 | 114 | 117 | 119 | 119 | 120 | 120 | 121 | 121 | 121 | 123 |
| 4 Agriculture | 6'091 | 6'099 | 5'980 | 5'965 | 5'809 | 5'795 | 5'753 | 5'530 | 5'516 | 5'509 | 5'500 | 5'456 | 5'425 |
| 5 Land-Use Change and Forestry | -1'293 | -1'359 | -1'443 | -2'408 | -2'411 | -2'375 | -2'527 | -2'694 | -2'622 | -2'276 | 130 | 430 | 285 |
| 6 Waste | 3'140 | 3'060 | 3'035 | 3'033 | 2'995 | 3'058 | 3'097 | 3'125 | 3'203 | 3'250 | 3'360 | 3'463 | 3'515 |
| Total (with net $CO_2$ emissions/removals) | 51'844 | 53'546 | 53'185 | 49'671 | 48'789 | 49'588 | 50'093 | 49'022 | 50'436 | 50'931 | 52'475 | 53'788 | 52'539 |
| **Total (without $CO_2$ from LUCF)** | **53'137** | **54'905** | **54'629** | **52'079** | **51'201** | **51'963** | **52'620** | **51'715** | **53'058** | **53'207** | **52'345** | **53'358** | **52'254** |

Table 3 Summary of Switzerland's GHG emissions by source and sink categories in $CO_2$ equivalent (Gg), 2002.

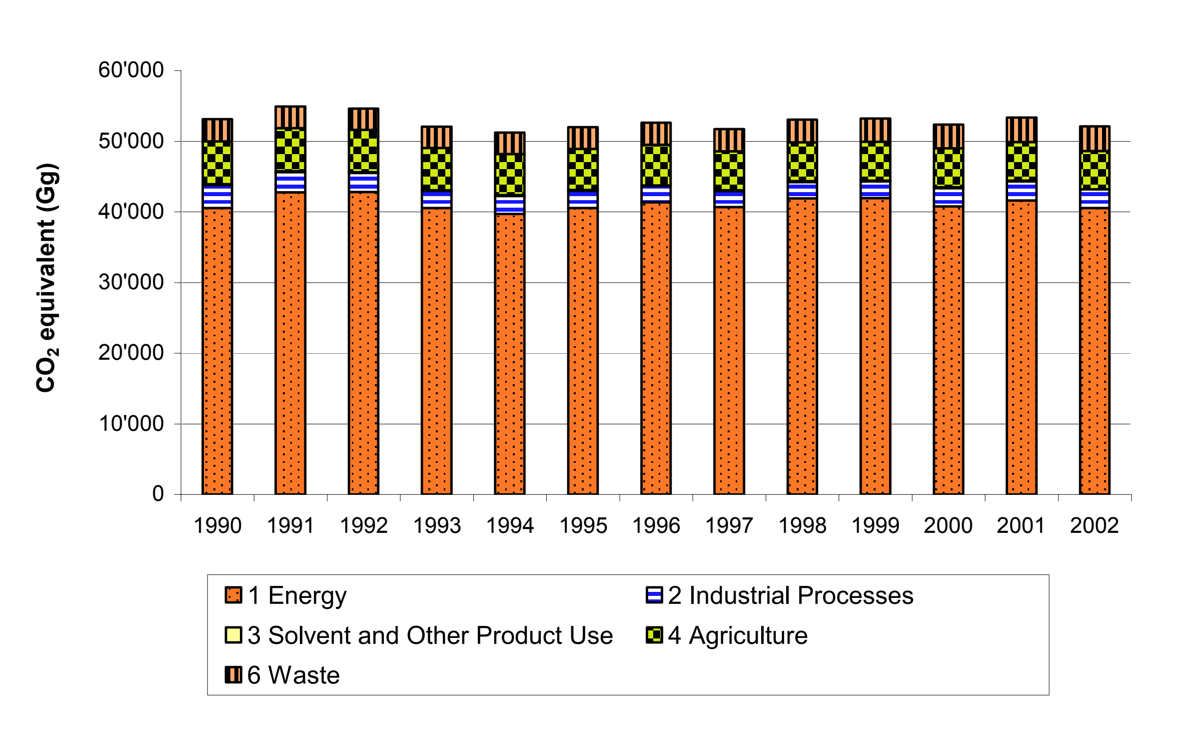


Figure 2 Switzerland’s greenhouse gas emissions by main source categories in $CO_2$ equivalent (Gg), 1990–2002 (without $CO_2$ from LUCF).

Removals from LUCF decreased twice in the period 1990–2002 due to two severe storms in early 1990 (storm 'Vivian') and in late 1999 (storm 'Lothar') that caused large losses of forest trees (see Table 3). The reduced $CO_2$ uptake over several years is due to 3-year averaging of the storm effects.

Table 4 shows sector contributions to total emissions for selected years. Between 1990 and 2002, the contribution of source category 1 Energy and 6 Waste increased by 1.3% and 0.8%, respectively, whereas 2 Industrial Processes and 4 Agriculture decreased by 1.0% and 1.1%, respectively.

| **Source and Sink Categories** | **1990** | | **1995** | | **2000** | | **2002** | |
|---|---|---|---|---|---|---|---|---|
| | Gg | % | Gg | % | Gg | % | Gg | % |
| 1 Energy | 40'571 | 76.4% | 40'552 | 78.0% | 40'758 | 77.9% | 40'545 | 77.6% |
| 2 Industrial Processes | 3'228 | 6.1% | 2'440 | 4.7% | 2'606 | 5.0% | 2'646 | 5.1% |
| 3 Solvent and Other Product Use | 108 | 0.2% | 119 | 0.2% | 121 | 0.2% | 123 | 0.2% |
| 4 Agriculture | 6'091 | 11.5% | 5'795 | 11.2% | 5'500 | 10.5% | 5'425 | 10.4% |
| 6 Waste | 3'140 | 5.9% | 3'058 | 5.9% | 3'360 | 6.4% | 3'515 | 6.7% |
| **Total (without $CO_2$ from LUCF)** | **53'137** | **100.0%** | **51'963** | **100.0%** | **52'345** | **100.0%** | **52'254** | **100.0%** |

Table 4 Switzerland's GHG emissions 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 the 1996 submission, its national greenhouse gas inventory has been reported based on IPCC guidelines. From 1998 on, the inventories were submitted in the Common Reporting Format. The present report is Switzerland's first National Inventory Report established under the UNFCCC. It includes, as a separate document, Switzerland's 2002 Inventory in the Common Reporting Format (SAEFL 2004).

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 2005.

## *1.2. Institutional Arrangements for Inventory Preparation*

The Swiss Agency for the Environment, Forests and Landscape (SAEFL) is in charge of compiling the emission data and bears overall responsibility for the Swiss greenhouse gas inventory. SAEFL has maintained a national emissions database for air pollutants since the early 1990s. This is part of the implementation of the national policy and the Federal Law on the Protection of the Environment (adopted in 1983). The emissions database is periodically updated. It forms the basis for preparation of the national GHG inventory.

In addition to the SAEFL, the following governmental institutions are directly involved in the process of compiling the greenhouse gas inventory:

- Swiss Federal Office of Energy (SFOE),
- Swiss Federal Office for Agriculture (FOAG) through its Swiss Federal Research Station for Agroecology and Agriculture (FAL),
- Federal Office for Civil Aviation (FOCA).

For building and maintaining the inventory, at present the institutional arrangements are well established on an informal basis. The definition of a formal National System is in preparation. Quality control measures have been implemented for the energy and industry sector, but quality control is not standardised for all sectors. A complete quality control system will be introduced stepwise up to full implementation in 2006.

## *1.3. Process for Inventory Preparation*

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 databases used to compile the internal inventory files are collected by several agencies (see Figure 3):

A large body of emission data stems 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”). 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, Volume I). 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 results from EMIS that are relevant for the GHG inventory are imported to the SAEFL internal GHG inventory files. Independently from EMIS, a number of data sources are relevant for compiling the GHG inventory files: These comprise the SFOE Swiss global energy statistics, SAEFL statistics and models for emissions from road transportation and 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.

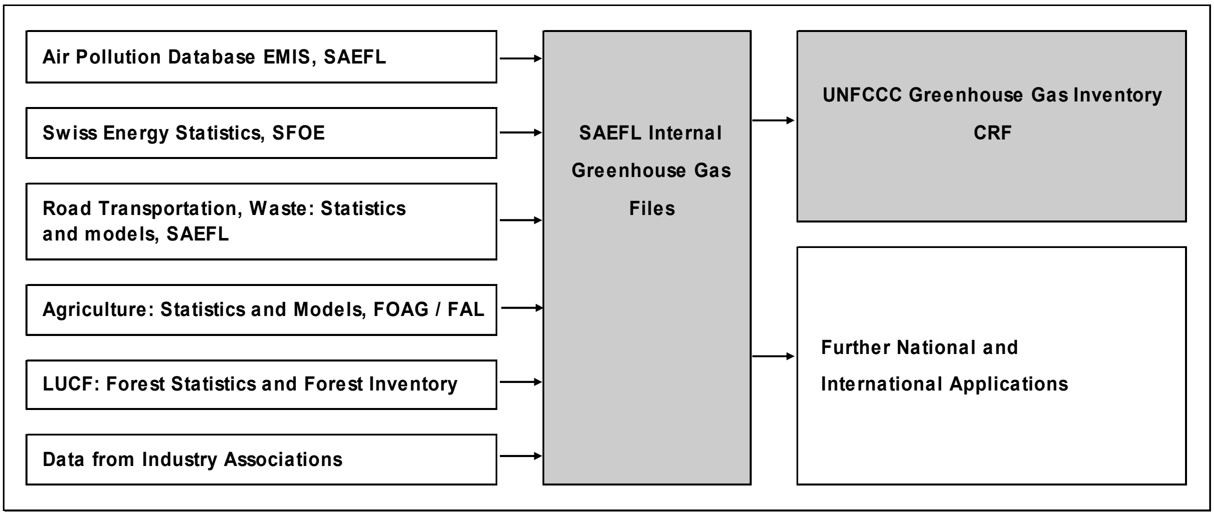


Figure 3 Data sources and greenhouse gas inventories.

The 1995 EMIS database (EMIS1995) 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 allow automated completion of the GHG inventory in the CRF and it will help to fulfil various other reporting obligations of Switzerland regarding air pollutants.

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 continue to be included in Switzerland's Greenhouse Gas Inventory for the 2005 submission, but this will change in 2006, when all emissions of the Principality of Liechtenstein will be excluded for all inventory years.

# 1.4. *Methodologies*

## 1.4.1. General Description

The emissions in the SAEFL Internal Greenhouse Gas Files are calculated as products of emission factors and activity rates. For a number of source categories, the emissions are calculated in the data sources listed in Figure 3, e.g., in EMIS. In those cases, the resulting emission data are inserted directly into the SAEFL Internal Greenhouse Gas Files. In other cases, data from EMIS are recalculated and extrapolated in the SAEFL Internal Greenhouse Gas Files.

The emissions are calculated based on the standard methods and procedures according to the Intergovernmental Panel on Climate Change (IPCC) in its Revised 1996 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 3. For the different sectors, Tier 1, 2 and 3 methodologies according to IPCC Guidelines (IPCC 1997b) 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 (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 contents of the fuel. 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, 2A2 Lime production: CORINAIR, Tier 2 method.
  Emission factors: Country-specific; exception $N_2O$: IPCC default.
- 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 ($CH_4$), 6C Waste Incineration ($CO_2$): Country-specific Tier 2 method based on CORINAIR.
  Emission factors: Country-specific.

## 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 2003). 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 1.04 % in 2002 (see Chapter 3.6).

## 1.5. Key Source Categories

The key source analysis was 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%.

Nineteen sources have been identified as key sources.

| No. | Switzerland's Key Sources 2002 | | | | Fuel | Gas | Key Source | |
|---|---|---|---|---|---|---|---|---|
| | Source Category | | | | | | by Level | by Trend |
| 1 | 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Liquid fuels | $CO_2$ | yes | yes |
| 2 | 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Gasoline | $CO_2$ | yes | yes |
| 3 | 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Gaseous fuels | $CO_2$ | yes | yes |
| 4 | 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Diesel | $CO_2$ | yes | yes |
| 5 | 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Liquid fuels | $CO_2$ | yes | yes |
| 6 | 4A | 4. Agricult. | A. Enteric Fermentation | | | $CH_4$ | yes | yes |
| 7 | 6C | 6. Waste | C. Waste Incineration | | | $CO_2$ | yes | yes |
| 8 | 4D | 4. Agricult. | D. Agricultural Soils | | | $N_2O$ | yes | yes |
| 9 | 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Gaseous fuels | $CO_2$ | yes | yes |
| 10 | 2A | 2. Industr. P. | A. Mineral Products | | | $CO_2$ | yes | yes |
| 11 | 6A | 6. Waste | A. Solid Waste Disposal on Land | | | $CH_4$ | yes | yes |
| 12 | 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Liquid fuels | $CO_2$ | yes | yes |
| 13 | 1A5 | 1. Energy | A. Fuel Combustion | 5. Other | Liquid fuels | $CO_2$ | yes | no |
| 14 | 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Solid fuels | $CO_2$ | yes | yes |
| 15 | 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Gasoline | $N_2O$ | yes | yes |
| 16 | 2F | 2. Industr. P. | F. Consumption of Halocarbons and SF6 | | | HFCs | yes | yes |
| 17 | 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Gaseous fuels | $CO_2$ | no | yes |
| 18 | 2C | 2. Industr. P. | C. Metal Production | | | $CO_2$ | no | yes |
| 19 | 2C | 2. Industr. P. | C. Metal Production | | | PFCs | no | yes |

Table 5 List of Switzerland's Key Sources 2002.

The two major key sources are:

- 1A4 Energy, Fuel Combustion, Other Sectors (liquid fuels, $CO_2$)
- 1A3 Energy, Fuel Combustion, Transport (gasoline, $CO_2$)

These two major key sources account for 48.94% of total $CO_2$ equivalent emissions in the level assessment. 11 of the 19 key sources are in sector 1 Energy, producing 76.50% of total $CO_2$ equivalent emissions. The other key sources are in sectors 4 Agriculture (8.82%), 6 Waste (6.28%) and 2 Industrial Processes (4.43%). More results from the key source analysis are provided in Annex 1.

| No. | Source Category | 1990 CO$_2$ eq (Gg) | 2002 CO$_2$ eq (Gg) | Level Contrib. | Level Cumulat. | Trend Contrib. | Key Source by Level | Key Source by Trend |
|---|---|---|---|---|---|---|---|---|
| 1 | 1A4 | 16'411 | 13'788 | 26.39% | 26.39% | 22.16% | yes | yes |
| 2 | 1A3 | 11'562 | 11'782 | 22.55% | 48.94% | 3.89% | yes | yes |
| 3 | 1A4 | 2'141 | 3'624 | 6.94% | 55.87% | 14.33% | yes | yes |
| 4 | 1A3 | 2'625 | 3'413 | 6.53% | 62.40% | 7.85% | yes | yes |
| 5 | 1A2 | 2'294 | 2'787 | 5.33% | 67.74% | 5.01% | yes | yes |
| 6 | 4A | 2'767 | 2'453 | 4.69% | 72.43% | 2.53% | yes | yes |
| 7 | 6C | 1'691 | 2'285 | 4.37% | 76.81% | 5.87% | yes | yes |
| 8 | 4D | 2'418 | 2'158 | 4.13% | 80.93% | 2.07% | yes | yes |
| 9 | 1A2 | 1'348 | 1'720 | 3.29% | 84.23% | 3.72% | yes | yes |
| 10 | 2A | 2'568 | 1'689 | 3.23% | 87.46% | 7.89% | yes | yes |
| 11 | 6A | 1'248 | 998 | 1.91% | 89.37% | 2.16% | yes | yes |
| 12 | 1A1 | 691 | 743 | 1.42% | 90.79% | 0.60% | yes | yes |
| 13 | 1A5 | 709 | 653 | 1.25% | 92.04% | 0.42% | yes | no |
| 14 | 1A2 | 1'471 | 593 | 1.13% | 93.17% | 8.05% | yes | yes |
| 15 | 1A3 | 320 | 533 | 1.02% | 94.20% | 2.06% | yes | yes |
| 16 | 2F | 0.023 | 471 | 0.90% | 95.10% | 4.45% | yes | yes |
| 17 | 1A1 | 235 | 334 | 0.64% | 95.74% | 0.97% | no | yes |
| 18 | 2C | 260 | 143 | 0.27% | 96.01% | 1.06% | no | yes |
| 19 | 2C | 100 | 11 | 0.02% | 96.03% | 0.83% | no | yes |

Table 6 Details to Switzerland's Key Sources: Contributions in level and trend analysis ("Level Contrib.", "Trend Contrib.") and cumulated level contributions ("Level Cumulat."). For "No." see also Table 5.

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

### 1.6.1. Current Quality Control Procedures

Most of the QC activities as recommended by the IPCC Good Practice Guidance (IPCC 2000, table 8.1) have been applied during the 2002 inventory preparation process: Checks for correctness of the assumptions, input parameters and calculations and checks for integrity, consistency and completeness of the data were performed. Emissions from 1A3 Transport, synthetic gases from 2 Industrial Processes (2C Metal Production, 2E Production of Halocarbons and $SF_6$, 2F Consumption of Halocarbons and $SF_6$), 4 Agriculture and 5 LUCF were modelled by external specialists under the supervision and quality control of internal and external experts.

**Consistency of Information in CRF and NIR**

All inventory data are compiled and prepared for input in the CRF tables by a specialized SAEFL task force. The members of the task force are also members of the group in charge of the development of the National Inventory Report (NIR). They critically review the work carried out by consultants in establishing the NIR. Apparent inconsistencies of input data in the NIR and in the CRF are eliminated by means of an iterative process.

**Sources of Information**

The information on activity data (energy consumption) originates mainly from long-standing national statistics. These form a very reliable basis for the GHG inventory. Complementary information is provided by industry associations and industries. As per the provisions in the Swiss Federal Law on the Protection of the Environment and related ordinances, there is an obligation for private parties to provide information as required to enforce the law.

Emission factors have been gathered and updated for more than ten years by SAEFL based on measurements, technical literature, supplier documentation or international databases.

**Accuracy**

Using the Reference Approach, which is based on federal import statistics of oil products and precise knowledge of the carbon content of fuels, total $CO_2$ emissions from fuel consumption can be determined with a very high degree of certainty. The accuracy is confirmed by the fact that the Reference Approach and the National Approach are in very good agreement. Within SAEFL, a thorough crosscheck of Swiss CRF tables with the SAEFL Internal Greenhouse Gas Files (CRF-independent spreadsheets and calculations) is carried out for the emissions of 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.

**Treatment of Confidential Data**

SAEFL collects the data needed for calculating the emissions of HFCs, PFCs and $SF_6$ from private companies or branch associations. In the National Inventory Report the activity data underlying the emission of HFCs, PFCs and $SF_6$ are only partly presented on the most disaggregated level for reasons of confidentiality. However, emissions are reported in detail 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.

**Record Keeping and Archiving**

The annually reported CRF tables and all auxiliary tables are archived daily at SAEFL in electronic form on two servers at different locations. Back-up copies on CD-ROM are produced for the data submitted to the UNFCCC.

**Quality Assurance**

SAEFL mandated the consultants assisting in the preparation of this first NIR to assess the correspondence of the modelling of emissions in some sectors with the recommendations of the IPCC Good Practice Guidance. This constitutes a first step towards quality assurance.

## 1.6.2. Further development of QA/QC activities

As a general contribution to high data quality, consistency and completeness, in the context of the redesign of the EMIS database work is being undertaken to further integrate and consolidate information relevant to the national GHG inventory in one single information management system.

A fully formalized system for QA/QC of the inventory process, including archiving of background documentation, has not yet been established. A QA/QC plan is foreseen in the context of the National Inventory System and will be implemented stepwise from 2004 to 2006.

In Chapters 3 to 8, the sectoral quality controls are described in more detail.

A comprehensive independent domestic review of the inventory is foreseen to take place in 2005, once the recommendations of the in-country review by a UNFCCC expert team have been implemented.

## 1.7. Uncertainty Evaluation

The underlying uncertainties associated with Switzerland's GHG emission estimates have been assessed qualitatively for the majority of sources (CRF Table 7, Sheets 1–3). Generally, the data quality is "**medium**",[1] with the following exceptions among the key sources:

- 1 Energy, 1A1–1A5 Fuel combustion: High data quality for $CO_2$ (see comment below) and $SO_2$,
- 2 Industrial Processes: High data quality for $CO_2$,
- 4 Agriculture, 4A Enteric Fermentation: High data quality for $CH_4$; 4D Agricultural Soils: Low data quality for $N_2O$.

A quantitative uncertainty estimate, following the good practice guidance, will be established in line with the development of the QA/QC plan and included in the 2005 submission.

## 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 marginal exceptions.

[1] For the EMIS database a qualitative classification is used, with the values high, medium and low. Where uncertainties can be quantified, an indicative order of magnitude is used: high data quality – uncertainty $\pm$ 5%; medium data quality – uncertainty $\pm$ 20 % and low data quality – uncertainty $\pm$ 50 %.

# 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 1990–2002.

## *2.1. Aggregated Greenhouse Gas Emissions 2002*

In 2002, Switzerland contributed 52,254 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 7 below shows the emissions for individual gases and sectors in Switzerland for the year 2002. A breakdown of Switzerland's total emissions by gas is shown in Figure 4 below. Figure 5 is a bar chart of contributions to GHG emissions by gas and sector.

| **Emissions 2002** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **HFCs** | **PFCs** | **$SF_6$** | ***Total*** |
|---|---|---|---|---|---|---|---|
| | **$CO_2$ equivalent (Gg)** | | | | | | |
| 1 All Energy | 39'541 | 359 | 644 | | | | ***40'545*** |
| 2 Industrial Processes | 1'846 | 9 | 97 | 473 | 36.3 | 185 | ***2'646*** |
| 3 Solvent Use | NO | NO | 123 | | | | ***123*** |
| 4 Agriculture (1 year average) | NO | 2'856 | 2'570 | | | | ***5'425*** |
| 6 Waste | 2'354 | 1'033 | 128 | | | | ***3'515*** |
| **Total (without $CO_2$ from LUCF)** | **43'741** | **4'258** | **3'561** | **473** | **36.3** | **185** | ***52'254*** |
| 5 Land Use Change/Forestry | 285 | NO | NO | 0 | 0 | 0 | ***285*** |
| Total (with net $CO_2$ emissions/removals) | 44'027 | 4'258 | 3'561 | 473 | 36.3 | 185 | ***52'539*** |
| International Bunkers | 4'132 | 5 | 41 | 0 | 0 | 0 | ***4'177*** |

Table 7 Summary of Switzerland's GHG emissions by gas and sector in $CO_2$ equivalent (Gg), 2002.

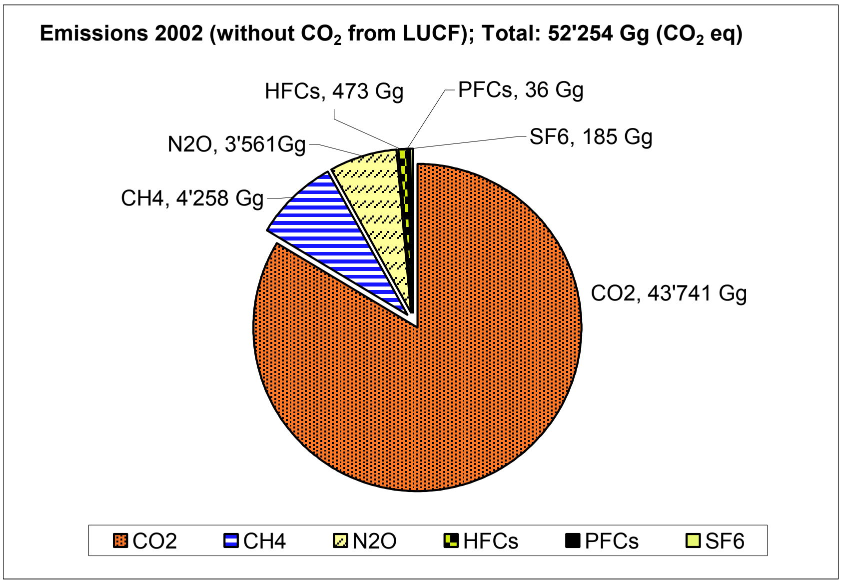


Figure 4 Switzerland's GHG emissions by gas without $CO_2$ emissions from LUCF, 2002

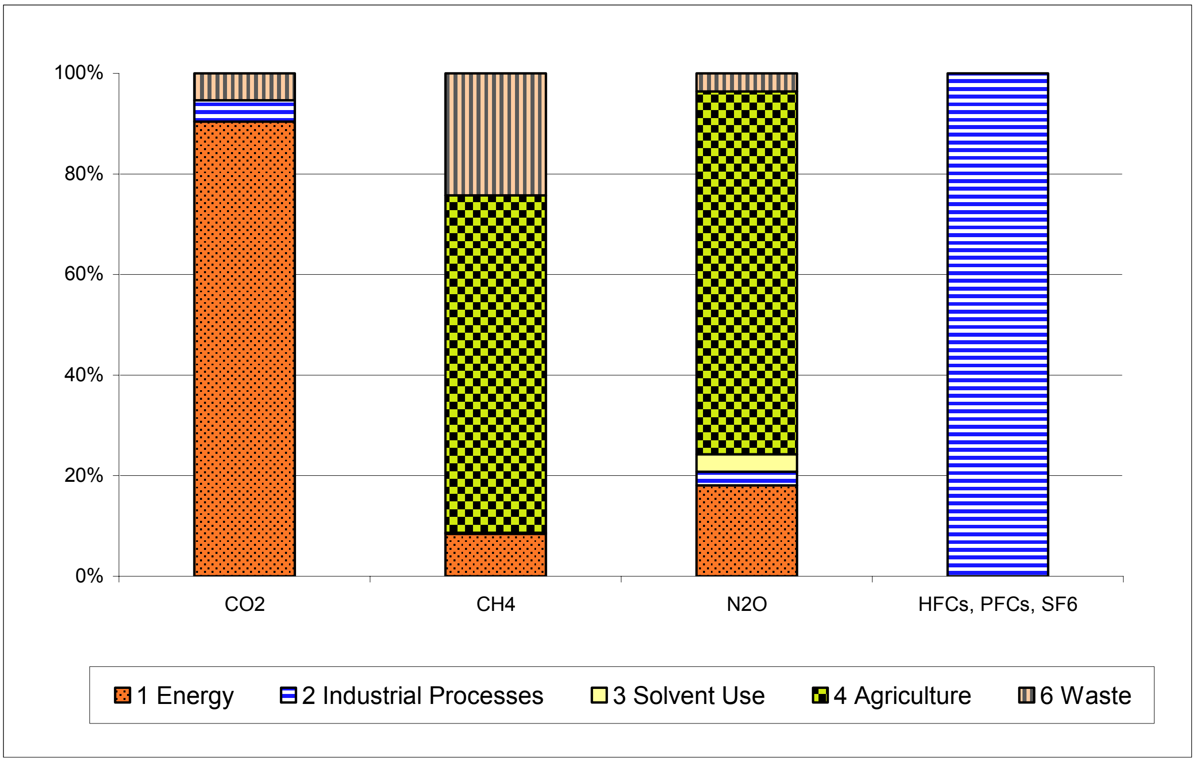


Figure 5 Contribution to GHG emissions by gas and sector, 2002

Fuel combustion within the Energy sector was the largest source of emissions of $CO_2$ in 2002. Emissions of $CH_4$ and $N_2O$ originated mainly from Agriculture, and the synthetic gas emissions stemmed 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** | ***2002/1990*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | | *%* |
| Net $CO_2$ emissions/removals | 43'012 | 44'672 | 44'406 | 40'952 | 40'231 | 41'026 | 41'492 | 40'517 | 41'886 | 42'341 | 43'808 | 45'182 | 44'027 | *2.4%* |
| Gross $CO_2$ emissions (without LUCF) | 44'305 | 46'031 | 45'849 | 43'360 | 42'643 | 43'401 | 44'019 | 43'211 | 44'508 | 44'617 | 43'678 | 44'752 | 43'741 | *-1.3%* |
| $CH_4$ | 4'988 | 4'974 | 4'843 | 4'826 | 4'682 | 4'696 | 4'638 | 4'484 | 4'449 | 4'433 | 4'369 | 4'361 | 4'258 | *-14.7%* |
| $N_2O$ | 3'565 | 3'635 | 3'682 | 3'655 | 3'653 | 3'633 | 3'682 | 3'622 | 3'642 | 3'649 | 3'668 | 3'567 | 3'561 | *-0.1%* |
| HFCs | 0.02 | 0.4 | 2.9 | 61 | 80 | 115 | 166 | 206 | 276 | 334 | 376 | 435 | 473 | --- |
| PFCs | 100 | 85 | 69 | 30 | 18 | 15 | 17 | 24 | 28 | 31 | 68 | 30 | 36 | *-63.8%* |
| $SF_6$ | 178 | 180 | 182 | 148 | 125 | 103 | 97 | 168 | 155 | 143 | 186 | 213 | 185 | *3.6%* |
| Total (with net $CO_2$ emissions/removals) | 51'844 | 53'546 | 53'185 | 49'671 | 48'789 | 49'588 | 50'093 | 49'022 | 50'436 | 50'931 | 52'475 | 53'788 | 52'539 | *1.3%* |
| **Total (without $CO_2$ from LUCF)** | **53'137** | **54'905** | **54'629** | **52'079** | **51'201** | **51'963** | **52'620** | **51'715** | **53'058** | **53'207** | **52'345** | **53'358** | **52'254** | ***-1.7%*** |

Table 8 Summary of Switzerland's GHG emissions in $CO_2$ equivalent (Gg) by gas, 1990–2002 (CRF table 10s5). The column at far right (in italics) shows the percent change in emissions in 2002 as compared to the base year 1990.

The emission trends in individual sectors are as follows (see Table 8 above, Table 9 and Figure 6 below):

- Total emissions (not including $CO_2$ in the LUCF sector) were constant, with fluctuations within a range of less than 5%. The 2002 total emissions decreased by -1.7% as compared to the emissions recorded in the base year 1990. $CO_2$ contributed the largest share of 2002 emissions, accounting for about 84% of the total.
- The total with net $CO_2$ emissions/removals in 2002 show an increase of 1.3% over net emissions recorded in the base year 1990. This increase is explained by 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. The reduced $CO_2$ uptake remains visible over several years due to 3-year averaging of the storm effects (see also Figure 8 below).
- The variation of $CO_2$ emissions in the period 1990–2002 followed in the main the climatic variations during the same period, as a comparison with the number of heating degree days indicates (see below, Figure 11).
- $CH_4$ showed a decrease of -14.7%, which was mainly the result of 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 9.4% in 1990 to 8.1% in 2002.
- $N_2O$ emissions remained almost constant (-0.1%) over the period, which resulted from two opposite tendencies: The reduction of the amount of fertilisers applied in agriculture over the period was compensated by the increase of the emissions from catalytic converters in passenger cars. The share of the $N_2O$ emissions accounted for about 7% of the total GHG emissions over the period 1990–2002.
- HFC emissions increased due to the role of HFCs as substitutes for CFCs. Compared to 1990 levels, $SF_6$ emissions increased, while PFC emissions declined. The share of all synthetic gases together increased from 0.5% in 1990 to 1.3% in 2002.

| **Greenhouse Gas Emissions** | **1990** | | **1995** | | **2000** | | **2002** | |
|---|---|---|---|---|---|---|---|---|
| | Gg | % | Gg | % | Gg | % | Gg | % |
| Gross $CO_2$ emissions (without LUCF) | 44'305 | 83.4% | 43'401 | 83.5% | 43'678 | 83.4% | 43'741 | 83.7% |
| $CH_4$ | 4'988 | 9.4% | 4'696 | 9.0% | 4'369 | 8.3% | 4'258 | 8.1% |
| $N_2O$ | 3'565 | 6.7% | 3'633 | 7.0% | 3'668 | 7.0% | 3'561 | 6.8% |
| HFCs | 0 | 0.0% | 115 | 0.2% | 376 | 0.7% | 473 | 0.9% |
| PFCs | 100 | 0.2% | 15 | 0.0% | 68 | 0.1% | 36 | 0.1% |
| $SF_6$ | 178 | 0.3% | 103 | 0.2% | 186 | 0.4% | 185 | 0.4% |
| **Total (without $CO_2$ from LUCF)** | **53'137** | **100.0%** | **51'963** | **100.0%** | **52'345** | **100.0%** | **52'254** | **100.0%** |

Table 9 Share of emissions by gas for selected years.

Figure 6 below shows Switzerland's relative GHG emission trend. The base year 1990 is set to 100%.

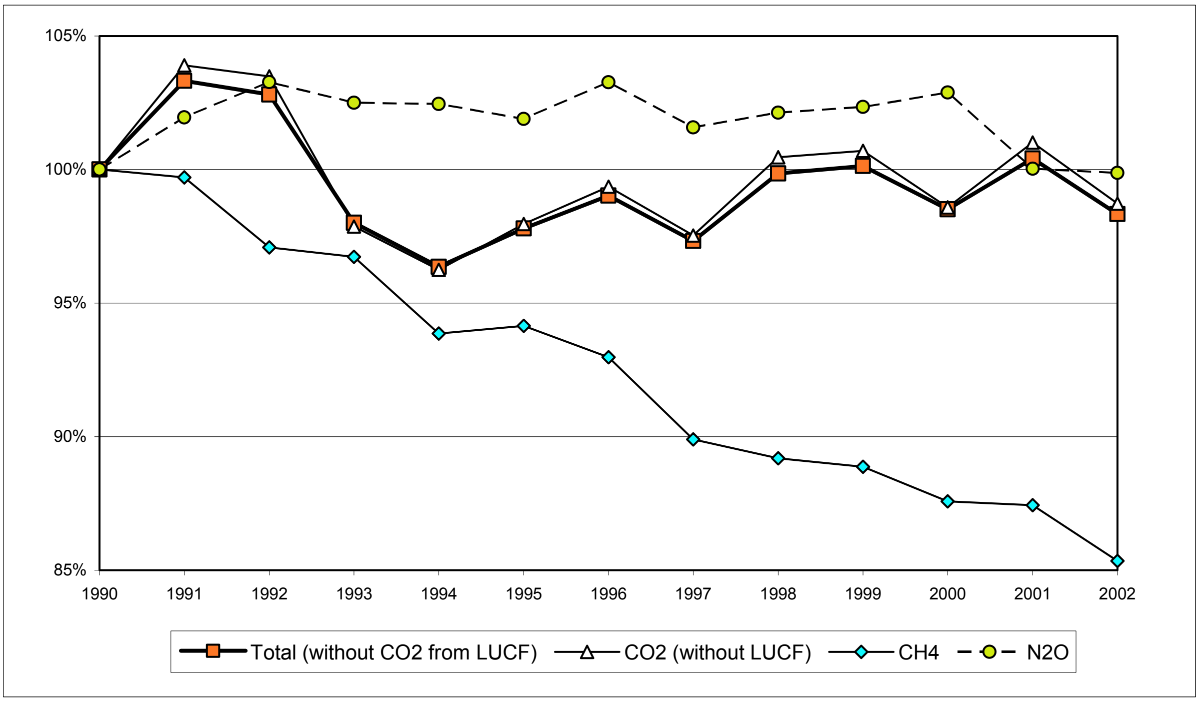


Figure 6 Relative trend of Switzerland's GHG emissions by gas, 1990–2002 (base year 1990 = 100%). The increase of the synthetic gases is not shown (it reaches 350% in 2002).

## *2.3. Emission Trends by Source*

Table 10 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. Figure 7 to Figure 10 show the data in graphical representations.

| **Source and Sink Categories** | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **$CO_2$ equivalent (Gg)** | | | | | | | | | | | | |
| **1 Energy** | **40'571** | **42'764** | **42'797** | **40'544** | **39'717** | **40'552** | **41'346** | **40'698** | **41'906** | **41'962** | **40'758** | **41'630** | **40'545** |
| 1A1 Energy Industries | 980 | 1'327 | 1'402 | 1'091 | 1'109 | 1'125 | 1'300 | 1'213 | 1'437 | 1'192 | 993 | 1'073 | 1'081 |
| 1A2 Manufacturing Industries and Construction | 5'131 | 5'242 | 4'830 | 4'678 | 4'694 | 4'829 | 4'563 | 4'437 | 4'573 | 5'451 | 5'109 | 5'408 | 5'120 |
| 1A3 Transport | 14'632 | 15'195 | 15'554 | 14'498 | 14'722 | 14'419 | 14'503 | 15'119 | 15'356 | 15'989 | 16'248 | 15'922 | 15'784 |
| 1A4 Other Sectors | 18'723 | 19'909 | 19'933 | 19'205 | 18'125 | 19'124 | 19'927 | 18'889 | 19'507 | 18'306 | 17'376 | 18'193 | 17'526 |
| 1A5 Other (Offroad) | 723 | 719 | 715 | 711 | 707 | 703 | 696 | 687 | 679 | 671 | 663 | 666 | 668 |
| 1B Fugitive emissions from oil and natrual gas | 382 | 372 | 364 | 361 | 360 | 351 | 359 | 353 | 353 | 353 | 346 | 348 | 345 |
| **2 Industrial Processes** | **3'228** | **2'872** | **2'704** | **2'422** | **2'563** | **2'440** | **2'304** | **2'243** | **2'314** | **2'364** | **2'606** | **2'688** | **2'646** |
| **3 Solvent and Other Product Use** | **108** | **110** | **112** | **114** | **117** | **119** | **119** | **120** | **120** | **121** | **121** | **121** | **123** |
| **4 Agriculture** | **6'091** | **6'099** | **5'980** | **5'965** | **5'809** | **5'795** | **5'753** | **5'530** | **5'516** | **5'509** | **5'500** | **5'456** | **5'425** |
| **6 Waste** | **3'140** | **3'060** | **3'035** | **3'033** | **2'995** | **3'058** | **3'097** | **3'125** | **3'203** | **3'250** | **3'360** | **3'463** | **3'515** |
| **Total (without $CO_2$ from LUCF)** | **53'137** | **54'905** | **54'629** | **52'079** | **51'201** | **51'963** | **52'620** | **51'715** | **53'058** | **53'207** | **52'345** | **53'358** | **52'254** |
| 5 Land-Use Change and Forestry | -1'293 | -1'359 | -1'443 | -2'408 | -2'411 | -2'375 | -2'527 | -2'694 | -2'622 | -2'276 | 130 | 430 | 285 |
| Total (with net $CO_2$ emissions/removals) | 51'844 | 53'546 | 53'185 | 49'671 | 48'789 | 49'588 | 50'093 | 49'022 | 50'436 | 50'931 | 52'475 | 53'788 | 52'539 |

Table 10 Summary of Switzerland's GHG emissions by source in $CO_2$ equivalent (Gg), 1990–2002.

The percentage shares of source categories are shown for selected years in Table 11. Figure 7 through Figure 10 are graphical representations of Table 10 data. The development of the sub-sectors of source 1 Energy is illustrated in Figure 10 and in Chapter 3, Figure 14 to Figure 16.

From 1998 to 1999, Swiss global energy statistics changed the definition of the categories “Industry” and “Services”. As a result, the time series are distorted, as can be seen in Table 10 and Figure 10: 1A2 Manufacturing Industries increased from 4’573 Gg (1998) to 5’451 Gg (1999), whereas 1A4 Other Sectors dropped from 19’507 Gg (1998) to 18’306 Gg (1999). Work is currently underway to analyse and correct this trend inconsistency. The results will be included in the 2005 submission.

| **Source and Sink Categories** | **1990** | | **1995** | | **2000** | | **2002** | |
|---|---|---|---|---|---|---|---|---|
| | Gg | % | Gg | % | Gg | % | Gg | % |
| 1 Energy | 40'571 | 76.4% | 40'552 | 78.0% | 40'758 | 77.9% | 40'545 | 77.6% |
| 1A1 Energy Industries | 980 | 1.8% | 1'125 | 2.2% | 993 | 1.9% | 1'081 | 2.1% |
| 1A2 Manufacturing Industries and Construction | 5'131 | 9.7% | 4'829 | 9.3% | 5'109 | 9.8% | 5'120 | 9.8% |
| 1A3 Transport | 14'632 | 27.5% | 14'419 | 27.7% | 16'271 | 31.1% | 15'804 | 30.2% |
| 1A4 Other Sectors | 18'723 | 35.2% | 19'124 | 36.8% | 17'376 | 33.2% | 17'526 | 33.5% |
| 1A5 Other (Offroad) | 723 | 1.4% | 703 | 1.4% | 663 | 1.3% | 668 | 1.3% |
| 1B Fugitive emissions from oil and natrual gas | 382 | 0.7% | 351 | 0.7% | 346 | 0.7% | 345 | 0.7% |
| 2 Industrial Processes | 3'228 | 6.1% | 2'440 | 4.7% | 2'606 | 5.0% | 2'646 | 5.1% |
| 3 Solvent and Other Product Use | 108 | 0.2% | 119 | 0.2% | 121 | 0.2% | 123 | 0.2% |
| 4 Agriculture | 6'091 | 11.5% | 5'795 | 11.2% | 5'500 | 10.5% | 5'425 | 10.4% |
| 6 Waste | 3'140 | 5.9% | 3'058 | 5.9% | 3'360 | 6.4% | 3'515 | 6.7% |
| **Total (without $CO_2$ from LUCF)** | **53'137** | **100.0%** | **51'963** | **100.0%** | **52'345** | **100.0%** | **52'254** | **100.0%** |

Table 11 Annual share of total emissions by source category in $CO_2$ equivalent (Gg), selected years.

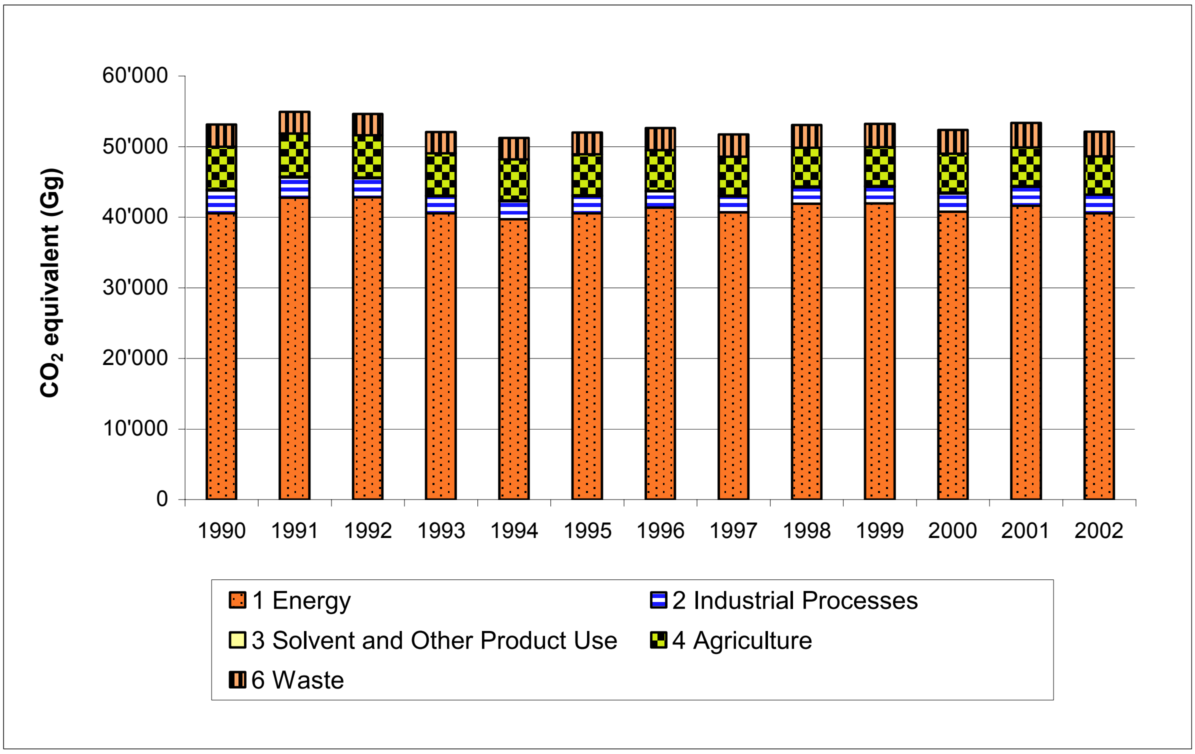


Figure 7 Switzerland’s greenhouse gas emissions by main source categories in $CO_2$ equivalent (Gg), 1990–2002 (without $CO_2$ from LUCF).

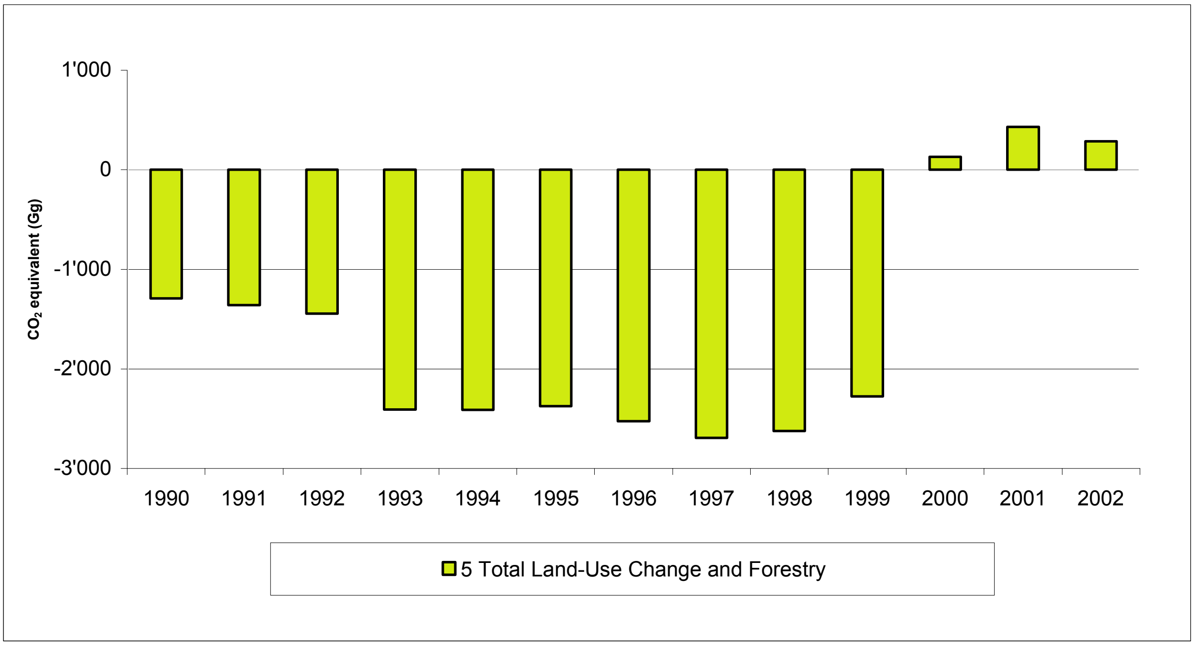


Figure 8 Switzerland's GHG removals (negative emissions) by sinks from LUCF, 1990–2002.

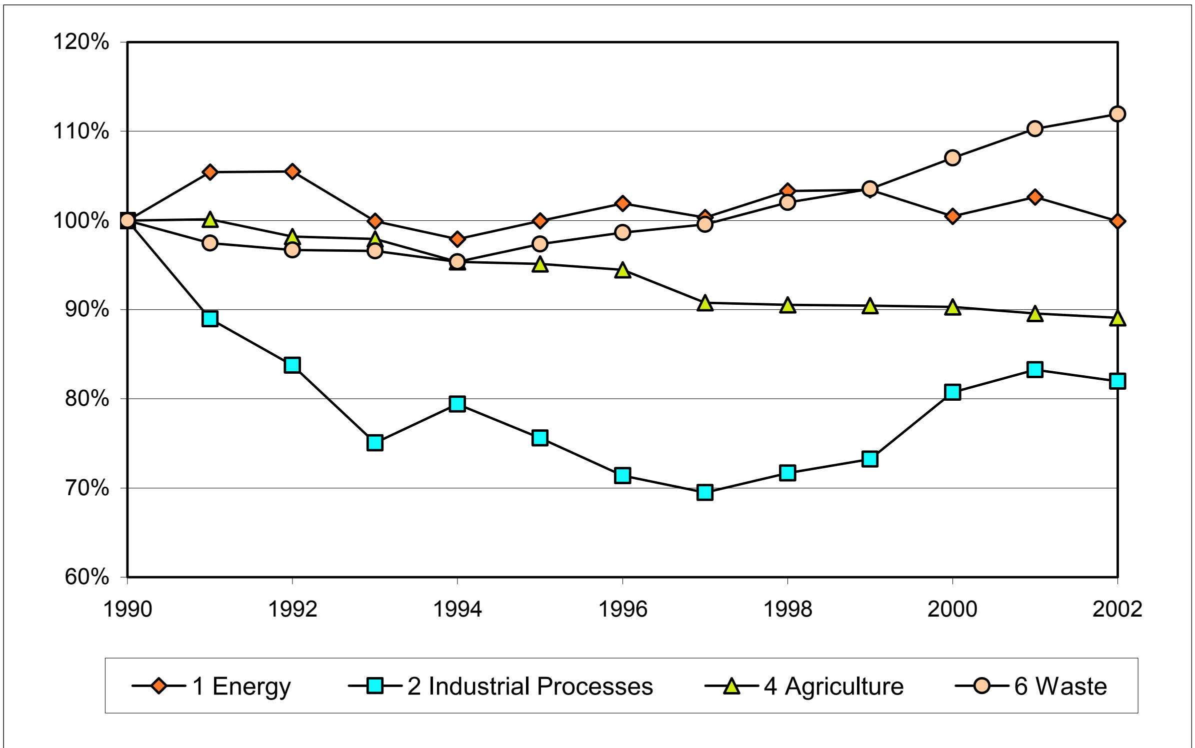


Figure 9 Relative emission trends by main source category (base year 1990 = 100%).

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 10 and comments below).

- 2 Industrial Processes: 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.
- 4 Agriculture: Due to decreasing populations of cattle and swine and reduced fertilizer use, the $CO_2$ equivalent emissions decreased.
- 6 Waste: $CO_2$ emissions from waste increased steadily from 1994 till 2002 because incineration has become the mandatory disposal option (landfill disposal of burnable waste is generally prohibited since the year 2000). The associated decrease in $CH_4$ emissions will only become apparent over the next few years.

The Energy sector, the major source of Switzerland's GHG emissions, is shown divided into the main Energy sub-sectors in Figure 10.

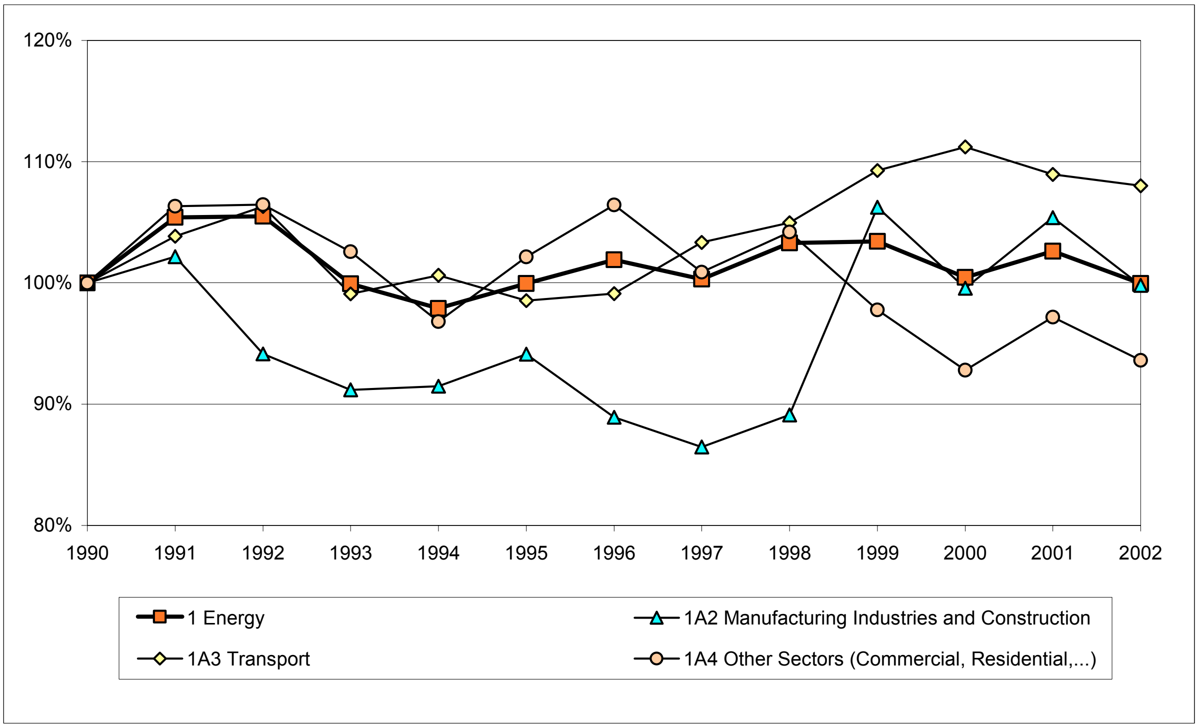


Figure 10 Emission trends of the three main source sub-categories, which account for 95% of emissions in the Energy sector (not shown are the categories of minor importance: 1A1 Energy Industries and 1A5 Other/Off-road and 1B Fugitive Emissions). The bold line "1 Energy" shows the total for the Energy sector.

It is noteworthy that, due to the particular electricity production structure (2002: 96% of electricity produced in hydroelectrical and nuclear power plants), the sector 1A1 Energy Industries plays a very minor role in the Swiss GHG inventory and is thus not represented in Figure 10.

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 trend of the Energy sector (bold line in Figure 10).
- In 1A3 Transport there was a slightly increasing trend in the period 1990–2002. Between 2000 and 2002, road transportation and domestic aviation emissions declined, reflecting the combined effects of increased fuel efficiency and smaller growth rates of traffic volume than in the previous years.
- The crossover of 1A2 Manufacturing Industries and 1A4 Other Sectors in Figure 10 between 1998 and 1999 does not correspond to a real change of emissions. It results

from a change in the definitions of “Industry” and “Services” in the Swiss global energy statistics 1998/1999 (see also remark at Table 10 above; recalculated, consistent trend data will be presented in the 2005 submission).

- 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 (see Figure 11). Note that the number of “heating degree days” is high in cold winters and low in warm years.
  In order to eliminate trend distortions due to changing category definitions in Swiss global energy statistics, the sum of 1A4 Other Sectors and 1A2 Manufacturing Industries is represented in Figure 11. Since the category 1A1 Energy Industries is sensitive to climatic variations as well, it is also included in the figure.
  In the period 1990–2002, the number of buildings and apartments increased as well as the average floor space per person and per work place. Both phenomena resulted in an increase of total area heated. Over the same period, however, higher standards for building insulation and for efficiency of combustion installation were instituted, thereby compensating the additional area heated.

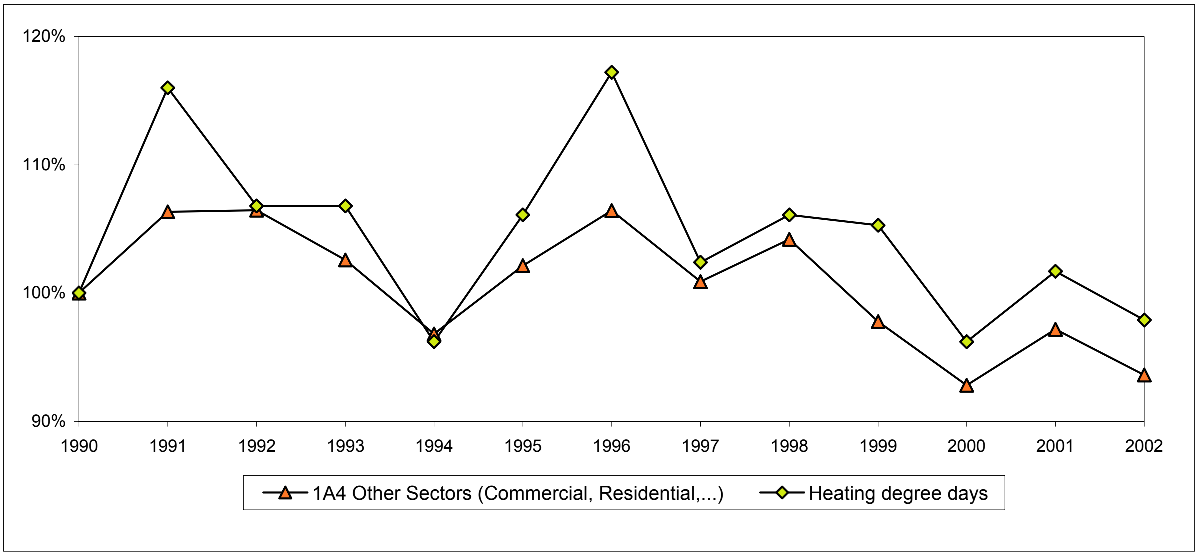


Figure 11 Relative emission trend of the sum of 1A1 Energy Industries, 1A2 Manufacturing Industries and 1A4 Other Sectors (Commercial, Residential, Off-Road Transportation in Agriculture and Forestry) in comparison with the number of heating degree days (see text above).

## *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 2002. The main reduction measures were abatement 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gg | | | | | | | | | | | | |
| $NO_x$ | 172 | 167 | 157 | 141 | 135 | 128 | 121 | 115 | 111 | 107 | 104 | 99 | 94 |
| CO | 770 | 743 | 696 | 613 | 571 | 534 | 517 | 494 | 469 | 453 | 427 | 404 | 383 |
| NMVOC | 297 | 281 | 262 | 238 | 223 | 207 | 199 | 190 | 181 | 173 | 154 | 148 | 143 |
| $SO_2$ | 45 | 41 | 36 | 29 | 30 | 29 | 28 | 26 | 24 | 20 | 18 | 21 | 19 |

Table 12 Switzerland's indirect GHG and $SO_2$ emissions in Gg, 1990–2002.

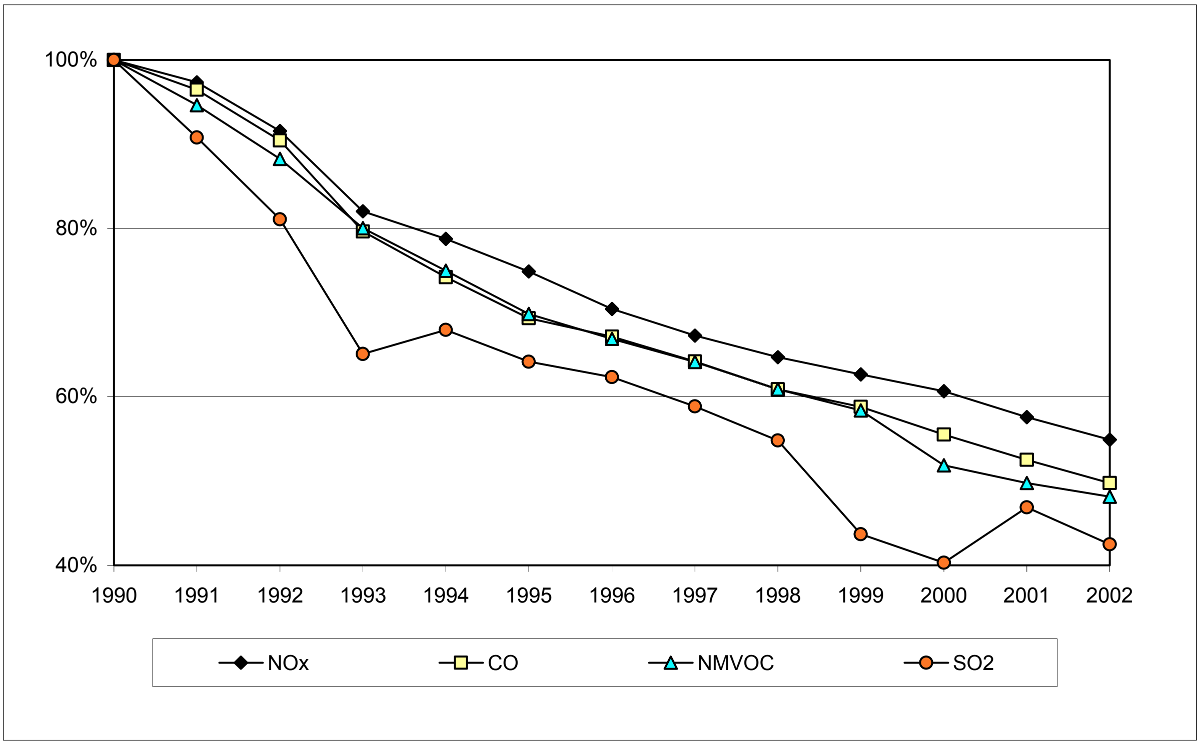


Figure 12 Relative trends of Switzerland's indirect GHG gas and $SO_2$ emissions, 1990-2002 (base year 1990 = 100%).

Sector 1 Energy was by far the largest source of the indirect greenhouse gas emissions (see Table 13). The only exceptions are NMVOCs, where the percentage contribution of category 3 Solvent and Other Product Use covered 60% of the total.

| Sources | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|
| | Emissions 2002 (Gg ) | | | |
| 1 Energy | 78.5 | 360.0 | 41.3 | 13.0 |
| 2 Industrial Processes | 0.32 | 12.01 | 7.96 | 3.57 |
| 3 Solvent and Other Product Use | 0.05 | 0.09 | 88.65 | 0.04 |
| 4 Agriculture | 9.52 | 5.88 | 4.22 | 0.00 |
| 5 Land-Use Change and Forestry | NO | NO | NO | NO |
| 6 Waste | 5.82 | 5.19 | 0.88 | 2.32 |
| Total | 94.2 | 383.2 | 143.0 | 19.0 |

Table 13 Indirect GHG and $SO_2$ emissions by source in Gg, 2002 (NO: Not occurring).

Figure 13 shows the data from Table 13 expressed in percent of the total by individual gas. Sector 1 Energy is clearly visible as the main source of $NO_x$, CO and $SO_2$.

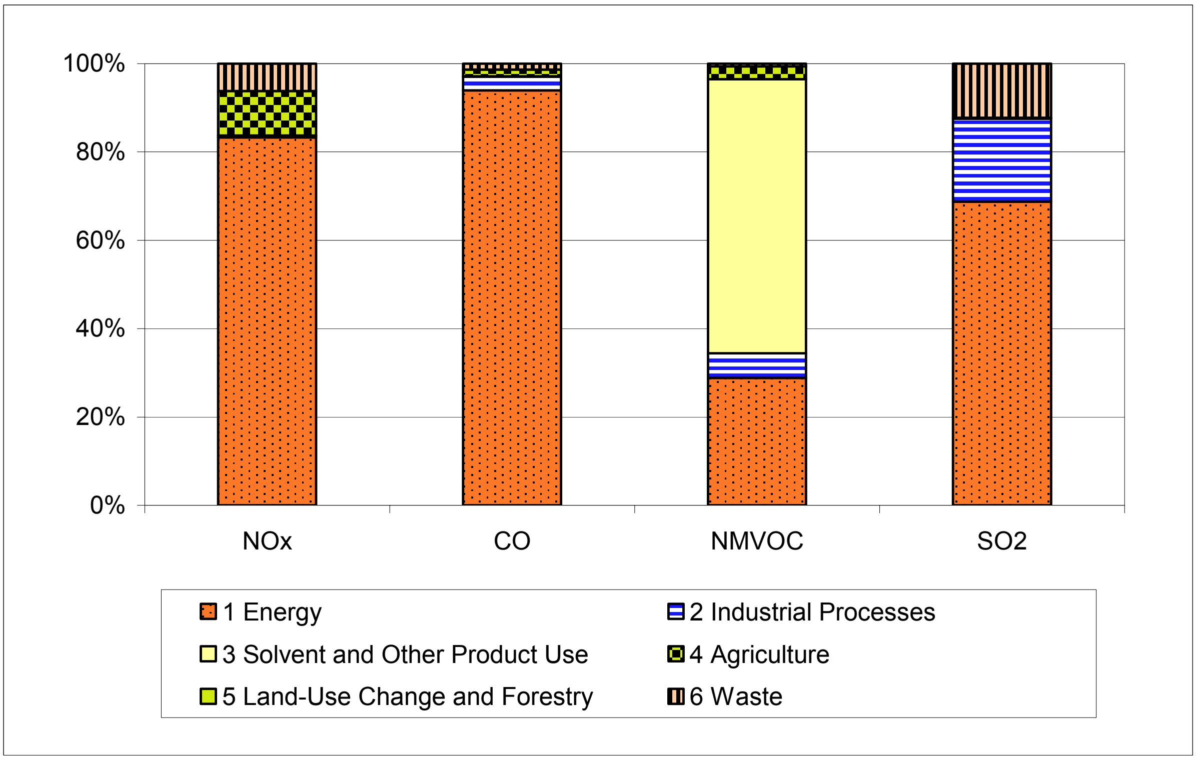


Figure 13 Percentage contributions of indirect GHGs and $SO_2$ emissions by source, 2002.

# 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 2002, it emitted 40'545 Gg $CO_2$ equivalent, which correspond to 77.6% of total emissions (52'254 Gg, without $CO_2$ from LUCF). The emissions of the period 1990–2002 are depicted in Figure 14.

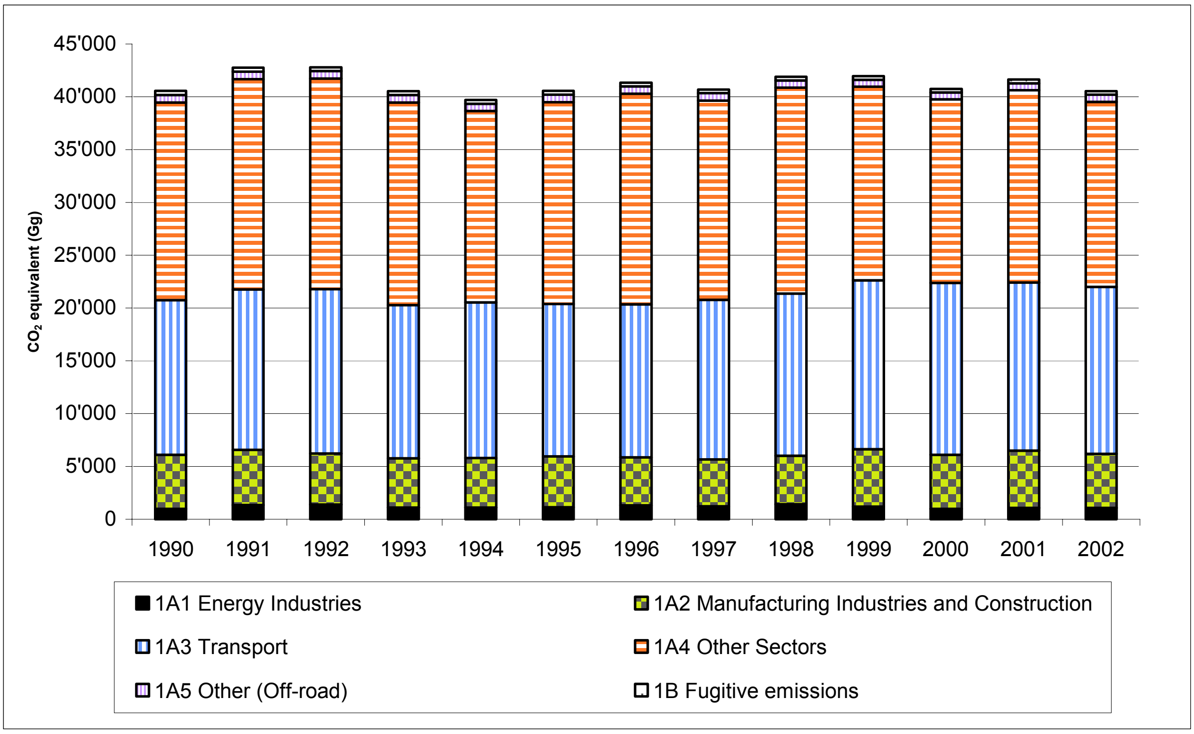


Figure 14 Switzerland's GHG emissions of source category 1A Energy 1990–2002 in $CO_2$ equivalent (Gg).

For the total emissions of the energy sector, no significant trend may be observed in the period 1990–2002. Three sub-categories dominate the emissions:

- 1A3 Transport and 1A4 Other Sectors are the main sources that cover 39.0% and 43.2%, respectively, of total emissions.
- 1A2 Manufacturing Industries and Construction are of minor importance. They contribute 12.6% to the total emissions.
- 1A1 Energy Industries, 1A5 Other (Off-road) and 1B Fugitive Emissions only play a minor role. In 2002, they cover 2.7%, 1.6% and 0.9%, 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 97.5% of the category. Its fluctuations reflect climatic variability in Switzerland (see Figure 10 and related comments).

- In 2002, $CH_4$ emissions contributed less than 1% 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.
- The changes in $N_2O$ emissions may be explained by changes in the emission factors 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | |
| $CO_2$ | 39'675 | 41'801 | 41'782 | 39'546 | 38'701 | 39'531 | 40'289 | 39'624 | 40'820 | 40'861 | 39'679 | 40'585 | 39'541 |
| $CH_4$ | 471 | 470 | 455 | 435 | 416 | 402 | 402 | 390 | 385 | 379 | 370 | 367 | 359 |
| $N_2O$ | 424 | 493 | 560 | 563 | 600 | 619 | 656 | 684 | 700 | 722 | 708 | 678 | 644 |

Table 14 GHG emissions of source category 1 Energy by gas in $CO_2$ equivalent (Gg), 1990–2002.

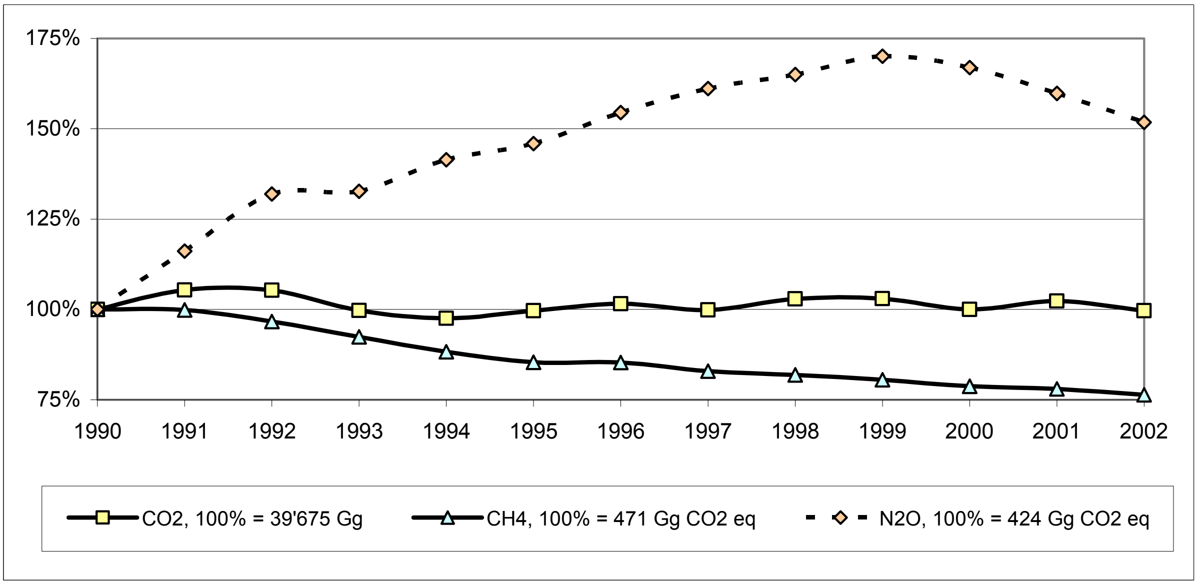


Figure 15 Relative trends of the greenhouse gases of source category 1 Energy in the period 1990–2002. The base year 1990 represents 100%.

The following table summarises the emissions of source category 1 Energy in 2002. 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 2002 | $CO_2$ | $CH_4$ | $N_2O$ | *Total* |
|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | |
| **1 Energy** | **39'541** | **359** | **644** | ***40'545*** |
| **1A Fuel Combustion** | **39'450** | **105.8** | **644.2** | ***40'200*** |
| 1A1 Energy Industries | 1'077 | 1.4 | 2.5 | ***1'081*** |
| 1A2 Manufacturing Industries and Construction | 5'099 | 8.5 | 12.2 | ***5'120*** |
| 1A3 Transport | 15'195 | 35.8 | 572.6 | ***15'804*** |
| 1A4 Other Sectors | 17'425 | 52.3 | 49.6 | ***17'526*** |
| 1A5 Other | 653 | 7.9 | 7.4 | ***668*** |
| **1B Fugitive Emissions from Fuels** | **92** | **253.4** | **0.0** | ***345*** |
| **International Bunkers** | 4'132 | 5 | 41 | ***4'177*** |
| **$CO_2$ Emissions from Biomass** | 1'944 | 0 | 0 | ***1'944*** |

Table 15 Summary of source category 1 Energy, emissions in 2002 in $CO_2$ equivalent (Gg).

The Swiss greenhouse gas inventory identifies twenty key sources (see Chapter 1.5), ten of which belong to the energy sector. These are depicted in the next figure. Most dominant are the $CO_2$ emissions from 1A4 Other Sectors (liquid fuels) and 1A3 Transport (gasoline).

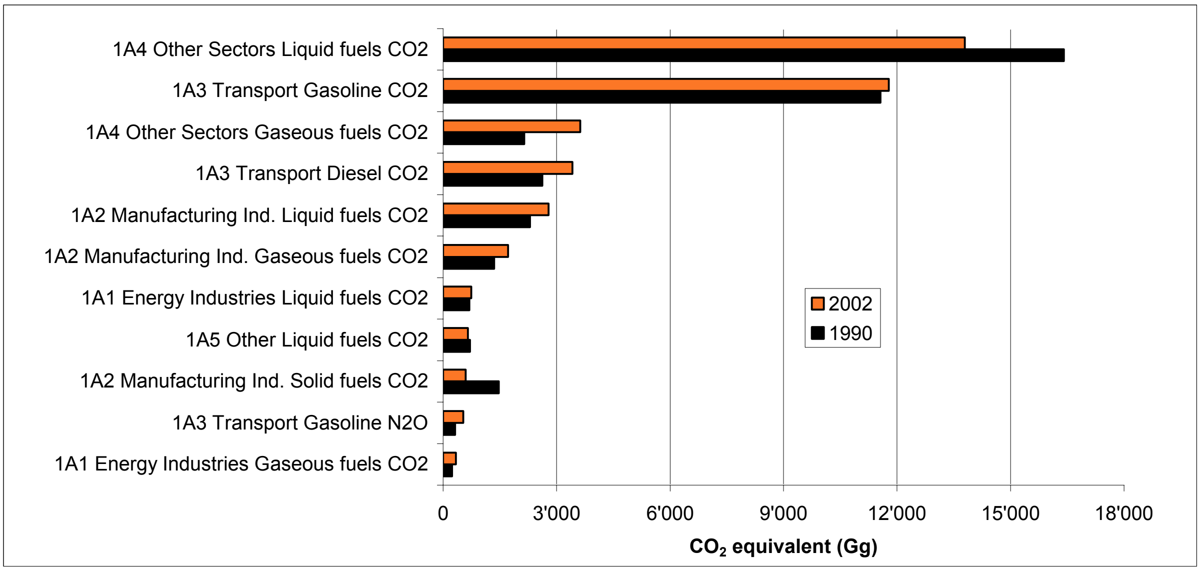


Figure 16 Key sources in the Swiss GHG inventory pertaining to the energy sector.

### 3.1.2. $CO_2$ Emission Factors

The $CO_2$ emission factors used for the calculation of the emissions of 1 Energy are shown in Table 16. Further details are given in Annex 2, Methodology for Estimating $CO_2$ Emissions.

| $CO_2$ Emission Factors | |
|---|---|
| **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 16 $CO_2$ emission factors for fuels.

### 3.1.3. Feedstocks

Energy data are taken from the Swiss global energy statistics (SFOE 2002). These statistics account for production, imports, exports, transformations 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)

$CO_2$ from the combustion of liquid fuels in Energy Industries (1A1) is a key source regarding level and trend; $CO_2$ from the combustion of gaseous fuels in Energy Industries (1A1) is a key source 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”.

In Switzerland, electricity production is dominated by hydroelectric power plants (56.2 %) and nuclear power stations (39.5 %). Thermal power stations account only for about 4.3 % of the electricity generated in Switzerland (SFOE 2002; table 24; data for the year 2002).

| 1A1 | Source | Specification | Data Source |
|---|---|---|---|
| 1A1 a | Public Electricity and Heat Production | 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. | Activity: SFOE 2002: EMIS 1995<br>EF: SAEFL 2000a; SFOE 2000 |
| 1A1 b | Petroleum Refining | Combustion activities supporting the refining of petroleum products, excluding evaporative emissions. | Activity: SFOE 2002<br>EF: Industry data |
| 1A1 c | Manufacture of Solid Fuels and Other Energy Industries | Not occurring in Switzerland | - |

Table 17 Specification of source category 1A1 "Energy Industries" (Activity: activity data; EF: emission factors)

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

$CO_2$ from the combustion of gaseous, liquid and solid fuels in Manufacturing Industries and Construction (1A2) is a key source regarding both level and trend.

The source category 1A2 "Manufacturing Industries and Construction" comprises all emissions from the combustion of fuels in stationary boilers, gas turbines and engines within manufacturing industries and construction, including emissions from 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 contrast to the IPCC provisions (IPCC 1997c), emissions from the combustion of waste-to-energy fuels that substitute for conventional energy carriers (fossil or biomass waste fuels such as waste plastic or waste wood) in the cement and the paper industries are not included in category 1A2. Instead, such fuels are taken into account in source category 6 ("Waste"). This is motivated by the fact that the Swiss $CO_2$ law (CO2G 1999) considers only $CO_2$ emissions from conventional fossil fuels. 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: industry data; EMIS 1995<br>EF: EMIS 1995, SAEFL 2000a |
| 1A2 b | Non-ferrous Metals | Included in category 1A2f (see below) | |
| 1A2 c | Chemicals | Included in category 1A2f (see below) | |
| 1A2 d | Pulp, Paper and Print | Included in category 1A2f (see below) | |
| 1A2 e | Food Processing, Beverages and Tobacco | Included in category 1A2f (see below) | |
| 1A2 f | Other (Combustion Installations in Industries) | Category 1A2 f contains sum of sources 1A2 b-f (Non-ferrous Metals; Chemicals; Pulp, Paper and Print; Food Processing, Beverages and Tobacco; Cement, Lime and Glass). | Activity: SFOE 2002; EMIS 1995<br>EF: EMIS 1995, SAEFL 2000a; SFOE 2000 |

Table 18 Specification of source category 1A2 Manufacturing Industries and Construction (Activity: activity data; EF: emission factors)

### c) Transport (1A3)

$CO_2$ and $N_2O$ from the combustion of gasoline in Transport (1A3) are key sources regarding both level and trend. $CO_2$ from the combustion of diesel in Transport (1A3) is a key source regarding both level and trend.

The source category includes civil and military aviation, road transport, railways, navigation and other transportation. In Switzerland, “civil aviation” is extended to “aviation” including civil and military aviation. “Other transportation” is not occurring in Switzerland. Off-road transportation is included in category 1A4 Other Sectors (off-road transport in agriculture and forestry) and 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 | Aviation (Domestic) | Civil *and* military aviation | SFOE 2002, SAEFL 1996a, 2000d |
| 1A3 b | Road Transportation | Light and heavy motor vehicles, Two-wheelers | SFOE 2002,<br>SAEFL 1995a, 2000b, 2000c |
| 1A3 c | Railways | Diesel locomotives | SFOE 2002, SAEFL 1996a, 2000d |
| 1A3 d | Navigation (Domestic) | Passenger ships, motor and sailing boats on the Swiss lakes | SFOE 2002, SAEFL 1996a, 2000d |

Table 19 Specification of Swiss source category 1A3 Transport.

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

$CO_2$ from the combustion of gaseous and liquid fuels in Other Sectors (1A4) 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 2002<br>EF: EMIS 1995, SAEFL 2000a; SFOE 2000 |
| 1A4 b | Residential | Emissions from fuel combustion in households | Activity: SFOE 2002<br>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 2000d<br>EF: EMIS 1995, SAEFL 2000a; SFOE 2000; SAEFL 1995a, 2000d |

Table 20 Specification of source category 1A4 “Other sectors” (Activity: activity data; EF: emission factors).

### e) Other (1A5 – Off-road)

$CO_2$ from the combustion of liquid fuels in Source Category Other 1A5 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 to account for about 97 % of the category total.

| 1A5 | Off-road | Specification | Data Source |
|---|---|---|---|
| | Construction | Construction vehicles and machinery | SFOE 2002, SAEFL 1996a, SAEFL 2000d |
| | Hobby | Household and gardening machinery and motorised equipment | |
| | Industry | Industrial off-road vehicles and machinery | |
| | Military (without military aviation) | Tanks and similar vehicles | |

Table 21 Specification of Swiss source category 1A5 “Other” (off-road).

## 3.2.2. Methodological Issues

Two methods are applied for source category 1 Energy, the Sectoral or National Approach and the Reference Approach.

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 global energy statistics (SFOE 2002) and the yearly reports of the Swiss Petroleum Association [Erdöl-Vereinigung/Union pétrolière] (EV 2003). 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.

### a) Energy Industries (1A1)

$CO_2$ from the combustion of liquid fuels in Energy Industries (1A1) is a key source regarding level and trend; $CO_2$ from the combustion of gaseous fuels in Energy Industries (1A1) is a key source regarding trend.

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

- "Public Electricity and Heat Production" (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), a country specific Tier 2 method is used, based on CORINAIR. A top-down method based on aggregated fuel consumption data from the Swiss global 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.

*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).

The activity data on LFO use from the Swiss global energy statistics (SFOE 2002) 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 | 73.46 | | 1 | 0.6 | 40 | 11 | 2 | 37 |
| Natural gas | 55 | | 6 | 0.1 | 28 | 14 | 2 | 0.5 |
| Biomass | | 92 | 21 | 1.6 | 140 | 650 | 7 | 20 |

Table 22 Emission Factors for 1A1a Public Electricity and Heat Production in Energy Industries in 2002.

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 (73.7 t/TJ) and LPG (65.5 t/TJ) emissions.

*Activity Data*

Activity data on fuel consumption (TJ) for Public Electricity and Heat Production (1A1a) is extracted from the Swiss global energy statistics. The activity data for 2002 correspond to the consumption of LFO, natural gas and biomass in public district heating systems (SFOE 2002; tables 21, 26, and 28).

| Source/Fuel | Unit | 1990 | 1995 | 2000 | 2002 |
|---|---|---|---|---|---|
| **1A1a Public Electricity/Heat Fuel Consumption** | | | | | |
| Total | TJ | 9’019 | 7’773 | 6’395 | 6’717 |
| Light fuel oil | TJ | 980 | 546 | 495 | 512 |
| Heavy fuel oil | TJ | 3'195 | 1’791 | NO | NO |
| Natural gas | TJ | 4'270 | 5’330 | 5’830 | 6’075 |
| Coal | TJ | 534 | 56 | NO | NO |
| Biomass | TJ | 40 | 50 | 70 | 130 |

Table 23 Activity data in 1A1a Public Electricity/Heat.

The increase of natural gas consumption by over 40% in public district heating systems is the reason for “Consumption of Gaseous Fuels” in source category 1A1 Energy/Transformation 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, based on CORINAIR. 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 1.3) 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 24 Emission Factors for 1A1b Petroleum Refining in 2002.

*Activity Data*

Activity data on fuel combustion (TJ) for Petroleum Refining (1A1b) is extracted from the Annual Reports of the Swiss Petroleum Association (EV 2003, p. 54).

| Source/Fuel | Unit | 1990 | 1995 | 2000 | 2002 |
|---|---|---|---|---|---|
| **1A1b Petroleum Refining Fuel consumption** | | | | | |
| Total | TJ | 5’906 | 10’317 | 10’091 | 11’447 |
| Heavy fuel oil | TJ | 1’296 | 1’834 | 1’952 | 1’518 |
| Gas (refinery LPG) | TJ | 4'610 | 8’483 | 8’139 | 9’929 |

Table 25 Activity data in 1A1b Petroleum Refining

The table above documents the increase of gas (refinery LPG) consumption for Petroleum refining by more than 100% from 1990 to 2002. 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.

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

The combustion of gaseous, liquid and solid fuels in Manufacturing Industries and Construction (1A2) is a key source regarding both level and trend.

**Methodology**

For fuel combustion in Manufacturing Industries and Construction (1A2) a country specific Tier 2/3 method is used, based on CORINAIR. The method combines both bottom-up and top-down elements (see Figure below). Emissions of GHGs are calculated by multiplying levels of activity by emission factors. Total emissions from 1A2 “Manufacturing Industries and Construction” are the sum of emissions from sources calculated bottom-up and from sources calculated top-down.

- A *bottom-up* (Tier2/Tier3) method is used to calculate the emissions from a group of sources characterised by heterogeneous emission factors. This group comprises cement, lime, glass, 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 *top-down* method based on aggregated fuel consumption data from the Swiss global energy statistics is used to calculate emissions from all other sources in 1A2 “Manufacturing Industries and Construction”, including chemicals, pulp, paper, print, food processing, beverages and tobacco industries. These sources are characterised by rather similar industrial combustion processes. Identical emission factors are applied throughout these sources. The unit of emission factors refers to fuel consumption (in TJ).

The following figure gives an overview on the two methods used in 1A2:

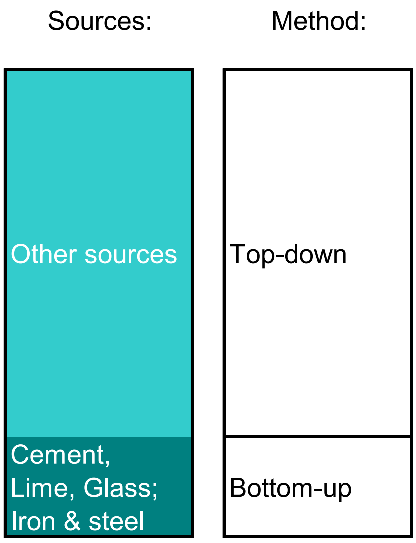


Figure 17: Overview on the two methods used in 1A2 Manufacturing Industries and Construction.

Based on available data, source categories 1A2 b-f (Non-ferrous Metals; Chemicals; Pulp, Paper and Print; Food Processing, Beverages and Tobacco; Other) can not be disaggregated at present in the requested format and are reported as a sum (see also Section 3.2.6 on planned improvements).

### Emission factors

*Bottom-up approach*

Following IPCC Tier 3, bottom-up 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 1.3).

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

| 1A2 a Iron and Steel (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 | 94.1 | 9.0 | 1.6 | 48 | 20 | 29.0 | 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 26 Emission factors for 1A2a Iron and Steel in Manufacturing Industries and Construction in 2002.

| 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 | NE | NE | 1.16 | 0.4 | 0.005 | 0.08 |

Table 27 Emission factors for cement industry in 2002 (NE: not estimated). Source: EMIS 1995. Emission factors for $CO_2$ are fuel specific; they are the same as in the top-down approach (see table below).

*Top-down approach*

For all sources in 1A2 "Manufacturing Industries and Construction" other than cement, lime, glass, iron and steel industries, emission factors are the same as for source category 1A1. 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).

The activity data on LFO use from the Swiss global energy statistics (SFOE2002) includes also LPG consumption. Therefore the LFO emission factor for $CO_2$ (see remark following the Table below) is a mixed emission factor that results as a weighted average of the LFO emission factor and LPG emission factor.

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 $CH_4$, $N_2O$, NOx, CO and NMVOC are country specific based on comprehensive life cycle analysis of industrial boilers, documented in SAEFL 2000a (pp. 14-27). For NOx emission factors, expert judgement has been used to estimate the fraction of low-NOx 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 1A2b-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 |
|---|---|---|---|---|---|---|---|---|
| **1A2f Other (includes 1A2 b-f)** | | | | | | | | |
| Light fuel oil (LFO) | 73.46 | | 1.0 | 0.6 | 40 | 11 | 2 | 37 |
| Heavy fuel oil (HFO) | 77.00 | | 4.0 | 0.8 | 125 | 15 | 4 | 398 |
| 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 | 650 | 7 | 20 |

Table 28 Emission factors for 1A2f “Other” in “Manufacturing Industries and Construction” (without cement/ lime/ glass industries) for 2002.

*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 $CO_2$ 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.

## Activity data

*Bottom-up approach*

Activity data on fuel consumption (TJ) for source category 1A2 a (Iron and Steel) stem from SAEFL 1995b based on production data provided by the industry association VSM for 1990. These data have been extrapolated by expert estimate since then (as documented in the EMIS 1995 database; see Section 1.3).

| Source/Production | Unit | 1990 | 1995 | 2000 | 2002 |
|---|---|---|---|---|---|
| **1A2a Iron and Steel** | | | | | |
| Iron foundries: cupol ovens | Gg | 90 | 72 | 60 | 52 |
| Steel plants: reheating furnaces | Gg | 1’108 | 730 | 760 | 780 |

Table 29 Activity data: Production in 1A2a Iron and Steel.

Production data and activity data on fuel consumption for cement production is provided annually by the Swiss cement industries.

| Source/Production | Unit | 1990 | 1995 | 2000 | 2002 |
|---|---|---|---|---|---|
| **Cement industry (part of 1A2f)** | | | | | |
| Heavy fuel oil | TJ | 1’906 | 2’713 | 1’532 | 1’079 |
| Natural gas | TJ | 362 | 166 | 17 | 15 |
| Coal | TJ | 12’113 | 6’807 | 5’399 | 4’652 |
| Not included in 1A2: | | | | | |
| Waste (waste-to-energy fuels) | TJ | 2’054 | 3’109 | 3’981 | 5’261 |

Table 30 Activity data: Fuel consumption in 1A2f Cement Production.

*Remark:* The use of waste as fuel in the cement industry is reported under Source Category 6C Waste Incineration, not under 1A2.

Production data and activity data on fuel consumption for lime and glass production has been provided by the Swiss glass industries for 1995 and has been extrapolated by expert estimate since then. They are documented in the EMIS 1995 database.

*Top-down approach*

Activity data on fuel consumption (TJ) for “top-down” sources in category 1A2 are extracted from the Swiss global energy statistics. These include construction, chemicals, pulp, paper, print, food processing, beverages and tobacco industries.

The Swiss global energy statistics (SFOE 2002; table 17) provide annual *aggregated* consumption data for different fuels for the category “ Industry”. The data is derived from measurements and data provided by industry associations and from estimates based on selected surveys in industry and expert judgements. In the following is described, how the activity data relevant for the CRF source categories are extracted from this aggregated data:

In the category “Industry” in SFOE 2002 (see Figure below) the fuel consumption of the following sources are summed up:

- cement, lime, glass, iron and steel industries,
- other manufacturing industries and construction (other 1A2 sources),
- sources that are not part of category 1A2 (non-1A2)[2].

[2] The sources that are not part of source category 1A2 include cellulose (part of source category 6), grass drying (1A4), steamboats (1A3) and process emissions from non-ferrous metals, foundries, aluminimum smelting and production, and graphite (2).

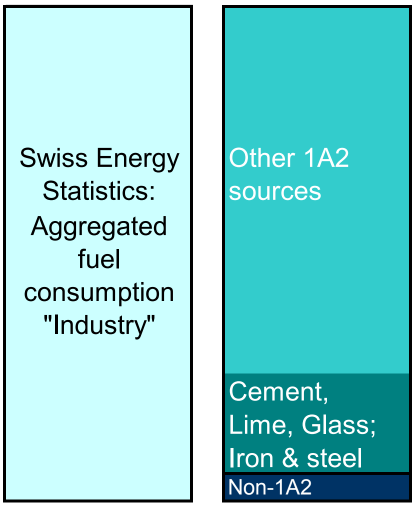


Figure 18: The category “Industry” in the Swiss global energy statistics (SFOE 2002) comprises several IPCC source categories.

The fuel consumption in “ Other 1A2 sources” ($FUEL_{other1A2}$) is then the difference between the total fuel consumption in “Industry” in SFOE 2002 ($FUEL_{Industry}$) and the fuel consumption in cement, lime, glass, iron, and steel industries ($FUEL_{CLGIS}$) and non-1A2 sources[2] ($FUEL_{non-1A2}$):

$$FUEL_{other1A2} = FUEL_{Industry} - FUEL_{CLGIS} - FUEL_{non\text{-}1A2}$$

where $FUEL_{CLGIS}$ and $FUEL_{non-1A2}$ are calculated bottom-up as described above.

The resulting fuel consumption of the “Other 1A2 sources” ($FUEL_{other1A2}$) is the activity data used to calculate the related emissions in the top-down approach.

Total emissions from 1A2 “Manufacturing Industries and Construction” are the sum of emissions from sources calculated bottom-up and from sources calculated top-down.

*Disaggregation of Sources*

The CRF foresees the disagreggation of emissions in 1A2 “Manufacturing Industries and Construction” in sub-categories 1A2a to 1A2f. The present level of disaggregation of the data in the Swiss global energy statistics (SFOE 2002) and in the EMIS 1995 database allows only to provide disaggregated data for emissions from 1A2a “Iron and Steel”, based on the bottom-up approach.

Based on available data from Swiss global energy statistics (SFOE 2002), at present it is not possible to disaggregate source categories 1A2 b-f (Non-ferrous Metals; Chemicals; Pulp, Paper and Print; Food Processing, Beverages and Tobacco; Other) (see Section 3.2.6 below). Hence, they are reported aggregated as a sum in category 1A2f (Other).

### c) Transport (1A3)

$CO_2$ and $N_2O$ from the combustion of gasoline in Transport (1A3) are key sources regarding both level and trend. $CO_2$ from the combustion of diesel in Transport (1A3) is a key source regarding both level and trend.

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

- Aviation (1A3a, domestic civil and military aviation),

- Road Transportation (1A3b),
- Railways (1A3c),
- Navigation (1A3d, domestic).

**Aviation (1A3a)**

*Methodology*

Civil aviation

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

The calculation of total $CO_2$ emissions (incl. bunkers) is based on the national fuel statistics, which is part of the Swiss global energy statistics (SFOE 2002), and on the carbon content of the fuel used (see Annex 2).

A detailed modelling (LTO and cruise) of fuel consumption and of emissions of $CO_2$, $NO_x$, VOC and CO is carried out yearly by the Federal Office of Civil Aviation (FOCA). For the latest year 2002, the activity data is not available yet, but the Swiss global energy statistics (SFOE 2002) provide the kerosene consumption for all years including 2002. Therefore, SAEFL calculates 2002 emissions by extrapolating kerosene consumption from 1990–2001 data.

FOCA runs a “reference database” that contains all data needed to calculate the emissions of civil aviation. 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[3] of the aircraft, the reference database includes emission factors in order to calculate the emissions for every individual flight.

Separation of domestic from international aviation: In the reference database, international and domestic flights may not be distinguished at the level of the individual movement. The fraction of international bunker emissions is separated from the total emissions for reporting under the source category “Memo items, International Bunkers” (1C). This step is done in an ex post extension by SAEFL using expert judgment from FOCA about the yearly average split of international and domestic flights (FOCA 1999, see Table 31 below). Therefore, the bottom-up approach includes a top-down element. At the moment it is not possible to replace this expert judgment due to a lack of information about the destination of foreign aircraft.

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.

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.

Military aviation

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

The fuel consumption 1990–2002 is known yearly since it is being copied from the logbooks of the military aircrafts (SAEFL 2000d). A very small fraction of fuel is consumed for training abroad and might be allocated under “International Bunkers” (less than 3% of total consumption). Since the exact number is not known, it is not subtracted from the total

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

consumption but included under domestic 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 by the Federal Office for Military Aviation (Bundesamt für Betriebe der Luftwaffe) for 1990, 1995. For the other years, the emissions are interpolated or extrapolated (extrapolation using the corresponding fuel consumption). The extension to $CO_2$, $CH_4$, $N_2O$, NMVOC and $SO_2$ is accomplished by SAEFL.

*Emission Factors*

Civil and military aviation

- $CO_2$: The emission factor of 73.2 t/TJ is country specific and is based on measurements and analyses of fuel samples (see Table 16).
- $NO_x$, VOC, CO: For civil aviation, the factors of the ICAO "Aircraft Engine Exhaust Emissions Data Bank" are used. (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). For military aviation, engine producer information is used (for details on both, civil and military aviation, see SAEFL 1996a, p. 202).
- $CH_4$, 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 jet kerosene. For 2002 the following values are used: civil aviation bunker 0.023 t/TJ, civil aviation domestic 0.018 t/TJ, military aviation 0.032 t/TJ.

*Activity Data*

Civil aviation

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 domestic civil aviation. In this database, the consumption is known for LTO / cruise phase and Airport / airfield types, respectively. The percentage of consumption attributed to domestic aviation is given in Table 31 (expert judgement by FOCA), the fuel consumption is shown in Table 32.

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

Table 31 Shares applied for allocation of fuel consumption (territorial database). Large aircraft include jet and turboprop engines, small aircraft operate with piston engines (expert judgment, FOCA 1999).

Military aviation

The fuel consumption 1990–2002 is available on a yearly basis. For modelling non-$CO_2$ emissions, the split of the fuel consumption between LTO and cruise phase must be known. This split was determined for the two years1990 (21%:79%) and 1995 (22%:78%) (SAEFL 1996a). For the years between 1990 and 1995, the split is linearly interpolated, for 1996–2002 it is set constant (22%:78%).

Fuel consumption of civil and military aviation

| Aviation | 1990 | 1995 | 2000 | 2002 |
|---|---|---|---|---|
| Fuel Consumption | | TJ | | |
| Civil | 1'270 | 975 | 1'122 | 1'061 |
| Military | 2'735 | 1'955 | 1'793 | 1'837 |
| **Sum** | **4'005** | **2'930** | **2'915** | **2'898** |

Table 32 Fuel consumption (jet kerosene) of civil and military aviation.

**Road Transportation (1A3b)**

*Methodology*

The $CO_2$ emissions are calculated with a tier 1 method (top-down) using country-specific emission factors as suggested by IPCC Good Practice Guidance (see Table 16). The other gases are modelled with a well-documented national method (SAEFL 1995a, 2000b, 2000c). The approach corresponds methodologically to Box 1 in the decision tree of Figure 2.5 (p. 2.45) of IPCC Good Practice Guidance.

The determination of $CO_2$ emissions is based on the amounts of gasoline and diesel fuel sold in Switzerland. These numbers are taken from the national fuel statistics, which are part of the Swiss global energy statistics (SFOE 2002). $CO_2$ emissions are calculated taking into account the carbon content of fuels.

For the determination of the other greenhouse gases and for further disaggregation 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 (SAEFL 1995a, 2000c). The traffic model is based on a origin-destination matrix that is assigned to a network of about 40'000 road-sections (links). The model is calibrated by traffic counts from the national traffic-counter network (239 stations all over Switzerland, ASTRA 2000). The model generates the average daily traffic (vehicles per day) for every link including vehicle category and traffic situation (dynamic driving behaviour). For every situation there are emission factors in the database, which allow calculating the hot exhaust emissions of all gases. Vehicle stocks[4], number of starts, trip length distributions and standing time distributions are further elements of the traffic model that are needed for modelling the cold start and evaporative emissions[5].

Due to fuel price differences, in the vicinity of the national borders, gasoline stations sell relevant amounts of gasoline to foreigners. This fuel is mainly consumed abroad. Thus, related non-$CO_2$ emissions 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 global energy statistics and fuel consumption derived from the traffic model. The resulting amount of fuel is multiplied with mean emission factors to determine the related emissions of $CH_4$, $N_2O$, $NO_x$, CO, NMVOC, $SO_2$.

[4] The vehicle registration in Switzerland delivers all inputs to build up the fleet composition 1990-2002, which is characterized e.g. by vehicle category, motor size, fuel type, total weight, vehicle age and exhaust technology.

[5] Evaporative NMVOC emissions from fuel leakages during driving cycles ("running losses") are not modelled since no reliable emissions factors are available.

*Emission Factors*

The emission factors for $CO_2$ are country-specific and based on measurements and analyses of fuel samples (see Table 16). Emission factors for the further gases are derived from “emissions functions” which are measured for a large number of driving patterns and exhaust technologies within an international measurement program[6] of Switzerland together with Austria, Germany and the Netherlands. The database “Handbook of Emissions Factors” documents specific fleet compositions for specific years (SAEFL 2000c). Corrective factors are provided to account for future changes in exhaust technologies.

The following table shows a selection of mean emission factors. The $CO_2$ factors are constant over the whole period 1990–2002 due to constant fuel qualities. For the other gases, more or less pronounced decreases occur due to new emission regulations (mandatory use of catalytic converters for gasoline cars and lower limits for sulphur content in diesel fuels). $N_2O$ has been emitted by early models of catalytic converters, leading to an emission increase until 1998. Recent converter technologies have overcome this problem resulting in a decrease of the (mean) emission factor.

| **Emission Factors for Road Transport (All Vehicle Categories)** | | | | | | |
|---|---|---|---|---|---|---|
| **Gas** | **Fuel type** | **unit** | **1990** | **1995** | **2000** | **2002** |
| $CO_2$ | gasoline | t/TJ | 73.9 | 73.9 | 73.9 | 73.9 |
| | diesel | t/TJ | 73.6 | 73.6 | 73.6 | 73.6 |
| $CH_4$ | gasoline | kg/TJ | 28.1 | 18.6 | 11.7 | 9.8 |
| | diesel | kg/TJ | 2.6 | 2.3 | 1.6 | 1.4 |
| $N_2O$ | gasoline | kg/TJ | 6.7 | 11.1 | 11.8 | 10.9 |
| | diesel | kg/TJ | 2.7 | 2.8 | 2.8 | 2.8 |
| $NO_x$ | gasoline | kg/TJ | 504 | 299 | 173 | 140 |
| | diesel | kg/TJ | 773 | 710 | 567 | 496 |
| CO | gasoline | kg/TJ | 3755 | 2391 | 1551 | 1330 |
| | diesel | kg/TJ | 244 | 208 | 130 | 109 |
| NMVOC | gasoline | kg/TJ | 632 | 349 | 165 | 125 |
| | diesel | kg/TJ | 107 | 92 | 64 | 56 |
| $SO_2$ | gasoline | kg/TJ | 9.4 | 9.4 | 6.7 | 4.8 |
| | diesel | kg/TJ | 65.4 | 23.4 | 14.0 | 9.3 |

Table 33 Selected mean emission factors for road transport. Average over all vehicle categories. For more details see Annex 3.

Further emission factors are given in more detail in Annex 3.

*Activity Data*

The determination of the emissions is based on the amount of gasoline and diesel fuel sold in Switzerland.

[6] Measurement cycle is the „Neuer Europäischer Fahrzyklus“ (NEFZ)

| Fuel sales in Switzerland (1990 = 100%) | | | | | |
|---|---|---|---|---|---|
| **Fuel type** | **unit** | **1990** | **1995** | **2000** | **2002** |
| gasoline | TJ | 152'489 | 148'276 | 164'761 | 156'566 |
| | % | 100% | 97% | 108% | 103% |
| diesel | TJ | 33'878 | 34'269 | 41'723 | 44'557 |
| | % | 100% | 101% | 123% | 132% |
| Sum | TJ | 188'357 | 184'540 | 208'484 | 203'124 |
| | % | 100% | 98% | 111% | 108% |

Table 34 Gasoline and diesel sales in Switzerland (Swiss Global energy statistics, SFOE 2002). 100% refers to 1990.

Further activity data needed for modelling non-$CO_2$ emissions are vehicle kilometres (Table 35), vehicle stocks and the number of starts per vehicle (Table 36):

| Vehicle Kilometres | | | | |
|---|---|---|---|---|
| **Vehicle category** | **1990** | **1995** | **2000** | **2002** |
| | million vehicle-km (1990 = 100%) | | | |
| Passenger Car | 42'649 | 45'592 | 48'492 | 49'380 |
| | 100% | 107% | 114% | 116% |
| Light Duty Vehicle | 2'594 | 2'794 | 3'252 | 3’475 |
| | 100% | 108% | 125% | 134% |
| Heavy Duty Vehicle | 2'195 | 2'186 | 2'551 | 2’508 |
| | 100% | 100% | 116% | 114% |
| Coach | 108 | 110 | 122 | 131 |
| | 100% | 102% | 113% | 121% |
| Urban Bus | 174 | 192 | 200 | 200 |
| | 100% | 110% | 115% | 115% |
| Motorcycle | 1'163 | 1'318 | 1'464 | 1’499 |
| | 100% | 113% | 126% | 129% |
| Moped | 862 | 410 | 338 | 326 |
| | 100% | 48% | 39% | 38% |

Table 35 Vehicle kilometres by vehicle categories. The base year 1990 is set to 100%.

In 2002, 86% of total vehicle kilometres are driven by passenger cars, 6% and 4.4% by light and heavy duty vehicles, respectively. The kilometres travelled increased for all vehicle categories (except mopeds), totalling 16% in the period 1990–2002 (1.2% per year). In the same period, fuel consumption increased by 8%, indicating improved fuel efficiency.

| Vehicle category | specification | 1990 | 1995 | 2000 | 2002 |
|---|---|---|---|---|---|
| Passenger Cars | stock in 1000 veh. | 2'985 | 3'229 | 3'400 | 3’480 |
| | starts per veh. per day | 2.91 | 2.83 | 2.75 | 2.72 |
| Light Duty Vehicles | stock in 1000 veh. | 196 | 211 | 246 | 263 |
| | starts per veh. per day | 1.97 | 1.97 | 1.96 | 1.96 |

Table 36 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 railway statistics (kilometres travelled, number of engines per engine-power class, SAEFL 2000d).

*Emission Factors*

Only diesel fuel is being used. The emission factor for $CO_2$ is 73.6 t/TJ (Diesel oil, see Table 16). For $N_2O$, $NO_x$, CO, VOC, $SO_2$ emission factors for diesel engines are used (SAEFL 1996a, pp. 201 ff). VOC emissions are split into $CH_4$ and NMVOC according to a constant split of 3 % $CH_4$ and 97 % NMVOC.

*Activity data*

Detailed information (stock numbers, engine-power classes, operating hours, fuel consumption) is available from the Swiss Federal Railways.

| Railways: locomotive and other tractive vehicles | unit | 1990 | 1995 | 2000 | 2002 |
|---|---|---|---|---|---|
| Diesel consumption | t | 9'698 | 8'495 | 8'364 | 8'363 |
| | TJ | 415 | 364 | 358 | 358 |
| $CO_2$ emission | Gg $CO_2$ | 31 | 27 | 26 | 26 |

Table 37 Activity data and $CO_2$ emissions for railways.

## Navigation (1A3d)

*Methodology*

Passenger ships, dredgers, fishing boats, motor and sailing boats on the lakes in Switzerland and on the river Rhine are 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 and 1995. For the other years, the emissions are interpolated/extrapolated based on the kilometres travelled.

*Emission Factors*

All relevant $CO_2$ emission factors are documented in Annex 2. For $N_2O$, $NO_x$, CO, VOC, $SO_2$ emission factors for diesel and gasoline engines are used (SAEFL 1996a, p. 201, 203). VOC emissions are divided into $CH_4$ and NMVOC depending on the fuel type (SAEFL 1996a, p. 204).

*Activity data*

The kilometres of passenger ships add up to 2.2 million per year. The value is approximately constant over the period 1990–2002. For all other motor boats the emission model is based on the number of operating hours which are estimated at 3 million hours per year. Again, this value is almost constant over the period 1990–2002. The fuel consumption is shown in the following table. The fuel types used in navigation are: diesel (2002: 453 TJ), gasoline (2002: 747 TJ), light fuel oil (2002: 231 TJ) and heavy fuel oil (2002: 25 TJ).

| Navigation | unit | 1990 | 1995 | 2000 | 2002 |
|---|---|---|---|---|---|
| Fuel consumption | TJ | 1'369 | 1'243 | 1'368 | 1'456 |
| $CO_2$ emission | Gg $CO_2$ | 101 | 92 | 101 | 107 |

Table 38 Activity data and $CO_2$ emissions for navigation.

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

$CO_2$ from the combustion of gaseous and liquid fuels in Other Sectors (1A4) is a key source regarding both level and trend.

"Other Sectors" (source category 1A4) comprises

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

### d) 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, based on CORINAIR. A top-down method based on aggregated fuel consumption data from the Swiss global energy statistics is used to calculate emissions. These sources are characterized by rather similar combustion processes and the same emission factors are applied throughout these sources. Emissions of GHGs are calculated by multiplying levels of activity by emission factors.

*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).

The activity data on LFO use from the Swiss global energy statistics (SFOE2002) 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. For CO emissions from coal, expert judgement has been used to estimate the fraction of modern boilers vs. older high-CO boilers.

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 | 37 |
| 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 | 2'600 | 40 | 20 |

Table 39 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 $CO_2$ 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.

*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 global energy statistics (SFOE 2002; table 17).

| Source/Fuel | Unit | 1990 | 1995 | 2000 | 2002 |
|---|---|---|---|---|---|
| **1A4a Commercial/Institutional** | | | | | |
| Total (excl. Biomass) | TJ | 88'110 | 89'160 | 83'712 | 82'922 |
| Light fuel oil | TJ | 75'070 | 73'490 | 56'572 | 55'122 |
| Natural gas | TJ | 13'010 | 15'650 | 27'050 | 27'800 |
| Coal | TJ | 30 | 20 | 90 | NO |
| Biomass | TJ | 3'330 | 4'510 | 4'400 | 5'300 |
| **1A4b Residential** | | | | | |
| Total (excl. Biomass) | TJ | 165'440 | 172'150 | 157'380 | 160'600 |
| Light fuel oil | TJ | 139'170 | 137'810 | 120'960 | 122'670 |
| Natural gas | TJ | 25'620 | 33'880 | 36'290 | 37'790 |
| Coal | TJ | 650 | 460 | 130 | 140 |
| Biomass | TJ | 8'430 | 9'420 | 8'560 | 8'030 |

Table 40 Activity data in 1A4a Commercial/Institutional and 1A4b Residential

### Agriculture/Forestry (1A4c)

*Methodology*

For source category 1A4c, a country specific Tier 3 method is used, based on CORINAIR. 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 e) "Other – Off-road" below.

*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 1.3). Some of the emission factors have been updated based on expert judgement.

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

*Activity Data*

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

Off-road machinery: Activity data is documented in SAEFL 2000d.

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

$CO_2$ from the combustion of liquid fuels in Source Category Other 1A5 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 2000d). Tier 2 methods were applied. For the sections construction, hobby, industry, and military, the emissions were modelled individually.

*Emission Factors*

All relevant $CO_2$ emission factors are documented in Annex 2. For $N_2O$, $NO_x$, CO, VOC, $SO_2$, emission factors for diesel and gasoline engines are used (SAEFL 1996a, p. 201, 203). VOC emissions are divided into $CH_4$ and NMVOC depending on the fuel type (SAEFL 1996a, p. 204).

*Activity Data*

All motorised vehicles that have to be registered (and thus carry a license number) are recorded in a national database (MOFIS/BATT) including off-road vehicles for construction, hobby, industry, and military. Information on the number of vehicles, engine power and fuel type are taken from the database for emission modelling. For small vehicles without license number, the information needed was gathered from the vehicle producers and other professional associations.

| **Source** | **1990** | | **1995** | | **2000** | | **2002** | |
|---|---|---|---|---|---|---|---|---|
| | Fuel Cons. TJ | Emission Gg $CO_2$ | Fuel Cons. TJ | Emission Gg $CO_2$ | Fuel Cons. TJ | Emission Gg $CO_2$ | Fuel Cons. TJ | Emission Gg $CO_2$ |
| Construction | 6'295 | 463 | 5'941 | 437 | 5'178 | 381 | 5'108 | 376 |
| Hobby | 1'666 | 123 | 1'538 | 114 | 1'724 | 127 | 1'835 | 136 |
| Industry | 1'609 | 119 | 1'815 | 134 | 1'851 | 136 | 1'873 | 138 |
| Military (without aviation) | 51 | 4 | 56 | 4 | 43 | 3 | 43 | 3 |
| **Sum** | **9'622** | **709** | **9'350** | **689** | **8'796** | **648** | **8'859** | **653** |

Table 41 Activity data (fuel consumption) and $CO_2$ emissions for off-road activities Construction, Hobby, Industry and Military (without Military Aviation, which is included in Aviation).

## 3.2.3. Uncertainties and Time-Series Consistency

### Energy Industries (1A1), Manufacturing Industries and Construction (1A2) and Other Sectors (Commercial, Residential, Agriculture, Forestry; 1A4)

Completeness: All estimates are complete.

Uncertainty: A preliminary uncertainty assessment for source categories 1A1, 1A2 and 1A4 based on expert judgement results in high confidence in estimations of aggregate $CO_2$ emissions (and partially of the $SO_2$ emissions), because of the high quality of activity data and emission factors. Uncertainty in emissions of other gases is estimated to be medium[7].

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

Time-series consistency: Consistency in 1A2 and 1A4: In 1999, Swiss global energy statistics (SFOE 2002) changed the definition of categories “Industry” and “Services”. In particular, construction industry has been shifted from “Services” to “Industry”. This is the main reason for emissions from 1A2 Manufacturing Industries and Construction to rise by almost 1000Gg $CO_2$eq between 1998 and 1999, while emissions from 1A4 Other Sectors drop about the same amount (see Table 10 in Section 2.3). Therefore, the time-series of Swiss global energy statistics, that form the basis for these inventory categories, are distorted. The removal of this distortion is a planned improvement.
The time-series in 1A1 is consistent.

**Transport (1A3)**

Aviation (1A3a)

Completeness: The estimates of fuel consumption for civil and military aviation are complete. Therefore, the emissions may be considered complete as well.

Uncertainty: Two levels of uncertainty may be distinguished. The first level contains all – domestic 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 domestic 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 that the result is not strongly dependent on the value of the split factors. Therefore, the quality level of the domestic and the bunker emissions is still considered “high” for $CO_2$ and $SO_2$ emissions and “medium” for all other gases.

Time-series consistency: The activity data for 1990–2001 is consistent. 2002 data are extrapolated from 2001 data and will be replaced as soon as the actual data 2002 are available.

Road Transportation (1A3b)

Completeness: All estimates are complete.

Uncertainty: For $CO_2$ and $SO_2$ the quality of estimates is “high” (uncertainty less than 5%) due to the complete fuel sales statistics and the regularly measured carbon and sulphur contents of the fuels. For the other gases uncertainties have been estimated: Traffic activity data were estimated twice by independent experts with resulting uncertainties of 15 % (SVI 1992) and 10 % (JRC-IPSC 2001), respectively. For the total of $NO_x$ road transportation emissions an uncertainty of 20%–25% is reported (SVI 1992). A Monte Carlo simulation by JRC-IPSC yielded a value of 25%–30 % for $NO_x$ and VOC. The quality of the emission estimates for $CH_4$, NMVOC, $NO_x$ and CO may therefore be classified as “medium”.

Time-series are consistent.

**Other (Off-road; 1A5**)

Completeness: All estimates are complete.

Uncertainty: No estimates of the uncertainties have been performed.

Time-series are consistent.

### 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 global energy statistics of SFOE. The differences in total $CO_2$ emissions for the years 1990–2002 are below 0.02 %, which marks an excellent agreement.

SAEFL-internally, a comprehensive cross check of CRF tables with the Internal Greenhouse Gas 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 determination of the emission factors for road vehicles is overseen by a group of external and international experts that guarantee an independent quality control.

**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

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 1.3).

**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 2004. 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.

CH4 and N2O emissions from cement industry are currently not estimated. It will be considered to report these emissions in future inventories.

1A2 and 1A4: The time series of Swiss global energy statistics (SFOE 2002), that form the basis for the CRF tables, are distorted (see Section on Uncertainties and Time-Series Consistency above). It is planned to perform a recalculation to resolve this inconsistency in time series.

**Disaggregation in Manufacturing Industries and Construction (1A2)**

A study on the detailed disaggregation of fuel consumption data from manufacturing industries and construction from Swiss global energy statistics is under preparation for SAEFL and is planned to be finalised in 2004. With this, a disaggregation of emissions in the individual source categories 1A2 b-f (Non-ferrous Metals; Chemicals; Pulp, Paper and Print; Food Processing, Beverages and Tobacco; Other) can be achieved in future inventory submissions.

The time series in 1A2 (and 1A4) are not fully consistent (see Section 3.2.3). It is planned to remove these inconsistencies in future inventory 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), will undergo major revision. The objective is to establish a new model with structures similar to the on-road traffic model: updated activity data, a common database for the emission factors and a new emission model. In the first step, reference data for 2000 will be established, forecasts follow later. Results should be available in 2005.

**Other Sectors (1A4)**

The time series in 1A4 (and 1A2) are not fully consistent (see Section 3.2.3). It is planned to remove these inconsistencies in future inventory submissions.

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

As mentioned above (Transportation 1A3), the off-road sector will be updated, including construction, hobby, industry and military as well.

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

### 3.3.1. Source Category Description

Fugitive Emissions from Fuels (1B) are not a key source.

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 2002<br>EF: EMIS 1995 |
| 1B2 b | Natural Gas | Emissions from gas pipelines and the compressor station in Ruswil, Lucerne. | Activity: Kilchmann 1995, SFOE2002<br>EF: Battelle 1994, Kilchmann 1995 |
| 1B2 c | Venting / Flaring | The release/combustion of excess gas at the oil refinery | Activity: SFOE2002<br>EF: EMIS 1995 |

Table 42 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, length and the pressure of the gas pipelines. 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), stem from Battelle 1994 and Kilchmann 1995. They 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 global energy statistics. The activity data for methane of Natural Gas (source 1B2b), is provided by Kilchmann 1995.

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).

The data on fuel consumption for the operation of the compressor station at Ruswil is based on the Swiss global energy statistics (SFOE 2002; Table 13)

### 3.3.3. Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment 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 1.3).

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 is not occurring (NO).

| International Bunker Fuels | Specification | Data Source |
|---|---|---|
| Aviation | Country-specific model | FOCA 1999: |

Table 43 Specification of Swiss source category International Bunkers for aviation.

### 3.4.2. Methodological Issues

The methodologies used are described in chapter 3.2.2: The emissions from domestic civil and military aviation are calculated with a Tier 2b method. International Bunker fuels are calculated using a top-down approach. Emissions from total jet kerosene consumption are calculated from the Swiss global energy statistics data. The emissions of domestic civil and military aviation are subtracted from this total to determine the International Bunker fuel.

| International Bunker Fuels | 1990<br>TJ | 1995<br>TJ | 2000<br>TJ | 2002<br>TJ |
|---|---|---|---|---|
| Civil Aviation | 44'069 | 52'024 | 65'111 | 56'442 |

Table 44 Fuel consumption for international bunkers (for Switzerland, only civil aviation is included).

### 3.4.3. Uncertainties and Time-Series Consistency

See remarks in chapter 3.2.2., Aviation (1A3).

### 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).

## *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 6 (Waste).

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

All data that are required for carrying out the Reference Approach (data on production; imports, exports and stock changes of all kind of fuels), are contained in the Internal Greenhouse Gas Files of SAEFL. 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). The results are exported from the Internal Greenhouse Gas Files of SAEFL into the UNFCCC Greenhouse Gas 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. Figures are taken from the Swiss global energy statistics (SFOE 2002) and from the yearly report of the Swiss Petroleum Association [Erdöl-Vereinigung/Union pétrolière] (EV 2003). 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 below 1.0% and 1.7%.

| Difference between Reference and Sectoral Approach | | | | |
|---|---|---|---|---|
| | 1990 | 1995 | 2000 | 2002 |
| Energy Consumption | 2.07% | 2.80% | 2.41% | 2.01% |
| $CO_2$ Emissions | 0.81% | 1.68% | 1.30% | 1.04% |

Table 45 Differences in energy consumption and $CO_2$ emissions between the Reference and the Sectoral (National) Approach for some 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.
- Liquid fuels/Solid fuels: in the national approach, petroleum coke as a derivate of liquid fuels is subsumed under solid fuels.
- 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).
- The conversion factors and carbon emission factors in CRF Table 1.A (b) are country-specific (see Appendix 2). Exception for crude oil: the IPCC default carbon emission factor is used (IPCC 1997b).
- In Switzerland, 100% of the gas sold is imported. The figures of gas imports in the Swiss global energy statistics (SFOE 2002) are published in GWh or TJ, therefore no conversion must be carried out.
- Most of the carbon stored in the refinery feedstock output is carbon stored in bitumen; the corresponding $CO_2$ emissions are calculated in CRF Table 1.A (d). The carbon emission factor is the IPCC default emission factor (IPCC 1997b).
- The fraction of carbon oxidized is consistently set to 1.00. For gaseous and liquid fuels this may result in a very small error in the range of 0.1% to 0.3% in the $CO_2$ emission factors. For domestic coal use this error increases to about 3%; since the fraction of coal burnt in households is smaller than 2% of all coal burnt, the overall resulting error is negligible.

# 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).

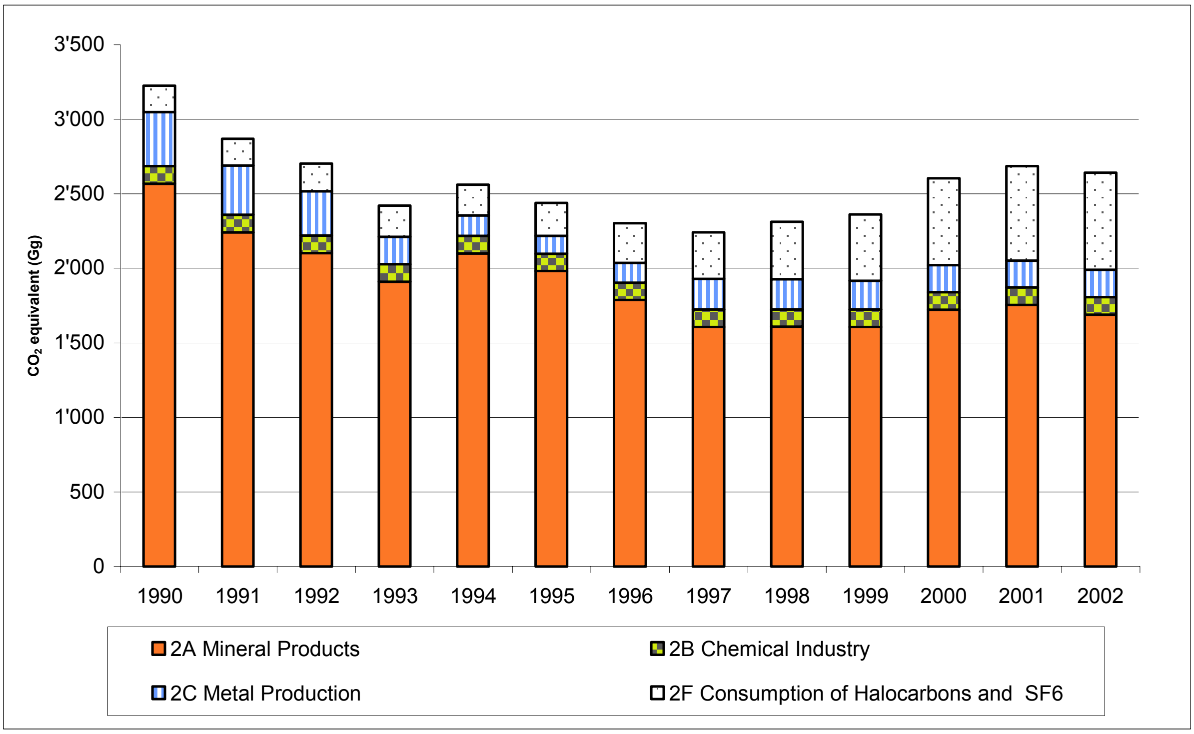


Figure 19 Switzerland's GHG emissions of source category 2 Industrial Processes 1990 – 2002. The emissions of the source category 2G Other are very small (about 1.4 Gg) and are not shown in the figure.

| Gas | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | |
| $CO_2$ | 2'841.9 | 2'499.0 | 2'342.1 | 2'076.9 | 2'234.9 | 2'101.9 | 1'918.2 | 1'738.7 | 1'748.9 | 1'750.7 | 1'869.9 | 1'904.2 | 1'845.7 |
| $CH_4$ | 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 |
| $N_2O$ | 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 |
| synthetic gases | 278.5 | 265.3 | 254.3 | 238.8 | 223.0 | 232.8 | 280.5 | 398.4 | 459.3 | 507.8 | 630.1 | 677.7 | 693.9 |
| **sum** | **3'228.2** | **2'871.8** | **2'703.9** | **2'422.3** | **2'563.2** | **2'439.9** | **2'304.0** | **2'242.5** | **2'313.7** | **2'364.2** | **2'605.9** | **2'687.8** | **2'645.8** |

Table 46 GHG emissions of source category 2 Industrial Processes 1990-2002 by gases in $CO_2$ equivalent (Gg).

Although its emissions have decreased by almost 20% in the period 1990-2002, 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 2.5 in the same period, because of the change from CFC to HFC in a lot of technical applications.

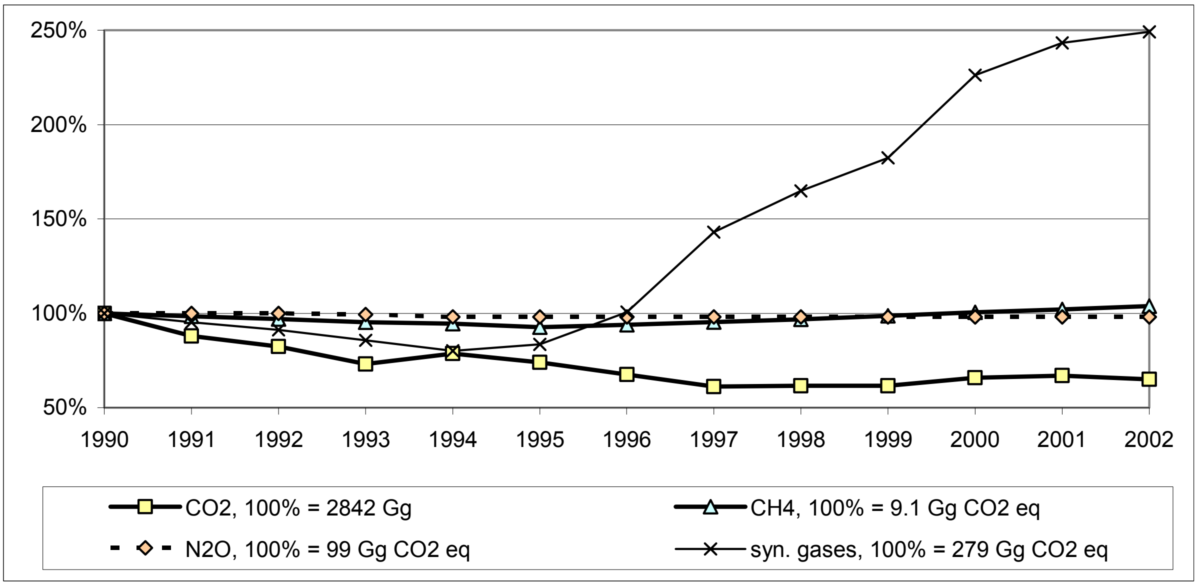


Figure 20 Relative trends of the greenhouse gases of source category 2 Industrial Processes in the period 1990-2002. The base year 1990 represents 100%.

The $CO_2$ emissions have declined to 65% whereas the synthetic gases have increased by 150% in the period 1990-2002.

## *4.2. Source Category 2A – Mineral Products*

### 4.2.1. Source Category Description

The non-energy $CO_2$ emissions in Mineral Products (2A) 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. | Activity: SAEFL 2002; EMIS 1995<br>EF: $CO_2$: WBCSD 2001; Other gases: EMIS 1995, SAEFL 2000a |
| 2A2 | Lime Production | Emissions from calcination process in lime production. | Activity: EMIS 1995<br>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 | Not estimated | |
| 2A6 | Road Paving with Asphalt | Emissions from road paving | Activity: EMIS 1995<br>EF: EMIS 1995 |
| 2A7 | Other | Not occurring in Switzerland | |

Table 47 Specification of source category 1A Mineral Products (Activity: activity data; EF: emission factors)

## 4.2.2. Methodological Issues

### a) Cement Production (2A1)

#### Methodology

*Calcination*: For the GHG emissions in Cement Production (2A1) from calcination, the Tier 2 approach of IPCC GPG is used. Emissions of GHGs related to calcination are calculated by multiplying the annual clinker output (level of activity) by emission factors. In contrast to the IPCC GPG, emissions related to cement kiln dust are not estimated. 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 based on CORINAIR. 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. Following IPCC GPG, the IPCC default CaO content of 65% in clinker is used.

The IPCC approach neglects $CO_2$ from decomposition of $MgCO_3$. In the Swiss inventory, these emissins are included based on a MgO content in clinker of 2% which results in an emission factor of 525 kg/t clinker. This emission factor has also been recommended as a default value by the Working Group Cement of the World Business Council on Sustainable Development (WBCSD 2001; Appendix 4).

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 1.3).

*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 1.3).

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

| 2A1 Cement Production | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|
| | kg/t *clinker* | g/t cem. | | | g/t cem. | g/t cem. | g/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 48 Emission Factors for 2A1 Cement Production for 2002 (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 | 1990 | 1995 | 2000 | 2002 |
|---|---|---|---|---|
| **2A1 Cement Production** | Gg | Gg | Gg | Gg |
| Cement production | 5’117 | 3’994 | 3’754 | 3’771 |
| Clinker production | 4’808 | 3’706 | 3’214 | 3150 |

Table 49 Activity data in 2A1 Cement Production.

The table above documents the decrease of Swiss cement production by 26.3% from 1990 to 2002. Cement being by far the largest $CO_2$ source in category Mineral Products (2A), this decline results in category 2A 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 GHGs are calculated by multiplying the annual lime output (level of activity) by the emission factor.

### 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 1.3).

### 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 1.3). 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 GHGs are calculated by multiplying the annual amount of asphalt products used for road paving (level of activity) by the emission factor.

**Emission Factors**

The emission factor for NMVOC emissions from Road Paving with Asphalt is country specific and amounts to 0.54 kg/t (2002). 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 1.3).

**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 1.3).

### 4.2.3. Uncertainties and Time-Series Consistency

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, $CO_2$ 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

It is planned to include emissions related to cement kiln dust to source category 2A1.

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

## *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 | |
| 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 50 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 1.3).

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 51 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 taken 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 (2B2), 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.

### 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 1.3).

**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 1.3).

## *4.4. Source Category 2C – Metal Production*

### 4.4.1. Source Category Description

The non-energy $CO_2$ emissions and PFC emissions in Metal Production (2C) 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 SF6 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 | Activity and EF: EMIS 1995 |
| 2C2 | Ferroalloys Production | Emissions from the production of Ferroalloys including consumption of fossil fuels. | Activity and EF: EMIS 1995 |
| 2C3 | Aluminium Production | Emissions from the production of Aluminium | Activity and EF: Industry Data, www.alu.ch |
| 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 |
| 2C5 | Other | Not occurring in Switzerland | |

Table 52 Specification of source category 2C Metal Production (Activity: activity data; EF: emission factors)

In source category 2C2, process emissions and emissions from combustion cannot be separated and are included under this source category.

### 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 Ferroalloys Production (2C2) a country specific approach is used. In source category 2C2 process emissions and emissions from combustion cannot be separated and therefore (negligible) combustion emissions are included in this source category. Emissions of CO and NMVOC are calculated on the basis of annual production output of ferroalloys (in t/a). Emissions of $CO_2$, $CH_4$, $N_2O$ and $SO_2$ are calculated based on fuel consumption data (in TJ) and emission factors for industrial fuel combustion.

In Aluminium Production (2C3) a country specific approach is used to calculate $CO_2$, $NO_x$, CO, NMVOC and $SO_2$ emissions. The emissions are calculated by multiplying the annual production output of aluminium (level of activity) by emission factors. Emission data for PFC is based on a Tier 3b approach. Operating parameter data (duration and frequency of anode effect) are continuously collected and emissions are calculated using activity data and smelter specific long term relationship between measured emissions and operating parameters. From this data year wise emission factors for $CF_4$ and $C_2F_6$ emission factors have been established. The emissions are then calculated by multiplying production output of aluminium by emission factors.

### Emission Factors

The emission factors for $CO_2$, $CH_4$, $N_2O$, $NO_x$, 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 1.3).

In Ferroalloys Production (2C2) no measured data for the emission of $CO_2$, $CH_4$, $N_2O$ and $SO_2$ is available. Therefore, the emission factors in 2C2 for $CO_2$, $CH_4$, $N_2O$ and $SO_2$ are based on emission factors of industrial fuel combustion.

For PFC emissions the emission factors have decreased in the last ten years by a factor of about 4. The factors according to Table 53 are used.

| Year | Emission factor (kg/t) | |
|---|---|---|
| | $CF_4$ | $C_2F_6$ |
| 1990 | 0.612 | 0.068 |
| 1991 | 0.549 | 0.061 |
| 1992 | 0.486 | 0.054 |
| 1993 | 0.423 | 0.047 |
| 1994 | 0.36 | 0.04 |
| 1995 | 0.333 | 0.037 |
| 1996 | 0.306 | 0.034 |
| 1997 | 0.279 | 0.031 |
| 1998 | 0.252 | 0.028 |
| 1999 | 0.216 | 0.024 |
| 2000 | 0.144 | 0.016 |
| 2001 | 0.144 | 0.016 |
| 2002 | 0.144 | 0.016 |

Table 53 PFC emissions factors for aluminium production.

### 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 1.3). 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).

$SF_6$ is used in Swiss magnesium foundries since 1995 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** | **1990** | **1995** | **2000** | **2001** | **2002** |
|---|---|---|---|---|---|
| **2C Metal Production** | Gg | Gg | Gg | Gg | Gg |
| 2C1 Iron and Steel | 1'288 | 902 | 938 | 950 | 960 |
| 2C3 Aluminium | 87.8 | 20.7 | 35.5 | 36.3 | 40.2 |

Table 54 Activity data for 2C Metal Production

The table above documents the decrease of iron and steel production by 25 % from 1990 to 2002 and the decrease of aluminium production by 54 % from 1990 to 2002. Iron and steel, and aluminium production being by far the largest $CO_2$ and PFC emission sources in the category Metal Production (2C), this decline results in category 2C being a key source regarding trend (however not regarding level).

## 4.4.3. Uncertainties and Time-Series Consistency

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

**2C1 Iron and Steel Production**

No uncertainty assessment has been carried out. The time series is consistent.

**2C2 Ferralloys Production**

No uncertainty assessment has been carried out. The time series is consistent.

**2C3 Aluminium Production**

No uncertainty assessment has been carried out. The time series is consistent.

**2C4 $SF_6$ used in Aluminium and Magnesium Foundries**

No uncertainty assessment has been carried out. The time series is consistent.

**2C5 Other**

No emissions occurring in this sector within Switzerland. All emissions from metal production processes are reported under 2C1 to 2C4.

## 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 1.3).

## 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

HFC emissions under Consumption of Halocarbons and $SF_6$ (2F) are a key source regarding level and trend.

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

Table 55 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.

[8] e.g. statistics on registration of cars and trucks, import statistics SAEFL on F-gases.

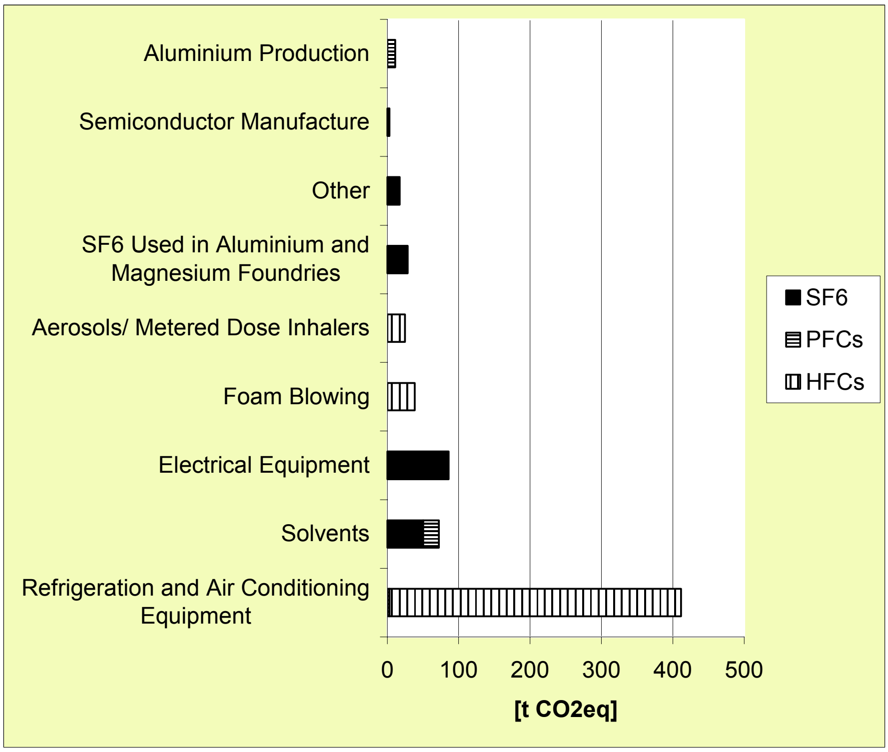


Figure 21 Distribution of emissions under source category 2F - Consumption of Halocarbons and $SF_6$ (2002 data).

## 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. 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 is documented (e.g. Table 56).

### 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 56 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] | Charge of new product [kg] | Manufacturing emission factor [% per annum] | Product life emission factor [% per annum] | Charge at end of life [% charge of new product] | Disposal loss emission factor [% charge of new product] |
|---|---|---|---|---|---|---|
| Domestic Refrigeration | 12 | 0.1 | 0.2 | 0.5 | 94 | 35 |
| 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 |

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

Table 56 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. For illustration, the detailed calculation model for car AC including the time series for the activity data can be seen from Annex 3.3. Car AC accounts for approx. 30% of the total emissions ($CO_{2\ eq}$) of 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 and PU spray applications 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.

### 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<br>HFC 152a | 50 | 6.5 | 10 | 25 / 0.7**<br>100 / 0** | 0 |
| PU spray | | 50 | 10.5 / 4.6 /3.0 * | 0.7 | 95 / 2.5 ** | 0 |

* Data for 1990 / 2000 / 2010

** Data for 1st year / following years

NR Not relevant, because no substances according to this protocol has been used

Table 57 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 95% of total production volume. For PU and XPS foams the export rate is around 20%. This has been taken into account. XPS has been produced in Switzerland in the years 1990 to 2000 using blowing agents which are not under this protocol. Today there is no production in Switzerland of XPS. 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 and $SF_6$ emissions are calculated according to 'Tier 1' method according to IPCC GPG on basis of a 'top down' approach using import statistics.

### Emission Factors

An emission factor of 50% in the first and in the second year, respectively, is applied in line with IPCC GPG.

### Activity Data

Activity data is based on import statistics. Detailed activity data for this sub-source category is available at SAEFL but not reported due to confidentiality.

## 2F6 Semiconductor Manufacturing

### Methodology

Because of the small amount of F-gases consumed for semiconductor manufacturing in Switzerland and unavailability of process specific information, emissions are estimated on basis of Tier 1 using available import statistics.

### Emission Factors

Emission factors according to IPCC GPG are being used.

### 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.

## 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). These unallocated emissions of $SF_6$ have been assigned to cables and electrical control systems using a Tier 2 approach.

**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 and 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 2001 (not for 2002). 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 58 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 2001” represents the actual emissions in Gg $CO_2$ equivalent for the specific application as used for calculating the 2001 CRF tables. The average, median, uncertainty, min. and max. 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 as well as Domestic Refrigeration have medium quality level (uncertainties between 17% and 35%), while Mobile Air-Conditioning has a high quality level (uncertainty of 7%). Detailed analysis for the stock parameters show a need for improvement on stock data for Stationary Air-Conditioning as well as PU spray stocks.

| **Application** | **Model para-meter** | **value 2001** Gg $CO_2$ eq. | **Average** Gg $CO_2$ eq. | **Median** Gg $CO_2$ eq. | **Uncer-tainty**[9] % | **min.** Gg $CO_2$ eq. | **max.** Gg $CO_2$ eq. |
|---|---|---|---|---|---|---|---|
| Commercial / Industrial Refrigeration | Emissions in Gg $CO_2$ eq. | 181 | 202 | 202 | 17 | 154 | 247 |
| Mobile Air-Conditioning | | 171 | 177 | 177 | 7 | 161 | 193 |
| Foam Blowing | | 53 | 48 | 48 | 27 | 33 | 69 |
| Stationary Air-Conditioning | | 34 | 52 | 50 | 32 | 30 | 87 |
| Transport Refrigeration | | 10 | 9.3 | 9.3 | 21 | 6 | 12 |
| Domestic Refrigeration | | 0.26 | 0.35 | 0.35 | 34 | 0.22 | 0.55 |

Table 58 Summary of results for model parameter “emissions” from Monte Carlo Analysis for 2001 data on selected emission sources.

For other categories under source category 2F no detailed uncertainty assessment has been carried out. A preliminary uncertainty assessment based on expert judgement results in medium confidence in these emissions estimates.

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.

### 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.

## *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.

[9] Uncertainty defined as 2*sd/av*100% with sd = standard deviation and av = average.

| 2G | Source | Specification | Data Source |
|---|---|---|---|
| 2G | Other | Emissions from other industry production, including food, drink, pulp and paper industries, and from crematories.<br>In Switzerland, source category 2G includes the sources pertaining to source category 2D. | Activity and EF: EMIS 1995 |

Table 59 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 1.3).

### 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 1.3). 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 1.3).

# 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 the Waste Chapter under 8. Emissions from the use of halocarbons and sulphur hexafluoride are reported in the Industrial Processes Chapter under 2 F. 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.

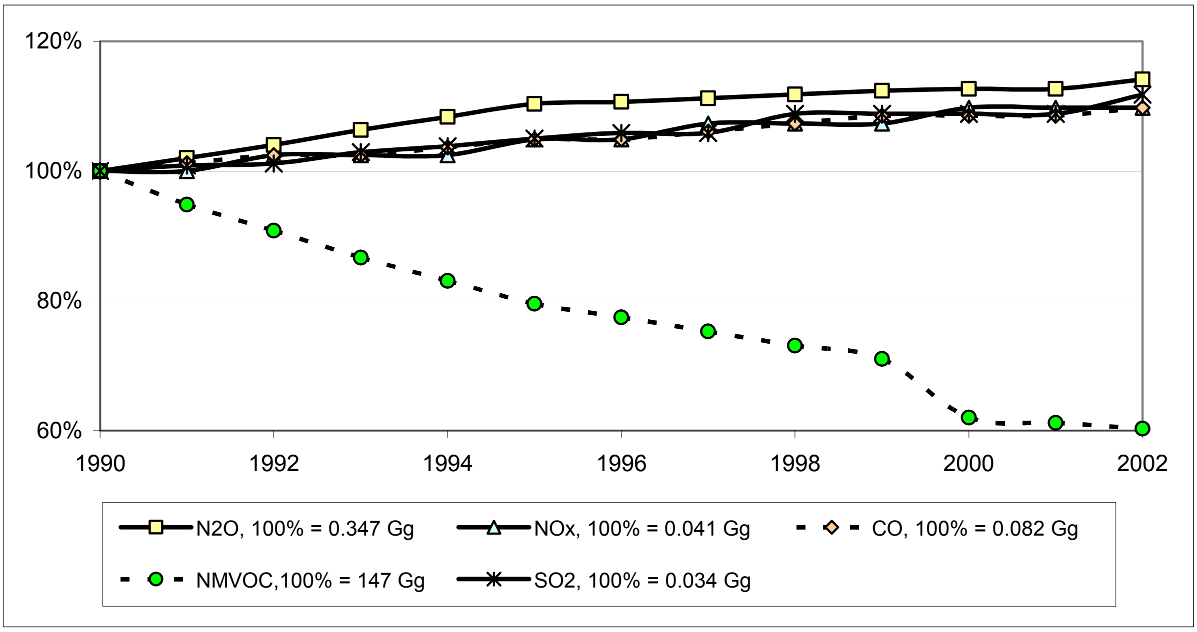


Figure 22: Overview over emissions in category 5 Solvent and other product use in Switzerland.

NMVOC emissions have diminished since 1990 by more than a third due to different reduction efforts. The introduction of the VOC-tax in 2000 (CH 2003) has reduced the VOC emissions between 1999 and 2002 by about 14 Gg according to expert judgement. The other emissions have increased since 1990 by about 10%.

## 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: EMIS 1995<br>EF: EMIS 1995 |

Table 60: Specification of source category 3A " Paint Application " (Activity: activity data; EF: emission factors)

## 5.2.2. Methodological Issues

### Methodology

For paint application (3A) a country specific method based on the consumption of paint and its solvent content is used, based on CORINAIR.

### Emission Factors

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

### Activity Data

The activity data correspond to the annual consumption of paints. They are based on data from industry and expert estimates, documented in the EMIS 1995 database. The introduction of the VOC-tax on January 1st 2000 has lead to a reduction of NMVOC emissions. The impact of this tax on NMVOC emissions is estimated based on expert judgement (SAEFL) and is subtracted globally for all solvent emissions.

## 5.2.3. 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.

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 recalculations have been carried out.

## 5.2.6. Source-Specific Planned Improvements

For the years 1998 and 2001 a complete recalculation of the NMVOC emissions is available (SAEFL 2003). This recalculation shows, that the estimations of the NMVOC emissions tend to be overestimated. The main reason are new prescriptions in the Ordinance on Air Pollution Control of 1992 and 1998, which had a greater effect than estimated in the EMIS database (EMIS 1995).

Recalculation of the complete time series (incl. 1998 and 2001) will be done for a later submission.

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

## 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, EMIS 1995<br>EF: industry data, EMIS 1995 |

Table 61: 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 is used, according to the detailed CORINAIR method.

**Emission Factors**

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

**Activity Data**

The activity data are based on data from industry and expert estimates, documented in the EMIS 1995 database. The introduction of the VOC-tax on January 1st 2000 has lead to a reduction of NMVOC emissions. The impact of this tax on NMVOC emissions is estimated based on expert judgement (SAEFL) and is subtracted globally for all solvent emissions.

### 5.3.3. 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 (SAEFL 2003) results in medium confidence in emissions estimates.

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 recalculations have been carried out.

### 5.3.6. Source-Specific Planned Improvements

It is planned to update the emission factors as well as the activity databased on SAEFL 2003 for a later submission (See section 5.2.6.).

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

## *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; production of perfume /aroma and cosmetics; processing of PVC, polystyrene foam, polyurethane and polyester; | Activity: industry data, EMIS 1995<br>EF: industry data, EMIS 1995 |

Table 62: Specification of source category 3B "Degreasing and Dry Cleaning" (Activity: activity data; EF: emission factors)

### 5.4.2. Methodological Issues

#### Methodology

For category 3C country specific methods based on CORINAIR are used. The emissions of fine chemical production are based on a mass balance analysis, consistent with the detailed CORINAIR methodology. 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 the production of cosmetics, perfume and aroma are calculated per employee. 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 the EMIS 1995 database. 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 EMIS 1995 database. The introduction of the VOC-tax on January 1st 2000 has lead to a reduction of NMVOC emissions. The impact of this tax on NMVOC emissions is estimated based on expert judgement (SAEFL) and is subtracted globally for all solvent emissions.

### 5.4.3. 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.

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 recalculations have been carried out.

### 5.4.6. Source-Specific Planned Improvements

It is planned to update the emission factors as well as the activity databased on SAEFL 2003 for a later submission (See section 5.2.6.).

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

## *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; fireworks; $N_2O$ in households, hospitals; 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; solvent use; wood preservation; medical practitioners; other health care institutions; not attributable solvent emissions; | Activity: industry data, EMIS 1995 EF: industry data, EMIS 1995 |

Table 63: 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, based on CORINAIR.

### Emission Factors

Emission factors for $N_2O$, $NO_x$, CO, NMVOC and $SO_2$ are country specific based on data from industry and expert estimates, documented in the EMIS 1995 database.

### Activity Data

The activity data correspond to the annual production/consumption of solvents. They are based on data from industry and expert estimates, documented in the EMIS 1995 database. The introduction of the VOC-tax on January 1st 2000 has lead to a reduction of NMVOC emissions. The impact of this tax on NMVOC emissions is estimated based on expert judgement (SAEFL) and is subtracted globally for all solvent emissions.

## 5.5.3. 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 judgement results in medium confidence in emissions estimates.

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 recalculations have been carried out.

## 5.5.6. Source-Specific Planned Improvements

It is planned to update the emission factors as well as the activity databased on SAEFL 2003 for a later submission (See section 5.2.6.).

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

# 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 2002 were 5'425 Gg $CO_2$ equivalents in total, which is a contribution of 10.4% to the total of Swiss greenhouse gas emissions. Main agricultural source of greenhouse gases in 2002 were enteric fermentation emitting 2'453 Gg $CO_2$ equivalents, followed by agricultural soils with 2'158 Gg $CO_2$ equivalents. Emissions in all source categories are declining.

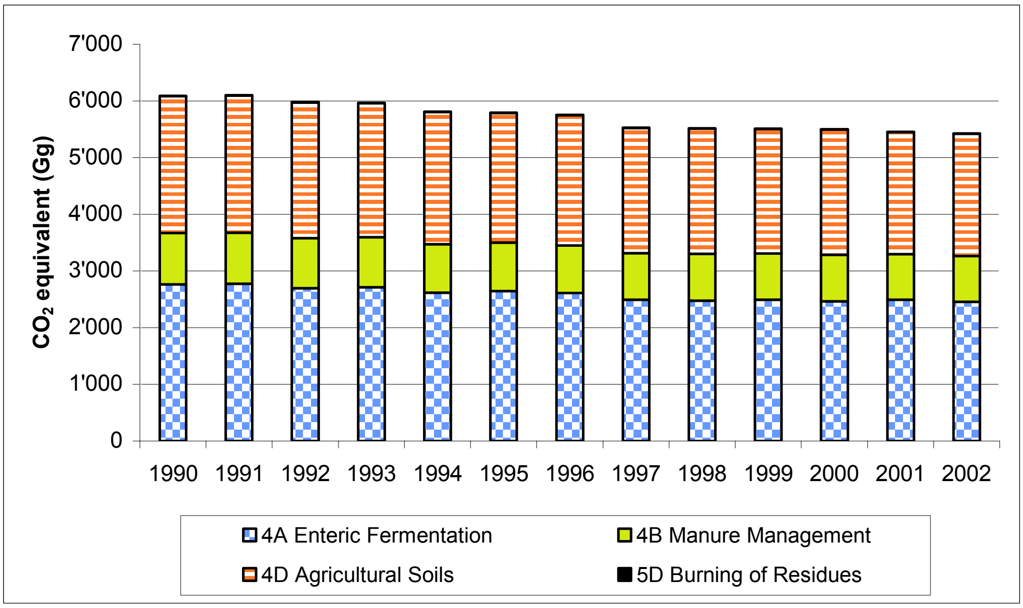


Figure 23 Greenhouse gas emissions in Gg $CO_2$ equivalents of agriculture1990–2002.

Main greenhouse gases are methane and $N_2O$. No $CO_2$ emissions are reported in the agricultural sector. $CO_2$ emissions from soils are reported under land use change and forestry.

| Gas | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | |
| $CO_2$ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| $CH_4$ | 3'225 | 3'235 | 3'142 | 3'163 | 3'048 | 3'080 | 3'028 | 2'898 | 2'886 | 2'900 | 2'871 | 2'903 | 2'856 |
| $N_2O$ | 2'866 | 2'864 | 2'838 | 2'802 | 2'760 | 2'715 | 2'725 | 2'632 | 2'630 | 2'609 | 2'629 | 2'553 | 2'570 |

Table 64 Greenhouse gas emissions in Gg $CO_2$ equivalents of agriculture1990–2002 (NO: not occurring).

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

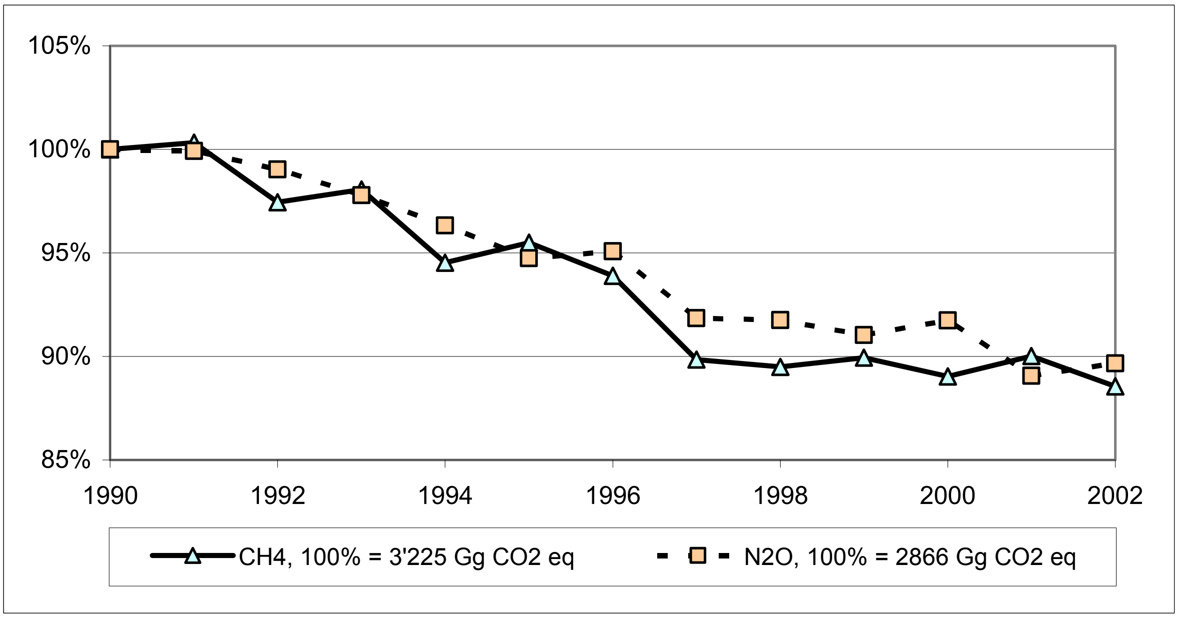


Figure 24 Trend of the greenhouse gases of the agricultural sector 1990–2002. The base year 1990 represents 100%.

Among the nineteen key sources of the Swiss inventory, two are out of the agricultural sector, namely $CH_4$ emissions from enteric fermentation and $N_2O$ emissions from agricultural soils.

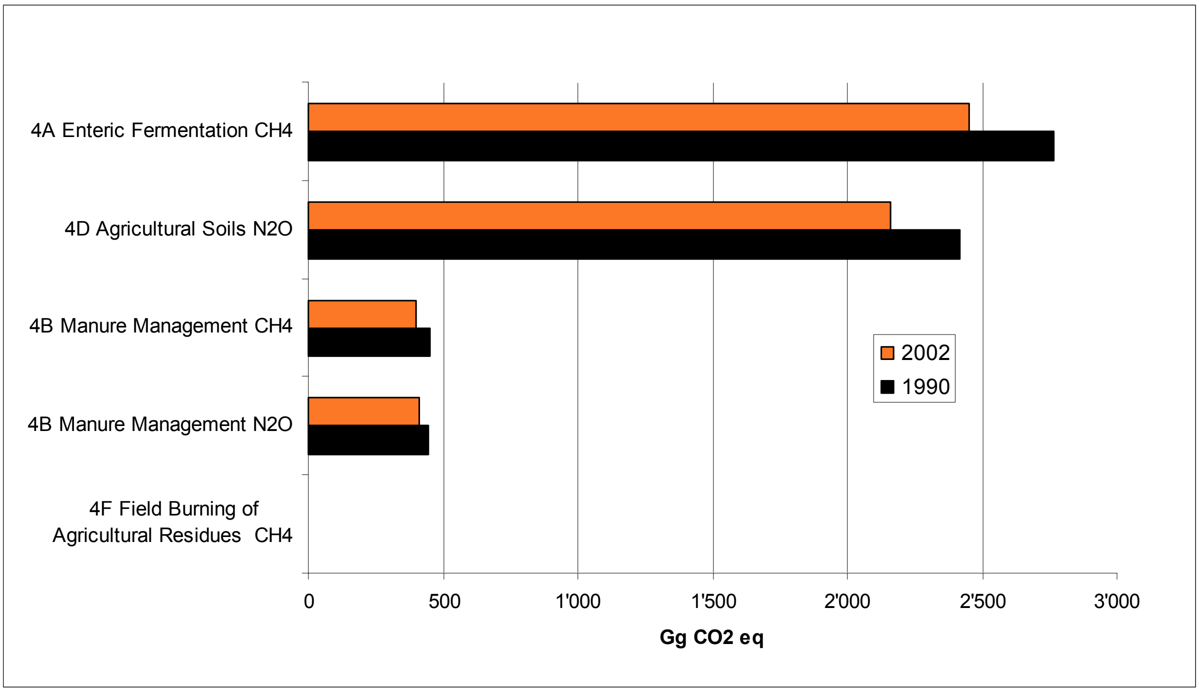


Figure 25 Emissions in $CO_2$ equivalents per source category in the agricultural sector. 4A and 4D are key source categories.

## 6.2. *Source Category 4A – Enteric Fermentation*

### 6.2.1. Source Category Description

The $CH_4$ emissions from 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 were declining since 1990, mainly due to a reduction of the number of cattle. Emissions from cattle contribute to approximately 95% of the emissions from enteric fermentation.

| 4A | Source | Specification | Data Source |
|---|---|---|---|
| 4A1<br><br>4A3<br>4A4 | Cattle<br><br>Sheep<br>Goats | Emissions from Dairy cattle and non-dairy cattle (beef cattle) | Activity: Livestock data, net energy and feed intake losses from SBV 2002<br>EF: SAEFL 1998 |
| 4A6<br>4A8 | Horses<br>Swine | | Activity: Livestock data, digestible energy, feed intake losses from SBV 2002<br>EF: SAEFL 1998 |
| A47 | Mules and asses | | Activity: Livestock data from SFSO 2002; digestible energy and Feed intake losses from SBV 2002<br>EF: SAEFL 1998 |
| 4A9 | Poultry | | Activity: Livestock data from SBV 2002 and SFSO 2002; metabolizable energy from SBV 2002, Feed intake losses from SBV 2002<br>EF: SAEFL 1998 |

Table 65 Specification of source category 4A Enteric Fermentation. Activity: activity data; EF: emission factors.

### 6.2.2. Methodological Issues

#### Methodology

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

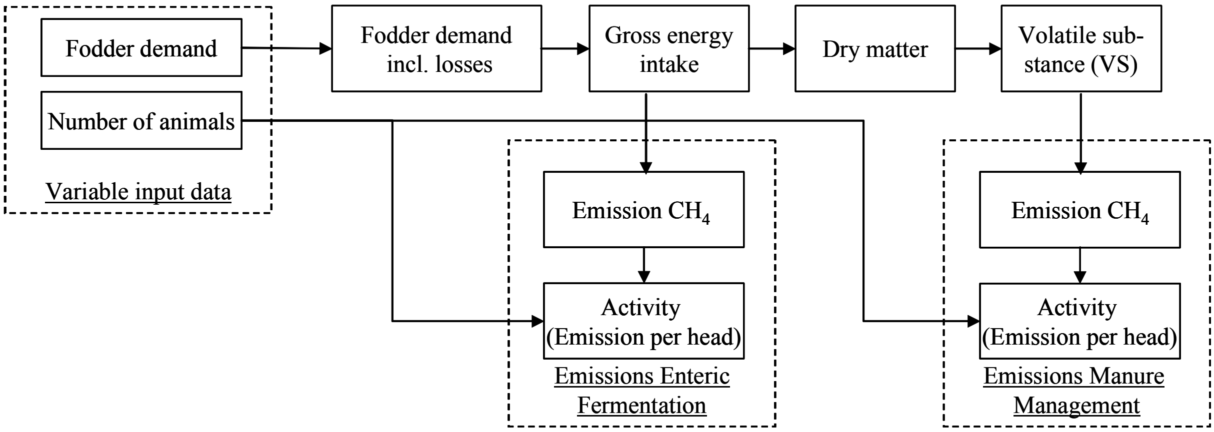


Figure 26 Diagram of the $CH_4$ Emissions in Agriculture.

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. Equation is based on the parameters gross energy intake and the methane conversion rate. The **gross energy intake** has been calculated from available data on net energy (lactation, growth), digestible energy and metabolizable energy (SAEFL 1998, p. 62f.).

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. 65f. and Hadorn 1994).

### 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:

| Livestock Groups | Gross energy intake (MJ/head/y) | | | |
|---|---|---|---|---|
| | 1990 | 2000 | 2001 | 2002 |
| Cattle | 171.98 | 177.86 | 177.25 | 175.90 |
| Dairy cattle | 259.19 | 260.76 | 263.21 | 256.75 |
| Non-Dairy cattle | 106.57 | 110.09 | 107.81 | 109.94 |
| Sheep | 19.72 | 21.66 | 21.73 | 21.53 |
| Goats | 28.17 | 25.86 | 28.53 | 27.52 |
| Horses | 141.63 | 130.74 | 135.88 | 135.70 |
| Ponies, Mules and Asses | 157.91 | 98.38 | 96.41 | 92.88 |
| Swine | 30.54 | 31.57 | 30.54 | 30.32 |
| Poultry | 2.30 | 2.07 | 2.12 | 2.18 |

Table 66 Gross energy intake of different livestock groups. References: SBV 2002.

### Activity data

The activity data input has been obtained from statistics published by the Swiss Farmers Association (SBV 2002) and by the Swiss Federal Statistical Office (SFSO 2002).

The activity data are grouped into the livestock categories required for emission calculation.[10]

| Livestock Groups | Population Size (1000 head) | | | |
|---|---|---|---|---|
| | 1990 | 2000 | 2001 | 2002 |
| Cattle | 1’855 | 1’588 | 1’611 | 1’594 |
| Dairy cattle | 795 | 714 | 720 | 716 |
| Non-Dairy cattle | 1'060 | 874 | 891 | 878 |
| Sheep | 395 | 421 | 420 | 430 |
| Goats | 68 | 62 | 63 | 66 |
| Horses | 45 | 50 | 50 | 51 |
| Ponies, Mules and Asses | 7 | 12 | 12 | 13 |
| Swine | 1'787 | 1’498 | 1’548 | 1’557 |
| Poultry | 5'932 | 6’983 | 6’939 | 7’206 |

Table 67 Activity for calculating methane emissions from enteric fermentation. Reference: SBV 2002 and SFSO 2002.

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

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

### 6.2.3. Uncertainties and Time-Series Consistency

No formal uncertainty assessment has been carried out. Expert judgment assumes that uncertainties are low. According to SAEFL 1998 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).

The time series 1990–2002 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).

### 6.2.5. Source-Specific Recalculations

See chapter 9.

### 6.2.6. Source-Specific Planned Improvements

No planned improvements.

## *6.3. Source Category 4B – Manure Management*

### 6.3.1. Source Category Description

| Source category 4B “Manure Management” is not a key source. |
|---|

$CH_4$, $N_2O$ 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<br><br>4B3<br>4B4<br>4B6<br>4B8 | Cattle<br><br>Sheep<br>Goats<br>Horses<br>Swine | Dairy cattle and non-dairy cattle (beef cattle) | Activity: SBV 2002<br>EF: SAEFL 1998 |
| 4B7 | Mules and Asses | | Activity: SFSO 2002<br>EF: SAEFL 1998 |
| 4B9 | Poultry | | Activity: SBV 2002and SFSO 2002<br>EF: SAEFL 1998 |

Table 68 Specification of source category 4B Manure Management ($CH_4$). (Activity: Activity data; EF: Emission factors)

| 4B | Source | Specification | Data Source |
|---|---|---|---|
| 4B11<br>4B12 | Liquid Systems<br>Solid storage and dry lot | | Activity: SBV 2002, SFSO 2002, FAL/RAC 2001; FAL 1997<br>EF: IPCC 2000 |

Table 69 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.

### 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 is applied (SAEFL 1998, p. 71), based on the parameters organic substance in the feed intake[11] and its digestibility.[12] For the Methane Producing

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

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).

### 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 2002. Data on mules and asses as well as data on other poultry are taken from SFSO 2002.

## 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. IULIA is described in detail in FAL 2000.

For calculation of emissions from manure management IULIA differentiates the animal waste management systems Liquid systems and Dry lots. $N_2O$ 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 considered (no emissions reported). The basic animal waste management systems included in IULIA are defined in FAL 1997.

### Emission factors

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

| Source | Emission factor per animal waste management system (kg $N_2O$-N / kg N) |
|---|---|
| Liquid systems | 0.001 |
| Solid storage and dry lot | 0.020 |

Table 70 Emission factors for calculating $N_2O$ emissions from manure management. Reference: 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 2002), data on mules and asses and other poultry from SFSO 2002. Data on nitrogen excretion per animal category (kg N/head/year) are taken from FAL/RAC 2001 the fraction of animal waste management system from FAL 1997.

Input data on livestock groups are taken and converted into the following livestock categories (Walther et al. 1994).

---

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

| Livestock Group | Population Size (1'000 head) | | | |
|---|---|---|---|---|
| | 1990 | 2000 | 2001 | 2002 |
| Dairy cattle | 795 | 714 | 720 | 716 |
| Non-dairy cattle | | | | |
| Rearing cattle 1st year | 346 | 236 | 238 | 230 |
| Rearing cattle 2nd year | 253 | 222 | 219 | 219 |
| Rearing cattle 3rd year | 151 | 130 | 130 | 126 |
| Fattening calves | 122 | 139 | 155 | 161 |
| Fattening cattle < ½ year | 88 | 43 | 40 | 38 |
| Fattening cattle > ½ year | 100 | 105 | 109 | 104 |
| Swine [1)] | | | | |
| Fattening pig places | 1'012 | 851 | 868 | 874 |
| Breeding pig places | 184 | 145 | 149 | 150 |
| Sheep (sheep places) [1] | 191 | 217 | 217 | 220 |
| Goats (goat places) [1] | 40 | 37 | 35 | 36 |
| Horses [2)] | 45 | 50 | 50 | 51 |
| Foals (< 1 year) | 4 | 4 | 4 | 3 |
| Foals (1 – 2 years) | 5 | 6 | 6 | 6 |
| Other horses | 36 | 40 | 40 | 42 |
| Mules and Asses | 7 | 12 | 12 | 13 |
| Poultry | 5'932 | 6'983 | 6'939 | 10'206 |
| Laying hens | 3'083 | 2'150 | 2'069 | 2'154 |
| Young hens (< 18 weeks) | 719 | 832 | 745 | 754 |
| Broilers | 2'020 | 3'808 | 3'993 | 7'294 |
| Other poultry (turkeys) | 110 | 193 | 132 | 132 |

Table 71 Activity data for calculating $N_2O$ emissions from manure management. Reference: SBV 2002 and SFSO 2002. [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.

Information on Nitrogen excretion (kg N/head/yr) is taken from FAL/RAC 2001 (p. 48/49) (see Annex 3.4). Calculation of Nitrogen excretion of dairy cattle is based on milk production reported. The split of nitrogen flows into the different animal waste management systems including ammonia emissions is taken from FAL 1997.

## c) $NO_x$ Emissions

### Methodology

$NO_x$ emissions from manure management are estimated by taking 1.5% of nitrogen excretion from livestock. This factor is based on studies from Smith / McTaggart / Tsuruta 1997 and

Williams / Hutchinson / Fehsenfeld 1992: Data on N-excretion (kg N/head/yr) is taken from FAL/RAC 2001, the emission factor from FAL 2000.

### 6.3.3. Uncertainties and Time-Series Consistency

Quality of $CH_4$ estimates is considered to be medium. 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). For example for the category cattle this leads to an emission factor between 8.97 (minimum) and 22.75 (maximum).

Uncertainty of $N_2O$ estimates is considered to be high (minimum and maximum estimates differ by a factor between 6 and 10). The reason can be found in the emission factors for solid storage and dry lot, which have an uncertainty range between -50% and +100% (IPCC 2000). Time series between 1990 and 2002 are consistent.

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

No source-specific activities have been carried out. An internal quality control is done regularly.

### 6.3.5. Source-Specific Recalculations

See Chapter 9.

### 6.3.6. Source-Specific Planned Improvements

No improvements are planned.

## *6.4. Source Category 4C – Rice Cultivation*

Rice Cultivation is not occurring in Switzerland.

## *6.5. Source Category 4D – Agricultural Soils*

### 6.5.1. Source Category Description

| $N_2O$ emissions from agricultural soils are a key source by level. |
|---|

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 2002, FAL/RAC 2001; SFSO 2002; FAL 2003; SBV 2002<br>EF: IPCC 1997b ($N_2O$) and FAL 2000 |
| 4D2 | Animal production | Only emissions from pasture range and paddock | Activity: SBV 2002, SFSO 2002, FAL/RAC 2001; FAL 1997<br>EF: IPCC 1997b |
| 4D3 | Indirect emissions | Leaching and run-off, N deposition air to soil | Activity: SBV 2002; FAL/RAC 2001; SFSO 2002; FAC 1994a, FAC 1994b.<br>EF: IPCC 1997b |

Table 72 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.

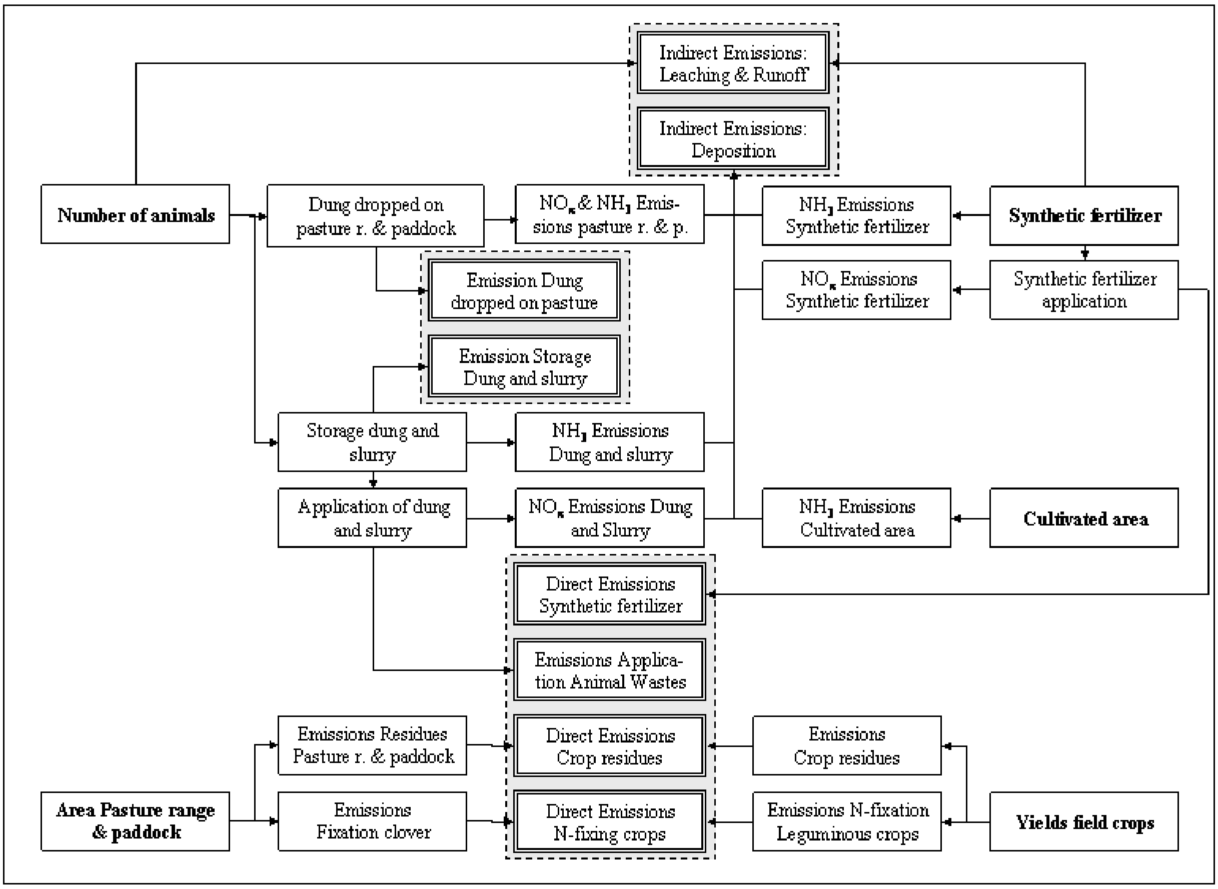


Figure 27 Diagram of the $N_2O$ Emissions in Agriculture.

Differences between IPCC and IULIA method are described in the corresponding paragraphs. For comparison of the N-flows, calculated according to the methods IPCC and IULIA, see FAL 2000, p. 74.

### *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, settlement sewage sludge and compost. The amount of Nitrogen in fertilizer is taken from SBV 2002. According to the method IULIA losses to the atmosphere are set to 6% ($NH_3$) and 1.5% ($NO_x$) instead of the IPCC value 10% (FAL 2000, p. 63).
- 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 1.5% of the excreted N.
- Emissions from crop residues are based on the amount of nitrogen transferred to the soil from crop residue. In IULIA (FAL 2000, p. 68 and p. 100) this amount is based on dry matter input data reported on crop yields (SBV 2002), the standard values for arable crop yields (FAL/RAC 2001) and standard amounts of nitrogen transferred to the soil from crop residue (FAL/RAC 2001). From 2001 on actual standard values and amounts of nitrogen transferred 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 2002.

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

For estimation of $NO_x$ emissions the method IULIA considers the results based on studies conducted by Smith / McTaggart / Tsuruta 1997 and Williams / Hutchinson / Fehsenfeld 1992. 1.5% of nitrogen in fertilizer is emitted as $NO_x$.

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.[13]

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 1.5% 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 FAL 2000.

### *Indirect emissions (4D3)*

Calculation of the indirect emissions is based on IPCC Tier 1b.

- For calculation of $N_2O$ emission 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 2002, FAC 1994a and FAC 1994b. $Frac_{Leach}$ is set as 0.2 instead of the IPCC default of 0.3.
- $N_2O$ emissions from deposition are based on $NH_3$ and $NO_x$ emissions. Losses to the atmosphere are calculated according to FAL 1997, Smith / McTaggart / Tsuruta 1997 and Williams / Hutchinson / Fehsenfeld 1992. 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 1.5% of nitrogen excretion from livestock and mineral fertilizer is emitted as $NO_x$ (FAL 2000, p. 66).

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[13] Similar to IPCC 2000£, 4.42, equation 4.18 but with national N excretion rates.

### 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 Dry biomass |
| N-fixing crops | 0.0125 kg $N_2O$ -N/kg Dry biomass |
| Organic soils | 5 kg $N_2O$ -N/ha, new 8 kg $N_2O$-N/ha [1] |
| 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 |

Table 73 Emission factors for calculating $N_2O$ emissions from agricultural soils. References: IPCC 1997c, tables 4.18 (direct emissions) and 4.23 (indirect emissions). [1] Until now calculations are based on the emission factor 5 kg $N_2O$-N/ha. This will be adapted according to the IPCC Revised Guidelines (8 kg $N_2O$-N/ha).

### Activity data

Activity data for calculation of direct soil emissions has been provided by SBV 2002 (use of synthetic fertilizer, crops produced), FAL/RAC 2001, p. 48/49 (nitrogen excretion), SFSO 2002 (area of pasture range and paddock) and FAL 2003 (revised area of cultivated organic soils).

| Emission source | Related activity data | Value | | | |
|---|---|---|---|---|---|
| **Direct emissions** | | | | | |
| | | **1990** | **2000** | **2001** | **2002** |
| Synthetic fertilizer | Use of synthetic fertilizers (t N/yr): Mineral fertilizer, sewage sludge, compost | 70’688 | 56'494 | 60’348 | 59’032 |
| Animal manure | Nitrogen input from manure applied to soils (t N/yr) | 82’387 | 74'934 | 71'239 | 71’689 |
| Crop residue | Dry production of other crops (t dry biomass/yr) | 9’448’543 | 9'851'278 | 9'377'080 | 9’094’892 |
| N-fixing crops | Peas, dry beans, soybeans and leguminous vegetables produced (t dry biomass/yr) | 998’594 | 1'097'848 | 1'056'740 | 1’065’282 |
| Organic soils | Area of cultivated organic soils (ha) | 17’000 | 17’000 | 17'000 | 17’000 |
| Residues pasture range and paddock | Area of pasture range and paddock (ha) | 784’867 | 806’369 | 809’441 | 809’597 |
| N-fixing pasture range and paddock | Area of pasture range and paddock (ha) | 784’867 | 806’369 | 809’441 | 809’597 |
| **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 | 39'299 | 38’629 | 38’513 |
| Deposition | Volatized N ($NH_3$ and $NO_x$) from fertilizers and animal wastes (t N/yr) | 57’723 | 52'265 | 50’214 | 50’647 |
| **Animal production** | | | | | |
| Pasture, range and paddock | N excretion on pasture range and paddock (t N/yr) | 20’548 | 18'270 | 16’685 | 16’515 |

Table 74 Activity data for calculating $N_2O$ emissions from agricultural soils.

## 6.5.3. Uncertainties and Time-Series Consistency

Low and high estimates for $N_2O$ emissions are available. Quality of estimates is considered to be low since minimum and maximum estimates differ by a factor between 6 (animal production) and 32 (indirect emissions). This can be explained both by uncertainty in estimates of N-excretions per animal and by uncertainty in the emission factors. 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. For verification of $NO_x$ emissions a comparison with the results of Stohl et al. 1996 has been made by FAL in 2003, which shows an average deviation of 38%.

## 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 currently 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.

By mistake, these emissions were not adjusted for 1.5% $NO_x$ volatilisation, but only for a share of 6% $NH_3$. This will be corrected in the submission 2005.

## *6.6. Source Category 4E – Burning of savannas*

Burning of savannas does not occur 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.

| **Emission from burning of branches in agriculture and forestry** | **Emission factor** kg/Gg wood equivalent |
|---|---|
| $CH_4$ | 0.0033 |
| $NO_x$ | 0.0004 |
| CO | 0.07 |
| NMVOC | 0.003 |

Table 75 Emission factors for calculating emissions from burning of branches in agriculture and forestry. References: 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 76 Activity data for calculating emissions from burning of branches in agriculture and forestry. References: EMIS (1995) database. 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. 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.

# 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 5B2 Temperate Forests are included in 5A2 Temperate Forests; the emissions of 5B4 Grassland Conversion are not estimated.
- 5C Abandonment of Managed Lands: The emissions of 5C2 Temperate Forests are included in 5A2 Temperate Forests.
- 5D $CO_2$ Emissions and Removals from Soil (cultivated peat soils only)
- 5E Other Emissions are not occurring

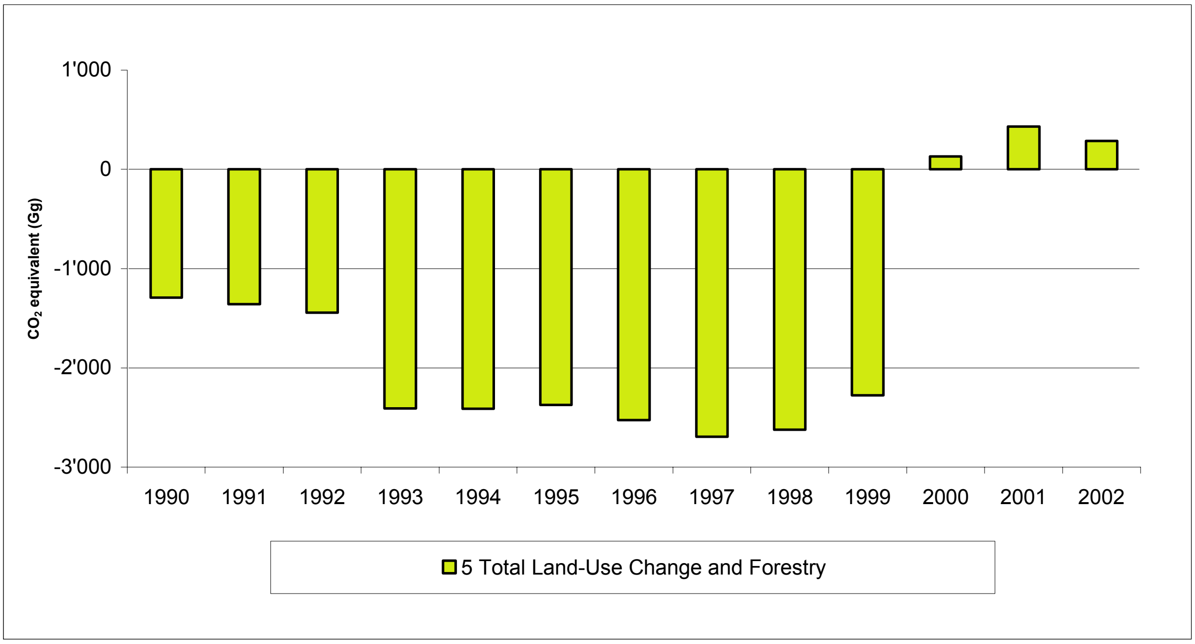


Figure 28 Switzerland's $CO_2$ emissions/removals of source category 5 Land-Use Change and Forestry 1990–2002 in Gg $CO_2$. Positive values refer to emissions, negative values to removals.

| **Land-Use Change and Forestry** | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ (Gg) | | | | | | | | | | | | |
| 5 Total Land-Use Change and Forestry | -1'293 | -1'359 | -1'443 | -2'408 | -2'411 | -2'375 | -2'527 | -2'694 | -2'622 | -2'276 | 130 | 430 | 285 |
| 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 |
| 5D $CO_2$ Emissions and Removals from Soil | 593 | 593 | 593 | 593 | 593 | 593 | 593 | 593 | 593 | 593 | 593 | 593 | 593 |

Table 77 $CO_2$ 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 2-3'000 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 display the situation with normal harvests without such outstanding events.

In previous inventory submissions, $CO_2$ emissions from soils were not estimated yet. This omission has now partly been removed. It results in an increase of the net emission balance of the LUCF sector by a constant value of 593 Gg $CO_2$.

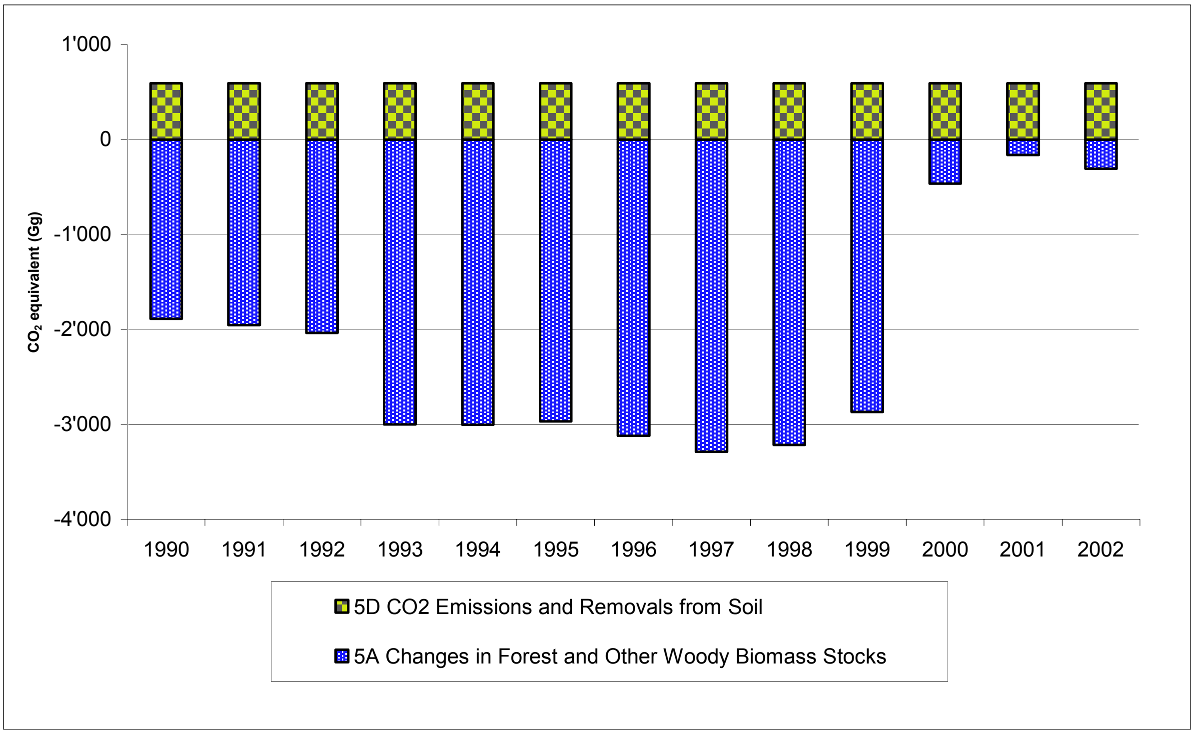


Figure 29 The $CO_2$ emissions of the sub-categories of Land-Use Change and Forestry 1990 – 2002.

## *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 occuring in Switzerland.

| 5A2 | Source/Sink | Specification | Data Source |
|---|---|---|---|
| | Temperate/ Commercial | Evergreen (coniferous) and deciduous are separated | Brassel 1999 (2nd Swiss National Forest Inventory 1995)<br>SFSO 2002a: Annual forest statistics |

Table 78 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 1996 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 area of forest/biomass stocks,
- AGR (in g dry matter/hectare/a) is the average annual growth rate,
- G (= 8.034 $m^3$/hectare/year)[14] is the gross annual growth rate of timber on managed forest land (under bark, derived from Brassel 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 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 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[15]" comparing the two national forest inventories (Table 79 and Table 80):

[14] A value of 9.09 $m^3$/ha/year was reported up to 2001. This older parameter was based on the total forest area and not on the managed forest area only.

[15] Shown as productive forest area in the statistics.

| **Swiss Forest Area** | **National forest inventory 1985 (ha)** | **National forest inventory 1995 (ha)** |
|---|---|---|
| Total forest area | 1'186'300 | 1'234'000 |
| Non managed forest area:<br>Tracks (cable cars, high tension lines etc) and adjoining slopes | 4'700 | 5'500 |
| Areas within forests permanently without tree cover (forest roads etc.) | 45'700 | 31'100 |
| Inaccessible forest | 33'100 | 33'400 |
| Scrub forest | 55'700 | 60'800 |
| Total non managed forest area | 139'200 | 130'800 |
| Total managed forest area | 1'047'100 | 1'103'200 |

Table 79 Specification of Swiss forest area in hectares (ha).

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

| **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 80 Calculation of gross annual growth rate based on first (1985) and second (1995) National Forest Inventory.

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, but this improvement is not planned yet.

### 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 81 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 82 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 1999) as well as the annual national forest statistics (SFSO 2002a):
- Area of forest / biomass stocks A (ha): The annual forest statistics (SFSO 2002a, p 62) provide yearly data on the forested area.
- 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 provide data for fuel wood plus timber in $m^3$/a. In addition to this reported stock decrease, a loss factor of 0.396 is added to the harvested fuel wood and timber (Table 83). The result is the total biomass removed. 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. 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.

| | |
|---|---|
| Annual utilized timber/fuel wood, (stemwood source Brassel 1999) | 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) | 66.279 mio $m^3$ = a (92%) |
| Commercially used timber and fuel wood as per annual national forest statistics | 47.47 mio $m^3$ = b |
| Difference between the national forest inventory and the annual forest statistics: | 18.809 mio $m^3$ = a-b |
| Loss factor growth – harvest: 18.809/47.47 | 0.396 = (a-b)/b |

Table 83 Calculation of loss factor

- The expansion factor 1.45 (Burschel 1993) is accounting for leaves, roots and twigs/small branches of no commercial value;
- The annual harvest reported is the three year average, total by categories;
- Traditional fuel wood consumed (= deciduous or coniferous fuel wood): figures derived from annual forest statistics (SFSO 2002a).

## 7.2.3. Uncertainties and Time-Series Consistency

Uncertainties are assessed 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 84). The forest area since 1995 has been updated on the basis of annual forest statistics (SFSO 2002a), 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.

| | 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 84 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 NFI become available.

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

Plausibility crosschecks 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 2003 (Fischlin et al. 2003).

## 7.2.5. Source-Specific Recalculations

See Chapter 9.

## 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 80, 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.

## *7.4. Source Category 5C – Abandonment of Managed Lands*

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

## *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 only.

In 1999, a tentative estimation was made for the forest soil carbon budget of the year 1985 (Perruchoud et al). 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 $ha^{-1}$ $a^{-1}$) (Leifeld / Bassin / Fuhrer 2003).

#### 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 $ha^{-1}$ $a^{-1}$ (Leifeld / Bassin / Fuhrer 2003, SAEFL 1998).

#### 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 (Leifeld / Bassin / Fuhrer 2003).

### 7.5.3. Uncertainties and Time-Series Consistency

Due to uncertainties in emission factors as well as of in activity data, upper and lower emission estimates differ by a factor of 3. 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*

Within the waste sector emissions from three source categories are considered:

- 6A Solid Waste Disposal on Land,
- 6B Wastewater Handling,
- 6C Waste Incineration.

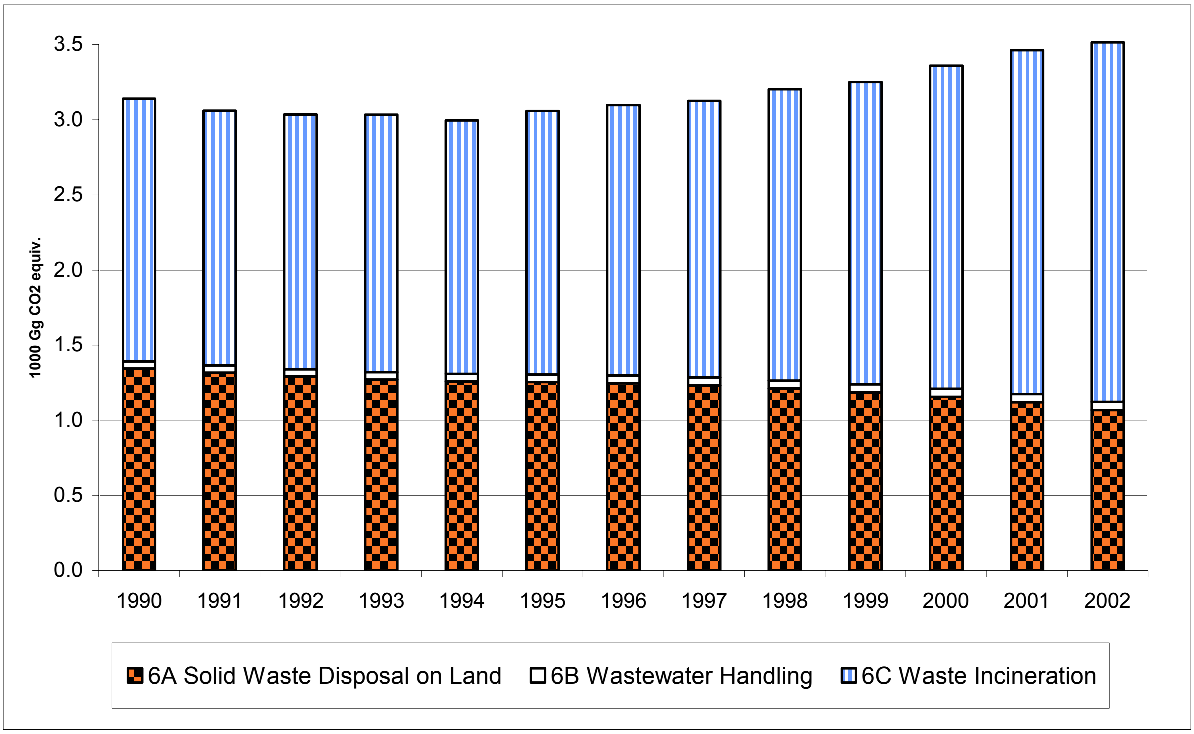


Figure 30: Switzerland's greenhouse gas emissions in the waste sector 1990 – 2002

| Gas | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | | | | | | | |
| $CO_2$ | 1'787 | 1'730 | 1'725 | 1'737 | 1'706 | 1'768 | 1'812 | 1'849 | 1'939 | 2'005 | 2'129 | 2'263 | 2'354 |
| $CH_4$ | 1'284 | 1'259 | 1'237 | 1'219 | 1'210 | 1'206 | 1'199 | 1'187 | 1'169 | 1'145 | 1'118 | 1'082 | 1'033 |
| $N_2O$ | 69 | 70 | 74 | 77 | 79 | 83 | 86 | 89 | 95 | 101 | 113 | 118 | 128 |

Table 85: Trend of total GHG emissions from waste management in Switzerland from 1990 until 2002.

In the waste sector a total of 3'515 Gg GHG were emitted in the year 2002. 68.0% of the emissions stem from the sub-category 6C Waste Incineration, 30.4% from 6A Solid Waste Disposal on Land and 1.6% from 6B Wastewater Treatment. The GHG emissions show an increase from 1994 until 2002. The increase of overall emissions is caused by the $CO_2$ emissions in 6C Waste Incineration. Simultaneously, the emissions from 6A Waste Disposal decrease slightly. $N_2O$ is of minor importance in the waste sector. The relative trends of the gases may be seen in Figure 31

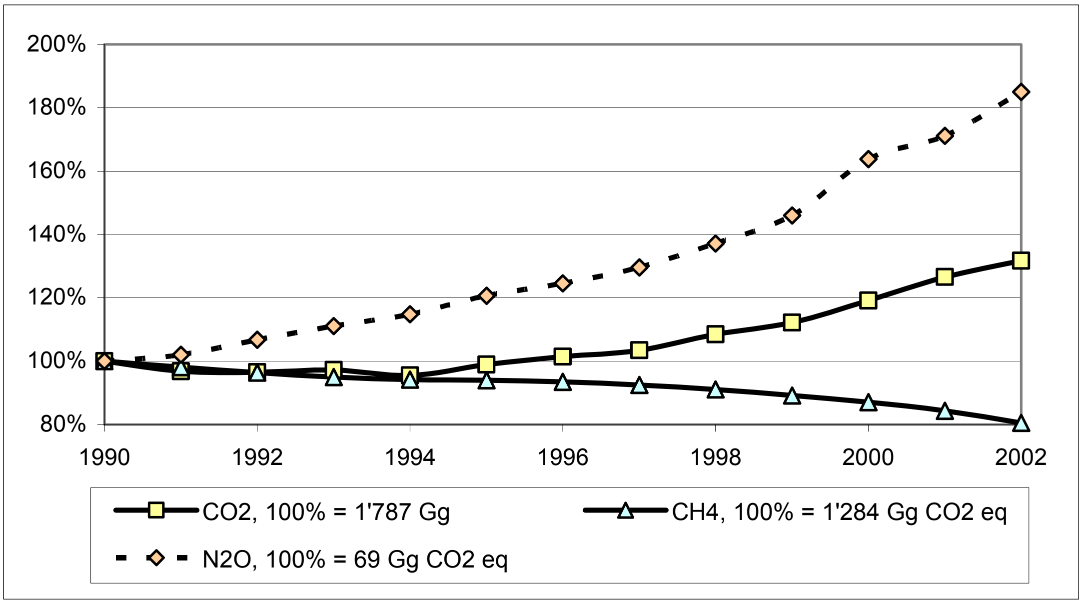


Figure 31: Trend of total GHG emissions from waste management in Switzerland from 1990 until 2002.

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

### 8.2.1. Source Category Description

The $CH_4$ emissions from Solid Waste Disposal on Land (6A) are a key source regarding level and trend.

The source category 6A1 “Managed Waste Disposal on Land” comprises all emissions from handling of solid waste on managed landfill sites.

Emissions from the source category 6A2 “Unmanaged Waste Disposal Sites” are included in source category 6A1 “Managed Waste Disposal on Land”. This is motivated by the fact that in Switzerland officially no unmanaged waste disposal sites exist. The effective quantity of waste not properly treated in landfills is estimated to be very small. However, no reliable data is available.

| 6A | Source | Specification | Data Source |
|---|---|---|---|
| 6A1 | Managed Waste Disposal on Land | Emissions from handling of solid waste on managed landfill sites. | Activity: SAEFL 2003b; EMIS 1995<br>EF: EMIS 1995 |
| 6A2 | Unmanaged Waste Disposal Sites | Emissions from all other waste disposal sites that don't fall into 6A1.<br><br>(included in 6A1) | |
| 6A3 | Others | Not occurring in Switzerland | |

Table 86 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

For this source category (6A1), a country specific Tier 2 method is used, based on CORINAIR.

The emissions are calculated in four steps:

i) In a first step the $CH_4$ emissions produced on landfill sites are calculated with a specific model (SAEFL 1996b). The input data of the model are the yearly quantity of the waste types "municipal solid waste", "construction waste" and "sewage sludge" disposed on landfills. The model calculates for each of the waste types the respective $CH_4$ generation. This calculation takes into account the different rates of the degradation processes of organic material. The model acknowledges the fact that $CH_4$ is emitted over a long period of time. Therefore a kinetic approach has been applied that reflects the various factors which influence the rate and extent of $CH_4$ generation in a landfill.

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

iii) In the third step the $CH_4$ emissions from on-site open burning are added. This results in the total $CH_4$ emissions from landfill sites.

iv) In the fourth and last step the emissions of the other gases are calculated. The respective emission 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 $CO_2$, $CH_4$, $N_2O$, CO, NMVOC and $SO_2$ are country specific based on measurements and expert estimates, documented in the EMIS 1995 database (see Section 1.3 of this report). $CO_2$ 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 | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|
| **6A1 Managed Waste Disposal on Land** | **t / t $CH_4$ produced** | | | | | | |
| Direct emissions from landfill | 2.25 | 1 | | | | 10 | |
| | **t / t $CH_4$ burned** | | | | | | |
| Co-generation | 2.75 | | | 32 | 22 | | 1 |
| Flaring | 2.75 | | | 1.6 | 20 | | 1 |
| | **kg / t waste burned** | | | | | | |
| Open burning | 1360 | 6 | | 2 | 60 | 16 | 1 |

Table 87 Emission Factors for 6A1 “Managed Waste Disposal Sites on Land” in 2002.

### Activity data

The activity data for Managed Waste Disposal on Land (6A1) are the waste quantities disposed on landfills, the municipal solid waste burned on-site and the fraction of $CH_4$ recovered.

Activity data for Managed Waste Disposal on Land (6A1) are extracted from SAEFL 2003b for waste quantities disposed, and from EMIS 1995 for open burning and recovery rate of $CH_4$.

| Source/Parameter | Unit | 1990 | 1995 | 1999 | 2000 | 2002 |
|---|---|---|---|---|---|---|
| **6A1 Managed Waste Disposal on Land** | | | | | | |
| Municipal solid waste (MSW) | Gg | 530 | 540 | 470 | 290 | 50 |
| Construction waste | Gg | 500 | 100 | 90 | 90 | 45 |
| Sewage sludge | Gg (dry) | 92 | 50 | 30 | 10 | 1 |
| Open burned MSW | Gg | 50 | 23 | 7 | 3 | 2.6 |
| $CH_4$ as fuel for co-generation units | % | 11 | 15 | 19 | 20 | 22 |
| $CH_4$ flared | % | 9 | 10 | 10 | 10 | 10 |

Table 88: Activity data in 6A1 Managed Waste Disposal on Land.

The table above documents the reduction by about 11 times of municipal solid waste, construction waste and sewage sludge disposed of over the period 1990 – 2002. The amount of open burned municipal solid waste has strongly declined, as well. 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.

Together with the increase of $CH_4$ recovery by 50% from 1990 until 2002, 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

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

The time series is consistent.

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

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

### 8.2.5. Source-Specific Recalculations

See Chapter 9.

### 8.2.6. Source-Specific Planned Improvements

The emissions of $CH_4$ and $CO_2$ from landfills depend on the waste's content of organic matter. The composition of solid waste disposed has changed over time.

The share of organic matter differs between “municipal solid waste”, “construction waste” and “sewage sludge” and is also variable over time. Based on recent investigations, the GHG emissions could be calculated in a more accurate way. For further improvement of the calculation of source category 6A emissions, the following sources will be used:

- For “municipal solid waste” the $CO_2$ emission factors can be estimated based on the effective waste composition. Taking into account the results of the surveys conducted by (SAEFL 1995c and SAEFL 2003b), the $CO_2$ emission factors can be determined more accurately and extrapolated between the reference years 1992/93 and 2002/2003.
- For “construction waste” the $CO_2$ emission factors can be estimated based on the composition of waste disposed on landfills. Considering the results of SAEFL 2001, the fraction of organic matter in construction waste is very small (max. about 6%).
- For “sewage sludge” the content of organic matter is in average about 45% related to dry matter.

The model to calculate the $CH_4$ emission from landfills will be redesigned. It will use the IPCC method. The new emission estimates will be ready for the 2005 submission.

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

## *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).

| 6B | Source | Specification | Data Source |
|---|---|---|---|
| 6B1 | Industrial Waste Water | Emissions from handling of liquid wastes and sludge from industrial processes.<br>(included in 6B2) | |
| 6B2 | Domestic and Commercial Waste Water | Emissions from handling of liquid wastes and sludge from housing and commercial sources | Activity: SFSO 2002b<br>EF: EMIS 1995 |
| 6B3 | Others | Not occurring in Switzerland | |

Table 89: 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 (see Section 1.3).

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 90 Emission Factors for 6B2 Domestic and Commercial Waste Water in 2002.

### Activity data

Activity data for Domestic and Commercial Waste Water (6B2) are extracted from SFSO 2002b for the population and from an unpublished document of SAEFL for the fraction of population connected to waste water treatment plants.

| 6B2 Domestic and Commercial Waste Water | Unit | 1990 | 1995 | 2000 | 2002 |
|---|---|---|---|---|---|
| Population | inhabitants | 6'796'000 | 7'062'000 | 7'200'000 | 7'349'000 |
| Fraction connected to waste water treatment plant | % | 90% | 95% | 97% | 97% |

Table 91 Activity data in 6B2 Domestic and Commercial Waste Water

### 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 judgement 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 2002 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 2002.

At present, on site pre-treatment and treatment of industrial waste water and sludge is not considered. The respective $CH_4$ recovery will be taken into account in future submissions, based on SFOE 2002.

However, since the overall contribution of greenhouse gas emissions from this source category (6B) is very small, the above mentioned improvements are of low priority.

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

## *8.4. Source Category 6C – Waste Incineration*

### 8.4.1. Source Category Description

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

In this source category (6C) all waste incineration facilities are taken into account. In contrast to the IPCC provisions (IPCC 1997c), emissions from the combustion of waste-to-energy fuels (e.g. waste plastic, waste wood, waste oil etc.) in the cement and the paper industry are taken into account in the present source category 6C “Waste Incineration”, and not in 1A “Fuel Combustion Activities” in Energy. This allocation is motivated by the Swiss $CO_2$ law which regulates $CO_2$ emissions from the use of fossil fuels. Emissions from the energetic use of (fossil) wastes are not covered by this law. Thus, in implementing the law, $CO_2$ emissions from fossil fuels must be strictly separated from emissions originating from the use of waste-to-energy fuels. For this reason, in the Swiss Greenhouse Gas Inventory the source category 1A “Fuel Combustion Activities” focuses on fossil fuels covered by the $CO_2$ law (and its statistics), whereas waste-to-energy production is subsumed in the source category 6C "Waste Incineration".

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

Waste incineration plants in Switzerland are generally equipped with energy recovery equipment.

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

| 6C Waste incineration | Specification | Data Source |
|---|---|---|
| **Municipal solid waste incineration plants** | Emissions from waste incineration in municipal solid waste incineration plants | Activity: SAEFL 2003b<br>EF: $CO_2$ Fahrni 1999, EMIS 1995 |
| Hospital waste incineration | Emissions from incinerating hospital waste in hospital incinerators | Activity: EMIS 1995<br>EF: EMIS 1995 |
| Households, illegal waste | Emissions from illegal gardening and household waste incineration | Activity: EMIS 1995, SAEFL 2003b<br>EF: EMIS 1995 |
| Paper pulp, black liquor | Emissions from incineration of black liquor as fuel for paper/pulp production | Activity: EMIS 1995, SAEFL 2003b<br>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<br>EF: EMIS 1995 |
| **Special waste** | Emissions from incinerating industrial and hazardous wastes | Activity: SAEFL 1999 Sonderabfallstatistik<br>EF: EMIS 1995 |
| Insulation material from cables | Emissions from incinerating cable insulation materials | Activity: EMIS 1995<br>EF: EMIS 1995 |
| Sewage sludge | Emissions from sewage sludge incineration plants | Activity: SAEFL 2003b<br>EF: EMIS 1995 |
| Waste at construction sites | Emissions from waste incineration at construction sites (open burning) | Activity: EMIS 1995<br>EF: EMIS 1995 |
| **Waste-to-energy fuels for the cement industry** | Emissions from waste used as fuel for cement production | Activity: Cemsuisse 2002<br>EF: SAEFL internal files |

Table 92: Specification of source category 6C Waste Incineration (Activity: activity data; EF: emission factors; most important sources in bold).

In the year 2002 98.0% of the $CO_2$ emissions from source category 6C stem from three sources: (i) from waste incineration in municipal solid waste incineration plants, (ii) from waste used as fuel for cement production and (iii) from incineration of special waste.

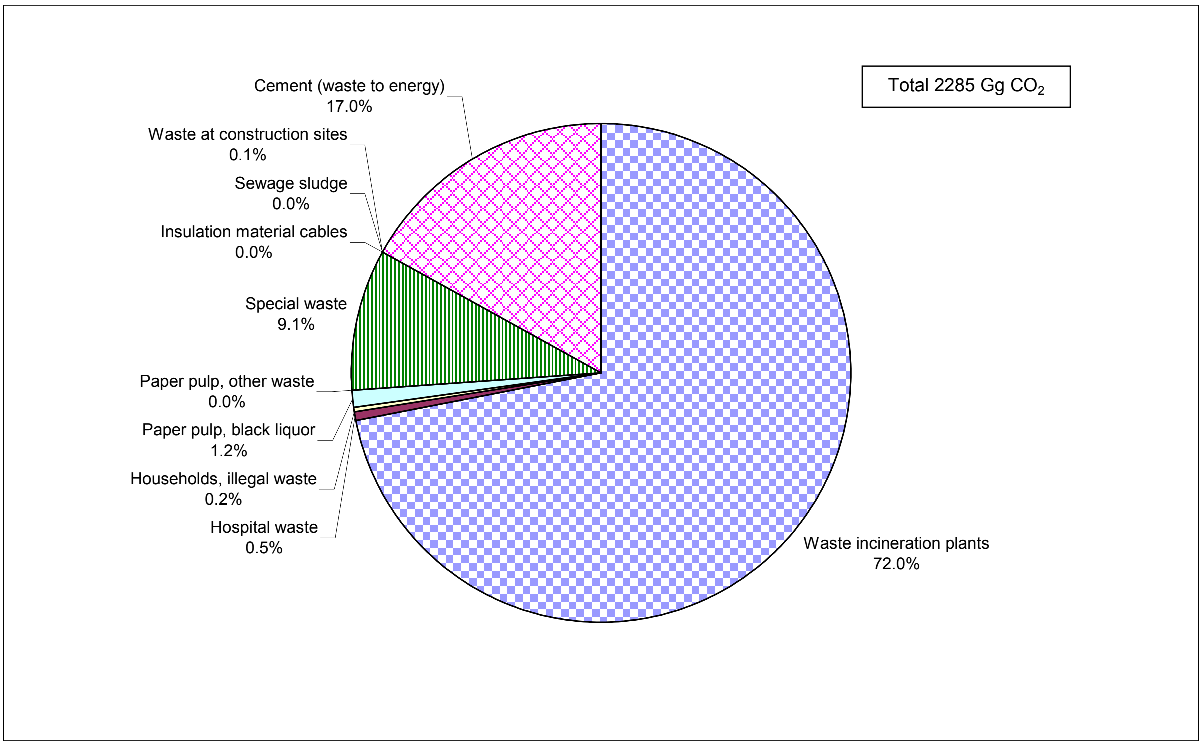


Figure 32: $CO_2$ emissions of source category 6 Waste Incineration in 2002.

## 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, waste use as fuel in cement production, 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 (see Section 1.3).

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

| Source | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC | $SO_2$ |
|---|---|---|---|---|---|---|---|
| | t/t | kg/t | g/t | kg/t | kg/t | kg/t | kg/t |
| **6C Waste Incineration** | | | | | | | |
| Municipal Solid Waste Incineration Plants | 0.544 | | 102 | 0.960 | 0.224 | 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 | | 102 | 0.880 | 0.224 | 0.020 | 0.15 |
| Insulation material cables | 1.300 | | | 1.300 | 2.500 | 0.500 | 6.000 |
| Sewage sludge plants | 0 | 0.112 | 102 | 0.960 | 0.224 | 0.006 | 0.3 |
| Waste at construction sites | 0.544 | 6 | | 2 | 60 | 16 | 1 |
| | t/TJ | kg/TJ | | | | | |
| Cement (waste to energy) | 73.7 | 1.8 | 0.2 | 279 | 509 | 14 | 66 |

Table 93: Emission Factors for 6C “Waste Incineration” in 2002.

## 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.

| Source/Parameter | Unit | 1990 | 1995 | 2000 | 2002 |
|---|---|---|---|---|---|
| **6C Waste Incineration** | | | | | |
| Municipal solid waste incineration plants | Gg | 2’470 | 2’270 | 2’800 | 3'025 |
| Hospital waste incineration | Gg | 30 | 22 | 15 | 12 |
| Households, illegal waste | Gg | 8.3 | 7.3 | 7.3 | 7.3 |
| Paper pulp, black liquor | Gg | 196.7 | 145.5 | 159 | 133.2 |
| Paper pulp, other waste | Gg | 14.7 | 22.8 | 19 | 19.5 |
| Special waste | Gg | 125.6 | 165.2 | 230 | 230 |
| Insulation material cables | Gg | 7.5 | 0 | 0 | 0 |
| Sewage sludge | Gg dry | 57 | 57.5 | 64.3 | 64.9 |
| Waste at construction sites | Gg | 50 | 32 | 4 | 3.3 |
| Cement (waste to energy) | Gg | 65 | 123 | 167.5 | 206 |
| **Total** | Gg | **3'024.8** | **2'846.3** | **3'466.1** | **3'701.2** |

Table 94: 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, special waste incineration as well as use of waste as waste-to-energy fuel in cement production. The increasing incineration of these wastes is the reason for source category 6C being a key source regarding trend.

### 8.4.3. 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.

### 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. The CO2 emissions could be estimated more accurately based on the results of recent investigations on the composition of the different waste types (see Section 8.2.6 on Planned Improvements under 6A).

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 2005.

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.

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

## *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.

| 6D | Source | Specification | Data Source |
|---|---|---|---|
| | Other | Emissions from car shreddering plants | Activity: EMIS(1995)<br>EF: EMIS 1995 |

Table 95 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 96 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 | 1995 | 2000 | 2002 |
|---|---|---|---|---|---|
| **6D Other (Shredder)** | | | | | |
| Scrap | t/a | 363'000 | 422'000 | 482'000 | 495'000 |

Table 97 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 judgement 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

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

# 9. Recalculations

## 9.1. Explanations and Justifications for Recalculation

In 2003, the GHG inventory submission (2001 data) contained fully recalculated CRF tables for the years 1990, 2000 and 2001. For the present 2004 submission additional recalculations have been carried out with the following reasons.

**1 Energy**

- 1A3a Aviation: the emissions for the years 2000 and 2001 had to be updated due to the new activity data provided by the Federal Office of Civil Aviation.
- 1A5 Other (Off-road): Recalculation with updated activity data and emission factors. For some sub-categories, correction of rounding errors lead to further, very small differences.
- Memo Items, International Bunkers: Recalculation with new activity data for civil aviation (see remark above for 1A3a Aviation).

**2 Industrial Processes**

- Source categories 2C, 2E, 2F (metal production, production and consumption of halocarbons and $SF_6$): Update of activity rates and extensions of the modelling procedures for the synthetic gases provided new emission results.

**4 Agriculture**

An extension of the agricultural models, updated activity rates and emission factors required several recalculations.

4A Enteric Fermentation ($CH_4$)

- Elimination of rounding errors (calculations based on non-rounded data).
- Correction calculation of the methane conversion factor for swine in 2000/2001.
- Recalculation of the methane conversion rate for horses and poultry.
- Inclusion of the categories ponies, mules and asses in order to guarantee methodological consistency in time series and between the animal categories for $N_2O$ and $CH_4$ calculation. The fodder demand is divided in 85% for horses and 15% for ponies, mules and asses, according to SBV 2002.
- Inclusion of the category turkey.

4B Manure Management

- $N_2O$ emissions from some animal categories change from 2001 on due to new data on N excretion (changes in fodder composition). New estimates of the milk production of dairy cattle lead also to new estimates of N-excretion. No recalculation is needed since the method remained unchanged.
- Recalculation for $N_2O$ emissions of manure management. Only very small differences that are explained by rounding errors.

4D Agricultural Soils

- $N_2O$ emissions from farmed organic soils have been recalculated because of new data available on the area of farmed organic soils and the updated IPCC emission factor. $N_2O$ emissions from crop residues of maize and potatoes have been recalculated in retrospective to 1990 due to an improved method to distinguish yields of silage maize from green maize and due to erroneous estimates on N contents in the older inventories. $N_2O$ emissions from crop residues of peas and fodder beet were recalculated due to erroneous specification on the standard values for arable crop yields (FAL/RAC 2001). Recalculations have also been made for the emissions of mineral fertilizers applied to soils.

4F Field Burning of Agricultural Residues

- Additionally for the latest submission, the source category 4F Field Burning of Agricultural Residues was newly incorporated into to emission estimation.

**5 Land-Use Change and Forestry**

- 5A Changes in Forest and Other Woody Biomass Stocks:The annual growth rate factor G (gross annual growth rate of timber on managed forest land) has been recalculated (see Section 7.2.2).
- 5D $CO_2$ Emissions and Removals from Soil. This source category was newly estimated and incorporated into the inventory.

**6 Waste**

- 6A Solid Waste Disposal on Land was recalculated with an updated $CO_2$ emission factor for burning of $CH_4$ on landfills.

## *9.2. Implications for Emissions Levels*

The effect of recalculations on 2001 data is summarised in the following table. The major difference arises from Land-Use Change and Forestry where the improvements result in a significant change in the emission level. The other differences are much smaller.

The recalculated total of the $CO_2$ emissions for Switzerland (without LUCF) is lowered by 100 Gg of $CO_2$ equivalent corresponding to a reduction of -0.19%. If LUCF emissions are included, the recalculated total is increased by 1859 Gg or 3.58%.

| Recalculation | $CO_2$ | | | $CH_4$ | | | $N_2O$ | | | Sum ($CO_2$, $CH_4$ and $N_2O$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Emissions for 2001 | Prev. | Latest | Differ. | Prev. | Latest | Differ. | Prev. | Latest | Differ. | Prev. | Latest | Differ. |
| Source and Sink Categories | $CO_2$ equivalent (Gg) | | | | | | | | | $CO_2$ equivalent (Gg) | | |
| 1 Energy | 40'644 | 40'585 | -59 | 366 | 367 | 1 | 678 | 678 | 0 | 41'688 | 41'630 | -58 |
| 2 Ind. Processes (without syn. gases) | 1'904 | 1'904 | 0 | 9 | 9 | 0 | 97 | 97 | 0 | 2'010 | 2'010 | 0 |
| 3 Solvent and Other Product Use | NO | NO | --- | 0 | 0 | 0 | 121 | 121 | 0 | 121 | 121 | 0 |
| 4 Agriculture | IE | IE | --- | 2'897 | 2'903 | 6 | 2'550 | 2'553 | 2 | 5'447 | 5'456 | 9 |
| 5 Land-Use Change and Forestry | -1'529 | 430 | 1'959 | NO | NO | --- | NO | NO | --- | -1'529 | 430 | 1'959 |
| 6 Waste | 2'280 | 2'263 | -17 | 1'082 | 1'082 | 0 | 118 | 118 | 0 | 3'480 | 3'463 | -17 |

| Recalculation | HFC | | | PFC | | | SF6 | | | Sum (synthetic gases) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Emissions for 2001 | 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) | 473.9 | 434.3 | -39.5 | 26.1 | 29.6 | 3.5 | 210.7 | 213.4 | 2.7 | 710.7 | 677.3 | -33.4 |

| Recalculation | | Sum (all gases) | | |
|---|---|---|---|---|
| Emissions for 2001 | | Prev. | Latest | Differ. |
| Source and Sink Categories | | $CO_2$ equivalent (Gg) | | |
| **Total $CO_2$ eq Em. with LUCF** | | **51'928** | **53'787** | **1'859** |
| **Total $CO_2$ eq Em. without LUCF** | | **53'457** | **53'357** | **-100** |
| | | 100.00% | 99.81% | -0.19% |

Table 98 Overview of recalculations. The emissions for 2001 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 (2004) comprises the full set of CRF tables for all years from 1990 until 2002. The recalculations are complete and all the time series are consistent (exception see Chapter 3.2.3). Recalculations lead to an almost unchanged Total (without LUCF) and to a general increase of the Total (with LUCF) due to the introduction of a new source category (5D $CO_2$ Emissions and Removals from Soil) with constant emissions over the period considered. The recalculations performed for the 2004 inventory submission have no significant effect on emission trends between 1990 and 2002.

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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%. In all source categories sources have been disaggregated into sources (e.g. 2A, 2B, 2C etc.) and gases ($CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, and $SF_6$). 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.).

# Results of Key Source Analysis – Level

| IPCC Source Categories (and fuels if applicable) | | | | | Direct Greenhouse Gas | Base Year 1990 Estimate | Year 2002 Estimate | Level Assess-ment | Cumulative Total Column E-L | Result level assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $CO_2$ eq (Gg) | $CO_2$ eq (Gg) | % | % | key source = 1 |
| *TOTAL* | | | | | *All* | *53'137.14* | *52'252.07* | *100.00%* | *0%* | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Liquid fuels | CO2 | 16'410.76 | 13'788.46 | 26.39% | 26.39% | 1 |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Gasoline | CO2 | 11'562.11 | 11'782.34 | 22.55% | 48.94% | 1 |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Gaseous fuels | CO2 | 2'141.15 | 3'623.95 | 6.94% | 55.87% | 1 |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Diesel | CO2 | 2'625.28 | 3'413.13 | 6.53% | 62.40% | 1 |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Liquid fuels | CO2 | 2'293.73 | 2'786.75 | 5.33% | 67.74% | 1 |
| 4A | 4. Agricult. | A. Enteric Fermentation | | | CH4 | 2'766.81 | 2'452.56 | 4.69% | 72.43% | 1 |
| 6C | 6. Waste | C. Waste Incineration | | | CO2 | 1'690.75 | 2'285.25 | 4.37% | 76.81% | 1 |
| 4D | 4. Agricult. | D. Agricultural Soils | | | N2O | 2'417.65 | 2'157.53 | 4.13% | 80.93% | 1 |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Gaseous fuels | CO2 | 1'347.54 | 1'719.87 | 3.29% | 84.23% | 1 |
| 2A | 2. Industrial | A. Mineral Products | | | CO2 | 2'567.62 | 1'688.59 | 3.23% | 87.46% | 1 |
| 6A | 6. Waste | A. Solid Waste Disposal on Land | | | CH4 | 1'247.82 | 998.50 | 1.91% | 89.37% | 1 |
| 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Liquid fuels | CO2 | 691.23 | 743.24 | 1.42% | 90.79% | 1 |
| 1A5 | 1. Energy | A. Fuel Combustion | 5. Other | Liquid fuels | CO2 | 708.89 | 652.81 | 1.25% | 92.04% | 1 |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Solid fuels | CO2 | 1'470.84 | 592.85 | 1.13% | 93.17% | 1 |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Gasoline | N2O | 319.89 | 533.19 | 1.02% | 94.20% | 1 |
| 2F | 2. Industrial | F. Consumption of Halocarbons and SF6 | | | HFCs | 0.02 | 471.36 | 0.90% | 95.10% | 1 |
| 4B | 4. Agricult. | B. Manure Management | | | N2O | 448.20 | 412.14 | 0.79% | 95.89% | |
| 4B | 4. Agricult. | B. Manure Management | | | CH4 | 452.34 | 397.40 | 0.76% | 96.65% | |
| 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Gaseous fuels | CO2 | 234.83 | 334.13 | 0.64% | 97.29% | |
| 1B2 | 1. Energy | B. Fugitive Emissions | 2. Oil and Natural Gas | | CH4 | 307.34 | 253.40 | 0.48% | 97.77% | |
| 2F | 2. Industrial | F. Consumption of Halocarbons and SF6 | | | SF6 | 178.31 | 155.91 | 0.30% | 98.07% | |
| 2C | 2. Industrial | C. Metal Production | | | CO2 | 260.02 | 143.13 | 0.27% | 98.34% | |
| 3 | 3. Solvent and Other Product Use | | | | N2O | 107.57 | 122.76 | 0.23% | 98.58% | |
| 6C | 6. Waste | C. Waste Incineration | | | N2O | 50.02 | 105.55 | 0.20% | 98.78% | |
| 2B | 2. Industrial | B. Chemical Industry | | | N2O | 96.72 | 96.72 | 0.19% | 98.97% | |
| 1B2 | 1. Energy | B. Fugitive Emissions | 2. Oil and Natural Gas | | CO2 | 74.71 | 91.74 | 0.18% | 99.14% | |
| 6A | 6. Waste | A. Solid Waste Disposal on Land | | | CO2 | 96.67 | 68.80 | 0.13% | 99.27% | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Liquid fuels | N2O | 46.79 | 40.85 | 0.08% | 99.35% | |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Diesel | N2O | 29.61 | 39.39 | 0.08% | 99.43% | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Biomass | CH4 | 29.64 | 33.59 | 0.06% | 99.49% | |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Gasoline | CH4 | 91.46 | 33.24 | 0.06% | 99.55% | |
| 6B | 6. Waste | B. Wastewater Handling | | | CH4 | 28.26 | 32.94 | 0.06% | 99.62% | |
| 2C | 2. Industrial | C. Metal Production | | | SF6 | NO | 28.68 | 0.05% | 99.67% | |
| 2F | 2. Industrial | F. Consumption of Halocarbons and SF6 | | | PFCs | NO | 25.41 | 0.05% | 99.72% | |
| 6B | 6. Waste | B. Wastewater Handling | | | N2O | 18.96 | 22.10 | 0.04% | 99.76% | |
| 2B | 2. Industrial | B. Chemical Industry | | | CO2 | 13.28 | 13.00 | 0.02% | 99.79% | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Solid fuels | CO2 | 64.03 | 12.24 | 0.02% | 99.81% | |
| 2C | 2. Industrial | C. Metal Production | | | PFCs | 100.17 | 10.89 | 0.02% | 99.83% | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Liquid fuels | CH4 | 14.03 | 9.57 | 0.02% | 99.85% | |
| 2B | 2. Industrial | B. Chemical Industry | | | CH4 | 8.17 | 8.65 | 0.02% | 99.87% | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Gaseous fuels | CH4 | 4.91 | 8.30 | 0.02% | 99.88% | |
| 1A5 | 1. Energy | A. Fuel Combustion | 5. Other | Liquid fuels | CH4 | 6.97 | 7.88 | 0.02% | 99.90% | |
| 1A5 | 1. Energy | A. Fuel Combustion | 5. Other | Liquid fuels | N2O | 7.02 | 7.36 | 0.01% | 99.91% | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Biomass | N2O | 5.83 | 6.61 | 0.01% | 99.92% | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Liquid fuels | N2O | 5.50 | 6.44 | 0.01% | 99.94% | |
| 4F | 4. Agricult. | F. Field Burning of Agricultural Residues | | | CH4 | 5.82 | 5.82 | 0.01% | 99.95% | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Biomass | N2O | 2.64 | 3.80 | 0.01% | 99.96% | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Gaseous fuels | CH4 | 2.82 | 3.68 | 0.01% | 99.96% | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Biomass | CH4 | 2.35 | 3.38 | 0.01% | 99.97% | |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Diesel | CH4 | 3.37 | 2.53 | 0.00% | 99.97% | |
| 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Liquid fuels | N2O | 2.07 | 2.22 | 0.00% | 99.98% | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Gaseous fuels | N2O | 1.21 | 2.04 | 0.00% | 99.98% | |
| 6C | 6. Waste | C. Waste Incineration | | | CH4 | 7.59 | 1.68 | 0.00% | 99.99% | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Gaseous fuels | N2O | 0.85 | 1.07 | 0.00% | 99.99% | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Liquid fuels | CH4 | 1.53 | 1.01 | 0.00% | 99.99% | |
| 2G | 2. Industrial | G. Other | | | CO2 | 1.00 | 1.00 | 0.00% | 99.99% | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Solid fuels | N2O | 2.25 | 0.92 | 0.00% | 99.99% | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Solid fuels | CH4 | 4.28 | 0.82 | 0.00% | 99.99% | |
| 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Gaseous fuels | CH4 | 0.54 | 0.77 | 0.00% | 100.00% | |

Table 99 Key source analysis regarding level.

## Results of Key Source Analysis – Trend

| IPCC Source Categories (and fuels if applicable) | | | | | Direct Green-house Gas | Base Year 1990 Estimate | Year 2002 Estimate | Level Assess-ment | Trend Assess-ment | % Contri-bution in Trend | Cumu-lative Total Col. F | Result level assess-ment | Result trend assess-ment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $CO_2$ eq (Gg) | $CO_2$ eq (Gg) | % | --- | % | % | key source = 1 | |
| *TOTAL* | | | | | *All* | *53'137.14* | *52'252.07* | *100.00%* | *0.20628* | 100.00% | | | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Liquid fuels | CO2 | 16'410.76 | 13'788.46 | 26.39% | 0.04572 | 22.2% | 22.2% | 1 | 1 |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Gaseous fuels | CO2 | 2'141.15 | 3'623.95 | 6.94% | 0.02955 | 14.3% | 36.5% | 1 | 1 |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Solid fuels | CO2 | 1'470.84 | 592.85 | 1.13% | 0.01661 | 8.1% | 44.5% | 1 | 1 |
| 2A | 2. Industrial | A. Mineral Products | | | CO2 | 2'567.62 | 1'688.59 | 3.23% | 0.01628 | 7.9% | 52.4% | 1 | 1 |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Diesel | CO2 | 2'625.28 | 3'413.13 | 6.53% | 0.01618 | 7.8% | 60.3% | 1 | 1 |
| 6C | 6. Waste | C. Waste Incineration | | | CO2 | 1'690.75 | 2'285.25 | 4.37% | 0.01212 | 5.9% | 66.2% | 1 | 1 |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Liquid fuels | CO2 | 2'293.73 | 2'786.75 | 5.33% | 0.01034 | 5.0% | 71.2% | 1 | 1 |
| 2F | 2. Industrial | F. Consumption of Halocarbons and SF6 | | | HFCs | 0.02 | 471.36 | 0.90% | 0.00917 | 4.4% | 75.6% | 1 | 1 |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Gasoline | CO2 | 11'562.11 | 11'782.34 | 22.55% | 0.00803 | 3.9% | 79.5% | 1 | 1 |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Gaseous fuels | CO2 | 1'347.54 | 1'719.87 | 3.29% | 0.00768 | 3.7% | 83.2% | 1 | 1 |
| 4A | 4. Agricult. | A. Enteric Fermentation | | | CH4 | 2'766.81 | 2'452.56 | 4.69% | 0.00522 | 2.5% | 85.8% | 1 | 1 |
| 6A | 6. Waste | A. Solid Waste Disposal on Land | | | CH4 | 1'247.82 | 998.50 | 1.91% | 0.00445 | 2.2% | 87.9% | 1 | 1 |
| 4D | 4. Agricult. | D. Agricultural Soils | | | N2O | 2'417.65 | 2'157.53 | 4.13% | 0.00428 | 2.1% | 90.0% | 1 | 1 |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Gasoline | N2O | 319.89 | 533.19 | 1.02% | 0.00425 | 2.1% | 92.1% | 1 | 1 |
| 2C | 2. Industrial | C. Metal Production | | | CO2 | 260.02 | 143.13 | 0.27% | 0.00219 | 1.1% | 93.1% | | 1 |
| 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Gaseous fuels | CO2 | 234.83 | 334.13 | 0.64% | 0.00201 | 1.0% | 94.1% | | 1 |
| 2C | 2. Industrial | C. Metal Production | | | PFCs | 100.17 | 10.89 | 0.02% | 0.00171 | 0.8% | 94.9% | | 1 |
| 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Liquid fuels | CO2 | 691.23 | 743.24 | 1.42% | 0.00124 | 0.6% | 95.5% | 1 | 1 |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Gasoline | CH4 | 91.46 | 33.24 | 0.06% | 0.00110 | 0.5% | 96.1% | | |
| 6C | 6. Waste | C. Waste Incineration | | | N2O | 50.02 | 105.55 | 0.20% | 0.00110 | 0.5% | 96.6% | | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Solid fuels | CO2 | 64.03 | 12.24 | 0.02% | 0.00099 | 0.5% | 97.1% | | |
| 1B2 | 1. Energy | B. Fugitive Emissions | 2. Oil and Natural Gas | | CH4 | 307.34 | 253.40 | 0.48% | 0.00095 | 0.5% | 97.5% | | |
| 4B | 4. Agricult. | B. Manure Management | | | CH4 | 452.34 | 397.40 | 0.76% | 0.00092 | 0.4% | 98.0% | | |
| 1A5 | 1. Energy | A. Fuel Combustion | 5. Other | Liquid fuels | CO2 | 708.89 | 652.81 | 1.25% | 0.00086 | 0.4% | 98.4% | 1 | |
| 4B | 4. Agricult. | B. Manure Management | | | N2O | 448.20 | 412.14 | 0.79% | 0.00056 | 0.3% | 98.7% | | |
| 6A | 6. Waste | A. Solid Waste Disposal on Land | | | CO2 | 96.67 | 68.80 | 0.13% | 0.00051 | 0.2% | 98.9% | | |
| 2F | 2. Industrial | F. Consumption of Halocarbons and SF6 | | | SF6 | 178.31 | 155.91 | 0.30% | 0.00038 | 0.2% | 99.1% | | |
| 1B2 | 1. Energy | B. Fugitive Emissions | 2. Oil and Natural Gas | | CO2 | 74.71 | 91.74 | 0.18% | 0.00036 | 0.2% | 99.3% | | |
| 3 | 3. Solvent and Other Product Use | | | | N2O | 107.57 | 122.76 | 0.23% | 0.00033 | 0.2% | 99.4% | | |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Diesel | N2O | 29.61 | 39.39 | 0.08% | 0.00020 | 0.1% | 99.5% | | |
| 6C | 6. Waste | C. Waste Incineration | | | CH4 | 7.59 | 1.68 | 0.00% | 0.00011 | 0.1% | 99.6% | | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Liquid fuels | N2O | 46.79 | 40.85 | 0.08% | 0.00010 | 0.0% | 99.6% | | |
| 6B | 6. Waste | B. Wastewater Handling | | | CH4 | 28.26 | 32.94 | 0.06% | 0.00010 | 0.0% | 99.7% | | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Biomass | CH4 | 29.64 | 33.59 | 0.06% | 0.00009 | 0.0% | 99.7% | | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Liquid fuels | CH4 | 14.03 | 9.57 | 0.02% | 0.00008 | 0.0% | 99.8% | | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Gaseous fuels | CH4 | 4.91 | 8.30 | 0.02% | 0.00007 | 0.0% | 99.8% | | |
| 6B | 6. Waste | B. Wastewater Handling | | | N2O | 18.96 | 22.10 | 0.04% | 0.00007 | 0.0% | 99.8% | | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Solid fuels | CH4 | 4.28 | 0.82 | 0.00% | 0.00007 | 0.0% | 99.8% | | |
| 2C | 2. Industrial | C. Metal Production | | | N2O | 1.92 | 0.00 | 0.00% | 0.00004 | 0.0% | 99.9% | | |
| 2B | 2. Industrial | B. Chemical Industry | | | N2O | 96.72 | 96.72 | 0.19% | 0.00003 | 0.0% | 99.9% | | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Solid fuels | N2O | 2.25 | 0.92 | 0.00% | 0.00003 | 0.0% | 99.9% | | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Biomass | N2O | 2.64 | 3.80 | 0.01% | 0.00002 | 0.0% | 99.9% | | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Biomass | CH4 | 2.35 | 3.38 | 0.01% | 0.00002 | 0.0% | 99.9% | | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Liquid fuels | N2O | 5.50 | 6.44 | 0.01% | 0.00002 | 0.0% | 99.9% | | |
| 1A5 | 1. Energy | A. Fuel Combustion | 5. Other | Liquid fuels | CH4 | 6.97 | 7.88 | 0.02% | 0.00002 | 0.0% | 99.9% | | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Gaseous fuels | CH4 | 2.82 | 3.68 | 0.01% | 0.00002 | 0.0% | 99.9% | | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Biomass | N2O | 5.83 | 6.61 | 0.01% | 0.00002 | 0.0% | 100.0% | | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Gaseous fuels | N2O | 1.21 | 2.04 | 0.00% | 0.00002 | 0.0% | 100.0% | | |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Diesel | CH4 | 3.37 | 2.53 | 0.00% | 0.00002 | 0.0% | 100.0% | | |
| 2B | 2. Industrial | B. Chemical Industry | | | CH4 | 8.17 | 8.65 | 0.02% | 0.00001 | 0.0% | 100.0% | | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Solid fuels | CH4 | 0.94 | 0.41 | 0.00% | 0.00001 | 0.0% | 100.0% | | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Liquid fuels | CH4 | 1.53 | 1.01 | 0.00% | 0.00001 | 0.0% | 100.0% | | |
| 1A5 | 1. Energy | A. Fuel Combustion | 5. Other | Liquid fuels | N2O | 7.02 | 7.36 | 0.01% | 0.00001 | 0.0% | 100.0% | | |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Solid fuels | N2O | 0.34 | 0.06 | 0.00% | 0.00001 | 0.0% | 100.0% | | |
| 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Gaseous fuels | CH4 | 0.54 | 0.77 | 0.00% | 0.00000 | 0.0% | 100.0% | | |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Gaseous fuels | N2O | 0.85 | 1.07 | 0.00% | 0.00000 | 0.0% | 100.0% | | |
| 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Liquid fuels | N2O | 2.07 | 2.22 | 0.00% | 0.00000 | 0.0% | 100.0% | | |
| 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Liquid fuels | CH4 | 0.44 | 0.57 | 0.00% | 0.00000 | 0.0% | 100.0% | | |
| 2A | 2. Industrial | A. Mineral Products | | | CH4 | 0.54 | 0.40 | 0.00% | 0.00000 | 0.0% | 100.0% | | |
| 4F | 4. Agricult. | F. Field Burning of Agricultural Residues | | | CH4 | 5.82 | 5.82 | 0.01% | 0.00000 | 0.0% | 100.0% | | |
| 2B | 2. Industrial | B. Chemical Industry | | | CO2 | 13.28 | 13.00 | 0.02% | 0.00000 | 0.0% | 100.0% | | |
| 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Gaseous fuels | N2O | 0.13 | 0.19 | 0.00% | 0.00000 | 0.0% | 100.0% | | |

Table 100 Key source analysis regarding trend.

## List of Key Sources

| IPCC Source Categories (and fuels if applicable) | | | | | Direct Green-house Gas | Base Year 1990 Estimate | Year 2002 Estimate | Level Assess-ment | Cumulative Total Column E-L | Trend Assess-ment | % Contri-bution in Trend | Cumulative Total Col. F | Result level assess-ment | Result trend assess-ment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $CO_2$ eq (Gg) | $CO_2$ eq (Gg) | % | % | --- | % | % | key source = 1 | |
| 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Gaseous fuels | CO2 | 235 | 334 | 0.64% | 38.51% | 0.0020 | 1.0% | 94.1% | | 1 |
| 1A1 | 1. Energy | A. Fuel Combustion | 1. Energy Industries | Liquid fuels | CO2 | 691 | 743 | 1.42% | 39.95% | 0.0012 | 0.6% | 95.5% | 1 | 1 |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Gaseous fuels | CO2 | 1'348 | 1'720 | 3.29% | 25.84% | 0.0077 | 3.7% | 83.2% | 1 | 1 |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Liquid fuels | CO2 | 2'294 | 2'787 | 5.33% | 53.93% | 0.0103 | 5.0% | 71.2% | 1 | 1 |
| 1A2 | 1. Energy | A. Fuel Combustion | 2. Manufacturing Ind. | Solid fuels | CO2 | 1'471 | 593 | 1.13% | 34.46% | 0.0166 | 8.1% | 44.5% | 1 | 1 |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Diesel | CO2 | 2'625 | 3'413 | 6.53% | 44.22% | 0.0162 | 7.8% | 60.3% | 1 | 1 |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Gasoline | CO2 | 11'562 | 11'782 | 22.55% | 22.55% | 0.0080 | 3.9% | 79.5% | 1 | 1 |
| 1A3 | 1. Energy | A. Fuel Combustion | 3. Transport | Gasoline | N2O | 320 | 533 | 1.02% | 37.59% | 0.0043 | 2.1% | 92.1% | 1 | 1 |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Gaseous fuels | CO2 | 2'141 | 3'624 | 6.94% | 33.32% | 0.0296 | 14.3% | 36.5% | 1 | 1 |
| 1A4 | 1. Energy | A. Fuel Combustion | 4. Other Sectors | Liquid fuels | CO2 | 16'411 | 13'788 | 26.39% | 26.39% | 0.0457 | 22.2% | 22.2% | 1 | 1 |
| 1A5 | 1. Energy | A. Fuel Combustion | 5. Other | Liquid fuels | CO2 | 709 | 653 | 1.25% | | 0.0009 | 0.4% | 98.4% | 1 | |
| 2A | 2. Industrial | A. Mineral Products | | | CO2 | 2'568 | 1'689 | 3.23% | 37.69% | 0.0163 | 7.9% | 52.4% | 1 | 1 |
| 2C | 2. Industrial | C. Metal Production | | | CO2 | 260 | 143 | 0.27% | 37.87% | 0.0022 | 1.1% | 93.1% | | 1 |
| 2C | 2. Industrial | C. Metal Production | | | PFCs | 100 | 11 | 0.02% | 38.53% | 0.0017 | 0.8% | 94.9% | | 1 |
| 2F | 2. Industrial | F. Consumption of Halocarbons and SF6 | | | HFCs | 0.023 | 471 | 0.90% | 54.83% | 0.0092 | 4.4% | 75.6% | 1 | 1 |
| 4A | 4. Agricult. | A. Enteric Fermentation | | | CH4 | 2'767 | 2'453 | 4.69% | 30.53% | 0.0052 | 2.5% | 85.8% | 1 | 1 |
| 4D | 4. Agricult. | D. Agricultural Soils | | | N2O | 2'418 | 2'158 | 4.13% | 36.57% | 0.0043 | 2.1% | 90.0% | 1 | 1 |
| 6A | 6. Waste | A. Solid Waste Disposal on Land | | | CH4 | 1'248 | 998 | 1.91% | 32.45% | 0.0044 | 2.2% | 87.9% | 1 | 1 |
| 6C | 6. Waste | C. Waste Incineration | | | CO2 | 1'691 | 2'285 | 4.37% | 48.60% | 0.0121 | 5.9% | 66.2% | 1 | 1 |

Table 101 Key sources in Switzerland. Most of the key sources are identified in both the level and the trend analysis.

# Annex 2: Methodology and Input Data for Estimating $CO_2$ Emissions

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 global energy statistics 2002 (SFOE 2002).

### a) 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 102

### b) $CO_2$ 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 103

### c) Swiss Energy Flux

The diagram on the following page shows a summary of the Swiss energy flux 2002 as published by the Swiss Federal Office of Energy (SFOE). The diagram languages are German and French, an English version does not exist.

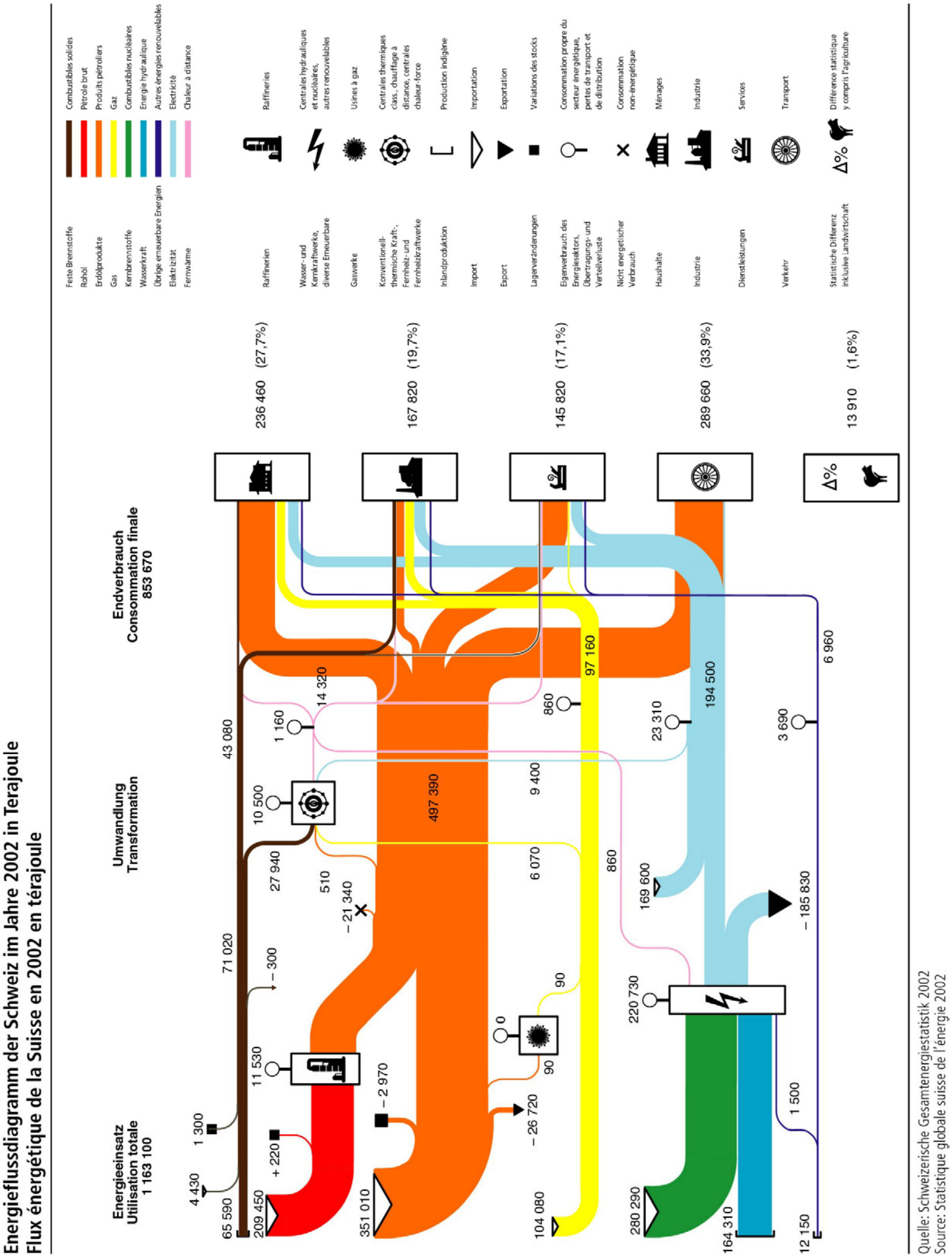


Figure 33 Energy flux in Switzerland 2002 (SFOE 2002)

# Annex 3: Other Detailed Descriptions and Data for Individual Sources

## *Annex 3.1: Industry*

Overview on Processes that are subsumed under the category "industry" in EMIS 1995.

| **Industrial process (English)** | **Industrial process (German)** | **Remark** |
|---|---|---|
| non-ferrous metals | Buntmetall | Included in source category 2 |
| foundries | Giessereien | Iron and steel |
| Gas steel plants | Wärmeöfen | Iron and steel |
| Aluminium smelting | Aluminium umschmelzen | Included in source category 2 |
| Aluminium production (Anodes) | Aluminiumproduktion (Anoden) | Included in source category 2 |
| Graphite | Graphit | Included in source category 2 |
| Mineral wool | Steinwolle | Cement/lime/Glass |
| Glass wool | Glaswolle | Cement/lime/Glass |
| Glass | Glas | Cement/lime/Glass |
| Container glass | Hohlglas | Cement/lime/Glass |
| Asphalt concrete plants | Mischgut | Cement/lime/Glass |
| Fine ceramics materials | Feinkeramik | Cement/lime/Glass |
| Brick and tile | Grobkeramik | Cement/lime/Glass |
| Plaster | Gips | Cement/lime/Glass |
| Lime | Kalk | Cement/lime/Glass |
| Cement | Zement | Cement/lime/Glass |
| Cellulose | Zellulose | Included in source category 6 |
| Gras drying | Grastrocknung | Included in source category 1A4 |
| Steamboats | Dampfschiffe | Included in source category 1A3 |

Table 104 Overview on Processes included in the category "industry" in EMIS 1995.

# Annex 3.2: Emission Factors Road Transportation

## Emission factors for light motor vehicles (<3.5 tons)

| Gas | Vehicle category | Engine /Exhaust concept | 1990 g/veh-km | 1995 g/veh-km | 2000 g/veh-km | 2002 g/veh-km |
|---|---|---|---|---|---|---|
| $CO_2$ | PC | PC / gasoline / Conventional | 225.8 | 222.0 | 215.6 | 213.9 |
| $CO_2$ | PC | PC / gasoline / GKat<91 | 213.4 | 213.6 | 211.7 | 212.1 |
| $CO_2$ | PC | PC / gasoline / EURO 1 / FAV 1 | | 213.3 | 214.1 | 213.1 |
| $CO_2$ | PC | PC / gasoline / EURO 2 | | | 206.0 | 206.6 |
| $CO_2$ | PC | PC / gasoline / EURO 3 | | | 200.2 | 196.9 |
| $CO_2$ | PC | PC / diesel / conventional | 202.5 | 197.6 | 195.5 | 196.4 |
| $CO_2$ | PC | PC / diesel / XXIII / FAV 1 | 185.3 | 185.4 | 186.9 | 186.8 |
| $CO_2$ | PC | PC / diesel / EURO 2 | | | 178.7 | 178.7 |
| $CO_2$ | PC | PC / diesel / EURO 3 | | | 176.0 | 171.9 |
| $CO_2$ | LDV | LDV / gasoline / Conventional | 301.9 | 298.7 | 299.3 | 286.4 |
| $CO_2$ | LDV | LDV / gasoline / GKat<91 | 311.0 | 311.5 | 312.0 | 312.0 |
| $CO_2$ | LDV | LDV / gasoline / EURO 1 / FAV 1 | | 311.5 | 311.0 | 310.7 |
| $CO_2$ | LDV | LDV / gasoline / EURO 2 | | | 297.8 | 296.2 |
| $CO_2$ | LDV | LDV / gasoline / EURO 3 | | | 291.4 | 285.9 |
| $CO_2$ | LDV | LDV / diesel / conventional | 343.9 | 322.2 | 318.3 | 317.3 |
| $CO_2$ | LDV | LDV / diesel / EURO 1 / FAV 1 | | 312.6 | 310.2 | 311.0 |
| $CO_2$ | LDV | LDV / diesel / EURO 2 | | | 297.9 | 296.2 |
| $CO_2$ | LDV | LDV / diesel / EURO 3 | | | 292.4 | 286.4 |
| VOC | PC | PC / gasoline / Conventional | 2.63 | 2.52 | 2.39 | 2.70 |
| VOC | PC | PC / gasoline / GKat<91 | 0.46 | 0.56 | 0.58 | 0.60 |
| VOC | PC | PC / gasoline / EURO 1 / FAV 1 | | 0.33 | 0.31 | 0.32 |
| VOC | PC | PC / gasoline / EURO 2 | | | 0.23 | 0.24 |
| VOC | PC | PC / gasoline / EURO 3 | | | 0.11 | 0.11 |
| VOC | PC | PC / diesel / conventional | 0.19 | 0.16 | 0.14 | 0.14 |
| VOC | PC | PC / diesel / XXIII / FAV 1 | 0.08 | 0.08 | 0.08 | 0.08 |
| VOC | PC | PC / diesel / EURO 2 | | | 0.05 | 0.05 |
| VOC | PC | PC / diesel / EURO 3 | | | 0.05 | 0.05 |
| VOC | LDV | LDV / gasoline / Conventional | 2.68 | 2.61 | 2.56 | 2.78 |
| VOC | LDV | LDV / gasoline / GKat<91 | 0.26 | 0.31 | 0.33 | 0.35 |
| VOC | LDV | LDV / gasoline / EURO 1 / FAV 1 | | 0.27 | 0.30 | 0.31 |
| VOC | LDV | LDV / gasoline / EURO 2 | | | 0.21 | 0.21 |
| VOC | LDV | LDV / gasoline / EURO 3 | | | 0.11 | 0.11 |
| VOC | LDV | LDV / diesel / conventional | 0.48 | 0.26 | 0.21 | 0.20 |
| VOC | LDV | LDV / diesel / EURO 1 / FAV 1 | | 0.10 | 0.10 | 0.10 |
| VOC | LDV | LDV / diesel / EURO 2 | | | 0.07 | 0.07 |
| VOC | LDV | LDV / diesel / EURO 3 | | | 0.04 | 0.04 |
| $NO_x$ | PC | PC / gasoline / Conventional | 2.28 | 2.20 | 2.24 | 2.23 |
| $NO_x$ | PC | PC / gasoline / GKat<91 | 0.42 | 0.58 | 0.67 | 0.69 |
| $NO_x$ | PC | PC / gasoline / EURO 1 / FAV 1 | | 0.33 | 0.45 | 0.50 |
| $NO_x$ | PC | PC / gasoline / EURO 2 | | | 0.23 | 0.26 |
| $NO_x$ | PC | PC / gasoline / EURO 3 | | | 0.11 | 0.11 |
| $NO_x$ | PC | PC / diesel / conventional | 0.74 | 0.70 | 0.68 | 0.68 |
| $NO_x$ | PC | PC / diesel / XXIII / FAV 1 | 0.62 | 0.62 | 0.63 | 0.63 |
| $NO_x$ | PC | PC / diesel / EURO 2 | | | 0.50 | 0.50 |
| $NO_x$ | PC | PC / diesel / EURO 3 | | | 0.38 | 0.38 |
| $NO_x$ | LDV | LDV / gasoline / Conventional | 2.99 | 2.93 | 2.94 | 2.62 |
| $NO_x$ | LDV | LDV / gasoline / GKat<91 | 0.55 | 0.77 | 0.91 | 0.95 |
| $NO_x$ | LDV | LDV / gasoline / EURO 1 / FAV 1 | | 0.61 | 0.77 | 0.82 |
| $NO_x$ | LDV | LDV / gasoline / EURO 2 | | | 0.35 | 0.40 |
| $NO_x$ | LDV | LDV / gasoline / EURO 3 | | | 0.16 | 0.18 |
| $NO_x$ | LDV | LDV / diesel / conventional | 1.30 | 1.24 | 1.23 | 1.23 |
| $NO_x$ | LDV | LDV / diesel / EURO 1 / FAV 1 | | 0.85 | 0.85 | 0.85 |
| $NO_x$ | LDV | LDV / diesel / EURO 2 | | | 0.73 | 0.73 |
| $NO_x$ | LDV | LDV / diesel / EURO 3 | | | 0.55 | 0.55 |

Table 105

## Emission factors for heavy motor vehicles (>3.5 tons)

| Gas | Vehicle category | Engine / Exhaust concept | 1990 g/veh-km | 1995 g/veh-km | 2000 g/veh-km | 2002 g/veh-km |
|---|---|---|---|---|---|---|
| $CO_2$ | Coach | 70ties | 893 | 896 | | |
| $CO_2$ | Coach | 80ties | 811 | 815 | 817 | 818 |
| $CO_2$ | Coach | EURO 1 / FAV 2 | | 774 | 776 | 777 |
| $CO_2$ | Coach | EURO 2 | | | 776 | 777 |
| $CO_2$ | Coach | EURO 3 | | | 776 | 777 |
| $CO_2$ | UBus | 70ties | 1'106 | 1'127 | | |
| $CO_2$ | UBus | 80ties | 1'005 | 1'024 | 1'031 | 1033 |
| $CO_2$ | UBus | EURO 1 / FAV 2 | | 973 | 979 | 982 |
| $CO_2$ | UBus | EURO 2 | | | 979 | 982 |
| $CO_2$ | UBus | EURO 3 | | | 979 | 982 |
| $CO_2$ | HDV | 70ties | 868 | 836 | | |
| $CO_2$ | HDV | 80ties | 863 | 834 | 832 | 810 |
| $CO_2$ | HDV | EURO 1 / FAV 2 | | 828 | 856 | 836 |
| $CO_2$ | HDV | EURO 2 | | | 906 | 882 |
| $CO_2$ | HDV | EURO 3 | | | 910 | 910 |
| VOC | Coach | 70ties | 1.57 | 1.55 | | |
| VOC | Coach | 80ties | 1.40 | 1.38 | 1.38 | 1.38 |
| VOC | Coach | EURO 1 / FAV 2 | | 0.97 | 0.96 | 0.96 |
| VOC | Coach | EURO 2 | | | 0.69 | 0.69 |
| VOC | Coach | EURO 3 | | | 0.55 | 0.55 |
| VOC | UBus | 70ties | 1.97 | 1.97 | | |
| VOC | UBus | 80ties | 1.75 | 1.76 | 1.76 | 1.76 |
| VOC | UBus | EURO 1 / FAV 2 | | 1.23 | 1.23 | 1.23 |
| VOC | UBus | EURO 2 | | | 0.88 | 0.88 |
| VOC | UBus | EURO 3 | | | 0.70 | 0.70 |
| VOC | HDV | 70ties | 1.56 | 1.55 | | |
| VOC | HDV | 80ties | 1.37 | 1.35 | 1.39 | 1.39 |
| VOC | HDV | EURO 1 / FAV 2 | | 0.92 | 0.96 | 0.96 |
| VOC | HDV | EURO 2 | | | 0.68 | 0.68 |
| VOC | HDV | EURO 3 | | | 0.54 | 0.53 |
| $NO_x$ | Coach | 70ties | 10.55 | 10.67 | | |
| $NO_x$ | Coach | 80ties | 10.55 | 10.67 | 10.73 | 10.75 |
| $NO_x$ | Coach | EURO 1 / FAV 2 | | 7.47 | 7.51 | 7.53 |
| $NO_x$ | Coach | EURO 2 | | | 6.44 | 6.45 |
| $NO_x$ | Coach | EURO 3 | | | 4.29 | 4.30 |
| $NO_x$ | UBus | 70ties | 15.50 | 15.88 | | |
| $NO_x$ | UBus | 80ties | 15.50 | 15.88 | 16.01 | 16.06 |
| $NO_x$ | UBus | EURO 1 / FAV 2 | | 11.12 | 11.21 | 11.24 |
| $NO_x$ | UBus | EURO 2 | | | 9.61 | 9.64 |
| $NO_x$ | UBus | EURO 3 | | | 6.41 | 6.42 |
| $NO_x$ | HDV | 70ties | 9.88 | 9.44 | | |
| $NO_x$ | HDV | 80ties | 10.92 | 10.49 | 10.41 | 10.10 |
| $NO_x$ | HDV | EURO 1 / FAV 2 | | 7.65 | 7.98 | 7.76 |
| $NO_x$ | HDV | EURO 2 | | | 7.26 | 7.06 |
| $NO_x$ | HDV | EURO 3 | | | 4.86 | 4.85 |

Table 106

## Emission factors for 2-wheelers

| Gas | Vehicle category | Engine / Exhaust concept | 1990 g/veh-km | 1995 g/veh-km | 2000 g/veh-km | 2002 g/veh-km |
|---|---|---|---|---|---|---|
| $CO_2$ | Moped (<30km/h) | Moped (<30km/h) / without cat. conv. | 43.3 | 43.3 | 43.4 | 43.4 |
| $CO_2$ | Moped (<30km/h) | Moped (<30km/h) / with cat. conv. | 33.6 | 33.6 | 33.6 | 33.6 |
| $CO_2$ | Motorcycle | Moped / Conventional | 46.8 | 46.5 | 46.4 | 46.4 |
| $CO_2$ | Motorcycle | Moped / EU 1 / FAV 3-2 | 34.3 | 34.2 | 34.2 | 34.2 |
| $CO_2$ | Motorcycle | Motorcycle / 2-strokes / <=ECE40 | 102.2 | 102.1 | 102.0 | 102.0 |
| $CO_2$ | Motorcycle | Motorcycle / 2-strokes / EU 1 / FAV 3-2 | 78.2 | 78.0 | 77.9 | 77.9 |
| $CO_2$ | Motorcycle | Motorcycle / 4-strokes / <=ECE40 | 106.9 | 107.9 | 106.0 | 104.2 |
| $CO_2$ | Motorcycle | Motorcycle / 4-strokes / EU 1 / FAV 3-2 | 102.1 | 102.4 | 102.4 | 102.4 |
| VOC | Moped (<30km/h) | Moped (<30km/h) / without cat. conv. | 2.9 | 2.9 | 2.9 | 2.9 |
| VOC | Moped (<30km/h) | Moped (<30km/h) / with cat. conv. | 1.01 | 1.01 | 0.97 | 0.95 |
| VOC | Motorcycle | Moped / Conventional | 3.28 | 3.25 | 3.25 | 3.18 |
| VOC | Motorcycle | Moped / EU 1 / FAV 3-2 | 1.11 | 1.10 | 1.10 | 1.08 |
| VOC | Motorcycle | Motorcycle / 2-strokes / <=ECE40 | 9.95 | 10.03 | 10.04 | 9.84 |
| VOC | Motorcycle | Motorcycle / 2-strokes / EU 1 / FAV 3-2 | 4.28 | 4.29 | 4.29 | 4.20 |
| VOC | Motorcycle | Motorcycle / 4-strokes / <=ECE40 | 1.43 | 1.51 | 1.54 | 1.49 |
| VOC | Motorcycle | Motorcycle / 4-strokes / EU 1 / FAV 3-2 | 0.72 | 0.74 | 0.74 | 0.72 |
| $NO_x$ | Moped (<30km/h) | Moped (<30km/h) / without cat. conv. | 0.01 | 0.01 | 0.01 | 0.01 |
| $NO_x$ | Moped (<30km/h) | Moped (<30km/h) / with cat. conv. | 0.01 | 0.01 | 0.01 | 0.01 |
| $NO_x$ | Motorcycle | Moped / Conventional | 0.01 | 0.01 | 0.01 | 0.01 |
| $NO_x$ | Motorcycle | Moped / EU 1 / FAV 3-2 | 0.01 | 0.01 | 0.01 | 0.01 |
| $NO_x$ | Motorcycle | Motorcycle / 2-strokes / <=ECE40 | 0.04 | 0.04 | 0.04 | 0.04 |
| $NO_x$ | Motorcycle | Motorcycle / 2-strokes/EU 1 / FAV 3-2 | 0.07 | 0.07 | 0.07 | 0.07 |
| $NO_x$ | Motorcycle | Motorcycle / 4-strokes / <=ECE40 | 0.27 | 0.27 | 0.26 | 0.24 |
| $NO_x$ | Motorcycle | Motorcycle / 4-strokes / EU 1 / FAV 3-2 | 0.34 | 0.34 | 0.34 | 0.33 |

Table 107

# Annex 3.3: Documentation of Model for Mobile Air-Conditioning / Cars

## Kenndaten PW-Klimaanlagen

| | | |
|---|---|---|
| Emissionsfaktor 1995 | 8.5% | [Anteil Füllmg./a] Verluste bei der Wartung und Entsorgung separat ausgewiesen |
| *davon Nachfüllung* | *6.0%* | Hinweis: Um die Daten mit der Importstatistik zu korrellieren, wird die nachgefüllte Menge ausgewiesen (Blatt commercial Refrig.) |
| *davon nicht nachgefüllt* | *2.5%* | Die Angaben werden zur Plausibilisierung über Tier 1b verwendet. |
| Emissionsfaktor sinkt bis 2010 | 3% | [Anteil Füllmg./a] |
| Lebensdauer | 12 | [a] |
| Füllmenge [kg] | 0.81 | 1995 0.78 2000 (für andere Jahre Linear inter- / extrapolieren) |
| ausgemusterter PW | 60% | [Anteil Füllmgenge, Literaturangabe] |
| Freisetzung von R134 bei Entsorgung | 100% | bis 2004 |
| | 30% | ab 2005 |
| Altautos ins Ausland verkauft | 50% | |
| Emissionsverluste bei Wartung | zwei Mal | 10% über Lebensdauer |
| alle Neugeräte werden gefüllt importiert | | |
| Marktwachstum pro Jahr | 1% | |

## Modellierung PW-Klimaanlagen

| Jahr | Neu-zulassungen | Bestände | ausge-schieden | Klimaanlagen Neuwagen | | | Bestand an Klimaanlagen | | Ausge-mustert | Füllmenge |
|---|---|---|---|---|---|---|---|---|---|---|
| | (VSAI, EFKO) | (B. f. Statistik) | | PW-Input [%] | R134a [%] | Anzahl R134 | Bestand [%] | Anz. R134 | Anz. R134 | kg / Fzg |
| 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 | 828'711 | 2'204 | 0.79 |
| 2000 | 315'398 | 3'545'247 | 237'426 | 77 | 100 | 242'856 | 30 | 1'063'575 | 7'992 | 0.78 |
| 2001 | 317'126 | 3'629'713 | 232'660 | 85 | 100 | 269'557 | 36 | 1'308'848 | 24'284 | 0.78 |
| 2002 | 295'109 | 3'704'822 | 220'000 | 87 | 100 | *256'745* | 41 | *1'519'421* | *46'172* | 0.78 |
| *2003* | *298'060* | *3'782'882* | *220'000* | *89* | *100* | *265'273* | *45* | *1'719'199* | *65'495* | 0.78 |
| *2004* | *301'041* | *3'863'923* | *220'000* | *91* | *100* | *273'947* | *49* | *1'890'725* | *102'421* | 0.78 |
| *2005* | *304'051* | *3'947'974* | *220'000* | *92* | *100* | *279'727* | *51* | *2'028'783* | *141'669* | 0.78 |
| *2006* | *307'092* | *4'035'065* | *220'000* | *92* | *100* | *282'524* | *52* | *2'109'119* | *202'188* | 0.78 |
| *2007* | *310'163* | *4'125'228* | *220'000* | *93* | *100* | *288'451* | *52* | *2'159'081* | *238'489* | 0.78 |
| *2008* | *313'264* | *4'218'492* | *220'000* | *93* | *100* | *291'336* | *52* | *2'207'561* | *242'856* | 0.78 |
| *2009* | *316'397* | *4'314'889* | *220'000* | *94* | *100* | *297'413* | *52* | *2'235'416* | *269'557* | 0.78 |
| *2010* | *319'561* | *4'414'450* | *220'000* | *94* | *100* | *300'387* | *52* | *2'279'059* | *256'745* | 0.78 |

### Modellierung Kältemittel in PW-Klimaanlagen

| R 134a | Input | Lager | Emissionen | | | Import für Wartung |
|---|---|---|---|---|---|---|
| | | | Lager + Wartung | Entsorgung | Wartung | |
| | [t] | [t] | [t] | [t] | [t] | [t] |
| 1990 | 0 | 0 | 0 | 0.0 | 0 | 0 |
| 1991 | 2 | 2 | 0 | 0.0 | 0 | 0.1 |
| 1992 | 7 | 8 | 0 | 0.0 | 0 | 0.3 |
| 1993 | 20 | 28 | 2 | 0.0 | 0 | 1.1 |
| 1994 | 38 | 64 | 4 | 0.0 | 0 | 2.8 |
| 1995 | 53 | 113 | 8 | 0.0 | 0 | 5.3 |
| 1996 | 82 | 188 | 13 | 0.0 | 1 | 9.0 |
| 1997 | 113 | 287 | 22 | 0.0 | 2 | 14.3 |
| 1998 | 160 | 425 | 34 | 0.0 | 4 | 21.4 |
| 1999 | 187 | 579 | 48 | 0.0 | 5 | 30.1 |
| 2000 | 189 | 720 | 63 | 0.0 | 8 | 39.0 |
| 2001 | 210 | 867 | 79 | 0.0 | 11 | 47.6 |
| 2002 | 200 | 989 | 95 | 0.0 | 16 | 55.7 |
| *2003* | *207* | *1'101* | *108* | *1.1* | *19* | 62.7 |
| *2004* | *214* | *1'206* | *117* | *4.0* | *19* | 69.2 |
| *2005* | *218* | *1'303* | *128* | *3.6* | *21* | 75.3 |
| *2006* | *220* | *1'392* | *135* | *6.8* | *20* | 80.8 |
| *2007* | *225* | *1'476* | *143* | *9.5* | *21* | 86.0 |
| *2008* | *227* | *1'551* | *150* | *14.8* | *21* | 90.8 |
| *2009* | *232* | *1'618* | *156* | *20* | *22* | 95.1 |
| *2010* | *234* | *1'675* | *162* | *29* | *22* | 98.8 |

Table 108: Model structure and assumptions for calculating emissions from mobile air conditioning in cars

# *Annex 3.4: Agriculture*

## Lifestock Population Data for $N_2O$ Emission Calculation

| Animals 2002 | Number of animals | kg N per head/year | $Frac_{GASM}$ (6) | N volatilized (kg N) |
|---|---|---|---|---|
| **Cattle** | **1'593'697** | | | |
| dairy cows (1) | 716'027 | 105.27 | 0.335 | 25'251'014 |
| rearing cattle 1st year | 229'514 | 25 | 0.235 | 1'348'395 |
| rearing cattle 2nd year | 219'092 | 40 | 0.235 | 2'059'465 |
| rearing cattle 3rd year | 126'028 | 55 | 0.235 | 1'628'912 |
| fattening cattle >1/2 hear | 103'530 | 33 | 0.385 | 1'315'349 |
| fattening cattle < 1/2 year | 38'176 | 8 | 0.385 | 117'582 |
| fattening calves | 161'330 | 13 | 0.385 | 807'457 |
| **Pigs** | **1'556'717** | | | |
| fattening pig places (2) | 874'215 | 13 | 0.475 | 5'398'278 |
| breeding pig places (3) | 147'973 | 35 | 0.475 | 2'460'051 |
| **Sheep** | **429'503** | | | |
| sheep places (4) | 219'877 | 12 | 0.155 | 408'971 |
| **Goats** | **65'950** | | | |
| goat places (5) | 35'502 | 16 | 0.305 | 173'250 |
| **Horses** | **51'236** | | | |
| foals < 1 year | 3'358 | 17 | 0.335 | 19'124 |
| foals 1 - 3 years | 6'169 | 42 | 0.335 | 86'798 |
| > 3 years | 41'709 | 44 | 0.335 | 614'791 |
| **Ponies, Mules and Asses** | **13'209** | 26 | 0.335 | 115'050 |
| **Poultry** | **10'338'616** | | | |
| laying hens | 2'154'133 | 0.71 | 0.555 | 848'836 |
| young hens < 18 weeks | 753'918 | 0.34 | 0.555 | 142'264 |
| broilers | 7'298'170 | 0.4 | 0.495 | 1'445'038 |
| turkeys | 132'395 | 1.4 | 0.495 | 91'750 |
| **Total** | **14'048'928** | | | **44'332'373** |

(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 2002: 5570 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 109

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

| $N_2O$ (2002) | Nitrogen incorporated with crop residues (t N) | Dry matter production (kg DM) | $N_2O$ emissions from crop residues (t $N_2O$) | N fixed per kg crop (kg N/kg crop) | N fixed (kg N) | $N_2O$ emissions from N fixation (t $N_2O$) |
|---|---|---|---|---|---|---|
| **1. Cereals** | | | | | | |
| Wheat | 3'189 | 427'975'000 | 63 | | | |
| Barley | 1'195 | 210'137'000 | 23 | | | |
| Maize | 1'346 | 160'618'550 | 26 | | | |
| Oats | 137 | 18'297'950 | 3 | | | |
| Rye | 144 | 17'680'000 | 3 | | | |
| | | | | | | |
| *Other (please specify)* | | | | | | |
| Triticale | 65 | 7'310'000 | 18 | | | |
| Spelt | 899 | 76'386'950 | 1 | | | |
| Mix of fodder cereals | 10 | 1'830'050 | 0 | | | |
| Mix of bread cereals | 1 | 85'000 | 0 | | | |
| **2. Pulse** | | | | | | |
| Dry bean | 41 | 1'043'800 | 1 | 0.0443 | 54'339 | 1.1 |
| Eiweisserbsen/peas | 310 | 13'155'450 | 6 | 0.0330 | 510'741 | 10.0 |
| Soybeans | 183 | 4'425'100 | 4 | 0.0571 | 297'367 | 5.8 |
| *Other (please specify)* | | | | | | |
| Leguminous vegetable | 306 | 2'987'308 | 6 | 0.0177 | 294'135 | 5.8 |
| **3. Tuber and Root** | | | | | | |
| Potatoes | 503 | 115'764'000 | 10 | | | |
| *Other (please specify)* | | | | | | |
| Fodder beet | 238 | 25'500'000 | 5 | | | |
| Sugar beet | 2'924 | 309'738'000 | 57 | | | |
| **5. Other (please specify)** | | | | | | |
| Grass | 22'220 | 6'207'942'780 | 436 | 0.0050 | 31'142'750 | 611.7 |
| Silage corn | 246 | 1'092'960'000 | 5 | | | |
| Green corn | 27 | 185'803'200 | 1 | | | |
| Fruit | 243 | 60'727'570 | 5 | | | |
| Vine | 174 | 29'067'000 | 3 | | | |
| Renewable energy crops | 86 | 5'524'200 | 2 | | | |
| Non-leguminous vegetables | 985 | 63'065'400 | 19 | | | |
| Sunflowers | 282 | 13'336'500 | 6 | | | |
| Tobacco | 38 | 1'462'000 | 1 | | | |
| Rape | 654 | 42'068'700 | 13 | | | |
| **Total Non-leguminous** | 35'608 | 9'073'279'850 | 699 | 0.0050 | 31'142'750 | 611.7 |
| **Total Leguminous** | 841 | 21'611'658 | 17 | 0.1521 | 1'156'582 | 22.7 |
| **Total** | 36'449 | 9'094'891'509 | 716 | 0.1571 | 32'299'332 | 634.5 |

Table 110