Switzerland’s Greenhouse Gas Inventory 1990–2012

National Inventory Report 2014

including reporting elements under the Kyoto Protocol

Submission of 15 April 2014
under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol

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Glossary

AD	Activity data
AEF	Area expansion factor
AREA1	Swiss Land Use Statistics 1979/85 (ASCH1 data re-evaluated according to the AREA set of land-use and land-cover categories)
AREA2	Swiss Land Use Statistics 1992/97 (ASCH2 data re-evaluated according to the AREA set of land-use and land-cover categories)
AREA3	Swiss Land Use Statistics, third survey 2004/09
ART	Agroscope Reckenholz-Tänikon Research Station (formerly FAL) since 2014 Agroscope
ASCH1	Swiss Land Use Statistics, first survey 1979/85
ASCH2	Swiss Land Use Statistics, second survey 1992/97
BEF, BCEF	biomass expansion factor, biomass conversion and expansion factor
Carbura	Swiss Central Office for the Import of Liquid Fuels
Cemsuisse	Association of the Swiss Cement Industry
CC	Combination category
CH_4	Methane, 1995 IPCC GWP: 21 (UNFCCC 2006b, Table 1)
CFC	Chlorofluorocarbon (organic compound: refrigerant, propellant)
CHP	Combined heat and power production
CO	Carbon monoxide
CO_2, CO_2 eq	Carbon dioxide, carbon dioxide equivalent
CORINAIR	CORe INventory of AIR emissions (under the European Topic Centre on Air Emissions and under the European Environment Agency)
CRF	Common reporting format
DBH	Diameter (of trees) at breast height
EF	Emission factor
EMEP	European Monitoring and Evaluation Programme (under the Convention on Long-range Transboundary Air Pollution)
EMIS	Swiss national air pollution database
EMPA	Swiss Federal Laboratories for Material Testing and Research
EV	Erdöl-Vereinigung (Swiss Petroleum Association)
DETEC	Dept. of the Environment, Transport, Energy and Communications
FAL	Swiss Federal Research Station for Agroecology and Agriculture (since 2006: ART)
FCCC	Framework Convention on Climate Change
FiBL	Research Institute of Organic Agriculture
FOAG	Federal Office for Agriculture
FOCA	Federal Office of Civil Aviation

FOEN	Federal Office for the Environment (former name SAEFL until 2005)
FOITT	Federal Office of Information Technology, Systems and Telecommunication
Gg	Gigagram (10^9 g = 1’000 tons)
GHG	Greenhouse gas
GL, GPG	Guidelines, Good Practice Guidance
GVS	Swiss Foundry Association
GWP	Global Warming Potential
ha	hectare
HFC	Hydrofluorocarbons (e.g. HFC-32 difluoromethane)
HFO	Heavy fuel oil
IDM	FOEN Internal Document Management System
IDP	Inventory Development Plan
IPCC	Intergovernmental Panel on Climate Change
KCA	key category analysis
kha	kilo hectare
LPG	Liquefied Petroleum Gas (Propane/Butane)
LTO	Landing-Takeoff-Cycle (Aviation)
LULUCF	Land Use, Land-Use Change and Forestry
MSW	Municipal solid waste
NABO	Swiss Soil Monitoring Network
NCV	Net calorific value
NFI 1, NFI 2, NFI 3	First (1983-1985), Second (1993-1995) and Third (2004-2006) National Forest Inventory
NIR	National Inventory Report
NIS	National Inventory System
NMVOC	Non-methane volatile organic compounds
N_2O	Nitrous oxide; 1995 IPCC GWP: 310 (UNFCCC 2006b, Table 1)
NO_x	Nitrogen oxides
PCDD/PCDF	Polychlorinated Dibenzodioxins and -furanes
PFC	Perfluorinated carbon compounds (e.g. Tetrafluoromethane)
SAEFL	Swiss Agency for the Environment, Forests and Landscape (since 2006: Federal Office for the Environment FOEN)
SF_6	Sulphur hexafluoride, 1995 IPCC GWP: 23’900 (UNFCCC 2006b, Table 1)
SFOE	Swiss Federal Office of Energy
SFSO	Swiss Federal Statistical Office
SO_2	Sulphur dioxide
SOC	Soil organic carbon

SVGW/SSIG/SGWA	Schweizerischer Verein des Gas- und Wasserfaches / Société Suisse de l'Industrie du Gaz et des Eaux / Swiss Gas and Water Industry Association
SWISSMEM	Swiss Mechanical and Electrical Engineering Industries (Schweizer Maschinen-, Elektro- und Metallindustrie)
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compounds
VTG	Luftwaffe (Swiss Air Force Administration)
WSL	Swiss Federal Institute for Forest, Snow and Landscape Research

Executive Summary

ES 1 Background Information on Greenhouse Gas Inventories, Climate Change and Supplementary Information Required Under Art. 7.1. KP

ES 1.1 Background Information on Climate Change

Recent data confirms a warming trend in Switzerland with an observed increase in mean annual temperature of 1.75°C between 1864 and 2012 (FOEN 2014d). Over the last 30 years Swiss temperature has increased with an annual average warming rate of 0.35°C/decade (CH2011, 2011). The most visible change in the Alps resulting from global warming is the retreat of glaciers, which showed a volume loss of 12% since 1999 (FOEN 2014d).

The observed trends in precipitation are less distinct than in temperature. They generally show an increase in winter and spring, whereas for summer and autumn no significant trends are detectable. Regional scenarios predict an increase in mean winter precipitation and a decrease in summer, which will have a marked impact on the hydrological cycle. Further, higher intensity of storms and reduced snowfall and snow cover duration are expected, increasing the risk and frequency of floods, landslides and debris flows.

Concerning biodiversity, climate change is expected to affect species composition, distribution, their cycles, synchronicity, the overall genetic diversity and the provision of ecosystem services. It will enhance the vulnerability of forests and potentially impair their protective, productive and social functions.

For agriculture, a moderate warming of 2°C to 3°C might increase productivity; however, if temperature will rise beyond that level, the increase in heat waves and drought periods would prove problematic for the cultivation of land and for livestock husbandry.

Various sectors of the Swiss economy are likely to be adversely affected by progressing climate change: In particular, winter tourism will suffer from increased scarcity of snow, hydroelectric power stations are confronted with altered runoff and sediment transport regimes, and insurance companies may face increased losses due to winter storms and floods. Natural hazards and extreme weather events potentially pose a growing risk to infrastructure and human health. Heat waves and elevated tropospheric ozone levels are cause for serious concern. Finally, it remains to be seen to what extent vector borne diseases spread due to changing climatic conditions. Recently Switzerland has analysed these challenges in detail and developed an effective adaptation strategy in order to hedge against negative effects resulting from climate change in Switzerland (FOEN, 2012b).

ES.1.2 Background Information on Greenhouse Gas Inventories

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

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

The 2014 inventory submission under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol (FOEN 2014) includes the NIR on hand, the greenhouse gas inventory 1990–2012 and the Kyoto Protocol LULUCF tables 2008–2012 in the common reporting format as well as the SEF tables and the standard independent assessment report (SIAR) from the National Registry. As a supplement, the update of the Description of the Quality Management System (FOEN 2014a) is provided.

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

In preparing the national greenhouse gas inventory, Switzerland took into account the findings of the individual reviews of the inventory by the expert review teams of the UN (UNFCCC 2004, UNFCCC 2006, UNFCCC 2007, UNFCCC 2009, UNFCCC 2010, UNFCCC 2011, UNFCCC 2012, UNFCCC 2013). The recommendations of the Annual Review Report (ARR) for the submission 2013 (UNFCCC 2014) as well as the recommendations of the "Saturday Paper" (UNFCCC 2013a) are included in the present submission (see Chapter 16).

The structure of the NIR corresponds to the UNFCCC annotated outline (UNFCCC 2009a) and it contains three parts: **PART 1** reports the obligations under the UNFCCC, **PART 2** the additional obligations under the Kyoto Protocol and several **Annexes** with detailed information on selected issues of Part 1 and Part 2.

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

- The data sources used to compile the national inventory and to estimate greenhouse gas emissions and removals are: the Swiss national air pollution database (EMIS), national energy statistics, data from industry associations, as well as further statistics and models for road transportation, off-road vehicles and machinery, agriculture, land use, land-use change and forestry (LULUCF) and waste. Emissions are calculated according to methodologies recommended by the IPCC and contained in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1997a, 1997b, 1997c), in the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000), and for LULUCF in the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003). Furthermore, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) have been consulted in a few cases. However, the nomenclature of the Revised 1996 IPCC Guidelines has been used throughout the current NIR. The data in the EMIS database are pre-processed in order to enable transfer to the CRF Reporter required for reporting under the UNFCCC and under the Kyoto Protocol.
- All inventory data are assembled and prepared for input into the CRF Reporter by the GHG Inventory Core Group, which is responsible for ensuring the conformity of the inventory with the Updated UNFCCC Reporting Guidelines on Annual Inventories (UNFCCC 2006b) and the 2008 Kyoto Protocol Reference Manual (UNFCCC 2008). In the preparation of this report, the Inventory Group was supported by consultants. Their mandate included editing of the NIR, and an analysis of the consistency between the emission modelling and the recommendations of the IPCC Good Practice Guidance. Furthermore, the consultants contributed to the key category analyses and carried out the uncertainty analyses. They were also involved in inventory improvement, e.g. by performing tasks contained in the Inventory Development Plan.
- The inventory quality management system is designed to comply with the objectives of good practice guidance, i.e. to ensure and improve transparency, consistency, comparability, completeness, accuracy and confidence in national GHG emission and removal estimates. The QA/QC Officer is responsible for enforcement of the defined quality standards. The National Inventory System complies with the ISO 9001:2008

standard (Quality Management System) and is certified by the Swiss TS Technical Services AG (Swiss-TS 2013).

- A National Inventory System Supervisory Board was established by decision of the FOEN Directorate in summer 2006. The Board oversees activities related to the GHG Inventory and to the National Registry.
- Furthermore, Chapter 1 provides information on key categories and uncertainties.

Chapter 2 contains an analysis of trends in Switzerland's greenhouse gas emissions by sources and removals by sinks for all sectors.

Chapters 3 to 9 provide principal source and sink category estimates.

Chapter 10 justifies, explains and summarises the recalculations and planned improvements. They result in a very small change of -0.30% (without LULUCF) in the base year emissions (1990) compared with the latest submission in 2013 and a small change in the latest year of recalculations 2011 by -0.38%. The chapter also contains an overview of the planned improvements.

In **PART 2**, **Chapter 11** reports KP LULUCF data, **Chapter 12** presents information on accounting of Kyoto Units, **Chapter 13** lists changes in the National System, **Chapter 14** documents changes in the National Registry, **Chapter 15** provides information on the minimization of adverse effects and **Chapter 16** contains other information including the "Saturday Paper" (UNFCCC 2013a) that resulted from the 2013 review, together with the party's responses.

ES.1.3 Background Information on Supplementary Information Required under Article 7.1. of the Kyoto Protocol (KP)

Chapter 11 of PART 2 as mentioned above, provides information on KP-LULUCF. Switzerland has decided to account for Forest Management under the elective voluntary activities of Article 3, paragraph 4 of the Kyoto Protocol. In accordance with the Annex to Decision 16/CMP.1, credits from Forest Management are capped in the first commitment period. For Switzerland the cap amounts to 1.83 Mt CO_2 (0.5 Mt C) per year, or 9.167 Mt CO_2 for the whole commitment period.

Switzerland has chosen to account annually for emissions and removals from activities under the Kyoto Protocol. The current submission contains the mandatory inventory years 2008, 2009, 2010, 2011 and 2012. In the NIR, additional information about 1999 to 2007 is included.

ES.2 Summary of National Emission and Removal Related Trends, and Emission and Removals from KP-LULUCF Activities

ES.2.1 GHG Inventory

In 2012, Switzerland emitted 51'449 Gg (kilotonnes) CO_2 equivalent, corresponding to 6.43 tonnes CO_2 equivalent per capita (CO_2: 5.41 tonnes per capita), to the atmosphere, excluding emissions from international bunkers (aviation and marine) and excluding emissions and removals from the sector Land Use, Land-Use Change and Forestry (LULUCF)[1]. For the emissions that are relevant under the Kyoto Protocol see chapter ES.3.3.

Several Key Category Analyses (with, without LULUCF and combined) are carried out for 2012 and for the base year 1990.

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[1] Inhabitants in Switzerland in 2012: 7.997 million (SFSO 2013a)

- Tier 1 analysis (without LULUCF): For 2012, among a total of 135 categories, 31 have been identified as key categories (level and/or trend) with an aggregated contribution of 97.2% to total national emissions. Of the 31 key categories, 19 are in sector 1 Energy, accounting for 79.5% of total CO_2 equivalent emissions in 2012.
- Tier 2 analysis (without LULUCF): For 2012, among a total of 135 categories, 30 have been identified as key categories (level and/or trend) with an aggregated contribution of 94.0% of the sum of all level assessments weighted with their uncertainty in 2012. Of the 30 key categories, 14 are in sector 1 Energy, accounting for 29.8% of the sum of all level assessments weighted with their uncertainty in 2012. Sector 4 Agriculture accounts for 51.0% of that sum. Tier 2 key category analysis shows that these two sectors have the highest impact on inventory uncertainty.
- A Tier 1 and Tier 2 analysis with LULUCF was conducted as well (see 1.5.1.3 and Annex A1.5).

Table E-1 shows Switzerland's annual GHG emissions by individual GHGs from 1990 (base year) to 2012. Despite clear trends in some GHG emissions (see below), there is no significant trend in the total emissions of the period 1990–2012. Year-to-year variations of total emissions are mainly caused by changing winter temperatures and their effect on CO_2 emissions from fuel combustion (source category 1A4). In 2012, total gross GHG emissions (excluding LULUCF) show a decrease of 2.7% compared to the level recorded for 1990 (see also Table E-2).

Table E-1 Summary of Switzerland's GHG emissions in CO_2 equivalent (Gg), 1990–2012 (from CRF-tables 10s5, 10s5.2 and 10s5.3, upper half). HFCs increased by 5'526'548% compared to 1990 levels (0.02 Gg CO_2 equivalent).

Greenhouse Gas Emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	42'677	44'356	44'111	40'386	40'550	40'519	41'588	40'257	41'833	42'724
CO_2 emissions excluding net CO_2 from LULUCF	44'639	46'369	46'258	43'718	42'981	43'683	44'340	43'514	44'812	44'894
CH_4 emissions including CH_4 from LULUCF	4'576	4'563	4'471	4'377	4'330	4'328	4'283	4'225	4'170	4'073
CH_4 emissions excluding CH_4 from LULUCF	4'546	4'551	4'461	4'367	4'315	4'311	4'270	4'187	4'156	4'063
N_2O emissions including N_2O from LULUCF	3'472	3'463	3'433	3'345	3'307	3'295	3'289	3'177	3'161	3'124
N_2O emissions excluding N_2O from LULUCF	3'461	3'457	3'427	3'339	3'300	3'287	3'283	3'166	3'155	3'119
HFCs	0	0	7	15	34	182	228	301	358	421
PFCs	100	85	69	30	18	15	17	20	23	36
SF_6	144	146	148	126	112	98	94	131	160	147
Total (including LULUCF)	**50'969**	**52'613**	**52'239**	**48'279**	**48'350**	**48'436**	**49'501**	**48'112**	**49'704**	**50'524**
Total (excluding LULUCF)	**52'890**	**54'607**	**54'370**	**51'595**	**50'760**	**51'576**	**52'233**	**51'319**	**52'663**	**52'680**

Greenhouse Gas Emissions	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	43'949	46'171	44'805	43'584	42'967	44'337	44'238	42'145	44'658	43'453
CO_2 emissions excluding net CO_2 from LULUCF	43'952	44'904	43'844	45'025	45'650	46'290	45'911	43'931	45'447	44'280
CH_4 emissions including CH_4 from LULUCF	3'995	3'983	3'939	3'849	3'806	3'801	3'804	3'801	3'850	3'787
CH_4 emissions excluding CH_4 from LULUCF	3'985	3'973	3'922	3'829	3'797	3'791	3'793	3'787	3'840	3'777
N_2O emissions including N_2O from LULUCF	3'114	3'133	3'106	3'047	2'997	2'981	2'977	3'006	3'043	3'008
N_2O emissions excluding N_2O from LULUCF	3'109	3'128	3'100	3'040	2'993	2'977	2'972	3'001	3'039	3'004
HFCs	501	597	635	710	820	905	936	976	1'042	1'083
PFCs	69	45	40	57	53	33	33	29	39	36
SF_6	158	157	168	174	190	213	201	186	245	187
Total (including LULUCF)	**51'787**	**54'085**	**52'694**	**51'421**	**50'834**	**52'271**	**52'189**	**50'144**	**52'878**	**51'554**
Total (excluding LULUCF)	**51'775**	**52'805**	**51'710**	**52'835**	**53'503**	**54'209**	**53'846**	**51'910**	**53'653**	**52'366**

Greenhouse Gas Emissions	**2010**	**2011**	**2012**	Change baseyear to 2012 (%)
	CO_2 equivalent (Gg)			
CO_2 emissions including net CO_2 from LULUCF	44'976	39'934	42'109	*-1.3%*
CO_2 emissions excluding net CO_2 from LULUCF	45'923	41'848	43'251	*-3.1%*
CH_4 emissions including CH_4 from LULUCF	3'773	3'723	3'698	*-19.2%*
CH_4 emissions excluding CH_4 from LULUCF	3'764	3'711	3'689	*-18.8%*
N_2O emissions including N_2O from LULUCF	3'082	3'019	3'011	*-13.3%*
N_2O emissions excluding N_2O from LULUCF	3'078	3'015	3'007	*-13.1%*
HFCs	1'138	1'195	1'245	*see caption*
PFCs	37	40	33	*-67.0%*
SF_6	155	164	224	*56.0%*
Total (including LULUCF)	**53'161**	**48'076**	**50'320**	***-1.3%***
Total (excluding LULUCF)	**54'095**	**49'973**	**51'449**	***-2.7%***

With regard to the distribution of emissions by individual greenhouse gases, CO_2 is the largest single contributor to emissions, accounting for 84.1% of total gross GHG emissions (excluding LULUCF) in 2012 (1990: 84.4%). The share of CH_4 decreased from 8.6% (1990) to 7.2% (2012). Over the same period, the share of N_2O decreased from 6.5% to 5.8%, while the share of F-gases increased from 0.5% to 2.9%.

Table E-2 Switzerland's total gross GHG emissions (excluding LULUCF) and the contribution of individual gases in CO_2 equivalent (Gg), selected years.

Greenhouse Gas Emissions	**1990**		**1995**		**2000**		**2005**	
(excluding LULUCF)	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
CO_2	44'639	84.4%	43'683	84.7%	43'952	84.9%	46'290	85.4%
CH_4	4'546	8.6%	4'311	8.4%	3'985	7.7%	3'791	7.0%
N_2O	3'461	6.5%	3'287	6.4%	3'109	6.0%	2'977	5.5%
HFCs	0	0.0%	182	0.4%	501	1.0%	905	1.7%
PFCs	100	0.2%	15	0.0%	69	0.1%	33	0.1%
SF_6	144	0.3%	98	0.2%	158	0.3%	213	0.4%
Total (excluding LULUCF)	**52'890**	**100%**	**51'576**	**100%**	**51'775**	**100%**	**54'209**	**100%**

Greenhouse Gas Emissions	**2009**		**2010**		**2011**		**2012**	
(excluding LULUCF)	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
CO_2	44'280	84.6%	45'923	84.9%	41'848	83.7%	43'251	84.1%
CH_4	3'777	7.2%	3'764	7.0%	3'711	7.4%	3'689	7.2%
N_2O	3'004	5.7%	3'078	5.7%	3'015	6.0%	3'007	5.8%
HFCs	1'083	2.1%	1'138	2.1%	1'195	2.4%	1'245	2.4%
PFCs	36	0.1%	37	0.1%	40	0.1%	33	0.1%
SF_6	187	0.4%	155	0.3%	164	0.3%	224	0.4%
Total (excluding LULUCF)	**52'366**	**100%**	**54'095**	**100%**	**49'973**	**100%**	**51'449**	**100%**

Figure E-1 shows the shares of 2012 emissions contributed by individual greenhouse gases. As the shares of emissions contributed by the individual gases have remained relatively constant, the diagram is also representative of the other years in the period 1990–2012.

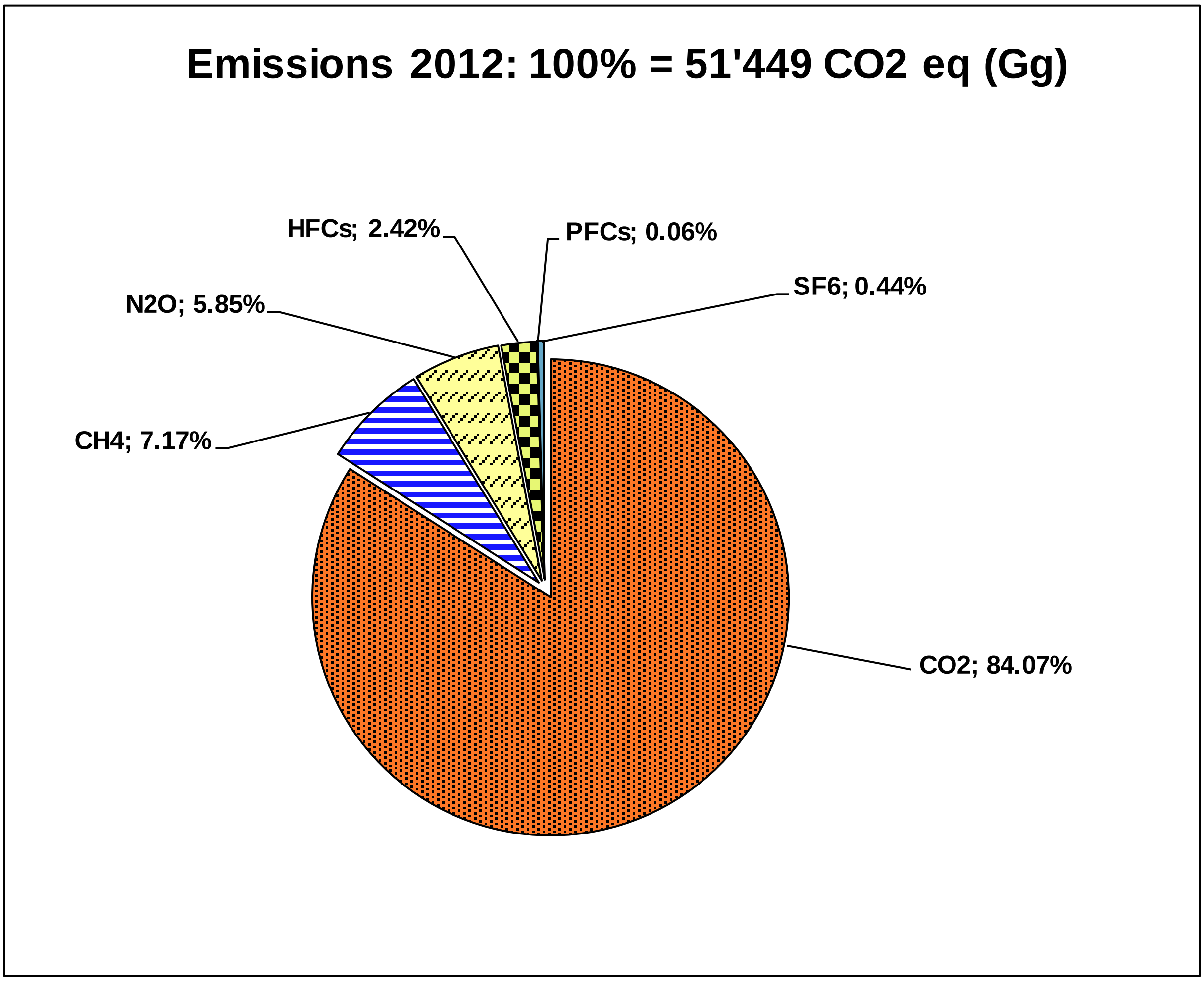

Figure E-1 Contribution of individual gases to Switzerland's GHG emissions (excluding LULUCF) in 2012. 100% = 51'449 Gg CO_2 eq. (Numbers may not add to total due to rounding.)

For the emission data of 2012 excluding LULUCF, an uncertainty analysis on Tier 1 level was carried out resulting in a **level uncertainty of 3.65% and a trend uncertainty of 1.87% (1990-2012).** The analysis was also carried out including the LULUCF sector resulting in increases of the uncertainties to 7.43% (level uncertainty) and 2.46% (trend uncertainty). Tier 2 show somewhat higher uncertainties: **level uncertainty of 3.86% and a trend uncertainty of 3.11%.** Including the LULUCF sector, the level uncertainty is 7.51% and the trend uncertainty 8.82%. In the Tier 2 analyses, asymmetric probability distributions and positive correlations cause higher uncertainties than in the Tier 1 analyses.

Chapter 10 explains and justifies recalculations that have been performed since the previous inventory submission to the UNFCCC secretariat in September 2013 after the centralized review 2013. The recalculations result in a decrease of the total base year (1990) emissions of 0.30% in CO_2 equivalents compared to the previous inventory (without LULUCF). For the year 2011 emissions, the decrease is 0.38% without emissions and removals from LULUCF. If the LULUCF sector is included there is a increase of 2.15% in 1990 and a decrease of 2.83% in 2011.

ES.2.2 KP-LULUCF Activities

Switzerland reports the mandatory LULUCF activities Afforestation and Deforestation (Reforestation is not occurring in Switzerland) under Article 3, paragraph 3 of the Kyoto Protocol, and Forest Management under the elective voluntary activities of Article 3, paragraph 4 of the Kyoto Protocol. The total contribution of these activities is shown in Table E-3.

Table E-3 Contribution of activities accounted for under Article 3, paragraph 3 and paragraph 4 (Forest Management) of the Kyoto Protocol, Gg CO_2 eq., 1999-2012.

Greenhouse gas source and sink activities	1999	2000	2001	2002	2003	2004	2005
	Net CO_2 equivalent emissions/removals (Gg CO_2 eq)						
Article 3.3 activities	216.97	216.83	215.84	214.33	212.51	210.95	174.16
Article 3.4 activities	-3330.01	-395.31	166.35	219.39	-2434.18	-2810.38	-2663.60

Greenhouse gas source and sink activities	2006	2007	2008	2009	2010	2011	2012
	Net CO_2 equivalent emissions/removals (Gg CO_2 eq)						
Article 3.3 activities	147.05	117.04	81.74	162.22	197.10	201.52	204.74
Article 3.4 activities	-2804.38	-1901.42	-1202.77	-1419.28	-2020.23	-2063.62	-2236.38

ES.3. Overview of Source and Sink Category Estimates and Trends, including KP-LULUCF Activities

ES.3.1 GHG Inventory (Convention on Climate Change)

Table E-4 and Figure E-2 show the GHG emissions and removals by the main source and sink categories. The energy sector is by far the largest source of national emissions, accounting for 80.6% of the total GHG emissions (excluding LULUCF). There are decreasing trends in the source categories 3. Solvent and Other Product Use, 4. Agriculture, and 6. Waste as well as an increasing trend in source category 2 Industrial Processes. However, there is no significant trend in total emissions over the period 1990–2012 due to the dominating emissions of the energy sector with its year-to-year variability caused by changing winter temperatures and their effect on CO_2 emissions from fuel combustion.

Table E-4 Switzerland's GHG emissions and removals by source and sink categories in CO_2 equivalent (Gg), 1990–2012 (from CRF-tables 10s5, 10s5.2 and 10s5.3).

Source and Sink Categories	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
1. Energy	41'989	44'121	44'191	41'915	41'029	41'916	42'787	42'147	43'474	43'533
1A1 Energy Industries	2'601	2'859	2'939	2'584	2'613	2'643	2'855	2'813	3'132	3'165
1A2 Manufacturing Industries and Construction	6'138	6'326	5'988	5'909	5'911	6'106	5'885	5'784	5'969	5'954
1A3 Transport	14'600	15'094	15'418	14'352	14'539	14'225	14'287	14'844	15'056	15'663
1A4 Other Sectors	18'095	19'273	19'276	18'500	17'407	18'393	19'207	18'138	18'745	18'227
1A5 Other (Military)	206	188	180	171	166	148	137	147	146	132
1B Fugitive emissions from oil and natural gas	349	381	390	399	393	400	416	420	426	392
2. Industrial Processes	3'320	2'957	2'793	2'484	2'649	2'626	2'498	2'431	2'517	2'580
3. Solvent and Other Product Use	470	444	420	392	374	354	331	308	286	273
4. Agriculture	6'092	6'069	5'979	5'877	5'843	5'819	5'780	5'606	5'578	5'511
6. Waste	1'007	1'004	976	914	852	847	823	814	795	768
7. Other	12	12	13	13	13	13	13	13	14	14
Total (excluding LULUCF)	52'890	54'607	54'370	51'595	50'760	51'576	52'233	51'319	52'663	52'680
5. Land Use, Land-Use Change and Forestry	-1'921	-1'995	-2'131	-3'316	-2'410	-3'140	-2'732	-3'207	-2'959	-2'155
Total (including LULUCF)	50'969	52'613	52'239	48'279	48'350	48'436	49'501	48'112	49'704	50'524

Source and Sink Categories	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	CO_2 equivalent (Gg)									
1. Energy	42'429	43'330	42'297	43'497	43'922	44'432	44'084	42'078	43'628	42'506
1A1 Energy Industries	3'064	3'187	3'268	3'295	3'617	3'804	4'078	3'835	4'025	3'949
1A2 Manufacturing Industries and Construction	5'839	6'125	5'865	6'001	6'120	6'173	6'320	6'159	6'173	5'798
1A3 Transport	15'896	15'597	15'522	15'689	15'767	15'827	15'939	16'257	16'624	16'427
1A4 Other Sectors	17'133	17'946	17'186	18'092	18'021	18'239	17'360	15'462	16'450	15'983
1A5 Other (Military)	136	134	140	125	114	124	127	120	115	116
1B Fugitive emissions from oil and natural gas	362	341	317	295	283	265	260	245	242	232
2. Industrial Processes	2'836	2'938	2'922	2'970	3'235	3'425	3'397	3'421	3'535	3'446
3. Solvent and Other Product Use	259	245	234	225	212	211	206	205	202	201
4. Agriculture	5'496	5'561	5'536	5'461	5'447	5'474	5'493	5'556	5'645	5'587
6. Waste	741	717	708	669	673	654	653	637	629	612
7. Other	14	14	14	14	14	14	14	14	14	14
Total (excluding LULUCF)	51'775	52'805	51'710	52'835	53'503	54'209	53'846	51'910	53'653	52'366
5. Land Use, Land-Use Change and Forestry	12	1'281	984	-1'414	-2'669	-1'939	-1'657	-1'766	-775	-813
Total (including LULUCF)	51'787	54'085	52'694	51'421	50'834	52'271	52'189	50'144	52'878	51'554

Source and Sink Categories	**2010**	**2011**	**2012**	**2012/1990**
	CO_2 equivalent (Gg)			%
1. Energy	44'004	39'945	41'477	*-1.2%*
1A1 Energy Industries	4'180	3'968	4'064	*56.3%*
1A2 Manufacturing Industries and Construction	5'954	5'449	5'515	*-10.1%*
1A3 Transport	16'321	16'205	16'331	*11.9%*
1A4 Other Sectors	17'193	13'994	15'240	*-15.8%*
1A5 Other (Military)	121	108	116	*-43.6%*
1B Fugitive emissions from oil and natural gas	234	220	209	*-40.0%*
2. Industrial Processes	3'634	3'642	3'628	*9.3%*
3. Solvent and Other Product Use	199	202	200	*-57.5%*
4. Agriculture	5'637	5'572	5'539	*-9.1%*
6. Waste	608	598	591	*-41.3%*
7. Other	14	14	14	*16.2%*
Total (excluding LULUCF)	54'095	49'973	51'449	*-2.7%*
5. Land Use, Land-Use Change and Forestry	-934	-1'897	-1'129	*-41.2%*
Total (including LULUCF)	53'161	48'076	50'320	*-1.3%*

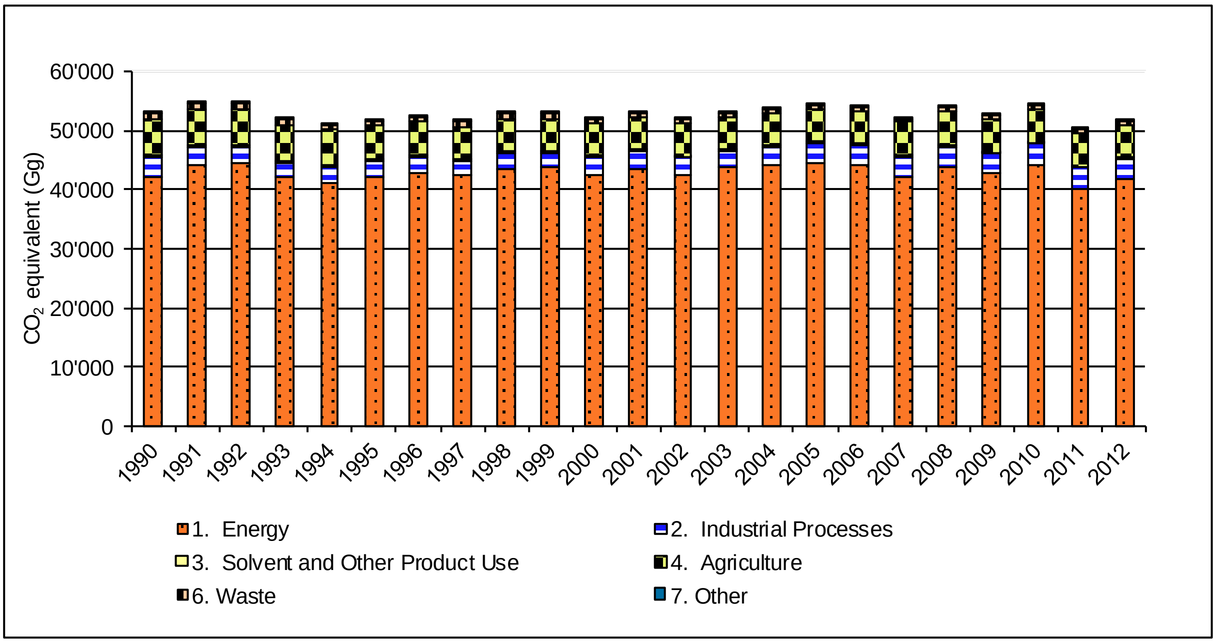

Figure E-2 Switzerland's greenhouse gas emissions in CO_2 equivalent (Gg) by main source categories, 1990–2012 (excluding LULUCF).

Table E-5 shows the contributions of individual sectors to total emissions excl. LULUCF for selected years in more detail. Between 1990 and 2012, the relative contribution of sector 1 Energy increased marginally from 79.4% to 80.6%, whereas emissions from sector 4 Agriculture decreased from 11.5% to 10.8% and those from sector 6 Waste changed from 1.9% to 1.1%. Sector 2 Industrial Processes contributed 6.3% to total emissions in 1990 and 7.1 % in 2012, but with lower values in between (1995, 2000).

Table E-5 Switzerland's total gross GHG emissions (excluding LULUCF) in CO_2 equivalent (Gg) and the contribution of individual source categories, selected years.

Source and Sink Categories	**1990**		**1995**		**2000**		**2005**		**2007**	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1. Energy	41'989	79.4%	41'916	81.3%	42'429	81.9%	44'432	82.0%	42'078	81.1%
1A1 Energy Industries	*2'601*	*4.9%*	2'643	*5.1%*	3'064	*5.9%*	3'804	*7.0%*	3'835	*7.4%*
1A2 Manufacturing Industries and Construction	*6'138*	*11.6%*	6'106	*11.8%*	5'839	*11.3%*	6'173	*11.4%*	6'159	*11.9%*
1A3 Transport	*14'600*	*27.6%*	14'225	*27.6%*	15'896	*30.7%*	15'827	*29.2%*	16'257	*31.3%*
1A4 Other Sectors	*18'095*	*34.2%*	18'393	*35.7%*	17'133	*33.1%*	18'239	*33.6%*	15'462	*29.8%*
1A5 Other (Military)	*206*	*0.4%*	148	*0.3%*	136	*0.3%*	124	*0.2%*	120	*0.2%*
1B Fugitive emissions from oil and natural gas	*349*	*0.7%*	400	*0.8%*	362	*0.7%*	265	*0.5%*	245	*0.5%*
2. Industrial Processes	3'320	6.3%	2'626	5.1%	2'836	5.5%	3'425	6.3%	3'421	6.6%
3. Solvent and Other Product Use	470	0.9%	354	0.7%	259	0.5%	211	0.4%	205	0.4%
4. Agriculture	6'092	11.5%	5'819	11.3%	5'496	10.6%	5'474	10.1%	5'556	10.7%
6. Waste	1'007	1.9%	847	1.6%	741	1.4%	654	1.2%	637	1.2%
7. Other	12	0.0%	13	0.0%	14	0.0%	14	0.0%	14	0.0%
Total (excluding LULUCF)	52'890	100.0%	51'576	100.0%	51'775	100.0%	54'209	100.0%	51'910	100.0%

Source and Sink Categories	**2008**		**2009**		**2010**		**2011**		**2012**	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1. Energy	43'628	81.3%	42'506	81.2%	44'004	81.3%	39'945	79.9%	41'477	80.6%
1A1 Energy Industries	*4'025*	*7.5%*	3'949	*7.5%*	4'180	*7.7%*	3'968	*7.9%*	4'064	*7.9%*
1A2 Manufacturing Industries and Construction	*6'173*	*11.5%*	5'798	*11.1%*	5'954	*11.0%*	5'449	*10.9%*	5'515	*10.7%*
1A3 Transport	*16'624*	*31.0%*	16'427	*31.4%*	16'321	*30.2%*	16'205	*32.4%*	16'331	*31.7%*
1A4 Other Sectors	*16'450*	*30.7%*	15'983	*30.5%*	17'193	*31.8%*	13'994	*28.0%*	15'240	*29.6%*
1A5 Other (Military)	*115*	*0.2%*	116	*0.2%*	121	*0.2%*	108	*0.2%*	116	*0.2%*
1B Fugitive emissions from oil and natural gas	*242*	*0.5%*	232	*0.4%*	234	*0.4%*	220	*0.4%*	209	*0.4%*
2. Industrial Processes	3'535	6.6%	3'446	6.6%	3'634	6.7%	3'642	7.3%	3'628	7.1%
3. Solvent and Other Product Use	202	0.4%	201	0.4%	199	0.4%	202	0.4%	200	0.4%
4. Agriculture	5'645	10.5%	5'587	10.7%	5'637	10.4%	5'572	11.1%	5'539	10.8%
6. Waste	629	1.2%	612	1.2%	608	1.1%	598	1.2%	591	1.1%
7. Other	14	0.0%	14	0.0%	14	0.0%	14	0.0%	14	0.0%
Total (excluding LULUCF)	53'653	100.0%	52'366	100.0%	54'095	100.0%	49'973	100.0%	51'449	100.0%

ES.3.2 KP-LULUCF Activities

An overview of net CO_2 equivalent emissions and removals of activities under Article 3, paragraph 3 and Forest Management under paragraph 4 of the Kyoto Protocol is shown in Table E-6. In 2012, Deforestations were responsible for an emission of 221.87 Gg CO_2 equivalent, whereas Afforestations stored -17.13 Gg CO_2 equivalent and Forest Management -2236.38 Gg CO_2 equivalent.

Detailed quantitative information of the inventory years 2008, 2009, 2010, 2011 and 2012 as well as data for the previous years 1999–2007 are reported in Chapter 11.4, Chapter 11.5 and displayed in Table 11-4. Annual changes in the emissions from Deforestation can directly be attributed to the changes in the area of Deforestations. Year-to-year fluctuations in removals from Afforestations are mainly due to changes in the yearly afforested area and the application of a logistical growth curve for Afforestations. Fluctuations in the contribution of Forest Management can mainly be explained by differences in the losses of living (cut and mortality) and dead biomass (dead wood and litter), whereas changes in the area of managed forest are relatively small.

Table E-6 Contribution of the carbon pools under Activities under Article 3, paragraph 3 and paragraph 4 (Forest Management) of the Kyoto Protocol, Gg CO_2 eq., 1999-2012.

Greenhouse gas source and sink activities	1999	2000	2001	2002	2003	2004	2005
	Net CO_2 equivalent emissions/removals (Gg CO_2 eq)						
A. Article 3.3 activities	**216.97**	**216.83**	**215.84**	**214.33**	**212.51**	**210.95**	**174.16**
A.1. Afforestation and Reforestation	-6.09	-6.82	-7.80	-9.17	-10.83	-12.60	-14.86
A.1.1. Units of land not harvested since the beginning of the commitment period	-6.09	-6.82	-7.80	-9.17	-10.83	-12.60	-14.86
A.1.2. Units of land harvested since the beginning of the commitment period	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.2. Deforestation	223.06	223.66	223.63	223.50	223.34	223.55	189.02
B. Article 3.4 activities	**-3330.01**	**-395.31**	**166.35**	**219.39**	**-2434.18**	**-2810.38**	**-2663.60**
B.1. Forest Management incl. biomass burning	-3330.01	-395.31	166.35	219.39	-2434.18	-2810.38	-2663.60
gains above ground living biomass	-9617.06	-9624.02	-9630.98	-9637.94	-9644.90	-9651.86	-9662.29
gains below ground living biomass	-2839.47	-2841.80	-2844.13	-2846.46	-2848.79	-2851.12	-2856.62
losses above ground living biomass	7758.43	10051.40	10371.01	10243.29	8273.08	8004.19	8365.83
losses below ground living biomass	2252.11	2847.55	2925.45	2894.29	2392.50	2319.62	2410.48
changes litter	-335.15	-271.92	-166.56	-34.20	-201.14	-218.05	-467.97
changes dead wood	-555.68	-563.91	-495.37	-423.47	-435.68	-418.28	-458.88
changes soil C min. soils	-2.28	-2.95	-3.46	-3.79	-4.07	-4.50	-5.04
changes soil C org. soils	8.68	8.68	8.68	8.69	8.69	8.69	8.70
sum forest management exl. biomass burning	-3330.43	-396.98	164.63	200.40	-2460.30	-2811.31	-2665.78
biomass burning	0.42	1.67	1.71	18.99	26.12	0.93	2.18
B.2. Cropland Management (if elected)	NA	NA	NA	NA	NA	NA	NA
B.3. Grazing Land Management (if elected)	NA	NA	NA	NA	NA	NA	NA
B.4. Revegetation (if elected)	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink activities	2006	2007	2008	2009	2010	2011	2012
	Net CO_2 equivalent emissions/removals (Gg CO_2 eq)						
A. Article 3.3 activities	**147.05**	**117.04**	**81.74**	**162.22**	**197.10**	**201.52**	**204.74**
A.1. Afforestation and Reforestation	-17.18	-20.14	-22.17	-24.33	-23.34	-19.62	-17.13
A.1.1. Units of land not harvested since the beginning of the commitment period	-17.18	-20.14	-22.17	-24.33	-23.00	-18.89	-15.89
A.1.2. Units of land harvested since the beginning of the commitment period	0.00	0.00	0.00	0.00	-0.34	-0.73	-1.25
A.2. Deforestation	164.23	137.19	103.91	186.56	220.45	221.14	221.87
B. Article 3.4 activities	**-2804.38**	**-1901.42**	**-1202.77**	**-1419.28**	**-2020.23**	**-2063.62**	**-2236.38**
B.1. Forest Management incl. biomass burning	-2804.38	-1901.42	-1202.77	-1419.28	-2020.23	-2063.62	-2236.38
gains above ground living biomass	-9844.35	-10013.44	-10184.68	-10196.75	-10201.54	-10206.14	-10210.74
gains below ground living biomass	-2925.08	-2989.60	-3055.14	-3060.06	-3062.02	-3063.86	-3065.70
losses above ground living biomass	8106.69	8426.45	8467.86	8105.81	7882.81	7839.72	7757.11
losses below ground living biomass	2288.18	2387.54	2417.30	2332.60	2285.48	2283.19	2264.70
changes litter	-222.74	71.47	383.78	354.85	29.07	115.00	134.28
changes dead wood	-214.87	202.23	761.98	1037.66	1039.35	954.69	876.33
changes soil C min. soils	-5.60	-5.63	-5.05	-4.07	-3.27	-2.69	-2.12
changes soil C org. soils	8.71	8.72	8.73	8.74	8.74	8.74	8.74
sum forest management excl. Biomass burning	-2809.05	-1912.26	-1205.22	-1421.23	-2021.39	-2071.35	-2237.40
biomass burning	4.68	10.84	2.45	1.95	1.16	7.73	1.02
B.2. Cropland Management (if elected)	NA	NA	NA	NA	NA	NA	NA
B.3. Grazing Land Management (if elected)	NA	NA	NA	NA	NA	NA	NA
B.4. Revegetation (if elected)	NA	NA	NA	NA	NA	NA	NA

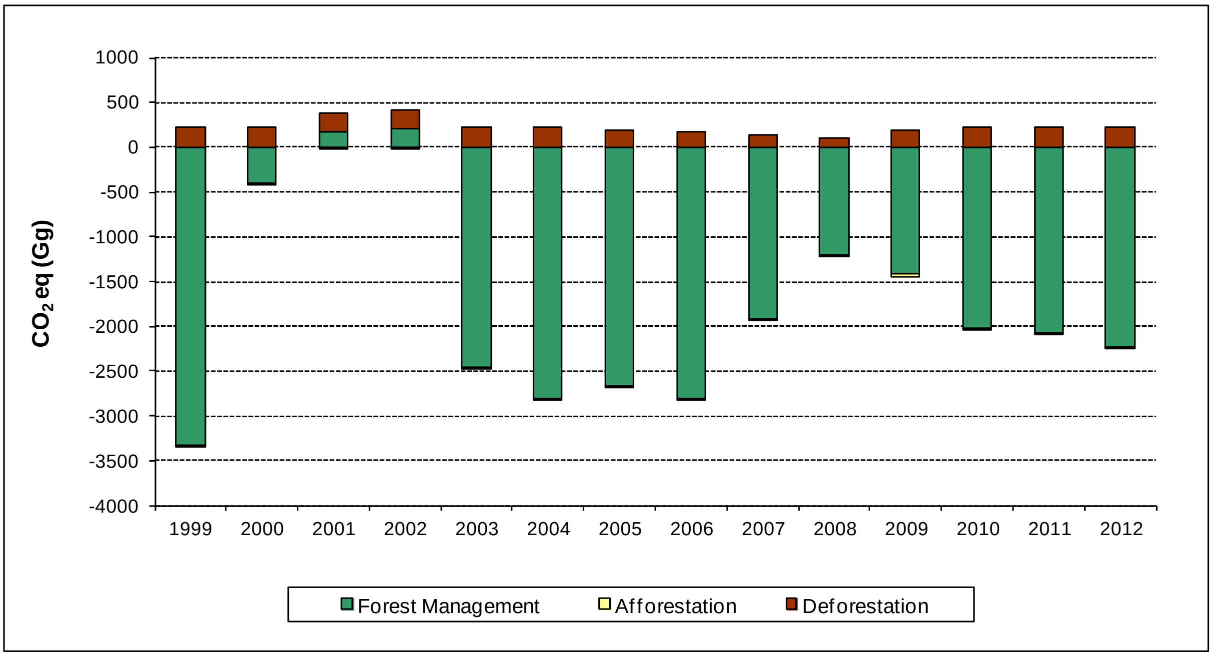

Figure E-3: Emissions (positive sign) and removals (negative sign) of CO_2 eq from Afforestation and Deforestation under Article 3, paragraph 3 and Forest Management under Article 3, paragraph 4, 1999-2012.

ES.3.3 GHG Inventory (Kyoto Protocol)

Relevant emissions and removals under the Kyoto Protocol are shown in table E-7 and E-8, sorted by sectors and gases respectively. The reported total emissions differ from those reported under the UNFCCC, as sector 7 Other – in addition to LULUCF and international bunkers – is not accounted for under the Kyoto Protocol. On the other hand, activities under article 3.3 (Afforestation, Reforestation and Deforestation) and 3.4 (forest, cropland and grazing management and revegetation) are taken into account over the commitment period 2008-2012. Under the elective voluntary activities of Article 3, paragraph 4 of the Kyoto Protocol, Switzerland only accounts for Forest Management. Base year emissions (as shown in tables E-7 and E-8) for the first commitment period are fixed at the value reported in the Initial Report 2006 (FOEN 2006h, UNFCCC 2007a).

Table E-7 Summary of Switzerland's GHG emissions in CO_2 equivalent (Gg), 1990–2012 excluding emissions from sectors LULUCF, Other and International Bunkers.

		Sector	Base year inital report	1990	1991	1992	1993	1994	1995	1996	1997	1998
			CO_2 equivalent (Gg)									
Annex A sources		1 Energy	42'134	41'989	44'121	44'191	41'915	41'029	41'916	42'787	42'147	43'474
		2 Industrial Processes	3'258	3'320	2'957	2'793	2'484	2'649	2'626	2'498	2'431	2'517
		3 Solvent and Other Product Use	466	470	444	420	392	374	354	331	308	286
		4 Agriculture	5'903	6'092	6'069	5'979	5'877	5'843	5'819	5'780	5'606	5'578
		6 Waste	1'030	1'007	1'004	976	914	852	847	823	814	795
		Total (Annex A sources)	**52'791**	**52'878**	**54'595**	**54'358**	**51'582**	**50'747**	**51'563**	**52'220**	**51'305**	**52'650**

		Sector	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
			CO_2 equivalent (Gg)									
Annex A sources		1 Energy	43'533	42'429	43'330	42'297	43'497	43'922	44'432	44'084	42'078	43'628
		2 Industrial Processes	2'580	2'836	2'938	2'922	2'970	3'235	3'425	3'397	3'421	3'535
		3 Solvent and Other Product Use	273	259	245	234	225	212	211	206	205	202
		4 Agriculture	5'511	5'496	5'561	5'536	5'461	5'447	5'474	5'493	5'556	5'645
		6 Waste	768	741	717	708	669	673	654	653	637	629
		Total (Annex A sources)	**52'666**	**51'761**	**52'790**	**51'696**	**52'821**	**53'489**	**54'195**	**53'832**	**51'896**	**53'639**
KP-LULUCF	Art.3.3	Afforestation & reforestation										-22
		Deforestation										104
	Art.3.4	Forest management										-1'203
		Cropland management										NA
		Grazing land management										NA
		Revegetation										NA
		Total (Art. 3.3 + 3.4)										**-1'121**

		Sector	2009	2010	2011	2012	2012 – base year
			CO_2 equivalent (Gg)				%
Annex A sources		1 Energy	42'506	44'004	39'945	41'477	-1.6%
		2 Industrial Processes	3'446	3'634	3'642	3'628	11.4%
		3 Solvent and Other Product Use	201	199	202	200	-57.1%
		4 Agriculture	5'587	5'637	5'572	5'539	-6.2%
		6 Waste	612	608	598	591	-42.5%
		Total (Annex A sources)	**52'352**	**54'081**	**49'959**	**51'435**	**-2.6%**
KP-LULUCF	Art.3.3	Afforestation & reforestation	-24	-23	-20	-17	
		Deforestation	187	220	221	222	
	Art.3.4	Forest management	-1'419	-2'020	-2'064	-2'236	
		Cropland management	NA	NA	NA	NA	
		Grazing land management	NA	NA	NA	NA	
		Revegetation	NA	NA	NA	NA	
		Total (Art. 3.3 + 3.4)	**-1'257**	**-1'823**	**-1'862**	**-2'032**	

Table E-8 Switzerland's total GHG emissions (excluding LULUCF, Other and International Bunkers) and the contribution of individual gases in CO_2 equivalent (Gg), 1990-2012.

		GHG	Base year inital report	1990	1991	1992	1993	1994	1995	1996	1997	1998
			CO_2 equivalent (Gg)									
Annex A sources		CO_2	44'553	44'628	46'357	46'247	43'706	42'969	43'672	44'328	43'502	44'799
		CH_4	4'370	4'545	4'551	4'460	4'367	4'315	4'310	4'269	4'186	4'155
		N_2O	3'623	3'461	3'456	3'426	3'339	3'299	3'287	3'283	3'165	3'154
		HFCs	0.0	0.0	0.2	7	15	34	182	228	301	358
		PFCs	100	100	85	69	30	18	15	17	20	23
		SF_6	144	144	146	148	126	112	98	94	131	160
		Total (Annex A sources)	**52'791**	**52'878**	**54'595**	**54'358**	**51'582**	**50'747**	**51'563**	**52'220**	**51'305**	**52'650**

		GHG	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
			CO_2 equivalent (Gg)									
Annex A sources		CO_2	44'881	43'939	44'891	43'831	45'012	45'637	46'277	45'898	43'918	45'434
		CH_4	4'063	3'985	3'972	3'922	3'828	3'797	3'791	3'793	3'786	3'840
		N_2O	3'118	3'109	3'127	3'099	3'039	2'992	2'976	2'971	3'001	3'039
		HFCs	421	501	597	635	710	820	905	936	976	1'042
		PFCs	36	69	45	40	57	53	33	33	29	39
		SF_6	147	158	157	168	174	190	213	201	186	245
		Total (Annex A sources)	**52'666**	**51'761**	**52'790**	**51'696**	**52'821**	**53'489**	**54'195**	**53'832**	**51'896**	**53'639**
KP-LULUCF	Art.3.3	CO_2										82
		CH_4										NO
		N_2O										0.1
	Art.3.4	CO_2										-1'204
		CH_4										1.0
		N_2O										0.2
		Total (Art. 3.3 + 3.4)										**-1'121**

		GHG	2009	2010	2011	2012	2012 – base year
			CO_2 equivalent (Gg)				%
Annex A sources		CO_2	44'267	45'910	41'835	43'238	-3.0%
		CH_4	3'776	3'763	3'710	3'688	-15.6%
		N_2O	3'003	3'077	3'014	3'007	-17.0%
		HFCs	1'083	1'138	1'195	1'245	NA
		PFCs	36	37	40	33	-67.0%
		SF_6	187	155	164	224	56.0%
		Total (Annex A sources)	**52'352**	**54'081**	**49'959**	**51'435**	**-2.6%**
KP-LULUCF	Art.3.3	CO_2	162	197	202	205	
		CH_4	NO	NO	NO	NO	
		N_2O	0.0	0.0	0.0	0.0	
	Art.3.4	CO_2	-1'420	-2'021	-2'068	-2'237	
		CH_4	0.8	0.5	3.2	0.4	
		N_2O	0.2	0.1	0.7	0.1	
		Total (Art. 3.3 + 3.4)	**-1'257**	**-1'823**	**-1'862**	**-2'032**	

ES.4. Other information

Emission trends for indirect greenhouse gases show a very pronounced decline (see Table 2-6 and Figure 2-9). A strict air pollution control policy and the implementation of a large number of emission reduction measures led to a decrease of 49% to 74% in the period 1990-2012 in emissions of air pollutants. The main reduction measures were abatement of exhaust emissions from road vehicles and stationary combustion equipment, taxation of solvents and sulphured fuels, and voluntary agreements with industry sectors (FOEN 2010i, Swiss Confederation 1985, 1997).

Acknowledgements

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

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

PART 1

1 Introduction

1.1 Background Information on Swiss Greenhouse Gas Inventories, Climate Change and Supplementary Information of the Kyoto Protocol (KP)

1.1.1 Information on Climate Change

The report of the Swiss Advisory Body on Climate Change (OcCC) provides an assessment of the observed and expected impacts of climate change on Switzerland and the vulnerability of various ecological and socio-economic systems (OcCC, 2008). In the course of the 21st century, Swiss climate is projected to depart significantly from present and past conditions (CH2011 2011). Recent data confirms a warming trend with an observed increase in mean annual temperature of 1.75°C between 1864 and 2012 (FOEN 2014d). Over the last 100 years, mean annual temperatures increased by 0.13-0.20°C per decade, with a substantially accelerated warming in recent decades. According to the non-intervention scenarios (A2, A1B), seasonal mean temperatures will rise by another 2.7 °C to 4.8 °C by the end of this century compared to the period 1980-2009. Under the climate stabilization scenario (RCP3PD), Swiss climate would still change over the next decades, but is projected to stabilize at a mean warming of 1.2-1.8°C (FOEN 2014d).

The most visible change in the Alps resulting from global warming is the retreat of glaciers, which showed a volume loss of 12% since 1999 (FOEN 2014d). The area covered by alpine glaciers continuously diminishes. From about 2’900 km^2 of Alpine glacier area in the mid-1970s, only 2’100 km^2 remained in 2003 and an estimated 1’900 km^2 in 2013. A dramatic future loss in glacier covered area of 50-90% by 2100 has recently been modelled for a temperature increase between 2°C and 6°C for Switzerland (FOEN 2014d).

The observed trends in precipitation are less distinct than in temperature. Compared to the last 30 years, and depending on the scenario considered, the best estimates of summer mean precipitation for all Swiss regions is projected to decrease by 8-28% over the 21st century. Uncertainties due to climate model imperfections and natural variability typically amount to 15% in precipitation (CH 2011 2011). This change in summer mean precipitation will have a marked impact on the hydrological cycle: on the Central Plateau and in the very south of Switzerland, small and medium watercourses will dry up more frequently and natural replenishment of groundwater will decrease accordingly. Apart from changes to the mean temperature and precipitation, the nature of extreme events is also expected to change (CH2011 2011). More frequent, intense and longer-lasting summer warm spells and heat waves are expected, while the number of cold winter days and nights decrease in the projections for future climate in Switzerland. This is particularly relevant for alpine areas, tourism and forestry due to the risk of more frequent floods, landslides and debris flows.

The warming trend and changing precipitation patterns are expected to have significant effects on ecosystems. The Biodiversity Monitoring Switzerland reports that impacts of climate change are already being observed. A report about climate change in Switzerland summarizes several climate change afffected indicators such as the phenological spring phases, flowering indices and animal specific indices (FOEN 2014d). The indicators shows significant changes in a wide range of ecosystems during the last decades. The report also emphasizes that typical alpine vascular plants have shifted uphill over the past century. Generally, climate change is expected to affect species composition, distribution, their cycles, synchronicity, the overall genetic diversity and the provision of ecosystem services. It will enhance the vulnerability of forests and impair their protective, productive and social functions. For agriculture, a moderate warming of 2°C to 3°C might increase productivity, however, if temperature will rise beyond that level, the increase in heat waves and drought periods would prove problematic for the cultivation of land and for livestock husbandry.

Various sectors of the Swiss economy are likely to be affected by progressing climate change. In particular, the tourism industry will be hit, as the potentially beneficial effects for summer tourism will not compensate for the loss of income in mountain resorts during winter due to scarcity of snow. Cable car stations may loose their stability due to instabilities of permafrost soils. Hydroelectric power stations may be affected by altered runoff and sediment transport regimes, and insurance companies may face increased losses due to winter storms and floods. Natural hazards and extreme weather events potentially pose a growing risk to infrastructure and human health. Heat waves and elevated tropospheric ozone levels are cause for serious concern, as evidenced by the impacts of the heat wave in 2003. Finally, it remains to be seen to what extent vector borne diseases spread due to changing climatic conditions. Recently Switzerland has analysed these challenges in detail and developed an effective adaptation strategy in order to hedge against negative effects resulting from climate change in Switzerland (FOEN, 2012b).

1.1.2 Information on the Greenhouse Gas Inventory

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

On 9 July 2003, Switzerland ratified the Kyoto Protocol under the UNFCCC. In November 2006 Switzerland submitted its Initial Report under Article 7, paragraph 4 of the Kyoto Protocol (FOEN 2006h). The Swiss National Inventory System (NIS) according to Article 5.1 of the Kyoto Protocol has been implemented and is fully operational. On 6 December 2007, the NIS quality management system was certified to comply with ISO 9001:2000 requirements (SQS 2008); it has been audited and recertified in November 2010 and 2013. It includes the accounting and reporting of the national registry as well (ISO 9001:2008, SQS 2010, Swiss TS 2013). The April 2008 submission of the Swiss GHG inventory (FOEN 2008) has been Switzerland’s first submission under both the UNFCCC and the Kyoto Protocol.

For the submission in 2010, the NIR has been restructured according to the new outline (UNFCCC 2009a), which includes extended reporting under the Kyoto Protocol.

The 2014 inventory submission under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol (FOEN 2014) includes the NIR on hand, the greenhouse gas inventory 1990–2012 and the Kyoto Protocol LULUCF tables 2008–2012 in the common reporting format as well as the SEF tables and the standard independent assessment report (SIAR) from the National Registry. As a supplement, the update of the Description of the Quality Management System (FOEN 2014a) is provided.

1.1.3 Supplementary Information Required under Art. 7.1. KP

Switzerland has decided to account for Forest Management under the elective voluntary activities of Article 3, paragraph 4 of the Kyoto Protocol. In accordance with the Annex to Decision 16/CMP.1, credits from Forest Management are capped in the first commitment period. For Switzerland, the cap amounts to 1.83 Mt CO_2 (0.5 Mt C) per year, or 9.167 Mt CO_2 for the whole commitment period.

Switzerland has chosen to account annually for emissions and removals from the LULUCF sector. The current submission contains the mandatory inventory years 2008-2012 in the

Common Reporting Format. In addition, Switzerland includes KP-LULUCF information for the years 1999-2007 on a voluntary basis in the NIR.

1.2 Institutional Arrangements for Inventory Preparation

1.2.1 Overview of Institutional, Legal and Procedural Arrangements for Compiling GHG Inventory and Supplementary Information for KP

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

As part of a comprehensive project (Swiss Climate Reporting Project), the FOEN directorate mandated its Economics, Research and Environmental Observation Division in early 2004 to design and establish the NIS in order to ensure full compliance with the reporting requirements of the UNFCCC and the Kyoto Protocol by 2006. Today, the NIS is fully operational. The responsibility lies within the Climate Division of the FOEN which was established on 1st January 2010. Having regard to the provisions of Art. 5, paragraph 1 of the Kyoto Protocol, the NIS covers the following elements:

- arrangements with partner institutions, relating to roles and responsibilities, participation in the inventory development process, data use, communication and publication,
- inventory development plan,
- QA/QC system,
- official consideration and approval of data,
- upgrading and updating of the national air pollution database (EMIS),
- data documentation and storage.

With the formal approval of Switzerland's initial report under article 7, paragraph 4 of the Kyoto Protocol (FOEN 2006h) by the Federal Council on 8 November 2006 the Swiss NIS became operative. By providing for structures and in defining tasks and responsibilities of institutions, organisations and consultants involved, the NIS itself is a key tool in ensuring and improving the quality as well as the process management of inventory preparation. Figure 1-1 gives a schematic overview of the institutional setting of the NIS.

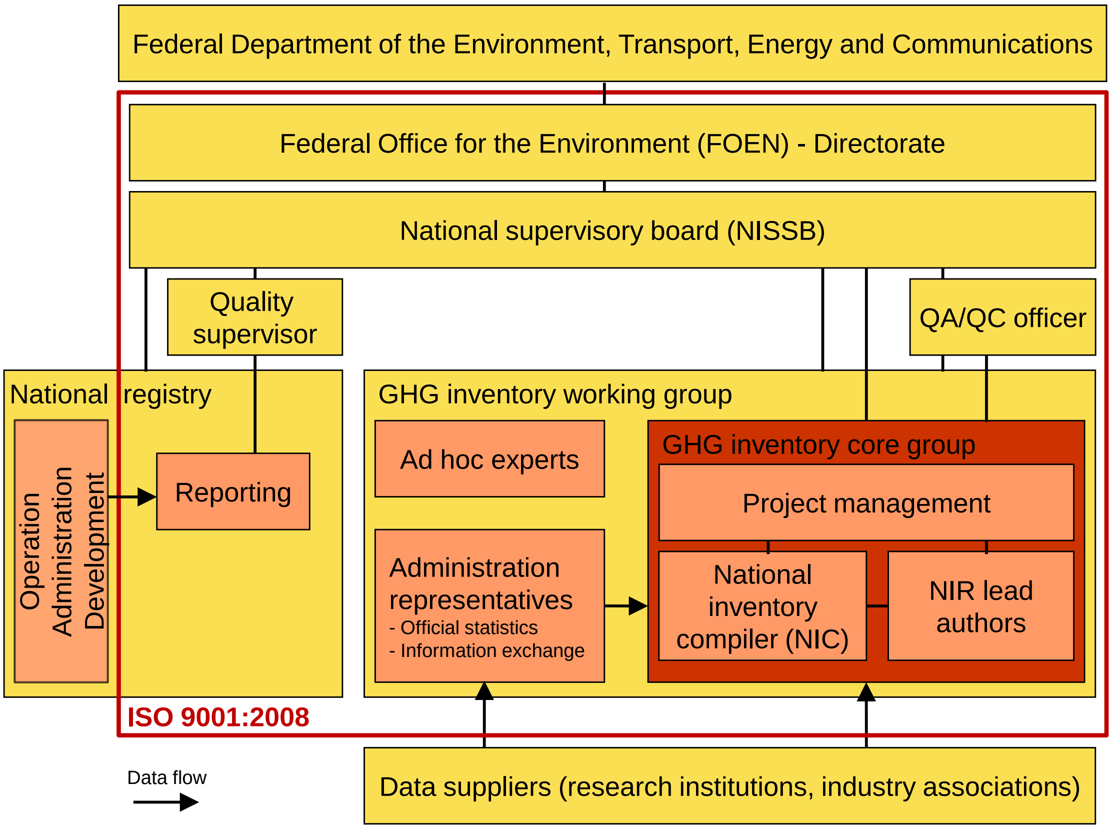

Figure 1-1 Institutional setting of the National Inventory System. The red frame marks the institutions that are included in the ISO 9001:2008 certification.

The **national inventory system supervisory board (NISSB)** was established by decision of the FOEN directorate in summer 2006. The board oversees activities related to the GHG inventory and to the national registry. It is independent of the inventory preparation and the registry administration and, by its composition, combines technical expertise and political authority. In order to put more emphasis on operational and security issues of the national registry, the national supervisory board has updated its formal mandate in 2011 to explicitly cover registry specific issues and assign the corresponding responsibilities.

The main tasks of the national supervisory board are:

- official consideration of the annual inventory submission and recommendation of the inventory for official approval by the FOEN directorate;
- assessment and approval of the recalculation of inventory data;
- handling of any issues arising from the UNFCCC review process that cannot be resolved at the level of the inventory project management or the registry administration;
- facilitation of any non-technical negotiation, consideration or approval processes involving other institutions within the federal administration;
- support of the registry administration in maintaining a secure and reliable registry environment.

The **national registry** is largely run independently of the national greenhouse gas inventory. Its operation is coordinated by the **registry administrator**, whose work is overseen by the registry **quality supervisor**.

The GHG **QA/QC officer** is responsible for enforcement of the defined quality standards of the national inventory. The officer also advises the national supervisory board on matters relating to the conformity of the inventory with reporting requirements. Tasks and competencies are described in detail in the Description of the Quality Management System (FOEN 2014a), annexed to this report.

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

The **GHG inventory core group** comprises the inventory experts employed at the FOEN or mandated on a regular basis, which are entrusted with specific, major responsibilities for inventory planning, preparation and/or management. All inventory data are assembled and prepared for input into the CRF Reporter by the GHG inventory core group, which is responsible for ensuring the conformity of the inventory with the updated UNFCCC Reporting Guidelines on Annual Inventories (UNFCCC 2006b) and the 2008 Kyoto Protocol Reference Manual (UNFCCC 2008). Further details of the function of the core group and the roles and responsibilities of its members are given in the Description of the Quality Management System (FOEN 2014a).

The core group consists of

- the inventory project management (with overall responsibility for the integrity of the inventory, communication of data, and information exchange with the UNFCCC secretariat);
- the national inventory compiler (responsible for the EMIS inventory data base, key category analyses, and for the CRF-tables);
- the NIR lead authors (responsible for the inventory report and carrying out centralized data assessments such as uncertainty analysis);
- selected sectoral experts.

The QA/QC officer, albeit no formal member, attends the meetings of the core group.

The GHG inventory core group coordinates and integrates the activities of data suppliers within and outside the FOEN as well as those of mandated experts. Further data suppliers contributing to the inventory are research institutions and industry associations (Table 1-1). The latter are obliged by Art. 46 of the Environmental Protection Act (Swiss Confederation 1983) to provide the authorities with the information needed to enforce the law and, where necessary, to carry out inquiries.

The formal arrangements (agreements, contracts, and documentations of roles and responsibilities) that have been established to consolidate and formalize cooperation between the relevant partners contributing to, or involved in, the GHG inventory preparation process are described in Chapter H.1.1 of Switzerland's Initial Report under Article 7, paragraph 4 of the Kyoto Protocol (FOEN 2006h). Changes to the national system are reported in chapter 13 of the NIR.

Information relating to the Swiss GHG inventory is made publicly accessible through a website hosted by FOEN (www.climatereporting.ch), where detailed contact information is also available.

Table 1-1 Suppliers of raw and processed data: 1–15 provide annual updates; 16–20 provide sporadic updates. The IPCC nomenclature (IPCC 1997a) is used for the inventory categories (1A1 = Energy Industries, 1A2 = Manufacturing Industries and Construction etc.). RA = Reference Approach. For further abbreviations and acronyms see the glossary. Coloured boxes mark those sectors to which each data supplier contributes.

	Institution	**Subject**	**Data supplied for inventory category**												
			1A1	1A2	1A3	1A4	1A5	1B	RA	2	3	4	5/KP	6	7
	Data suppliers (annual updates)														
1	FOEN, Air Pollution Control	EMIS Database	■	■		■	■	■		■	■	■		■	■
2	FOEN, Waste and Raw Materials	Waste Statistics	■	■										■	
3	FOEN, Forest Div.	Forest Statistics											■		
4	SFOE	Swiss overall energy statistics	■	■	■	■		■	■	■				■	
5	SFOE	Swiss wood energy statistics	■	■		■									
6	FOCA	Civil Aviation			■										
7	Swiss Air Force Administration	Military Aviation					■								
8	SFSO	Agriculture, LULUCF										■	■		
9	Agroscope	Agriculture, LULUCF										■	■		
10	WSL	National Forest Inventory											■		
11	Prognos	Energy Consum-ption		■		■									
12	Carbotech	F-gases								■					
13	Industry Assoc.: Swissmem, VSAI etc.	Ind. Processes, Solvents and Other Prod. Use								■	■				
14	Swiss Petroleum Association	Oil Statistics							■						
15	Sigmaplan, Meteotest	LULUCF											■		
	Data suppliers (sporadic updates)														
16	FOEN, Air Pollution Control	Off-road Data-base, NMVOC		■	■	■	■				■				
17	SGWA	Gas Distribution Losses						■							
18	EMPA/Intertek	Various Em Fact.	■	■	■	■									
19	INFRAS	On-road Emission Model			■										
20	INFRAS	Off-road Emission Model		■	■	■	■								

1.2.2 Overview of Inventory Planning

Inventory planning, preparation, and management follow an annual cycle that is documented in Table 1 of the QMS (FOEN, 2014a). It marks milestones in the planning and preparation process in relation to QA/QC activities as specified in the quality manual. Key elements of the cycle contain:

- meetings of the supervisory board, the core group and the working group
- modelling of emissions / removals and implementation in the CRF reporter
- QA/QC activities including checklists and reviews and their inclusion in the inventory development plan
- key category and uncertainty analyses
- official consideration, approval, and submission
- publication and archiving

1.2.3 Overview of Inventory Preparation and Management, Including for Supplementary Information for Kyoto Protocol

The overall responsibility of the inventory preparation is held by the Climate Division at FOEN. The project leader coordinates the activities and oversees the compilation of the inventory and related documentation. QA/QC procedures are also coordinated by the Climate Division, and the QA/QC officer ensures archiving of all relevant data and documentation on the internal document management system of the FOEN. Details regarding the inventory preparation are given in section 1.3, while the QA/QC system is described briefly in section 1.6 and more comprehensively in the QMS supplement (FOEN 2014a).

1.3 Process for Inventory Preparation

1.3.1 GHG Inventory and KP-LULUCF Inventory

All inventory data, including activity data and emission factors for both inventories are compiled centrally by the FOEN. While emissions and removals from sector 5 LULUCF and KP-LULUCF are calculated by the Forest Division, all other sectors are calculated or compiled by the Air Pollution Control and Chemicals Division. Activity data are provided by the data suppliers (Table 1-1), while emission factors are partly updated by the data suppliers and partly by the Air Pollution Control Division.

1.3.2 Data Collection, Processing and Storage, Including for KP-LULUCF Inventory

The data needed to prepare the UNFCCC greenhouse gas inventory in the CRF is collected by the various data suppliers (Table 1-1). Since the individual data suppliers bear the main responsibility for the quality of data provided, they are also responsible for the collection of activity data, emission factors, and for the selection of methods compliant with the relevant guidelines (IPCC 1997a, 1997b, 1997c, 2000, 2003). Some data suppliers have further started to adopt the good practice guidance presented in the 2006 IPCC guidelines (IPCC 2006). Several QA/QC activities (see Chapter 1.6.1 and FOEN 2014a) ensure and continuously improve the quality of inventory data.

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

Figure 1-2 illustrates in a simplified manner the data collection and processing steps leading to the CRF-tables required for reporting under the UNFCCC and under the Kyoto Protocol. From EMIS, an interface transfers the data to the CRF Reporter (Version 3.7) that generates the CRF-tables that are to be submitted using the UNFCCC submission portal released in February 2009. Representative data from the CRF-tables are shown in the NIR. The NIR authors and the reviewers control the correctness of the data transferred from EMIS into the NIR. Figures and tables shown in the NIR are exported directly from EMIS. The NIR authors check the correspondence between the exports and the CRF-tables. A detailed illustration of the sectoral steps of inventory processing is given in the monitoring protocols of NIS core processes and sub-processes, as shown in a couple of examples in FOEN (2014a).

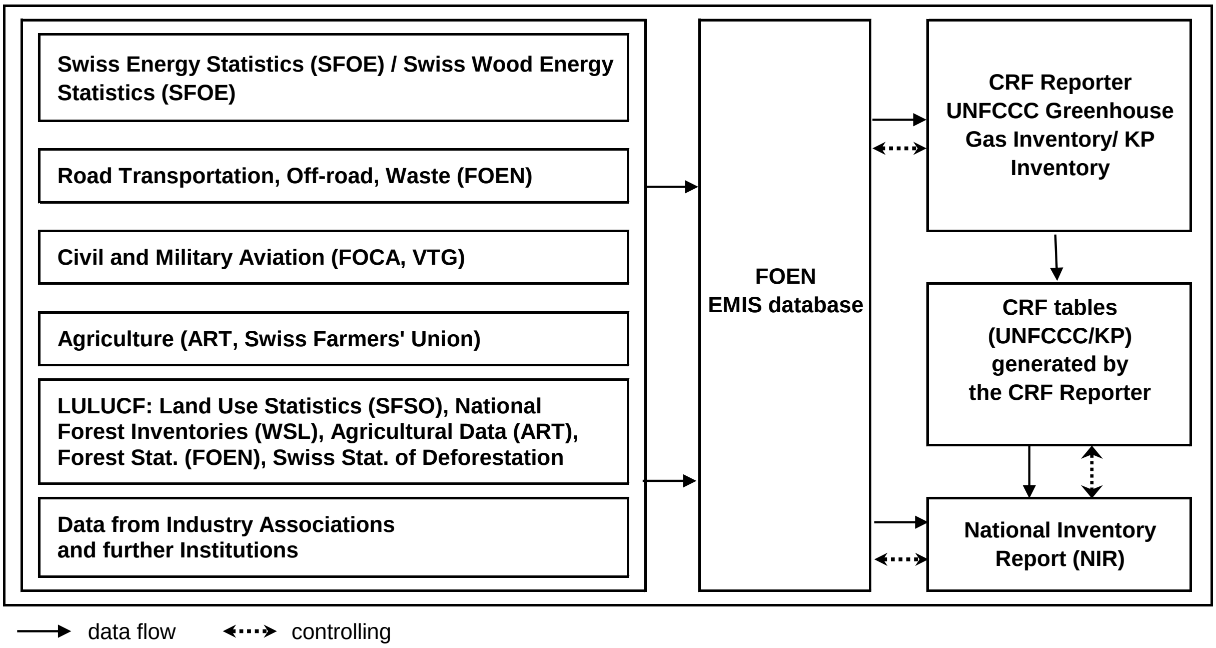

Figure 1-2 Schematic overview: Data collection for EMIS database, CRF Reporter and National Inventory Report (NIR).

1.3.3 QA /QC procedures and extensive review of GHG Inventory and KP-LULUCF Inventory

The national inventory system has an established quality management system (QMS) that complies with the requirements of ISO 9001:2008. Certification has been obtained in 2007 and upheld since through annual audits. An overview over QA/QC procedures and review activities is given in section 1.6.1, a full description of the QMS is provided as a supplement (FOEN 2014a) to the national inventory report.

1.4 Methodologies and Data Sources

1.4.1 GHG Inventory

1.4.1.1 General Description

Emissions are calculated on the basis of the standard methods and procedures published in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1997a, 1997b, 1997c), in IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000), and in IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003). Under the UNFCCC, these guidelines have been adopted for mandatory use in reporting on GHG inventories. The 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006), adopted in April 2006 by the IPCC, have been consulted in a few cases.

The national approach for sector 1 Energy is based on import and fuel consumption statistics (fuel sales in the transport sector) in Switzerland (see Chapter 1.4.1.2). The other sectors rely on national statistics and data surveys. For the various sectors, Tier 1, Tier 2 and Tier 3 methodologies according to IPCC Guidelines (IPCC 1997b) and Good Practice Guidance (IPCC 2000) are used. GHG emissions by sources and removals by sinks due to land use, land-use change and forestry (LULUCF sector) are calculated according to IPCC 2003. The following list (Table 1-2) indicates the approaches adopted.

Table 1-2 Summary table for emission factors and methods used (from CRF-tables Summary3) in 2012.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	**CS,D,T2,T3**	**CS,D**	**CS,D,T2,T3**	**CR,CS,D**	**CS,D,T2,T3**	**CS,D**
A. Fuel Combustion	CS,T2,T3	CS	CS,T2,T3	CR,CS	CS,D,T2,T3	CS,D
1. Energy Industries	CS,T2	CS	CS,T2	CS	CS,D	CS,D
2. Manufacturing Industries and Constr.	CS,T2	CS	CS,T2,T3	CS	D	D
3. Transport	T2,T3	CS	T2,T3	CR,CS	CS,D,T2,T3	CS,D
4. Other Sectors	CS,T2	CS	CS,T2	CS	D	D
5. Other	T2	CS	T2	CS	T2	CS
B. Fugitive Emissions from Fuels	CS,D	CS,D	CS,D	CS,D	D	D
1. Solid Fuels	NA	NA	NA	NA	NA	NA
2. Oil and Natural Gas	CS,D	CS,D	CS,D	CS,D	D	D
2. Industrial Processes	**CS,T2**	**CS,D,PS**	**CS,T2**	**D,PS**	**CS,T2**	**PS**
A. Mineral Products	CS,T2	CS,D,PS	NA	NA	NA	NA
B. Chemical Industry	CS,T2	PS	CS,T2	D,PS	CS,T2	PS
C. Metal Production	CS	CS	NA	NA	NA	NA
D. Other Production	NA	NA				
E. Production of Halocarbons and SF_6						
F. Consumption of Halocarbons and SF_6						
G. Other	CS	CS	NA	NA	NA	NA
3. Solvent and Other Product Use	**CS**	**CS**			**CS**	**CS**
4. Agriculture			**T2**	**CS,D**	**CS,T1b**	**D**
A. Enteric Fermentation			T2	CS		
B. Manure Management			T2	CS,D	CS	D
C. Rice Cultivation			NA	NA		
D. Agricultural Soils			NA	NA	CS,T1b	D
E. Prescribed Burning of Savannas			NA	NA	NA	NA
F. Field Burning of Agricultural Residues			NA	NA	NA	NA
G. Other			NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	T2	CS	**T1**	**CS**	**T1**	**D**
A. Forest Land	T2	CS	T1	CS	T1	D
B. Cropland	T2	CS	NA	NA	T1	D
C. Grassland	T2	CS	T1	CS	T1	D
D. Wetlands	T2	CS	T1	CS	NA	NA
E. Settlements	T2	CS	NA	NA	NA	NA
F. Other Land	T2	CS	NA	NA	NA	NA
G. Other	NA	NA	NA	NA	NA	NA
6. Waste	**CS**	**CS**	**CS,D**	**CS,D**	**CS**	**CS**
A. Solid Waste Disposal on Land	NA	NA	CS,D	CS,D		
B. Waste-water Handling			CS,D	CS,D	CS	CS
C. Waste Incineration	CS	CS	CS	CS	CS	CS
D. Other	NA	NA	CS	CS	CS	CS
7. Other (as specified in Summary 1.A)	T1	CS	T1	CS	CS,T1b	CS,D

GREENHOUSE GAS SOURCE AND SINK	HFCs		PFCs		SF_6	
2. Industrial Processes	**T1,T2**	**CS,D**	**T1,T2**	**CS,D**	**T1,T2,T3**	**CS,D**
A. Mineral Products						
B. Chemical Industry	NA	NA	NA	NA	NA	NA
C. Metal Production	NA	NA	NA	NA	T1,T2,T3	D
D. Other Production						
E. Production of Halocarbons and SF_6	NA	NA	NA	NA	NA	NA
F. Consumption of Halocarbons and SF_6	T1,T2	CS,D	T1,T2	CS,D	T1,T2,T3	CS,D
G. Other	NA	NA	NA	NA	NA	NA

1.4.1.2 National and Reference Approach for Sector 1 Energy

The Reference Approach is used as a check for (i) overall energy consumption and (ii) the resulting CO_2 emissions reported in source category 1 Energy. In Switzerland, it is applied on the basis of data published in the Swiss overall energy statistics (SFOE 2013). The results of the Reference Approach are compared with the results of the sectoral approach for sector 1 Energy in order to test the quality and completeness of the inventory. For the current inventory, the two approaches show a good correspondence; with CO_2 emissions differing by 0.89% and energy consumption by 0.62% in 2012 (see chapter 3.2.1).

1.4.1.3 National Air Pollution Database EMIS

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

EMIS calculates emissions for various pollutants using emission factors and activity data according to the EMEP/CORINAIR methodology. Pollutants in EMIS include sulphur dioxide (SO_2), nitrogen oxides (NO_x), nitrous oxide (N_2O), ammonia (NH_3), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), black carbon (BC), hydrochloric acid (HCl), particulate matter, heavy metals (lead, zinc, cadmium, mercury), polychlorinated dibenzodioxins and -furanes (PCDD/PCDF), hexachlorobenzene (HCB), hydrogen fluoride (HF), hydrofluorocarbons (HFC), perfluorinated carbon compounds (PFC), sulphur hexafluoride (SF_6), methane (CH_4), carbon dioxide CO_2 (fossil/geological origin) and CO_2 (biogenic). The input data originate from a variety of sources, such as production data and emission factors from industry, industry associations and research institutions, as well as population, employment, waste and agriculture statistics. EMIS is documented in an internal FOEN manual for the database (FOEN 2006c).

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

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

1.4.2 KP- LULUCF Inventory

Emission factors for parts of sector 5 LULUCF (forest land) and the KP-LULUCF tables are calculated by the Forest Division of the FOEN. A detailed description of the calculation of these emission factors can be found in Chapter 7.3 and Chapter 11.3. Both data sets are imported in the EMIS database (FOEN 2006c).

1.5 Description of Key Categories

1.5.1 GHG Inventory

1.5.1.1 Methodology

The key category analyses are performed according to the IPCC Good Practice Guidance (IPCC 2000, chapter 7) for 1990 and the latest reported year. A Tier 1 level and trend assessment is applied with the proposed threshold of 95%. A Tier 2 key category analyses has also been carried out for this submission with the proposed threshold of 90% of the sum of all level assessments weighted with their relative source uncertainty. The uncertainty used for the calculations is the Tier 1 uncertainty (see chapter 1.7).

According to good practice guidance (IPCC 2000), the result of Tier 2 key category analysis should be used when results between Tier 1 and Tier 2 differ. However, it would also be possible to keep Tier 1 key categories as key categories based on qualitative criteria. The GHG inventory core group has agreed to keep Tier 1 key categories in this submission as key categories, even if they are not key in Tier 2 (and vice versa). This procedure would also be compatible with the 2006 IPCC Guidelines (IPCC 2006), which recommend exactly such a procedure of combining results from Tier 1 and Tier 2 categories if results from the two approaches differ. When combining Tier 1 and Tier 2 key category analysis results, we consider a category to be key because of level, if the category is key due to level according to Tier 1 or Tier 2, and a category is considered to be key because of trend, if the category is key due to trend according to Tier 1 or Tier 2.

1.5.1.2 KCA without LULUCF categories

Tier 1

For 2012, among a total of 135 categories, 31 have been identified as key categories with an aggregated contribution of 97.2% to total national emissions. 23 categories are key due to the level assessment, 27 due to the trend assessment.

Of the 31 key categories, 19 are in sector 1 Energy, accounting for 79.5% of total CO_2 equivalent emissions in 2012. The other key categories are from sectors 2 Industrial Processes (5.7%), 3 Solvent and Other Product Use (0.3%), 4 Agriculture (10.7%) and 6 Waste (1.0%).

There are three major key sources each contributing more than 10 % to the level assessment:

- 1A3b Energy, Fuel Combustion, Road Transportation, Gasoline, CO_2, level contribution 17.5%
- 1A4b Energy, Fuel Combustion, Other Sectors, Residential, Liquid Fuels, CO_2, level contribution 14.3%
- 1A3b Energy, Fuel Combustion, Road Transportation, Diesel, CO_2, level contribution 13.2%

Compared to the key category analysis in the previous inventory report of April 2013 (FOEN 2013), the following category is a new key category:

- CO_2 emissions from 1A3b Road Transportation, Gaseous Fuels: the reason for being a new key category is the significant higher activity data based on recalculations in in this source category (see chapter 3.2.8.5)

The following category is no longer key category in Tier 1 compared to the previous submission of April 2013:

- CO_2 emissions from 2C1 Industrial Processes, Steel Production: The reason for not being key category anymore is the significant reduction of emissions based on recalculations in the implied emission factor in this sector (see chapter 4.4.5)

The following table shows the contributions of the individual key categories. The complete results of the key category analysis for 2012 are given in Annex A1.2.

Table 1-3 List of Switzerland's Tier 1 key categories 2012 without LULUCF categories, sorted by category code.

Tier 1 Key category analysis 2012 without LULUCF categories													
	A					B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (without LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Year 2012 Estimate [Gg CO2 eq]	Level Assessm	Trend Assessm	% Contrib in Trend	Result level assessm	Result trend assessm
1	1A1	1. Energy	A. Fuel Comb.	1. Energy Industries	Gaseous Fuels	CO2	289.73	498.74	0.97%	0.00434	1.0%	KC level	KC trend
2	1A1	1. Energy	A. Fuel Comb.	1. Energy Industries	Liquid Fuels	CO2	693.69	805.16	1.56%	0.00261	0.6%	KC level	KC trend
3	1A1	1. Energy	A. Fuel Comb.	1. Energy Industries	Other Fuels	CO2	1519.73	2714.50	5.28%	0.02471	5.8%	KC level	KC trend
4	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Gaseous Fuels	CO2	1074.09	2096.41	4.07%	0.02102	5.0%	KC level	KC trend
5	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Liquid Fuels	CO2	3692.22	2640.18	5.13%	0.01900	4.5%	KC level	KC trend
6	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Other Fuels	CO2	134.15	288.60	0.56%	0.00316	0.7%	KC level	KC trend
7	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Solid Fuels	CO2	1204.47	454.87	0.88%	0.01432	3.4%	KC level	KC trend
8	1A3a	1. Energy	A. Fuel Comb.	3. Transport; Civil Aviation		CO2	252.55	136.65	0.27%	0.00218	0.5%	-	KC trend
9	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Diesel	CO2	2587.68	6767.05	13.15%	0.08494	20.1%	KC level	KC trend
10	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Gasoline	CO2	11335.27	9016.58	17.53%	0.04013	9.5%	KC level	KC trend
11	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Gasoline	N2O	142.38	27.52	0.05%	0.00222	0.5%	-	KC trend
12	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Gaseous Fuels	CO2	0.00	83.59	0.16%	0.00167	0.4%	-	KC trend
13	1A4a	1. Energy	A. Fuel Comb.	4. Other Sectors; Com./Instit.	Gaseous Fuels	CO2	987.24	1482.76	2.88%	0.01044	2.5%	KC level	KC trend
14	1A4a	1. Energy	A. Fuel Comb.	4. Other Sectors; Com./Instit.	Liquid Fuels	CO2	4606.43	3038.51	5.91%	0.02881	6.8%	KC level	KC trend
15	1A4b	1. Energy	A. Fuel Comb.	4. Other Sectors; Residential	Gaseous Fuels	CO2	1424.38	2649.60	5.15%	0.02527	6.0%	KC level	KC trend
16	1A4b	1. Energy	A. Fuel Comb.	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.79	7374.50	14.33%	0.05183	12.3%	KC level	KC trend
17	1A4c	1. Energy	A. Fuel Comb.	4. Other Sectors; Agric./Forestry	Liquid Fuels	CO2	547.34	540.01	1.05%	0.00015	0.0%	KC level	-
18	1A5	1. Energy	A. Fuel Comb.	5. Other	Liquid Fuels	CO2	203.58	114.80	0.22%	0.00166	0.4%	-	KC trend
19	1B2	1. Energy	B. Fugitive Emis	2. Oil and Natural Gas		CH4	263.72	169.45	0.33%	0.00174	0.4%	-	KC trend
20	2A1	2. Ind. Proc	A. Mineral Products; Cement Production-CO2			CO2	2524.68	1787.11	3.47%	0.01336	3.2%	KC level	KC trend
21	2F1	2. Ind. Proc	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	1137.81	2.21%	0.02274	5.4%	KC level	KC trend
22	3	3. Solvent and Other Product Use				CO2	360.04	155.28	0.30%	0.00389	0.9%	-	KC trend
23	4A	4. Agric.	A. Enteric Fermentation			CH4	2635.45	2496.98	4.85%	0.00132	0.3%	KC level	-
24	4B	4. Agric.	B. Manure Management			CH4	671.61	646.11	1.26%	0.00014	0.0%	KC level	-
25	4B	4. Agric.	B. Manure Management			N2O	454.68	335.81	0.65%	0.00213	0.5%	KC level	KC trend
26	4D1	4. Agric.	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.48	1143.10	2.22%	0.00342	0.8%	KC level	KC trend
27	4D2	4. Agric.	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	220.79	0.43%	0.00192	0.5%	KC level	KC trend
28	4D3	4. Agric.	D. Agricultural Soils; Indirect Emissions			N2O	822.48	674.93	1.31%	0.00250	0.6%	KC level	KC trend
29	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	158.26	0.31%	0.01021	2.4%	-	KC trend
30	6B	6. Waste	B. Wastewater Handling			N2O	184.72	240.28	0.47%	0.00121	0.3%	KC level	-
31	6D	6. Waste	D. Other			CH4	29.94	113.76	0.22%	0.00169	0.4%	-	KC trend

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

Tier 1 Key category analysis for the base year 1990 without LULUCF categories									
	A					B	C	E-L	M
No.	IPCC Source Categories and fuels if applicable (without LULUCF categories)					Direct GHG	Base Year 1990 Estimate	Level Assessm.	Result level assessm.
1	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	289.73	0.55%	KC level
2	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	693.69	1.31%	KC level
3	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1519.73	2.87%	KC level
4	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1074.09	2.03%	KC level
5	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3692.22	6.98%	KC level
6	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1204.47	2.28%	KC level
7	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	0.48%	KC level
8	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2587.68	4.89%	KC level
9	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11335.27	21.43%	KC level
10	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	987.24	1.87%	KC level
11	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4606.43	8.71%	KC level
12	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1424.38	2.69%	KC level
13	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.79	19.38%	KC level
14	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	547.34	1.03%	KC level
15	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	203.58	0.38%	KC level
16	1B2	1. Energy	B. Fugitive Emissions from	2. Oil and Natural Gas		CH4	263.72	0.50%	KC level
17	2A1	2. Industrial P	A. Mineral Products; Cement Production-CO2			CO2	2524.68	4.77%	KC level
18	3	3. Solvent and Other Product Use				CO2	360.04	0.68%	KC level
19	4A	4. Agriculture	A. Enteric Fermentation			CH4	2635.45	4.98%	KC level
20	4B	4. Agriculture	B. Manure Management			CH4	671.61	1.27%	KC level
21	4B	4. Agriculture	B. Manure Management			N2O	454.68	0.86%	KC level
22	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.48	2.56%	KC level
23	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	822.48	1.56%	KC level
24	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	1.30%	KC level

There are 24 level key categories in the base year 1990 (see Table 1-4). All of them are also key categories in 2012.

Compared to the key category analysis in the previous inventory report of April 2013, the key categories in the base year 1990 are the same.

Tier 2

For 2012, among a total of 135 categories, 30 have been identified as key categories with an aggregated contribution of 94.0% of the sum of all level assessments weighted with their uncertainty in 2012. 23 categories are key due to the level assessment, 27 due to the trend assessment.

Of the 30 key categories, 14 are in sector 1 Energy, accounting for 29.8% of the sum of all level assessments weighted with their uncertainty in 2012 (12.5%, see Table A - 4). Sector 4 Agriculture accounts for 51.0% of that sum. The other key categories are from sectors 2 Industrial Processes (6.3%), 3 Solvent and Other Product Use (1.8%) and 6 Waste (5.1%). There are three major key categories contributing more than 10% to the level assessment weighted with their uncertainty:

- 4D3, Agricultural Soils; Indirect Emissions, N_2O, contribution of 17.4% to the sum of all level assessments weighted with their uncertainty.
- 4D1, Agricultural Soils; Direct Soil Emissions, N_2O, contribution of 14.8% to the sum of all level assessments weighted with their uncertainty.
- 1A1 Energy, Fuel Combustion, Energy Industries, Other Fuels, CO_2, contribution of 13.3% to the sum of all level assessments weighted with their uncertainty.

Table 1-5 shows the contributions of the individual key categories. The complete results of the key category analysis for 2012 are given in Annex A1.4.

Compared to the submission of April 2013, the following categories are new key category in Tier 2:

- CO_2 emissions from 2A3 Industrial Processes, Limestone and Dolomite use: the reason for being new key category is an increase in emissions based on recalculations in the implied emission factor in this sector (see chapter 4.2.5)
- SF_6 emissions from 2F9 Industrial Processes, consumption of Halocarbons and SF6: the reason for being new key category is an increase in the emissions in 2012 compared to 2011.

No longer key in Tier 2 is the following category:

- CO_2 emissions from 2C1 Industrial Processes, Steel Production: the reason for not being key category anymore is the significant reduction of emissions based on recaluclations in the implied emission factor in this sector (see chapter 4.4.5)

Table 1-5 List of Switzerland's Tier 2 key categories 2012 without LULUCF categories, sorted by category code.

Tier 2 Key category analysis 2012 without LULUCF categories														
	A					B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (without LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Year 2012 Estimate [Gg CO2 eq]	Level Assessm. with Uncertainty	Trend Assessm. with Uncertainty	% Contrib. in Trend	Result level assessm	Result trend assessm
1	1A1	1. Energy	A. Fuel Comb.	1. Energy Industries	Other Fuels	CO2	1519.73	2714.50	1.67%	0.00781	15.3%	KC level	KC trend
2	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Gaseous Fuels	CO2	1074.09	2096.41	0.20%	0.00105	2.1%	KC level	KC trend
3	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Other Fuels	CO2	134.15	288.60	0.18%	0.00100	2.0%	KC level	KC trend
4	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Solid Fuels	CO2	1204.47	454.87	0.07%	0.00111	2.2%	-	KC trend
5	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Diesel	CO2	2587.68	6767.05	0.29%	0.00190	3.7%	KC level	KC trend
6	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Gasoline	CH4	97.47	18.82	0.01%	0.00056	1.1%	-	KC trend
7	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Gasoline	CO2	11335.27	9016.58	0.45%	0.00103	2.0%	KC level	KC trend
8	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Gasoline	N2O	142.38	27.52	0.03%	0.00111	2.2%	-	KC trend
9	1A4a	1. Energy	A. Fuel Comb.	4. Other Sectors; Com./Instit.	Gaseous Fuels	CO2	987.24	1482.76	0.14%	0.00052	1.0%	KC level	KC trend
10	1A4a	1. Energy	A. Fuel Comb.	4. Other Sectors; Com./Instit.	Liquid Fuels	CO2	4606.43	3038.51	0.08%	0.00040	0.8%	-	KC trend
11	1A4b	1. Energy	A. Fuel Comb.	4. Other Sectors; Residential	Biomass	CH4	97.87	33.78	0.04%	0.00078	1.5%	-	KC trend
12	1A4b	1. Energy	A. Fuel Comb.	4. Other Sectors; Residential	Gaseous Fuels	CO2	1424.38	2649.60	0.26%	0.00127	2.5%	KC level	KC trend
13	1A4b	1. Energy	A. Fuel Comb.	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.79	7374.50	0.20%	0.00072	1.4%	KC level	KC trend
14	1B2	1. Energy	B. Fugitive Emis	2. Oil and Natural Gas		CH4	263.72	169.45	0.10%	0.00052	1.0%	KC level	KC trend
15	2A1	2. Ind. Proc	A. Mineral Products; Cement Production-CO2			CO2	2524.68	1787.11	0.10%	0.00038	0.7%	KC level	-
16	2A3	2. Ind. Proc	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2			CO2	150.39	98.48	0.10%	0.00049	1.0%	-	KC trend
17	2F1	2. Ind. Proc	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	1137.81	0.27%	0.00273	5.3%	KC level	KC trend
18	2F9	2. Ind. Proc	F. Consumption of Halocarbons and SF6; Other			HFC	0.00	76.14	0.12%	0.00122	2.4%	KC level	KC trend
19	2F9	2. Ind. Proc	F. Consumption of Halocarbons and SF6; Other			SF6	79.58	135.91	0.21%	0.00094	1.8%	KC level	KC trend
20	3	3. Solvent and Other Product Use				CO2	360.04	155.28	0.15%	0.00195	3.8%	KC level	KC trend
21	3	3. Solvent and Other Product Use				N2O	110.14	44.62	0.07%	0.00100	2.0%	-	KC trend
22	4A	4. Agric.	A. Enteric Fermentation			CH4	2635.45	2496.98	0.89%	0.00024	0.5%	KC level	-
23	4B	4. Agric.	B. Manure Management			CH4	671.61	646.11	0.68%	0.00008	0.2%	KC level	-
24	4B	4. Agric.	B. Manure Management			N2O	454.68	335.81	0.41%	0.00135	2.6%	KC level	KC trend
25	4D1	4. Agric.	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.48	1143.10	1.85%	0.00285	5.6%	KC level	KC trend
26	4D2	4. Agric.	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	220.79	0.36%	0.00163	3.2%	KC level	KC trend
27	4D3	4. Agric.	D. Agricultural Soils; Indirect Emissions			N2O	822.48	674.93	2.18%	0.00415	8.1%	KC level	KC trend
28	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	158.26	0.18%	0.00596	11.7%	KC level	KC trend
29	6B	6. Waste	B. Wastewater Handling			N2O	184.72	240.28	0.23%	0.00061	1.2%	KC level	KC trend
30	6D	6. Waste	D. Other			CH4	29.94	113.76	0.22%	0.00170	3.3%	KC level	KC trend

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

Tier 2 Key category analysis for the base year 1990 without LULUCF categories									
	A					B	C	E-L	M
No.	IPCC Source Categories and fuels if applicable (combined without LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Level Assessm. with Uncertainty	Result level assessm.
1	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1519.73	0.91%	KC level
2	1A2	1. Energy	A. Fuel Combustion	2. Manuf. Ind. and Constr.	Solid Fuels	CO2	1204.47	0.18%	KC level
3	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11335.27	0.55%	KC level
4	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	142.38	0.13%	KC level
5	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Com./Instit.	Liquid Fuels	CO2	4606.43	0.12%	KC level
6	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	97.87	0.12%	KC level
7	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1424.38	0.14%	KC level
8	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.79	0.27%	KC level
9	1B2	1. Energy	B. Fugitive Emissions fro	2. Oil and Natural Gas		CH4	263.72	0.15%	KC level
10	2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2524.68	0.14%	KC level
11	2A3	2. Industrial Proc.	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2			CO2	150.39	0.15%	KC level
12	2F9	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Other			SF6	79.58	0.12%	KC level
13	3	3. Solvent and Other Product Use				CO2	360.04	0.34%	KC level
14	3	3. Solvent and Other Product Use				N2O	110.14	0.17%	KC level
15	4A	4. Agriculture	A. Enteric Fermentation			CH4	2635.45	0.91%	KC level
16	4B	4. Agriculture	B. Manure Management			CH4	671.61	0.69%	KC level
17	4B	4. Agriculture	B. Manure Management			N2O	454.68	0.55%	KC level
18	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.48	2.12%	KC level
19	4D2	4. Agriculture	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	0.21%	KC level
20	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	822.48	2.58%	KC level
21	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	0.76%	KC level
22	6B	6. Waste	B. Wastewater Handling			N2O	184.72	0.17%	KC level

There are 22 level Tier 2 key categories in the base year 1990 (see Table 1-6). All of them are also key categories in 2012.

Compared to the key category analysis in the previous inventory report of April 2013, there is one new key category in 2012 for the base year 1990:

CO_2 emissions from 2A3 Industrial Processes, Limestone and Dolomite use: The reason for being new key category is an increase in emissions based on recalculations in the implied emission factor in this sector (see chapter 4.2.5).

1.5.1.3 Combined KCA without and with LULUCF categories

The key category analysis including LULUCF categories has also been carried out for 2012 and 1990. The complete results of the key category analysis for 2012 are shown in Annex

A1. According to IPCC Good Practice Guidance for LULUCF (IPCC 2003, Section 5.4.2), the set of key categories consists of all non-LULUCF key categories that result from the KCA without LULUCF combined with all LULUCF key categories that result from the KCA including LULUCF.

Tier 1

In the Tier 1 KCA for the year 2012 including LULUCF categories there are five additional categories out of the LULUCF sector:

- CO_2 emissions from 5A1 Forest Land remaining Forest Land (level and trend key category)
- CO_2 emissions from 5A2 Land converted to Forest Land (level and trend key category)
- CO_2 emissions from 5B1 Cropland remaining Cropland (level and trend key category)
- CO_2 emissions from 5C2 Land converted to Grassland (trend key category)
- CO_2 emissions from 5E2 Land converted to Settlements (level key category)

The categories 5A1 Forest Land remaining Forest Land and 5B1 Cropland remaining Cropland are large categories, contributing for 3.8% and 1.3% to the level assessment. Categories 5A2, 5C2 and 5E2 contribute less to the level assessment with 0.9%, 0.3% and 0.5%, respectively.

The five LULUCF key categories 5A1, 5A2, 5B1, 5C2 and 5E2 were also key in the analysis for 2011 as contained in the previous inventory report of April 2013 (FOEN 2013).

For the combined KCA without and with LULUCF, these categories are added to the other 31 key categories from the KCA without LULUCF.

In the KCA for the year 1990, four of these five LULUCF categories are also key categories. Categories 5C2 is not key category for the year 1990.

For the combined KCA without and with LULUCF categories, these categories are added to the other 24 key categories from the KCA without LULUCF. The results of the combined Tier 1 KCA are summarised in Table 1-7 (year 2012) and Table 1-8 (1990).

Tier 2

In the Tier 2 KCA for 2012 including LULUCF categories, there are seven additional categories out of the LULUCF sector: CO_2 emissions from 5A1, 5A2, 5B1, 5B2, 5C1, 5C2 and 5E2. Five of these categories are also key categories out of the LULUCF sector as in Tier 1. Additionally, CO_2 emissions from 5B2 and 5C1 are key in Tier 2.

The categories 5C1 Grassland remaining Grassland, 5A1 Forest Land remaining Forest Land and 5B1 Cropland remaining Cropland are large categories, contributing for 23.2%, 11.1% and 6.4% of the sum of all level assessments weighted with their uncertainty. Source categories 5A2, 5B2, 5C2 and 5E2 contribute less, with 2.7%, 0.3%, 0.9% and 1.3%, respectively.

The six of the seven LULUCF key categories were also key in the analysis for 2011 as contained in the previous inventory report of April 2013 (FOEN 2013). Source category 5B2 land converted to Cropland is new key category for 2012.

For the combined KCA without and with LULUCF categories, these categories are added to the other 30 key categories from the KCA without LULUCF.

In the KCA for the year 1990, five of these seven LULUCF categories are also key categories. Source categories 5B2 and 5C2 are not key categories for the year 1990.

Compared to the previous submission of April 2013 (FOEN 2013), 5C1 is new key category.

For the combined KCA without and with LULUCF categories, these categories are added to the other 22 key categories from the KCA without LULUCF. The results of the combined Tier 2 KCA are summarised in Table 1-9 (year 2012) and Table 1-10 (year 1990).

Table 1-7 List of Switzerland's Tier 1 key categories, combined KCA without and with LULUCF (in italic) categories 2012, sorted by category code.

Combined Tier 1 Key category analysis 2012 without and with LULUCF categories													
	A					B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (without LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Year 2012 Estimate [Gg CO2 eq]	Level Assessm	Trend Assessm	% Contrib in Trend	Result level assessm	Result trend assessm
1	1A1	1. Energy	A. Fuel Comb.	1. Energy Industries	Gaseous Fuels	CO2	289.73	498.74	0.97%	0.00434	1.0%	KC level	KC trend
2	1A1	1. Energy	A. Fuel Comb.	1. Energy Industries	Liquid Fuels	CO2	693.69	805.16	1.56%	0.00261	0.6%	KC level	KC trend
3	1A1	1. Energy	A. Fuel Comb.	1. Energy Industries	Other Fuels	CO2	1519.73	2714.50	5.28%	0.02471	5.8%	KC level	KC trend
4	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Gaseous Fuels	CO2	1074.09	2096.41	4.07%	0.02102	5.0%	KC level	KC trend
5	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Liquid Fuels	CO2	3692.22	2640.18	5.13%	0.01900	4.5%	KC level	KC trend
6	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Other Fuels	CO2	134.15	288.60	0.56%	0.00316	0.7%	KC level	KC trend
7	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Solid Fuels	CO2	1204.47	454.87	0.88%	0.01432	3.4%	KC level	KC trend
8	1A3a	1. Energy	A. Fuel Comb.	3. Transport; Civil Aviation		CO2	252.55	136.65	0.27%	0.00218	0.5%	-	KC trend
9	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Diesel	CO2	2587.68	6767.05	13.15%	0.08494	20.1%	KC level	KC trend
10	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Gasoline	CO2	11335.27	9016.58	17.53%	0.04013	9.5%	KC level	KC trend
11	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Gasoline	N2O	142.38	27.52	0.05%	0.00222	0.5%	-	KC trend
12	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Gaseous Fuels	CO2	0.00	83.59	0.16%	0.00167	0.4%	-	KC trend
13	1A4a	1. Energy	A. Fuel Comb.	4. Other Sectors; Com./Instit.	Gaseous Fuels	CO2	987.24	1482.76	2.88%	0.01044	2.5%	KC level	KC trend
14	1A4a	1. Energy	A. Fuel Comb.	4. Other Sectors; Com./Instit.	Liquid Fuels	CO2	4606.43	3038.51	5.91%	0.02881	6.8%	KC level	KC trend
15	1A4b	1. Energy	A. Fuel Comb.	4. Other Sectors; Residential	Gaseous Fuels	CO2	1424.38	2649.60	5.15%	0.02527	6.0%	KC level	KC trend
16	1A4b	1. Energy	A. Fuel Comb.	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.79	7374.50	14.33%	0.05183	12.3%	KC level	KC trend
17	1A4c	1. Energy	A. Fuel Comb.	4. Other Sectors; Agric./Forestry	Liquid Fuels	CO2	547.34	540.01	1.05%	0.00015	0.0%	KC level	-
18	1A5	1. Energy	A. Fuel Comb.	5. Other	Liquid Fuels	CO2	203.58	114.80	0.22%	0.00166	0.4%	-	KC trend
19	1B2	1. Energy	B. Fugitive Emis	2. Oil and Natural Gas		CH4	263.72	169.45	0.33%	0.00174	0.4%	-	KC trend
20	2A1	2. Ind. Proc.	A. Mineral Products; Cement Production-CO2			CO2	2524.68	1787.11	3.47%	0.01336	3.2%	KC level	KC trend
21	2F1	2. Ind. Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	1137.81	2.21%	0.02274	5.4%	KC level	KC trend
22	3	3. Solvent and Other Product Use				CO2	360.04	155.28	0.30%	0.00389	0.9%	-	KC trend
23	4A	4. Agric.	A. Enteric Fermentation			CH4	2635.45	2496.98	4.85%	0.00132	0.3%	KC level	-
24	4B	4. Agric.	B. Manure Management			CH4	671.61	646.11	1.26%	0.00014	0.0%	KC level	-
25	4B	4. Agric.	B. Manure Management			N2O	454.68	335.81	0.65%	0.00213	0.5%	KC level	KC trend
26	4D1	4. Agric.	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.48	1143.10	2.22%	0.00342	0.8%	KC level	KC trend
27	4D2	4. Agric.	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	220.79	0.43%	0.00192	0.5%	KC level	KC trend
28	4D3	4. Agric.	D. Agricultural Soils; Indirect Emissions			N2O	822.48	674.93	1.31%	0.00250	0.6%	KC level	KC trend
29	*5A1*	*5. LULUCF*	*A. Forest Land*	*1. Forest Land remaining Forest Land*		*CO2*	*-2416.89*	*-2134.56*	*3.84%*	*0.00409*	*1.0%*	*KC level*	*KC trend*
30	*5A2*	*5. LULUCF*	*A. Forest Land*	*2. Land converted to Forest Land*		*CO2*	*-621.57*	*-518.61*	*0.93%*	*0.00161*	*0.4%*	*KC level*	*KC trend*
31	*5B1*	*5. LULUCF*	*B. Cropland*	*1. Cropland remaining Cropland*		*CO2*	*345.17*	*707.27*	*1.27%*	*0.00683*	*1.7%*	*KC level*	*KC trend*
32	*5C2*	*5. LULUCF*	*C. Grassland*	*2. Land converted to Grassland*		*CO2*	*59.85*	*169.07*	*0.30%*	*0.00204*	*0.5%*	*-*	*KC trend*
33	*5E2*	*5. LULUCF*	*E. Settlements*	*2. Land converted to Settlements*		*CO2*	*382.71*	*302.93*	*0.54%*	*0.00129*	*0.3%*	*KC level*	*-*
34	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	158.26	0.31%	0.01021	2.4%	-	KC trend
35	6B	6. Waste	B. Wastewater Handling			N2O	184.72	240.28	0.47%	0.00121	0.3%	KC level	-
36	6D	6. Waste	D. Other			CH4	29.94	113.76	0.22%	0.00169	0.4%	-	KC trend

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

Combined Tier 1 Key category analysis for the base year 1990 without and with LULUCF categories									
A						B	C	E-L	M
No.	IPCC Source Categories and fuels if applicable (without LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Level Assessm.	Result level assessm.
1	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	289.73	0.55%	KC level
2	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	693.69	1.31%	KC level
3	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1519.73	2.87%	KC level
4	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and C	Gaseous Fuels	CO2	1074.09	2.03%	KC level
5	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and C	Liquid Fuels	CO2	3692.22	6.98%	KC level
6	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and C	Solid Fuels	CO2	1204.47	2.28%	KC level
7	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	0.48%	KC level
8	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatior	Diesel	CO2	2587.68	4.89%	KC level
9	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatior	Gasoline	CO2	11335.27	21.43%	KC level
10	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Gaseous Fuels	CO2	987.24	1.87%	KC level
11	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Liquid Fuels	CO2	4606.43	8.71%	KC level
12	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1424.38	2.69%	KC level
13	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.79	19.38%	KC level
14	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fore	Liquid Fuels	CO2	547.34	1.03%	KC level
15	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	203.58	0.38%	KC level
16	1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CH4	263.72	0.50%	KC level
17	2A1	2. Industrial I	A. Mineral Products; Cement Production-CO2			CO2	2524.68	4.77%	KC level
18	3	3. Solvent and Other Product Use				CO2	360.04	0.68%	KC level
19	4A	4. Agriculture	A. Enteric Fermentation			CH4	2635.45	4.98%	KC level
20	4B	4. Agriculture	B. Manure Management			CH4	671.61	1.27%	KC level
21	4B	4. Agriculture	B. Manure Management			N2O	454.68	0.86%	KC level
22	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.48	2.56%	KC level
23	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	822.48	1.56%	KC level
24	*5A1*	*5. LULUCF*	*A. Forest Land*	*1. Forest Land remaining Forest Land*		*CO2*	*-2416.89*	*4.24%*	*KC level*
25	*5A2*	*5. LULUCF*	*A. Forest Land*	*2. Land converted to Forest Land*		*CO2*	*-621.57*	*1.09%*	*KC level*
26	*5B1*	*5. LULUCF*	*B. Cropland*	*1. Cropland remaining Cropland*		*CO2*	*345.17*	*0.61%*	*KC level*
27	*5E2*	*5. LULUCF*	*E. Settlements*	*2. Land converted to Settlements*		*CO2*	*382.71*	*0.67%*	*KC level*
28	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	1.30%	KC level

Table 1-9 List of Switzerland's Tier 2 key categories, combined KCA without and with LULUCF (*in italic*) categories 2012, sorted by category code.

Combined Tier 2 Key category analysis 2012 without and with LULUCF categories													
A						B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (without LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Year 2012 Estimate [Gg CO2 eq]	Level Assessm. with Uncertainty	Trend Assessm. with Uncertainty	% Contrib. in Trend	Result level assessm	Result trend assessm
1	1A1	1. Energy	A. Fuel Comb.	1. Energy Industries	Other Fuels	CO2	1519.73	2714.50	1.67%	0.00781	15.3%	KC level	KC trend
2	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Gaseous Fuels	CO2	1074.09	2096.41	0.20%	0.00105	2.1%	KC level	KC trend
3	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Other Fuels	CO2	134.15	288.60	0.18%	0.00100	2.0%	KC level	KC trend
4	1A2	1. Energy	A. Fuel Comb.	2. Manuf. Ind. and Constr.	Solid Fuels	CO2	1204.47	454.87	0.07%	0.00111	2.2%	-	KC trend
5	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Diesel	CO2	2587.68	6767.05	0.29%	0.00190	3.7%	KC level	KC trend
6	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Gasoline	CH4	97.47	18.82	0.01%	0.00056	1.1%	-	KC trend
7	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Gasoline	CO2	11335.27	9016.58	0.45%	0.00103	2.0%	KC level	KC trend
8	1A3b	1. Energy	A. Fuel Comb.	3. Transport; Road Transp.	Gasoline	N2O	142.38	27.52	0.03%	0.00111	2.2%	-	KC trend
9	1A4a	1. Energy	A. Fuel Comb.	4. Other Sectors; Com./Instit.	Gaseous Fuels	CO2	987.24	1482.76	0.14%	0.00052	1.0%	KC level	KC trend
10	1A4a	1. Energy	A. Fuel Comb.	4. Other Sectors; Com./Instit.	Liquid Fuels	CO2	4606.43	3038.51	0.08%	0.00040	0.8%	-	KC trend
11	1A4b	1. Energy	A. Fuel Comb.	4. Other Sectors; Residential	Biomass	CH4	97.87	33.78	0.04%	0.00078	1.5%	-	KC trend
12	1A4b	1. Energy	A. Fuel Comb.	4. Other Sectors; Residential	Gaseous Fuels	CO2	1424.38	2649.60	0.26%	0.00127	2.5%	KC level	KC trend
13	1A4b	1. Energy	A. Fuel Comb.	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.79	7374.50	0.20%	0.00072	1.4%	KC level	KC trend
14	1B2	1. Energy	B. Fugitive Emis	2. Oil and Natural Gas		CH4	263.72	169.45	0.10%	0.00052	1.0%	KC level	KC trend
15	2A1	2. Ind. Proc.	A. Mineral Products; Cement Production-CO2			CO2	2524.68	1787.11	0.10%	0.00038	0.7%	KC level	-
16	2A3	2. Ind. Proc.	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2			CO2	150.39	98.48	0.10%	0.00049	1.0%	-	KC trend
17	2F1	2. Ind. Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	1137.81	0.27%	0.00273	5.3%	KC level	KC trend
18	2F9	2. Ind. Proc.	F. Consumption of Halocarbons and SF6; Other			HFC	0.00	76.14	0.12%	0.00122	2.4%	KC level	KC trend
19	2F9	2. Ind. Proc.	F. Consumption of Halocarbons and SF6; Other			SF6	79.58	135.91	0.21%	0.00094	1.8%	KC level	KC trend
20	3	3. Solvent and Other Product Use				CO2	360.04	155.28	0.15%	0.00195	3.8%	KC level	KC trend
21	3	3. Solvent and Other Product Use				N2O	110.14	44.62	0.07%	0.00100	2.0%	-	KC trend
22	4A	4. Agric.	A. Enteric Fermentation			CH4	2635.45	2496.98	0.89%	0.00024	0.5%	KC level	-
23	4B	4. Agric.	B. Manure Management			CH4	671.61	646.11	0.68%	0.00008	0.2%	KC level	-
24	4B	4. Agric.	B. Manure Management			N2O	454.68	335.81	0.41%	0.00135	2.6%	KC level	KC trend
25	4D1	4. Agric.	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.48	1143.10	1.85%	0.00285	5.6%	KC level	KC trend
26	4D2	4. Agric.	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	220.79	0.36%	0.00163	3.2%	KC level	KC trend
27	4D3	4. Agric.	D. Agricultural Soils; Indirect Emissions			N2O	822.48	674.93	2.18%	0.00415	8.1%	KC level	KC trend
28	*5A1*	*5. LULUCF*	*A. Forest Land*	*1. Forest Land remaining Forest Land*		*CO2*	*-2416.89*	*-2134.56*	*2.41%*	*0.00257*	*3.5%*	*KC level*	*KC trend*
29	*5A2*	*5. LULUCF*	*A. Forest Land*	*2. Land converted to Forest Land*		*CO2*	*-621.57*	*-518.61*	*0.59%*	*0.00101*	*1.4%*	*KC level*	*KC trend*
30	*5B1*	*5. LULUCF*	*B. Cropland*	*1. Cropland remaining Cropland*		*CO2*	*345.17*	*707.27*	*1.40%*	*0.00751*	*10.2%*	*KC level*	*KC trend*
31	*5B2*	*5. LULUCF*	*B. Cropland*	*2. Land converted to Cropland*		*CO2*	*43.33*	*22.26*	*0.06%*	*0.00053*	*0.7%*	*-*	*KC trend*
32	*5C1*	*5. LULUCF*	*C. Grassland*	*1. Grassland remaining Grassland*		*CO2*	*107.09*	*134.74*	*5.05%*	*0.01165*	*15.8%*	*KC level*	*KC trend*
33	*5C2*	*5. LULUCF*	*C. Grassland*	*2. Land converted to Grassland*		*CO2*	*59.85*	*169.07*	*0.21%*	*0.00138*	*1.9%*	*KC level*	*KC trend*
34	*5E2*	*5. LULUCF*	*E. Settlements*	*2. Land converted to Settlements*		*CO2*	*382.71*	*302.93*	*0.27%*	*0.00065*	*0.9%*	*KC level*	*KC trend*
35	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	158.26	0.18%	0.00596	11.7%	KC level	KC trend
36	6B	6. Waste	B. Wastewater Handling			N2O	184.72	240.28	0.23%	0.00061	1.2%	KC level	KC trend
37	6D	6. Waste	D. Other			CH4	29.94	113.76	0.22%	0.00170	3.3%	KC level	KC trend

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

Combined Tier 2 Key category analysis for the base year 1990 without and with LULUCF categories									
A						B	C	E-L	M
No.	**IPCC Source Categories and fuels if applicable (combined without LULUCF categories)**					**Direct GHG**	**Base Year 1990 Estimate** [Gg CO2 eq]	**Level Assessm. with Uncertainty**	**Result level assessm.**
1	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1519.73	0.91%	KC level
2	1A2	1. Energy	A. Fuel Combustion	2. Manuf. Ind. and Constr.	Solid Fuels	CO2	1204.47	0.18%	KC level
3	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11335.27	0.55%	KC level
4	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	142.38	0.13%	KC level
5	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Com./Instit.	Liquid Fuels	CO2	4606.43	0.12%	KC level
6	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	97.87	0.12%	KC level
7	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1424.38	0.14%	KC level
8	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.79	0.27%	KC level
9	1B2	1. Energy	B. Fugitive Emissions from F	2. Oil and Natural Gas		CH4	263.72	0.15%	KC level
10	2A1	2. Ind Proc.	A. Mineral Products; Cement Production-CO2			CO2	2524.68	0.14%	KC level
11	2A3	2. Ind Proc.	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2			CO2	150.39	0.15%	KC level
12	2F9	2. Ind Proc.	F. Consumption of Halocarbons and SF6; Other			SF6	79.58	0.12%	KC level
13	3	3. Solvent and Other Product Use				CO2	360.04	0.34%	KC level
14	3	3. Solvent and Other Product Use				N2O	110.14	0.17%	KC level
15	4A	4. Agriculture	A. Enteric Fermentation			CH4	2635.45	0.91%	KC level
16	4B	4. Agriculture	B. Manure Management			CH4	671.61	0.69%	KC level
17	4B	4. Agriculture	B. Manure Management			N2O	454.68	0.55%	KC level
18	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.48	2.12%	KC level
19	4D2	4. Agriculture	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	0.21%	KC level
20	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	822.48	2.58%	KC level
21	*5A1*	*5. LULUCF*	*A. Forest Land*	*1. Forest Land remaining Forest Land*		*CO2*	*-2416.89*	*2.66%*	*KC level*
22	*5A2*	*5. LULUCF*	*A. Forest Land*	*2. Land converted to Forest Land*		*CO2*	*-621.57*	*0.68%*	*KC level*
23	*5B1*	*5. LULUCF*	*B. Cropland*	*1. Cropland remaining Cropland*		*CO2*	*345.17*	*0.66%*	*KC level*
24	*5C1*	*5. LULUCF*	*C. Grassland*	*1. Grassland remaining Grassland*		*CO2*	*107.09*	*3.91%*	*KC level*
25	*5E2*	*5. LULUCF*	*E. Settlements*	*2. Land converted to Settlements*		*CO2*	*382.71*	*0.34%*	*KC level*
26	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	0.76%	KC level
27	6B	6. Waste	B. Wastewater Handling			N2O	184.72	0.17%	KC level

Overview of KCA for Tier 1 and Tier 2

Table 1-11 presents an overview on key categories according to the combined KCA without and with LULUCF categories for both Tier 1 and Tier 2, and for both 1990 and 2012.

Table 1-11 Overview on key categories according to the combined KCA without and with LULUCF categories for both Tier 1 and Tier 2, and for both 2012 and 1990, sorted by category code.

Overview on key categories according to the combined KCA without and with LULUCF categories for both Tier 1 and 2, and for both the submission and the base year											
						2012		1990	2012		1990
IPCC Source Categories and fuels if applicable (with LULUCF categories)					Direct GHG	Tier 1	Tier 1	Tier 1	Tier 2	Tier 2	Tier 2
1A1	1. Energy	A. Fuel Comb	1. Energy Industries	Gaseous Fuels	CO2	KC level	KC trend	KC level	-	-	-
1A1	1. Energy	A. Fuel Comb	1. Energy Industries	Liquid Fuels	CO2	KC level	KC trend	KC level	-	-	-
1A1	1. Energy	A. Fuel Comb	1. Energy Industries	Other Fuels	CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
1A2	1. Energy	A. Fuel Comb	2. Manuf Ind and Constr	Gaseous Fuels	CO2	KC level	KC trend	KC level	KC level	KC trend	-
1A2	1. Energy	A. Fuel Comb	2. Manuf Ind and Constr	Liquid Fuels	CO2	KC level	KC trend	KC level	-	-	-
1A2	1. Energy	A. Fuel Comb	2. Manuf Ind and Constr	Other Fuels	CO2	KC level	KC trend	-	KC level	KC trend	-
1A2	1. Energy	A. Fuel Comb	2. Manuf Ind and Constr	Solid Fuels	CO2	KC level	KC trend	KC level	-	KC trend	KC level
1A3a	1. Energy	A. Fuel Comb	3. Transport; Civil Aviation		CO2	-	KC trend	KC level	-	-	-
1A3b	1. Energy	A. Fuel Comb	3. Transport; Road Transp	Diesel	CO2	KC level	KC trend	KC level	KC level	KC trend	-
1A3b	1. Energy	A. Fuel Comb	3. Transport; Road Transp	Gasoline	CH4	-	-	-	-	KC trend	-
1A3b	1. Energy	A. Fuel Comb	3. Transport; Road Transp	Gasoline	CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
1A3b	1. Energy	A. Fuel Comb	3. Transport; Road Transp	Gasoline	N2O	-	KC trend	-	-	KC trend	KC level
1A3b	1. Energy	A. Fuel Comb	3. Transport; Road Transp	Natural Gas	CO2	-	KC trend	-	-	-	-
1A4a	1. Energy	A. Fuel Comb	4. Other Sectors; Com/Instit	Gaseous Fuels	CO2	KC level	KC trend	KC level	KC level	KC trend	-
1A4a	1. Energy	A. Fuel Comb	4. Other Sectors; Com/Instit	Liquid Fuels	CO2	KC level	KC trend	KC level	-	KC trend	KC level
1A4b	1. Energy	A. Fuel Comb	4. Other Sectors; Residential	Biomass	CH4	-	-	-	-	KC trend	KC level
1A4b	1. Energy	A. Fuel Comb	4. Other Sectors; Residential	Gaseous Fuels	CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
1A4b	1. Energy	A. Fuel Comb	4. Other Sectors; Residential	Liquid Fuels	CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
1A4c	1. Energy	A. Fuel Comb	4. Other Sectors; Agric/Forestry	Liquid Fuels	CO2	KC level	-	KC level	-	-	-
1A5	1. Energy	A. Fuel Comb	5. Other	Liquid Fuels	CO2	-	KC trend	KC level	-	-	-
1B2	1. Energy	B. Fugitive Emiss	2. Oil and Natural Gas		CH4	-	KC trend	KC level	KC level	KC trend	KC level
2A1	2. Ind Proc.	A. Mineral Products; Cement Production-CO2			CO2	KC level	KC trend	KC level	KC level	-	KC level
2A3	2. Ind Proc.	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2			CO2	-	-	-	-	KC trend	KC level
2F1	2. Ind Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	KC level	KC trend	-	KC level	KC trend	-
2F9	2. Ind Proc.	F. Consumption of Halocarbons and SF6; Other			HFC	-	-	-	KC level	KC trend	-
2F9	2. Ind Proc.	F. Consumption of Halocarbons and SF6; Other			SF6	-	-	-	KC level	KC trend	KC level
3	3. Solvent and Other Product Use				CO2	-	KC trend	KC level	KC level	KC trend	KC level
3	3. Solvent and Other Product Use				N2O	-	-	-	-	KC trend	KC level
4A	4. Agric	A. Enteric Fermentation			CH4	KC level	-	KC level	KC level	-	KC level
4B	4. Agric	B. Manure Management			CH4	KC level	-	KC level	KC level	-	KC level
4B	4. Agric	B. Manure Management			N2O	KC level	KC trend	KC level	KC level	KC trend	KC level
4D1	4. Agric	D. Agricultural Soils; Direct Soil Emissions			N2O	KC level	KC trend	KC level	KC level	KC trend	KC level
4D2	4. Agric	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	KC level	KC trend	-	KC level	KC trend	KC level
4D3	4. Agric	D. Agricultural Soils; Indirect Emissions			N2O	KC level	KC trend	KC level	KC level	KC trend	KC level
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO2	-	-	-	-	KC trend	-
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	-	-	-	KC level	KC trend	KC level
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO2	-	KC trend	-	KC level	KC trend	-
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	KC level	-	KC level	KC level	KC trend	KC level
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	-	KC trend	KC level	KC level	KC trend	KC level
6B	6. Waste	B. Wastewater Handling			N2O	KC level	-	-	KC level	KC trend	KC level
6D	6. Waste	D. Other			CH4	-	KC trend	-	KC level	KC trend	-

1.5.2 KP-LULUCF Inventory

Switzerland identified three key categories for activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol (Forest Management, Afforestation and Reforestation, Deforestation). The approach relies on full inventory KCA (with LULUCF), KP - CRF association and qualitative assessment. A detailed description is presented in chapter 11.6.1 and in Table 11-3.

1.6 Quality Assurance and Quality Control (QA/QC)

1.6.1 QA / QC Procedures

In 2002, a total quality management system was introduced within the Federal Office for the Environment (FOEN), within which the GHG inventory was registered as a process. Subsequent to an audit in 2004, an inventory-specific quality management system (QMS) was developed. This QMS is designed to comply with the quality objectives of Good Practice

Guidance of IPCC (2000), to ensure and continuously improve transparency, consistency, comparability, completeness, accuracy, and confidence in national GHG emission and removal estimates. Furthermore, Switzerland adopted timeliness as a quality criterion. Switzerland's inventory system is designed to produce a high quality inventory that ensures full compliance with the reporting requirements of the UNFCCC and the Kyoto Protocol.

The quality management system is designed according to a plan-do-check-act cycle (PDCA cycle), which is a generally accepted model according to international standards. Key findings from QA/QC procedures are included in the inventory development plan (IDP), which represents the main instrument for continuous improvement in subsequent inventory cycles. This approach is in accordance with procedures described in decision 19/CMP.1 (UNFCCC 2006a) and in the IPCC Good Practice Guidance (IPCC 2000, chapter 8). The QMS complies with the ISO 9001:2008 standard and has been certified by the Swiss association for quality and management systems (SQS) in December 2007 (SQS, 2008), re-certified in 2010 (SQS, 2010) and in 2013 (Swiss-TS, 2013). Certification is upheld since through annual audits. Annual audits are part of the recertification procedure.

The main QMS elements are summarized below. The detailed state of its implementation is documented in the Description of the Quality Management System (FOEN 2014a), submitted alongside this report. All activities are embedded in an annual cycle of inventory planning, preparation, and management (see Table 1 in FOEN 2014a).

1.6.1.1 Responsibilities for QA/QC activities

The national inventory system has a dedicated QA/QC officer who is responsible for coordinating and ensuring compliance with procedures related to quality control and quality assurance. QA/QC activities are carried out by everyone involved in inventory preparation, and various cross-checks are set up to minimise inconsistencies and errors in the inventory. Individual responsibilities are described in detail in sections 2.1 and 5.1 of FOEN (2014a). Results from QA/QC activities are documented and reviewed by the QA/QC officer. Based on these feedbacks, suggestions for further improvements of the inventory are developed by the QA/QC officer, which are then discussed in the GHG inventory core group, added to the inventory development plan and assigned to the relevant expert.

1.6.1.2 QA/QC plan

The QA/QC plan is represented by a quality manual as required by the ISO 9001:2008 standard. This quality manual constitutes the core of the quality management system. It consists of a systematic compilation of all documents relevant to quality issues on the FOEN internal document management system. The quality manual contains information regarding requirements, core processes and results of the inventory process and the national registry, as well as QA/QC activities, management and supporting documents (Figure 1-3). The core processes are represented by detailed flowcharts that specify tasks and responsibilities, data sources and collection processes, reference material and guidelines, and archived documents.

The quality manual is reviewed annually by the QA/QC officer and modified after consultation with the project management if necessary. Since 2007, most contributors to the GHG inventory are authorised to access the FOEN-based inventory files by means of a SSL connection to a web platform, including the quality manual with the underlying documents.

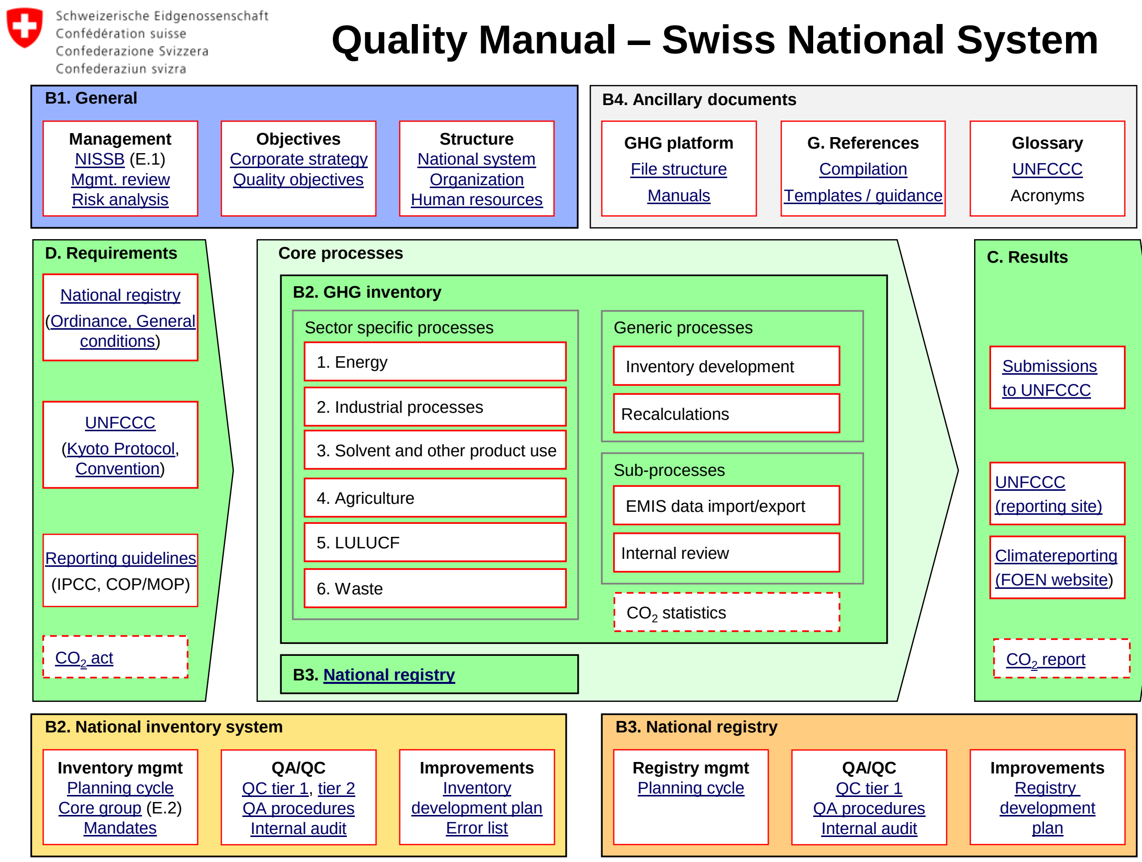

Figure 1-3: Overview of the quality manual of the national inventory system

1.6.1.3 QC procedures

All contributors to the inventory complete checklists that have been designed according to table 8.1 of the Good Practice Guidance (IPCC 2000). During the period of data collection, the data suppliers fill in the checklists. Once completed, the checklists are returned to FOEN. Simultaneously to GHG inventory preparation, the suppliers of emission data, the national inventory compiler, the NIR lead authors, and the project management complete the respective checklists. The QA/QC officer reviews and archives the checklists and contacts the suppliers if concerns about data integrity and/or the performance of quality control procedures arise and arranges for necessary measures to be taken.

In addition to general QC, the inventory project management promotes specific Tier 2 QC procedures both by providing for a FOEN (co-)funding of selected research projects and by initiating internal studies, where appropriate (see FOEN 2014a, Annex D for a list of past and current activities). Significant outcomes are fed into the inventory development plan (IDP; FOEN 2014a, chapter 3, Annex E) in order to be considered in future inventory submissions.

1.6.1.4 QA review procedures

Apart from the **UNFCCC reviews** of the Swiss inventory, various other efforts are made to assure the high quality standards set out in the quality objectives:

Expert peer reviews are commissioned periodically to provide in-depth analysis of specific sectors. In 2006, energy and industrial processes have been scrutinized, as well as methane emissions from agriculture. In 2009, the waste sector was subject to a domestic expert review. At the end of 2010, a thorough review of the LULUCF sector has taken place. Furthermore the industrial processes sector has undergone a substantial external review in 2013 (CSD, 2013). Further reviews are planned after the implementation of the revised reporting guidelines.

Internal reviews of the NIR, GHG inventory CRF-tables, Kyoto Protocol LULUCF CRF-tables, and the QA/QC supplement are made prior to each submission. They are performed by members of the GHG inventory core group as well as by the staff of the consultancies involved in inventory compilation.

The outcomes of all those reviewing activities are evaluated by the project management and the QA/QC officer, resulting in suggestions for amendments and improvements. The core group decides which items are to be followed up and who will take on the responsibility for implementation of the changes in future submissions (see inventory development plan).

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

1.6.1.5 Implementation of the recommendations of the ERT

All issues raised by the ERT are added to the inventory development plan (see also chapter 1.6.1.2 and FOEN2014a). The tables below give an overview over how and where recommendations (Table 1-12) and encouragements (Table 1-13) of the ERT have been implemented in the current submission. Outstanding issues, which could not be fully implemented in the current submission remain in the IDP and will be followed-up for future submissions (see Annex E in FOEN 2014a).

The first column in table (Table 1-12) refers to the relevant paragraph in the review report. The second column gives a brief description of the issue; the third column shows what has been improved and where the changes have been implemented. The fourth column refers to the corresponding entry in the inventory development plan (see Annex E in FOEN 2014a).

Table 1-12 Implementation of recommendations of the Expert Review Team.

ARR (para.)	Recommendation	Improvement – NIR chapter	IDP
Energy			
22	Adhere to QA/QC procedures	In order to identify any mistakes or errors, QA/QC procedures were conscientiously implemented. However, even with rigorous QA/QC procedures, minor errors may pass unnoticed or may be identified too late to be corrected for the current submission. The QA/QC system in place strives to continuously improve the inventory and will ensure progress.	-
23	Provide a better description of the fuel allocation in the inventory in comparison to the national energy statistics	The entire chapter describing emissions in the energy sector has been overhauled. The allocation of energy use to the different categories is described in section 3.2.5 Country-specific Issues.	10, 17
24	Implementation of the results of the ongoing study on CO_2 EFs and NCVs from liquid fuels in the 2015 submission	Study is on-going. Results are expected for mid-2014. Implementation is planned for the 2015 submission.	19
28	Disaggregation of feedstocks and non-energy use of fuels	Naphtha and LPG are reported separately (see chapter 3.2.3). A follow-up with the industry is planned in the coming year. Data for naphta and LPG use are confidential and can be provided on demand to the reviewers.	8
29	Review of the CO_2 EF of refinery gas	The emission factor has been reassessed. It resulted in a recalculation of the entire time series. See section 3.2.6.2 for a detailed description of the revised EF.	16
30	Provide documentation of CO_2 EFs of solid fuels and use correct values	The CO_2 EFs are documented in section 3.2.5.2. The error with regard to the CO_2 EF of coal that occurred in the last submission has been corrected.	9
37	Communicate correct charcoal production data to FAO	The correct numbers were sent to FAO.	18
40	Reporting and documentation of emissions from oil pipelines	Emissions from oil pipelines are reported using the IPCC tier 1 default methodology and documented in section 3.3.2.2	12
42	Estimate emissions from gas production from 1990-1994	Emissions from gas production are reported using the IPCC tier 1 default methodology and documented in section 3.3.3.2	14
43	Review of emissions from the gas industry and improve documentation of fugitive emissions	The emissions from the Swiss gas industry were reassessed and led to a recalculation of the entire time series. Documentation can be found in section 3.3.3.2	14
44	Expand the description of the methodology used to estimate fugitive emissions from venting and flaring	The description of the entire source category 1B has been overhauled (see section 3.3.3.2)	13
IP			
47	Recalculation of emissions from blasting using the correct EF	The correct emission factor is used (see 4.2.2.1)	6
50/51	Provide improved estimate and documentation of the CO_2 EF for brick and tile production	New data for brick and tile production could be obtained. The procedure to derive the CO2 EF for brick and tile production is described in section 4.2.2.3.	8
52	Include information regarding the justification of the N_2O EF for nitric acid production	Section 4.3.2.2 describes how the N_2O EF for nitric acid production was derived.	9
Agriculture			
58	Include information on conversion factors used for energy requirements of dairy cattle	All energy conversion factors are included in Table 6-3 (see section 6.2.2).	10
60	Include information and references regarding the choice of MCF of 10.0 per cent	Studies supporting the MCF of 10% for deep litter are included now in section 6.3.2.	5

LULUCF			
67	Provide full coverage of the land use statistics AREA	Full coverage of the land use statistics AREA is provided (see Chapter 7.2.2.1)	2
70	Improve presentation of the methods and include criteria for the use of each method, the reasoning behind it and the relevant references	The methodology of calculating carbon stock changes was changed, simplified and harmonized with the reporting of carbon stock changes under UNFCCC and under the Kyoto Protocol. Applied methods and the reasoning behind it are described in Chapter 7.1.3.2, Chapter 11.3.1.1 and in Chapter 11.3.1.4. All information provided in these Chapters is referenced, including specifications for AD, factors and parameters used.	3
71	Provide references and improve documentation to justify not reporting certain carbon pools under afforestation	Requested references and supplementary information were inserted in Chapter 11.3.1.1 and in Chapter 11.3.1.2.	13
72	Report above-ground and below-ground carbon pools separately	Above- and belowground living biomass is reported separately under the Kyoto Protocol. The approach is described in Chapter 7.3.4.6.	3
74	Improve documentation to justify not reporting soil organic carbon changes in mineral soils for unproductive forests	The description of unproductive forests has been extended. The reasoning why the carbon pools of unproductive forests are not a net source of emissions was supported with references (see section 7.3.4.9).	12
Waste			
77	Improve documentation of the methodology used to estimate waste water emissions	See improved description in Chapter 8.3.2.	9
78	Further expand on the amounts of waste that are reported in the energy sector	See new Figure 8-4 and respective description.	6
79	Provide information regarding the composition of wastes in SWDS used to derive the degradable organic fraction	See new table 8-3.	11
81	Disaggregate the emissions of subcategory 6D.	Emissions from subcategory 6D are listed separately for composting, fermentation, shredder and other non-specified sources in CRF table 6.	8
KP-LULUCF			
83	Improve comparability of reporting of land converted to forest land under the convention and afforestation and reforestation under the Kyoto Protocol	An area budget for LULUCF and KP-LULUCF reporting was introduced in Chapter 11.2.3. Further, see comment on para 70.	3, 10
86	Use notation key “IE” for losses in living biomass in KP-LULUCF table 5 (KP-I)A.1.2	The methodology was changed. For afforestations older than 20 years, emission factors of productive forests were applied (see Chapter 7.1.3.2 and Chapter 11.3.1.1). The losses in living biomass were noted as “R” (reported).	NA, (3)
87	Improve documentation regarding emissions from mineral soils in afforested units harvested and of dead wood and litter in units harvested	Requested references and supplementary information were inserted in Chapter 11.3.1.1 and in Chapter 11.3.1.2.	13
88	Improve documentation of the methodology used to calculate carbon stock changes under forest management	Supplementary documentation is provided by Didion (2014). A summary of this report was inserted in Chapter 11.3.2.	14

Table 1-13 Implementation of encouragements of the Expert Review Team

ARR (para.)	Encouragement	Improvement – NIR chapter	IDP
General			
Table 4	Highlight planned improvements in key categories	The revised reporting guidelines will give rise to a considerable workload. Therefore, major improvements linked to the revised guidelines will be given priority in the next submission. This is stated accordingly in the relevant sections of the NIR ("Planned improvements").	5
14	Explain changes in uncertainty estimates between submissions	Changes in uncertainty estimates is included in chapter 1.7.1.3	
Energy			
44	Reassess emission factors used for venting and flaring	Emissions from venting and flaring are of minor importance in Switzerland, as there is no gas and oil production. Therefore, the reassessment of emission factors for venting and flaring is assigned a low priority. It will not be possible to implement the encouragement for the next submission.	-
Agriculture			
56	Improve the reporting of agricultural residues in biogas digesters and the split in the energy, agriculture and waste sector	The reporting of manure used for biogas production could not yet be improved and harmonized due to delays in the regulation for national compensation projects. The planned improvement has been postponed to the submission 2015 (see also section 6.3.6.	3
57	Implement a comparison between Swiss estimates and the IPCC tier 2 default to calculate the CH_4 emissions for all animal categories	Country specific emission factor for enteric fermentation of cattle have been compared to IPCC Tier 2 emission factor. Results are presented in ART 2013a (see also section 6.2.4).	9
59	Split the sheep population to use the corresponding CH_4 conversion rates for mature sheep and other categories provided by IPCC	Postponed to submission 2015.	11
62	Provide information regarding the causes for the trend of percentage of dairy cattle on pasture	Information provided in section 6.3.2.	12
64	Explain the differences in N_2O emissions from agricultural soils calculated using the country-specific method and the IPCC default method	Differences between the country specific and the IPCC default model are explained in section 6.5.2 and in ART 2013a. A more extensive comparison will not be conducted earliest with the implementation of the new 2006 IPCC Guidelines.	7
LULUCF			
67	Report CH_4 and N_2O emissions from the non-mandatory categories that are currently not reported	The implementation of this encouragement was evaluated. The party decided not to report these emissions.	4
74	Use a coherent approach for LULUCF reporting under the Convention and under the Kyoto	See comments on para 70 and on para 83.	3
Waste			
80	Enhance investigations regarding N_2O emissions from waste water handling	Emissions from waste water are on the list of potential areas for improvements in future emissions. The encouragement will be taken into consideration when the sector waste water handling will be fully reassessed.	12
KP-LULUCF			
85	Clarify in the NIR that afforested and reforested areas are not reclassified to forest management	Supplementary text was inserted in Chapter 11.2.3, Chapter 11.3.1.1 and in the new Chapter 11.5.4.	NA

1.6.1.6 Documentation and archiving procedures

Inventory data as well as background information on activity data and emission factors are archived by the national inventory compiler in the EMIS data base. EMIS allows to file background information (e.g. interim worksheets; references; rationale for choice of methods) for any subset of inventory-related data. Whenever such documents are used they are labled as "EMIS 2014/(NFR-Code)" in this report.

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

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

1.6.2 Verification Activities

The time series have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013.
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

For each check, the CRF-table cells are marked in green if values are identical, in grey if they differ by no more than 20%, in orange if they differ by 20% to 50%, and in red if they differ by more than 50%. The findings are discussed among the core group members and the modelling specialists. All differences are investigated and the reasons for the differences sought. This procedure has already led to the identification of several mistakes, which were subsequently corrected before submission.

The current submission has been reviewed by personnel not directly involved in the preparation of a particular section of the inventory and revised accordingly.

The FOEN supports a monitoring campaign at the high altitude research station Jungfraujoch, where various greenhouse gases are measured continuously. The location of the research station normally provides for analysis of tropospheric background concentrations. However, under special meteorological conditions, an estimate of Swiss emissions can be derived from the measurements. For a couple of F-gases, a comparison of the inventory data with the inferred emissions is presented in Annex A6.1. Further research is needed to refine the approach and apply it to other greenhouse gases.

As an additional activity, the emission factor of all source categories used in the Swiss Inventory have been compared to the corresponding emission factors of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) and to the IPCC default value if available (INFRAS 2012). If respective Swiss values deviate more than ±10% from other countries' average or from the IPCC default value, explanations for the divergence are provided.

1.6.3 Treatment of Confidentiality Issues

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

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

The FOEN collects the data needed for calculating emissions of HFCs, PFCs and SF_6 from private companies or industry associations. In the National Inventory Report, the activity data underlying emission estimates of HFCs, PFCs and SF_6 are only partly presented at the most disaggregated level for reasons of confidentiality. However, complete emissions are reported in aggregated tables.

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

1.7 Uncertainty Evaluation

1.7.1 GHG Inventory

1.7.1.1 Tier 1 and Tier 2 analysis

This chapter presents the main results of the uncertainty evaluation Tier 1 and Tier 2 in accordance with the IPCC Good Practice Guidance:

- Tier 1 methodology (IPCC 2000: p. 6.13ff.)
- Tier 2 methodology, Monte Carlo simulation (IPCC 2000: p. 6.18ff.)

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

The uncertainty analysis Tier 1 is updated yearly and the uncertainty analysis Tier 2 (Monte Carlo simulation) is carried out every two years. Within this submission, the Tier 1 and Tier 2 analysis have been carried out.

The following chapters present the overall results of the uncertainty evaluation. Specific information about the uncertainty estimation for activity data, emission factors or emissions of each source category is included in the respective sectoral chapters (3–9) below.

1.7.1.2 Data Used

The evaluation includes uncertainties regarding activity data and emission factors. Uncertainties in the GWP values are not taken into account.

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

For source categories with quantitative uncertainty data available, the input information from studies or from the data suppliers is used for the uncertainty evaluation. This is mainly the case for key categories. For several key categories, no explicit information on uncertainties is available. For these cases, authors of the NIR chapters, FOEN experts involved and several data suppliers derived estimates of uncertainties based on the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000) default values and on information concerning the process of data collection for activity data and emission factors (import or sales statistics, surveys or modelling). Several experts from data suppliers were contacted for further information on some of the uncertainties. Some industry associations/sources also provided published or unpublished uncertainty estimates for their data. The data sources can be found in the relevant sub-sections on “Uncertainties and Time-Series Consistency” in each of the sectoral chapters (3–9) below.

For categories with no quantitative uncertainty data available, the NIR provides qualitative estimates of uncertainties. The elaboration of a quantitative uncertainty assessment for these categories would present a large effort with only limited effect on the overall uncertainty and therefore it has been decided to realize a semi-quantitative assessment. This includes the definition of a list of the combined uncertainties for all gases and three uncertainty levels: low, medium and high (see Table 1-14). These values are motivated by the comparison of uncertainty analyses of several countries carried out by de Keizer et al. (2007), as presented at the 2nd Internat. Workshop on Uncertainty in Greenhouse Gas Inventories (Vienna 27-28

September 2007), and by Table A1-1 of IPCC Guidelines, Vol. 1, Annex 1, Managing uncertainties (IPCC 1997a).

Table 1-14 Semi-quantitative (combinded) uncertainties (U) for the emission of categories with no quantitative uncertainty data available.

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

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

1.7.1.3 Results of Tier 1 Uncertainty Evaluation

With this submission, updated results of the uncertainty evaluation are presented. There is a calculation of the uncertainty excluding the LULUCF sector and an uncertainty evaluation including LULUCF. As described in IPCC (2000) and IPCC (2003), the uncertainty estimates of the LULUCF sector were combined with the uncertainty estimates of the non-LULUCF sector to obtain the total inventory uncertainty.

The resulting **Tier 1 level uncertainty in the national total annual CO_2 equivalent emissions without LULUCF is estimated to be 3.65%. Tier 1 trend uncertainty is 1.87%** meaning that the change of the base year (1990) to 2012, reported as -2.7%, lies with a probability of 95% between -4.6% and -0.8%.

Compared to the results of the previous inventory 2012 (level 3.55%, trend 1.89%; FOEN 2013), the level and the trend uncertainties for 2012 for the emissions without the LULUCF sector are slightly higher. This is mainly based on higher activity data and emission factor uncertainty in the sectors Energy - Fugitive CO_2-Emissions (1B2), N_2O and CH_4 emissions in Agriculture (4A, 4B and 4D), Industrial Processes (CO_2 emissions in 2A3, HFC emissions in 2F4 and PFC emissions in 2F9), and N_2O and CH_4 emissions in Others (7). This is partially compensated by the lower activity data uncertainty in the Energy sector and the correction of the emission factor uncertainty of the cement production (2A1).

The resulting **Tier 1 level uncertainty in the national total annual CO_2 equivalent emissions including LULUCF sector is estimated to be 7.43%. Tier 1 trend uncertainty is 2.46%.**

Compared to the results of the previous inventory 2012 (level 4.79%, trend 1.99%; FOEN 2013), the level and the trend uncertainties for 2012 for the emissions including LULUCF sector are higher. This is based on the significant higher emission factor uncertainty of CO_2-Emissions of 5C1 Grassland remaining Grassland (further information is included in chapter 7.5.5).

The results of the Tier 1 uncertainty analysis for GHG emissions 2012 are summarized in Table 1-16. Details of the uncertainty estimates for specific sources are provided in the sub-sections on “Uncertainties and Time-Series Consistency” in each of the chapters on source categories below.

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

- correlations existing between source categories that have not been considered by the Tier 1 approach (e.g. production data used for industry emissions in both categories 1A2 Manufacturing Industries and 2 Industrial Processes, or cattle numbers used for emissions related to enteric fermentation and animal manure production);
- errors due to the assumption of constant parameters;
- errors due to non-normal, asymmetric distribution of the uncertainties;
- errors due to methodological shortcomings;
- errors due to sources not reported (these are assumed to be very small).

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

Ranked by their contribution to uncertainty in the total national emissions level, the following categories are the top contributors to uncertainty with a contribution of over 97% to level and trend uncertainty (cf. Column H, Table 1-15):

- CO_2 from 5C1 Grassland remaining Grassland (combined uncertainty 5.6%)
- CO_2 from 5A1 Forest Land remaining Forest Land (2.7%)
- Indirect (4D3) and direct (4D1) emissions of N_2O from Agricultural Soils (2.3%)
- CO_2 from 1A1 Energy Industries (Other fuels) (1.9%)
- CO_2 from 5B1 Cropland remaining Cropland (1.7%)

These six source categories contribute with 7.2% to the level (root of sumsquare of the individual combined uncertainty) and with 2.1% to the trend uncertainty including LULUCF (root of sumsquare of the individual uncertainty introduced into the trend in total national emissions).

This allows for the identification of future areas of improvement in the context of the Inventory Development Plan (IDP).

Table 1-15 Ranked combined level uncertainties for sources in Switzerland.

Tier 1 Uncertainty Calculation and Reporting

A	B	C	D	E	F	G	H
IPCC Source category	Gas	Base year emissions 1990	Year 2012 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emission in year t
		Input data	Input data	Input data	Input data	Calc/Input	
		Gg CO2 eq	Gg CO2 eq	%	%	%	%
5C15. LULUCFC. Grassland1. Grassland remaining Grassland	CO2	107.09	134.74	6.0	2084.30	2084.3	5.581
5A15. LULUCFA. Forest Land1. Forest Land remaining Forest Land	CO2	-2'416.89	-2'134.56	2.0	62.80	62.8	2.665
4D34. AgricultureD. Agricultural Soils; Indirect Emissions	N2O	822.48	674.93	31.8	163.00	166.1	2.227
4D14. AgricultureD. Agricultural Soils; Direct Soil Emissions	N2O	1'351.48	1'143.10	20.4	80.63	83.2	1.889
1A11. Energy A. Fuel Combustion 1. Energy IndustriesOther Fuels	CO2	1'519.73	2'714.50	10.0	30.00	31.6	1.706
5B15. LULUCFB. Cropland1. Cropland remaining Cropland	CO2	345.17	707.27	5.0	109.79	109.9	1.545
4A4. AgricultureA. Enteric Fermentation	CH4	2'635.45	2'496.98	6.4	17.17	18.3	0.910
4B4. AgricultureB. Manure Management	CH4	671.61	646.11	6.4	54.13	54.5	0.700
1A3b1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	CO2	11'335.27	9'016.58	2.2	1.36	2.6	0.462
4B4. AgricultureB. Manure Management	N2O	454.68	335.81	29.5	56.25	63.5	0.424
4D24. AgricultureD. Agricultural Soils; Pasture, Range and Paddock Manure	N2O	128.10	220.79	57.3	62.50	84.8	0.372
5E25. LULUCFE. Settlements2. Land converted to Settlements	CO2	382.71	302.93	5.0	50.00	50.2	0.303
1A3b1. EnergyA. Fuel Combustion 3. Transport; Road TransportationDiesel	CO2	2'587.68	6'767.05	2.2	0.47	2.2	0.301
2F12. Industrial Proc.F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	HFC	0.02	1'137.81	8.5	8.49	12.0	0.271
1A4b1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialGaseous Fuels	CO2	1'424.38	2'649.60	2.0	4.60	5.0	0.264
6B6. Waste B. Wastewater Handling	N2O	184.72	240.28	1.3	50.00	50.0	0.239
6D6. Waste D. Other	CH4	29.94	113.76	10.0	100.00	100.5	0.227
5C25. LULUCFC. Grassland2. Land converted to Grassland	CO2	59.85	169.07	6.0	67.34	67.6	0.227
2F92. Industrial Proc.F. Consumption of Halocarbons and SF6; Other	SF6	79.58	135.91	56.6	56.57	80.0	0.216
1A21. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionGaseous Fuels	CO2	1'074.09	2'096.41	2.0	4.60	5.0	0.209
1A4b1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialLiquid Fuels	CO2	10'248.79	7'374.50	1.3	0.53	1.4	0.204
6A6. Waste A. Solid Waste Disposal on Land	CH4	688.16	158.26	30.0	50.00	58.3	0.183
1A21. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionOther Fuels	CO2	134.15	288.60	10.0	30.00	31.6	0.181
3 3. Solvent and Other Product Use	CO2	360.04	155.28	35.4	35.36	50.0	0.154
1A4a1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalGaseous Fuels	CO2	987.24	1'482.76	2.0	4.60	5.0	0.148
2F92. Industrial Proc.F. Consumption of Halocarbons and SF6; Other	HFC	0.00	76.14	56.6	56.57	80.0	0.121
5F25. LULUCFF. Other Land2. Land converted to Other Land	CO2	91.98	112.28	4.0	50.00	50.2	0.112
1B21. Energy B. Fugitive Emissions from Fuels2. Oil and Natural Gas	CH4	263.72	169.45	21.2	21.21	30.0	0.101
2A12. Industrial Proc.A. Mineral Products; Cement Production-CO2	CO2	2'524.68	1'787.11	2.0	2.00	2.8	0.100
2A32. Industrial Proc.A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2	CO2	150.39	98.48	1.4	50.98	51.0	0.100
1A4a1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalLiquid Fuels	CO2	4'606.43	3'038.51	1.3	0.53	1.4	0.084
1A21. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionLiquid Fuels	CO2	3'692.22	2'640.18	1.3	0.53	1.4	0.073
3 3. Solvent and Other Product Use	N2O	110.14	44.62	35.4	71.76	80.0	0.071
1A21. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionSolid Fuels	CO2	1'204.47	454.87	5.9	5.00	7.7	0.070
5B25. LULUCFB. Cropland2. Land converted to Cropland	CO2	43.33	22.26	6.0	143.39	143.5	0.063
1A11. Energy A. Fuel Combustion 1. Energy IndustriesGaseous Fuels	CO2	289.73	498.74	2.0	4.60	5.0	0.050
2B2. Industrial Proc.B. Chemical Industry	N2O	68.13	53.57	7.1	40.39	41.0	0.044
1A4b1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialBiomass	CH4	97.87	33.78	21.2	60.00	63.6	0.043
6D6. Waste D. Other	N2O	5.82	25.55	10.0	79.37	80.0	0.041
5E15. LULUCFE. Settlements1. Settlements remaining Settlements	CO2	3.60	33.69	5.0	50.00	50.2	0.034
1A11. Energy A. Fuel Combustion 1. Energy IndustriesOther Fuels	N2O	20.85	20.96	10.0	79.37	80.0	0.033
4D44. AgricultureD. Agricultural Soils; Use of sewage sludge as fertilizers	N2O	28.30	20.85	8.1	80.00	80.4	0.033
1A11. Energy A. Fuel Combustion 1. Energy IndustriesBiomass	N2O	27.72	19.75	21.2	77.14	80.0	0.031
1A4b1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialLiquid Fuels	N2O	25.94	18.69	1.3	79.99	80.0	0.030
1A3b1. EnergyA. Fuel Combustion 3. Transport; Road TransportationDiesel	N2O	5.74	66.06	2.2	22.00	22.1	0.029
5D25. LULUCFD. Wetlands2. Land converted to Wetlands	CO2	20.06	28.95	5.0	50.00	50.2	0.029
1A3b1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	N2O	142.38	27.52	2.2	50.00	50.0	0.027
1B21. Energy B. Fugitive Emissions from Fuels2. Oil and Natural Gas	CO2	84.62	39.29	21.2	21.21	30.0	0.023
1A11. Energy A. Fuel Combustion 1. Energy IndustriesLiquid Fuels	CO2	693.69	805.16	1.3	0.53	1.4	0.022
2B2. Industrial Proc.B. Chemical Industry	CO2	111.22	110.47	7.1	7.07	10.0	0.022
2F92. Industrial Proc.F. Consumption of Halocarbons and SF6; Other	PFC	0.00	13.10	56.6	56.57	80.0	0.021
6C6. Waste C. Waste Incineration	N2O	19.06	25.86	28.3	28.28	40.0	0.021
1A21. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionLiquid Fuels	N2O	13.92	11.76	1.3	79.99	80.0	0.019
2F72. Industrial Proc.F. Consumption of Halocarbons and SF6; Semiconductor Manufacture	SF6	0.00	19.55	28.3	28.28	40.0	0.016
1A4c1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/ForestryLiquid Fuels	CO2	547.34	540.01	1.3	0.53	1.4	0.015
1A4b1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialBiomass	N2O	10.79	9.07	21.2	77.14	80.0	0.014
1A3b1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	CH4	97.47	18.82	2.2	37.00	37.1	0.014
2F22. Industrial Proc.F. Consumption of Halocarbons and SF6; Hard Foam	HFC	0.00	13.27	34.6	34.65	49.0	0.013
5D25. LULUCFD. Land converted to Wetlands5(II) Non-CO2 emissions from drainage of soils ar	CH4	9.03	9.03	10.0	70.00	70.7	0.013
1A4a1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalLiquid Fuels	N2O	11.70	7.80	1.3	79.99	80.0	0.012
1A21. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionBiomass	N2O	1.68	6.85	21.2	77.14	80.0	0.011
2F42. Industrial Proc.F. Consumption of Halocarbons and SF6; Metered Dose Inhalers and Othe	HFC	0.00	13.22	28.3	28.28	40.0	0.011
77. Other	CO2	10.96	12.92	28.3	28.28	40.0	0.010
6C6. Waste C. Waste Incineration	CO2	54.10	12.34	28.3	28.28	40.0	0.010
2C2. Industrial Proc.C. Metal Production; Magnesium Foundries	SF6	0.00	31.72	10.6	10.61	15.0	0.009
1A4c1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/ForestryLiquid Fuels	N2O	4.96	5.54	1.3	79.99	80.0	0.009
1A3b1. EnergyA. Fuel Combustion 3. Transport; Road TransportationNatural Gas	CO2	0.00	83.59	3.5	3.55	5.0	0.008
1A21. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionOther Fuels	N2O	2.28	5.24	10.0	79.37	80.0	0.008
2C12. Industrial Proc.C. Metal Production; Steel Production	CO2	9.20	9.89	5.0	40.00	40.3	0.008
6C6. Waste C. Waste Incineration	CH4	11.58	6.14	28.3	52.92	60.0	0.007
2F82. Industrial Proc.F. Consumption of Halocarbons and SF6; Electrical Eq.	SF6	64.04	36.81	7.1	7.07	10.0	0.007
1A3a1. EnergyA. Fuel Combustion 3. Transport; Civil Aviation	CO2	252.55	136.65	2.2	1.16	2.5	0.007
5B25. LULUCFB. Cropland2. Land converted to Cropland	N2O	5.58	3.58	6.0	90.00	90.2	0.006
6B6. Waste B. Wastewater Handling	CH4	4.65	9.28	1.3	29.97	30.0	0.006
1A3b1. EnergyA. Fuel Combustion 3. Transport; Road TransportationNatural Gas	N2O	0.00	3.47	3.5	79.92	80.0	0.006

Table 1-16 Tier 1 uncertainty results for sources in Switzerland 2012 (IPCC 2000, Table 6.1, IPCC 2003).

IPCC GPG Table 6.1
Tier 1 Uncertainty Calculation and Reporting

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	Gas	Base year emissions 1990	Year 2012 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emission in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data	Calc/Input						
		Gg CO2 eq	Gg CO2 eq	%	%	%	%	%	%	%	%	%
Total Uncertainty including LULUCF		**50'968.63**	**50'320.09**				**7.43**					**2.46**
Emissions without LULUCF												
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Gaseous Fuels	CH4	0.65	1.12	2.0	29.9	30.0	0.001	0.0000	0.0000	0.00	0.00	0.00
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Liquid Fuels	CH4	0.49	0.67	1.3	30.0	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Solid Fuels	CH4	0.10	0.00	5.9	29.4	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Biomass	CH4	0.33	0.43	21.2	21.2	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Gaseous Fuels	CO2	289.73	498.74	2.0	4.6	5.0	0.050	0.0042	0.0098	0.02	0.03	0.03
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Liquid Fuels	CO2	693.69	805.16	1.3	0.5	1.4	0.022	0.0024	0.0158	0.00	0.03	0.03
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Solid Fuels	CO2	44.84	0.00	5.9	5.0	7.7	0.000	-0.0009	0.0000	0.00	0.00	0.00
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Other Fuels	CO2	1'519.73	2'714.50	10.0	30.0	31.6	1.706	0.0238	0.0533	0.71	0.75	1.04
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Gaseous Fuels	N2O	0.16	0.28	2.0	80.0	80.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Liquid Fuels	N2O	2.15	2.86	1.3	80.0	80.0	0.005	0.0000	0.0001	0.00	0.00	0.00
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Solid Fuels	N2O	0.24	0.00	5.9	79.8	80.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Biomass	N2O	27.72	19.75	21.2	77.1	80.0	0.031	-0.0001	0.0004	-0.01	0.01	0.02
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Other Fuels	N2O	20.85	20.96	10.0	79.4	80.0	0.033	0.0000	0.0004	0.00	0.01	0.01
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Gaseous Fuels	CH4	2.66	4.74	2.0	29.9	30.0	0.003	0.0000	0.0001	0.00	0.00	0.00
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Liquid Fuels	CH4	2.32	1.04	1.3	30.0	30.0	0.001	0.0000	0.0000	0.00	0.00	0.00
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Solid Fuels	CH4	0.40	0.14	5.9	29.4	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Biomass	CH4	2.46	1.56	21.2	21.2	30.0	0.001	0.0000	0.0000	0.00	0.00	0.00
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Other Fuels	CH4	0.54	0.37	10.0	28.3	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Gaseous Fuels	CO2	1'074.09	2'096.41	2.0	4.6	5.0	0.209	0.0203	0.0411	0.09	0.12	0.15
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Liquid Fuels	CO2	3'692.22	2'640.18	1.3	0.5	1.4	0.073	-0.0197	0.0518	-0.01	0.09	0.09
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Solid Fuels	CO2	1'204.47	454.87	5.9	5.0	7.7	0.070	-0.0144	0.0089	-0.07	0.07	0.10
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Other Fuels	CO2	134.15	288.60	10.0	30.0	31.6	0.181	0.0031	0.0057	0.09	0.08	0.12
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Gaseous Fuels	N2O	0.59	1.15	2.0	80.0	80.0	0.002	0.0000	0.0000	0.00	0.00	0.00
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Liquid Fuels	N2O	13.92	11.76	1.3	80.0	80.0	0.019	0.0000	0.0002	0.00	0.00	0.00
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Solid Fuels	N2O	6.44	2.41	5.9	79.8	80.0	0.004	-0.0001	0.0000	-0.01	0.00	0.01
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Biomass	N2O	1.68	6.85	21.2	77.1	80.0	0.011	0.0001	0.0001	0.01	0.00	0.01
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Other Fuels	N2O	2.28	5.24	10.0	79.4	80.0	0.008	0.0001	0.0001	0.00	0.00	0.00
1A3a 1. Energy A. Fuel Combustion 3. Transport; Civil Aviation	CH4	0.24	0.25	2.2	60.0	60.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3a 1. Energy A. Fuel Combustion 3. Transport; Civil Aviation	CO2	252.55	136.65	2.2	1.2	2.5	0.007	-0.0022	0.0027	0.00	0.01	0.01
1A3a 1. Energy A. Fuel Combustion 3. Transport; Civil Aviation	N2O	2.49	1.35	2.2	150.0	150.0	0.004	0.0000	0.0000	0.00	0.00	0.00
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Natural Gas	CH4	0.00	0.10	3.5	29.8	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Diesel	CH4	1.38	0.55	2.2	20.0	20.1	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Gasoline	CH4	97.47	18.82	2.2	37.0	37.1	0.014	-0.0015	0.0004	-0.06	0.00	0.06
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Biomass	CH4	0.00	-0.02	21.2	56.1	60.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Diesel	CO2	2'587.68	6'767.05	2.2	0.5	2.2	0.301	0.0826	0.1328	0.04	0.41	0.41
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Gasoline	CO2	11'335.27	9'016.58	2.2	1.4	2.6	0.462	-0.0426	0.1769	-0.06	0.55	0.55
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Natural Gas	CO2	0.00	83.59	3.5	3.5	5.0	0.008	0.0016	0.0016	0.01	0.01	0.01
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Diesel	N2O	5.74	66.06	2.2	22.0	22.1	0.029	0.0012	0.0013	0.03	0.00	0.03
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Gasoline	N2O	142.38	27.52	2.2	50.0	50.0	0.027	-0.0022	0.0005	-0.11	0.00	0.11
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Natural Gas	N2O	0.00	3.47	3.5	79.9	80.0	0.006	0.0001	0.0001	0.01	0.00	0.01
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Biomass	N2O	0.00	0.70	21.2	148.5	150.0	0.002	0.0000	0.0000	0.00	0.00	0.00
1A3c 1. Energy A. Fuel Combustion 3. Transport; Railways Liquid Fuels	CH4	0.01	0.01	1.3	30.0	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3c 1. Energy A. Fuel Combustion 3. Transport; Railways Liquid Fuels	CO2	28.69	39.69	1.3	0.5	1.4	0.001	0.0002	0.0008	0.00	0.00	0.00
1A3c 1. Energy A. Fuel Combustion 3. Transport; Railways Liquid Fuels	N2O	0.38	0.52	1.3	150.0	150.0	0.002	0.0000	0.0000	0.00	0.00	0.00
1A3d 1. Energy A. Fuel Combustion 3. Transport; Navigation Gas/Diesel Oil	CH4	0.01	0.02	2.2	29.9	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3d 1. Energy A. Fuel Combustion 3. Transport; Navigation Gasoline	CH4	0.58	0.54	2.2	29.9	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3d 1. Energy A. Fuel Combustion 3. Transport; Navigation	CO2	111.93	121.14	2.2	0.5	2.3	0.005	0.0002	0.0024	0.00	0.01	0.01
1A3d 1. Energy A. Fuel Combustion 3. Transport; Navigation Gas/Diesel Oil	N2O	0.66	0.82	2.2	150.0	150.0	0.002	0.0000	0.0000	0.00	0.00	0.00
1A3d 1. Energy A. Fuel Combustion 3. Transport; Navigation Gasoline	N2O	0.60	0.55	2.2	150.0	150.0	0.002	0.0000	0.0000	0.00	0.00	0.00
1A3e 1. Energy A. Fuel Combustion 3. Transport; Other non-specified	CH4	0.06	0.03	2.2	35.4	35.4	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3e 1. Energy A. Fuel Combustion 3. Transport; Other non-specified	CO2	31.42	45.44	2.2	4.5	5.0	0.005	0.0003	0.0009	0.00	0.00	0.00
1A3e 1. Energy A. Fuel Combustion 3. Transport; Other non-specified	N2O	0.02	0.03	2.2	80.0	80.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A4a 1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institut Gaseous Fuels	CH4	2.41	3.83	2.0	29.9	30.0	0.002	0.0000	0.0001	0.00	0.00	0.00
1A4a 1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institut Liquid Fuels	CH4	3.06	1.40	1.3	30.0	30.0	0.001	0.0000	0.0000	0.00	0.00	0.00
1A4a 1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institut Biomass	CH4	9.74	4.13	21.2	21.2	30.0	0.002	-0.0001	0.0001	0.00	0.00	0.00
1A4a 1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institut Gaseous Fuels	CO2	987.24	1'482.76	2.0	4.6	5.0	0.148	0.0100	0.0291	0.05	0.08	0.09
1A4a 1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institut Liquid Fuels	CO2	4'606.43	3'038.51	1.3	0.5	1.4	0.084	-0.0296	0.0596	-0.02	0.11	0.11
1A4a 1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institut Gaseous Fuels	N2O	0.55	0.82	2.0	80.0	80.0	0.001	0.0000	0.0000	0.00	0.00	0.00
1A4a 1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institut Liquid Fuels	N2O	11.70	7.80	1.3	80.0	80.0	0.012	-0.0001	0.0002	-0.01	0.00	0.01
1A4a 1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institut Biomass	N2O	1.45	3.23	21.2	77.1	80.0	0.005	0.0000	0.0001	0.00	0.00	0.00
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Gaseous Fuels	CH4	3.24	6.10	2.0	29.9	30.0	0.004	0.0001	0.0001	0.00	0.00	0.00
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Liquid Fuels	CH4	6.00	2.26	1.3	30.0	30.0	0.001	-0.0001	0.0000	0.00	0.00	0.00
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Solid Fuels	CH4	3.71	2.28	5.9	29.4	30.0	0.001	0.0000	0.0000	0.00	0.00	0.00
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Biomass	CH4	97.87	33.78	21.2	60.0	63.6	0.043	-0.0012	0.0007	-0.07	0.02	0.08
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Gaseous Fuels	CO2	1'424.38	2'649.60	2.0	4.6	5.0	0.264	0.0244	0.0520	0.11	0.15	0.18
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Liquid Fuels	CO2	10'248.79	7'374.50	1.3	0.5	1.4	0.204	-0.0537	0.1447	-0.03	0.26	0.27
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Solid Fuels	CO2	54.59	33.60	5.9	5.0	7.7	0.005	-0.0004	0.0007	0.00	0.01	0.01
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Gaseous Fuels	N2O	0.79	1.46	2.0	80.0	80.0	0.002	0.0000	0.0000	0.00	0.00	0.00
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Liquid Fuels	N2O	25.94	18.69	1.3	80.0	80.0	0.030	-0.0001	0.0004	-0.01	0.00	0.01
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Solid Fuels	N2O	0.29	0.18	5.9	79.8	80.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Biomass	N2O	10.79	9.07	21.2	77.1	80.0	0.014	0.0000	0.0002	0.00	0.01	0.01
1A4c 1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/Forestry Gaseous Fuels	CH4	0.09	0.04	2.0	29.9	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A4c 1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/Forestry Liquid Fuels	CH4	1.62	1.43	1.3	30.0	30.0	0.001	0.0000	0.0000	0.00	0.00	0.00
1A4c 1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/Forestry Biomass	CH4	0.80	0.15	21.2	21.2	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A4c 1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/Forestry Gaseous Fuels	CO2	41.45	18.48	2.0	4.6	5.0	0.002	-0.0004	0.0004	0.00	0.00	0.00
1A4c 1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/Forestry Liquid Fuels	CO2	547.34	540.01	1.3	0.5	1.4	0.015	0.0000	0.0106	0.00	0.02	0.02
1A4c 1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/Forestry Gaseous Fuels	N2O	0.02	0.01	2.0	80.0	80.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A4c 1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/Forestry Liquid Fuels	N2O	4.96	5.54	1.3	80.0	80.0	0.009	0.0000	0.0001	0.00	0.00	0.00
1A4c 1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/Forestry Biomass	N2O	0.21	0.35	21.2	77.1	80.0	0.001	0.0000	0.0000	0.00	0.00	0.00
1A5 1. Energy A. Fuel Combustion 5. Other Liquid Fuels	CH4	0.16	0.12	1.3	30.0	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A5 1. Energy A. Fuel Combustion 5. Other Liquid Fuels	CO2	203.58	114.80	1.3	0.5	1.4	0.003	-0.0017	0.0023	0.00	0.00	0.00
1A5 1. Energy A. Fuel Combustion 5. Other Liquid Fuels	N2O	2.01	1.13	1.3	150.0	150.0	0.003	0.0000	0.0000	0.00	0.00	0.00
1B2 1. Energy B. Fugitive Emissions 2. Oil and Natural Gas	CH4	263.72	169.45	21.2	21.2	30.0	0.101	-0.0018	0.0033	-0.04	0.10	0.11
1B2 1. Energy B. Fugitive Emissions 2. Oil and Natural Gas	CO2	84.62	39.29	21.2	21.2	30.0	0.023	-0.0009	0.0008	-0.02	0.02	0.03
1B2 1. Energy B. Fugitive Emissions 2. Oil and Natural Gas	N2O	0.62	0.68	21.2	21.2	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00

Table 1-16 continued. Tier 1 uncertainty results for sources in Switzerland 2012 (IPCC 2000, Table 6.1, IPCC 2003).

IPCC GPG Table 6.1
Tier 1 Uncertainty Calculation and Reporting

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	Gas	Base year emissions 1990	Year 2012 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emission in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data	Calc/Input						
		Gg CO2 eq	Gg CO2 eq	%	%	%	%	%	%	%	%	%
Total Uncertainty including LULUCF		**50'968.63**	**50'320.09**				**7.43**					**2.46**
Emissions without LULUCF												
2A1 2. Industria A. Mineral Products;	CO2	2'524.68	1'787.11	2.0	2.0	2.8	0.100	-0.0138	0.0351	-0.03	0.10	0.10
2A2 2. Industria A. Mineral Products;	CO2	53.35	54.26	1.4	1.4	2.0	0.002	0.0000	0.0011	0.00	0.00	0.00
2A3 2. Industria A. Mineral Products;	CO2	150.39	98.48	1.4	51.0	51.0	0.100	-0.0010	0.0019	-0.05	0.00	0.05
2A7 2. Industria A. Mineral Products;	CO2	15.30	7.68	1.4	1.4	2.0	0.000	-0.0001	0.0002	0.00	0.00	0.00
2B 1. Industria B. Chemical Industry	CH4	1.54	2.39	7.1	29.2	30.0	0.001	0.0000	0.0000	0.00	0.00	0.00
2B 2. Industria B. Chemical Industry	CO2	111.22	110.47	7.1	7.1	10.0	0.022	0.0000	0.0022	0.00	0.02	0.02
2B 2. Industria B. Chemical Industry	N2O	68.13	53.57	7.1	40.4	41.0	0.044	-0.0003	0.0011	-0.01	0.01	0.02
2C 2. Industria C. Metal Production;	SF6	0.00	0.00	10.6	10.6	15.0	0.000	0.0000	0.0000	0.00	0.00	0.00
2C 2. Industria C. Metal Production;	SF6	0.00	31.72	10.6	10.6	15.0	0.009	0.0006	0.0006	0.01	0.01	0.01
2C1 2. Industria C. Metal Production;	CO2	9.20	9.89	5.0	40.0	40.3	0.008	0.0000	0.0002	0.00	0.00	0.00
2C3 2. Industria C. Metal Production;	CO2	139.26	0.00	7.1	7.1	10.0	0.000	-0.0027	0.0000	-0.02	0.00	0.02
2C3 2. Industria C. Metal Production;	PFC	100.17	0.00	13.0	13.0	18.4	0.000	-0.0019	0.0000	-0.03	0.00	0.03
2C5 2. Industria C. Metal Production;	CO2	1.65	1.36	7.1	7.1	10.0	0.000	0.0000	0.0000	0.00	0.00	0.00
2F1 2. Industria F. Consumption of H	HFC	0.02	1'137.81	8.5	8.5	12.0	0.271	0.0223	0.0223	0.19	0.27	0.33
2F1 2. Industria F. Consumption of H	PFC	0.04	6.14	8.5	8.5	12.0	0.001	0.0001	0.0001	0.00	0.00	0.00
2F2 2. Industria F. Consumption of H	HFC	0.00	13.27	34.6	34.6	49.0	0.013	0.0003	0.0003	0.01	0.01	0.02
2F4 2. Industria F. Consumption of H	HFC	0.00	13.22	28.3	28.3	40.0	0.011	0.0003	0.0003	0.01	0.01	0.01
2F5 2. Industria F. Consumption of H	HFC	0.00	4.59	1.4	1.4	2.0	0.000	0.0001	0.0001	0.00	0.00	0.00
2F5 2. Industria F. Consumption of H	PFC	0.00	7.29	1.4	1.4	2.0	0.000	0.0001	0.0001	0.00	0.00	0.00
2F7 2. Industria F. Consumption of H	PFC	0.00	6.54	28.3	28.3	40.0	0.005	0.0001	0.0001	0.00	0.01	0.01
2F7 2. Industria F. Consumption of H	SF6	0.00	19.55	28.3	28.3	40.0	0.016	0.0004	0.0004	0.01	0.02	0.02
2F8 2. Industria F. Consumption of H	SF6	64.04	36.81	7.1	7.1	10.0	0.007	-0.0005	0.0007	0.00	0.01	0.01
2F9 2. Industria F. Consumption of H	HFC	0.00	76.14	56.6	56.6	80.0	0.121	0.0015	0.0015	0.08	0.12	0.15
2F9 2. Industria F. Consumption of H	PFC	0.00	13.10	56.6	56.6	80.0	0.021	0.0003	0.0003	0.01	0.02	0.03
2F9 2. Industria F. Consumption of H	SF6	79.58	135.91	56.6	56.6	80.0	0.216	0.0011	0.0027	0.06	0.21	0.22
2G 2. Industria G. Other	CO2	1.04	0.91	7.1	7.1	10.0	0.000	0.0000	0.0000	0.00	0.00	0.00
3 3. Solvent a	CO2	360.04	155.28	35.4	35.4	50.0	0.154	-0.0039	0.0030	-0.14	0.15	0.21
3 3. Solvent a	N2O	110.14	44.62	35.4	71.8	80.0	0.071	-0.0013	0.0009	-0.09	0.04	0.10
4A 4. Agricultu A. Enteric Fermentati	CH4	2'635.45	2'496.98	6.4	17.2	18.3	0.910	-0.0021	0.0490	-0.04	0.45	0.45
4B 4. Agricultu B. Manure Managem	CH4	671.61	646.11	6.4	54.1	54.5	0.700	-0.0003	0.0127	-0.02	0.12	0.12
4B 4. Agricultu B. Manure Managem	N2O	454.68	335.81	29.5	56.3	63.5	0.424	-0.0022	0.0066	-0.12	0.28	0.30
4D1 4. Agricultu D. Agricultural Soils;	N2O	1'351.48	1'143.10	20.4	80.6	83.2	1.889	-0.0038	0.0224	-0.30	0.65	0.71
4D2 4. Agricultu D. Agricultural Soils;	N2O	128.10	220.79	57.3	62.5	84.8	0.372	0.0019	0.0043	0.12	0.35	0.37
4D3 4. Agricultu D. Agricultural Soils;	N2O	822.48	674.93	31.8	163.0	166.1	2.227	-0.0027	0.0132	-0.44	0.59	0.74
4D4 4. Agricultu D. Agricultural Soils;	N2O	28.30	20.85	8.1	80.0	80.4	0.033	-0.0001	0.0004	-0.01	0.00	0.01
6A 6. Waste A. Solid Waste Dispo	CH4	688.16	158.26	30.0	50.0	58.3	0.183	-0.0102	0.0031	-0.51	0.13	0.53
6A 6. Waste A. Solid Waste Dispo	CO2	9.24	0.00	30.0	26.5	40.0	0.000	-0.0002	0.0000	0.00	0.00	0.00
6B 6. Waste B. Wastewater Handl	CH4	4.65	9.28	1.3	30.0	30.0	0.006	0.0001	0.0002	0.00	0.00	0.00
6B 6. Waste B. Wastewater Handl	N2O	184.72	240.28	1.3	50.0	50.0	0.239	0.0011	0.0047	0.06	0.01	0.06
6C 6. Waste C. Waste Incineration	CH4	11.58	6.14	28.3	52.9	60.0	0.007	-0.0001	0.0001	-0.01	0.00	0.01
6C 6. Waste C. Waste Incineration	CO2	54.10	12.34	28.3	28.3	40.0	0.010	-0.0008	0.0002	-0.02	0.01	0.02
6C 6. Waste C. Waste Incineration	N2O	19.06	25.86	28.3	28.3	40.0	0.021	0.0001	0.0005	0.00	0.02	0.02
6D 6. Waste D. Other	CH4	29.94	113.76	10.0	100.0	100.5	0.227	0.0017	0.0022	0.17	0.03	0.17
6D 6. Waste D. Other	CO2	0.00	0.00	10.0	0.0	10.0	0.000	0.0000	0.0000	0.00	0.00	0.00
6D 6. Waste D. Other	N2O	5.82	25.55	10.0	79.4	80.0	0.041	0.0004	0.0005	0.03	0.01	0.03
7 7. Other	CH4	0.55	0.57	28.3	74.8	80.0	0.001	0.0000	0.0000	0.00	0.00	0.00
7 7. Other	CO2	10.96	12.92	28.3	28.3	40.0	0.010	0.0000	0.0003	0.00	0.01	0.01
7 7. Other	N2O	0.62	0.62	28.3	147.3	150.0	0.002	0.0000	0.0000	0.00	0.00	0.00
LULUCF												
5E1 5. LULUCF E. Settlements 1. Settlements remaining Settlements	CO2	3.60	33.69	5.0	50.0	50.2	0.034	0.0006	0.0007	0.03	0.00	0.03
5E2 5. LULUCF E. Settlements 2. Land converted to Settlements	CO2	382.71	302.93	5.0	50.0	50.2	0.303	-0.0015	0.0059	-0.07	0.04	0.08
5A1 5. LULUCF A. Forest Land 1. Forest Land remaining Forest Land	CH4	20.90	0.42	10.0	70.0	70.7	0.001	-0.0004	0.0000	-0.03	0.00	0.03
5A1 5. LULUCF A. Forest Land 1. Forest Land remaining Forest Land	CO2	-2'416.89	-2'134.56	2.0	62.8	62.8	-2.665	0.0049	-0.0419	0.31	-0.12	0.33
5A1 5. LULUCF A. Forest Land 1. Forest Land remaining Forest Land Biomass Burning, V	CO2	25.36	0.51	10.0	70.0	70.7	0.001	-0.0005	0.0000	-0.03	0.00	0.03
5A1 5. LULUCF A. Forest Land 1. Forest Land remaining Forest Land	N2O	4.77	0.09	10.0	70.0	70.7	0.000	-0.0001	0.0000	-0.01	0.00	0.01
5A2 5. LULUCF A. Forest Land 2. Land converted to Forest Land	CO2	-621.57	-518.61	2.0	62.8	62.8	-0.648	0.0019	-0.0102	0.12	-0.03	0.12
5B1 5. LULUCF B. Cropland 1. Cropland remaining Cropland	CO2	345.17	707.27	5.0	109.8	109.9	1.545	0.0072	0.0139	0.79	0.10	0.80
5B2 5. LULUCF B. Cropland 2. Land converted to Cropland	CO2	43.33	22.26	6.0	143.4	143.5	0.063	-0.0004	0.0004	-0.06	0.00	0.06
5B2 5. LULUCF B. Cropland 2. Land converted to Cropland	N2O	5.58	3.58	6.0	90.0	90.2	0.006	0.0000	0.0001	0.00	0.00	0.00
5C1 5. LULUCF C. Grassland 1. Grassland remaining Grassland	CH4	0.41	0.00	6.0	70.0	70.3	0.000	0.0000	0.0000	0.00	0.00	0.00
5C1 5. LULUCF C. Grassland 1. Grassland remaining Grassland	CO2	107.09	134.74	6.0	2084.3	2084.3	5.581	0.0006	0.0026	1.19	0.02	1.19
5C1 5. LULUCF C. Grassland 1. Grassland remaining Grassland	N2O	0.19	0.00	6.0	70.0	70.3	0.000	0.0000	0.0000	0.00	0.00	0.00
5C2 5. LULUCF C. Grassland 2. Land converted to Grassland	CO2	59.85	169.07	6.0	67.3	67.6	0.227	0.0022	0.0033	0.15	0.03	0.15
5D1 5. LULUCF D. Wetlands 1. Wetlands remaining Wetlands	CO2	-2.87	-0.56	30.0	100.0	104.4	-0.001	0.0000	0.0000	0.00	0.00	0.00
5D2 5. LULUCF D. Land converted to 5(II) Non-CO2 emissions from draina	CH4	9.03	9.03	10.0	70.0	70.7	0.013	0.0000	0.0002	0.00	0.00	0.00
5D2 5. LULUCF D. Wetlands 2. Land converted to Wetlands	CO2	20.06	28.95	5.0	50.0	50.2	0.029	0.0002	0.0006	0.01	0.00	0.01
5F2 5. LULUCF F. Other Land 2. Land converted to Other Land	CO2	91.98	112.28	4.0	50.0	50.2	0.112	0.0004	0.0022	0.02	0.01	0.02

Table 1-16 continued. Tier 1 uncertainty results for sources in Switzerland 2012 (IPCC 2000, Table 6.1, IPCC 2003).

Table 6.1 (CONTINUED)
Tier 1 Uncertainty Calculation and Reporting

A (continued)		B	N	O	P	Q
IPCC Source category		Gas	Emission factor quality indicator IPCC Default, Measurement based, national Referenced data	Activity data quality indicator IPCC Default, Measurement based, national Referenced data	Expert judgement reference numbers	Reference to section in NIR
1A1	1. Energy A. Fuel Comb 1. Energy Indu Gaseous Fuels	CO2	M	D		Section 3.2.6
1A1	1. Energy A. Fuel Comb 1. Energy Indu Liquid Fuels	CO2	M	R		Section 3.2.6
1A1	1. Energy A. Fuel Comb 1. Energy Indu Other Fuels	CO2	R	R		Section 3.2.6
1A2	1. Energy A. Fuel Comb 2. Manufactur Gaseous Fuels	CO2	M	D		Section 3.2.7
1A2	1. Energy A. Fuel Comb 2. Manufactur Liquid Fuels	CO2	M	R		Section 3.2.7
1A2	1. Energy A. Fuel Comb 2. Manufactur Solid Fuels	CO2	D	D, R		Section 3.2.7
1A2	1. Energy A. Fuel Comb 2. Manufactur Other Fuels	CO2	R	R		Section 3.2.7
1A3a	1. Energy A. Fuel Comb 3. Transport; Civil Aviation	CO2	M	R		Section 3.2.8
1A3b	1. Energy A. Fuel Comb 3. Transport; I Diesel	CO2	M	R		Section 3.2.8
1A3b	1. Energy A. Fuel Comb 3. Transport; I Gasoline	CO2	M	R		Section 3.2.8
1A4a	1. Energy A. Fuel Comb 4. Other Secto Gaseous Fuels	CO2	M	D		Section 3.2.9
1A4a	1. Energy A. Fuel Comb 4. Other Secto Liquid Fuels	CO2	M	R		Section 3.2.9
1A4b	1. Energy A. Fuel Comb 4. Other Secto Gaseous Fuels	CO2	M	D		Section 3.2.9
1A4b	1. Energy A. Fuel Comb 4. Other Secto Liquid Fuels	CO2	M	R		Section 3.2.9
1A4b	1. Energy A. Fuel Comb 4. Other Secto Biomass	CO2	M	R		Section 3.2.9
1A4c	1. Energy A. Fuel Comb 4. Other Secto Liquid Fuels	CO2	M	R		Section 3.2.9
1A5	1. Energy A. Fuel Comb 5. Other Liquid and Gaseo	CO2	M	R		Section 3.3.10
1A1	1. Energy A. Fuel Comb 1. Energy Ind. Other Fuels	N2O	R	R		Section 3.2.6
1A3b	1. Energy A. Fuel Comb 3b. Road Trar Gasoline	N2O	R	R		Section 3.2.8
1A3b	1. Energy A. Fuel Comb 3b. Road Trar Gasoline	CH4	R	R		Section 3.2.8
1B2	1. Energy B. Fugitive En 2. Oil and Natural Gas	CH4	D	D		Section 3.3.2
2A1	2. Industrial P A. Mineral Products; Cement Production-CO2	CO2	D	D		Section 4.2.3
2C	2. Industrial P C. Metal Production without Aluminium Produc	CO2	R	R		Section 4.4.3
2F1	2. Industrial P F. Consumption of Halocarbons and SF6	PFC	R	R		Section 4.7.3
2F9	2. Industrial P F. Consumption of Halocarbons and SF6; Ref	HFC	R	R		Section 4.7.3
2F9	2. Industrial P F. Consumption of Halocarbons and SF6; Ref	SF6	R	R		Section 4.7.3
3	3. Solvent and Other Product Use	CO2	R	R		Section 5.2.3
3	3. Solvent and Other Product Use	N2O	R	R		Section 5.2.3
4A	4. Agriculture A. Enteric Fermentation	CH4	R	R		Section 6.2.3
4B	4. Agriculture B. Manure Management	CH4	R	R		Section 6.3.3
4B	4. Agriculture B. Manure Management	N2O	D	R		Section 6.3.3
4D1	4. Agriculture D. Agricultural Soils; Direct Soil Emissions	N2O	D	R		Section 6.5.3
4D2	4. Agriculture D. Agricultural Soils; Pasture, Range and Padd	N2O	D	R		Section 6.5.3
4D3	4. Agriculture D. Agricultural Soils; Indirect Emissions	N2O	D	R		Section 6.5.3
5A1	5. LULUCF A. Forest Lan 1. Forest Land remaining Fores	CO2	R	R		Section 7.3.5
5A2	5. LULUCF A. Forest Lan 2. Land converted to Forest Lar	CO2	R	R		Section 7.3.5
5B1	5. LULUCF B. Cropland 1. Cropland remaining Cropland	CO2	M	R		Section 7.4.5
5C1	5. LULUCF B. Grassland 1. Grassland remaining Grassla	CO2	R	R		Section 7.5.5
5C2	5. LULUCF B. Grassland 2. Land converted to Grassland	CO2	R	R		Section 7.5.5
5E2	5. LULUCF E. Settlement 2. Land converted to Settlement	CO2	R	R		Section 7.7.5
6A	6. Waste A. Solid Waste Disposal on Land	CH4	R	R		Section 8.2.3
6B	6. Waste B. Wastewater Handling	N2O	R	R		Section 8.3.3
6D	6. Waste D. Other	CH4	R	R		Section 8.5.3
	Rest of sources	CO2	R	R		Exp. est.

1.7.1.4 Results of Tier 2 Uncertainty Evaluation (Monte Carlo)

A Tier 2 uncertainty analysis for Switzerland's GHG Inventory was carried out for the inventory submitted in 2012 (FOEN 2012) and contained a level uncertainty for 2010 and a trend uncertainty for the period 1990-2010. For the inventory year 2012 (i.e. the current submission) the Monte Carlo simulation has been updated.

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

In the present analysis, Monte Carlo simulations were performed to estimate uncertainties both in emissions 2012 and in emission trends 1990–2012, at the source category level as well as for the inventory as a whole (excluding and including LULUCF). The simulations were run with the commercial software package Crystal Ball (® Decisioneering). This tool generates random numbers within user defined probability ranges and probability distributions. As a result, selected statistics are produced for the forecast variables.

The main Monte Carlo results for level and trend analyses are:

Uncertainties without LULUCF

The total uncertainty level of Switzerland's 2012 emissions is **3.86%** of the total GHG emissions without LULUCF. The 95% confidence interval is slightly asymmetric and lies between **96.37% and 104.09% of the total GHG emissions without LULUCF.**

The change in total emissions between 1990 and 2012 is -2.72%. With a probability of 95%, the change lies within the range of **-6.11% to +0.12**%, corresponding to a trend uncertainty of **3.11%.**

Uncertainties with LULUCF

The total uncertainty level of the 2012 Swiss emissions is **7.51%** of the total GHG emissions with LULUCF. The 95% confidence interval is almost symmetric and lies between **92.57% and 107.59%.**

The change in total emissions between 1990 and 2012 is -1.27%. With a probability of 95%, the change lies within the range of **-10.23% to 7.41%,** corresponding to a trend uncertainty of **8.82%.**

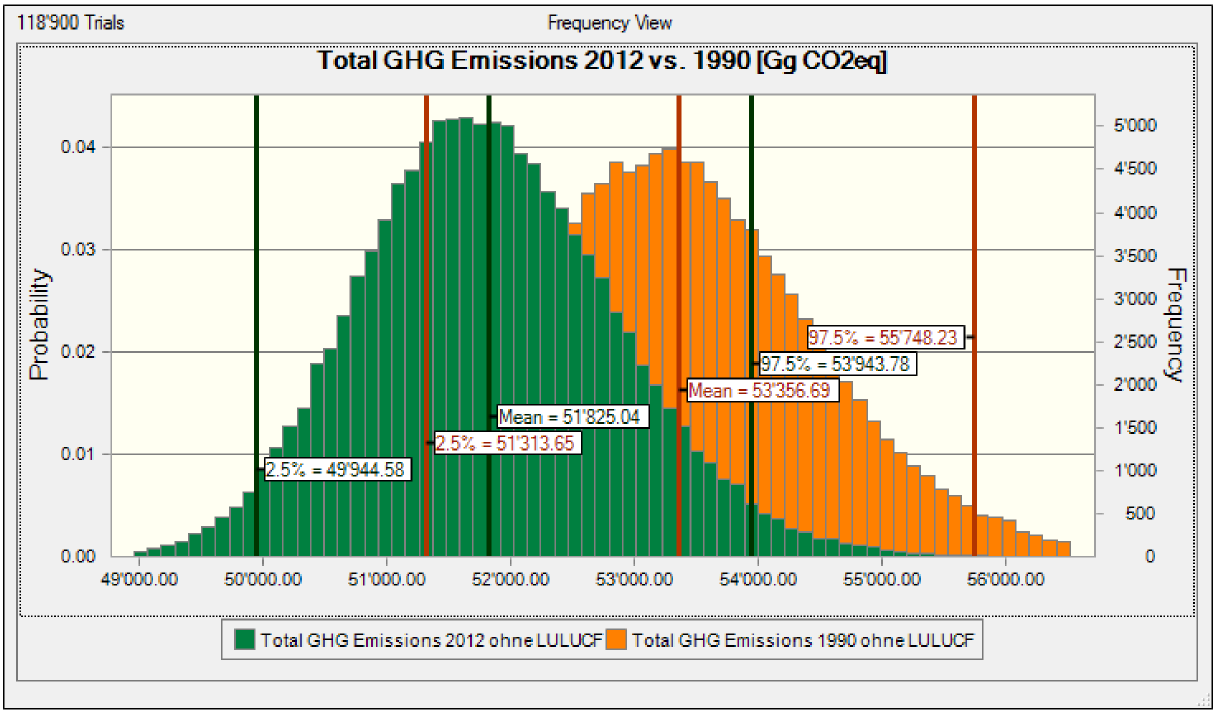

Figure 1-4: Probability distributions of the simulated total emissions for the base year 1990 (in orange) and year t=2012 (in green). On the horizontal axis the total emissions (without LULUCF) are given in Gg CO_2 eq. The number of Monte Carlo runs is 118'900. The vertical lines show simulated mean and percentile values. Note that the simulated values slightly deviate from the reported inventory values Table A - 37.

The uncertainties are also evaluated by gas with the following results of the Monte Carlo siumultation. CO_2 emissions have the higest precision or the lowest uncertainties (2.17%) among the Kyoto gases, as expected.

Table 1-17 Level uncertainties by gas 2012 for the total national emissions without LULUCF.

Gas	**Emission 2012 excl. LULUCF** Gg CO_2 eq	**Lower bound 2.5 percentile** Gg CO_2 eq	**Upper bound 97.5 percentile** Gg CO_2 eq	**Mean absolute uncertainty** Gg CO_2 eq	**Mean relative uncertainty** %
CO_2	43'251	42'322	44'200	939	2.17%
CH_4	3'689	3'088	4'299	605	16.41%
N_2O	3'007	1'712	4'621	1'455	48.38%
HFC	1'245	1'095	1'394	150	12.03%
PFC	33	22	44	11	32.68%
SF_6	224	115	333	109	48.70%
Total	51'449	49'582	53'552	1'985	3.86%

Table 1-18 shows the Tier 2 uncertainty results in the structure of table 6.2 of IPCC Good Practice Guidance and Uncertainty Management (IPCC 2000).

The Tornado (Figure A-10 in Annex 7) shows that the very high uncertainty of the emissions of category 5C1 Grasland remaining Grasland (CO_2) cause the most important contribution to the total uncertainty. Further important contributions stem from 5A1 Forestland remaining Forestland (CO_2), 4D1 Direct Soil Emission, Synthetic Fertilizers (N_2O), 4D3 Indirect Emissions, Leaching and Runoff (N_2O).

Table 1-18 Level and trend Tier 2 uncertainties by gas 2012 for the total national emissions including LULUCF.

IPPC Source Category					Gas	Base year (1990) emissions	Year t (2012) emissions	Uncertainty in year t emissions as % of emissions in the category		Unc. introduced on national total in year t	% change in emissions betw. year t and base year	Range of likely % change between year t and base year	
						Gg CO2 eq	Gg CO2 eq	% below 2.5 perc.	% above 97.5 perc.	(%)	(%)	% below 2.5 perc.	% above 97.5 perc.
1. Energy	A. Fuel Combustion	1. Energy Industries	1A1	Gaseous Fuel	CH4	0.65	1.12	70.0	129.9	0.00	41.9	12	132
			1A1	Liquid Fuels	CH4	0.49	0.67	70.0	129.9	0.00	25.7	-16	85
			1A1	Solid Fuels	CH4	0.10	-	NO	NO	-	NO	-130	-70
			1A1	Biomass	CH4	0.33	0.43	71.8	131.6	0.00	22.2	-20	78
			1A1	Gaseous Fuel	CO2	289.73	498.74	95.0	105.0	0.05	41.9	62	82
			1A1	Liquid Fuels	CO2	693.69	805.16	98.6	101.4	0.02	13.8	14	18
			1A1	Solid Fuels	CO2	44.84	-	NO	NO	-	NO	-108	-92
			1A1	Other Fuels	CO2	1'519.73	2'714.50	68.8	132.6	1.71	44.0	29	130
			1A1	Gaseous Fuel	N2O	0.16	0.28	19.9	180.2	0.00	41.9	-87	231
			1A1	Liquid Fuels	N2O	2.15	2.86	19.8	180.0	0.00	24.6	-100	165
			1A1	Solid Fuels	N2O	0.24	-	NO	NO	-	NO	-181	-20
			1A1	Biomass	N2O	27.72	19.75	22.2	183.7	0.03	-40.4	-129	69
			1A1	Other Fuels	N2O	20.85	20.96	20.1	181.2	0.03	0.5	-113	114
		2. Manufacturing Industries and Construction	1A2	Gaseous Fuel	CH4	2.66	4.74	70.1	130.1	0.00	43.8	17	139
			1A2	Liquid Fuels	CH4	2.32	1.04	69.7	130.2	0.00	-122.5	-88	-22
			1A2	Solid Fuels	CH4	0.40	0.14	70.2	130.4	0.00	-174.8	-96	-32
			1A2	Biomass	CH4	2.46	1.56	71.4	131.9	0.00	-57.5	-73	-2
			1A2	Other Fuels	CH4	0.54	0.37	70.7	130.7	0.00	-46.8	-69	4
			1A2	Gaseous Fuel	CO2	1'074.09	2'096.41	95.0	105.1	0.21	48.8	85	106
			1A2	Liquid Fuels	CO2	3'692.22	2'640.18	98.6	101.4	0.07	-39.8	-30	-27
			1A2	Solid Fuels	CO2	1'204.47	454.87	92.4	107.9	0.07	-164.8	-71	-54
			1A2	Other Fuels	CO2	134.15	288.60	68.9	132.3	0.18	53.5	41	191
			1A2	Gaseous Fuel	N2O	0.59	1.15	20.2	179.9	0.00	48.7	-81	270
			1A2	Liquid Fuels	N2O	13.92	11.76	20.3	180.0	0.02	-18.3	-120	89
			1A2	Solid Fuels	N2O	6.44	2.41	19.9	180.3	0.00	-166.9	-148	23
			1A2	Biomass	N2O	1.68	6.85	22.0	183.2	0.01	75.5	-20	657
			1A2	Other Fuels	N2O	2.28	5.24	20.5	180.7	0.01	56.4	-69	332
		3. Transport; Civil Aviation	1A3a		CH4	0.24	0.25	39.9	159.9	0.00	2.1	-84	88
			1A3a		CO2	252.55	136.65	97.5	102.5	0.01	-84.8	-49	-43
			1A3a		N2O	2.49	1.35	-50.2	251.5	0.00	-84.8	-217	125
		3. Transport; Road Transportation	1A3b	Natural Gas	CH4	-	0.10	69.9	130.0	0.00	100.0	NO	NO
			1A3b	Diesel	CH4	1.38	0.55	79.9	120.2	0.00	-149.0	-82	-38
			1A3b	Gasoline	CH4	97.47	18.82	62.9	137.0	0.01	-418.0	-119	-43
			1A3b	Biomass	CH4	-	-0.02	162.9	42.4	0.00	100.0	NO	NO
			1A3b	Diesel	CO2	2'587.68	6'767.05	97.8	102.2	0.30	61.8	156	167
			1A3b	Gasoline	CO2	11'335.3	9'016.6	97.5	102.6	0.46	-25.7	-23	-18
			1A3b	Natural Gas	CO2	-	83.59	95.1	105.0	0.01	100.0	NO	NO
			1A3b	Diesel	N2O	5.74	66.06	77.9	122.2	0.03	91.3	795	1'307
			1A3b	Gasoline	N2O	142.38	27.52	50.2	150.3	0.03	-417.3	-132	-30
			1A3b	Natural Gas	N2O	-	3.47	20.1	180.3	0.01	100.0	NO	NO
			1A3b	Biomass	N2O	-	0.70	-47.9	254.9	0.00	100.0	NO	NO
		3. Transport; Railways	1A3c	Liquid Fuels	CH4	0.01	0.01	70.0	130.0	0.00	26.6	-14	87
			1A3c	Liquid Fuels	CO2	28.69	39.69	98.6	101.4	0.00	27.7	36	41
			1A3c	Liquid Fuels	N2O	0.38	0.52	-49.2	249.8	0.00	26.9	-218	290
		3. Transport; Navigation	1A3d	Gas/Diesel Oil	CH4	0.01	0.02	69.9	129.8	0.00	6.8	-37	51
			1A3d	Gasoline	CH4	0.58	0.54	70.0	130.0	0.00	-8.6	-49	33
			1A3d		CO2	111.93	121.14	97.8	102.3	0.01	7.6	5	12
			1A3d	Gas/Diesel Oil	N2O	0.66	0.82	-49.0	250.0	0.00	19.6	-215	265
			1A3d	Gasoline	N2O	0.60	0.55	-50.4	249.5	0.00	-7.9	-213	197
		3. Transport; Other non-specified	1A3ei		CH4	0.06	0.03	64.7	135.4	0.00	-72.8	-83	-1
			1A3ei		CO2	31.42	45.44	95.0	105.0	0.00	30.9	36	53
			1A3ei		N2O	0.02	0.03	19.6	179.8	0.00	30.9	-97	185
		4. Other Sectors; Commercial/Institutional	1A4a	Gaseous Fuel	CH4	2.41	3.83	70.3	130.0	0.00	36.9	3	115
			1A4a	Liquid Fuels	CH4	3.06	1.40	70.0	129.8	0.00	-119.1	-87	-22
			1A4a	Biomass	CH4	9.74	4.13	71.8	131.6	0.00	-135.6	-91	-26
			1A4a	Gaseous Fuel	CO2	987.24	1'482.76	95.0	105.0	0.15	33.4	41	59
			1A4a	Liquid Fuels	CO2	4'606.43	3'038.51	98.6	101.4	0.08	-51.6	-35	-33
			1A4a	Gaseous Fuel	N2O	0.55	0.82	20.1	180.7	0.00	33.4	-95	195
			1A4a	Liquid Fuels	N2O	11.70	7.80	20.2	180.1	0.01	-50.0	-130	63
			1A4a	Biomass	N2O	1.45	3.23	22.2	184.3	0.01	55.0	-70	324

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IPPC Source Category					Gas	Base year (1990) emissions	Year t (2012) emissions	Uncertainty in year t emissions as % of emissions in the category		Unc. introduced on national total in year t	% change in emissions between year t and base year	Range of likely % change between year t and base year	
						Gg CO2 eq	Gg CO2 eq	% below 2.5 perc.	% above 97.5 perc.	(%)	(%)	% below 2.5 perc.	% above 97.5 perc.
1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	1A4b	Gaseous Fuels	CH4	3.24	6.10	70.1	130.2	0.00	47.0	25	153
			1A4b	Liquid Fuels	CH4	6.00	2.26	70.2	130.1	0.00	-165.3	-94	-30
			1A4b	Solid Fuels	CH4	3.71	2.28	70.2	130.3	0.00	-62.5	-74	-3
			1A4b	Biomass	CH4	97.87	33.78	38.8	167.0	0.04	-189.7	-135	0
			1A4b	Gaseous Fuels	CO2	1'424.38	2'649.60	95.0	105.0	0.26	46.2	76	96
			1A4b	Liquid Fuels	CO2	10'248.8	7'374.50	98.6	101.4	0.20	-39.0	-29	-27
			1A4b	Solid Fuels	CO2	54.59	33.60	92.4	107.9	0.01	-62.5	-48	-29
			1A4b	Gaseous Fuels	N2O	0.79	1.46	20.1	179.5	0.00	46.2	-83	255
			1A4b	Liquid Fuels	N2O	25.94	18.69	19.2	180.3	0.03	-38.7	-127	72
			1A4b	Solid Fuels	N2O	0.29	0.18	20.4	180.5	0.00	-62.5	-133	55
			1A4b	Biomass	N2O	10.79	9.07	22.7	183.6	0.01	-19.0	-123	88
		4. Other Sectors; Agriculture / Forestry	1A4c	Gaseous Fuels	CH4	0.09	0.04	70.0	130.2	0.00	-124.3	-88	-23
			1A4c	Liquid Fuels	CH4	1.62	1.43	70.1	129.9	0.00	-13.1	-52	29
			1A4c	Biomass	CH4	0.80	0.15	71.6	131.6	0.00	-450.2	-114	-53
			1A4c	Gaseous Fuels	CO2	41.45	18.48	95.0	105.1	0.00	-124.3	-61	-50
			1A4c	Liquid Fuels	CO2	547.34	540.01	98.6	101.4	0.01	-1.4	-3	1
			1A4c	Gaseous Fuels	N2O	0.02	0.01	19.6	179.8	0.00	-124.3	-143	32
			1A4c	Liquid Fuels	N2O	4.96	5.54	19.5	180.6	0.01	10.5	-108	131
			1A4c	Biomass	N2O	0.21	0.35	22.1	183.3	0.00	40.1	-87	228
		5. Other	1A5	Liquid Fuels	CH4	0.16	0.12	69.9	129.9	0.00	-38.0	-65	9
			1A5	Liquid Fuels	CO2	203.58	114.80	98.6	101.4	0.00	-77.3	-45	-42
			1A5	Liquid Fuels	N2O	2.01	1.13	-49.6	249.6	0.00	-77.1	-215	129
	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas	1B2		CH4	263.72	169.45	69.8	130.2	0.10	-55.6	-71	-0
			1B2		CO2	84.62	39.29	70.1	130.0	0.02	-115.4	-87	-21
			1B2		N2O	0.62	0.68	71.5	131.6	0.00	8.3	-36	54
2. Industrial Proc.	A. Mineral Products; Cement Production-CO2		2A1		CO2	2'524.68	1'787.11	97.2	102.8	0.10	-41.3	-33	-26
	A. Mineral Products; Lime Production-CO2		2A2		CO2	53.35	54.26	98.0	102.0	0.00	1.7	-1	5
	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2		2A3		CO2	150.39	98.48	49.1	150.8	0.10	-52.7	-95	26
	A. Mineral Products; Other non-specified-CO2		2A7		CO2	15.30	7.68	98.0	102.0	0.00	-99.1	-52	-48
	B. Chemical Industry		2B		CH4	1.54	2.39	70.0	129.9	0.00	35.8	0	111
			2B		CO2	111.22	110.47	90.0	110.0	0.02	-0.7	-15	13
			2B		N2O	68.13	53.57	58.9	140.9	0.04	-27.2	-73	31
	C. Metal Production; Magnesium Foundries		2C		SF6	-	31.72	85.0	114.9	0.01	100.0	NO	NO
	C. Metal Production; Steel Production		2C1		CO2	9.20	9.89	59.8	140.3	0.01	7.0	-52	66
	C. Metal Production; Aluminium Production-CO2		2C3		CO2	139.26	-	NO	NO	-	NO	-110	-90
	C. Metal Production; Aluminium Production-PFC		2C3		PFC	100.17	-	NO	NO	-	NO	-119	-82
	C. Metal Production; Non-ferrous metals-CO2		2C5		CO2	1.65	1.36	90.1	110.2	0.00	-21.2	-30	-5

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IPPC Source Category				Gas	Base year (1990) emissions	Year t (2012) emissions	Uncertainty in year t emissions as % of emissions in the category		Uncertainty introduced on national total in year t	% change in emissions between year t and base year	Range of likely % change between year t and base year	
					Gg CO2 eq	Gg CO2 eq	% below 2.5 perc.	% above 97.5 perc.	(%)	(%)	% below 2.5 perc.	% above 97.5 perc.
2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	2F1		HFC	0.02	1'137.81	88.0	112.0	0.27	100.0	4.4E+06	5.7E+06
	F. Consumption of Halocarbons and SF6; Refrigeration	2F1		PFC	0.04	6.14	88.0	111.9	0.00	99.3	1.3E+04	1.6E+04
	F. Consumption of Halocarbons and SF6; Hard Foam	2F2		HFC	-	13.27	50.7	149.1	0.01	100.0	NO	NO
	F. Consumption of Halocarbons and SF6; Metered Dose Inhalers and Other	2F4		HFC	-	13.22	60.1	140.1	0.01	100.0	NO	NO
	F. Consumption of Halocarbons and SF6; Solvents	2F5		HFC	-	4.59	98.0	102.0	0.00	100.0	NO	NO
		2F5		PFC	-	7.29	98.0	102.0	0.00	100.0	NO	NO
	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture	2F7		PFC	-	6.54	59.9	140.2	0.01	100.0	NO	NO
		2F7		SF6	-	19.55	59.9	140.0	0.02	100.0	NO	NO
	F. Consumption of Halocarbons and SF6; Electrical Eq.	2F8		SF6	64.04	36.81	90.0	110.0	0.01	-74.0	-54	-31
	F. Consumption of Halocarbons and SF6; Other	2F9		HFC	-	76.14	19.7	180.1	0.12	100.0	NO	NO
		2F9		PFC	-	13.10	20.0	179.8	0.02	100.0	NO	NO
		2F9		SF6	79.58	135.91	20.1	179.9	0.21	41.4	-88	229
	G. Other	2G		CO2	1.04	0.91	90.0	110.0	0.00	-14.6	-26	1
3. Solvent and Other Product Use		3		CO2	360.04	155.28	54.2	155.0	0.15	-131.9	-115	-6
		3		N2O	110.14	44.62	20.0	180.2	0.07	-146.8	-146	27
4. Agriculture	A. Enteric Fermentation	4A		CH4	2'635.45	2'496.98	81.9	118.5	0.90	-5.5	-12	1
	B. Manure Management	4B		CH4	671.61	646.11	45.8	155.1	0.70	-3.9	-11	2
		4B	liquid	N2O	43.47	36.79	15.4	169.3	0.04	-18.2	-42	16
		4B	solid	N2O	411.21	299.02	39.3	158.0	0.31	-37.5	-49	-7
	D. Agricultural Soils; Direct Soil Emissions	4D1	fertilizer	N2O	1'279.41	1'073.89	-5.6	242.0	2.62	-19.1	-118	69
		4D1	organic soils	N2O	72.07	69.21	40.8	170.6	0.09	-4.1	-52	43
	D. Agricultural Soils; Pasture, Range and Paddock Manure	4D2	-	N2O	128.10	220.79	40.2	151.2	0.21	42.0	28	105
	D. Agricultural Soils; Indirect Emissions	4D3	deposition	N2O	286.78	236.85	37.1	181.5	0.36	-21.1	-70	23
		4D3	leaching and runoff	N2O	535.69	438.08	39.1	223.6	1.72	-22.3	-153	42
	D. Agricultural Soils; Sewage sludge and compost	4D4	-	N2O	28.30	20.85	19.9	180.0	0.03	-35.7	-48	-5
6. Waste	A. Solid Waste Disposal on Land	6A		CH4	688.16	158.26	41.5	158.1	0.18	-334.8	-142	-21
		6A		CO2	9.24	-	NO	NO	-	NO	-140	-60
	B. Wastewater Handling	6B		CH4	4.65	9.28	70.1	130.1	0.01	49.9	33	167
		6B		N2O	184.72	240.28	50.0	149.8	0.24	23.1	-52	112
	C. Waste Incineration	6C		CH4	11.58	6.14	43.8	164.8	0.01	-88.5	-119	19
		6C		CO2	54.10	12.34	62.7	143.2	0.01	-338.3	-121	-39
		6C		N2O	19.06	25.86	62.7	143.2	0.02	26.3	-31	105
	D. Other	6D		CH4	29.94	113.76	-0.6	200.6	0.23	73.7	-114	673
		6D		N2O	5.82	25.55	19.4	180.6	0.04	77.2	-23	698
7. Other		7		CH4	0.55	0.57	20.3	179.4	0.00	2.4	-113	117
		7		CO2	10.96	12.92	60.1	140.2	0.01	15.1	-44	80
		7		N2O	0.62	0.62	-50.8	250.9	0.00	0.0	-213	212

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IPPC Source Category					Gas	Base year (1990) emissions	Year t (2012) emissions	Uncertainty in year t emissions as % of emissions in the category		Unc. introduced on national total in year t	% change in emissions between year t and base year	Range of likely % change between year t and base year	
						Gg CO2 eq	Gg CO2 eq	% below 2.5 perc.	% above 97.5 perc.	(%)	(%)	% below 2.5 perc.	% above 97.5 perc.
LULUCF													
5. LULUCF	E. Settlements	1. Settlements remaining Settlements	5E1		CO2	3.60	33.69	49.6	150.1	0.03	89.3	361	1'310
5. LULUCF	E. Settlements	2. Land converted to Settlements	5E2		CO2	382.71	302.93	50.3	150.2	0.30	-26.3	-85	43
5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	5A1		CH4	20.90	0.42	28.9	170.9	0.00	-4901.0	-169	-28
5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	5A1		CO2	-2'416.89	-2'134.56	162.7	37.2	2.64	-13.2	71	-96
5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	5A1	Biomass Burning, Wildfires	CO2	25.36	0.51	29.7	171.5	0.00	-4911.5	-169	-28
5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	5A1		N2O	4.77	0.09	29.2	170.8	0.00	-5033.3	-169	-27
5. LULUCF	A. Forest Land	2. Land converted to Forest Land	5A2		CO2	-621.57	-518.61	163.2	37.2	0.64	-19.9	66	-98
5. LULUCF	B. Cropland	1. Cropland remaining Cropland	5B1		CO2	345.17	707.27	-9.7	209.8	1.53	51.2	-145	357
5. LULUCF	B. Cropland	2. Land converted to Cropland	5B2		CO2	43.33	22.26	-44.7	243.5	0.06	-94.7	-210	113
5. LULUCF	B. Cropland	2. Land converted to Cropland	5B2		N2O	5.58	3.58	9.8	190.3	0.01	-56.1	-143	70
5. LULUCF	C. Grassland	1. Grassland remaining Grassland	5C1		CH4	0.41	0.00	30.2	170.8	0.00	-14445.2	-170	-30
5. LULUCF	C. Grassland	1. Grassland remaining Grassland	5C1		CO2	107.09	134.74	-1962.8	2064.7	5.52	20.5	-3'300	3'380
5. LULUCF	C. Grassland	1. Grassland remaining Grassland	5C1		N2O	0.19	0.00	30.0	170.2	0.00	-14439.4	-170	-29
5. LULUCF	C. Grassland	2. Land converted to Grassland	5C2		CO2	59.85	169.07	32.4	168.0	0.23	64.6	-20	386
5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands	5D1		CO2	-2.87	-0.56	204.5	-4.5	0.00	-408.8	27	-187
5. LULUCF	D. Land converted to Wetlands	5(II) Non-CO2 emissions from drainage of soils and wetlands, Flooded Lands	5D2		CH4	9.03	9.03	29.9	170.9	0.01	0.0	-100	100
5. LULUCF	D. Wetlands	2. Land converted to Wetlands	5D2		CO2	20.06	28.95	49.3	150.7	0.03	30.7	-44	133
5. LULUCF	F. Other Land	2. Land converted to Other Land	5F2		CO2	91.98	112.28	49.9	150.2	0.11	18.1	-58	101
Total	**without LULUCF**				**-**	**52'890**	**51'449**	**96.37**	**104.09**	**3.86**	**-2.87**	**-6.11**	**0.12**
Total	**with LULUCF**				**-**	**50'969**	**50'320**	**92.57**	**107.59**	**7.51**	**-1.40**	**-10.23**	**7.41**

Assumptions and further results to the Monte Carlo simulation are shown in Annex 7.

1.7.1.5 Comparison of Tier 1 and Tier 2 Results

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

Tier 2 uncertainty analysis produces an overall level uncertainty, which is slightly larger than the result of Tier 1 uncertainty analysis (T2: 3.86%, T1: 3.65%). The correct treating of large uncertainties, asymmetric distributions for agricultural sources, and – mainly – the existence of relevant positive correlations do all together increase the level uncertainty. This statement holds for the analyses with and without LULUCF.

The trend uncertainty of Tier 2 analysis is also larger than in Tier 1 analysis (T2: 2.87%, T1: 1.87%). Again, positive correlations for activity data and emission factors between of the base year and 2012 tend to increase the trend uncertainty (as may be seen from equation A1.8 of IPCC Good Practice Guidance (IPCC 2000) with $r > 0$). This statement holds again for the analyses with and without LULUCF.

1.7.2 KP-LULUCF Inventory

Uncertainty estimates for KP-LULUCF activities are presented in chapter 11.3.1.5.

1.8 Completeness Assessment

1.8.1 GHG Inventory

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

1.8.2 KP-LULUCF Inventory

For all known sources and sinks, complete estimates are accomplished for the current submission. The Swiss LULUCF inventory under the Kyoto Protocol is complete.

2 Trends in Greenhouse Gas Emissions and Removals

This chapter provides an overview of Switzerland's GHG emissions/removals and trends for the period 1990–2012. Numbers in the chapters 2.1-2.4 are relevant for reporting under the UNFCCC, whereas numbers in chapter 2.5 refer to accounting under the KP.

2.1 Aggregated Greenhouse Gas Emissions 2012 (UNFCCC)

In 2012, Switzerland emitted 51'449 Gg CO2 equivalent (excluding LULUCF and international bunkers) to the atmosphere or 6.43 tonnes CO_2 equivalent per capita (inhabitants 2012: 7.997 million, SFSO 2013a). The largest contributing gas was CO2 (excluding LULUCF and international bunkers) with 43'251 Gg (5.41 tonnes per capita), and the most important source was sector 1 Energy, 41'477 Gg CO2 equivalent (Table 2-1). A breakdown of Switzerland's total emissions by gas (excluding LULUCF) is given in Figure 2-1. Figure 2-2 charts the relative contributions of the individual sectors (excluding LULUCF) to the emission of each GHG.

Table 2-1 Switzerland's GHG emissions in CO_2 equivalent (Gg) by gas and sector in 2012.

Emissions 2012	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**Total**	**Share**
	CO_2 equivalent (Gg)							
1 Energy	41'000	255	221				41'477	80.6%
2 Industrial Processes	2'070	2	54	1'245	33	224	3'628	7.1%
3 Solvent an Other Product Use	155	NA	45				200	0.4%
4 Agriculture	NA	3'143	2'395				5'539	10.8%
6 Waste	12	287	292				591	1.1%
7 Other	13	1	1				14	0.0%
Total (excluding LULUCF)	43'251	3'689	3'007	1'245	33	224	51'449	100.0%
5 LULUCF	-1'142	9	4				-1'129	-2.2%
Total (including LULUCF)	42'109	3'698	3'011	1'245	33	224	50'320	97.8%
International Aviation Bunkers	4'658	1	45.9				*4'705*	
International Marine Bunkers	28	0.0048	0.3				*28*	

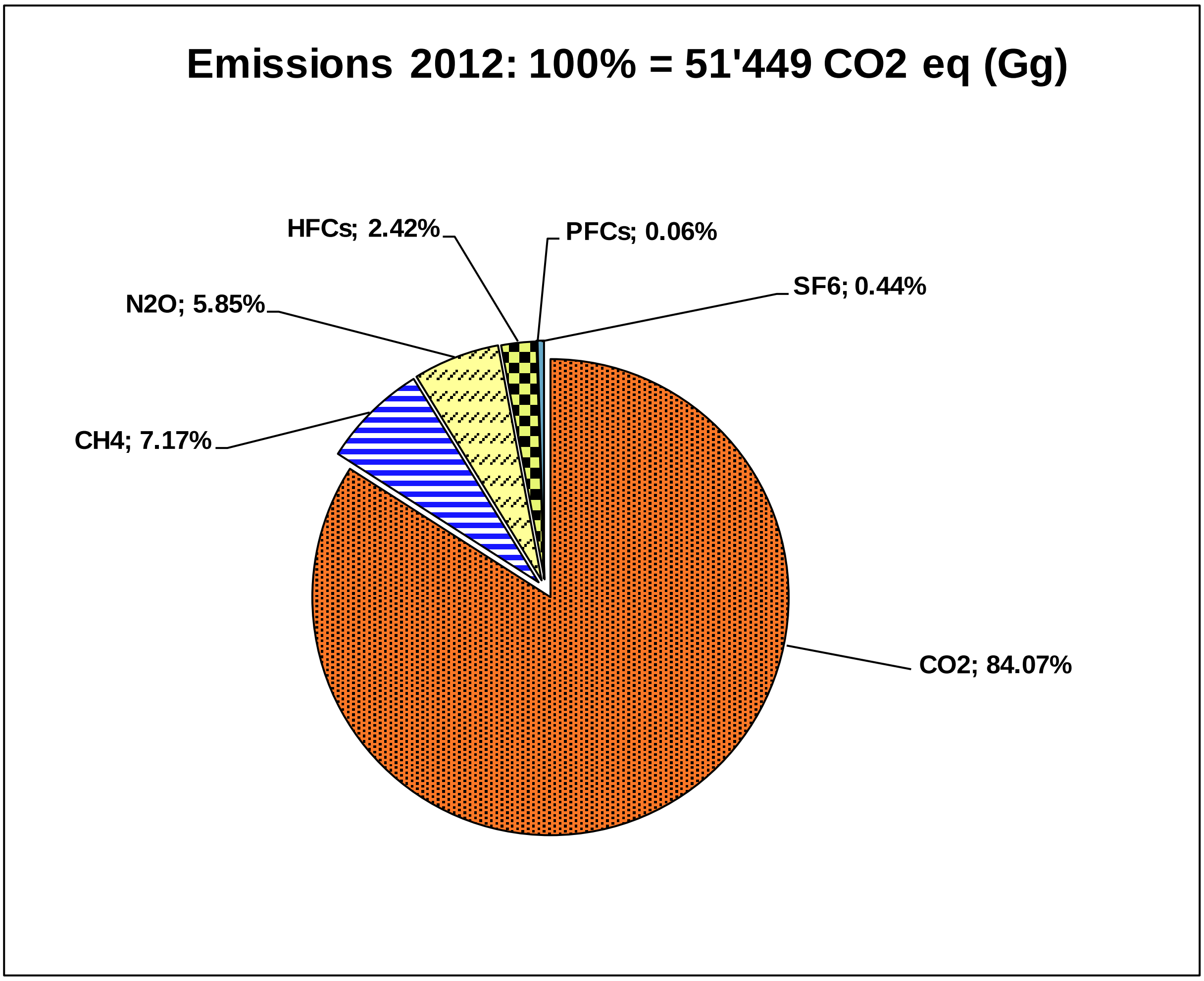


Figure 2-1 Contribution of individual gases to Switzerland's GHG emissions (excluding LULUCF) in 2012. 100% correspond to 51'449 CO_2 eq (Gg). (Numbers may not add to total due to rounding.)

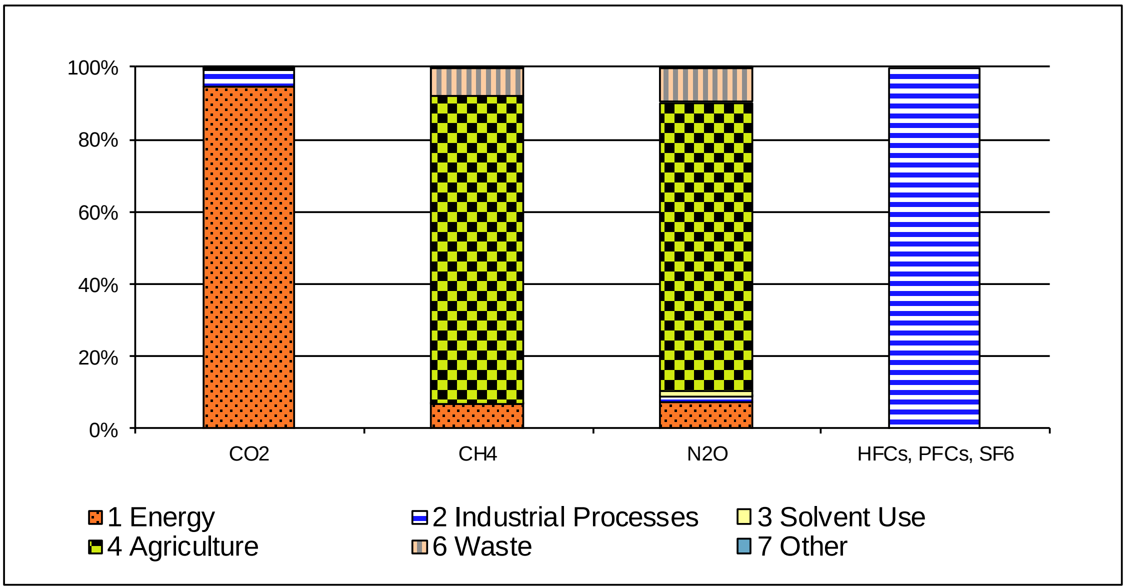


Figure 2-2 Relative contributions of the individual sectors (excluding LULUCF) to GHG emissions in 2012.

Fuel combustion within the energy sector was by far the largest source of emissions of CO_2 in 2012. Emissions of CH_4 and N_2O originated mainly from agriculture, and the F-gas emissions stemmed by definition from industrial processes.

2.2 Emission Trends by Gas

Emission trends by gas for the period 1990–2012 are summarized in Table 2-2.

Table 2-2 Switzerland's GHG emissions in CO_2 equivalent (Gg) by gas; 1990–2012 (corresponds to CRF-table 10s5/, 10s5.2, 10s5.3, upper half). The column below on the far right (digits in italics) indicates the percentage change in emissions in 2012 as compared to the base year 1990. HFCs increased by 5'526'548% when compared to 1990 levels (0.02 Gg CO_2 equivalent).

Greenhouse Gas Emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	42'677	44'356	44'111	40'386	40'550	40'519	41'588	40'257	41'833	42'724
CO_2 emissions excluding net CO_2 from LULUCF	44'639	46'369	46'258	43'718	42'981	43'683	44'340	43'514	44'812	44'894
CH_4 emissions including CH_4 from LULUCF	4'576	4'563	4'471	4'377	4'330	4'328	4'283	4'225	4'170	4'073
CH_4 emissions excluding CH_4 from LULUCF	4'546	4'551	4'461	4'367	4'315	4'311	4'270	4'187	4'156	4'063
N_2O emissions including N_2O from LULUCF	3'472	3'463	3'433	3'345	3'307	3'295	3'289	3'177	3'161	3'124
N_2O emissions excluding N_2O from LULUCF	3'461	3'457	3'427	3'339	3'300	3'287	3'283	3'166	3'155	3'119
HFCs	0	0	7	15	34	182	228	301	358	421
PFCs	100	85	69	30	18	15	17	20	23	36
SF_6	144	146	148	126	112	98	94	131	160	147
Total (including LULUCF)	**50'969**	**52'613**	**52'239**	**48'279**	**48'350**	**48'436**	**49'501**	**48'112**	**49'704**	**50'524**
Total (excluding LULUCF)	**52'890**	**54'607**	**54'370**	**51'595**	**50'760**	**51'576**	**52'233**	**51'319**	**52'663**	**52'680**

Greenhouse Gas Emissions	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	43'949	46'171	44'805	43'584	42'967	44'337	44'238	42'145	44'658	43'453
CO_2 emissions excluding net CO_2 from LULUCF	43'952	44'904	43'844	45'025	45'650	46'290	45'911	43'931	45'447	44'280
CH_4 emissions including CH_4 from LULUCF	3'995	3'983	3'939	3'849	3'806	3'801	3'804	3'801	3'850	3'787
CH_4 emissions excluding CH_4 from LULUCF	3'985	3'973	3'922	3'829	3'797	3'791	3'793	3'787	3'840	3'777
N_2O emissions including N_2O from LULUCF	3'114	3'133	3'106	3'047	2'997	2'981	2'977	3'006	3'043	3'008
N_2O emissions excluding N_2O from LULUCF	3'109	3'128	3'100	3'040	2'993	2'977	2'972	3'001	3'039	3'004
HFCs	501	597	635	710	820	905	936	976	1'042	1'083
PFCs	69	45	40	57	53	33	33	29	39	36
SF_6	158	157	168	174	190	213	201	186	245	187
Total (including LULUCF)	**51'787**	**54'085**	**52'694**	**51'421**	**50'834**	**52'271**	**52'189**	**50'144**	**52'878**	**51'554**
Total (excluding LULUCF)	**51'775**	**52'805**	**51'710**	**52'835**	**53'503**	**54'209**	**53'846**	**51'910**	**53'653**	**52'366**

Greenhouse Gas Emissions	**2010**	**2011**	**2012**	Change baseyear to 2012 (%)
	CO_2 equivalent (Gg)			
CO_2 emissions including net CO_2 from LULUCF	44'976	39'934	42'109	*-1.3%*
CO_2 emissions excluding net CO_2 from LULUCF	45'923	41'848	43'251	*-3.1%*
CH_4 emissions including CH_4 from LULUCF	3'773	3'723	3'698	*-19.2%*
CH_4 emissions excluding CH_4 from LULUCF	3'764	3'711	3'689	*-18.8%*
N_2O emissions including N_2O from LULUCF	3'082	3'019	3'011	*-13.3%*
N_2O emissions excluding N_2O from LULUCF	3'078	3'015	3'007	*-13.1%*
HFCs	1'138	1'195	1'245	*see caption*
PFCs	37	40	33	*-67.0%*
SF_6	155	164	224	*56.0%*
Total (including LULUCF)	**53'161**	**48'076**	**50'320**	***-1.3%***
Total (excluding LULUCF)	**54'095**	**49'973**	**51'449**	***-2.7%***

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

- Total emissions (excluding LULUCF) show a minimum of 94.5% in 2011 and a maximum of 103.2% in 1991 (100%: value of base year 1990). In 2012, the total emissions were 2.7% lower than the emissions recorded in the base year 1990. CO_2 contributed the largest share of emissions, accounting for 84.1% of the total in 2012.
- Total emissions (including LULUCF) in 2012 show a decrease of 1.3% compared to the emissions recorded in the base year 1990. The net CO_2 emissions/removals from LULUCF show considerable variability from year to year, because heavy storms in 1990 and 1999 ("Lothar") and other factors influence the wood harvesting and tree mortality rates in forests. In the period 1990-2012, wood harvesting generally increased but is still exceeded by the growth of living biomass. This led to reductions in net removals within the LULUCF sector between 1990 and 2012. Within the first commitment period 2008-2012, the total net CO_2 sink steadily increased.
- A comparison of CO_2 emissions with the number of heating degree days in the period 1990–2012 (see Figure 2-7 below) indicates a strong correlation between CO_2 emissions and winter climatic conditions. In the last few years, an increase in heating degree days did not proportionally translate into an equal increase in CO_2 emissions. For a definition of heating degree days see footnote 2 displayed with Figure 2-7.
- Between 1990 and 2012, CH_4 (excluding LULUCF) decreased by 18.8%, which was mainly attributable to a reduction of livestock that led to a reduction of emissions from enteric fermentation. Moreover, from 2000, a change in waste legislation, banning the disposal of municipal solid waste in landfills, contributed to this trend. The CH_4 share of total GHG emissions decreased from 8.6% in 1990 to 7.2% in 2012.
- In parallel to the reduction of CH_4 due to decreases in livestock populations, N_2O emissions from manure management and agricultural soils declined. Total N_2O emissions (excluding LULUCF) dropped by 13.1% between 1990 and 2012 and accounts now for 5.8% of total emissions.
- HFC emissions increased significantly due to their application as substitutes for CFCs, while PFC emissions declined by 67.0%. SF_6 emissions have shown relatively large fluctuations between 94.4 and 244.7 Gg CO_2 eq since 1990. In 2012, SF_6 emissions increased by 56.0% compared to 1990. The share of all F-gases (HFCs, PFCs and SF_6) in total emissions (excluding LULUCF) increased from 0.5% in 1990 to 2.9% in 2012.

Table 2-3 Switzerland's total GHG emissions (excluding LULUCF) in CO_2 equivalent (Gg), selected years.

Greenhouse Gas Emissions	**1990**		**1995**		**2000**		**2005**	
(excluding LULUCF)	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
CO_2	44'639	84.4%	43'683	84.7%	43'952	84.9%	46'290	85.4%
CH_4	4'546	8.6%	4'311	8.4%	3'985	7.7%	3'791	7.0%
N_2O	3'461	6.5%	3'287	6.4%	3'109	6.0%	2'977	5.5%
HFCs	0	0.0%	182	0.4%	501	1.0%	905	1.7%
PFCs	100	0.2%	15	0.0%	69	0.1%	33	0.1%
SF_6	144	0.3%	98	0.2%	158	0.3%	213	0.4%
Total (excluding LULUCF)	**52'890**	**100%**	**51'576**	**100%**	**51'775**	**100%**	**54'209**	**100%**

Greenhouse Gas Emissions	**2009**		**2010**		**2011**		**2012**	
(excluding LULUCF)	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
CO_2	44'280	84.6%	45'923	84.9%	41'848	83.7%	43'251	84.1%
CH_4	3'777	7.2%	3'764	7.0%	3'711	7.4%	3'689	7.2%
N_2O	3'004	5.7%	3'078	5.7%	3'015	6.0%	3'007	5.8%
HFCs	1'083	2.1%	1'138	2.1%	1'195	2.4%	1'245	2.4%
PFCs	36	0.1%	37	0.1%	40	0.1%	33	0.1%
SF_6	187	0.4%	155	0.3%	164	0.3%	224	0.4%
Total (excluding LULUCF)	**52'366**	**100%**	**54'095**	**100%**	**49'973**	**100%**	**51'449**	**100%**

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

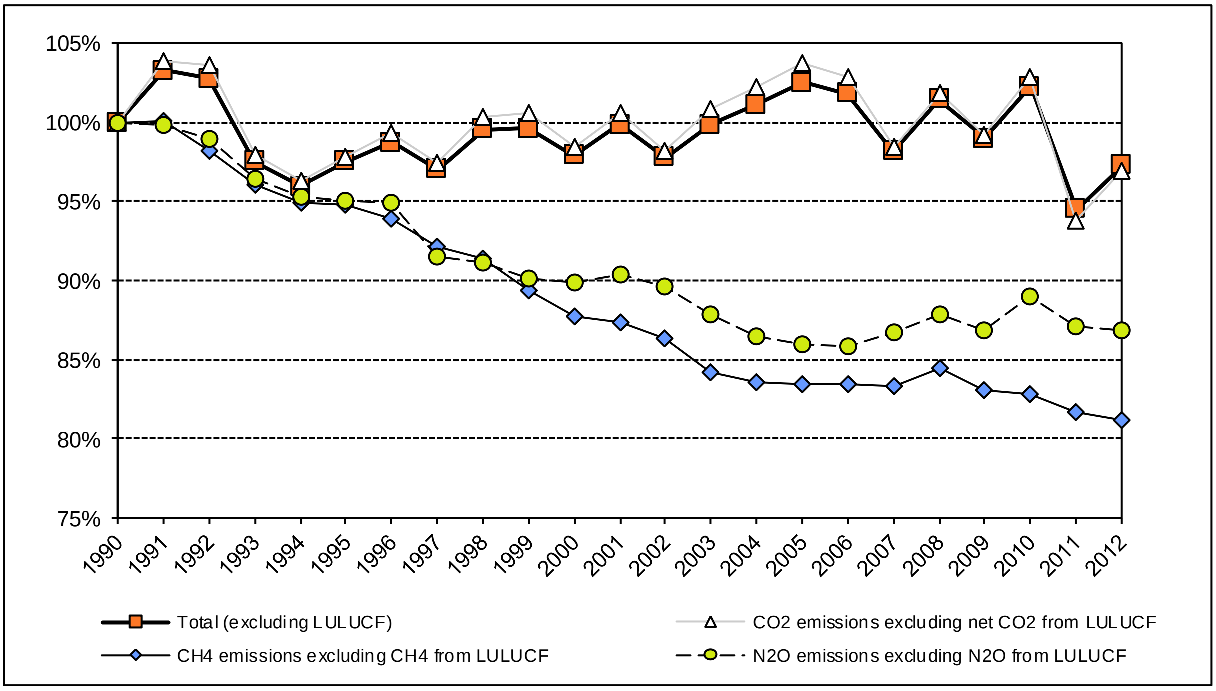


Figure 2-3 Relative trend of Switzerland's GHG emissions excluding LULUCF by gas, 1990–2012 (base year 1990: 100%). The increase of the F-gases is not shown (616% in 2012, compared to 1990).

2.3 Emission Trends by Sources and Sinks

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

Table 2-4 Switzerland's GHG emissions in CO_2 equivalent (Gg) by sources and sinks, 1990–2012. The column below on the far right (digits in italics) indicates the percentage change in emissions in 2012 as compared to the base year 1990.

Source and Sink Categories	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
1. Energy	41'989	44'121	44'191	41'915	41'029	41'916	42'787	42'147	43'474	43'533
1A1 Energy Industries	2'601	2'859	2'939	2'584	2'613	2'643	2'855	2'813	3'132	3'165
1A2 Manufacturing Industries and Construction	6'138	6'326	5'988	5'909	5'911	6'106	5'885	5'784	5'969	5'954
1A3 Transport	14'600	15'094	15'418	14'352	14'539	14'225	14'287	14'844	15'056	15'663
1A4 Other Sectors	18'095	19'273	19'276	18'500	17'407	18'393	19'207	18'138	18'745	18'227
1A5 Other (Military)	206	188	180	171	166	148	137	147	146	132
1B Fugitive emissions from oil and natural gas	349	381	390	399	393	400	416	420	426	392
2. Industrial Processes	3'320	2'957	2'793	2'484	2'649	2'626	2'498	2'431	2'517	2'580
3. Solvent and Other Product Use	470	444	420	392	374	354	331	308	286	273
4. Agriculture	6'092	6'069	5'979	5'877	5'843	5'819	5'780	5'606	5'578	5'511
6. Waste	1'007	1'004	976	914	852	847	823	814	795	768
7. Other	12	12	13	13	13	13	13	13	14	14
Total (excluding LULUCF)	52'890	54'607	54'370	51'595	50'760	51'576	52'233	51'319	52'663	52'680
5. Land Use, Land-Use Change and Forestry	-1'921	-1'995	-2'131	-3'316	-2'410	-3'140	-2'732	-3'207	-2'959	-2'155
Total (including LULUCF)	50'969	52'613	52'239	48'279	48'350	48'436	49'501	48'112	49'704	50'524

Source and Sink Categories	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	CO_2 equivalent (Gg)									
1. Energy	42'429	43'330	42'297	43'497	43'922	44'432	44'084	42'078	43'628	42'506
1A1 Energy Industries	3'064	3'187	3'268	3'295	3'617	3'804	4'078	3'835	4'025	3'949
1A2 Manufacturing Industries and Construction	5'839	6'125	5'865	6'001	6'120	6'173	6'320	6'159	6'173	5'798
1A3 Transport	15'896	15'597	15'522	15'689	15'767	15'827	15'939	16'257	16'624	16'427
1A4 Other Sectors	17'133	17'946	17'186	18'092	18'021	18'239	17'360	15'462	16'450	15'983
1A5 Other (Military)	136	134	140	125	114	124	127	120	115	116
1B Fugitive emissions from oil and natural gas	362	341	317	295	283	265	260	245	242	232
2. Industrial Processes	2'836	2'938	2'922	2'970	3'235	3'425	3'397	3'421	3'535	3'446
3. Solvent and Other Product Use	259	245	234	225	212	211	206	205	202	201
4. Agriculture	5'496	5'561	5'536	5'461	5'447	5'474	5'493	5'556	5'645	5'587
6. Waste	741	717	708	669	673	654	653	637	629	612
7. Other	14	14	14	14	14	14	14	14	14	14
Total (excluding LULUCF)	51'775	52'805	51'710	52'835	53'503	54'209	53'846	51'910	53'653	52'366
5. Land Use, Land-Use Change and Forestry	12	1'281	984	-1'414	-2'669	-1'939	-1'657	-1'766	-775	-813
Total (including LULUCF)	51'787	54'085	52'694	51'421	50'834	52'271	52'189	50'144	52'878	51'554

Source and Sink Categories	**2010**	**2011**	**2012**	**2012/1990**
	CO_2 equivalent (Gg)			%
1. Energy	44'004	39'945	41'477	*-1.2%*
1A1 Energy Industries	4'180	3'968	4'064	*56.3%*
1A2 Manufacturing Industries and Construction	5'954	5'449	5'515	*-10.1%*
1A3 Transport	16'321	16'205	16'331	*11.9%*
1A4 Other Sectors	17'193	13'994	15'240	*-15.8%*
1A5 Other (Military)	121	108	116	*-43.6%*
1B Fugitive emissions from oil and natural gas	234	220	209	*-40.0%*
2. Industrial Processes	3'634	3'642	3'628	*9.3%*
3. Solvent and Other Product Use	199	202	200	*-57.5%*
4. Agriculture	5'637	5'572	5'539	*-9.1%*
6. Waste	608	598	591	*-41.3%*
7. Other	14	14	14	*16.2%*
Total (excluding LULUCF)	54'095	49'973	51'449	*-2.7%*
5. Land Use, Land-Use Change and Forestry	-934	-1'897	-1'129	*-41.2%*
Total (including LULUCF)	53'161	48'076	50'320	*-1.3%*

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

Table 2-5 Switzerland's total gross GHG emissions (excluding LULUCF) in CO_2 equivalent (Gg) and the contribution of individual source categories for selected years.

Source and Sink Categories	**1990**		**1995**		**2000**		**2005**		**2007**	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1. Energy	41'989	79.4%	41'916	81.3%	42'429	81.9%	44'432	82.0%	42'078	81.1%
1A1 Energy Industries	*2'601*	*4.9%*	2'643	*5.1%*	3'064	*5.9%*	3'804	*7.0%*	3'835	*7.4%*
1A2 Manufacturing Industries and Construction	*6'138*	*11.6%*	6'106	*11.8%*	5'839	*11.3%*	6'173	*11.4%*	6'159	*11.9%*
1A3 Transport	*14'600*	*27.6%*	14'225	*27.6%*	15'896	*30.7%*	15'827	*29.2%*	16'257	*31.3%*
1A4 Other Sectors	*18'095*	*34.2%*	18'393	*35.7%*	17'133	*33.1%*	18'239	*33.6%*	15'462	*29.8%*
1A5 Other (Military)	*206*	*0.4%*	148	*0.3%*	136	*0.3%*	124	*0.2%*	120	*0.2%*
1B Fugitive emissions from oil and natural gas	*349*	*0.7%*	400	*0.8%*	362	*0.7%*	265	*0.5%*	245	*0.5%*
2. Industrial Processes	3'320	6.3%	2'626	5.1%	2'836	5.5%	3'425	6.3%	3'421	6.6%
3. Solvent and Other Product Use	470	0.9%	354	0.7%	259	0.5%	211	0.4%	205	0.4%
4. Agriculture	6'092	11.5%	5'819	11.3%	5'496	10.6%	5'474	10.1%	5'556	10.7%
6. Waste	1'007	1.9%	847	1.6%	741	1.4%	654	1.2%	637	1.2%
7. Other	12	0.0%	13	0.0%	14	0.0%	14	0.0%	14	0.0%
Total (excluding LULUCF)	52'890	100.0%	51'576	100.0%	51'775	100.0%	54'209	100.0%	51'910	100.0%

Source and Sink Categories	**2008**		**2009**		**2010**		**2011**		**2012**	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1. Energy	43'628	81.3%	42'506	81.2%	44'004	81.3%	39'945	79.9%	41'477	80.6%
1A1 Energy Industries	*4'025*	*7.5%*	3'949	*7.5%*	4'180	*7.7%*	3'968	*7.9%*	4'064	*7.9%*
1A2 Manufacturing Industries and Construction	*6'173*	*11.5%*	5'798	*11.1%*	5'954	*11.0%*	5'449	*10.9%*	5'515	*10.7%*
1A3 Transport	*16'624*	*31.0%*	16'427	*31.4%*	16'321	*30.2%*	16'205	*32.4%*	16'331	*31.7%*
1A4 Other Sectors	*16'450*	*30.7%*	15'983	*30.5%*	17'193	*31.8%*	13'994	*28.0%*	15'240	*29.6%*
1A5 Other (Military)	*115*	*0.2%*	116	*0.2%*	121	*0.2%*	108	*0.2%*	116	*0.2%*
1B Fugitive emissions from oil and natural gas	*242*	*0.5%*	232	*0.4%*	234	*0.4%*	220	*0.4%*	209	*0.4%*
2. Industrial Processes	3'535	6.6%	3'446	6.6%	3'634	6.7%	3'642	7.3%	3'628	7.1%
3. Solvent and Other Product Use	202	0.4%	201	0.4%	199	0.4%	202	0.4%	200	0.4%
4. Agriculture	5'645	10.5%	5'587	10.7%	5'637	10.4%	5'572	11.1%	5'539	10.8%
6. Waste	629	1.2%	612	1.2%	608	1.1%	598	1.2%	591	1.1%
7. Other	14	0.0%	14	0.0%	14	0.0%	14	0.0%	14	0.0%
Total (excluding LULUCF)	53'653	100.0%	52'366	100.0%	54'095	100.0%	49'973	100.0%	51'449	100.0%

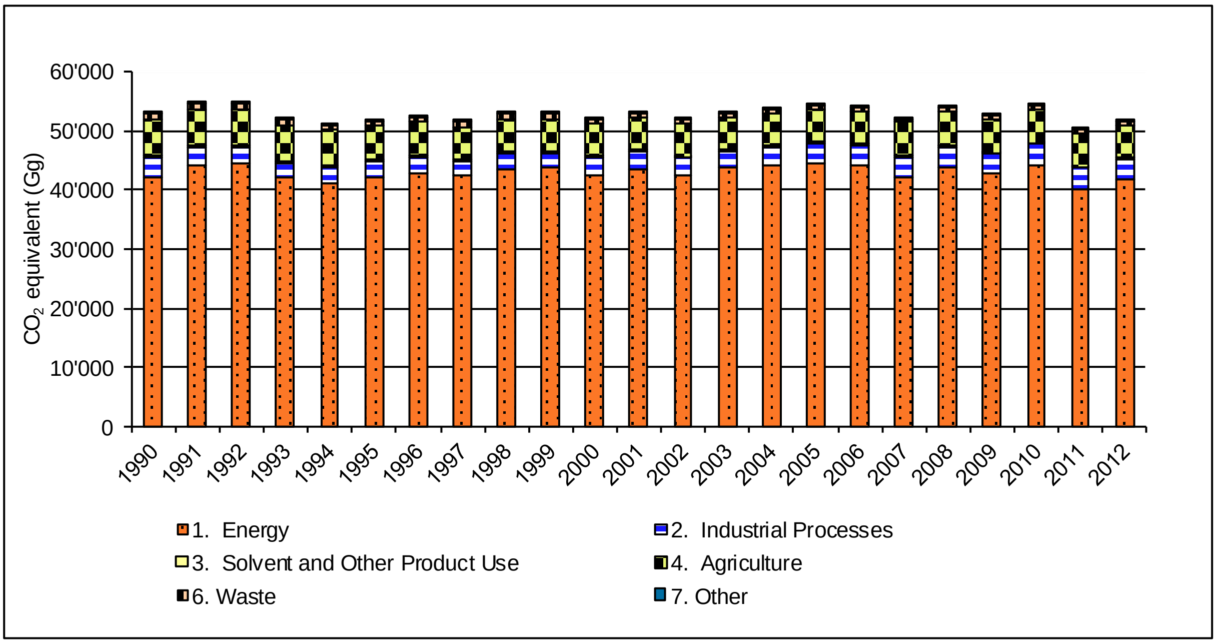


Figure 2-4 Switzerland's GHG emissions in CO_2 equivalent (Gg) by sectors, 1990–2012 (excluding LULUCF).

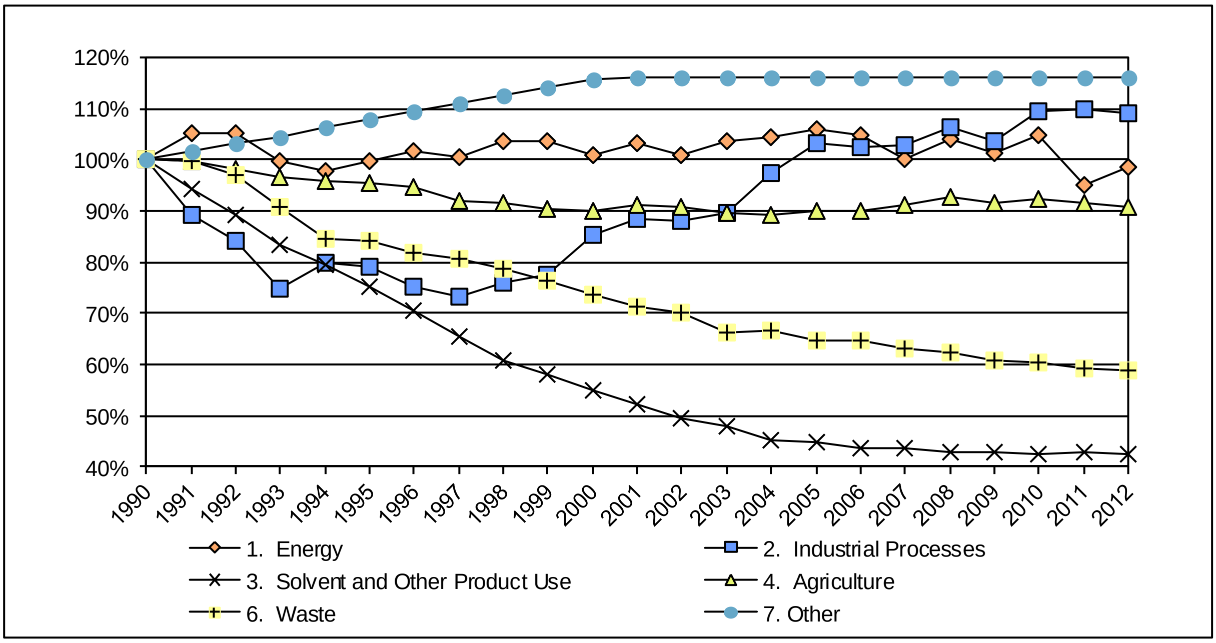


Figure 2-5 Relative emission (CO_2 eq.) trends by main source categories (base year 1990 = 100%).

Emission trends for the various sectors are as follows:

- 1 Energy: the variations can only be understood if the trends within individual source categories are considered separately. See Figure 2-6 and comments below.
- 2 Industrial Processes: in line with economic development, overall emissions in the industry sector showed a decreasing trend in the early 90s and a gradual increase between 1998 and 2012, except for the economically difficult year 2009. Since 2005 the Ordinance on Chemical Risk Reduction (Swiss Confederation 2005) is in place and regulates the use of F-Gases, which led to an emission stabilization in this source category.
- 3 Solvent and Other Product Use: there is a decreasing trend in overall emissions throughout all the years, which is however by far less pronounced since 2004. Whereas overall NMVOC emissions have decreased by 54.9% since 1990, direct CO_2 emissions from the post combustion of NMVOCs have increased. NMVOC emissions, the main source of indirect CO_2 emissions, have diminished between 1990 and 2004 due to their limitation brought by the Ordinance on Air Pollution Control (Swiss Confederation 1985) and due to the introduction of the VOC-tax in 2000 (Swiss Confederation 1997). Since 2004, emissions have remained relatively stable.
- 4 Agriculture: declining populations of cattle and swine and reduced fertilizer use have led to a decrease in CO_2 equivalent emissions until 2000. Since then, CH_4 emissions slightly increased again.
- 6 Waste: Total emissions from the source category Waste decreased steadily throughout the period 1990-2012. Since 2000, emissions have been further reduced by a change in legislation: disposal of combustible wastes in landfills has been banned, leading to an increasing amount of municipal solid waste being incinerated, with emissions reported under source 1A1 Energy Industries rather than sector 6 Waste. Altogether, “waste-related” emissions incl. emissions from waste management activities reported in sources 1A (Waste to energy) 4D (waste used as fertilizer) and 6 (waste treatment) have increased since 1990 by 34.25 % (see Figure 8-3 and 8-4 in Chapter 8).
- 7 Other: The total emissions from sector 7 Other increased troughout the period 1990-2000. Since 2000 the emissions are stable. Please consider that emissions from sector

7 Other are not accounted for in the Kyoto Protocol and are only of minor importance (0.03% of total CO_2 equivalent emissions).

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

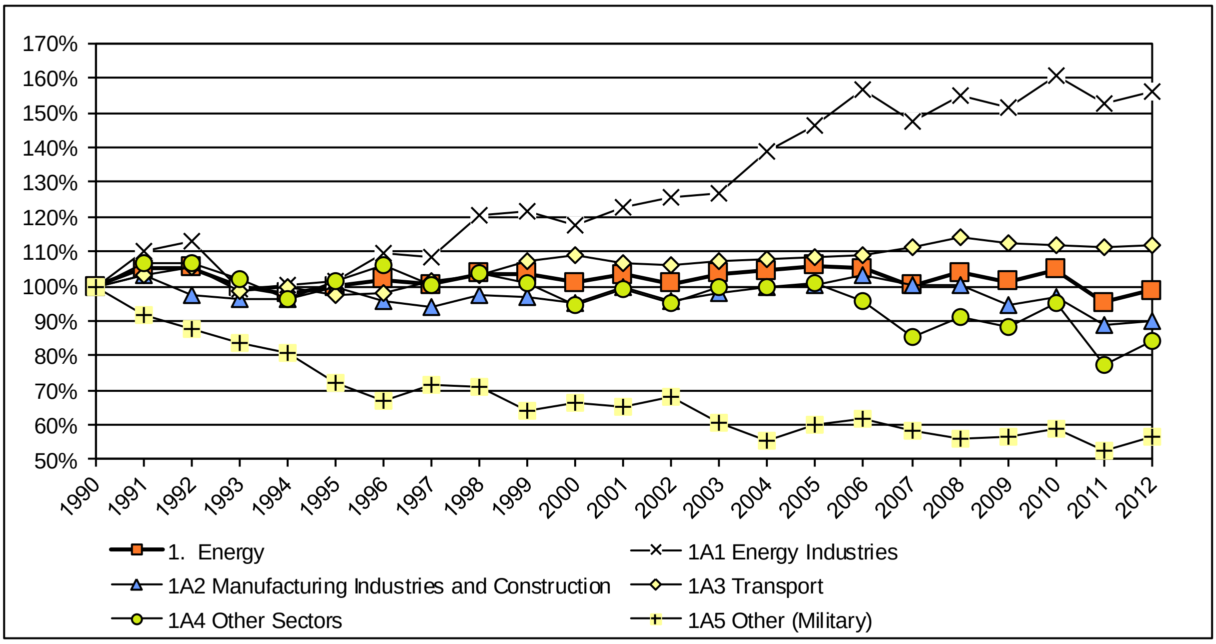


Figure 2-6 Emission trends (CO_2 eq.) for the source categories in sector 1 Energy/1A Fuel Combustion. The trend for the entire sector "1 Energy" is shown with a bold line. Not included in the figure is the trend for 1B Fugitive Emissions, which continuously decreased from 100% in 1990 to 60% in 2012.

It is noteworthy that, due to Switzerland's electricity production structure (about 94.5% generated by hydroelectric and nuclear power plants in 2012; see SFOE 2013: Table 24), sector 1A1 Energy Industries plays only a minor role – representing not classical thermal power stations but waste incineration plants in the Swiss GHG inventory. The following emission trends emerges within the Energy sector:

- Despite differing trends of individual source categories, the overall emissions from the energy sector remain at relatively constant level (bold line in Figure 2-6) until 2010 but noticeably decreased in 2011, mainly due to a exceptionally warm winter (see Figure 2-7). In 2012 a slight increase was detectable again.
- Overall emissions from source category 1A1 Energy Industry 2012 have increased by 56.3% since 1990. Fluctuations are caused by varying combustion activities in the petroleum refinery industry, waste incineration, new installations of district heating and weather related forcing of heating activities (see Figure 2-7). From 2010 to 2011, emissions from Gaseous Fuel consumption within source category 1A decreased by 11.3% due to the fact that 2011 was the warmest year measured since measurements started. Note that only approximately 10% of sector 1 Energy emissions stem from 1A1.
- The trend for sub-sector 1A3 Transport shows a slight increase over the period 1990–2008 by about 12%, but with fluctuations indicating a fairly strong correlation between this sector and overall economic development in Switzerland, with periods of stagnation (1991-1996, 2001–2003 and 2009) and growth (gross value-added) in 1997–2000 and 2004–2012 (except for 2009) (SFSO 2009a, SECO 2014). Since 2008 transport emissions show a slight decrease which points to a relative decoupling from overall economic development.

- The trend for sub-sector 1A4 Other Sectors reflects the impact of climatic variations on demand for heating. The strong correlation with the number of “heating degree days”[2] – used as an index of cold weather conditions – is apparent from Figure 2-7, which shows CO_2 emissions from sub-sector 1A4 Fuel Combustion – Other Sectors (only stationary sources) and the number of heating degree days. In 2012 heating degree days increased by 11.7% compared to 2011 and CO_2 emissions from fuel combustions in source category 1A4 Stationary Sources increased simultaneously by 9.3%. In the period 1990–2012, the number of buildings and apartments increased, as well as the average floor space per person and workplace. Both phenomena resulted in an increase in the total area heated by more than 30%. Over the same period, however, higher standards were specified for insulation and for combustion equipment efficiency for both new and renovated buildings, compensating for the emissions from the additional area heated.

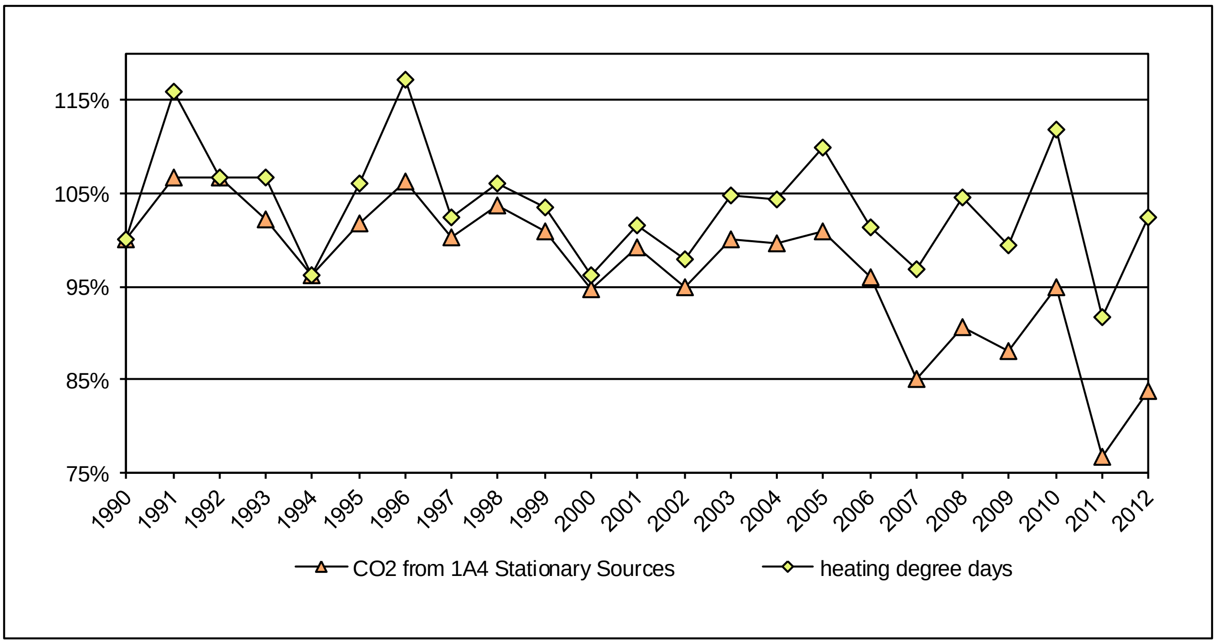


Figure 2-7 Relative trend for CO_2 emissions from 1A4 Fuel Combustion - Other Sectors (stationary sources only) compared with the number of heating degree days.

Figure 2-8 shows the net emissions and removals from the LULUCF sector in Switzerland, which is dominated by biomass dynamics in forests. Except for 2001 and 2002 the removals in the LULUCF sector were higher than the emissions throughout the period 1990-2012. However, a strong year to year variation is evident over the whole period. The net removals decreased by 41.2% since 1990 but increased by 45.7% since 2008.The reason for the positive value in 2001 and 2002 is the winter storm “Lothar” end of 1999 which caused great damages in the forest stands and increased harvesting. The reduction of the removals from 2004 to 2008 is due to the reduction of dead wood as CO_2 sink (2005) towards a source in 2008.

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

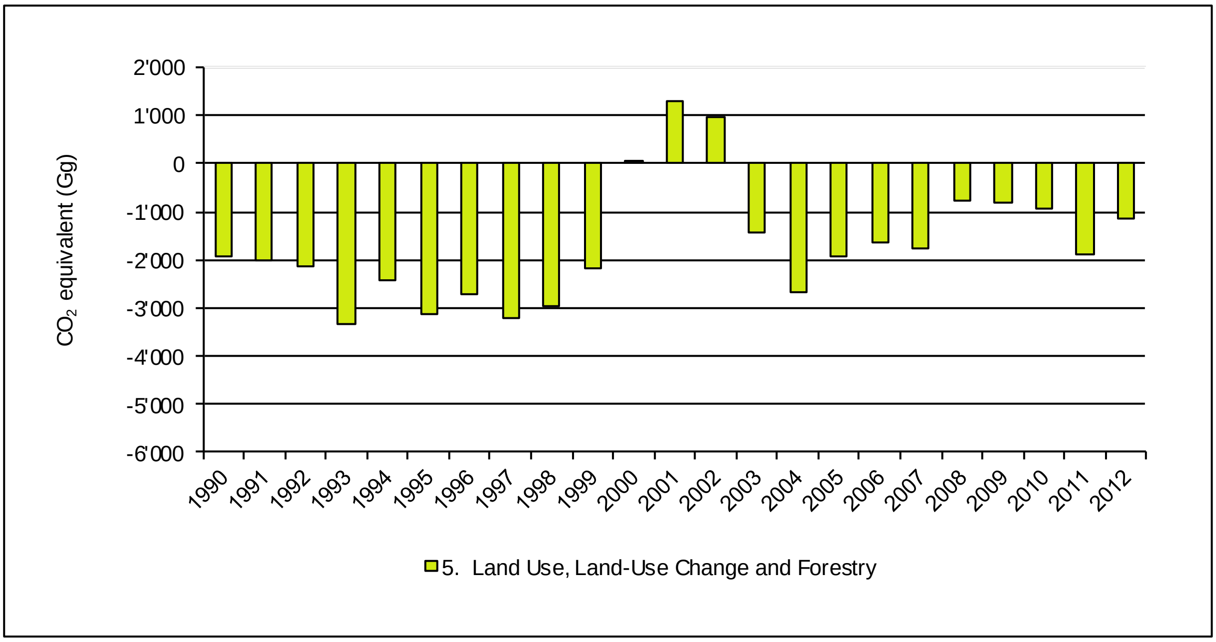


Figure 2-8 Switzerland's net CO_2 equivalent balance of sector Land Use, Land-Use Change and Forestry (LULUCF) 1990–2012 in Gg. Positive values refer to emissions, negative values refer to removals. Note that the annual contributions of CH_4 and N_2O emissions from LULUCF in this period are very small compared to the net CO_2 emissions and removals.

2.4 Emission Trends for Indirect Greenhouse Gases and SO_2

Emission trends for indirect greenhouse gases show a very pronounced decline (see Table 2-6 and Figure 2-9). A strict air pollution control policy and the implementation of a large number of emission reduction measures led to a decrease between 49% and 74% in emissions of respective air pollutants over the period 1990-2012. The main reduction measures were abatement of exhaust emissions from road vehicles and stationary combustion equipment, taxation of solvents and sulphured fuels, and voluntary agreements with industry sectors (FOEN 2010i, Swiss Confederation 1985, 1997).

Table 2-6 Switzerland's indirect GHG and SO_2 emissions (Gg), 1990–2012 (without NMVOC from LULUCF).

Indirect Greenhouse Gases and SO_2	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	Gg									
NO_x	145	143	136	125	123	119	115	111	111	111
CO	800	765	712	627	576	536	518	488	467	454
NMVOC	306	289	268	240	219	203	190	177	164	155
SO_2	41	37	34	27	28	26	26	24	23	17
Indirect Greenhouse Gases and SO_2	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	Gg									
NO_x	108	104	99	96	94	93	90	87	86	80
CO	427	405	378	366	347	330	307	289	279	263
NMVOC	146	137	126	118	108	104	100	97	95	93
SO_2	16	18	16	15	16	16	15	13	14	12
Indirect Greenhouse Gases and SO_2	**2010**	**2011**	**2012**							
	Gg									
NO_x	78	74	74							
CO	253	233	227							
NMVOC	91	88	86							
SO_2	12	10	11							

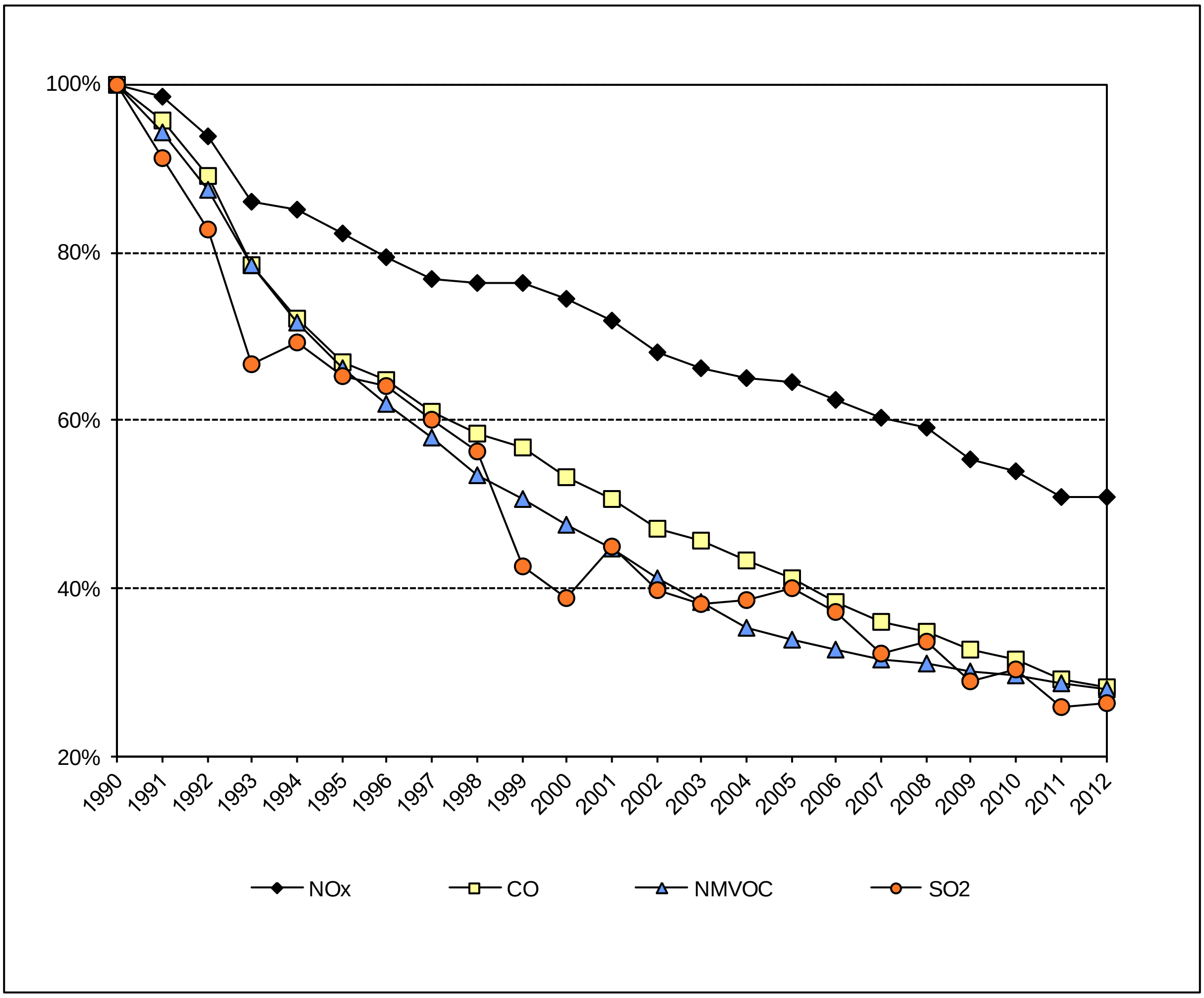


Figure 2-9 Relative trends for indirect GHG and SO_2 emissions (without NMVOC from LULUCF), 1990–2012 (base year 1990 = 100%).

The energy sector was by far the largest source of indirect greenhouse gas emissions (see Table 2-7), with the only exception being NMVOC, where sector 3 Solvent and Other Product Use accounted for 23.9% of the total. The total shown in Table 2-7 includes NMVOC emissions from LULUCF, which are estimated at constant 95.5 Gg per year (SAEFL 1996a). This corresponds to 52.7% of the total in 2012.

Table 2-7 Indirect GHG and SO_2 emissions (Gg) by source, 2012. The total NMVOC emissions including NMVOC from LULUCF.

Sources	**NO_x**	**CO**	**NMVOC**	**SO_2**
	Emissions 2012 (Gg)			
1 Energy	68.78	218.65	29.89	9.68
2 Industrial Processes	0.40	4.85	6.73	0.89
3 Solvent and Other Product Use	0.00	0.01	43.27	0.01
4 Agriculture	4.08	NO	3.91	NO
5 LULUCF	IE, NE	IE, NE	95.52	NE
6 Waste	0.38	2.58	1.91	0.08
7 Other	0.07	0.80	0.13	0.01
Total	**73.71**	**226.90**	**181.36**	**10.67**

Figure 2-10 shows the relative contributions (excluding LULUCF) of the various sectors for each individual gas (data from Table 2-7). The energy sector can clearly be identified as the main source of NO_x, CO and SO_2.

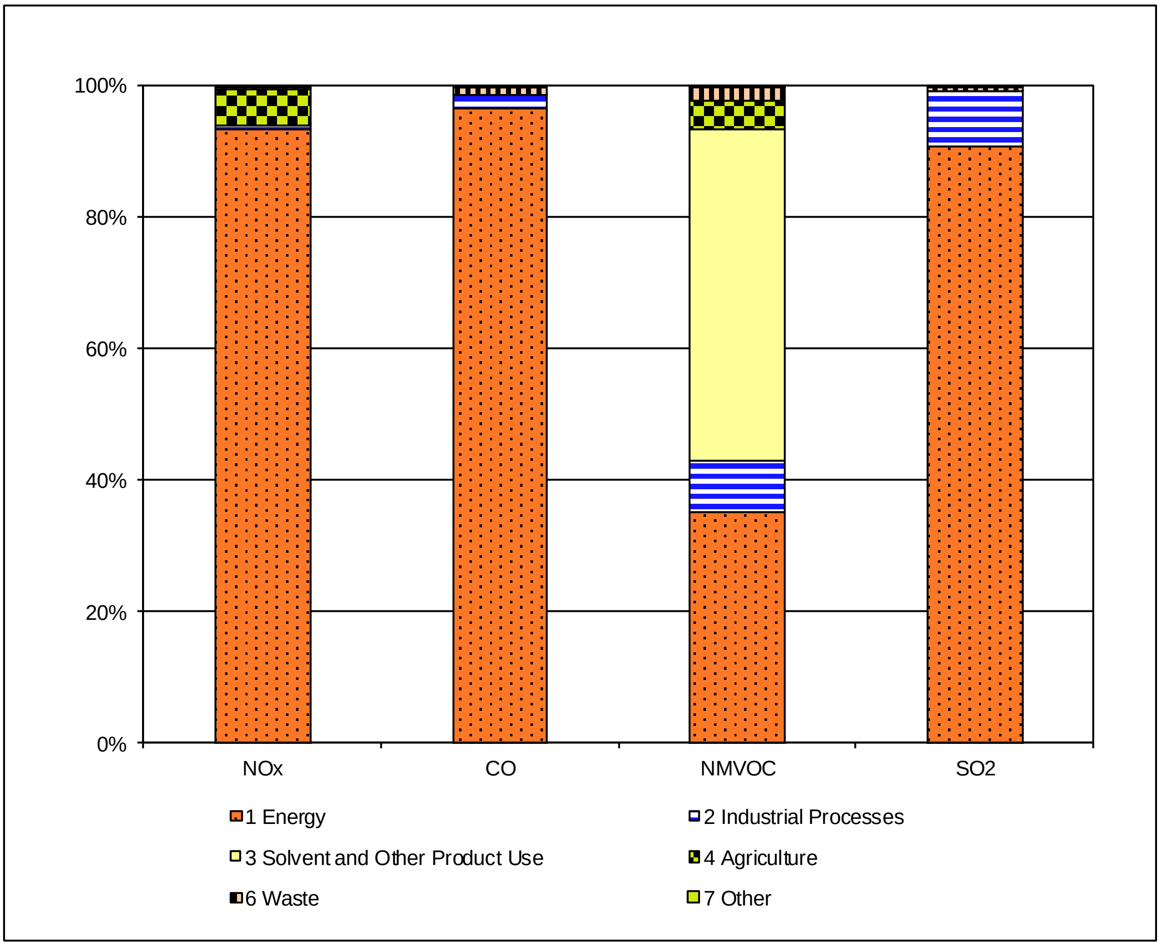


Figure 2-10 Relative contributions of individual sectors to indirect GHG and SO_2 emissions in 2012 (without NMVOC from LULUCF).

2.5 Emission Trends (Kyoto Protocol)

Relevant emission and removals under the Kyoto Protocol are shown in Table 2-8 and Table 2-9, sorted by sectors and gases respectively. Base year emissions for the first commitment period are fixed at the value reported in the Initial Report 2006 (FOEN 2006h, UNFCCC 2007a).

Table 2-8 Summary of Switzerland's GHG emissions in CO_2 equivalent (Gg), 1990–2012 excluding emissions from LULUCF, Other and International Bunkers.

	Sector	Base year inital report	1990	1991	1992	1993	1994	1995	1996	1997	1998
		CO_2 equivalent (Gg)									
Annex A sources	1 Energy	42'134	41'989	44'121	44'191	41'915	41'029	41'916	42'787	42'147	43'474
	2 Industrial Processes	3'258	3'320	2'957	2'793	2'484	2'649	2'626	2'498	2'431	2'517
	3 Solvent and Other Product Use	466	470	444	420	392	374	354	331	308	286
	4 Agriculture	5'903	6'092	6'069	5'979	5'877	5'843	5'819	5'780	5'606	5'578
	6 Waste	1'030	1'007	1'004	976	914	852	847	823	814	795
	Total (Annex A sources)	**52'791**	**52'878**	**54'595**	**54'358**	**51'582**	**50'747**	**51'563**	**52'220**	**51'305**	**52'650**

		Sector	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
			CO_2 equivalent (Gg)									
Annex A sources		1 Energy	43'533	42'429	43'330	42'297	43'497	43'922	44'432	44'084	42'078	43'628
		2 Industrial Processes	2'580	2'836	2'938	2'922	2'970	3'235	3'425	3'397	3'421	3'535
		3 Solvent and Other Product Use	273	259	245	234	225	212	211	206	205	202
		4 Agriculture	5'511	5'496	5'561	5'536	5'461	5'447	5'474	5'493	5'556	5'645
		6 Waste	768	741	717	708	669	673	654	653	637	629
		Total (Annex A sources)	**52'666**	**51'761**	**52'790**	**51'696**	**52'821**	**53'489**	**54'195**	**53'832**	**51'896**	**53'639**
KP-LULUCF	Art.3.3	Afforestation & reforestation										-22
		Deforestation										104
	Art.3.4	Forest management										-1'203
		Cropland management										NA
		Grazing land management										NA
		Revegetation										NA
		Total (Art. 3.3 + 3.4)										**-1'121**

		Sector	2009	2010	2011	2012	2012 – base year
			CO_2 equivalent (Gg)				%
Annex A sources		1 Energy	42'506	44'004	39'945	41'477	-1.6%
		2 Industrial Processes	3'446	3'634	3'642	3'628	11.4%
		3 Solvent and Other Product Use	201	199	202	200	-57.1%
		4 Agriculture	5'587	5'637	5'572	5'539	-6.2%
		6 Waste	612	608	598	591	-42.5%
		Total (Annex A sources)	**52'352**	**54'081**	**49'959**	**51'435**	**-2.6%**
KP-LULUCF	Art.3.3	Afforestation & reforestation	-24	-23	-20	-17	
		Deforestation	187	220	221	222	
	Art.3.4	Forest management	-1'419	-2'020	-2'064	-2'236	
		Cropland management	NA	NA	NA	NA	
		Grazing land management	NA	NA	NA	NA	
		Revegetation	NA	NA	NA	NA	
		Total (Art. 3.3 + 3.4)	**-1'257**	**-1'823**	**-1'862**	**-2'032**	

Table 2-9 Switzerland's total GHG emissions (excluding LULUCF, Other and International Bunkers) and the contribution of individual gases in CO_2 equivalent (Gg), 1990-2012.

		GHG	Base year inital report	1990	1991	1992	1993	1994	1995	1996	1997	1998
			CO_2 equivalent (Gg)									
Annex A sources		CO_2	44'553	44'628	46'357	46'247	43'706	42'969	43'672	44'328	43'502	44'799
		CH_4	4'370	4'545	4'551	4'460	4'367	4'315	4'310	4'269	4'186	4'155
		N_2O	3'623	3'461	3'456	3'426	3'339	3'299	3'287	3'283	3'165	3'154
		HFCs	0.0	0.0	0.2	7	15	34	182	228	301	358
		PFCs	100	100	85	69	30	18	15	17	20	23
		SF_6	144	144	146	148	126	112	98	94	131	160
		Total (Annex A sources)	**52'791**	**52'878**	**54'595**	**54'358**	**51'582**	**50'747**	**51'563**	**52'220**	**51'305**	**52'650**

		GHG	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
			CO_2 equivalent (Gg)									
Annex A sources		CO_2	44'881	43'939	44'891	43'831	45'012	45'637	46'277	45'898	43'918	45'434
		CH_4	4'063	3'985	3'972	3'922	3'828	3'797	3'791	3'793	3'786	3'840
		N_2O	3'118	3'109	3'127	3'099	3'039	2'992	2'976	2'971	3'001	3'039
		HFCs	421	501	597	635	710	820	905	936	976	1'042
		PFCs	36	69	45	40	57	53	33	33	29	39
		SF_6	147	158	157	168	174	190	213	201	186	245
		Total (Annex A sources)	**52'666**	**51'761**	**52'790**	**51'696**	**52'821**	**53'489**	**54'195**	**53'832**	**51'896**	**53'639**
KP-LULUCF	Art.3.3	CO_2										82
		CH_4										NO
		N_2O										0.1
	Art.3.4	CO_2										-1'204
		CH_4										1.0
		N_2O										0.2
		Total (Art. 3.3 + 3.4)										**-1'121**

		GHG	2009	2010	2011	2012	2012 – base year
			CO_2 equivalent (Gg)				%
Annex A sources		CO_2	44'267	45'910	41'835	43'238	-3.0%
		CH_4	3'776	3'763	3'710	3'688	-15.6%
		N_2O	3'003	3'077	3'014	3'007	-17.0%
		HFCs	1'083	1'138	1'195	1'245	NA
		PFCs	36	37	40	33	-67.0%
		SF_6	187	155	164	224	56.0%
		Total (Annex A sources)	**52'352**	**54'081**	**49'959**	**51'435**	**-2.6%**
KP-LULUCF	Art.3.3	CO_2	162	197	202	205	
		CH_4	NO	NO	NO	NO	
		N_2O	0.0	0.0	0.0	0.0	
	Art.3.4	CO_2	-1'420	-2'021	-2'068	-2'237	
		CH_4	0.8	0.5	3.2	0.4	
		N_2O	0.2	0.1	0.7	0.1	
		Total (Art. 3.3 + 3.4)	**-1'257**	**-1'823**	**-1'862**	**-2'032**	

The reported total emissions differ from those reported under the UNFCCC, as sector Other – in addition to LULUCF and international bunkers – is not accounted for under the Kyoto Protocol. On the other hand, activities under article 3.3 (Afforestation, reforestation and Deforestation) and 3.4 (forest-, cropland- and grazing management and revegetation) are taken into account over the commitment period 2008-2012. Under the elective voluntary activities of Article 3, paragraph 4 of the Kyoto Protocol, Switzerland only accounts for Forest Management.

3 Energy

3.1 Overview

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

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

In Switzerland, the energy sector is the most relevant greenhouse gas source. In 2012, it emitted 41’477 Gg CO_2 equivalent which corresponds to 80.6% of total emissions (51’449 Gg CO_2 equivalent, national total without LULUCF). The emissions of the period 1990–2012 are depicted in Figure 3-1.

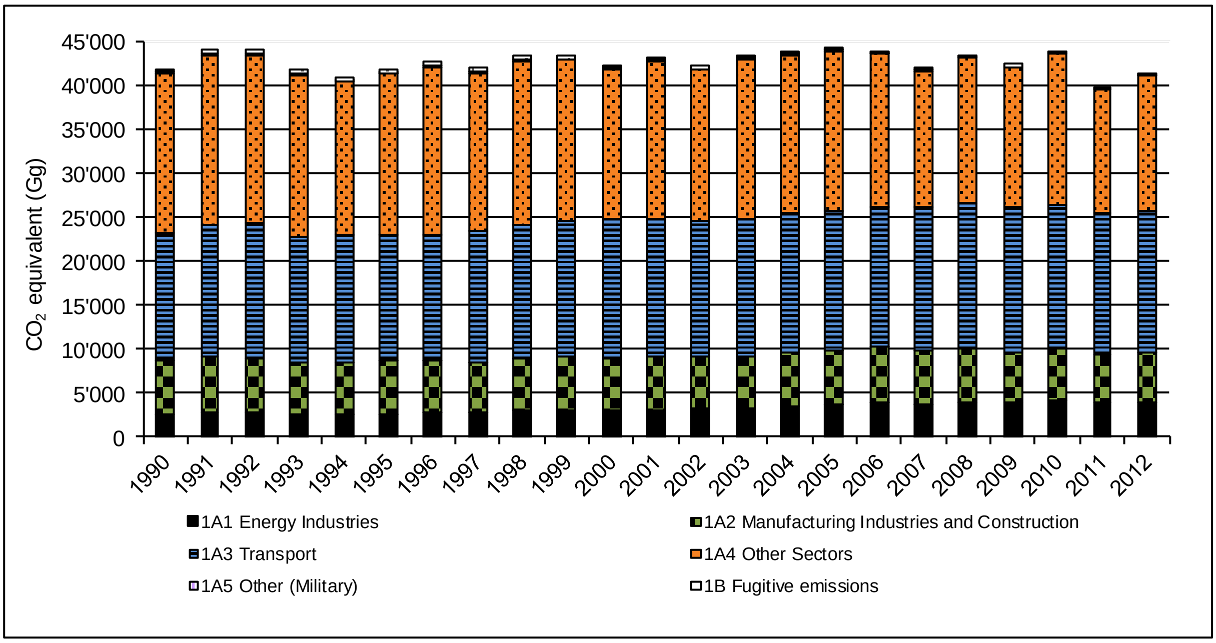


Figure 3-1 Switzerland’s GHG emissions of sector 1 Energy 1990–2012 in CO_2 equivalent (Gg).

For the total emissions of the energy sector, there are fluctuations up to 6% (100% = emissions 1990) in the period 1990–2012 but no trends. The value 2012 is 1.2% lower than the value of the base year 1990. Three sub-categories dominate the emissions:

- 1A3 Transport and 1A4 Other Sectors are the main sources of the sector energy that cover 39.4% and 36.7% of total energy emissions in 2012, respectively.
- 1A1 Energy Industries and 1A2 Manufacturing Industries and Construction are of lesser importance. They contribute 9.8% and 13.3% to the total emissions of the sector energy in 2012, respectively.
- 1A5 Other (Military) and 1B Fugitive Emissions only play a minor role. In 2012, they cover 0.3% and 0.5%, respectively, of the total emissions of the sector energy.

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

- By far the most important gas emitted from the sector energy is CO_2. It accounts for 98.9% of the the total greenhouse gas emissions of the sector. Its fluctuations reflect *inter alia* the climatic variability in Switzerland (see Figure 2-7 and related comments).

- In 2012, CH_4 emissions contributed 0.62% to the total emissions of the sector energy. The decreasing trend since 1990 is the result of improved gas transmission network resulting in substantially lower fugitive emissions (12.56 Gg in 1990, 8.07 Gg in 2012) and reduced emissions from gasoline passenger cars due to catalytic converters. Furthermore improved combustion technologies in 1A4 Other Sectors also contributed to the decreasing trend.
- N_2O contributed 0.53% to the total emissions of the sector energy. The changes in N_2O emissions may mainly be explained by changes in the emission of road transportation and revised EFs for diesel and gasoline combustion by vehicles. The first generation of catalytic converters generated N_2O as undesirable by-product in the exhaust gases, leading to an increase of N_2O emissions until 2000. With new converter materials being used, the emission factors are decreasing since 2001. For further details see chapter 3.2.8.2 - 1A3b.

Table 3-1 GHG emissions of source category 1 Energy by gas in CO_2 equivalent (Gg), 1990–2012.

Gas	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
CO_2	41'199	43'297	43'360	41'101	40'223	41'098	41'948	41'315	42'637	42'730
CH_4	502	521	516	512	500	507	518	509	512	479
N_2O	288	304	314	302	306	310	321	323	325	325
Sum	41'989	44'121	44'191	41'915	41'029	41'916	42'787	42'147	43'474	43'533

Gas	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	CO_2 equivalent (Gg)									
CO_2	41'675	42'611	41'627	42'860	43'357	43'888	43'563	41'579	43'126	42'018
CH_4	439	414	382	362	342	325	307	291	285	274
N_2O	315	305	288	275	223	219	214	209	216	215
Sum	42'429	43'330	42'297	43'497	43'922	44'432	44'084	42'078	43'628	42'506

Gas	**2010**	**2011**	**2012**
	CO_2 equivalent (Gg)		
CO_2	43'503	39'479	41'000
CH_4	281	254	255
N_2O	220	212	221
Sum	44'004	39'945	41'477

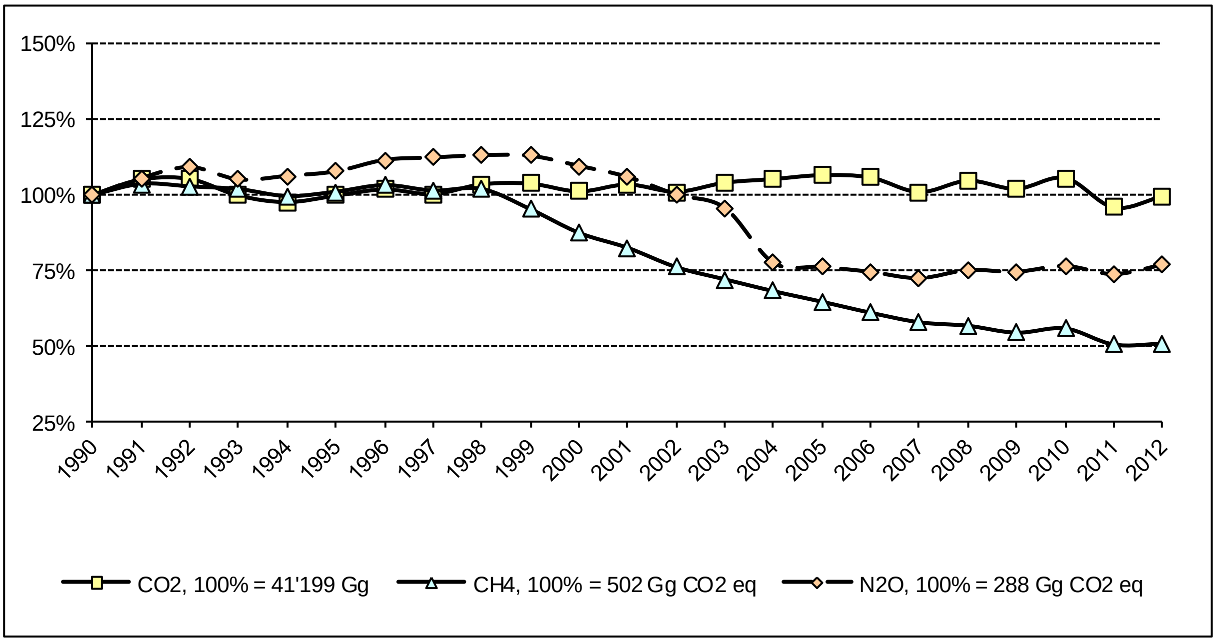


Figure 3-2 Relative trends of the greenhouse gases of source category 1 "Energy" in the period 1990–2012. The base year 1990 represents 100%.

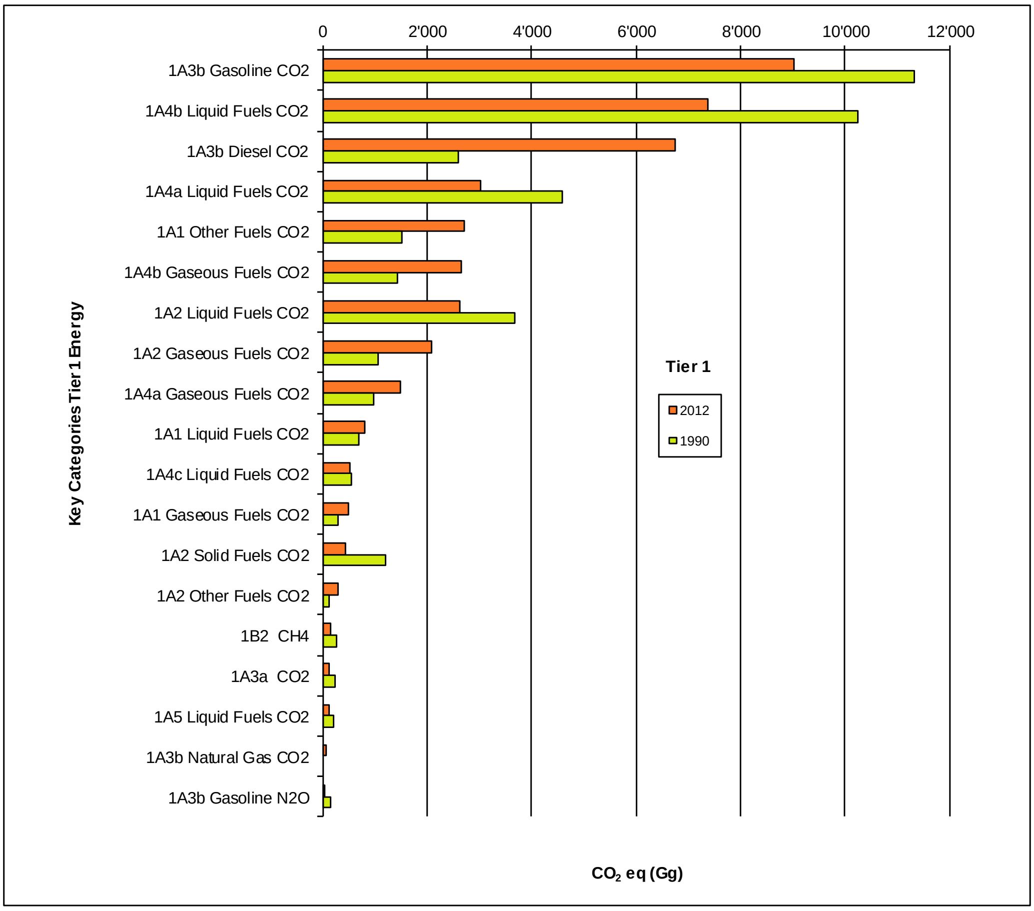
The following table summarises the emissions of the sector energy in 2012. The table includes emissions from international bunkers (aviation and marine) as well as CO2 emissions from biomass burning which both are not accounted for in the Kyoto Protocol but are contained in the CRF-tables.

Table 3-2 Summary of sector 1 Energy, emissions[3] in 2012 in Gg CO_2 equivalent (Total: rounded values).

Emissions 2012	**CO_2**	**CH_4**	**N_2O**	***Total***
	CO_2 equivalent (Gg)			
1 Energy	41'000.2	255.3	221.2	*41'477*
1A Fuel Combustion	40'960.9	85.9	220.6	*41'267*
1A1 Energy Industries	4'018.4	2.2	43.8	*4'064*
1A2 Manufacturing Industries and Construction	5'480.1	7.9	27.4	*5'515*
1A3 Transport	16'210.1	20.3	101.0	*16'331*
1A4 Other Sectors	15'137.5	55.4	47.2	*15'240*
1A5 Other (Military)	114.8	0.1	1.1	*116*
1B Fugitive Emissions from Fuels	39.3	169.5	0.7	*209*
International Bunkers	4'685.2	1.4	46.1	*4'733*
CO_2 Emissions from Biomass	6'804.5	IE	IE	*6'804*

In 2012, the Swiss greenhouse gas inventory identifies in Tier 1 analysis 31 key sources (without LULUCF), 19 of which belong to the energy sector. The key categories from the energy sector are depicted in Figure 3-3. Most dominant are the CO_2 emissions from 1A3b Transport (gasoline, CO_2) and 1A4b Other Sectors (liquid fuels, CO_2).

[3] For full biomass CO_2 emissions see Table 3-14.



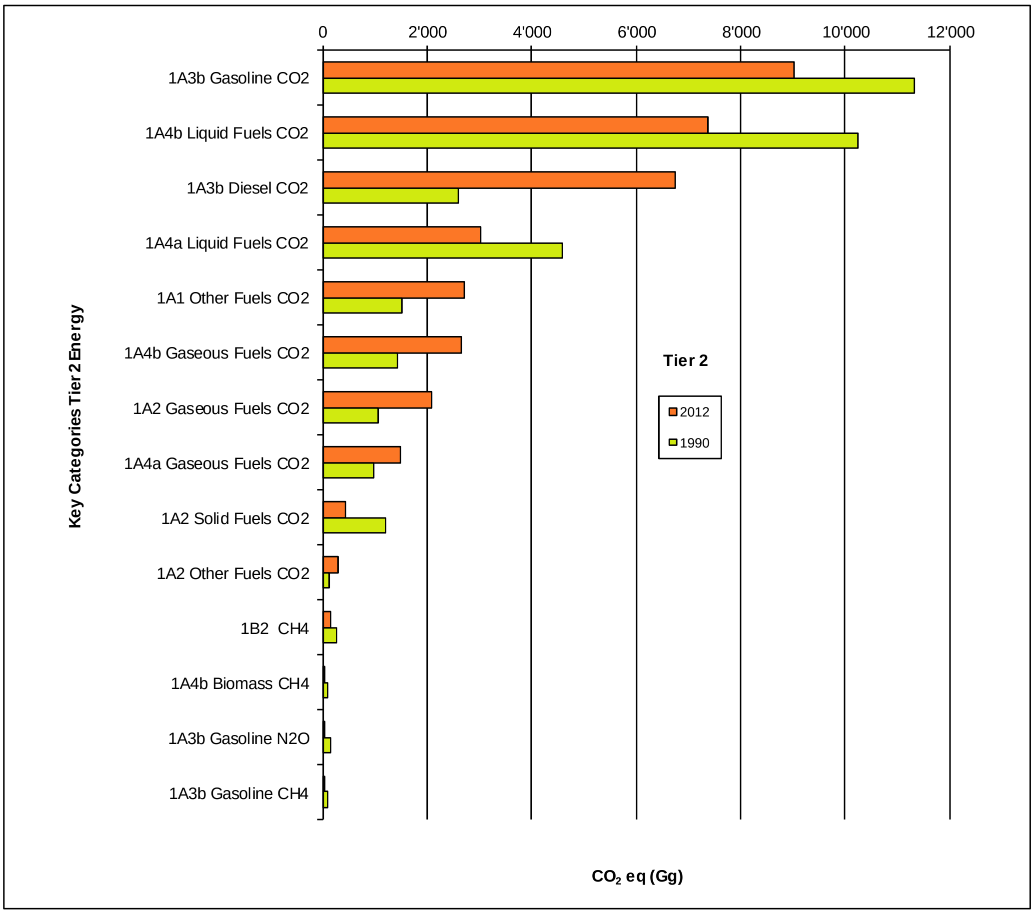


Figure 3-3 Key sources in the Swiss GHG inventory from the energy sector. Top: Tier 1, bottom Tier 2 analysis.

3.2 *Source Category 1A – Fuel Combustion Activities*

3.2.1 Comparison of the Sectoral Approach with the Reference Approach

Two methods are applied for modelling CO_2 emissions from the energy sector, the Sectoral (or National) Approach and the Reference Approach. For the inventory under the Framework Convention on Climate Change and the Kyoto Protocol the Sectoral (National) Approach is used. The Reference Approach is only used for verification purposes (quality control activity).

Figure 3-4 depicts the two approaches including the input data used and disaggregation of fuel types that ultimately allows for comparing the two approaches.

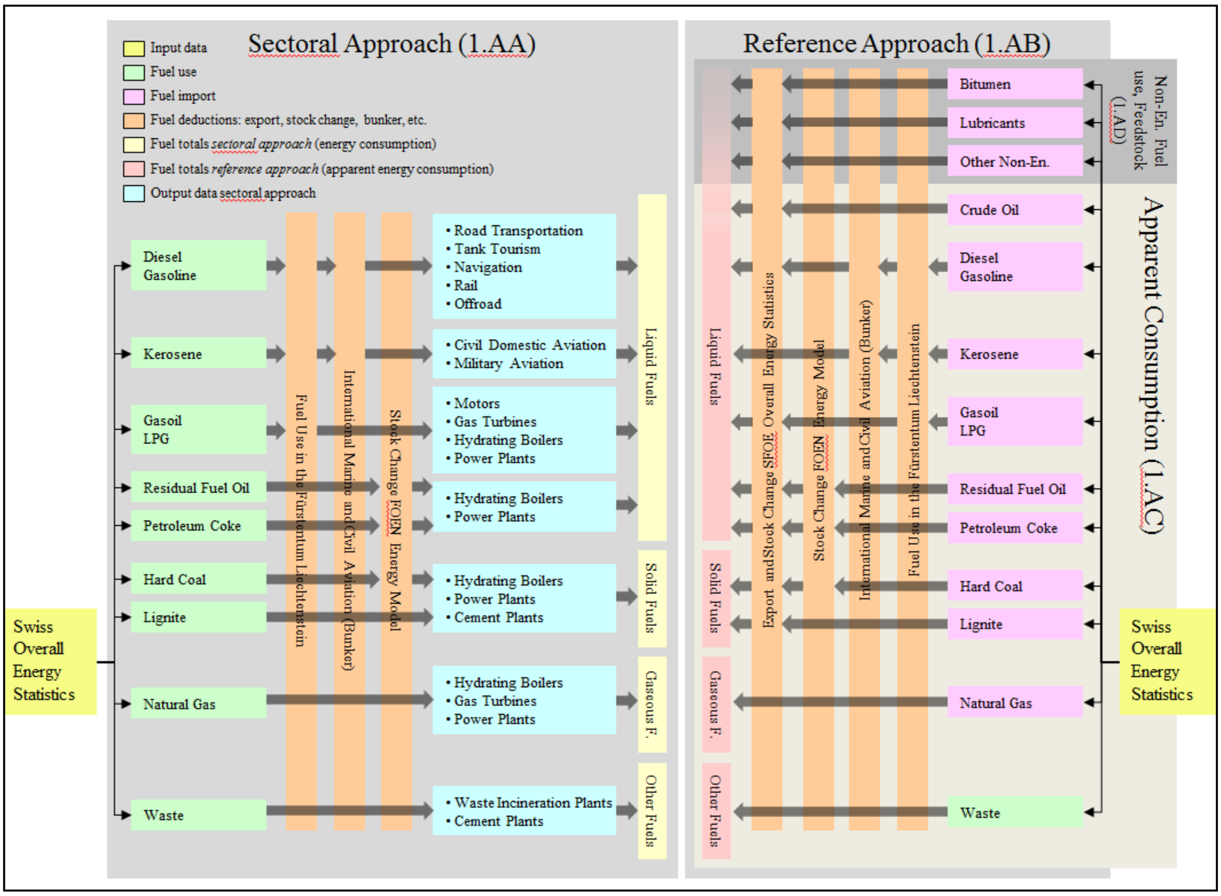


Figure 3-4 Calculation of the Reference and Sectoral Approach. The input data for both approaches stems from the Swiss overall energy statistics (SFOE 2013) but while the Reference Approach considers the net import/export balance, the Sectoral Approach considers the fuel use of the SFOE.

The Sectoral Approach is based on sectoral energy consumption and uses both the energy consumption as reported in the Swiss overall energy statistics (SFOE 2013) and additional specific methods for the various source categories. This includes fossil fuel consumption statistics (top-down approach, Tier 1) and bottom-up modelling of fuel consumption (bottom-up, Tier 2 and Tier 3). A detailed description of the sectoral approach is provided in chapter 3.2.5.

The Reference Approach on the other hand corresponds to a top-down approach (Tier 1) based on net quantities of fuel imported into Switzerland. Accordingly the fossil fuel supply statistics is used in this approach: all imports and exports of primary fuels (crude oil, natural gas, coal[4]), secondary fuels (gasoline, diesel oil etc.) and stock changes stem from the Swiss overall energy statistics (SFOE 2013). Subsequently the apparent consumption, the net carbon emissions, and the effective CO_2 emissions are calculated for the Reference Approach as reported in the CRF-tables 1A(b)–1A(d). Thus the Reference Approach covers the CO_2 emissions of all net imported primary fuels, emissions from crude oil refinement (secondary fuel production) in the two Swiss refineries and emissions of imported secondary fuels. In 2012 29% of all fossil fuels sold in Switzerland were produced in Swiss refineries from primary fuels (EV 2013).

All necessary data for calculating the Reference Approach is implemented in the EMIS database and all the data on import, export, bunkers, stock changes, apparent consumption, carbon emission factors, carbon stored and actual emissions are calculated within EMIS under the following conditions:

- The oxidation factor is consequently set to 1.0 due to the following reason: combustion installations in Switzerland have very good combustion properties; combined emissions of CO and unburnt VOC lie in the range of only 0.1 to 0.3 percent of CO_2 emissions for oil and gas combustion. Since most of the coal used in Switzerland goes to the cement industry, also for coal an oxidation factor of 1.0 was chosen[5]. For detailed description see chapter 3.2.5.2.
- For the Reference Approach gas oil and diesel are reported together, with a weighted average NCV (NCV gas oil 42.6 TJ/Gg, NCV diesel 42.8 TJ/Gg). In constrast, marine bunkers consist of diesel only and are reported using the country-specific NCV of 42.8 TJ/Gg.
- For the Reference Approach, Liechtenstein's fossil fuel consumption is subtracted from the input figures of fossil fuel consumption as statet in SFOE (2013), which originally include Liechtenstein's consumption except for natural gas (see also chapter 3.2.5).
- In the Reference Approach, carbon which is stored in feedstocks or non-energy fuel use has to be subtracted from fuel import in order to report the effective CO_2 emissions correctly (see also chapter 3.2.3).

On this basis the differences between Reference and Sectoral Approach are calculated within the EMIS system. The results 1990-2012 are shown in Table 3-3 and in Figure 3-5. The CO_2 emissions from both approaches (excluding non-energy use and feedstocks) concur very well. For all years the differences lie between 0.70% and 1.29% and the difference in 2012 is 0.89%. For the corresponding energy consumption (excluding non-energy use and feedstocks) the differences lie between 0.57% and 0.98% while the difference in 2012 is 0.62%.

The comparably small difference between Reference and Sectoral Approach is influenced by various effects. Amongst others, the energy and carbon content of crude oil varies over time. Furthermore the efficiency and amount of production of Swiss refineries varies from year to year.

[4] Coking coal is included under other bituminous coal in the reference approach.

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

Table 3-3 Differences in energy consumption and CO_2 emissions between the Reference and the Sectoral (National) Approach from CRF-table1.A(c). The difference is calculated according to [(RA-SA)/SA] 100% with RA = Reference Approach, SA = Sectoral (National) Approach. Energy consumption: excluding non-energy use and feedstocks.

Difference between Reference and Sectoral Approach	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	%									
Energy Consumption	0.69	0.87	0.86	0.98	0.95	0.84	0.73	0.75	0.64	0.57
CO_2 Emissions	0.75	0.91	0.93	1.10	1.11	0.93	0.88	0.98	0.89	0.79

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	%									
Energy Consumption	0.61	0.67	0.61	0.57	0.68	0.75	0.93	0.70	0.68	0.79
CO_2 Emissions	0.79	0.82	0.85	0.70	0.93	1.02	1.29	1.02	1.01	1.16

	2010	2011	2012
	%		
Energy Consumption	0.73	0.70	0.62
CO_2 Emissions	1.09	1.10	0.89

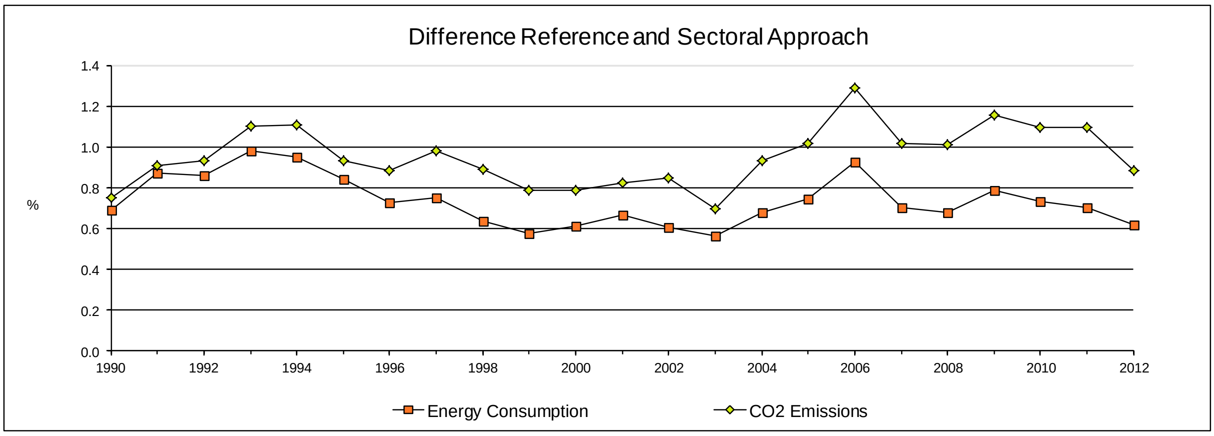


Figure 3-5 Time series for the differences between Reference and Sectoral Approach. Numbers are taken from Table 3-3. See caption in Table 3-3 for further information about how data is calculated.

After a major revision (INFRAS 2010a), the calculation of the Reference Approach has been further improved in consistency and in agreement with the Swiss Federal Office of Energy. The differences between the Reference Approach and numbers provided by the IEA statistics (IEA 2012) are discussed in Annex 4.

3.2.2 International Bunker Fuels

3.2.2.1 Source Category Description

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

For Switzerland, the sources of international bunker emissions are primarily aviation, but there are also some marine bunkers occurring from the use of diesel oil for navigation activities on the river Rhine between Basel (Switzerland) and Rotterdam (Netherlands) and on the two Swiss lakes with neighbouring countries (Lake of Geneva, Lake of Constance).

Table 3-4 Specification of Swiss source category International Bunkers.

International Bunker Fuels	Specificaitons	Data Source
Civil Aviation	Country specific model (Tier 3a)	FOCA 2006-2013
Marine Bunkers	Navigation on the Rhine river north of Basel (Tier 1). Naviagation on foreign territory on the Lake of Geneva and Lake of Constance (Bodensee).	CARBURA 2010, Schweiz. Bodenseeschifffahrt (SBS), Schifffahrt Untersee und Rhein (Urh), Compagne Générale de Navigation sur le lac Léman (CGN): INFRAS 2011a

3.2.2.2 Methodological Issues

Civil Aviation

The emissions from civil aviation (domestic and international) are calculated with a Tier 3a method. The Tier 3a method follows standard modelling procedures on the level of single aircraft movements based on detailed movement statistics. The emission factors are country specific with the exception of N_2O, for which a IPCC default value is applied. The activity data of the bunker is summarised in Table 3-6 (see also Table 3-31). Further information on the methodology used for international aviation is provided in chapter 3.2.8.2 a).

Due to the detailed information about activity data available, the resulting fuel consumption is considered complete. In spite of this, there remain small differences between the fuel consumption modelled bottom-up and the total fuel sold (SFOE 2013). In 1990, the modelled consumption adds up to 1.01 million tons, whereas 1.05 million tons were sold. The difference of 4% is considered acceptable, because discrepancies up to 10% can easily result from fuelling strategies of airlines (FOCA investigation showed that airlines are calculating whether it is economically beneficial to refuel at a place with lower fuel prize). In order to match the bottom up calculation with the fuel quantity sold, any occurring difference is attributed to international bunker emissions. The factor between calculated international fuel consumption and adjusted international fuel consumption is used to scale the bunker emissions linearly. For instance in 1990, the bunker fuel consumption and the emissions had to be expanded by the factor 1.045. For 2006, they had to be reduced by the factor 0.974 (FOCA 2007). For 2012, the correction factor was 0.969 (FOCA 2013). For the more recent years, the modelled and actual total fuel sales are listed in Table 3-5.

Table 3-5 Comparison between modelled and actual fuel sales in bunker fuel consumption for civil aviation.

Modelled and actual fuel sales	2005	2006	2007	2008	2009	2010	2011	2012
	t							
Modelled domestic fuel sales	38'754	38'550	43'968	37'627	39'626	39'252	42'047	43'414
Modelled international fuel sales	1'152'614	1'196'731	1'287'062	1'391'656	1'345'919	1'395'428	1'511'279	1'527'522
Total modelled fuel sales (FOCA)	1'191'368	1'235'281	1'331'030	1'429'283	1'385'545	1'434'680	1'553'326	1'570'936
Actual fuel sales (GEST)	1'148'131	1'203'868	1'289'152	1'382'835	1'324'224	1'390'824	1'531'805	1'523'116
Difference between FOCA and GEST	3.8%	2.6%	3.2%	3.4%	4.6%	3.2%	1.4%	3.1%
Correction factor	0.962	0.974	0.968	0.966	0.954	0.969	0.986	0.969

Marine Bunkers

Emissions from marine bunkers are calculated with a Tier 1 method. The emission factors are country specific and in accordance with Table 3-9. Since marine bunkers consist of diesel only a Swiss standard NCV of 42.8 TJ/Gg is used. Activity data of these bunkers is summarised in Table 3-6.

Since there is an exemption from the existing fuel taxation, activity data on marine river bunkers on the Rhine are well documented by the customs administration (Schiffahrt Untersee und Rhein Urh) as well as by CARBURA, the Swiss organisation for the compulsory stockpiling of oil products (CARBURA 2010). From the latter, coherent data series are used.

Activity data for the marine lake bunkers are not very well documented for the whole time series. Data from 1995 on have been provided by the three concerned companies (Schweizerische Bodenseeschiffahrt SBS, INFRAS 2011a). For older data proxies, such as passenger data on a national basis had to be consulted. As marine lake bunkers provide only a minor share of the total marine bunkers this approach seems to be justifiable.

Table 3-6 International bunker fuels. Consumption of kerosene and diesel oil in TJ. (Note that Liechtenstein's kerosene consumption is subtracted, see Chapter 3.2.5.

International Bunker Fuels	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	Fuel consumption in TJ									
Total international aviation(1A3ai)	41'884	40'872	43'499	45'342	46'840	49'918	51'975	53'983	56'599	60'805
Total marine bunkers (1A3di)	812	750	765	763	826	755	671	666	544	559
Total	42'696	41'623	44'265	46'105	47'666	50'673	52'646	54'649	57'142	61'365
1990 = 100%	100%	97%	104%	108%	112%	119%	123%	128%	134%	144%

International Bunker Fuels	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	Fuel consumption in TJ									
Total international aviation(1A3ai)	63'687	60'097	55'468	49'763	46'896	47'671	50'109	53'543	57'844	55'238
Total marine bunkers	525	426	350	422	426	498	460	474	456	432
Total	64'211	60'523	55'818	50'185	47'322	48'169	50'569	54'017	58'300	55'670
1990 = 100%	150%	142%	131%	118%	111%	113%	118%	127%	137%	130%

International Bunker Fuels	**2010**	**2011**	**2012**
	Fuel consumption in TJ		
Total international aviation(1A3ai)	58'118	64'060	63'627
Total marine bunkers	468	418	376
Total	58'586	64'477	64'003
1990 = 100%	137%	151%	150%

3.2.2.3 Uncertainties and Time-Series Consistency

Civil Aviation

See remarks in Chapter 3.2.8.3, sections Civil Aviation (1A3a).

Marine Bunkers

A comparison with the data by the customs administration over a period of 13 years reveals very high correlation. Therefore, data on marine bunkers is considered to be consistent.

3.2.2.4 Source-Specific QA/QC and Verification

No source specific QA/QC activities are implemented. The International Bunker Fuels are proofed by the general QA/QC proceeding for all source categories (see below):

The entire time series have been compared between the current and the previous submission as well as available energy data. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables,
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013,
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013.

3.2.2.5 Source-Specific Recalculations

- 1A3ai: kerosene consumption (AD) for international flights (bunker fuels) has been recalculated in the Swiss energy statistics (SFOE 2012) for the year 2011. Therefore, emissions from all gases have been recalculated for 2011 as well.
- 1A3dii: activity data of the international marine bunkers have been updated for 2011.
- 1A3dii: CH_4 and N_2O emission factors have been recalculated for the year 2011. They are now based on an interpolation of the emission factors between 2010 and 2015 .
- 1A3di: recalculations due to new activity data in 2004, 2008 and 2011 have been made which also affects the "tank tourism" of diesel fuel in 1A3b.

3.2.2.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. To accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

3.2.3 Feedstocks and Non-Energy Use of Fuels

The Swiss Overall Energy Statistics (SFOE 2013) reports feedstocks and so-called non-energy fuel use on an aggregated level only and does not provide a detailed breakdown into specific petroleum products. Some breakdown is provided by the petroleum balance of the annual report of the Swiss Petroleum Association (EV 2013).

Feedstocks and non-energy use of fuels is reported in CRF-table 1.A(d) and separated in the following fuel types:

- Naphtha and liquefied petroleum gas: They are used in a single Swiss plant as feedstocks in the thermal cracking process for the production of ammonia and ethylene (see source categories 2B1 and 2B5). Since data for naphtha and liquefied petroleum gas use are confidential they are included in fuel type Other in CRF-table 1.A(d). For reviewers there is an additional version of this subchapter available including all confidential data and information.
- Lubricants: Primary use of lubricants is considered non-emissive. However, used oil is collected and serves as alternative fuel in the cement industry (1A2f, Other fuels, waste oil) and in special waste incineration plants. NMVOC emissions of lubricants are reported in source category 3D5 Other.
- Bitumen: this is the most important petroleum product which is used as feedstock in Switzerland. It is mainly used for road paving with asphalt and to a lower extent in asphalt roofing (see source categories 2A5 and 2A6).
- Other: Additionally to the above mentioned feedstock use of naphtha and liquefied petroleum gas this fuel category comprises all the rest of unspecified petroleum products which are used as non-energy fuels including gasoline/petrol (andere Benzine), kerosene (andere Petrole), paraffines, waxes and white spirit.

  A re-assessment of the disaggregation of feedstocks is envisaged in the course of the implementation of the new reporting guidelines for the 2015 submission.

3.2.4 CO_2 Capture from Flue Gases and Subsequent CO_2 Storage

(Not applicable for Switzerland.)

3.2.5 Country-specific issues

In the following chapter, the general country specific approach of determining activity data and emission factors is presented. Specific information about each source category is included in the respective chapters 3.2.6 to 3.2.10.

3.2.5.1 Activity Data

The energy related activity data in the inventory corresponds to the energy balance provided in the Swiss overall energy statistics (SFOE 2013). It is updated annually and contains all relevant information about primary and final energy consumption. This includes annual aggregated consumption data for various fuels and main consumers such as housholds, transport, energy industries, and industry and services.

The aggregated data on fuel consumption in the Swiss Overall Energy Statistics is derived from the following sources:

- "Carbura" and Swiss Petroleum Association for data on import, export, sales, stocks of oil products and for processing of crude oil in refineries (EV 2013)
- Annual import data for natural gas from Swiss gas industry association
- Annual import data for coal from the customs administration
- Data provided by industry associations

Table 3-7 shows the energy balance in Switzerland in 2012. Energy flow charts for 2012 and for the base year 1990 are given in Annex 3.1.1.

A time series of the final energy consumption is depicted in Figure 3-6. The total consumption has increased by 10.5% in the period 1990-2012. Simultaneously significant substitutions occurred: heating fuel consumption decreased by 31.1%, natural gas and transport fuel consumption increased by 79.6% and 18.2%, respectively, and electricity by 26.6%.

Table 3-7 Energy balance for Switzerland 2012 (SFOE 2013) in TJ[6].

			Holzenergie	Kohle	Müll und Industrie-abfälle	Rohöl	Erdöl-produkte	Gas	Wasserkraft	Kern-brennstoffe	Übrige erneuerbare Energien	Elektrizität	Fernwärme	Total
			Energie du bois	Charbon	Ord. mén. et déchets ind.	Pétrole brut	Produits pétroliers	Gaz	Energie hydraulique	Combustibles nucléaires	Autres énergies renou-velables	Electricité	Chaleur à distance	Total
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Inlandproduktion	Production indigène	(a)	39 200	–	56 320	–	–	–	143 660	–	19 530	–	–	258 710
+ Import	Importation	(b)	1 180	5 630	–	147 260	351 500	122 520	–	265 580	250	312 570	–	1 206 490
+ Export	Exportation	(c)	– 300	0	–	–	– 13 190	–	–	–	–	–320 490	–	– 333 980
+ Lagerveränderung[1]	Variation de stock[1]	(d)	–	– 160	–	– 90	18 060	–	–	–	–	–	–	17 810
= Bruttoverbrauch	Consommation brute	(e)	40 080	5 470	56 320	147 170	356 370	122 520	143 660	265 580	19 780	– 7 920	0	1 149 030
+ Energieumwandlung:	Transformation d'énergie:													
• Wasserkraftwerke	• Centrales hydrauliques	(f)	–	–	–	–	–	–	– 143 660	–	–	143 660	–	0
• Kernkraftwerke	• Centrales nucléaires	(g)	–	–	–	–	–	–	–	–265 580	–	87 640	1 370	– 176 570
• konventionell-thermische Kraft-, Fernheiz- und Fernheizkraftwerke	• Centrales thermiques class., chauffage à distance, centrales chaleur-force	(h)	– 1 720	–	– 46 060	–	– 800	– 8 030	–	–	–	10 250	17 000	– 29 360
• Gaswerke	• Usines à gaz	(i)	–	–	–	–	–	–	–	–	–	–	–	0
• Raffinerien	• Raffineries	(j)	–	–	–	– 147 170	145 870	–	–	–	–	–	–	– 1 300
• Diverse Erneuerbare	• Renouvelables div.	(k)	– 1 320	–	–	–	–	320	–	–	– 3 460	3 320	0	– 1 140
+ Eigenverbrauch des Energiesektors, Netzverluste, Verbrauch der Speicherungen	Consommation propre du secteur énergétique, pertes de réseau, pompage d'accumulation	(l)	–	–	–	–	– 11 330	– 860	–	–	–	– 24 650	– 1 490	– 38 330
+ Nichtenergetischer Verbrauch	Consommation non énergétique	(m)	–	–	–	–	– 20 050	–	–	–	–	–	–	– 20 050
= Endverbrauch	Consommation finale	(n)	37 040	5 470	10 260	0	470 060	113 950	0	0	16 320	212 300	16 880	882 280
Haushalte	Ménages	(o)	19 340	400	–	–	100 040	47 230	–	–	11 300	66 000	6 480	250 790
Industrie	Industrie	(p)	10 120	5 070	10 260	–	27 790	35 630	–	–	1 370	68 500	6 520	165 260
Dienstleistungen	Services	(q)	6 830	–	–	–	40 690	23 060	–	–	2 940	63 110	3 880	140 510
Verkehr	Transport	(r)	–	–	–	–	299 420	1 490	–	–	520	11 140	–	312 570
Statistische Differenz inkl. Landwirtschaft	Différence statistique, y compris l'agriculture	(s)	750	0	0	–	2 120	6 540	–	–	190	3 550	0	13 150

[1] + Lagerabnahme
– Lagerzunahme

[1] + diminution de stock
– augmentation de stock

[6] Note that Liechtenstein's consumption of liquid fuel is included in the numbers (see chapter below on Final Swiss energy consumption). Numbers of gas consumption are from Switerland only.

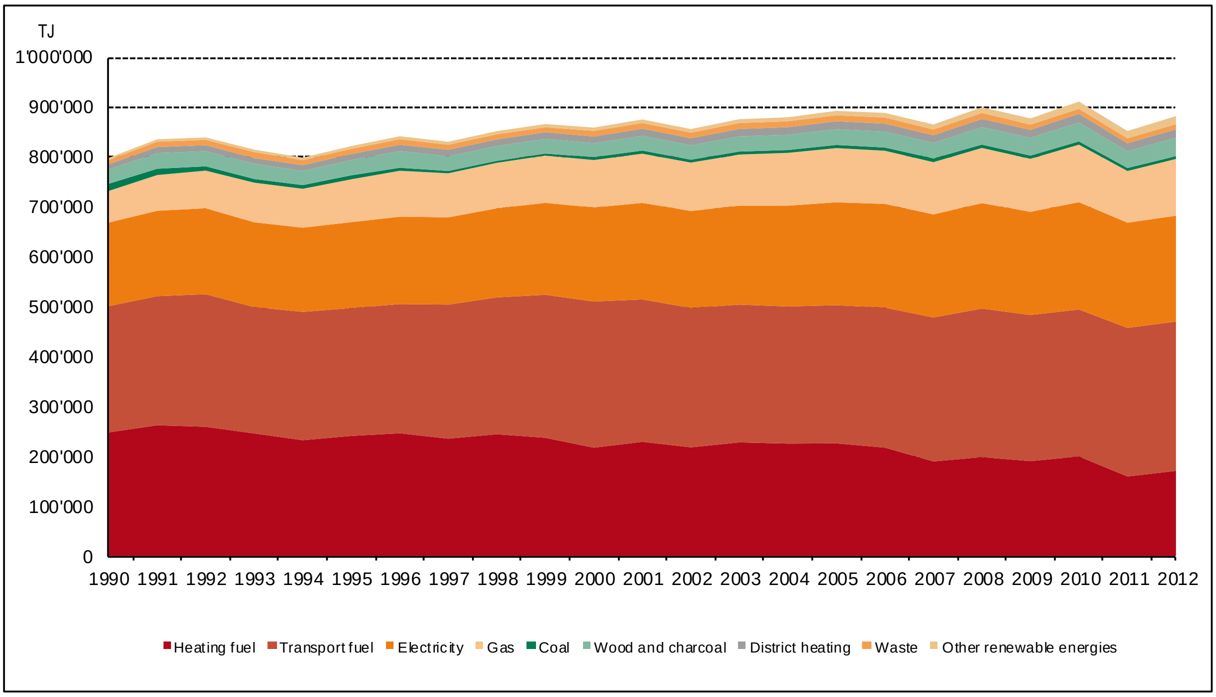


Figure 3-6 Final energy consumption in Switzerland between 1990 and 2012 by fuel type (SFOE 2013). Note that Liechtenstein's consumption of fuel is included in the numbers (see chapter below on Final Swiss energy consumption). It corresponds to 0.62% and 0.63% respectively of the Swiss fuel consumption.

Final Swiss energy consumption

The fundamental data on final energy consumption is provided by the Swiss overall energy statistics (SFOE 2013). However, since Switzerland and Liechtenstein form a customs and monetary union governed by a customs treaty, data regarding liquid fuels in the Swiss overall energy statistics also cover liquid fuel consumption in Liechtenstein. In order to calculate the correct Swiss fuel consumption, Liechtenstein's energy consumption (see Table 3-4 in Liechtenstein's NIR (OE 2014)) is subtracted from the figures provided by the Swiss overall energy statistics. In 2012, the sum of fossil fuels used in Liechtenstein was 2'780 TJ, corresponding to approximately 0.6% of the Swiss consumption of that year.

Disaggregation of the energy consumption

For the elaboration of the greenhouse gas inventory, information about energy consumption is needed at a much more detailed level than provided by the Swiss overall energy statistics. While the total amount of fuel consumption is given by the Swiss overall energy statistics, additional information sources are used to disaggregate fuel consumption into the source categories defined in the CRF-tables. For the different source categories the following sources are used:

- 1A1 Energy Industry: the fuel consumption for source category 1A1 is provided by data from the Swiss overall energy statistics (SFOE 2013).
- 1A2 Manufacturing Industries and Construction: For the industry sector, data are provided by the following sources (see also 3.2.7):

  1A2a – 1A2fi Stationary:

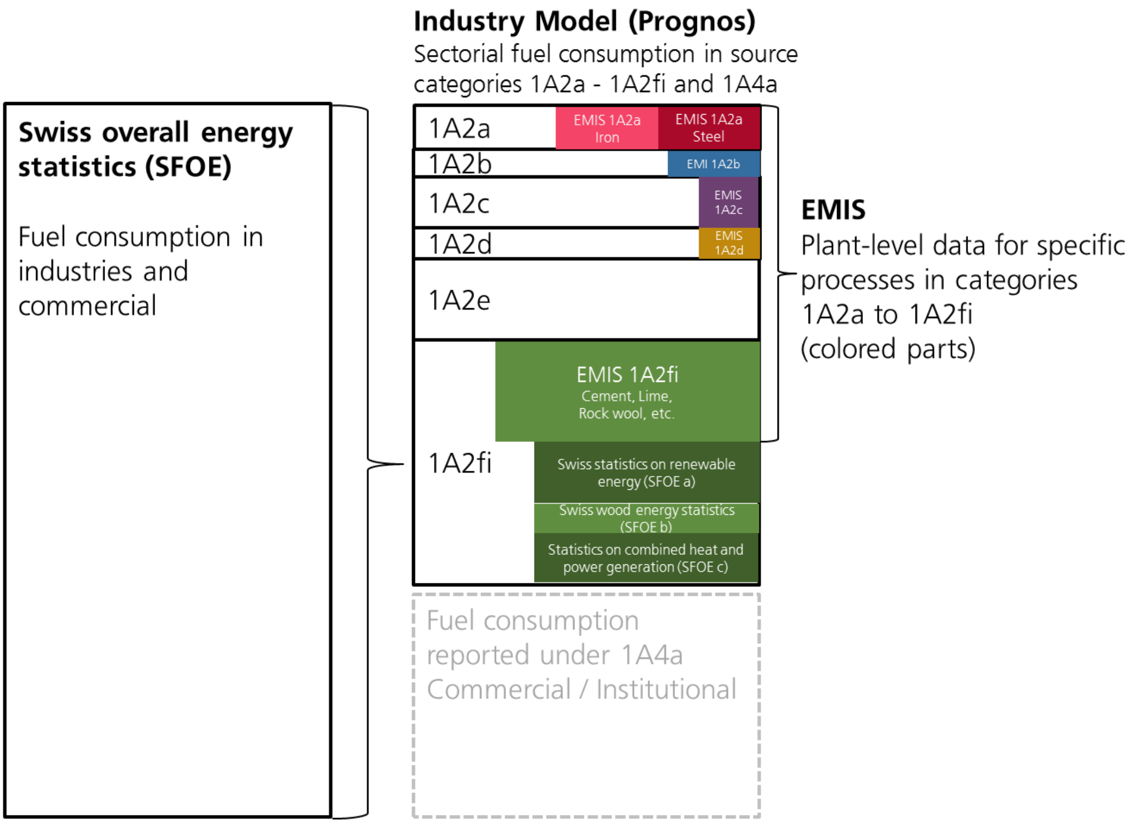


Figure 3-7 Schematic presentation of the sources used for the industrial sector 1A2a – fi. The overall fuel consumption of 1A2 and 1A4a corresponds to the fuel consumption reported in the Swiss overall energy statistics. The industry model (Prognos) distributes the fuel consumption into the different source categories. The coloured boxes show the specific industry information that is used in the different source categories. The fuel consumption for each source category is determined by the industry model (Prognos).

The Swiss overall energy statistics does not provide a specific category for industry fuel consumption, but only an aggregated level (SFOE 2013). Additionally, in 1999, a new classification of the economic sectors led to a change of the allocation of fuel consumption to industry and commercial sector together within the energy statistics as shown in the figure above. In order to provide a consistent time series for industrial (and commercial) fuel consumption, a model is used to split the consumption into the various source categories.

In order to separate these two categories (industrial and commercial), and to achieve the required disaggregation within the industry sector 1A2, a model that determines the fuel use in the different source categories of 1A2 is used (Industry model, Prognos 2013).

The model is based on 164 individual industrial processes and further 64 processes related to infrastructure in industry. Fuel consumption of a specific process is calculated as the product of the process activity data and the process specific fuel consumption factor. For example within the chocolate industry, the activity data would be tonnes of chocolate produced and the specific fuel consumption factor would be kWh natural gas per tonne of chocolate produced.

The model is adjusted and scaled to fit available energy data and statistics, including the following data sources:

- Swiss overall energy statistics (SFOE 2013)
- Statistic of energy consumption from industry and commercial sector, Data from soundings of Helbling Ltd. (since 1999) (SFOE 2013d)
- Swiss Statistics on Renewable Energy (SFOE 2013a)

- Statistics on combined heat and power generation in Switzerland (SFOE 2013c)
- Consumption data of the Federation of the Swiss Pulp, paper and board industry (ZPK 2013)
- Data from Cemsuisse for 1990 and 2000 to 2010 (Cemsuisse 2013)
- Fuel supply data from CARBURA for 1985 to 2010 (Carbura 2010)
- Data on full-time-jobs and on industrial production from SFSO (2013a)
- Expert estimates and industry data based on surveys and annual reports from industry associations (Prognos 2013)

The model provides energy consumption for each source category 1A2a to 1A2f and each fuel type. Total energy consumption in industry according to the model is then subtracted from the energy consumption of industry and services according to the Swiss overall energy statistics. The resulting difference in energy consumption is allocated to source category 1A4a Commercial and Institutional, ensuring completeness of reporting and consistency with the final energy consumption according to the Swiss overall energy statistics.

The fuel consumption determined by the model is considered as fuel used in boilers of each source category of 1A2.

For specific industries, plant-level information is available and considered in source categories 1A2a, 1A2b, 1A2c, 1A2d and 1A2fi, see chapter 3.2.7 (coloured boxes in Figure 3-7).

Additional detailed statistics are available for wood consumption from the Swiss Wood Energy Statistics (SFOE 2013b, see description in chapter 3.2.5.1), sewage and biogas from the Swiss Statistics on Renewable Energy (SFOE 2013a) and the Statistics on combined heat and power generation in Switzerland (SFOE 2013c)). Emissions from these sources are summarized under 1A2fi due to insufficient information regarding sectoral disaggregation.

These specific informations from industries and additional data sources constitute a subset of the fuel consumption allocated by the Prognos model. The fuel consumption of each source category is thus not changed and the sum of source category 1A2 and 1A4a corresponds to the fuel consumption as per the Swiss overall energy statistics of Switzerland (SFOE 2013).

The use of two different information sources from industry and the Prognos model result in a statistical stock change for natural gas, gas oil, residual fuel oil and liquefied petroleum gas in the Energy model. A statistical stock change is necessary to account for the difference between the total fuel consumption as per the model of Prognos based on the Swiss overall energy statistics and the integrated results from the industry data within the Energy model. If for example the fuel consumption of natural gas reported by industry is higher than the natural gas consumption provided by the model of Prognos, this difference is compensated through stock changes to reach the fuel consumption as per the Swiss overall energy statistics.

1A2fii Mobile: Emissions of off-road mobile machinery are modelled using a (territorial) emission model developed by INFRAS (2008). The emissions of all off-road categories like construction machines, railways, navigation etc (1A2fii, 1A3c, 1A3d, 1A4aii, 1A4bii, 1A4cii, and 1A5) are modelled by the same approach using a Tier 2 method. Some details of the emission modelling that hold for all off-road families are described in Annex A3.1.6. During the complete revision of the emissions of the off-road sector that took place between 2005 and 2008, activity data and emission factors were updated and a new database structured in analogy to the on-road database (INFRAS 2010) was developed for the emission calculation. Emissions are calculated in five-year intervals for 1990 up to 2030. For the years in-between, the emissions are interpolated linearly. A slight modification of the activity data was carried out in 2013 based on the latest numbers on growth of population and economy (Prognos 2012a).

- 1A3 Transport: For the transport sector, INFRAS developed an emission model for territorial road transportation (1A3b, INFRAS 2010; for details refer to Annex A3.1.5) and off-road transport (1A3c and 1A3d, INFRAS 2008, see paragraph on 1A2fii above). The Swiss overall energy statistics provides information on the amounts of fuel sold. From the amounts sold, the consumptions modelled by the territorial road and off-road models (INFRAS 2008, 2010) are subtracted. The differences to the amount of fuels sold represent tank tourism, i.e. the amount sold in Switzerland but consumed abroad.
- 1A4: Activity data of the Other Sectors is provided by the following sources:

  1A4ai, 1A4bi Other Sectors, Stationary: The Swiss overall energy statistics does provide information on the consumption by industry and the commercial sector together. The information provided by the model of Prognos determines the fuel consumption in source category 1A2 Industry. The difference between the fuel consumption in the Swiss overall energy statistics and the fuel consumption by Prognos determines thus the fuel consumption of source category 1A4ai. Source category 1A4bi is provided by the Swiss overall energy statistics. The fuel used for co-generation in turbines and engines in the commercial sector and households is deducted from a model of stationary engines developed by Eicher + Pauli (Kaufmann 2013). This model builds one information source for the Statistics on combined heat and power generation in Switzerland (SFOE 2013c).This amount are part of the fuel consumptions of the Swiss overall energy statistics.

  For 1A4bi Other Sectors, grass drying (1A4ci), specific bottom-up industry information is available and is deducted from the fuel consumption of 1A2. The information on grass drying is documented in the respective EMIS comment.

  1A4aii/bii/cii 1A4bi Other Sectors, Mobile: In addition to energy consumption in stationary installations, also mobile sources are reported in source category 1A4aii/bii/cii, the emissions of which are calculated using the INFRAS off-road model (INFRAS 2008, see paragraph on 1A2fii above).
- 1A5 Military: In Switzerland military energy consumption concerns only the two source categories Mobile Military off-road and Military Aviation. For the Mobile Military off-road energy consumption the INFRAS off-road model is used (INFRAS 2008, see paragraph on 1A2fii above). The energy consumption of Military aviation is copied from the logbooks of the military aircrafts (VTG 2013).

The compilation of the different information and the resulting disaggregation is made in the so-called Energy model developed and annually updated by FOEN.

The following figures show the information and data sources used for the disaggregation of each fuel type in each source category in the Energy model.

Natural Gas

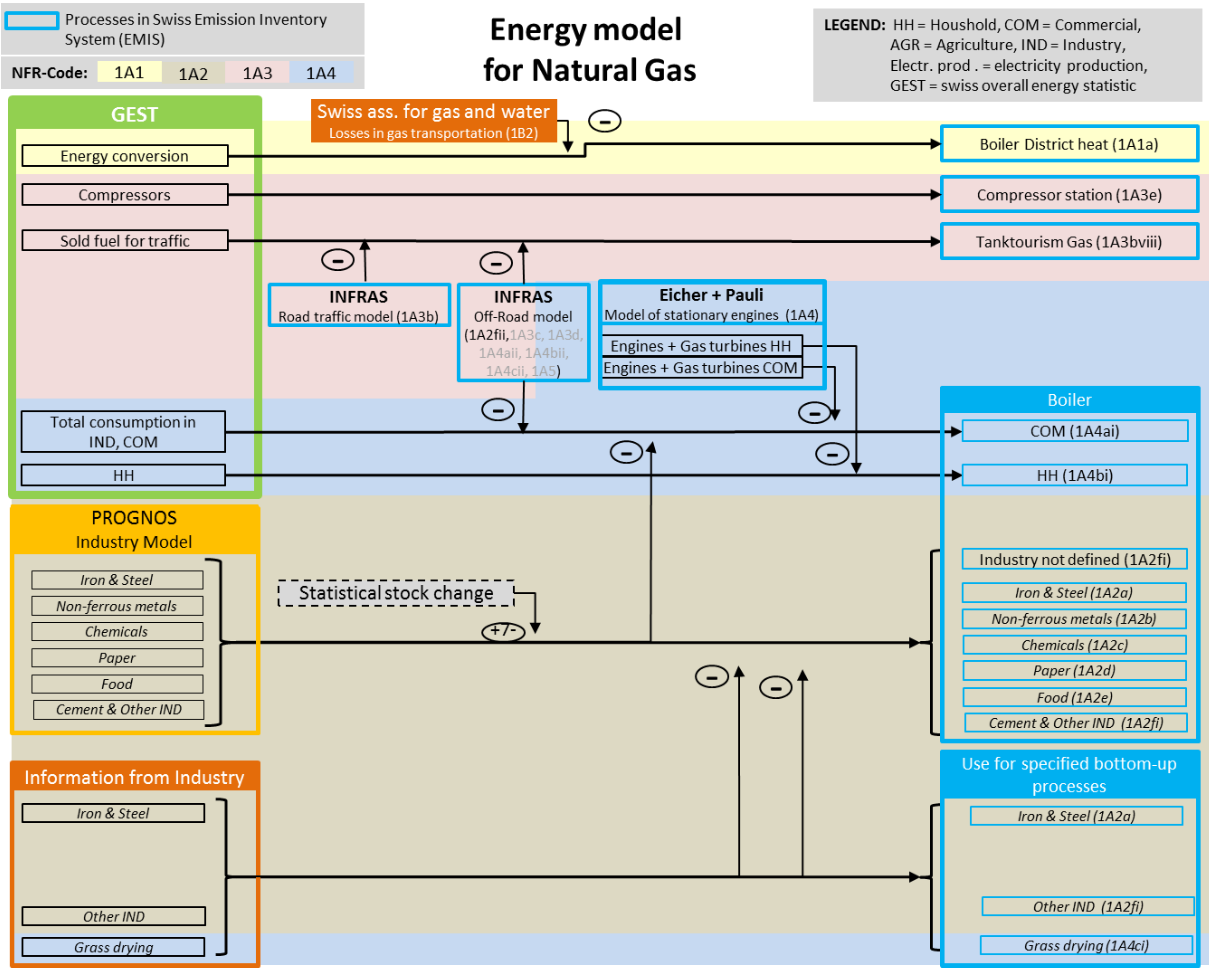


Figure 3-8 Schematic disaggregation of 1A Fuel Consumption for natural gas.

In addition to the information sources used as described above, the following specific informations are used for the disaggregation of the natural gas consumption:

- 1A1: The fuel consumption for Energy conversion from the Swiss overall energy statistics is corrected for losses in gas transportation as provided by the Swiss Gas and Water Industry Association. These fugitive emissions are reported under category 1B2. In the CRF-tables, the resulting fuel consumption under 1A1 for natural gas is reported under 1A1a Public Electricity and Heat Production.
- 1A3 Transport: Within the sector 1A3, natural gas consumption only occurs in source category 1A3b and 1A3e. As with other fuels, the consumption modelled by the territorial models is subtracted from the amount sold based on the energy statistics. The difference to the amount of fuel sold represents the tank tourism of natural gas, which is reported under 1A3bviii. Further information on the transport sector is provided in chapter 3.2.8.

Gas Oil

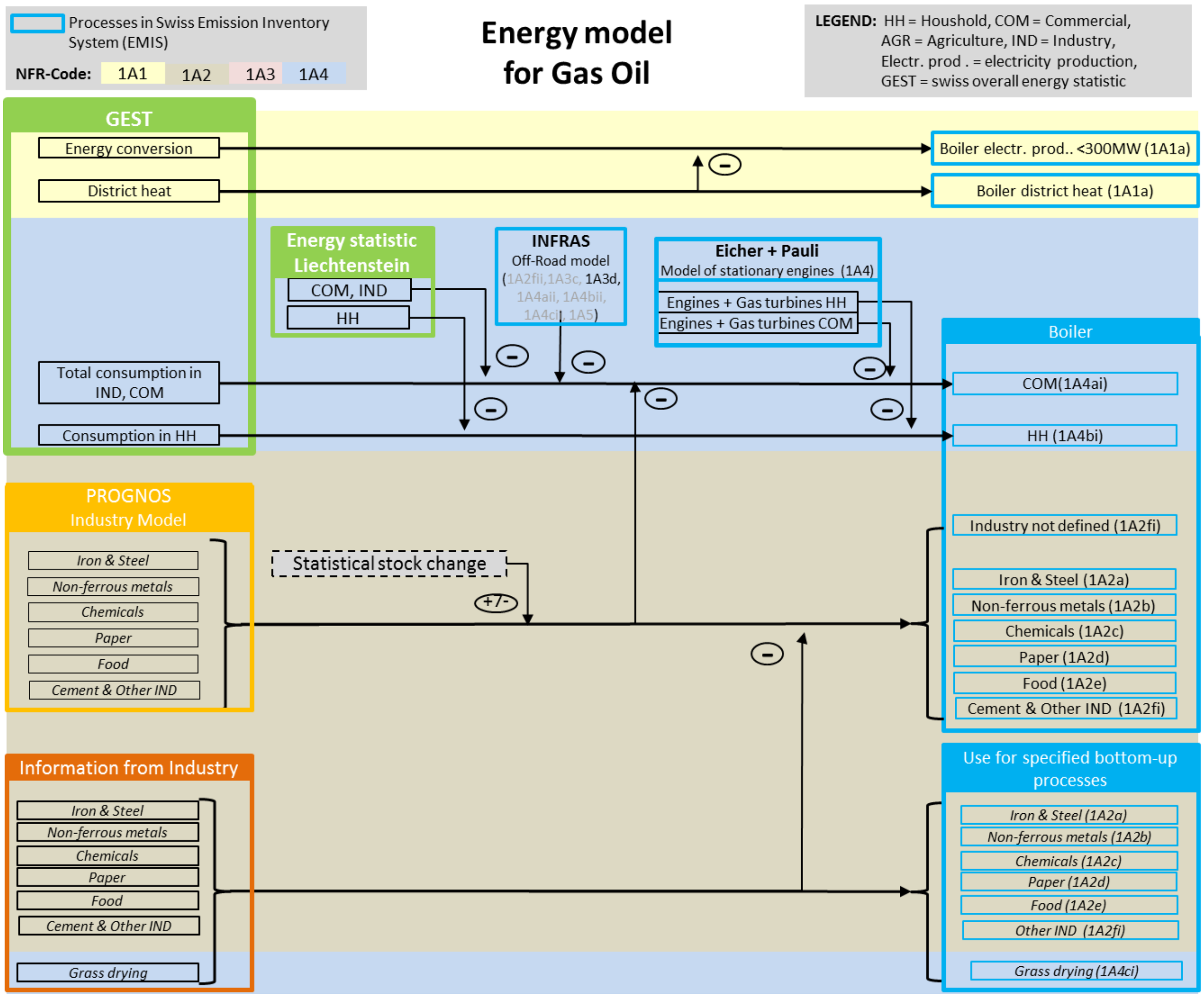


Figure 3-9 Schematic disaggregation of 1A Fuel Consumption for gas oil.

In addition to the information sources used as described above, the following specific informations are used for the disaggregation of the gas oil consumption:

- 1A1: Energy conversion and district heating is available within the Swiss overall energy statistics. As district heating is a sub category of energy conversion in the statistics, the respective fuel consumption is deducted from energy conversion to document boiler use in electricity production and in district heating separately within the activity data of source category 1A1a Public Electricity and Heat Production.
- 1A3: A small amount of gas oil is consumed by navigation 1A3d. It is subtracted from the total provided by the Swiss overall energy statistics before the rest is attributed to 1A4ai.
- 1A4ai: Within the commercial sector, the off-road gas oil consumption for 1A3d is deducted from the consumption of the commercial sector. As mentioned above, gas oil consumption of Liechtenstein is included in the total consumption of gas oil in the energy statistics, therefore, the amount used in Liechtenstein is subtracted from 1A4ai and 1A4bi.

Residual Fuel Oil

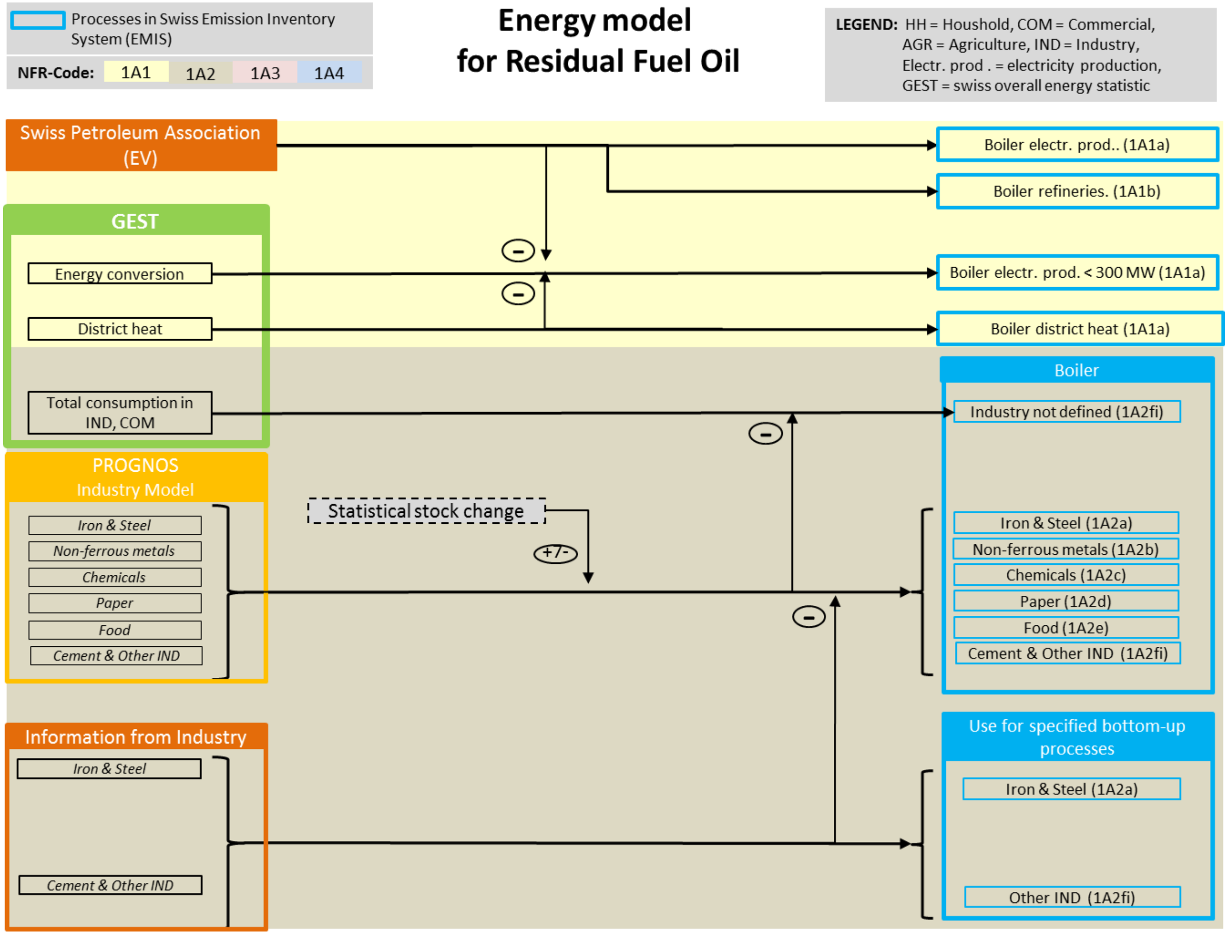


Figure 3-10 Schematic disaggregation of 1A Fuel Consumption for residual fuel oil.

In addition to the information sources used as described above, the following specific informations are used for the disaggregation of the residual fuel oil consumption:

- 1A1: Informations from the Swiss Petroleum Association (EV) is provided in addition to the information available from the Swiss overall energy statistics regarding district heating and energy conversion. The information of EV is used within source category 1A1a Public Electricity and Heat Production for the fuel use within boilers for electricity production (for the single fossil fuel power station that was operational from 1985 to 1994) and within 1A1b Petroleum refining for the use of fuel within the boilers of the refineries. As discussed under the section gas oil, residual fuel oil consumption from the Swiss overall energy statistics are reported for boiler use in electricity production and in district heating separately within the activity data of source category 1A1a Public Electricity and Heat Production.

Liquefied Petroleum Gas (LPG)

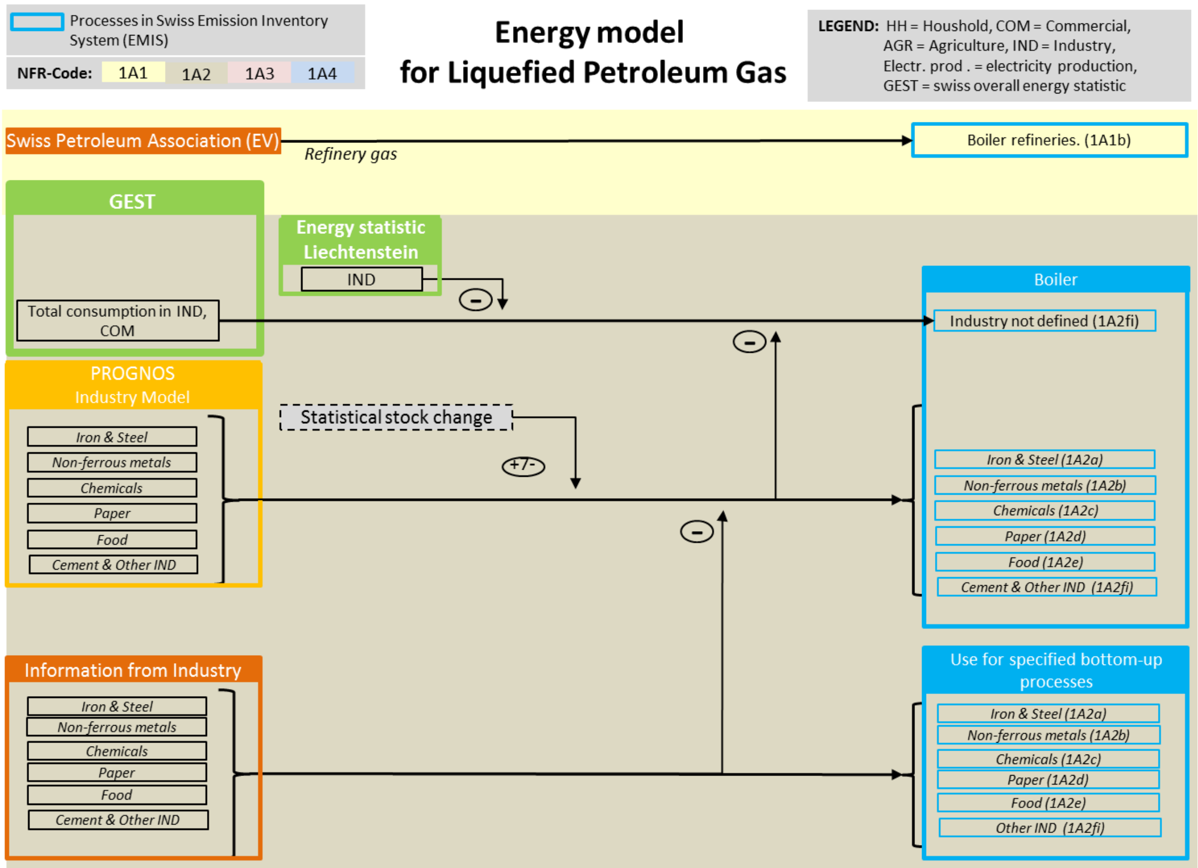


Figure 3-11 Schematic disaggregation of 1A Fuel Consumption for liquefied petroleum gas (LPG).

In addition to the information sources used as described above, the following specific informations are used for the disaggregation of the liquefied petroleum consumption:

- 1A1: Information on the refinery boilers is provided from the Swiss Petroleum Association (EV) and considered within source category 1A1b Petroleum refining. However, the caracteristics of refinery liquefied petroleum gas is not identical to the caracteristics of liquefied petroleum gas used in source category 1A2 and is therefore not deducted in source category 1A2.

Petroleum coke, Bituminous Coal and Lignite

For Petroleum coke, bituminous coal and lignite, the same approach as above described is used incluing the data from the Swiss overall energy statistics (SFOE 2013) and the Prognos model for the fuels used within the industry sector (Prognos 2013).

Wood

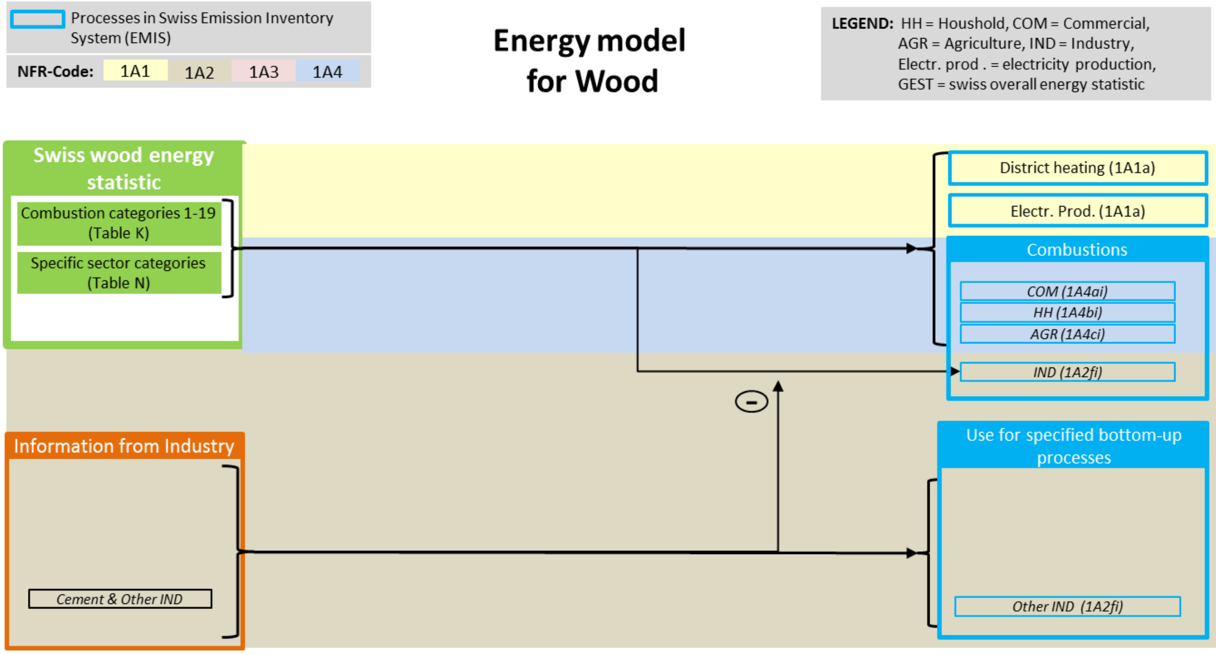


Figure 3-12 Schematic disaggregation of 1A Fuel Consumption for wood.

The Swiss wood energy statistics (SFOE 2013b) provides both the annual wood consumption for specified categories of combustion installations (Table K, categories 1-19) and the allocations of the combustion categories to the sectoral consumer categories (Table N, household, agriculture/forestry, industry, services, electricity and district heating). This allows to assign the annual wood consumption on the level of combustion installation categories, see Table 3-8, to the source categories 1A1a Public Electricity and Heat Production, 1A2fi Other, 1A4ai Commercial/Institutional, 1A4bi Residential and 1A4ci Agriculture/Forestry/Fisheries.

For some industries in source category 1A2fi, specific bottom-up information is available and included in the Energy model. Regarding wood consumption, the specific industry data is subtracted from the activity data of the respective combustion installation category in order to avoid double counting within source category 1A2fi. The information on the specific processes are documented in the respective EMIS comments (EMIS 2014/1A Holzfeuerungen).

Table 3-8 Categories of wood combustion installations based on SFOE 2013b.

1A Wood combustion, categories
Open fireplaces
Closed fireplaces, log wood stoves
Pellet stoves
Log wood hearths
Log wood boilers
Log wood dual chamber boilers
Automatic chip boilers < 50 kW
Automatic pellet boilers < 50 kW
Automatic chip boilers 50-500 kW w/o wood processing companies
Automatic pellet boilers 50-500 kW
Automatic chip boilers 50-500 kW within wood processing companies
Automatic chip boilers > 500 kW w/o wood processing companies
Automatic pellet boilers > 500 kW
Automatic chip boilers > 500 kW within wood processing companies
Combined chip heat and power plants
Plants for renewable waste from wood products

Gasoline and Diesel Oil

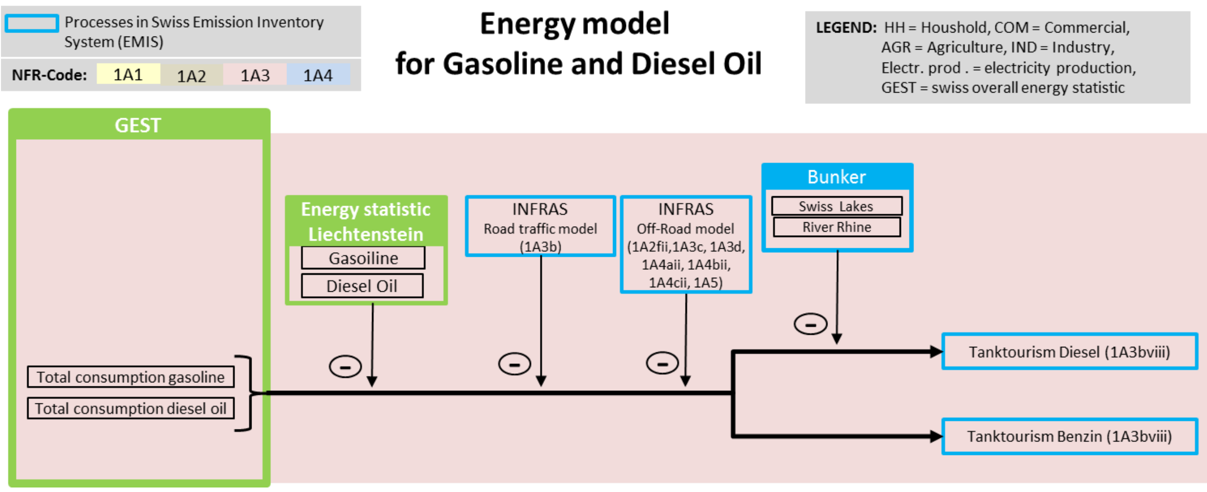


Figure 3-13 Schematic disaggregation of 1A Fuel Consumption for gasoline and diesel oil.

Gasoline and diesel oil consumption is reported in several source categories. In addition to the information provided above, the following sources are used for the disaggregation of gasoline and diesel oil consumption:

- As with other fuels, the Swiss overall energy statistics provides information the amounts sold; from these the consumptions of gasoline and diesel oil modelled by the territorial models (INFRAS 2008 and 2010, see above) are subtracted. The differences to the amount of fuels sold represent the tank tourism of gasoline and diesel oil which are reported under 1A3bviii.
- The customs statistics allow to quantify the amount of marine bunker fuels of diesel oil consumed by navigation on the river Rhine between Basel (Switzerland) and Rotterdam (Netherlands) and on two lakes with international navigation. See Chapter 3.2.2 for further details.

Further information on the transport sector is provided in chapter 3.2.8.

3.2.5.2 Emission Factors

The different sources categories within source category 1A Fuel Combustion are characterised by rather similar industrial combustion processes and thus the same emission factors are applied throughout 1A for the main fuels. Emission factors for fuels that are only used in one particular source category are described in the context of that particular source category.

CO_2 Emission Factors

Table 3-9 CO_2 Emission Factors and NCV from 1990 to 2012.

CO_2 Emission Factors 1990 - 2012				
Fuel	**t CO_2 / TJ**	**NCV [GJ/t]**	**CS/D**	**Data Sources**
Gasoline	73.9	42.5	CS	EMPA (1999)
Jet Kerosene	73.2	43.0	CS	EMPA (1999)
Diesel Oil	73.6	42.8	CS	EMPA (1999)
Gas Oil	73.7	42.6	CS	EMPA (1999)
Residual Fuel Oil	77.0	41.2	CS	EMPA (1999)
P-Coke	91.4	31.8	CS	FOEN (2011k)
Liquefied Petroleum Gas	65.5	46.0	CS	FOEN (2011k)
Natural Gas	56.1	46.5	D	IPCC Guidelines 2006
Bituminous Coal	92.7	25.5	CS	FOEN (2011k)
Lignite	96.1	23.6	CS	FOEN (2011k)
Biofuel	**t CO_2 / TJ**	**NCV [GJ/t]**	**CS/D**	**Data Sources**
Biodiesel	73.6	42.8	CS	assumed equal to diesel oil
Bioethanol	73.9	42.5	CS	assumed equal to gasoline
Biogas	56.1	46.5	D	assumed equal to natural gas
Wood	92.0	-	CS	SAEFL (2000)

CO_2 emission factors and NCV values for gasoline, jet kerosene, diesel oil, gas oil and residual fuel oil are country specific and are based on measurement campaigns of NCV and carbon content of fuels (EMPA 1999, Intertek 2008, Intertek 2012). The values from the 1998 study of EMPA are used for the entire period since 1990. According to expert judgment from the Swiss Petroleum Association, the natural variability of the products is much larger than the measurement uncertainty provided in the studies. Accordingly adjusting the emission factors every couple of years seems inappropriate given the variability between the samples. Therefore, only spot checks are made periodically to verify that the values of the 1998 study are still applicable, without changing the values if considered compatible with the 1998 study. The latest measurements in 2011 revealed a few deviations from the 1998 values that seemed to exceed the expected range. However, based on the small sample number (10 samples) and the large variations observed, the changes were not statistically significant. The results triggered the launch of a new measurement campaign that was set up over the past year. This on-going measurement campaign will be based on a representative sample which covers summer and winter samples from the main import streams. The sampling started in July 2013 and will carry on for six months. Fortnightly samples are going to be taken from nine different sites (large-scale storage facilities and the two Swiss refineries). Preliminary information confirms that there is no change in the CO_2 emission factors. Final results are expected in summer 2014 and will be available for the 2015 submission. After completion of the entire campaign, the use of NCV and CO_2-EF will be re-assessed (both for the greenhouse gas inventory and the energy statistics of the SFOE).

For liquefied petroleum gas, the values are country specific and based on the CRC Handbook of Chemistry and Physics (see documentation in FOEN 2011k).

For natural gas, the default values of the 2006 IPCC guidelines are used (IPCC 2006).

CO_2 emission factors and NCV values of petroleum coke, bituminous coal and lignite are country specific and based on samples that were taken from Switzerland's cement plants. Cement plants are the largest consumer of solid fossil fuels in Switzerland. The samples from the individual plants were compiled over nine months and have been analysed for calorific value and carbon content by an independent analytical laboratory. The original data is compiled in an internal document from cemsuisse. The results from the individual plants were weighted according to the relative contribution of each plant. The CO_2 emission factors are lower than the IPCC default values (IPCC 2006), however, they all lie within the range provided by the IPCC (see documentation in FOEN 2011k).

Regarding the small amount of biofuels used in Switzerland, the CO_2 emission factors and NCV values are taken from the respective fossil fuels that are being substituted by the respective biofuel. Therefore the values for biodiesel, bioethanol and biogas are assumed to be equal to the ones of diesel oil, gasoline and natural gas, respectively.

CO_2 emission factor for wood combustion is country specific and provided from the handbook of emission factors for stationary sources (SAEFL 2000) as documented in the respective EMIS comment (EMIS 2014/1A Holzfeuerungen). Since the NCV of wood depends on the wood product used as fuel (log wood, wood chips, pellets) it is not displayed in the table above but is reported in the Swiss wood energy statistics (SFOE 2013b).

For off-road activities the emission factors for CO_2 are country specific and assumed to be constant in the period 1990-2012 with values 73.6 t/TJ for diesel oil, 73.9 t/TJ for gasoline and 56.1 t/TJ for CNG (equal to natural gas). See also Table 3-9.

Note that specific emission factors in the unit of kg/h may be downloaded by query from the public part of the off-road database INFRAS (2008)[7].

Please note that the CO_2 emission factors and NCV values are constant over the whole period 1990-2012.

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

Liquid fuels:
Total uncertainty of net calorific values (NCVs) for liquid fuels is taken as a proxy for the uncertainty of the CO_2 emission factor of liquid fuels. Net calorific values are based on the determination of the gross calorific value and the calculation of the net calorific value by EMPA. To this aim, a set of fuel samples of different sources has been selected that is representative for the fuels traded in Switzerland in the year 1998. Assuming that this data on the uncertainty of the net calorific value is representative for the uncertainty of the emission factors in fuel combustion, a combined uncertainty of 0.51% (defined as two standard deviations, STD) results for the emission factor.

[7] http://www.bafu.admin.ch/luft/00596/06906/offroad-daten/index.html?lang=en [24.01.2012]

Table 3-10 Results from the analysis of the net calorific values of liquid fuels in Switzerland (EMPA 1999).

A	B	C	D		E	F	G
Fuel	**Net calorific value liquid fuels**						
	Mean [GJ/t]	STD [GJ/t]	STD [%]	Uncertainty [%]	=(C*G)^2 [GJ^2/t^2]	No. of samples []	Share 2012 (approx.)
Heavy fuel oil	41.2	0.85	2.06	4.13	0.000010	6	0%
Light fuel oil	42.6	0.13	0.31	0.61	0.002891	10	41%
Diesel	42.8	0.10	0.23	0.47	0.000707	10	27%
Gasoline	42.5	0.29	0.68	1.36	0.007966	30	31%
Jet kerosene	43.0	0.25	0.58	1.16	0.000004	10	1%
Sum	42.6				0.011579	66	100%
Combined STD/Unc		0.108	0.25	0.51			

Gaseous fuels:
The uncertainty of the emission factor for CO_2 has been derived from data on measurements of the NCVs of natural gas in the grid. SGWA (2007) provides a range of -2.3% and +2.3%. Interpreting 2.3% as one standard deviation, an uncertainty of 4.6% results (i.e. two standard deviations).

Solid fuels:
For the uncertainty of the emission factor for CO_2, the IPCC Good Practice Guidance default value of 5% for countries with well-developed energy data systems is used (IPCC 2000: p. 2.15).

Other fuels (waste to energy):
The dominant factor influencing the uncertainty of CO_2 emissions from municipal solid waste incineration (1A1) is the fraction of fossil carbon in the waste. For the fraction of C in incinerated waste an uncertainty of 20% has been estimated, and for the fraction of fossil C in total C an uncertainty of 10% has been estimated, resulting in a preliminary uncertainty estimate of 30% for the waste incineration CO_2 emission factor (SAEFL 2005h).

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

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

Table 3-11 Results from Tier 1 uncertainty calculation and reporting for CO_2 emissions in 1A Fuel Combustion.

A		B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category		Gas	Base year emissions 1990	Year 2012 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emission in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
1A1 1. Energy A. Fuel Combustion 1. Energy Industries	Gaseous Fuels	CO2	289.73	498.74	2.0	4.6	5.0	0.050	0.0042	0.0098	0.02	0.03	0.03
1A1 1. Energy A. Fuel Combustion 1. Energy Industries	Liquid Fuels	CO2	693.69	805.16	1.3	0.5	1.4	0.022	0.0024	0.0158	0.00	0.03	0.03
1A1 1. Energy A. Fuel Combustion 1. Energy Industries	Solid Fuels	CO2	44.84	0.00	5.9	5.0	7.7	0.000	-0.0009	0.0000	0.00	0.00	0.00
1A1 1. Energy A. Fuel Combustion 1. Energy Industries	Other Fuels	CO2	1'519.73	2'714.50	10.0	30.0	31.6	1.706	0.0238	0.0533	0.71	0.75	1.04
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons	Gaseous Fuels	CO2	1'074.09	2'096.41	2.0	4.6	5.0	0.209	0.0203	0.0411	0.09	0.12	0.15
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons	Liquid Fuels	CO2	3'692.22	2'640.18	1.3	0.5	1.4	0.073	-0.0197	0.0518	-0.01	0.09	0.09
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons	Solid Fuels	CO2	1'204.47	454.87	5.9	5.0	7.7	0.070	-0.0144	0.0089	-0.07	0.07	0.10
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons	Other Fuels	CO2	134.15	288.60	10.0	30.0	31.6	0.181	0.0031	0.0057	0.09	0.08	0.12
1A3a 1. Energy A. Fuel Combustion 3. Transport; Civil Aviation		CO2	252.55	136.65	2.2	1.2	2.5	0.007	-0.0022	0.0027	0.00	0.01	0.01
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation	Diesel	CO2	2'587.68	6'767.05	2.2	0.5	2.2	0.301	0.0826	0.1328	0.04	0.41	0.41
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation	Gasoline	CO2	11'335.27	9'016.58	2.2	1.4	2.6	0.462	-0.0426	0.1769	-0.06	0.55	0.55
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation	Natural Gas	CO2	0.00	83.59	3.5	3.5	5.0	0.008	0.0016	0.0016	0.01	0.01	0.01
1A3c 1. Energy A. Fuel Combustion 3. Transport; Railways	Liquid Fuels	CO2	28.69	39.69	1.3	0.5	1.4	0.001	0.0002	0.0008	0.00	0.00	0.00
1A3d 1. Energy A. Fuel Combustion 3. Transport; Navigation		CO2	111.93	121.14	2.2	0.5	2.3	0.005	0.0002	0.0024	0.00	0.01	0.01
1A3e 1. Energy A. Fuel Combustion 3. Transport; Other non-specified		CO2	31.42	45.44	2.2	4.5	5.0	0.005	0.0003	0.0009	0.00	0.00	0.00
1A4a 1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institut	Gaseous Fuels	CO2	987.24	1'482.76	2.0	4.6	5.0	0.148	0.0100	0.0291	0.05	0.08	0.09
1A4a 1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institut	Liquid Fuels	CO2	4'606.43	3'038.51	1.3	0.5	1.4	0.084	-0.0296	0.0596	-0.02	0.11	0.11
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential	Gaseous Fuels	CO2	1'424.38	2'649.60	2.0	4.6	5.0	0.264	0.0244	0.0520	0.11	0.15	0.18
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential	Liquid Fuels	CO2	10'248.79	7'374.50	1.3	0.5	1.4	0.204	-0.0537	0.1447	-0.03	0.26	0.27
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential	Solid Fuels	CO2	54.59	33.60	5.9	5.0	7.7	0.005	-0.0004	0.0007	0.00	0.01	0.01
1A4c 1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	41.45	18.48	2.0	4.6	5.0	0.002	-0.0004	0.0004	0.00	0.00	0.00
1A4c 1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	547.34	540.01	1.3	0.5	1.4	0.015	0.0000	0.0106	0.00	0.02	0.02
1A5 1. Energy A. Fuel Combustion 5. Other	Liquid Fuels	CO2	203.58	114.80	1.3	0.5	1.4	0.003	-0.0017	0.0023	0.00	0.00	0.00

CH_4 Emission Factors

Table 3-12 CH_4 Emission Factors from 1990 to 2012.

CH_4 Emission Factors 1990 - 2012			
Fuel	**g CH_4 / GJ**	**CS/D**	**Data Sources**
Gas Oil	1.0	CS	SAEFL (2000)
Residual Fuel Oil	4.0	CS	SAEFL (2000)
P-Coke	10.0	D	*
Liquefied Petroleum Gas	1.0	D	IPCC Guidelines 2006
Natural Gas	6.0	CS	SAEFL (2000)
Bituminous Coal	10.0	D	IPCC Guidelines 2006
Lignite	10.0	D	IPCC Guidelines 2006
Biofuel	**g CH_4 / GJ**	**CS/D**	**Data Sources**
Wood	2.8-230	CS	Nussbaumer, T., Boogen, N. (2010)

**This emission factor is still the same as for Coal because in previous submissions P-Coke was not reported separately. In Submission 2015 it has to be corrected to IPCC default value.*

CH_4 emission factors for gas oil, residual fuel oil, and natural gas are country specific and provided from the handbook of emission factors for stationary sources (SAEFL 2000).

For liquefied petroleum gas, P-coke, bituminous coal and lignite default values from the 2006 IPCC guidelines are used (IPCC 2006).

The CH_4 emission factors from wood combustion are country specific and have been modelled based on FID measurements from a series of wood combustion plants at various conditions (Nussbaumer, T., Boogen, N. 2010, unpublished). They vary between 2.8 and 230 g CH_4/GJ depending on the combustion installation, rated thermal input and technology used and thus decrease over time as result of improved technology.

For road transportation, the CH_4 emission factors are country specific; they are calculated as a fraction of hydrocarbon (HC) emissions, which in turn have been established through specialised measurement programmes (INFRAS 2010). The share of CH_4 in HC emissions is differentiated by emission concept (INFRAS 2004). For mobile off-road machinery, the CH_4 emission factor is country specific as well; it is based on VTT (2004) for diesel engines and EMPA (2004) for gasoline two- and four-stroke engines.

Please note that the CH_4 emission factors and NCV values are constant over the whole period 1990-2012. Only for wood combustion and road transportation, the CH_4 emission factors are not constant; they decrease over time as a result of improved technology (e.g. improved wood furnances).

N_2O Emission Factors

Table 3-13 N_2O Emission Factors from 1990 to 2012.

N_2O Emission Factors 1990 - 2012			
Fuel	**g N_2O / GJ**	**CS/D**	**Data Sources**
Gas Oil	0.6	CS	SAEFL (2000)
Residual Fuel Oil	0.8	CS	SAEFL (2000)
P-Coke	1.6	CS	*
Liquefied Petroleum Gas	0.1	D	IPCC Guidelines 2006
Natural Gas	0.1	D	IPCC Guidelines 2006
Bituminous Coal	1.6	CS	SAEFL (2000)
Lignite	1.6	CS	SAEFL (2000)
Biofuel	**g N_2O / GJ**	**CS/D**	**Data Sources**
Wood	1.6	CS	SAEFL (2000)

**This emission factor is still the same as for Coal because in previous submissions P-Coke was not reported separately. In Submission 2015 it has to be corrected to IPCC default value.*

The N_2O emission factors for gas oil, residual fuel oil, P-coke, bituminous coal, lignite and wood are country specific and provided from the handbook of emission factors for stationary sources (SAEFL 2000).

Default values from the 2006 IPCC guidelines are used for liquefied petroleum gas and natural gas(IPCC 2006).

For road transportation, N_2O emission factors are taken from the COPERT IV model (Gkatzoflias et al. 2012). For mobile off-road machinery, the (country-specific) N_2O emission factors are based on SAEFL (1996).

Please note that the N_2O emission factors and NCV values are constant over the whole period 1990-2012. Only for road transportation, the N_2O emission factors are not constant; they decrease over time as a result of technical improvements such as the further development of catalyst technologies.

Oxidation Factors

For the emission calculation, an oxidation factor of 100% is assumed for all fossil fuel combustion processes. A first reason for this is that technical standards for combustion installations in Switzerland are high. A second reason is that the small fraction of originally non-oxidised carbon retained in ash, particulates or soot is likely to be oxidized later naturally due to degradation processes.

As the fuel consumption of gaseous fuels strongly increased (1990 to 2012: +78.6% from 68’597 to 122’549 TJ), overestimation of oxidation factors for gaseous fuels would lead to overestimation of emission increase and would therefore be conservative. As the consumption of liquid fuels decreased (1990 to 2012: 10.6% from 465’212 to 416’051 TJ) overestimating of oxidation factors for liquid fuels would tend to overestimate emission reduction and would therefore not be conservative. Because of the reasons mentioned above for the assumption of an oxidationz factor of 100%, the possible overestimation of emission decrease is considered to be of minor importance.

For coal, IPCC 1996 provides a global average oxidation factor of 98.0%. In Switzerland, the consumption of coal plays a minor role (0.8% of total energy consumption in 2012) and decreased significantly over the considered period (1990 to 2011 by 62.8% from 14’055 to 5’226 TJ). In case of a decrease, overestimating of oxidation factors may tend to overestimate emission decrease. The main remaining consumer of coal in Switzerland is the cement industry that accounts for 80% of total Swiss coal consumption in 2012 (EMIS 2014/1A2fi Zementwerke Feuerung). According to EU guidelines, the oxidation factor in cement production is assumed to be 100% (EC 2004). Given the large share of coal used in cement production, and under the assumption of high efficiency boilers, the overestimation of emission decrease may become minor.

Therefore, for all fuel combustion activities, an oxidation factor of 100% is assumed in Switzerland. This is also confirmed by the EU and Swiss guidelines for the Emission Trading System, where an default oxidation factor of 100% is applied.

3.2.5.3 Emissions from Biomass

CO_2 emissions from biomass do not count for the national total emissions and are therefore a memo item only. The CO_2 emissions from biomass in the CRF-tables are incomplete and the following CO_2 emissions are not foreseen for reporting in the CRF-tables: 2D2 Food and Drink, 3D5 Consumption of tobacco, 6A Solid Waste Disposal on Land, 6B Wastewater Handling and 6D Composting and Fermentation of Waste.

The following table provides an overview of effective biomass CO_2 emissions in Switzerland in 2012 and their reporting in the CRF-tables (without land-use, land-use change and forestry). Data regarding waste incineration is provided by FOEN 2013j. Data for CO_2 emissions from wood combustion is provided from Swiss Wood Energy Statistics (SFOE 2013b) for activity data and from the handbook of emission factors for stationary sources (SAEFL 2000) and Nussbaumer, T., Boogen, N. 2010 for emission factors as documented in the chapter above. For 2D and 3D, the data is provided by industry and expert estimates as documented in the respective EMIS 2014. Also emissions from Solid waste disposal on land (6A) and Other waste (6D) are based on specific data as documented in the respective EMIS. Data on waste water handling is provided by SFOE 2013a. For further information on the biomass CO_2 emissions refer to the respective source category chapters below.

Table 3-14 Effective biomass CO_2 emissions in Switzerland in 2012 and their representation in the CRF-tables.

Biomass CO_2 emissions	Unit	2012	Note
1A1 Energy Industries (without MSW incineration)	Gg	599	Included in CRF
1A1 Energy generation from MSW Incineration	Gg	2'549	Included in CRF
1A2d Use of waste derived fuels in cellulose production	Gg	0	Included in CRF
1A2f Manufacturing Industry and Construction	Gg	1'209	Included in CRF
thereof use of waste derived fuels in cement production	Gg	49	
1A3 Transport	Gg	44	Included in CRF
1A4 Other Sectors (Commercial/Institutional, Residential)	Gg	2'403	Included in CRF
2D Food and Drink	Gg	15	Not included in CRF
3D Consumption of tabacco	Gg	13	Not included in CRF
6A Solid Waste Disposal on Land	Gg	25	Not included in CRF
6B Wastewater Handling	Gg	136	Not included in CRF
6C Waste Incineration (without MSW incineration)	Gg	137	Included in CRF
6D Other Waste (compost and fermentation of waste)	Gg	353	Not included in CRF
Total biomass combustion CO_2 emissions included in CRF	Gg	6'941	
Total energy related biomass combustion CO_2 emissions included in CRF 1A	Gg	6'804	See table "Summary 2" in CRF
Total biomass CO_2 emissions in Switzerland in 2011	Gg	7'483	

3.2.6 Source Category 1A1 - Energy Industries

3.2.6.1 Source Category Description

Tier 1 Key categories 1A1
CO_2 from the combustion of Liquid Fuels (level and trend)

CO_2 from the combustion of Gaseous Fuels (level and trend)

CO_2 from the combustion of Other Fuels (level and trend)

Tier 2 Key categories 1A1
CO_2 from the combustion of Other Fuels (level and trend)

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

In Switzerland, fuel extraction is virtually not occurring (apart from a very small charcoal production activity (traditional and historic craft)). Source category 1A1 includes therefore primarily emissions from the production of heat and/or electricity for sale to the public. Energy Industries (source category 1A1) comprise:

- Public Electricity and Heat Production including heat and power production in municipal solid waste incineration plants and special waste incineration (1A1a)
- Petroleum Refining (1A1b)
- Charcoal production within Manufacture of Solid Fuels and Other Energy Industries (1A1c)

Emissions from the industry producing heat and/or electricity for their own use are included in category 1A2 Manufacturing Industries and Construction. Emissions from producers of heat and/or power for their own use in waste incineration plants, however, are included in 1A1a.

In Switzerland, electricity production is dominated by hydroelectric power plants (59%) and nuclear power stations (35%). Fossil fuelled combined heat and power generation (CHP) provide 3% of electricity production. Power generation from renewable energy sources as solar, wind and biomass account only for about 3% of the electricity generated in Switzerland (SFOE 2013; table 24; data for the year 2012).

Table 3-15 Specification of source category 1A1 Energy Industries.
EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

1A1	Source	Specification	Data Source
1A1a	Public Electricity and Heat Production	Main source are waste incineration plants with heat and power generation (Other fuels) and public district heating systems, including a small fraction of combined heat and power. The only fossil fuelled public electricity generation unit "Vouvry" (300 MW_e; no public heat production) ceased operation in 1999.	Waste incineration: AD: FOEN 2013j; EMIS 2014/1A1a EF: Mohn 2011; Mohn 2013; EMIS 2014/1A1a Other sources: AD: SFOE 2013; SFOE 2013a; SFOE 2013b; EV 2013; EMIS 2014/1A1a EF: EMPA 1999; Intertek 2008; Intertek 2012; FOEN 2011k; IPCC 2006; EMIS 2014/1A Holzfeuerungen; SAEFL 2000; Nussbaumer, T., Boogen, N. 2010; EMIS 2014/1A1a
1A1b	Petroleum Refining	Combustion activities supporting the refining of petroleum products, excluding evaporative emissions.	AD: EV 2013, SFOE 2013 EF: Industry data
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Charcoal production	AD / EF: EMIS 2013/1A1c

3.2.6.2 Methodological Issues

a) Public Electricity and Heat Production (1A1a)

The public electricity and heat production in Switzerland includes:

- Fossil fuel combustion of gas oil, residual fuel oil, natural gas and coal.
- Waste-to-energy through the incineration of municipal solid waste and special waste (Other fuels)
- Biomass combustion includes wood and renewable waste and biogas generation from co-generation of landfills and fermentation engines

Methodology

The method applied within Public Electricity and Heat Production (1A1a) is country specific.

As explained in chapter 3.2.5, a country specific Tier 2 top-down approach based on aggregated fuel consumption data from the Swiss overall energy statistics is used to calculate emissions. For waste incineration, direct data from the incineration plants is used.

Emissions of GHGs are calculated based on the following methodology:

- For fossil fuel combustion, GHGs are calculated by multiplying fuel consumption (in TJ) by emission factors.
- For heat and/or power generation in municipal solid waste and special waste incineration plants the GHG emissions are calculated by multiplying the waste quantity incinerated by emission factors.
- For fermentation engines and co-generation on landfills the GHG emissions are calculated by multiplying quantities of combusted CH_4 by emission factors.

- For wood combustion in district combined heat and power units and plants for renewable waste from wood products the GHG emissions are calculated by multiplying the used wood chips and wood waste quantities by emission factors.

Emission Factors

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

Table 3-16 Emission Factors for 1A1a Public Electricity and Heat Production in Energy Industries in 2012. Grey shaded cells mark general emission factors as described in section 3.2.5.2.

1A1a Public Electricity/Heat	CO_2	CO_2 bio.	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	t/TJ	t/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
Gas oil	73.7		1.0	0.6	35	7	2.0	22
Residual fuel oil	77.0	0	4.0	0.8	125	13	4.0	291.0
Petroleum coke	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	56.1		6.0	0.1	19	11	2.0	0.5
Other (waste-to-energy), fossil	103.4		NA	2.6	33	7	1.1	4
Other (waste-to-energy), biogenic		110.6	NA	2.4				
Biomass (wood, renewable waste)		65.1	1.9	1.6	162	283	6.4	20
Biogas (co-generation from landfills, fermentation engines)		99.7	2	0.100	49	67	2.9	15

Emission factors highlighted in grey are explained in section 3.2.5.2. The study mentioned in 3.2.5.2 also included emission factors for NO_x, CO, NMVOC and SO_2.

Specific emission factors for 1A1a Public Electricity and Heat Production in Energy Industries are:

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

Emission factors of Other (waste-to-energy) corresponds to emission occurring in waste incineration with heat and/or power generation (reported under "Other fuels"). The emission factors for CO_2, N_2O, NO_x, CO, NMVOC and SO_2 emissions per ton of waste incinerated are country specific and based on measurements and expert estimates, as documented in EMIS 2014/1A1a Kehricht- und Sondermüllverbrennungsanlagen. Emission factors are taking into account flue gas cleaning standards in incineration plants. In addition, the burn-out efficiency in modern municipal solid and special waste incineration plants is very high.

CO_2 emission factors for other fuels fluctuate over the period 1990-2012. The emission factor of municipal waste incineration changes because of gradual changes in the biogenic fraction and small variations of the net calorific values of the waste. From 1990 till 1997, the emission factor gradually decreased and stabilised until 2005. From 2006 onwards, the emission factor is stable. Emission factor of special waste is constant over time. See respective documentation in EMIS 2014/1A1a Kehricht- und Sondermüllverbrennungsanlagen.

Regarding the percentage of fossil CO_2 within waste incineration, a study conducted by the Swiss Federal Laboratories for Materials Testing EMPA evaluated the waste incinerated in Switzerland (national and imported waste, Mohn 2011). Based on this information, the share of organic matter in the waste incinerated in MSW incineration plants is estimated to be 52.2% in 2012 (see documentation in EMIS 2014/1A1a Kehrichtverbrennungsanlagen).

Emissions of CH_4 are not occurring because of the high combustion temperatures in waste incineration plants.

N_2O emission factor is divided into fossil and biogenic emissions from waste incineration of municipal waste and special waste. The fossil emission factor is based on two processes: municipal waste incineration and special waste incineration. The biogenic emission factor includes only municipal waste incineration as special waste is considered not to be biogenic. In 2013, a study by EMPA has evaluated measurements that have been performed in the years 2010-2011 in five Swiss municipal waste incineration plants (MWIP, Mohn 2013).

Emission factors have been calculated according to the state of equipment of all the Swiss waste incineration plants (with two types of Denox-equipment (SCR, SNCR[8]) and without Denox-equipment). The emission factor is therefore not constant over time and decreases from 5.3 g/GJ in 1990 to 2.4 g/GJ in 2012 based on the installation of Denox-equipment in the Swiss municipal waste incineration plants. See respective documentation in EMIS 2014/1A1a Kehricht- und Sondermüllverbrennungsanlagen.

(b) Public Electricity and Heat Production from biogas

Emission factors for biogas is country specific and composed by four underlying processes: landfill engines, engines and boilers in agricultural fermentation plants and engines in industrial fermentation plants (see documentation in EMIS 2014/1 A 1 a und 6 D_Vergärung LW and EMIS 2014/1 A 1 a und 6 D_Vergärung IG). The emission factors displayed in Table 3-16 are a weighted mean value of these four processes.

CO_2 emission factor is provided by a study realised on behalf of SFOE based on measurements in several agricultural installations and a respective life-cycle assessment for electricity production from agricultural biogas (see documentation in EMIS 2014/1 A 1 a und 6 D_Vergärung LW and EMIS 2014/1 A 1 a und 6 D_Vergärung IG).

CH_4 emission factor for landfill engines corresponds to industrial gas engines reported in SAEFL 2000. The other CH_4 emission factor have been evaluated in 2009. Fermentation engines are based on a study realised on behalf of SFOE for the values until 2000 and expert judgement from 2000 onwards (see documentation in EMIS 2014/1 A 1 a und 6 D_Vergärung LW and EMIS 2014/1 A 1 a und 6 D_Vergärung IG). For agricultural fermentation boiles, the emission factor is provided by a study developed by Wolfgang Butz (see documentation in EMIS 2014/1 A 1 a und 6 D_Vergärung LW).

N_2O emission factors of biogas is considered to be the same as for natural gas engines in commercial and institutional buildings that corresponds to the IPCC default value for natural gas (IPCC 2006).

Alls emission factors described above are listed in Table 3-16.

Activity Data

Activity data for the different fuels is determined as described in chapter 3.2.5.1. This includes gas oil, residual fuel oil, natural gas and biomass. For the solid fuels bituminous coal and lignite, activity data is provided from the Swiss overall energy statistics (SFOE 2013). Other fuel is calculated from the annual amount of waste incinerated producing heat and/or electricity (seeTable 3-18). Activity data for co-generation from landfills and fermentation engines is taken from the Swiss renewable energies statistics (SFOE 2013a).

[8] SCR: Selective Catalytic Reduction SCR, SNCR: Selective Non Catalytic Reduction

Table 3-17 Activity data in 1A1a Public Electricity/Heat.

1A1a Public Electricity /Heat	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total fuel consumption	TJ	41'175	42'131	44'053	39'231	38'874	39'902	42'895	43'712	48'995	50'152
Gas oil	TJ	980	1'790	1'917	1'662	810	554	810	1'065	852	1'065
Residual fuel oil	TJ	3'195	5'006	6'336	1'748	1'541	1'791	2'420	1'063	4'093	1'227
Petroleum coke	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	TJ	5'165	5'249	5'239	5'229	5'472	6'137	7'468	7'828	7'701	9'998
Bituminous coal	TJ	484	102	102	51	76	51	0	0	0	0
Lignite	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other (waste-to-energy), fossil	TJ	13'874	13'363	13'718	13'379	13'842	14'029	14'492	15'396	16'899	17'514
Other (waste-to-energy), biogenic	TJ	16'895	16'006	15'967	16'216	16'038	16'235	16'419	17'265	18'386	19'270
Biomass (wood, renewable waste)	TJ	301	297	360	404	441	466	636	466	431	412
Biogas (co-generation from landfills, fermentation engines)	TJ	282	320	414	542	653	639	650	629	633	665

1A1a Public Electricity /Heat	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total fuel consumption	TJ	50'821	52'743	53'622	54'619	55'695	57'983	61'288	58'916	60'141	59'196
Gas oil	TJ	810	852	810	1'065	810	1'321	1'278	810	469	554
Residual fuel oil	TJ	314	371	377	455	350	289	297	242	158	124
Petroleum coke	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	TJ	9'109	9'493	9'691	10'470	10'471	10'560	9'379	8'571	9'160	8'739
Bituminous coal	TJ	0	0	0	0	0	0	0	0	0	0
Lignite	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other (waste-to-energy), fossil	TJ	18'564	18'995	19'321	19'559	20'492	21'551	24'023	23'506	24'144	23'675
Other (waste-to-energy), biogenic	TJ	20'807	21'814	22'164	21'740	22'294	22'956	24'857	23'699	23'199	22'427
Biomass (wood, renewable waste)	TJ	547	583	689	774	813	844	943	1'462	2'316	2'881
Biogas (co-generation from landfills, fermentation engines)	TJ	671	634	570	556	465	461	511	626	695	796

1A1a Public Electricity /Heat	Unit	2010	2011	2012
Total fuel consumption	TJ	63'489	61'525	65'417
Gas oil	TJ	512	426	810
Residual fuel oil	TJ	52	7	8
Petroleum coke	TJ	NO	NO	NO
Natural gas	TJ	10'715	8'170	8'890
Bituminous coal	TJ	0	0	0
Lignite	TJ	NO	NO	NO
Other (waste-to-energy), fossil	TJ	25'280	25'403	26'262
Other (waste-to-energy), biogenic	TJ	22'997	22'444	23'051
Biomass (wood, renewable waste)	TJ	2'964	3'988	5'025
Biogas (co-generation from landfills, fermentation engines)	TJ	969	1'086	1'370

The table above shows that in 2012 Other fuels are the major component with 75% of the total fuel consumptions. The fossil fuels contribute with a total of 15% while natural gas has the major contribution with 92% of the total fossil fuel contribution in this source category. Biomass and Biogas contribute with 10% to the total fuel consumption.

The table above documents the increase of Other Fuel consumption (fossil) by 89% from 1990 to 2012. Overall, Other Fuels increased by 60%. This increase is the reason for category 1A1 Other Fuels – CO_2 being a key category regarding trend. See further explanations on this source category below.

The consumption of natural gas increased by 72% and the consumption of liquid fuels decreased by 17% for gas oil and 100% for residual fuel oil. These developments are due to shift in fuel use of combined heat and power generation in Switzerland and show why the CO_2 emissions from liquid and gaseous are key categories regarding trend in this submission.

Municipal solid waste incineration ("Other fuels")

Figure 8-4 in Sector 6 Waste shows an overview of the type of treatment and amounts of waste fractions reported in the different sectors in Switzerland.

Municipal solid waste includes waste generated in households and waste from other sources of similar composition. Energy recovery from municipal solid waste incineration is mandatory in Switzerland and plants are equipped with energy recovery systems (Schwager 2005). The emissions from heat and/or power generation in municipal solid waste incineration plants are therefore reported under category 1A1a. Included are also emissions from the incineration of special waste, because these plants are also equipped with energy recovery systems. Activity data for waste incineration is taken from FOEN 2013j and provided in the table below.

Special waste is composed by special waste with high calorific value, wastewater and sludge with organic load, inorganic solids and dusts, inorganic sludge containing heavy metals, acids and alkalis, PCB-containing wastes, non-metallic shredder residues, contaminated soil, filter materials and chemicals residues and others.

Table 3-18 Activity data for 1A1a Other fuels: municipal solid waste and special waste incinerated with heat and/or power generation 1990 to 2012.

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

Source/fuel	**Unit**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1A1a Other fuels											
Total Other fuels in 1A1a	Gg	3'040	3'163	3'258	3'226	3'366	3'527	3'896	3'816	3'865	3'827
Municipal solid waste	Gg	2'801	2'936	3'027	2'995	3'135	3'297	3'646	3'580	3'610	3'597
Special waste	Gg	239	227	232	231	231	230	250	236	255	230

Source/fuel	**Unit**	**2010**	**2011**	**2012**
1A1a Other fuels				
Total Other fuels in 1A1a	Gg	3'968	3'924	4'104
Municipal solid waste	Gg	3'717	3'676	3'841
Special waste	Gg	252	247	263

The table above documents the increase by 56% of municipal solid waste and 97 % of special waste incinerated from 1990 to 2012. This is due to the fact that since 1st of January 2000, disposal on landfill sites of waste which can be incinerated is prohibited by law (TVA Art. 32). See also Chapter 8.4 on Waste Incineration. The increase is also partly due to municipal solid waste imported from neighbouring countries to optimize the load factor of MSW incineration plants.

This increase results in CO_2 emissions from Other fuels in category 1A1 being a key category regarding trend.

b) Petroleum Refining (1A1b)

Methodology

For fuel combustion in Petroleum Refining (1A1b), a country specific Tier 2 bottom-up method is used. The calculations are based on measurements and data from individual sources from the refining industry.

The emissions are calculated by multiplying the fuel consumption by the respective emission factor.

Emission Factors

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

Table 3-19 Emission Factors for 1A1b Petroleum Refining in 2012.

Source/fuel	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	t/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
1A1 b Petroleum Refining							
Residual fuel oil	77	4	0.8	110	15	2.5	490
Gas (refinery LPG)	59.8	1	0.6	55	15	2.3	25
P-Coke	91.4	10	1.6	200	100	10.0	500

Emission factors of residual fuel oil and P-Coke (highlighted in grey) are explained in section 3.2.5.2. The study mentioned in this chapter also included emission factors for NO_x, CO, NMVOC and SO_2.

Regarding the emission factor of refinery gas, no regular measurements are available. In 2010, one refinery provided specific information on refinery gas composition over three successive years. Swiss value is higher than IPCC default, but lies in the given range.

Activity Data

Activity data on fuel combustion (TJ) for Petroleum Refining (1A1b) is extracted from the Annual Reports of the Swiss Petroleum Association (EV 2013).

Table 3-20 Activity data for 1A1b Petroleum Refining.

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

Source/fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1A1b Petroleum Refining Fuel Consumption											
Total	TJ	10'091	10'909	11'447	10'525	14'257	14'395	15'814	13'482	14'841	14'200
Residual fuel oil	TJ	1'952	1'936	1'518	1'769	1'339	906	692	1'159	707	742
Gas (refinery LPG)	TJ	8'139	8'973	9'929	8'756	11'901	11'678	13'311	10'766	11'687	11'424
Petroleum coke	TJ	0	0	0	0	1'017	1'811	1'811	1'557	2'447	2'034

Source/fuel	Unit	2010	2011	2012
1A1b Petroleum Refining Fuel Consumption				
Total	TJ	13'912	12'969	11'162
Residual fuel oil	TJ	895	776	1'228
Gas (refinery LPG)	TJ	11'015	10'508	8'154
Petroleum coke	TJ	2'002	1'684	1'780

The table above documents gas (refinery liquefied petroleum gas) as the major fuel used in source category 1A1b with a contribution of 73% in 2012. Because of the increase of consumption for petroleum refining by 77% from 1990 to 2012, gas (refinery liquefied petroleum gas) is key category regarding trend in the present submission. This is explained by the fact that in 1990 one of the two Swiss refineries operated at reduced capacity and in later years resumed full production, leading to higher fuel consumption in the following years.

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

In 2012, one of the refineries was closed over six month based on the debt restructuring and the search for a new buyer, which explains the lower fuel consumption in 2012 (EV 2013).

c) Manufacture of Solid Fuels and Other Energy Industries (1A1c)

Methodology

In source category 1A1c Manufacture of Solid Fuels and Other Energy Industries the emissions from charcoal production are reported. A country specific Tier 2 bottom-up method is used. Emissions from charcoal production are calculated by multiplying the annual amount of produced charcoal by the corresponding emission factors.

Emission Factors

The following table presents the emission factors used in 1A1c:

Table 3-21 Emission Factor for 1A1c Manufacture of Solid Fuels and Other Energy Industries in 2012. CO_2 emission factor is biogenic.

1A1c Charcoal	Unit	CO_2 biog.	CH_4	NO_x	CO	NMVOC
Charcoal production	kg/TJ	16'900	1'000	10	7'000	1'700

CO_2 emission factor is based on literature (USEPA 1995) and CH_4, NO_x, CO and NMVOC emission factors are taken from Revised 1996 IPCC Guidelines as documented in EMIS 2014/1A1c.

Activity Data

The annual amount of charcoal produced in Switzerland base on data from the charcoal burner's association and single producers documented in EMIS 2014/1A1c. The value used differs from the data provided to the FAO. Nevertheless, the data used in the inventory is based on detailed queries with the few remaining sites where charcoal is produced. The main producer is the the Köhlerverein Romoos, small quantities are produced by individual traditional local trade shows (Karthause Ittingen, Freilichtmuseum Ballenberg). As the data is provided by detailed bottom-up information, this corresponds to the realistic value.

The production has increased by a factor of 2.6 between 1990 and 2012. This is due to two new charcoal production sites that started operation in 2004 as well as the reducing wood prices that increased production combined with a higher demand in Switzerland (Koehlerei, 2014).

Table 3-22 Activity data for 1A1c Manufacture of Solid Fuels and Other Energy Industries.

1A1c	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Charcoal production	TJ	1.25	1.67	1.25	1.55	1.64	1.43	1.73	2.43	1.78	1.90

1A1c	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Charcoal production	TJ	2.20	1.84	1.76	2.17	2.35	3.00	2.96	3.11	3.15	3.12

1A1c	Unit	2010	2011	2012
Charcoal production	TJ	2.82	2.93	3.25

3.2.6.3 Uncertainties and Time-Series Consistency

Overview of uncertainty in aggregated fuel consumption activity data (1A1 Fuel Combustion):

Details of uncertainty analysis of activity data (fuel consumption) in 1A1 are provided in the table below. For each fuel type, uncertainties of net import or net production data (column C) and uncertainties of stock changes (if applicable) have been estimated. From this, the combined uncertainty of final consumption of fuels has been calculated (column H).

Table 3-23 Details of uncertainty analysis of fuels in 1A1.

A	B	C	D	E	F	G	H	I
Fuel type (IPCC 2000)	Corresponding fuel type in SFOE 2013	Net import/ net production Input data =Import-Export [TJ]	Import/ production data uncertainty Input data [%]	Correction for stock changes etc. =G-C [TJ]	Correction uncertainty Input data [%]	Consumption Input data [TJ]	Final consumption uncertainty =WURZEL((C*D)^2+(E*F)^2)/G [%]	Comment
Liquid fuels	Erdölprodukte	400'503	1.0	18'060	20	418'563	1.3	1
Gaseous fuels	Gas	122'520	2	0	0	122'520	2.0	2
Solid fuels	Kohle	5'630	5	-160	100	5'470	5.9	3
Other fuels	Müll- und Industrieabfälle	56'320	10	0	0	56'320	10.0	4

Comments:

1 Col. D: Expert estimate from carbura (email M. Ruffer 24.1.05; overall uncertainty has been doubled to account for 95% interval). - Col. F: Conservative interpretation of rough expert estimate from carbura ("one-digit uncertainty", i.e. 10% is one sigma, resulting in unc = 2*sigma = 20%).

2 Col. D: 2% is GPG default value for developed countries siehe unten

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

4 Col. D: An uncertainty of amount of waste of 10% is assumed (expert judgement), because waste input is reasonably well measured since the nineties.

Data on stock changes is taken from the Swiss overall energy statistics (SFOE 2013; Table 4). Accordingly, also net import/net production data were taken from the Swiss overall energy statistics for the present uncertainty analysis.

The uncertainty of CO_2 emission factors is described in section 3.2.5.2.

Uncertainty in emissions of non-CO_2 gases are estimated to be medium resulting in 30% for CH_4 and 80% for N_2O (see 1.7).

Consistency and Completeness in 1A1 Fuel Combustion

Consistency:

- Time series for 1A1 are all consistent.
- CO_2 emissions from biomass in 1 Energy (memo item) are only partly included in the CRF-tables, see Section 3.2.5.1.

Completeness:

- All estimates in the sector 1A1 are assumed to be complete.

3.2.6.4 Source-specific QA/QC and Verification

a) General

At the level of total energy-related CO_2 emissions, a quality control consists in the comparison of emissions modelled using the Sectoral Approach with emissions calculated from fuel consumption according to the Swiss overall energy statistics of SFOE. The differences in total CO_2 emissions for the years 1990–2012 are negligible - indicating the completeness of the inventory.

The cross-check of the Reference and Sectoral Approach is also used for an assessment of emissions related to the consumption of fuels in the energy sector. Again, a good agreement between the two approaches is found (see Chapter 3.2.1).

The quality control activities have been documented in checklists as described in Chapter1.6

b) Specific Energy Industries

The time series have been compared between the current and the previous submission as well as available energy data. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of last submission 2013
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of last submission 2013

In 2012, the emission factors of category 1A1 used in the Swiss Inventory have been compared to the corresponding emission factors of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) and to the IPCC default value if available (INFRAS 2012). The emission factor for CO_2 from Other Fuels from Other Fuels are higher than the emission factors in other countries. Please see section 3.2.6.2.

3.2.6.5 Source-Specific Recalculations

- **1A all fuels:** Activity data of all fuels of the overall time series have been recalculated based on the new data from SFOE 2013. This includes data on 2011 for fossil fuels and waste, data for biomass on 1997, 2009 – 2011 and data of other fuels 1990 – 2011.
- **1A wood consumption:** Activity data have been recalculated for the overall time series based on the new data from SFOE 2013b.
- **1A gas oil:** SO_x emission factor value has been updated for 2010 based on sulphur analyses of the gas oil for the year 2010 (Directorate General of Customs) resulting in a revised value for 2011 as well.
- **1A bituminous coal:** CO_2 emission factor has been corrected from 94t CO_2/TJ to 92.7 t CO_2/TJ for the entire time series.
- **1A1a biogas production:** Activity data of biogas production from solid waste disposal sites have been recalculated for 2011 based on new values in the Swiss statistics of renewable energies SFOE 2013a.
- **1A1a waste incineration:** Emission factor of N_2O has been updated for the entire time series based on a new study realized by EMPA (Mohn 2013).
- **1A1a biomass fermentation:** Emission factor of CH_4 has been corrected for the entire time series.
- **1A1a / 6D industrial and agricultural biogas**: Activity data for fermentation of biogenic waste has been updated for the years 1999 to 2011 based on new data from the Swiss statistics of renewable energies SFOE 2013a.
- **1A1a industrial and agricultural biogas**: N_2O default emission factor from the IPCC guidelines has been introduced for the whole time series for fermentation of biogenic waste.
- **1A1a bituminous coal:** Activity data has been corrected over the whole time series as it was not consistent with other years.
- **1A1a gas oil:** Activity data has been corrected over the whole time series based on data from the Swiss overall energy statistics (SFOE 2013).

- **1A1a other fuels:** Activity data has been corrected for 2007 and 2008 based on correction of the energy content of waste.
- **1A1b refinery boilers:** Activity data for 2011 has been corrected for residual fuel oil as there was a mistake in the database in Submission 2013.
- **1A1b refinery boilers:** CO_2 Emission factor of refinery liquefied petroleum gas for 1990 to 2011 has been updated based on measurements that led to an average emission factor of 59‘800 g/GJ compared to the previous emission factor of 59’300 g/GJ that was based on expert judgement.
- **1A1c charcoal production:** Reporting of the biogenic CO_2 and precursor emissions has been shifted from source category 2D3 to 1A1c. (Please note that the reporting of the CH_4 emissions from the charcoal production has already been shifted from 2D3 to 1A1c within the resubmission of Switzerland’s Greenhouse Gas Inventory 1990–2011(FOEN 2013g).)
- **1A1c charcoal production:** Activity data from 2004 to 2012 has been corrected based on corrected data from small producers of charcoal.
- **1A1c charcoal production:** Emission factors have been corrected over the whole timeseries. The emission factors are newly based on Revised 1996 IPCC Guidelines for CO, NMVOC, CH_4, NO_x and USEPA (1995) for CO_2.

3.2.6.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

3.2.7 Source Category 1A2 - Manufacturing Industries and Construction

3.2.7.1 Source Category Description

Tier 1 Key categories 1A2
CO_2 from the combustion of Liquid Fuels (level and trend)
CO_2 from the combustion of Solid Fuels (level and trend)
CO_2 from the combustion of Gaseous Fuels (level and trend)
CO2 from the combustion of Other Fuels (level and trend)
Tier 2 Key categories 1A2
CO_2 from the combustion of Solid Fuels (level and trend)
CO_2 from the combustion of Gaseous Fuels (level and trend)
CO_2 from the combustion of Other Fuels (level and trend)

The source category 1A2 Manufacturing Industries and Construction comprises all emissions from the combustion of fuels in stationary boilers and cogeneration facilities within manufacturing industries and construction. This includes use of conventional fossil fuels as well as waste fuels and biomass. Use of fossil fuels as feedstocks or as so-called non-energy fuel as for example bitumen and lubricants are included in the reference approach and described in section 3.2.3.

In addition, this source category includes off-road construction and industrial vehicles and machinery in category 1A2fii, such as for example forklifts, diggers or industry tractors.

Table 3-24 Specification of source category 1A2 Manufacturing Industries and Construction. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

1A2	Source	Specification	Data Source
1A2a	Iron and Steel	Iron and Steel industry	AD: SFOE 2013; Prognos, 2013 EMIS 2014/1A2a EF: EMPA 1999; Intertek 2008; Intertek 2012; FOEN 2011k; IPCC 2006 EMIS 2014/1A2a
1A2b	Non-ferrous Metals	Non-ferrous Metals industry	AD: SFOE 2013; Prognos, 2013 EMIS 2014/1A2b EF: EMPA 1999; Intertek 2008; Intertek 2012; FOEN 2011k; IPCC 2006 EMIS 2014/1A2b
1A2c	Chemicals	Chemical industry	AD: SFOE 2013; Prognos, 2013 EMIS 2014/1A2c EF: EMPA 1999; Intertek 2008; Intertek 2012; FOEN 2011k; IPCC 2006 EMIS 2014/1A2c
1A2d	Pulp, Paper and Print	Pulp, Paper and Print industry	AD: SFOE 2013; Prognos, 2013 EMIS 2014/1A2d EF: EMPA 1999; Intertek 2008; Intertek 2012; FOEN 2011k; IPCC 2006 EMIS 2014/1A2d
1A2e	Food Processing, Beverages and Tobacco	Food Processing, Beverages and Tobacco industry	AD: SFOE 2012; Prognos 2013 EF: EMPA 1999; Intertek 2008; Intertek 2012; FOEN 2011k; IPCC 2006
1A2fi	Other (Combustion Installations in Industries)	Category 1A2fi contains: Cement, Lime, Brick and tile, Fine ceramics, Asphalt concrete plants, Container glass, Glass, Glass wool, Mineral wool, Fibreboard Production, industrial biogas boilers and engines that do not provide heat or electricity to the public.	AD: SFOE 2013; Prognos 2013; SFOE 2013a; SFOE 2013b; SFOE 2013c EMIS 2014/1A2fi EF: EMPA 1999; Intertek 2008; Intertek 2012; FOEN 2011k; IPCC 2006; EMIS 2014/1A Holzfeuerungen; SAEFL 2000; Nussbaumer, T., Boogen, N. 2010; EMIS 2014/1A2fi
1A2fii		Category 1A2f ii contains: off-road construction and industrial vehicles and machinery.	AD, EF: INFRAS 2008 AD (partial update): Prognos 2012, Keller/INFRAS 2013

3.2.7.2 Methodological Issues

Methodology

For fuel combustion in source category 1A2 Manufacturing Industries and Construction, a country specific approach, as explained in chapter 3.2.5, is used combining Tier 2 and Tier 3 methods.

Emissions of GHGs are calculated by multiplying the level of activity (fuel consumption) by the respective emission factors.

Within 1A2f, also emissions from diesel and gasoline use in construction and industrial machinery (off-road) is included and accounted for within source category 1A2fii. They are calculated with a Tier 2 method. Some details of the emission modelling that hold for all off-road families are described in Annex A3.1.6 Off-road vehicles. Emission calculation was carried out in a database structured in analogy to the on-road database (INFRAS 2008).

Emission factors

The following table presents the emission factors used in source category 1A2 Manufacturing Industries and Construction:

Table 3-25 Emission Factors for 1A2 Manufacturing Industries and Construction in 2012.

1A2 Emission factors (mix of bottom-up and top-down approach (modelling)) for GHG	**CO_2 fossil**	**CO_2 bio.**	**CH_4**	**N_2O**
	t/TJ	t/TJ	kg/TJ	kg/TJ
Gas oil	73.7		1.0	0.6
Liquefied petroleum gas	65.5		1.0	0.1
Residual fuel oil	77.0		3.2	0.8
Petroleum coke	91.4		2.1	1.6
Bituminous coal	92.7		1.6	1.6
Lignite	96.1		0.8	1.6
Natural gas	56.1		6.0	0.1
Biomass		85.0	5.4	1.6
Other fuels	70.4		4.3	9.5
Diesel and gasoline for construction and industrial machinery	73.6		2.2	2.8

All emission factors highlighted in grey are explained in section 3.2.5.2.

Other fuels consist of various fossil wastes (see detailed description below in section Cement under Other – Stationary (1A2f i)). The CO_2 emission factor is an implied emission factor based on the fossil waste fuel mix in cement production plants. The CH_4 emission factor includes the overall CH_4 emissions of the cement industry based on direct exhaust measurements at the chimneys of the cement plants (see respective documentation in EMIS 2014/1A2fi Zementwerke_Feuerung, Cemsuisse 2010a). CH_4 emission factors for residual fuel oil, petroleum coke, bituminous coal and lignite are lower than the emission factors explained in section 3.2.5.2. This is because the overall CH_4 emissions of the cement industry are reported under Other fuels (see explanation above).

The emission factors of the precursors NO_x, CO, NMVOC and SO_2 for all fuels in source category 1A2 are provided in Annex A3.1.3. Emission factors for CO and NOx for natural gas and gas oil of boilers are country specific and result from a specific modeling based on real measurements of 200’000 firing controls in eight Swiss cantons (Leupro 2012). NMVOC and SO_2 emission factors are country specific and based on measurements as documented in the respective EMIS documentation.

The emission factors for all other gases are country specific and shown in Table A - 15 to Table A - 18 in the Annex A3.1.6 (INFRAS 2008). NMVOC emissions are calculated as the difference of VOC and CH4 emissions .

For off-road activities the emission factors for CO_2 are country specific and assumed to be constant in the period 1990-2012 with values 73.6 t/TJ for diesel oil, 73.9 t/TJ for gasoline and 56.1t/TJ for CNG (equal to natural gas). See also Table 3 9.

Note that specific emission factors in the unit of kg/h may be downloaded by query from the public part of the off-road database INFRAS (2008), see footnote 7 on page 111.

For off-road activities SO_2 emission factors are country specific and further described in Table A - 6 in Annex A2.

Activity data

Activity data for the different fuels is determined as described in chapter 3.2.5.1.

Table 3-26 Activity data fuel consumption in 1A2 Manufacturing Industries and Construction 1990 to 2012.

Source	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
1A2 Manufacturing Industries and Constr. (Total)	TJ	83'907	88'028	84'591	84'318	84'414	87'966	86'534	85'874	88'569	88'788
Gas oil	TJ	19'307	23'533	23'578	23'368	21'996	23'421	24'499	25'525	26'591	28'492
Liquefied petroleum gas	TJ	4'495	5'236	4'723	4'542	4'683	4'684	4'866	5'789	6'157	6'664
Residual fuel oil	TJ	18'524	17'037	16'487	14'008	14'547	13'547	10'954	9'625	10'232	8'151
Petroleum coke	TJ	1'617	1'239	650	1'387	1'702	1'275	1'082	394	564	484
Bituminous coal	TJ	12'676	10'548	7'243	5'987	6'083	6'687	4'984	3'849	3'220	3'146
Lignite	TJ	306	353	306	259	259	188	236	165	139	136
Natural gas	TJ	19'146	21'865	23'386	26'065	26'679	28'658	29'263	29'970	30'694	30'531
Biomass	TJ	5'801	6'110	6'042	6'029	5'986	6'345	6'905	6'814	7'054	7'348
Other Fuels	TJ	2'035	2'106	2'176	2'673	2'480	3'162	3'746	3'744	3'918	3'837
1A2a Iron and Steel	TJ	3'212	3'807	3'345	4'036	3'247	2'444	2'353	2'558	2'757	2'860
Gas oil	TJ	400	413	455	432	412	256	248	291	304	464
Liquefied petroleum gas	TJ	604	632	575	512	509	287	286	361	407	463
Residual fuel oil	TJ	0	0	0	0	0	0	0	0	0	0
Petroleum coke	TJ	346	350	364	370	367	131	128	139	151	7
Bituminous coal	TJ	433	347	328	259	263	289	247	253	273	271
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Natural gas	TJ	1'429	2'067	1'622	2'464	1'695	1'481	1'443	1'513	1'622	1'654
Biomass	TJ	0	0	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
1A2b Non-Ferrous Metals	TJ	2'337	2'338	2'059	1'718	1'629	1'994	1'662	2'150	1'845	1'394
Gas oil	TJ	598	618	418	391	355	417	337	364	358	311
Liquefied petroleum gas	TJ	40	40	33	23	22	26	22	34	30	24
Residual fuel oil	TJ	0	0	0	0	0	0	0	0	0	0
Petroleum coke	TJ	0	0	0	0	0	0	0	0	0	0
Bituminous coal	TJ	0	0	0	0	0	0	0	0	0	0
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Natural gas	TJ	1'699	1'680	1'608	1'304	1'252	1'552	1'303	1'751	1'458	1'060
Biomass	TJ	0	0	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
1A2c Chemicals	TJ	15'638	15'047	15'036	14'017	14'999	16'432	16'100	14'845	15'071	15'036
Gas oil	TJ	4'020	3'787	3'073	3'307	3'168	3'978	3'908	3'344	2'948	5'295
Liquefied petroleum gas	TJ	323	323	321	317	319	319	319	321	323	320
Residual fuel oil	TJ	1'434	1'193	851	796	654	693	561	383	256	315
Petroleum coke	TJ	0	0	0	0	0	0	0	0	0	0
Bituminous coal	TJ	0	0	0	0	0	0	0	0	0	0
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Natural gas	TJ	9'861	9'744	10'791	9'597	10'859	11'442	11'312	10'797	11'544	9'107
Biomass	TJ	0	0	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
1A2d Pulp, Paper and Print	TJ	10'831	11'183	12'488	12'640	13'520	12'121	11'253	11'467	11'309	10'649
Gas oil	TJ	711	949	1'027	1'095	1'112	1'235	1'340	1'466	1'580	1'857
Liquefied petroleum gas	TJ	127	161	223	219	269	210	185	215	216	222
Residual fuel oil	TJ	5'250	4'904	4'136	3'667	3'228	3'061	2'867	2'885	2'739	2'023
Petroleum coke	TJ	0	0	0	0	0	0	0	0	0	0
Bituminous coal	TJ	0	0	0	0	0	0	0	0	0	0
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Natural gas	TJ	2'657	3'271	5'392	6'136	7'470	6'257	5'418	5'375	5'164	4'853
Biomass	TJ	2'085	1'898	1'711	1'524	1'441	1'358	1'442	1'526	1'610	1'694
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
1A2e Food Processing, Beverages and Tobacco	TJ	10'382	12'331	12'192	12'403	10'434	10'198	12'558	11'742	11'678	11'892
Gas oil	TJ	7'903	9'703	9'497	9'488	7'413	6'920	9'036	8'274	8'016	7'927
Liquefied petroleum gas	TJ	301	379	375	380	429	456	516	613	690	827
Residual fuel oil	TJ	1'160	1'009	810	705	553	466	405	284	221	184
Petroleum coke	TJ	0	0	0	0	0	0	0	0	0	0
Bituminous coal	TJ	0	0	0	0	0	0	0	0	0	0
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Natural gas	TJ	1'018	1'240	1'511	1'830	2'040	2'356	2'601	2'571	2'751	2'954
Biomass	TJ	0	0	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
1A2fi Other	TJ	47'019	49'023	45'361	45'584	46'854	51'235	49'188	49'814	52'731	53'902
Gas oil	TJ	5'675	8'063	9'109	8'655	9'536	10'615	9'629	11'786	13'385	12'638
Liquefied petroleum gas	TJ	3'099	3'701	3'196	3'092	3'135	3'387	3'538	4'244	4'492	4'808
Residual fuel oil	TJ	10'680	9'931	10'691	8'841	10'112	9'327	7'121	6'073	7'015	5'629
Petroleum coke	TJ	1'271	890	286	1'017	1'335	1'144	953	254	413	477
Bituminous coal	TJ	12'242	10'202	6'915	5'728	5'819	6'398	4'736	3'596	2'947	2'874
Lignite	TJ	306	353	306	259	259	188	236	165	139	136
Natural gas	TJ	2'481	3'864	2'461	4'734	3'364	5'569	7'186	7'963	8'155	10'904
Biomass	TJ	3'716	4'212	4'331	4'505	4'545	4'987	5'463	5'288	5'444	5'653
Other Fuels	TJ	2'035	2'106	2'176	2'673	2'480	3'162	3'746	3'744	3'918	3'837
1A2fii Diesel and gasoline for construction and industrial machinery	TJ	5'512	5'701	5'890	6'080	6'269	6'458	6'580	6'701	6'823	6'945

Table 3-26 continued: Activity data fuel consumption in 1A2 Manufacturing Industries and Construction.

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1A2 Manufacturing Industries and Constr. (Total)	TJ	93'846	98'832	95'600	98'467	100'342	100'830	103'061	101'697	102'442	96'034
Gas oil	TJ	26'216	27'786	27'499	28'933	28'140	28'710	27'338	25'863	25'738	24'260
Liquefied petroleum gas	TJ	5'928	5'562	6'160	5'331	5'194	4'596	5'054	4'548	4'319	4'595
Residual fuel oil	TJ	5'665	7'623	4'564	4'858	5'700	4'435	5'128	3'519	3'517	2'549
Petroleum coke	TJ	529	422	645	194	954	1'228	1'772	1'470	1'281	1'378
Bituminous coal	TJ	5'265	5'432	5'000	5'178	4'704	4'704	3'889	4'831	4'373	4'144
Lignite	TJ	136	71	94	94	94	777	2'026	2'003	1'767	1'555
Natural gas	TJ	31'496	32'250	31'254	32'722	33'817	34'754	36'077	36'928	38'338	34'904
Biomass	TJ	7'191	7'378	7'516	7'960	8'065	8'242	8'313	8'708	8'616	7'827
Other Fuels	TJ	11'419	12'308	12'869	13'197	13'673	13'384	13'463	13'828	14'493	14'823
1A2a Iron and Steel	TJ	2'912	3'009	3'186	3'412	3'417	3'153	4'075	4'266	3'963	2'918
Gas oil	TJ	367	472	451	523	463	398	338	352	341	302
Liquefied petroleum gas	TJ	427	392	506	447	405	324	465	440	368	319
Residual fuel oil	TJ	0	0	0	0	0	0	0	0	0	0
Petroleum coke	TJ	21	40	9	3	191	179	310	230	232	171
Bituminous coal	TJ	266	234	179	163	148	154	150	160	177	70
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Natural gas	TJ	1'832	1'870	2'042	2'276	2'209	2'098	2'811	3'085	2'844	2'056
Biomass	TJ	0	0	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
1A2b Non-Ferrous Metals	TJ	1'504	1'351	843	925	1'103	954	1'146	1'031	1'035	987
Gas oil	TJ	292	115	330	166	114	161	100	129	156	223
Liquefied petroleum gas	TJ	23	21	10	12	15	11	15	11	10	10
Residual fuel oil	TJ	0	0	0	0	0	0	0	0	0	0
Petroleum coke	TJ	0	0	0	0	0	0	0	0	0	0
Bituminous coal	TJ	0	0	0	0	0	0	0	0	0	0
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Natural gas	TJ	1'189	1'215	502	747	974	783	1'032	890	869	754
Biomass	TJ	0	0	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
1A2c Chemicals	TJ	14'333	14'985	13'981	15'767	16'100	16'522	16'636	15'557	15'691	13'809
Gas oil	TJ	4'139	4'073	3'806	4'409	4'482	4'394	4'498	3'450	3'192	3'484
Liquefied petroleum gas	TJ	318	318	319	318	317	316	316	315	364	313
Residual fuel oil	TJ	253	282	289	311	345	168	431	37	365	415
Petroleum coke	TJ	0	0	0	0	0	0	0	0	0	0
Bituminous coal	TJ	0	0	0	0	0	0	0	0	0	0
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Natural gas	TJ	9'623	10'313	9'567	10'729	10'957	11'645	11'391	11'756	11'770	9'598
Biomass	TJ	0	0	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
1A2d Pulp, Paper and Print	TJ	10'388	11'381	10'860	11'600	10'691	10'776	9'636	8'942	7'197	4'855
Gas oil	TJ	1'443	1'617	1'458	1'487	1'309	1'325	1'164	935	781	757
Liquefied petroleum gas	TJ	220	210	255	207	164	149	118	106	90	93
Residual fuel oil	TJ	1'421	2'256	1'235	1'941	2'074	1'811	2'239	1'644	1'175	643
Petroleum coke	TJ	0	0	0	0	0	0	0	0	0	0
Bituminous coal	TJ	0	0	0	0	0	0	0	0	0	0
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Natural gas	TJ	5'610	5'851	6'170	6'081	5'115	5'438	4'038	4'158	3'827	3'362
Biomass	TJ	1'694	1'447	1'741	1'885	2'029	2'053	2'076	2'099	1'324	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
1A2e Food Processing, Beverages and Tobacco	TJ	11'703	12'268	11'676	11'583	11'675	11'787	12'622	12'014	11'877	13'531
Gas oil	TJ	7'336	7'651	6'881	6'544	6'282	5'831	5'521	4'894	4'892	5'363
Liquefied petroleum gas	TJ	799	776	929	812	818	796	1'008	889	801	1'098
Residual fuel oil	TJ	137	141	113	96	114	0	0	0	0	0
Petroleum coke	TJ	0	0	0	0	0	0	0	0	0	0
Bituminous coal	TJ	0	0	0	0	0	0	0	0	0	0
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Natural gas	TJ	3'430	3'700	3'753	4'132	4'462	5'160	6'093	6'232	6'185	7'070
Biomass	TJ	0	0	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
1A2fi Other	TJ	53'005	55'837	55'053	55'180	57'355	57'638	58'945	59'887	62'679	59'933
Gas oil	TJ	12'638	13'858	14'573	15'805	15'491	16'601	15'717	16'104	16'376	14'133
Liquefied petroleum gas	TJ	4'141	3'844	4'141	3'536	3'475	3'002	3'132	2'787	2'687	2'761
Residual fuel oil	TJ	3'854	4'945	2'926	2'510	3'167	2'456	2'458	1'839	1'977	1'490
Petroleum coke	TJ	508	381	636	191	763	1'049	1'462	1'239	1'049	1'208
Bituminous coal	TJ	4'999	5'198	4'821	5'015	4'556	4'550	3'739	4'672	4'196	4'074
Lignite	TJ	136	71	94	94	94	777	2'026	2'003	1'767	1'555
Natural gas	TJ	9'812	9'302	9'220	8'758	10'101	9'630	10'711	10'808	12'843	12'063
Biomass	TJ	5'497	5'931	5'774	6'075	6'036	6'189	6'238	6'609	7'292	7'827
Other Fuels	TJ	4'353	5'204	5'729	6'020	6'460	6'133	6'136	6'426	7'015	7'268
1A2fii Diesel and gasoline for construction and industrial machinery	TJ	7'066	7'103	7'140	7'177	7'214	7'250	7'326	7'402	7'478	7'554

Table 3-26 continued: Activity data fuel consumption in 1A2 Manufacturing Industries and Construction.

Source	Unit	2010	2011	2012
1A2 Manufacturing Industries and Constr. (Total)	TJ	102'217	94'983	96'594
Gas oil	TJ	24'347	19'714	21'486
Liquefied petroleum gas	TJ	4'181	4'136	3'998
Residual fuel oil	TJ	1'955	1'518	1'568
Petroleum coke	TJ	4'322	3'813	3'686
Bituminous coal	TJ	4'322	3'813	3'686
Lignite	TJ	1'461	1'626	1'178
Natural gas	TJ	38'016	36'907	37'369
Biomass	TJ	7'916	7'562	8'289
Other Fuels	TJ	15'696	15'895	15'335
1A2a Iron and Steel	TJ	3'436	3'386	4'352
Gas oil	TJ	327	322	241
Liquefied petroleum gas	TJ	327	338	435
Residual fuel oil	TJ	149	1	0
Petroleum coke	TJ	0	0	0
Bituminous coal	TJ	64	73	55
Lignite	TJ	0	0	0
Natural gas	TJ	2'569	2'652	3'620
Biomass	TJ	0	0	0
Other Fuels	TJ	0	0	0
1A2b Non-Ferrous Metals	TJ	1'175	1'215	1'241
Gas oil	TJ	157	136	211
Liquefied petroleum gas	TJ	12	12	11
Residual fuel oil	TJ	0	0	0
Petroleum coke	TJ	0	0	0
Bituminous coal	TJ	0	0	0
Lignite	TJ	0	0	0
Natural gas	TJ	1'007	1'067	1'019
Biomass	TJ	0	0	0
Other Fuels	TJ	0	0	0
1A2c Chemicals	TJ	13'755	12'749	12'536
Gas oil	TJ	3'276	3'030	2'787
Liquefied petroleum gas	TJ	311	331	380
Residual fuel oil	TJ	217	3	0
Petroleum coke	TJ	0	0	0
Bituminous coal	TJ	0	0	0
Lignite	TJ	0	0	0
Natural gas	TJ	9'952	9'385	9'369
Biomass	TJ	0	0	0
Other Fuels	TJ	0	0	0
1A2d Pulp, Paper and Print	TJ	4'599	4'339	3'463
Gas oil	TJ	478	349	387
Liquefied petroleum gas	TJ	91	92	67
Residual fuel oil	TJ	83	1	2
Petroleum coke	TJ	0	0	0
Bituminous coal	TJ	0	0	0
Lignite	TJ	0	0	0
Natural gas	TJ	3'947	3'897	3'008
Biomass	TJ	0	0	0
Other Fuels	TJ	0	0	0
1A2e Food Processing, Beverages and Tobacco	TJ	14'430	14'437	13'980
Gas oil	TJ	5'723	5'520	5'324
Liquefied petroleum gas	TJ	984	1'008	929
Residual fuel oil	TJ	0	0	0
Petroleum coke	TJ	0	0	0
Bituminous coal	TJ	0	0	0
Lignite	TJ	0	0	0
Natural gas	TJ	7'723	7'909	7'727
Biomass	TJ	0	0	0
Other Fuels	TJ	0	0	0
1A2fi Other	TJ	62'141	56'315	58'703
Gas oil	TJ	14'385	10'357	12'537
Liquefied petroleum gas	TJ	2'455	2'355	2'176
Residual fuel oil	TJ	1'655	1'513	1'566
Petroleum coke	TJ	1'494	1'271	1'367
Bituminous coal	TJ	4'259	3'740	3'630
Lignite	TJ	1'461	1'626	1'178
Natural gas	TJ	12'820	11'997	12'626
Biomass	TJ	7'916	7'562	8'289
Other Fuels	TJ	8'066	8'350	7'875
1A2fii Diesel and gasoline for construction and industrial machinery	TJ	7'630	7'545	7'460

In Table 3-26 the specific fuel consumptions of source categories 1A2a–1A2f are given. Source category 1A2f Other is the most important category within source category 1A2 Manufacturing Industries and Construction and accounted for 61% of the overall fuel consumption in 2012. Categories 1A2e Food Processing, Beverages and Tobacco and 1A2c Chemicals are the second and third most important fuel consumers with 14% and 13% respectively.

Regarding the fuels used within Swiss industry, natural gas consumption represents 39% of fuel consumption in 2012 followed by gas oil and other fuels (fossil waste) with shares of 22% and 16%, respectively.

The table also documents the fuel switch within Swiss industry. From 1990 to 2012 the use of residual fuel oil and bituminous coal has decreased by 92% and 71%, repsectively. In the same period, natural gas and other fuel consumption increased by 95% and a factor of 7.5 (654%), respectively. These developments explain why liquid, solid, gaseous and other fuels are key categories regarding trend.

The following sections describe the different source categories of 1A2 Manufacturing Industries and Construction. Further information is documented in the respective EMIS documentation(EMIS 2014/1A2x).

Iron and Steel (1A2a)

The source category 1A2a Iron and Steel includes specific information from the industry as well as information from the Prognos model.

There is no primary iron and steel production in Switzerland. Only secondary steel and iron production using recycled steel scrap occurs.

Iron is produced in 14 iron foundries. About 75% of the iron is processed in induction furnaces and 25% in cupola furnaces. The share of induction furnaces increased since 1990 from 47% with a sharp increase in 2009 based on the closure of at least one cupola furnance. Induction furnaces use electricity for the melting process and therefore only process emissions occur, which are reported in source category 2C1 Iron and steel production. Within the production process iron foundries add bituminous coal in the production process to increase the carbon content of the raw material steel scrap to produce iron with higher carbon content. The use of bituminous coal decreased significantly from 434 TJ in 1990 to 55 TJ in 2012. This is due to the significant decrease of iron funding by 73% from 1990 to 2012 and the switch from cupola furnances to induction furnances.

Today, in Switzerland steel is produced in two steel production plants. Both plants use electric arc furnaces (EAF) with carbon electrodes for melting the steel scrap. Therefore only emissions from the heating furnaces are included in source category 1A2a. These furnaces use mainly natural gas for reheating the ingot moulds prior to the rolling mills. Process emissions from steel production are included in source category 2C1 Iron and steel production. Steel production and the related natural gas consumption was significantly reduced in 1995 through the closure of two steel companies. Since 1995, steel production increased continuously until 2004 to reach the same production level as 1990. Since then, steel production is constant. Only in 2009, the production was significantly lower based on economic crisis. One steel producer switched its production to high quality steel and therefore the specific energy use per tonne of steel produced increased between 1995 and 2000. This led to a higher natural gas consumption.

Fuel consumption of source category 1A2a represents 5% of overall industry fuel consumption in 2012. As displayed in

Table 3-26, natural gas (83%), liquefied petroleum gas (10%), gas oil (6%) and bituminous coal (1%) are used in source category 1A2a.

Fuel consumption increased within this source category by 35%. Nevertheless, there has been a major change in the fuels used in the processes. The consumption of bituminous coal decreased by 87% based on the reduced iron production and the switch from cupola to induction furnances in iron foundries. Gas oil and liquefied petroleum gas consumption also decreased by 40% and 28% respectively. Natural gas consumption increased by a total of 135% due to the switch to high quality steel production. This changes in fuel consumption result in an increase of GHG emissions by approximately 17%, significantly less than the fuel increase.

Non-ferrous Metals (1A2b)

The source category 1A2b Non-ferrous metals is based on specific information from the industry as well as information from the Prognos model and includes aluminium remelting plants as well as non-ferrous metal foundries, producing mainly copper alloys.

Until 1993, aluminium remelting plants have been in operation using gas oil. On the other hand emissions from primary aluminium production in Switzerland are reported in source category 2C3 as induction furnaces used Its last production site closed down in April 2006.

Regarding non-ferrous metal industry in Switzerland, only casting and no production of non-ferrous metals occur. There is one large and several small foundries which are organized within the Swiss foundries association (Schweizerischer Giessereiverband GVS) which both provide annual production data

Fuel consumption of source category 1A2b represents only 1% of the overall industry fuel consumption in 2012. As shown in Table 3-26, the fuels consumed in 2012 are mainly natural gas (82%), gas oil (17%) and liquefied petroleum gas (1%). Fuel consumption within this source category 1A2b decreased by 47% from 1990 to 2012 (see Table 3-25).

This is due both to the closure of the aluminium remelting plants and the strong reduction of 78% of the non-ferrous metal production since 2000. In the same time the consumption of gas oil and LPG went down by 65% and 72% respectively. The consumption of natural gas decreased by 40%. These developments result in a reduction of GHG emissions of 1A2b by approximately 52%.

Chemicals (1A2c)

The source category 1A2c Chemicals includes specific information from the industry as well as information from the Prognos model.

In Switzerland, there are more than thirty chemical companies mainly producing fine chemicals and pharamceuticals. Fossil fuels are mainly used for steam production and process heat. The process emissions from the production of basic chemicals, i.e. ammonia, nitric acid, ethylene, acetic acid and sulphuric acid as well as silicon carbide are reported in source category 2B, see Section 4.3.

There is one large company producing ammonia and ethylene by thermal cracking of liquefied petroleum gas and light virgin naphtha. As by-products from the cracking process, so-called heating gas (liquefied petroleum gas) and gas oil are produced which are used thermally for steam production within the same plant and are accounted for within source category 1A2c (see Section 3.2.3).

Fuel consumption within 1A2c accounts for 13% of the overall industry fuel consumption in 2012. The fuels consumed in 2012 included natural gas (75%), gas oil (22%) and LPG (3%) (see Table 3-25). Fuel consumption in this source category has decreased by 20% between 1990 and 2012. Together with a fuel switch from residual fuel oil (-100%) and gas oil (-31%) to LPG (+18%) and natural gas (+5%) the GHG emissions have decreased by 23%.

Pulp, Paper and Print (1A2d)

The source category 1A2d Pulp, Paper and Print is based on specific information from the industry as well as information from the Prognos model and includes the fuel emissions from the Swiss pulp and paper industry and printing facilities.

Around half a dozen paper producers and several printing facilities exist in Switzerland. The only cellulose production plant was closed in 2008. Thermal energy is mainly used for provision of steam used in the drying process within paper production.

Source category 1A2d represents 4% of the overall fuel consumption in source category 1A2 in 2012. The fuels used in 2012 are mainly natural gas (87%) and gas oil (11%) (see Table 3-25) In this category only biomass from cellulose production (until 2008) is included, based on data from the only production site. Biomass used in paper production is reported in source category 1A2fi, because no comprehensive data exists to distribute biomass consumption to the specific industries within 1A2 as explained in Section 3.2.5.3.

The overall fuel consumption within the Swiss pulp and paper industry has decreased by approximately 68%, basically due to the closure of the cellulose production plant in 2008 and the closure of several paper producers in the last years. Since 1990 liquid fuels such as residual fuel oil, LPG and gas oil have decreased by 100%, 47% and 46%, respectively. In the same time, natural gas consumption increased by 13%. Biomass consumption decreased by 100% as the cellulose production was in 2008. GHG emissions have also decreased by about 67%.

Food Processing, Beverages and Tobacco (1A2e)

The source category 1A2e Food Processing, Beverages and Tobacco is based on information from the Prognos model.

In Switzerland, the source category 1A2e Food, beverages and tobacco includes around 200 companies. According to the national food industry association, the major part of revenues is provided by meat production (22%), milk products (18%) and convenience food (13%). Other productions are chocolate, sugar or baby food (Fial 2013). There are also some tabacco production sites, which are usually rather small farms of not more than 2 ha. Fossil fuels are used for steam production and drying processes.

Source category 1A2e accounts for 14% of the overall fuel consumption in source category 1A2 Manufacturing Industries and Construction in 2012. The fuels used in this category in the year 2012 were mainly natural gas (55%), gas oil (38%) and LPG (7%) (see Table 3-25).

Source category 1A2e shows an increase in fuel consumption of 35% between 1990 and 2012. This is based on the increased production of this sector in Switzerland. The consumption of residual fuel oil and gas oil have decreased by 100% and 33% respectively, whereas LPG consumption increased by a factor 3 and natural gas consumption by a factor 7.6. This has led to a total increase of GHG emissions by 18%.

Other – Stationary (1A2fi)

The source category 1A2fi Other – Stationary is based on specific information from the industry as well as information from the Prognos model.

Source category 1A2fi Other stationary includes several large fuel consumers mainly from mineral industry, i.e. cement, brick and tile, container glass and rock wool production as well as fibre board production. Additionally, the use of biomass such as wood, biogas and sewage sludge from all industry sectors is entirely reported in this source category. 1A2 Other– Stationary accounts for approximately 61% of the overall fuel consumption in 1A2 Manufacturing Industries and Construction.

Fuel consumption in 2012 comprises mainly natural gas (22%), gas oil (21%), biomass (14%), other fuels (fossil waste, 13%) and bituminous coal (6%) (see Table 3-25).

The most important industry within this category is cement production with approximately 25% of the total fuel consumption in 1A2fi. The fuels consumed in this category are very diverse and depend on the fuel use within the specific industry (see detailed documentation below). Between 1990 and 2012 there has been a switch in fuel consumption from liquid and solid fuels with shares of 49% and 30%, respectively, to liquid fuels, biomass and natural gas with shares of 33%, 26% and 24%, respectively (Table 3-25).

The consumption of residual fuel oil and liquefied petroleum gas decreased by 85% and 30%, respectively whereas gas oil consumption increased by 121%. Solid fossil fuels consumption also decreased by 55%. Natural gas, other fuels and biomass consumption increased by factors 5, 3.8 and 2.2, respectively. This fuel switch results in a reduction of emissions from this category by 3% although the overall fuel consumption increased by 25%. Specific industry developments and information on fuel use are described in the following sub chapters.

Cement

In Switzerland, there are six plants producing clinker and cement. The Swiss plants are rather small and do not exceed a production capacity of 3’000 tonnes of clinker per day. All of them use modern dry process technology. Cement industry emissions stem from incineration of a wide variety of fossil and waste derived fuels used to generate high temperatures needed for the calcination process.

Emission Factors

Specific emission factors for the cement industry are shown in the tables below:

Table 3-27 Emission factors for cement industry in 2012. Source: EMIS data base (EMIS 2014/1A2f). Emission factors for CO_2 are fuel specific (see Table 3-28).

Cement industry (part of 1A2f)	CO_2	N_2O	CH_4	NO_x	CO	NMVOC	SO_2
	t/TJ		g/t cement				
Cement	fuel specific		4	832	1'400	45	359

As described above in Table 3-25, the CH_4 emission factor includes the overall CH_4 emissions of the cement industry based on direct exhaust measurements at the chimneys of the cement plants. Therefore these CH_4 emissions are reported under the category “Other Fuels” in the CRF-tables.

Table 3-28 CO_2 Emission factors and other characteristics of waste derived fuels (Other fuels and Biomass) used in the cement industry.

	NCV	EF CO_2 Tot.	Fraction biomass-C
Waste derived fuel	MJ/kg	kg CO_2/GJ	%
Waste oil	32.48	74.35	0
Waste coke from coke filters	23.70	97.00	0
Mixed industrial waste	18.34	74.00	0
Other fossil waste fuels	20.85	97.00	0
Solvents and residues from distillation	23.63	73.99	1
Waste Tyres and rubber	26.40	84.00	27
Plastics	25.24	84.66	28
Mix of special waste with saw dust (CSS)	9.22	102.40	78
Sewage sludge (dried)	9.39	94.52	100
Wood	16.26	99.90	100
Animal meal	16.81	86.66	100
Sawdust	16.26	99.90	100
Agricultural waste / other biomass	12.72	110.00	100

The NCVs and CO_2 emission factors for waste oil, solvents, plastics, CSS sewage sludge, animal meal and sawdust and base on a study of Cemsuisse (Cemsuisse 2010a). The values for waste tyres are taken from Hackl, A., Mauschitz, G. (2003). The biogenic fraction of waste tyres is also based on an Austrian study and published by the German Ministry of Environment (UBA 2006).

Activity Data

Fossil fuels used in cement industry are coal (bituminous coal and lignite), petroleum coke and, to a lesser extent, residual fuel oil, natural gas and gas oil. In addition, also fossil and biogenic waste derived fuels are used. Fossil wastes comprise solvents and residues from distillation, waste tyres and rubbers, platics and waste oil whereas biogenic wastes contain mainly waste wood, animal residues and sewage sludge.

The amount of fossil and waste derived fuels consumed in cement industry is shown in Table 3-29. Data is provided by cemsuisse and documented in the respective EMIS/1A2fi Zementwerke Feuerung.

Table 3-29 Activity data: Overview on fuel use in 1A2fi cement industry.

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cement industry											
Cement, total incl. waste	TJ	16'140	14'195	12'878	11'450	12'997	12'291	10'647	10'080	9'860	9'853
Cement fossil without waste	TJ	14'265	12'295	10'951	9'071	10'856	9'511	7'326	6'822	6'489	6'624
Residual fuel oil	TJ	1'907	2'957	4'377	3'263	4'589	2'825	3'507	3'206	3'168	3'260
Petroleum coke	TJ	900	670	50	500	980	830	550	240	410	466
Bituminous coal	TJ	10'790	8'300	6'150	5'000	5'000	5'500	3'000	3'200	2'710	2'640
Lignite	TJ	306	353	306	259	259	188	236	165	139	136
Gas	TJ	362	14	67	48	27	168	34	10	62	121
Cement, waste derived fuel	TJ	1'874	1'901	1'927	2'379	2'142	2'780	3'321	3'258	3'371	3'229
Waste oil	TJ	1'169	1'137	1'104	1'527	1'208	1'485	1'514	1'257	1'509	1'403
Sewage sludge (dried)	TJ	9	9	9	19	65	128	175	240	216	279
Wood	TJ	0	0	0	0	106	321	395	319	0	0
Solvents and residues from	TJ	284	378	473	284	127	181	274	410	375	272
Waste tyres and rubber	TJ	330	304	277	441	402	415	420	366	363	321
Plastics	TJ	0	0	0	0	27	55	177	274	508	553
Animal meal	TJ	0	0	0	0	0	0	197	233	223	211
Mix of special waste with s	TJ	23	14	5	51	147	136	111	100	118	132
Waste coke from coke filte	TJ	59	59	59	59	59	59	59	59	59	59
Sawdust	TJ	0	0	0	0	0	0	0	0	0	0
Mixed industrial waste	TJ	0	0	0	0	0	0	0	0	0	0
Other fossil waste fuels	TJ	0	0	0	0	0	0	0	0	0	0
Agricultural waste / other b	TJ	0	0	0	0	0	0	0	0	0	0

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cement industry											
Cement, total incl. waste	TJ	10'582	11'054	10'756	10'490	11'226	11'551	11'663	12'022	11'954	11'816
Cement fossil without waste	TJ	6'897	6'553	5'754	5'231	5'459	6'136	6'344	6'914	6'389	6'127
Residual fuel oil	TJ	1'530	1'194	1'079	621	754	637	220	175	135	100
Petroleum coke	TJ	458	327	590	187	515	638	903	912	1'036	994
Bituminous coal	TJ	4'750	4'950	3'980	4'330	4'080	4'120	3'383	4'033	3'618	3'650
Lignite	TJ	136	71	94	94	94	737	1'834	1'790	1'596	1'379
Gas	TJ	22	11	11	0	16	4	4	4	4	4
Cement, waste derived fuel	TJ	3'686	4'501	5'002	5'258	5'767	5'415	5'319	5'108	5'565	5'689
Waste oil	TJ	1'519	1'341	1'583	1'489	1'536	1'411	1'279	844	866	1'278
Sewage sludge (dried)	TJ	332	348	360	386	407	494	560	549	511	475
Wood	TJ	0	0	0	0	0	0	0	0	0	61
Solvents and residues from	TJ	427	517	726	740	1'002	976	981	1'295	1'476	1'032
Waste tyres and rubber	TJ	421	476	460	568	519	645	568	525	794	828
Plastics	TJ	572	600	527	525	770	841	926	1'013	995	1'119
Animal meal	TJ	198	1'030	1'172	1'379	1'326	856	799	664	658	621
Mix of special waste with s	TJ	158	130	116	114	163	133	146	164	157	131
Waste coke from coke filte	TJ	59	59	59	59	46	58	60	0	0	0
Sawdust	TJ	0	0	0	0	0	0	0	0	0	0
Mixed industrial waste	TJ	0	0	0	0	0	0	0	2	1	1
Other fossil waste fuels	TJ	0	0	0	0	0	0	0	48	105	137
Agricultural waste / other b	TJ	0	0	0	0	0	0	0	5	2	7

Source	Unit	2010	2011	2012
Cement industry				
Cement, total incl. waste	TJ	12'382	12'187	11'495
Cement fossil without waste	TJ	6'273	5'858	5'566
Residual fuel oil	TJ	112	101	297
Petroleum coke	TJ	1'130	1'081	1'081
Bituminous coal	TJ	3'662	3'167	3'097
Lignite	TJ	1'348	1'493	1'081
Gas	TJ	21	16	11
Cement, waste derived fuel	TJ	6'109	6'329	5'929
Waste oil	TJ	1'253	1'170	839
Sewage sludge (dried)	TJ	477	483	527
Wood	TJ	292	409	586
Solvents and residues from	TJ	1'189	1'264	1'294
Waste tyres and rubber	TJ	842	1'033	964
Plastics	TJ	1'252	1'163	964
Animal meal	TJ	624	614	572
Mix of special waste with s	TJ	123	96	100
Waste coke from coke filte	TJ	0	0	0
Sawdust	TJ	6	24	17
Mixed industrial waste	TJ	0	0	0
Other fossil waste fuels	TJ	45	55	36
Agricultural waste / other b	TJ	7	18	28

As shown in Table 3-29, in 2012 the Swiss cement industry used about 48% fossil fuels and 36% fossil and 16% biogenic waste derived fuels. The most important fossil fuels in 2012 were bituminous coal (27%), petroleum coke (9%) and lignite (9%).

Fuel consumption in cement plants has decreased by 39% between 1990 and 2012. This is partly due to a decrease in production since 1990 by about 15% and an increase in energy efficiency. In the same period the fuel mix has changed significantly from the use of mainly fossil fuels (88%) and some fossil waste derived fuels (11%) to the above mentioned mix of fossil fuels (48%), fossil and biogenic waste derived fuels (36% and 16%, respectively). The fossil fuels used in 1990 were bituminous coal, residual fuel oil and petroleum coke with shares of 67%, 12% and 6%, respectively, of the total fuel consumption.

Please note that all fossil waste derived fuels are reported as so-called Other Fuels in the CRF-tables, whereas the biogenic waste derived fuels belong to Biomass.

Lime

In Switzerland there is only one plant producing lime. Fossil fuels are used for the burning process (calcination) of limestone.

Since 1994 fuel consumption in lime production is mainly based on residual fuel oil with a share of99% in 2012. Since 1995, no petroleum coke is used anymore as it was replaced by residual fuel oil.

The fuel consumption of two sugar plants that autoproduce lime is reported in category 1A2e.

Fine ceramics

In Switzerland, the main production of fine ceramics is sanitary ware produced by one big and some small companies. In earlier years, also other ceramics were produced as for example glazed ceramics tiles, electrical porcelain and earthenware. Since 2001, only sanitary ware is produced.

Current fuel consumption within fine ceramics production is mainly natural gas (99%). In 2001 the fuel-mix was natural gas (62%) and gas oil (38%). Since then, fuel consumption has shifted strongly to the use of natural gas. Compared to the production of other fine ceramics, the production of sanitary ware is more energy-intensive. Therefore, the specific energy use per tonne of produced fine ceramics has increased since 1990. This results in a lower reduction of fuel consumption (68%) compared to the reduction in production (80%) between 1990 and 2012.

Rock wool

In Switzerland there is one single producer of rock wool. Fossil fuels are used for the melting of rocks at a temperature of 1500 °C in cupola furnaces.

Currently bituminous coal (83%) and natural gas (17%) are used in the production process. Until 2004 also gas oil and liquefied petroleum gas were used which were substituted by natural gas in 2005. Rock wool production has increased by approximately 48% from 1990 to 2012 whereas the fuel consumption has increased by 15% only.well.

Brick and tile

In Switzerland there are about 20 plants producing bricks and tiles. Fossil fuels are used for drying and burning of the clay blanks.

Fuels used in the brick and tile production in 2012 are natural gas (66%), residual fuel oil (22%) as well as small amounts of gas oil (4%),liquefied petroleum gas (3%) and residual fuel oil (3%). Apart from a production recovery in the years around 2004 the production has gradually decreased since 1990 by about 36% which is also represented in the overall fuel consumption decrease of about 37%. Regarding the fuels used, there has been a considerable shift from residual fuel oil to natural gas from 1990 onwards as well as a minor shif from gas oil and liquefied petroleum gas to natural gas from 2004 onwards. Paper production residues, wood and animal grease are used since 2000.

The emission factors for wood and the biogenic waste, i.e. paper production residues, and animal grease used in brick and tile production are 92kg/GJ, 86 kg/GJ and 81kg/GJ, respectively for animal grease (see documentation EMIS/1A2fi Ziegeleien).

Mixed goods

The production of mixed goods mainly includes the production of bitumen for road paving. A total of 110 production sites are producing mixed goods at stationary production sites.

The main fuel used is gas oil (71%) and natural gas (22%). The specific fuel consumption per ton of mixed goods was assumed to be constant between 1990 and 2012 and production of mixed goods oscilliates around five million tons per year. There has been a fuel switch from gas oil (reduction of 23%) to natural gas (increase of 40%) in this time.

Glass

In Switzerland glass production includes three types of glass: container glass, tableware glass and glass wool. Today there exist only one production plant for container glass and one for tableware glass. Glass wool is produced in two plants.

In 2012 fuel consumption for containter glass production includes mainly residual fuel oil (80%) and natural gas (20%). Since 1990, fuel consumption for container glass has drastically decreased due to reduction in production. Until 2003 only residual fuel oil was used in container glass production. Since 2004 the share of natural gas has increased to reach a stable contribution of 20% from 2006 onwards.

Fuel consumption for tableware glass currently includes only liquefied petroleum gas. Since 1990 fuel consumption for tableware glass strongly decreased because of the closure of one production plant in 2002 and another one in 2006. In addition, the consumption of residual fuel oil is eliminated since 2000 (17% in 1990 and 21% in 1995).

Fuel consumption for glass wool production includes currently only natural gas. Production of glass wool has increased since 1990 by approximately 60%, but the natural gas consumption decreased by approximately 10%. This can be explained by an increase in energy efficiency in the production process, i.e. a decrease of the specific energy consumption from 8.5 GJ/t to 4.8 GJ/t from 1990 to 2012.

Fibre board

Fibre board is produced in two companies in Switzerland. Thermal energy is used for heating and drying processes.

Current fuels used for fibre board production are waste wood (85%), natural gas (7%), residual fuel oil (5%) and animal grease (3%). Since 1990 the production of fibre board and thus the fuel consumption have increased significantly by a factor of 5. The fuel mix has strongly shifted between 1990 and 2012 from fossil fuels to biomass, i.e. a reduction in fossil fuel share from 65% to about 50% between 1996–2002 and from about 50% to 12% from 2006 to 2012. In 1990 the share of natural gas, wood waste and residual fuel oil amounted to 48%, 35% and 13%, respectively. Since 2001 also animal grease is used for fibre board production.

Other – Mobile (1A2fii)

Source category 1A2fii accounts for diesel and gasoline for mobile construction and industrial machinery (off-road). The most relevant mobile construction machines in terms of fuel consumption are excavators, loaders, dump trucks and mobile compressors. In the industry sector, forklifts and snow groomers consume the most fuel, but the share of electrical forklifts has been gradually increasing. Almost all fuel consumed in the sector (98%) is diesel oil, the rest is gasoline and natural gas. Activity data are taken from INFRAS (2008) and Keller/INFRAS (2013).

3.2.7.3 Uncertainties and Time-Series Consistency

The uncertainty of CO_2 emissions from fuel combustions is described in the uncertainty analysis of the Energy Industries (1A1) in Chapter 3.2.6.3. Uncertainty in emissions of other non-CO_2 gases is estimated to be medium: 30% for CH_4 and 80% for N_2O (see Table 1-14).

Consistency and Completeness in 1A2 Fuel Combustion

Consistency:

- Time series for 1A2 are all consistent.

Completeness:

- All estimates in the sector 1A2 are assumed to be complete.

3.2.7.4 Source-specific QA/QC and Verification

a) General

See Chapter 3.2.6.4.

b) Specific: Manufacturing Industries and Construction (1A2)

The time series have been compared between the current and the previous submission as well as available energy data. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables.
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of last year submission 2013.
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of last year submission 2013.

3.2.7.5 Source-Specific Recalculations

- **1A all fuels:** Activity data of all fuels of the overall time series have been recalculated based on the new data from SFOE 2013. This includes data on 2011 for fossil fuels and waste, data for biomass on 1997, 2009 – 2011 and data of other fuels 1990 – 2011.
- **1A gaseous fuels:** Activity data have been recalculated based on new data of from SFOE 2013.
- **1A wood consumption:** Activity data have been recalculated for the overall time series based on the new data from SFOE 2013b.
- **1A gas oil:** SO_x emission factor value has been updated for 2010 based on sulphur analyses of the gas oil for the year 2010 (Directorate General of Customs) resulting in a revised value for 2011 as well.

- **1A bituminous coal:** CO_2 emission factor has been corrected from 94t CO_2/TJ to 92.7 t CO_2/TJ for the entire time series.
- **1A2 liquefied petroleum gas:** N_2O emission factor of liquefied petroleum gas has been changed for the whole time series from 0.6 g/GJ to the IPCC 2006 emission factor of 0.1 g/GJ. In previous submissions, the emission factor for gas oil was used for liquefied petroleum gas because they have been reported jointly. This has been corrected in the present submission.
- **1A2 gas oil:** Since SO_x emission factor values for 2010 and 2011 have been updated based on sulphur analyses of gas oil for the year 2010 (Directorate General of Customs) also the SO_x emission factor values of liquefied petroleum gas for 2010 and 2011 have been revised as for all air pollutants the same EF are assumed as for gas oil.
- **1A2a iron foundries:** Activity data of bituminous coal has been revised due to corrected production shares of cupola and electric furnaces in iron foundries for 2010 and 2011. This change resulted in new activity data of bituminous coal in heat furnances for the same years.
- **1A2c cracker-by-product:** Activity data of steam production from the cracker-by-products has been updated for 1990 - 1999 based on new net calorific values. For calculation of the light virgin naphtha consumed as cracker feedstock the so far used net calorific value of gasoline has been replaced by the value for naphtha according to the 2006 IPCC guidelines resulting in revised activity data for 1990-1999.
- **1A2c cracker process:** Activity data of liquefied petroleum gas has been updated for 1990-1999 and 2011 based on new activity data from the cracker process and resulting steam production.
- **1A2fi glasswool production:** Activity data of one of the two glass wool production plants have been revised for 1991-2004 based on effective production data for 1996-2004 resulting in revised gas consumption.
- **1A2fi brick and tile and glasswool production:** Activity data of all fuels for 1991-2011 have been updated based on new production data.
- **1A2fi gas oil and natural gas:** Activity data from gas oil and natural gas have been revised for 1990-2011 by the substraction of nonroad from "Heizkessel GLD, HEL" and "Heizkessel GLD, Gas" instead of "Industrie Heizkessel weitere, HEL" and "Industrie Heizkessel weitere, Gas" within the Energy model.
- **1A2fi cement production:** Newly also CH_4 emissions are reported with a CH_4 emission factor of 5 g/t cement from 1990 to 1995 and 4 g/t cement from 2002 onwards.
- **1A2fi brick and tile production:** Activity data has been updated for 2001-2006 using effective production data instead of interpolated data. In addition, also so far interpolated fuel consumptions for these three plants have been replaced by effective values for 2000 and 2007-2011 resulting in overall revised fossil and biogenic fuel consumptions for 1991-2011 and 2000-2011.
- **1A2fi biogas from wastewater treatment plants:** Activity data has been updated for 2008, 2009 and 2011 based on recalculations in SFOE 2013a.
- **1A2fii Off-road:** Diesel and gasoline consumption is based on INFRAS (2008) and on an update carried out in 2013 based on the latest figures on economy and population (Prognos 2012a, Keller/INFRAS 2013). The consumption has been recalculated accordingly. Numbers from 2005 onwards are affected.

3.2.7.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

3.2.8 Source Category 1A3 - Transport

3.2.8.1 Source Category Description:

Tier 1 Key Categories 1A3
CO_2 from the combustion of gasoline (level and trend)
CO_2 from the combustion of diesel (level and trend)
CO_2 from the combustion of natural gas (trend)
CH_4 from the combustion of gasoline (trend)
N_2O from the combustion of gasoline (trend)

Tier 2 Key Categories 1A3
CO_2 from the combustion of gasoline (level and trend)
CO_2 from the combustion of diesel (level and trend)
CH_4 from the combustion of gasoline (trend)
N_2O from the combustion of gasoline (trend)

The source category includes civil aviation, road transportation, railways, navigation and other transportation. Further off-road transportation is included in category 1A2 Manufacturing Industries and Construction, in 1A4 Other Sectors and 1A5 Other (Military). For information on bunker fuel emissions from international aviation and navigation, see Chapter 3.2.2.

Table 3-30 Specification of Swiss source category 1A3 Transport. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

1A3	Source	Specification	Data Source
1A3a	Civil Aviation (National)	Large (jet, turboprop) and small (piston) aircrafts, helicopters	AD: SFOE 2013, FOCA 2006, 2006a, 2007, 2008, 2009, 2010, 2011, 2012, 2013
1A3b	Road Transportation	Light and heavy motor vehicles, coaches, two-wheelers	AD: SFOE 2013, SFCA 2013, SFSO 2013b; Method, EF: INFRAS 2010, INFRAS 2011, FOEN 2010a, Hausberger et al. 2009, EMPA 2009 AD: ARE 2012
1A3c	Railways	Diesel locomotives, abrasion by merchandise and person traffic	Method, AD, EF: INFRAS 2008, AD: Prognos 2012, Keller/INFRAS 2013
1A3d	Navigation (National)	Passenger ships, motor and sailing boats on the Swiss lakes and the river Rhine	Method, AD, EF: INFRAS 2008, AD: Prognos 2012, Keller/INFRAS 2013
1A3e	Pipeline Compressors	Compressor station in Ruswil, Lucerne	AD: SFOE 2013 EF: Battelle 1994, SAEFL 2000, SGWA 2007, Xinmin 2004

3.2.8.2 Methodological Issues

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

- Aviation (1A3a, national/domestic civil aviation),
- Road Transportation (1A3b),
- Railways (1A3c),
- Navigation (1A3d, national/domestic navigation).
- Compressor station for gas distribution (1A3e)

a) Aviation (1A3a)

Tier 1 Key Categories 1A3a
CO_2 from the combustion of fuel (kerosene) in civil aviation (trend)

Tier 2 Key Categories 1A3a
There are no Tier 2 Key categories in 1A3a

The emissions of civil aviation are modelled by a Tier 3a method developed by FOCA (2006). FOCA is represented in the emissions technical working group (CAEP WG3) and in the modelling and database group (CAEP MDG) of the International Civil Aviation Organisation (ICAO). FOCA is directly involved in the development of ICAO guidance material for the calculation of aircraft emissions and in the update of the IPCC guidelines (via the secretariat of ICAO CAEP (Committee on Aviation Environmental Protection). The Tier 3a method applied for the emission modelling is in line with the methods developed in the working groups mentioned. Note that the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) have been prepared by the IPCC Task Force on National Greenhouse Gas Inventories and have been adopted in April 2006 by the IPCC. Under the UNFCCC, they have not yet been adopted for mandatory use in reporting on GHG inventories. Formally, the method therefore should be considered as a country specific method until improvement. The modelling scheme for civil aviation starting with aircraft basic data, activity data, emission factors and ending with emissions imported into EMIS database is shown in Figure 3-14.

The Tier 3a method follows standard modelling procedures on the level of single movements based on detailed movement statistics. The primary key for all calculations is the aircraft tail number, which allows to calculate on the most precise level, namely on the level of the individual aircraft and engine type. Every aircraft is linked to the FOCA engine data base containing emission factors for more than 600 individual engines with different power settings. Emissions in the landing and take-off cycle (LTO) are calculated with aircraft category dependant flight times and corresponding power settings. Cruise emissions are calculated based on the individual aircraft type and the trip distance for every flight. For piston-engine powered aircraft and helicopters, to the knowledge of FOCA, it has been the only provider of publicly available engine data and a full methodology, so far. All piston engine data and study results have been published in 2007 (FOCA 2007a). The guidance on the determination of helicopter emissions has been published in 2009 (FOCA 2009a).

The movement database from Swiss Airports contains departure and destination airport. With this information, all flights from and to Swiss airports are separated into domestic (national) and international flights prior to the emission calculation. The emissions of domestic flights are reported under 1A3a Civil Aviation, the emissions of international flights are reported under international bunker emissions (memo items).

The emission factors used are country specific or are taken from the ICAO engine emissions databank, from EMEP/CORINAIR databases (EEA 2002), Swedish Defence Research Agency (FOI) and Swiss FOCA measurements (precursors). Cruise emission factors are generally calculated from the values of the ICAO engine emissions databank, adjusted to cruise conditions by using the Boeing Fuel Flow Method 2. For N_2O, the IPCC default emission factor is used. Activity data are derived from a detailed movement statistics.

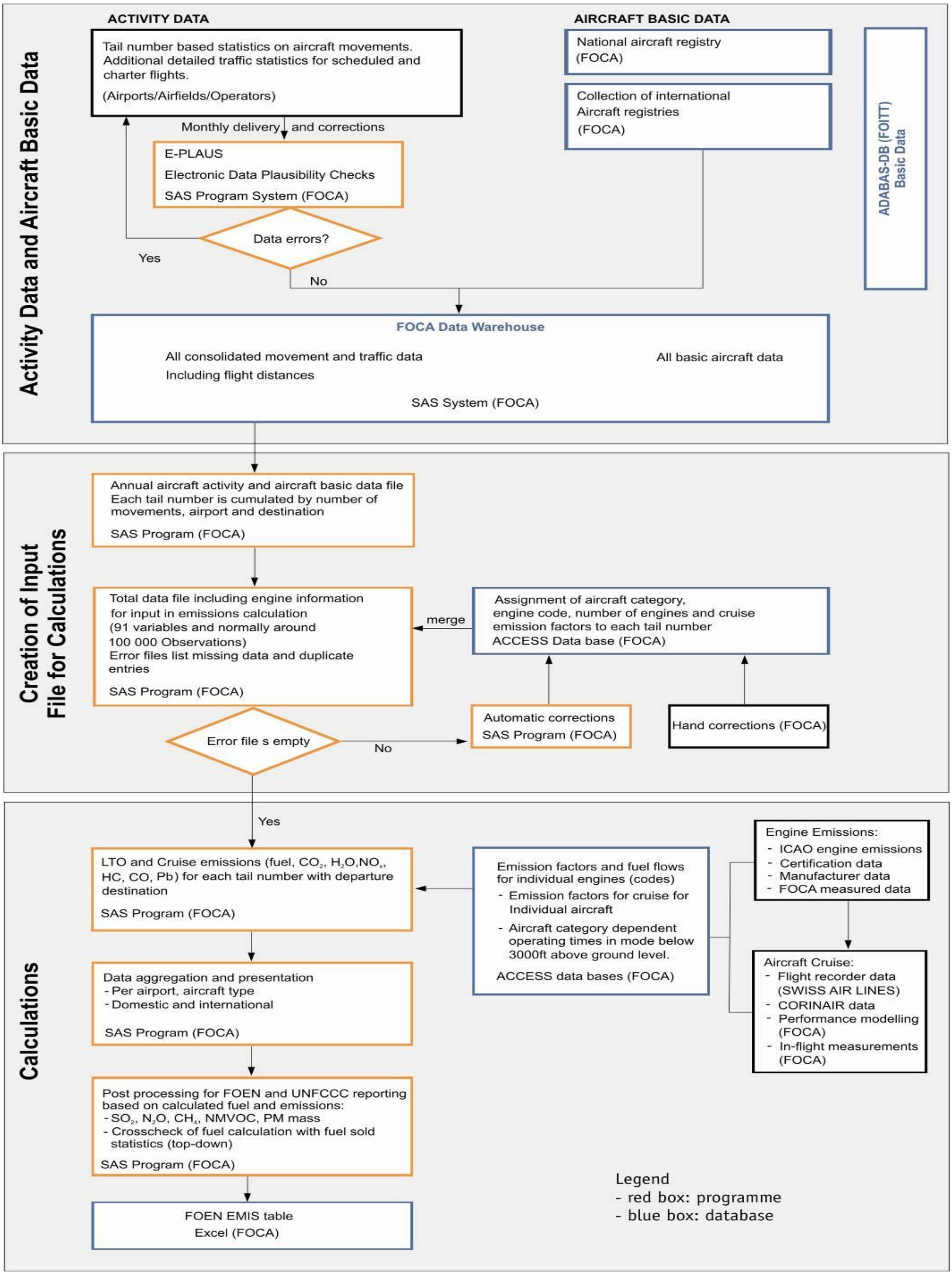


Figure 3-14 Modelling scheme (activity data, emission factors, emissions) for civil aviation.

A complete emission modelling (LTO and cruise emissions for domestic and international flights) has been carried out by Swiss FOCA for 1990, 1995, 2000, 2002, 2004–2012. The results of the emission modelling have been transmitted from FOCA to FOEN in an aggregated form. FOEN (the NIC) calculated the implied emission factors 1990, 1995, 2000, 2002, 2004 and carried out a linear interpolation for the years in-between. The interpolated implied emission factors were multiplied with the annual fuel sold from Swiss overall energy statistics (SFOE in respective years), providing the missing emissions of civil aviation for the years 1991-1994, 1996-1999, 2001 and 2003.

Details of emission factors and activity data follow below. Further tables containing more information are also given in Annex A3.1.4, more detailed descriptions of the emission modelling may be found in FOCA (2006).

Emission Factors

Kyoto gases:

- CO_2: The value of 73.2 t/TJ is country specific and is based on measurements and analyses of fuel samples (see Table 3-9). Small yearly variations have been neglected so far.
- CH_4, NMVOC (country specific; CORINAIR): VOC emissions (see Precursors below) are split into CH_4 and NMVOC by a constant share of 0.1 (CH_4) and 0.9 (NMVOC)[9]. For CH_4, the average emission factor for domestic flights is 2.0 kg/TJ in 2012 average LTO is 3.7 kg/TJ (international airports only), cruise 0.74 kg/TJ (international airports only) (FOCA 2013).
- N_2O: The IPCC default value 2.3 kg/TJ is used for the whole period 1990-2012 (IPCC 1997b).

SO_2 (IPCC):

- The emission factor is taken from the IPCC Guidelines 1996, 23.0 kg/TJ, and is assumed to be constant over the period 1990–2012 (IPCC 1997c, chapter 1.4.2.6)

Precursors (country specific; CORINAIR):

- Assignment of emission factors for 1990 and 1995: The fleet that operated in and from Switzerland during those years has been analysed. The corresponding most frequent engines within an aircraft category (ICAO Code) have been assigned to every aircraft type.
- Assignment of emission factors for the year 2000, 2002, 2004 to 2012: The actual engine of every single aircraft operating in and from Switzerland has been assigned. FOCA uses the aircraft tail number as the key variable which links activity data and individual aircraft engine information (see Annex A3.1.4 Table A-11 Aircraft Engine Combinations).

FOCA determines the emission factors of different precursors such as NO_x, VOC, CO and other pollutants as follows:

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[9] The share of 0.1 for methane is maintained until general acceptance of necessary corrections is reached. Studies indicate that during cruise, Methane exhaust concentrations are lower than Methane ambient concentrations, see Wiesen et al. (1994), Spicer et al. (1994) and Knighton et al. (2009). A first remark has been made in Table 1-52 of the IPCC Guidelines 1996.

LTO:
The Swiss FOCA engine emissions database consists of more than 600 individual engine data sets. Jet engine factors for engines above 26.7 kN thrust (emission certificated) are identical to the ICAO engine emissions databank. Emission factors for lower thrust engines, piston engines and helicopters were taken from manufacturers or from own measurements. Emission factors for turboprops could be obtained in collaboration with the Swedish Defence Research Agency (FOI).

Cruise:
The fuel flows of the whole Airbus fleet (which produces a great portion of the Swiss inventory) have been modelled on the basis of real operational aircraft data from flight data recorders (FDR) of Swiss International Airlines. Pollutant emission factors have been modelled on the basis of the ICAO engine databank and corrected to cruise conditions using FDR engine parameters and the Boeing Fuel Flow Method 2. Part of the cruise emission factors are taken from EMEP/CORINAIR (EEA 2002) and from former CROSSAIR (FOCA 1991). Other missing aircraft types have been modelled on the basis of FOCA aircraft performance modelling and the ICAO engine emissions databank, using the Boeing Fuel Flow Method 2, as well. For piston engine aircraft and helicopters, Swiss FOCA has produced its own data, which were taken under real flight conditions (2005 data, FOCA 2009a).

Activity data

Scheduled and charter aviation

The statistical basis has been extended after 1996. Therefore, the modelling details are not exactly the same for the years 1990-1995 as for the subsequent years. The source for the 1990 and 1995 modelling is the movement statistics, which records information for every movement on airline, number of seats, Swiss airport, arrival/departure, origin/destination, number of passengers, distance. From 1996 onwards, every movement in the FOCA statistics also contains the individual aircraft tail number (aircraft registration). This is the key variable to connect airport data and aircraft data. The statistics may contain more than one million records with individual tail numbers. All annual aircraft movements recorded are split into domestic and international flights (there are 455'422 aircraft movements in the total of scheduled and charter traffic in 2012 as given by FOCA 2013).

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

- Airports and most of the airfields report individual aircraft data (aircraft registration). FOCA may therefore compute the inventory for small aircraft with Tier 3a method, too. However, for 1990 and 1995, the emissions data for non-scheduled, non-charter and General Aviation (helicopters etc.) could not be calculated with a Tier 3a method. Its fuel consumption is estimated to be 10% of the domestic fuel consumption. Data were taken from two FOCA studies (FOCA 1991, FOCA 1991a). For 2000-2007, all movements from airfields are known, which allows a more detailed modelling of the emissions (FOCA 2007a).
- Helicopter flights which do not take off from an official airport or airfield such as transport flights, flights for lumbering, animal transports, supply of alpine huts, heli-skiing and flight trainings in alpine regions cannot be recorded with the movement data base from airports and airfields Although these helicopter movements only account for 0.1% of the total civil aviation emissions, these emissions are taken into account using the Unternehmensstatistik der Schweizer Helikopterunternehmen. This statics is officially collected by FOCA and updated annually (see FOCA 2004 as illustrative example for all subsequent years).

Since 2007, the data of the Unternehmensstatistik der Schweizer Helikopterunernehmen (statistics about Swiss helicopter companies) is included electronically in the data warehouse of the model and undergoes first some plausibility checks (E-plaus software). In order to distinguish between single engine helicopters and twin engine helicopter a fix split of 87 % for single engine helicopters and 13 % for twin engine helicopters is applied for the entire commitment period based on investigations in 2004 (FOCA 2004). Note that all emissions from helicopter flights without using an official airport or an official airfield are considered as domestic emissions. There is also a helicopter base in the Principality of Liechtenstein consuming a certain very small amount of fuel contained in the Swiss statistics. Thus, its consumption leads to domestic instead of international bunker emissions (about 0.4 Gg CO_2). FOCA and FOEN decided to report these emissions as Swiss-domestic since it is a very small amount and the effort for a separation would be considerable.

Fuel consumption: Table 3-31 summarises the activity data for domestic aviation (1A3a). It also includes international aviation, which belongs to the memo items, international bunkers/aviation (see also Chapter 3.2.2).

Note that the fuel consumption reported in the CRF is identical to the consumption due to the fuel sales reported in the Swiss overall energy statistics (see e.g. SFOE 2013) while the consumptions of military aircraft and of Liechtenstein's helicopter consumption is subtracted (see section 3.2.5). In fact, the emission model run by FOCA overestimates fuel consumption by ca. 1.5%. However, the domestic fuel consumption is reported according to the modelled value (conservative estimation), whereas the international fuel consumption (bunker) is scaled downwards so that the sum of domestic and international fuel consumption becomes identical with the fuel sold, as reported in the Swiss overall energy statistics.

Table 3-31 Fuel consumption of civil aviation in TJ. The "domestic" consumption and the corresponding emissions are reported under 1A3a, the "international" consumption is reported under Memo items, international bunkers (FOCA 2007, 2007a, 2008-2013).

1A3a Civil Aviation	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	Fuel consumption in TJ									
Total domestic (1A3aii)	3'450	3'194	3'217	3'165	3'077	3'075	2'972	2'850	2'742	2'684
Total international (1A3ai)	41'884	40'872	43'499	45'342	46'840	49'918	51'975	53'983	56'599	60'805
Sum	45'334	44'067	46'717	48'508	49'917	52'993	54'946	56'833	59'341	63'489
1990 = 100%	100%	97%	103%	107%	110%	117%	121%	125%	131%	140%

1A3a Civil Aviation	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	Fuel consumption in TJ									
Total domestic (1A3aii)	2'539	2'296	2'028	1'951	1'963	1'699	1'658	1'891	1'618	1'704
Total international (1A3ai)	63'687	60'097	55'468	49'763	46'896	47'671	50'109	53'543	57'844	55'238
Sum	66'225	62'393	57'495	51'714	48'859	49'370	51'766	55'434	59'462	56'942
1990 = 100%	146%	138%	127%	114%	108%	109%	114%	122%	131%	126%

1A3a Civil Aviation	**2010**	**2011**	**2012**
	Fuel consumption in TJ		
Total domestic (1A3aii)	1'688	1'808	1'867
Total international (1A3ai)	58'118	64'060	63'627
Sum	59'805	65'868	65'494
1990 = 100%	132%	145%	144%

b) Road Transportation (1A3b)

Tier 1 Key categories 1A3b

CO_2 from the combustion of gasoline (level and trend)
CO_2 from the combustion of diesel (level and trend)
CO_2 from the combustion of natural gas (trend)
N_2O from the combustion of gasoline (trend)

Tier 2 Key categories 1A3b
CO_2 from the combustion of gasoline (level and trend)
CO_2 from the combustion of diesel (level and trend)
CH_4 from the combustion of gasoline (trend)
N_2O from the combustion of gasoline (trend)

Methodology

The CO_2 emissions are calculated with a Tier 2 method (top-down) as suggested by IPCC Good Practice Guidance (IPCC 2003) using country specific emission factors. The emission factors are derived from the carbon content of fuels (see Table 3-9). The activity data corresponds to the amounts of gasoline and diesel fuel sold in Switzerland (sales principle). The numbers are taken from the national fuel statistics which is part of the Swiss overall energy statistics (SFOE 2013).

The consumption of biofuels is reported for Road Transportation as well. Fuels involved, emission factors and activity data are summarised in a comment to the EMIS database (EMIS 2013 1A3bi-viii Strassenverkehr). Most important data sources stem from the Swiss overall energy statistics (SFOE 2013) the Swiss renewable energy statistics (SFOE 2013a) and the Swiss Federal Customs Administrations (SFCA 2013).

Other gases

The other gases are modelled with a well-documented country specific method (SAEFL 1995, 2004, 2004a, FOEN 2010i, INFRAS 2010, INFRAS 2011, Hausberger et al. 2009). The approach corresponds methodologically to Box 1 in the decision tree of Figure 2.5 (p. 2.45) of IPCC Good Practice Guidance.

The emission computation is based on two sets of data:

- Traffic activity data: transport performance in vehicle kilometres (hot emissions), number of starts/stops and vehicle stock (cold start, evaporation emissions and running losses)
- Emission factors: specific pollutant emissions in grams per unit (vehicle kilometres, start/stop or vehicle)

For the calculation of emissions these two data sets are multiplied for all other gases as follows (further details of emission modelling are given in Annex A3.1.5):

Emission (gram) = activity data (veh-km/a, starts/stops/a, vehicles) *
emission factor (gram/veh-km, gram/start/stop, gram/vehicle),

Activity Data

The activity data is derived from different data sources:

- Vehicle stock: The Federal vehicle registration database (SFSO 2013b) supplies the number of vehicles (including age distributions) per vehicle category[10]. With the help of a fleet turnover model the vehicle categories are split up into so called «sub-segments», which are used to link with the specific emission factors (vehicle category/size class/fuel type/emission concept (see also INFRAS 2010).

[10] The vehicle registration in Switzerland delivers all inputs to build up the fleet composition 1990-2011 which is characterised e.g. by vehicle category, engine capacity, fuel type, total weight, vehicle age and exhaust technology.

- Transport performance: The transport performance (mileage) is calculated from the specific mileage per vehicle (based on household surveys/Mikrozensus ARE/SFSO 2005) times the number of vehicles. This figure is calibrated to the official statistics of traffic performance (SFSO 2009c and SFSO 2010c). Lately, a recalibration of the mileage per vehicle category has been performed (ARE 2012).
- Numbers of starts/stops: Derived from vehicles stock, with data on trip length distributions and parking time distributions (ARE/SFSO 2005).

For the determination of the non-CO_2 greenhouse gases and the precursors, the transport performance must be attributed to so called “traffic situations” (characteristic patterns of driving behaviour) which serve as a key to select the appropriate emission factor. The relative shares of these traffic situations is derived from a national road traffic model (operated by the Federal Office of Spatial Development, see ARE 2010). The traffic model is based on an origin-destination matrix that is assigned to a network of about 20’000 road segments. The model is calibrated partly bottom-up and partly top-down: Bottom-up by a number of traffic counts from the national traffic-counter network (333 stations all over Switzerland, FEDRO 2010), and top-down by the total of the mileage per vehicle category. Furthermore, it supplies the attributes needed for assigning a “traffic situation” to each road segment.

Due to fuel price differences in the vicinity of the national borders, gasoline stations sell relevant amounts of gasoline to foreign car owners. This amount of fuel is mainly consumed abroad (“tank tourism”) but the whole amount must be reported as national under 1A3b Road Transportation. For the CO_2 emissions, the amount of tank-tourism is irrelevant since it is included in the sales principle. The non-CO_2 emissions related to the “tank tourism”, however, are not captured by the traffic model. For the purpose of assuring completeness within the GHG inventory, these emissions are quantified on the basis of the difference between fuel consumption according to the Swiss overall energy statistics (sales principle) and fuel consumption derived from the traffic model. The resulting amount of “tank tourism” fuel is multiplied with mean emission factors to determine the related emissions of CH_4, N_2O, NO_x, CO, NMVOC, and SO_2. For CO_2, which dominates the emissions by a factor of approx. 1’000-10’000, the use of Swiss mean factors is correct, since the carbon content constitutes the emission factor. For CH_4 and N_2O there are differences between the Swiss mean factors and the implied emission factors of the four neighbouring countries Austria, France, Germany, Italy, as a comparison with their implied emission factors for 1990 and 2004 has shown. The differences are small between Switzerland, Austria, and Germany because all three countries use the same emission factors (SAEFL 2004a), whereas there are some differences when compared to France and Italy that use other emission factors (COPERT[11]). Nevertheless, the use of the mean Swiss emission factors seems to be the consistent approach.

The N_2O emissions from natural gas combustion for road transportation originate from two vehicle categories: Biofuel CNG/petrol passenger cars and urban buses running purely on CNG. The same data as for the estimation of other gases (e.g. CO_2) were used for these two vehicle categories. As for all other vehicle categories, a residual of the total activity is assigned to tank tourism.

Emission Factors

The emission factors for fossil CO_2 and other gases are country specific and based on measurements and analyses of fuel samples (Table 3-9). Emission factors for the further gases are country specific derived from “emission functions” which are determined from a compilation of measurements from various European countries with programs using similar

[11] see Euopean Environment Agency http://www.eea.europa.eu/publications/TEC05 [14.02.2013]

driving cycles (legislative as well as standardized real-world cycles, like “Common Artemis Driving Cycle” (CADC). The method has been developed in 1990-1995 and has been extended and updated in 2000, 2004 and 2010. These emission factors are compiled in a so called “Handbook of Emission Factors for Road Transport” (SAEFL 1995, 2004, 2004a, FOEN 2010i, INFRAS 2004, 2004a, 2010, 2011). The latest version (3.1) is presented and documented on the website http://www.hbefa.net/. Several reports may be downloaded from there:

- Documentation of the general emission factor methodology (INFRAS 2011; forthcoming in German),
- Emission Factors for Passenger Cars and Light Duty Vehicles Switzerland, Germany, Austria, Norway and Sweden (INFRAS 2010; in English),

The resulting emission factors are published on CD ROM (“Handbook of emission factors for Road Transport”, INFRAS 2010). The underlying database contains a dynamic fleet compositions model simulating the release of new exhaust technologies and the fading out of old technologies. Corrective factors are provided to account for future technologies. Further details are shown in Annex A3.1.5.

The following tables present a selection of mean emission factors. The CO_2 factors are constant over the whole period 1990–2012. The carbon content of the fuels has not changed. However, the increasing portion of biofuels to the fuels is encompassed by the data time series - see next chapter for the emission factors of biofuels. For the other gases, more or less pronounced decreases of the emission factors occur due to new emission regulations and subsequent new exhaust technologies (mandatory use of catalytic converters for gasoline cars and lower limits for sulphur content in diesel fuels). Early models of catalytic converters have been substantial sources of N_2O, leading to an emission increase until 1998. Recent converter technologies have overcome this problem resulting in a decrease of the (mean) emission factor.

As of Submission 2013 of the National Inventory Report, N_2O emission factors in g/km differentiated by vehicle category and technology from the Handbook of Emission Factors (INFRAS 2010) have been applied, in contrast to previous submissions that applied a constant value in g/TJ fuel consumption. This results in a more realistic change pattern over time of N_2O emissions from road transportation than in earlier submissions.

In contrast to the N_2O emission factors, the measurement sample for CH_4 emission factors remained the same. However, due to updates in the vehicles fleet composition, the implied emission factors changed eventually. Further detailed description of how the emission factors for CH_4 are estimated is provided in the Annex A3.1.5.

As of Submission 2013, N_2O emission factors for gaseous fuels have been applied. No country-specific EFs for N_2O are available. Therefore, emissions have been estimated using the EFs for alternative fuel vehicles provided in table 3.2.4 on page 3.23 of Volume 2 of the 2006 IPCC Guidelines (IPCC 1997b). The value of 101 mg/km from the 2006 IPCC Guidelines was used for urban buses running on CNG only. For the bi-fuel passenger cars, it is assumed that they use gasoline mainly during the start but otherwise run on CNG; therefore the respective CNG emission factor for light duty vehicles of 27 mg/km from the same source was applied. As for all other fuel categories, the emission factor used for tank tourism corresponds to the weighted average of the national transport mix.

Emission factors from the combustion of biofuels

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

- Biodiesel: The implied emission factors 1A3b for fossil diesel are used. Values for 2012: CO_2 73.6 t/TJ; CH_4 0.28 kg/TJ; N_2O 2.29 kg/TJ
- Bio ethanol: The implied emission factors 1A3b for gasoline are used. Values for 2012: CO_2 73.9 t/TJ; CH_4 5.69 kg/TJ; N_2O 0.71 kg/TJ
- Biogas: The implied emission factors 1A3b for CNG are used. Values for 2012: CO_2 56.1 t/TJ; CH_4 3.78 kg/TJ; N_2O 8.37 kg/TJ

Overview over mean emission factors

Table 3-32 Mean emission factors for road transport for passenger cars. For more details see Annex A3.1.5.

Gas	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Passenger Cars		t/TJ									
CO_2	Gasoline	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9
	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
	CNG										
CH_4	Gasoline	0.0266	0.0237	0.0213	0.0196	0.0178	0.0166	0.0155	0.0143	0.0132	0.0123
	Diesel	0.0015	0.0015	0.0013	0.0012	0.0013	0.0012	0.0011	0.0010	0.0009	0.0009
	CNG										
N_2O	Gasoline	0.0031	0.0033	0.0035	0.0037	0.0039	0.0041	0.0042	0.0042	0.0041	0.0039
	Diesel	0.0002	0.0003	0.0004	0.0005	0.0007	0.0008	0.0009	0.0010	0.0012	0.0014
NO_x	Gasoline	0.3449	0.3139	0.2832	0.2657	0.2568	0.2512	0.2469	0.2377	0.2274	0.2163
	Diesel	0.2527	0.2558	0.2463	0.2395	0.2457	0.2412	0.2404	0.2402	0.2422	0.2464
	CNG										
CO	Gasoline	3.1952	2.7878	2.4249	2.1754	1.9608	1.7979	1.6596	1.5308	1.4167	1.3193
	Diesel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CNG										
NMVOC	Gasoline	0.5008	0.4402	0.3865	0.3485	0.3131	0.2861	0.2623	0.2396	0.2192	0.2013
	Diesel	0.0608	0.0617	0.0547	0.0504	0.0515	0.0471	0.0445	0.0410	0.0380	0.0352
	CNG										
SO_2	Gasoline	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
	Diesel	0.3678	0.3651	0.3348	0.3076	0.2860	0.2656	0.2555	0.2365	0.2222	0.2079
	CNG										

Gas	Fuel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Passenger Cars		t/TJ									
CO_2	Gasoline	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9
	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
	CNG								56.1	56.1	56.1
CH_4	Gasoline	0.0114	0.0106	0.0098	0.0092	0.0086	0.0082	0.0076	0.0073	0.0069	0.0064
	Diesel	0.0008	0.0007	0.0006	0.0006	0.0006	0.0005	0.0004	0.0004	0.0004	0.0003
	CNG								0.0045	0.0043	0.0042
N_2O	Gasoline	0.0037	0.0034	0.0032	0.0029	0.0017	0.0016	0.0013	0.0013	0.0011	0.0010
	Diesel	0.0015	0.0017	0.0018	0.0019	0.0019	0.0020	0.0020	0.0020	0.0021	0.0021
NO_x	Gasoline	0.2050	0.1925	0.1772	0.1646	0.1528	0.1433	0.1263	0.1192	0.1075	0.0964
	Diesel	0.2543	0.2653	0.2765	0.2873	0.2922	0.2905	0.2774	0.2677	0.2594	0.2544
	CNG								0.0236	0.0232	0.0232
CO	Gasoline	1.2355	1.1774	1.1157	1.0698	1.0252	0.9934	0.9310	0.9065	0.8612	0.8144
	Diesel	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CNG								0.0842	0.0837	0.0841
NMVOC	Gasoline	0.1846	0.1722	0.1590	0.1486	0.1396	0.1334	0.1233	0.1200	0.1131	0.1063
	Diesel	0.0324	0.0293	0.0261	0.0243	0.0224	0.0205	0.0177	0.0164	0.0151	0.0140
	CNG								0.0004	0.0004	0.0004
SO_2	Gasoline	0.0067	0.0057	0.0048	0.0038	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
	Diesel	0.1832	0.1642	0.1448	0.1322	0.1131	0.1032	0.0903	0.0844	0.0785	0.0731
	CNG								0.0000	0.0000	0.0000

Gas	Fuel	2010	2011	2012
Passenger Cars		t/TJ		
CO_2	Gasoline	73.9	73.9	73.9
	Diesel	73.6	73.6	73.6
	CNG	56.1	56.1	56.1
CH_4	Gasoline	0.0060	0.0059	0.0057
	Diesel	0.0003	0.0003	0.0003
	CNG	0.0041	0.0054	0.0054
N_2O	Gasoline	0.0009	0.0008	0.0007
	Diesel	0.0021	0.0021	0.0022
NO_x	Gasoline	0.0861	0.0791	0.0726
	Diesel	0.2509	0.2487	0.2475
	CNG	0.0231	0.0221	0.0221
CO	Gasoline	0.7755	0.7530	0.7299
	Diesel	0.0000	0.0000	0.0000
	CNG	0.0839	0.1578	0.1570
NMVOC	Gasoline	0.1013	0.0991	0.0965
	Diesel	0.0133	0.0130	0.0127
	CNG	0.0004	0.0005	0.0005
SO_2	Gasoline	0.0004	0.0004	0.0004
	Diesel	0.0693	0.0673	0.0652
	CNG	0.0000	0.0000	0.0000

Table 3-33 Mean emission factors for road transport for heavy duty vehicles. For more details see Annex A3.1.5.

Gas	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Heavy duty vehicles		t/TJ									
CO_2	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH_4	Diesel	0.0019	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014
N_2O	Diesel	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009
NO_x	Diesel	1.029	1.028	1.025	1.016	0.986	0.956	0.935	0.920	0.911	0.902
CO	Diesel	0.219	0.218	0.218	0.214	0.206	0.201	0.196	0.191	0.184	0.178
NMVOC	Diesel	0.076	0.075	0.075	0.073	0.068	0.066	0.065	0.062	0.059	0.056
SO_2	Diesel	0.065	0.061	0.056	0.047	0.020	0.016	0.017	0.016	0.019	0.021

Gas	Fuel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Heavy duty vehicles		t/TJ									
CO_2	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH_4	Diesel	0.0013	0.0011	0.0010	0.0010	0.0009	0.0009	0.0008	0.0007	0.0005	0.0004
N_2O	Diesel	0.0009	0.0008	0.0008	0.0008	0.0007	0.0007	0.0009	0.0012	0.0017	0.0024
NO_x	Diesel	0.879	0.833	0.795	0.757	0.716	0.699	0.667	0.626	0.552	0.490
CO	Diesel	0.171	0.162	0.158	0.157	0.151	0.150	0.147	0.144	0.140	0.138
NMVOC	Diesel	0.053	0.046	0.043	0.040	0.036	0.035	0.031	0.028	0.022	0.017
SO_2	Diesel	0.0127	0.0117	0.0110	0.0093	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

Gas	Fuel	2010	2011	2012
Heavy duty vehicles		t/TJ		
CO_2	Diesel	73.6	73.6	73.6
CH_4	Diesel	0.0004	0.0003	0.0002
N_2O	Diesel	0.0028	0.0032	0.0034
NO_x	Diesel	0.451	0.416	0.390
CO	Diesel	0.136	0.135	0.134
NMVOC	Diesel	0.015	0.012	0.010
SO_2	Diesel	0.0005	0.0005	0.0005

Activity data

The amount of gasoline and diesel fuel sold in Switzerland serves as the activity data for the calculation of the CO_2 emissions: The Swiss overall energy statistics gives the amount of gasoline and diesel oil sold (SFOE 2013). From these numbers, the off-road consumption and the fugitive emissions from transmission, storage and fuelling of gasoline (reported under 1B2av Distribution of oil products) are subtracted. The result gives the inventory-relevant consumption for estimating the CO_2 emissions. It contains the fuel consumption due to the traffic model plus the amount of “tank tourism” (see above). The following table shows the details.

Table 3-34 Upper and middle part of table: Split of fuel sales into territorial on-road (model), off-road (model) and tank tourism (residual value to sales amounts) for gasoline and diesel oil in PJ. (Numbers may not add to totals due to rounding.)
Lower part of table: Consumption of biofuels for road transportation. Consumption starts in 1997. Note that the unit is TJ (not PJ like fossil fuels in the upper and middle part of the table) and that Vegetable/Waste oil is included in the numbers of Biodiesel as well as separately depicted. However no double counting occurs in the total sum and shares of total fuel consumption.

Activity data	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
on-road and off-road categories		PJ									
Gasoline											
on-road consumption (model)	1A3b	135.6	139.0	137.6	134.5	137.6	140.8	142.3	142.9	143.9	145.3
"tank tourism"	1A3b	17.8	20.8	28.1	19.0	16.1	8.1	10.5	16.0	16.3	20.4
off-road consumption (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3
Gasoline sold in Switzerland		155.8	162.2	168.1	155.9	156.1	151.3	155.2	161.2	162.5	168.0
Diesel											
on-road consumption (model)	1A3b	36.5	37.4	38.3	38.1	39.0	39.8	39.7	40.0	41.1	42.7
"tank tourism"	1A3b	-1.3	-1.8	-4.5	-6.2	-4.6	-4.8	-7.7	-6.5	-5.8	-4.7
off-road consumption (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	11.6	11.8	12.1	12.3	12.6	12.8	13.0	13.2	13.4	13.6
Diesel sold in Switzerland		46.7	47.4	45.9	44.2	46.9	47.8	44.9	46.7	48.7	51.6
Total											
on-road consumption (model)	1A3b	172.0	176.4	175.9	172.6	176.6	180.6	182.0	182.9	185.0	188.0
"tank tourism"	1A3b	16.5	19.0	23.7	12.9	11.5	3.3	2.8	9.5	10.5	15.7
off-road consumption (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	14.0	14.2	14.5	14.7	14.9	15.2	15.3	15.5	15.7	15.9
Gasoline and Diesel sold in Switzerland		202.5	209.6	214.0	200.1	203.0	199.1	200.1	207.9	211.1	219.6

Activity data	Source category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
on-road and off-road categories		PJ									
Gasoline											
on-road consumption (model)	1A3b	146.9	145.5	144.5	141.9	139.1	136.1	132.1	129.1	126.4	122.8
"tank tourism"	1A3b	18.9	15.6	13.4	15.3	15.4	13.6	12.9	14.5	14.0	13.7
off-road consump. (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Gasoline sold in Switzerland		168.0	163.4	160.2	159.5	156.6	151.8	147.2	145.8	142.6	138.7
Diesel											
on-road consumption (model)	1A3b	44.9	45.8	47.4	50.5	54.1	57.4	61.1	65.3	68.2	70.8
"tank tourism"	1A3b	-3.5	-3.3	-3.0	-2.7	-1.7	0.9	3.1	4.5	9.8	8.6
off-road consump. (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	13.7	13.8	13.9	13.9	14.0	14.1	14.2	14.4	14.6	14.7
Diesel sold in Switzerland		55.1	56.2	58.3	61.7	66.3	72.4	78.4	84.2	92.6	94.1
Total											
on-road consumption (model)	1A3b	191.7	191.3	191.9	192.4	193.1	193.5	193.2	194.4	194.6	193.6
"tank tourism"	1A3b	15.4	12.3	10.5	12.6	13.7	14.5	16.0	19.0	23.9	22.3
off-road consump. (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	16.0	16.1	16.1	16.1	16.2	16.2	16.4	16.6	16.7	16.9
Gasoline and Diesel sold in Switzerland		223.2	219.6	218.5	221.2	223.0	224.3	225.6	229.9	235.2	232.9

Activity data	Source category	2010	2011	2012
on-road and off-road categories		PJ		
Gasoline				
on-road consumption (model)	1A3b	119.3	116.0	112.7
"tank tourism"	1A3b	12.4	10.6	9.3
off-road consump. (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	2.2	2.1	2.1
Gasoline sold in Switzerland		133.8	128.7	124.1
Diesel				
on-road consumption (model)	1A3b	73.9	75.1	76.3
"tank tourism"	1A3b	9.0	10.6	15.6
off-road consump. (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	14.9	14.8	14.7
Diesel sold in Switzerland		97.8	100.5	106.6
Total				
on-road consumption (model)	1A3b	193.2	191.1	189.0
"tank tourism"	1A3b	21.4	21.1	25.0
off-road consump. (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	17.1	16.9	16.8
Gasoline and Diesel sold in Switzerland		231.6	229.1	230.7

Biofuels	1990-1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
	TJ																
Biodiesel	0	57	51	48	56	60.4	55.0	72.3	100.7	196.4	272.7	304.7	368.2	232.0	287.9	316.8	382.6
Bioethanol	0	0	0	0	0	0.0	0.0	0.0	0.0	19.0	22.3	67.1	69.2	31.2	54.6	85.2	97.3
Biogas	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	30.2	30.8	32.1	50.7	105.9	161.1
Sum	0	57.2	51.4	48.3	56.4	60.4	55.0	72.3	100.7	215.4	295.0	402.0	468.2	295.3	393.2	508.0	640.9
Share of total fuel consump. 1A3b	0.0%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.4%	0.5%	1.1%	1.5%	2.1%	2.4%	1.5%	2.0%	2.7%	3.4%

Further activity data needed for modelling the non-CO_2 emissions are the mileages (vehicle kilometres) per vehicle category in Table 3-35. Note that the activity data have been recalculated due based on the latest figures on population and economy (Prognos 2012a, ARE 2012).

Table 3-35 Mileages in millions of vehicle kilometres. PC: passenger cars, LDV: light duty vehicles, HDV: heavy duty vehicles).

Veh. category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	million vehicle-km									
PC	42'650	43'745	43'178	42'259	43'199	43'824	44'063	44'675	45'570	46'702
LDV	2'758	2'742	2'867	2'632	2'669	2'746	2'767	2'786	2'831	2'903
HDV	1'992	2'015	2'036	2'025	2'109	2'107	2'055	2'072	2'126	2'200
Coaches	108	108	109	109	110	110	109	108	101	98
Urban Bus	174	186	188	190	190	192	188	188	192	195
2-Wheelers	2'025	1'947	1'866	1'792	1'717	1'744	1'756	1'823	1'872	1'941
Sum	49'707	50'743	50'244	49'007	49'993	50'724	50'939	51'653	52'692	54'039
(1990=100%)	100%	102%	101%	99%	101%	102%	102%	104%	106%	109%

Veh. category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	million vehicle-km									
PC	48'063	48'509	49'062	49'527	50'019	50'465	50'812	51'208	51'949	52'852
LDV	2'978	3'059	3'119	3'149	3'215	3'300	3'374	3'473	3'529	3'584
HDV	2'273	2'165	2'109	2'115	2'144	2'127	2'189	2'203	2'223	2'172
Coaches	99	95	93	95	98	106	118	120	114	119
Urban Bus	200	205	211	215	220	229	233	240	245	249
2-Wheelers	1'999	2'048	2'098	2'152	2'190	2'204	2'262	2'300	2'366	2'385
Sum	55'612	56'082	56'693	57'253	57'886	58'432	58'989	59'544	60'426	61'361
(1990=100%)	112%	113%	114%	115%	116%	118%	119%	120%	122%	123%

Veh. category	2010	2011	2012
	million vehicle-km		
PC	53'341	54'000	54'730
LDV	3'621	3'663	3'701
HDV	2'210	2'250	2'290
Coaches	119	119	118
Urban Bus	251	254	257
2-Wheelers	2'407	2'436	2'465
Sum	61'950	62'722	63'562
(1990=100%)	125%	126%	128%

In 2012, 86.1% of total vehicle kilometres are driven by passenger cars, 5.8% and 3.6% by light and heavy duty vehicles, respectively. The mileages increased for all vehicle categories (except coaches), totalling 28% in the period 1990–2012. In the same period, fuel consumption increased less strongly, by 13.9%, indicating improved fuel efficiency. This effect is also reflected in Table 3-36 that depicts the specific fuel consumption per vehicle-km. For most vehicle categories, the specific consumption has decreased in the period 1990-2012 (between 3% and 23%). Consumption of light duty vehicles remained indifferent while two-wheelers (15%) have increased their average specific consumption. Concerning the whole car fleet, a decrease of 19% in specific consumption has been reached between 1990 and 2012.

Table 3-36 Fuel consumption of road transport, not including "tank tourism" (PC: passenger cars, LDV: light duty vehicles, HDV: heavy duty vehicles).

Veh. cat.	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		specific fuel consumption (MJ/veh-km)									
PC	Gasoline	3.18	3.20	3.22	3.23	3.23	3.23	3.22	3.21	3.19	3.17
	Diesel	2.91	2.91	2.92	2.98	2.90	2.90	2.90	2.91	2.89	2.86
	CNG										
LDV	Gasoline	3.17	3.18	3.17	3.18	3.18	3.18	3.18	3.17	3.17	3.18
	Diesel	3.86	3.87	3.87	3.88	3.87	3.86	3.83	3.81	3.79	3.77
HDV	Diesel	10.91	10.95	10.98	10.92	10.97	10.85	10.71	10.58	10.46	10.38
Coach	Diesel	11.84	11.85	11.87	11.81	11.75	11.69	11.62	11.55	11.48	11.42
Urban Bus	Diesel	16.22	16.29	16.33	16.34	16.32	16.29	16.20	16.10	16.02	15.90
	CNG										
2-Wheeler	Gasoline	1.11	1.14	1.17	1.19	1.21	1.22	1.22	1.24	1.24	1.24
Average		**3.45**	**3.47**	**3.49**	**3.51**	**3.51**	**3.49**	**3.45**	**3.42**	**3.39**	**3.36**
		100%	**100%**	**101%**	**102%**	**102%**	**101%**	**100%**	**99%**	**98%**	**97%**

Veh. cat.	Fuel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		specific fuel consumption (MJ/veh-km)									
PC	Gasoline	3.14	3.13	3.11	3.09	3.06	3.04	2.99	2.97	2.93	2.90
	Diesel	2.80	2.72	2.66	2.58	2.52	2.46	2.41	2.40	2.35	2.33
	CNG								2.91	2.88	2.85
LDV	Gasoline	3.18	3.17	3.18	3.19	3.19	3.19	3.21	3.21	3.20	3.19
	Diesel	3.75	3.71	3.63	3.56	3.48	3.42	3.37	3.34	3.32	3.31
HDV	Diesel	10.33	10.56	10.62	10.63	10.61	10.77	10.71	10.73	10.65	10.59
Coach	Diesel	11.33	11.25	11.21	11.19	11.21	11.22	11.23	11.22	11.18	11.16
Urban Bus	Diesel	15.80	15.71	15.60	15.45	15.45	15.37	15.24	15.23	15.05	14.94
	CNG								20.34	20.32	20.36
2-Wheeler	Gasoline	1.25	1.25	1.24	1.25	1.27	1.28	1.29	1.31	1.33	1.35
Average		**3.32**	**3.29**	**3.24**	**3.20**	**3.15**	**3.11**	**3.06**	**3.02**	**2.96**	**2.93**
		96%	**95%**	**94%**	**93%**	**91%**	**90%**	**89%**	**87%**	**86%**	**85%**

Veh. cat.	Fuel	2010	2011	2012
		MJ/veh-km		
PC	Gasoline	2.86	2.81	2.77
	Diesel	2.30	2.28	2.24
	CNG	2.83	2.53	2.51
LDV	Gasoline	3.18	3.17	3.15
	Diesel	3.31	3.30	3.29
HDV	Diesel	10.55	10.50	10.46
Coach	Diesel	11.16	11.15	11.14
Urban Bus	Diesel	14.81	14.76	14.72
	CNG	20.58	20.52	20.46
2-Wheeler	Gasoline	1.34	1.34	1.34
Average		**2.89**	**2.86**	**2.82**
		84%	**83%**	**82%**

For modelling of cold start and evaporative emissions of passenger cars and light duty vehicles, also vehicle stock and start numbers are used for activity data. The corresponding numbers are summarised in the next table. Vehicle stock figures correspond to registration data. The starts per vehicle are based on specific household surveys (ARE/SFSO 2005).

Table 3-37 Vehicle stock numbers and average number of starts per vehicle per day (PC: passenger cars, LDV: light duty vehicles).

Veh. Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	stock in 1000 vehicles									
PC	2'985	3'058	3'091	3'110	3'165	3'229	3'268	3'323	3'383	3'467
LDV	221	228	229	228	232	238	241	243	247	254
2-Wheelers	764	747	729	720	708	704	699	709	718	728
	starts per vehicle per day									
PC	2.61	2.60	2.58	2.56	2.54	2.53	2.53	2.51	2.49	2.47
LDV	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97
2-Wheelers	1.59	1.58	1.57	1.56	1.55	1.54	1.54	1.53	1.52	1.51

Veh. Category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	stock in 1000 vehicles									
PC	3'545	3'630	3'701	3'754	3'811	3'862	3'894	3'956	3'990	4'010
LDV	260	268	274	278	284	291	298	307	312	317
2-Wheelers	732	740	753	763	771	770	784	789	804	807
	starts per vehicle per day									
PC	2.46	2.45	2.44	2.43	2.41	2.40	2.39	2.38	2.37	2.35
LDV	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96
2-Wheelers	1.50	1.51	1.52	1.52	1.53	1.54	1.54	1.55	1.56	1.56

Veh. Category	2010	2011	2012
	stock in 1000 vehicles		
PC	4'076	4'195	4'302
LDV	326	328	331
2-Wheelers	816	815	815
	starts per vehicle per day		
PC	2.34	2.34	2.33
LDV	1.96	1.96	1.96
2-Wheelers	1.57	1.57	1.57

c) 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.

Emissions of diesel rail vehicles are modelled using the off-road model developed by INFRAS (2008). For details refer to Chapter 3.2.5.1 (paragraph on source category 1A2fii).

Emission Factors

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

- The emission factor for CO_2 is country specific and assumed to be constant in the period 1990-2012 with value 73.6 t/TJ (diesel oil, see Table 3-9, SFOE 2001).
- For SO_2 the emission factors are country specific. They are depicted in Table A - 6 in Annex A2, row diesel oil: Continuous decrease from 65.4 kg/TJ in 1990 to 12.7 kg/TJ in 2000 and to 0.47 kg/TJ in 2010.

The emission factors for all other gases are country specific and are shown in Table A - 19 in Annex A3.1.6. Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated as the difference of VOC and CH_4 emissions. Note that emission factors in the unit of kg/h may be downloaded by query from the public part of the off-road database (INFRAS 2008; see footnote 7 on page 111).

Activity data

The fuel consumption is calculated like emission modelling but with consumption factors using instead of emission factors (see Table A - 19). The operating hours depend on the number of vehicles per age and size class. In 2005 e.g., 1’260 vehicles were operating 0.77 million hours per year with an average number of 611 operating hours per year per vehicle (INFRAS 2008). As mentioned above, a slight update was carried out in 2013 based on the latest figures on population and economy (Prognos 2012a). The diesel consumption has been recalculated accordingly. Numbers from 2005 onwards are affected. The resulting fuel consumption is shown in Table 3-38.

Table 3-38 Activity data (diesel oil consumption) for railways.

1A3c Railways	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Diesel	TJ	390	400	410	420	430	441	443	446	449	452
1990=100%		100.0%	102.6%	105.2%	107.8%	110.4%	113.0%	113.8%	114.5%	115.2%	116.0%

1A3c Railways	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Diesel	TJ	455	460	466	472	477	483	494	504	515	526
1990=100%		116.7%	118.1%	119.6%	121.0%	122.4%	123.8%	126.6%	129.4%	132.2%	135.0%

1A3c Railways	Unit	2010	2011	2012
Diesel	TJ	537	538	539
1990=100%		137.8%	138.1%	138.3%

d) Navigation (1A3d)

Methodology

There are passenger ships, dredgers, fishing boats, motor and sailing boats on the lakes of Switzerland and on the river Rhine. Every boat is registered at the cantonal authorities.

Emissions of ships and boats are calculated using the off-road model developed by INFRAS (2008). For details refer to Chapter 3.2.5.1 (paragraph on source category 1A2fii).

On the river Rhine as well as on the lakes Geneva and Constance, some of the boats cross the border and go abroad (Germany, France). Fuels bought in Switzerland will therefore become bunker fuel. The amount of bunker diesel oil is evaluated in Section 3.2.2.

Emission Factors

- The emission factor for CO_2 is country specific and is assumed to be constant in the period 1990-2012 with value 73.6 t/TJ for diesel oil, 73.9 t/TJ for gasoline and 73.7 t/TJ for gas oil (Table 3-9, SFOE 2001).
- For SO_2 the emission factors are country specific and are given in Table A - 6 in Annex A2 (diesel oil, gasoline, gas oil).
- The emission factors for all other gases are country specific and are shown in Table A - 20 to Table A - 23 in Annex A3.1.6. Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated as the difference of VOC and CH_4 emissions.

Note that emission factors in the unit of kg/h may be downloaded by query from the public part of the off-road database INFRAS (2008), see footnote 7 on page 111.

Activity data

The numbers of vehicles and of operating hours are given in Annex A3.1.6 (INFRAS 2008). Table 3-39 shows the domestic fuel consumption. In 2012, the fuel-split was 52%, 38% and 10% for diesel oil, gasoline and gas oil. A slight modification of the activity data was carried out in 2013 based on the latest figures of population and economy (Prognos 2012a, Keller/INFRAS 2013). The consumption of liquid fuels has been recalculated accordingly.

Table 3-39 Fuel consumption of (domestic) navigation.

1A3d Navigation	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Diesel	TJ	705	703	701	698	696	694	708	723	737	752
Gasoline	TJ	701	692	683	673	664	654	647	639	631	623
Gas oil	TJ	111	117	122	128	134	140	141	143	145	146
Sum	TJ	1'518	1'512	1'506	1'500	1'494	1'488	1'496	1'505	1'513	1'522
1990 = 100%		100%	100%	99%	99%	98%	98%	99%	99%	100%	100%

1A3d Navigation	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Diesel	TJ	766	770	774	778	782	786	800	815	830	844
Gasoline	TJ	616	614	613	612	611	609	615	620	626	631
Gas oil	TJ	148	150	153	156	158	161	162	164	166	167
Sum	TJ	1'530	1'535	1'540	1'546	1'551	1'556	1'578	1'599	1'621	1'643
1990 = 100%		101%	101%	101%	102%	102%	103%	104%	105%	107%	108%

1A3d Navigation	Unit	2010	2011	2012
Diesel	TJ	859	853	847
Gasoline	TJ	637	632	626
Gas oil	TJ	169	169	170
Sum	TJ	1'665	1'654	1'643
1990 = 100%		110%	109%	108%

e) Pipeline Transportation (1A3e)

Source 1A3e includes emissions of CO_2, CH_4, N_2O, NO_x, CO, NMVOC and SO_2 from a compressor station located in Ruswil. The compressor station uses a centrifugal compressor according to Transitgas AG (the company operating the compressor station and the pipeline network).

Emission Factors

The emission factors for CO_2, CH_4 and N_2O for 1A3e correspond to the ones used for gas turbines in Switzerland (SAEFL 2000) as suggested by expert judgement (see also Battelle 1994 and Xinmin 2004). With regard to CH_4, the EF was assumed to be 5 g/GJ up to 1995 and 2 g/GJ from 2000 onwards, with linear interpolation in between. This corresponds to the assumption that a catalyst was fitted to the system, which reduced the CH_4 emissions of the gas turbine.

Activity data

The data on fuel consumption for the operation of the compressor station in Ruswil is based on the Swiss overall energy statistics (SFOE 2013), see also Figure 3-8.

3.2.8.3 Uncertainties and Time-Series Consistency

a) General

For a general description of the uncertainty analysis and time series consistency of the Energy Sector see Chapter 3.2.6.3 a).

b) Specific: Uncertainties for CH_4 and N_2O in 1A3b Road Transportation

Due to a study for the road transportation in Germany (IFEU/INFRAS 2009), where the same handbook of emission factors is used as in Switzerland, the uncertainties for the CH_4 and N_2O emission factors have been adopted:

- CH_4: 37% (gasoline) and 20% (diesel),
- N_2O: 50% (gasoline) and 22% (diesel).

For the CH_4 emissions of CNG the qualitative uncertainty “medium” (30%) is taken and for biomass the uncertainty "high" 60%) according to Table 1-3.

For the N_2O emissions of CNG the qualitative uncertainty “medium” (80%) is taken and for biomass the uncertainty "high" (150%) according to Table 1-3.

Consistency and Completeness in 1A3 Fuel Combustion

- Time series for 1A3 are all consistent.
- All estimates in the sector 1A3 are assumed to be complete.

3.2.8.4 Source-specific QA/QC and Verification

a) General

See chapter 3.2.6.4.

The emission factors of category 1A3b for CO_2, CH_4 and N_2O used in the Swiss Inventory were compared to the corresponding emission factors of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) and to the IPCC default value if available for submission 2012 (INFRAS 2012). Switzerland’s diesel and gasoline CO_2 emission factor lie in the midfield of the other countries. Furthermore CH_4 and N_2O emission factors for gasoline are significantly lower. For further explanations see Sat. Pap in Chapter 16.

b) Specific: Civil Aviation (1A3a)

Emissions

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

Emission factors

- From total fuel burnt, total distance, number of passenger (without freight) per aircraft type, the fuel consumption per 100 passenger km has been calculated (backward calculation). The result of 2 to 10 kg fuel/100 passenger km is in line with expectations for 1990 passenger fleets.
- The implied emission factors were calculated for 2012 and compared with previous years.

Activity data

- In an independent Tier 3b calculation, EUROCONTROL performed a fuel calculation for Switzerland’s international flights, based on collected flight plan data and single movements. The results for the years 2004, 2005 and 2007 matched the FOCA calculations by more than 97.4%. The FOCA results were generally 1% to 2% higher but included the total number of actual flight movements of all flights, including VFR (visual flight rules) and non-scheduled flights such as helicopter movementes in alpine regions.

- Comparison between total movement numbers in the calculation and in the corresponding published statistics. Example: In 1990 calculation, FOCA considered all flights for which there was a form 'Traffic report to the airport authorities' filled in (total heavy aircraft). The total number of movements in 1990 is 263'951 (without Basel). The published number of movements for scheduled and charter flights in 1990 is: 263'952 (without Basel).
- The bottom-up calculation of total fuel matches the total fuel sold within a few percents. The remaining difference can be attributed to fuelling.
- Real-world fuel consumption was compared with modelled consumption for selected aircrafts of four Swiss airlines. The difference between the two methods was smaller than 1%.

c) Specific: Road Transportation (1A3b)

The international project for the update of the emission factors for road vehicles is overseen by a group of external and international experts that guarantees an independent quality control. For the update of the modelling of Switzerland's road transport emissions, which has been carried out between 2008 and 2010, several experts from the federal administration have conducted the project. The results have undergone large plausibility checks and comparisons with earlier estimates.

The emission factors CH_4 and N_2O used for the modelling of 1A3b Road Transportation are taken from the handbook of emission factors (INFRAS 2010), which is also applied in Germany, Austria, Netherlands, and Sweden. The Swiss emission factors for CH_4 and N_2O used in 1A3b were additionally compared with those depicted in the CRF from Germany and a good match was found. Possible small differences might result from a varying fleet composition. For gasoline, the activity data is easily verified due to the fact, that 98.3% (2012) of the gasoline sold in Switzerland is consumed by 1A3b Road Transportation itself. Therefore the amount of gasoline reported in the Swiss overall energy statistics is a strong control and verification parameter for the activity data of 1A3b. For diesel, the same control is carried out and the amount of diesel consumed by 1A3b Road Transportation is 86.3% (2012) compared to the amount sold.

3.2.8.5 Source-Specific Recalculations

- 1A3b: The entire time series has been recalculated following an update based on the latest figures on population growth and economy (Prognos 2012a, ARE 2012). Vehicle kilometres from 1993 are slightly lower in total; fleet compositions have changed, with slight impacts on implied emission factors; fuel consumption in tank tourism has been recalculated; the modelled share of biofuels has been reduced to be consistent with real-world developments. The overall impacts of these recalculations on emissions are low.
- 1A3c, 1A3d: The activity data have so far been taken from INFRAS (2008). For this submission, the latest numbers on growth of population and economy (Prognos 2012a, Keller/INFRAS 2013) have been integrated in the off-road model.

3.2.8.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. To accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

3.2.9 Source Category 1A4 - Other Sectors (Commercial/Institutional, Residential, Agriculture/Forestry/Fisheries)

3.2.9.1 Source Category Description

Tier 1 Key categories 1A4
CO_2 from the combustion of Liquid Fuels in the Commercial/Institutional Sector (level and trend)
CO_2 from the combustion of Gaseous Fuels in the Commercial/Institutional Sector (level and trend)
CO_2 from the combustion of Liquid Fuels in the Residential Sector (level and trend)
CO_2 from the combustion of Gaseous Fuels in the Residential Sector (level and trend)
CO_2 from the combustion of Liquid Fuels in the Agriculture/Forestry/Fisheries Sector (level)

Tier 2 Key categories 1A4
CO_2 from the combustion of Liquid Fuels in the Commercial/Institutional Sector (trend)
CO_2 from the combustion of Gaseous Fuels in the Commercial/Institutional Sector (level and trend)
CO_2 from the combustion of Liquid Fuels in the Residential Sector (level and trend)
CO_2 from the combustion of Gaseous Fuels in the Residential Sector (level and trend)
CH_4 from the combustion of Biomass in the Residential Sector (trend)

Table 3-40 Specification of source category 1A4 Other sectors.
EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

1A4	Source	Specification	Data Source
1A4a	Commercial/ Institutional	Emission from stationary fuel combustion in commercial and institutional buildings (1A4ai) and from mobile off-road machinery (professional gardening) and motorised equipment (1A4aii)	AD: SFOE 2013, INFRAS 2008, Prognos 2012, Keller/INFRAS 2013, EMIS 2014/1A4div. EF: EMPA 1999; Intertek 2008; Intertek 2012; FOEN 2011k; IPCC 2006; EMIS 2014/1A Holzfeuerungen; SAEFL 2000; Nussbaumer, T., Boogen, N. 2010 EMIS 2014/1A4a INFRAS 2008, EMIS 2014/1A4div.
1A4b	Residential	Emissions from stationary fuel combustion in households (1A4bi) and from mobile machinery (hobby gardening) and motorised equipment (1A4bii)	AD: SFOE 2013, INFRAS 2008, Prognos 2012, Keller/INFRAS 2013, EMIS 2014/1A4div. EF: EMPA 1999; Intertek 2008; Intertek 2012; FOEN 2011k; IPCC 2006; EMIS 2014/1A Holzfeuerungen; SAEFL 2000; Nussbaumer, T., Boogen, N. 2010 EMIS 2014/1A4b INFRAS 2008, EMIS 2014/1A4div.
1A4c	Agriculture/ Forestry/ Fishing	Comprises stationary fuel combustion for heating in forestry and agriculture and grass drying (1A4ci) and mobile machinery (off-road) in agriculture and forestry (1A4cii)	Grass drying: EMIS 2013/1A4ci Off-road machinery: INFRAS 2008, Prognos 2012, Keller/INFRAS 2013 Wood heating: EMIS 2014/1A Holzfeuerungen

3.2.9.2 Methodological Issues

As explained in chapter 3.2.5, a country specific Tier 2 approach based on aggregated fuel consumption data from the Swiss overall energy statistics is used to calculate emissions (SFOE 2013). Source category 1A4b also includes charcoal use and bonfires in Switzerland.

Emissions of GHGs are calculated by multiplying levels of activity by emission factors.

For mobile off-road sources (1A4aii, 1A4bii and 1A4cii) the emissions are calculated by the same approach as all other off-road categories using the off-road model developed by INFRAS (2008). For details refer to Chapter 3.2.5.1 (paragraph on source category 1A2fii).

Emission Factors

The following table presents the emission factors used in 1A4a/b:

Table 3-41 Emission Factors for 1A4a/b Other Sectors Commercial/Institutional and Residential in 2012.

Source/fuel	CO_2	CO_2 biog.	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	t/TJ		kg/TJ					
1A4 a Other Sectors: Commercial/Institutional								
Gas oil (weighted average)	73.7		1.0	0.6	35.2	6.9	6.0	22.4
Gas oil (heat only boilers)	73.7		1.0	0.6	35.2	6.8	6.0	22.4
Gas oil (turbines)	NO		NO	NO	NO	NO	NO	NO
Gas oil (engines)	73.7		0.6	0.6	40.0	30.0	8.0	21.0
Natural gas (weighted average)	56.1		6.9	0.1	25.2	13.7	3.8	0.5
NG (heat only boilers)	56.1		6.0	0.1	18.4	10.6	4.0	0.5
NG (turbines)	56.1		2.0	0.1	60.0	15.0	0.1	0.5
NG (engines)	56.1		20.0	0.1	124.7	58.3	1.0	0.5
Bituminous coal	NO		NO	NO	NO	NO	NO	NO
Lignite	NO		NO	NO	NO	NO	NO	NO
Biomass (weighted average)		87.3	27.6	1.4	115.8	695.6	63.2	17.9
Biomass (wood)		90.6	29.8	1.6	125.8	766.3	69.5	19.7
Biomass (biogas)		56.1	6.0	0.1	18.4	10.6	2.0	0.5
Gasoline (gardening professional)	73.9		91.7	2.1	157.7	23416.7	2201.1	0.4
1A4 b Other Sectors: Residential								
Gas oil (weighted average)	73.7		1.0	0.6	37.0	12.6	6.0	22.4
Gas oil (heat only boilers)	73.7		1.0	0.6	37.0	12.6	6.0	22.4
Gas oil (turbines)	NO		NO	NO	NO	NO	NO	NO
Gas oil (engines)	73.7		2.0	0.6	40.0	30.0	8.0	21.0
Natural gas (weighted average)	56.1		6.2	0.1	17.6	14.1	4.0	0.5
NG (heat only boilers)	56.1		6.0	0.1	17.4	13.6	4.0	0.5
NG (turbines)	56.1		2.0	0.1	60.0	15.0	0.1	0.5
NG (engines)	56.1		20.0	0.1	36.7	58.3	1.0	0.5
Bituminous coal	92.7		300.0	1.6	65.0	2000.0	100.0	350.0
Lignite	NO		NO	NO	NO	NO	NO	NO
Biomass		90.3	83.4	1.6	91.9	1782.3	201.8	19.5
Gasoline (gardening)	73.9		51.9	2.4	154.4	24215.4	1589.9	0.4

Emission factors highlighted in grey are explained in section 3.2.5.2.

Emission factors for CO_2, CH_4 and N_2O of charcoal use in the residential sector (1A4bi) are based on the 2006 IPCC guidelines, being the same as those of the revised 1996 IPCC guidelines. CO_2 emission factor for bonfires in the residential sector (1A4bi) is based on SAEFL 2000 and CH_4 and N_2O emission factors are the same as for charcoal use.

Table 3-42 Emission Factors for 1A4a/b Other Sectors Commercial/Institutional and Residential in 2012. CO_2 emission factor is biogenic.

1A4bi	Unit	CO_2 biog.	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
use of charcoal	kg/TJ	112'000	200	1	50	6'000	1'300	10
bonfires	kg/TJ	92'000	200	1	50	6'000	1'300	10

Emission factors for mobile off-road sources

- The emission factors for CO_2 are country specific and are assumed to be constant in the period 1990-2012 with values 73.6 t/TJ for diesel oil, 73.9 t/TJ for gasoline and 56.1 t/TJ for CNG (equal to natural gas). See Table 3-9.
- For SO_2 the emission factors are country specific and are given in Table A - 6 in Annex A2.
- The emission factors for all other gases are country specific and shown in Table A - 15 to Table A - 18 in the Annex A3.1.6 (INFRAS 2008). The NMVOC emissions are calculated as the difference of VOC and CH_4 emissions.

Note that emission factors in the unit of kg/h may be downloaded by query from the public part of the off-road database INFRAS (2008), see footnote 7 on page 111.

Activity Data

Activity data for the different fuels is determined as described in chapter 3.2.5.1. This includes gas oil, residual fuel oil, natural gas and biomass. For the solid fuels bituminous coal and lignite, activity data is provided from the Swiss overall energy statistics (SFOE 2013).

Table 3-43 Activity data in 1A4a Commercial/Institutional and 1A4b Residential.

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A4a Commercial/Institutional	TJ	83'051	90'115	90'057	88'570	82'387	84'756	91'233	87'381	90'426	86'588
Gas oil	TJ	62'293	67'130	66'136	63'646	57'884	57'973	62'493	59'823	61'826	58'515
Gas oil heat only boilers	TJ	62'269	67'080	66'078	63'590	57'763	57'798	62'263	59'535	61'528	58'188
Gas oil turbines	TJ	0	0	0	0	0	0	0	0	0	0
Gas oil engines	TJ	24	51	58	56	122	175	231	288	298	327
Natural gas	TJ	17'598	19'381	20'315	21'201	20'879	22'657	24'062	23'163	23'895	23'216
NG heat only boilers	TJ	17'321	18'946	19'755	20'575	20'057	21'486	22'651	21'698	22'293	21'505
NG turbines	TJ	85	114	109	106	107	78	21	5	12	4
NG engines	TJ	192	321	451	520	715	1'093	1'390	1'460	1'590	1'706
Bituminous coal	TJ	0	0	0	0	0	0	0	0	0	0
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Biomass	TJ	2'952	3'382	3'373	3'479	3'368	3'858	4'399	4'105	4'405	4'547
Biomass (wood)	TJ	2'928	3'359	3'349	3'447	3'334	3'824	4'359	4'065	4'361	4'503
Biomass (biogas)	TJ	24	24	24	31	34	34	40	40	44	44
Gasoline (gardening professional)	TJ	209	221	233	244	256	267	278	289	300	311
1A4b Residential	TJ	186'816	199'371	199'011	190'210	179'234	193'165	200'920	186'313	192'543	189'445
Gas oil	TJ	138'916	145'507	145'175	136'252	128'901	137'597	139'992	131'915	136'508	131'838
Gas oil heat only boilers	TJ	138'915	145'506	145'173	136'251	128'900	137'593	139'961	131'877	136'459	131'785
Gas oil turbines	TJ	0	0	0	0	0	0	0	0	0	0
Gas oil engines	TJ	1	1	1	1	1	4	32	38	49	53
Natural gas	TJ	25'390	29'240	30'680	31'090	29'530	33'760	38'000	34'420	35'980	38'040
NG heat only boilers	TJ	25'330	29'138	30'536	30'922	29'326	33'502	37'693	34'107	35'630	37'635
NG turbines	TJ	0	0	0	0	0	0	0	0	0	0
NG engines	TJ	60	102	144	168	204	258	307	313	350	405
Bituminous coal	TJ	589	680	471	480	435	417	236	199	127	127
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Biomass	TJ	21'922	23'945	22'685	22'388	20'368	21'391	22'692	19'779	19'928	19'441
Gasoline (gardening)	TJ	145	147	150	153	155	158	160	162	165	167

Source/Fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1A4a Commercial/Institutional	TJ	84'398	88'139	82'656	86'877	86'101	87'220	82'030	73'800	79'215	76'286
Gas oil	TJ	55'485	57'502	53'946	56'415	54'631	54'629	51'065	44'249	47'255	44'626
Gas oil heat only boilers	TJ	55'135	57'135	53'594	56'082	54'306	54'311	50'772	44'067	47'085	44'472
Gas oil turbines	TJ	0	0	0	0	0	0	0	0	0	0
Gas oil engines	TJ	351	367	352	333	326	318	293	181	169	154
Natural gas	TJ	24'257	25'609	23'812	25'127	26'026	26'986	24'719	23'468	25'283	24'670
NG heat only boilers	TJ	22'521	23'803	21'902	23'130	24'059	24'953	22'767	21'542	23'425	22'856
NG turbines	TJ	0	3	12	28	31	28	23	28	29	26
NG engines	TJ	1'737	1'803	1'899	1'968	1'937	2'004	1'929	1'898	1'829	1'787
Bituminous coal	TJ	0	0	0	0	0	0	0	0	0	0
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Biomass	TJ	4'334	4'713	4'590	5'034	5'148	5'318	5'959	5'796	6'391	6'705
Biomass (wood)	TJ	4'289	4'660	4'530	4'966	5'065	5'204	5'778	5'506	6'036	6'307
Biomass (biogas)	TJ	45	53	60	69	83	114	181	290	355	398
Gasoline (gardening professional)	TJ	321	315	308	301	295	288	287	286	286	285
1A4b Residential	TJ	174'816	184'251	177'744	188'017	188'109	191'375	184'262	164'219	175'973	172'543
Gas oil	TJ	120'784	127'553	122'470	129'328	128'194	129'613	124'415	107'798	114'325	110'985
Gas oil heat only boilers	TJ	120'731	127'498	122'414	129'269	128'119	129'550	124'352	107'733	114'273	110'944
Gas oil turbines	TJ	0	0	0	0	0	0	0	0	0	0
Gas oil engines	TJ	53	55	56	58	74	63	63	65	52	42
Natural gas	TJ	36'290	38'000	37'790	40'330	41'660	42'790	41'080	39'320	42'550	42'630
NG heat only boilers	TJ	35'851	37'539	37'325	39'813	41'153	42'260	40'538	38'775	42'009	42'092
NG turbines	TJ	0	0	5	3	2	0	0	3	3	0
NG engines	TJ	439	461	460	514	505	530	542	542	537	538
Bituminous coal	TJ	118	118	118	118	362	362	362	362	362	362
Lignite	TJ	0	0	0	0	0	0	0	0	0	0
Biomass	TJ	17'624	18'581	17'366	18'241	17'893	18'610	18'405	16'739	18'736	18'565
Gasoline (gardening)	TJ	169	167	165	162	160	158	157	156	155	155

Source/Fuel	Unit	2010	2011	2012
1A4a Commercial/Institutional	TJ	82'310	68'483	74'788
Gas oil	TJ	47'763	39'177	40'950
Gas oil heat only boilers	TJ	47'640	39'066	40'847
Gas oil turbines	TJ	0	0	0
Gas oil engines	TJ	122	111	103
Natural gas	TJ	27'067	22'876	26'431
NG heat only boilers	TJ	25'313	21'202	24'737
NG turbines	TJ	23	17	5
NG engines	TJ	1'730	1'657	1'688
Bituminous coal	TJ	0	0	0
Lignite	TJ	0	0	0
Biomass	TJ	7'197	6'148	7'130
Biomass (wood)	TJ	6'709	5'602	6'463
Biomass (biogas)	TJ	488	546	667
Gasoline (gardening professional)	TJ	284	281	277
1A4b Residential	TJ	187'067	150'376	165'972
Gas oil	TJ	118'021	92'168	99'913
Gas oil heat only boilers	TJ	117'984	92'133	99'878
Gas oil turbines	TJ	0	0	0
Gas oil engines	TJ	37	36	34
Natural gas	TJ	48'390	41'070	47'230
NG heat only boilers	TJ	47'870	40'571	46'722
NG turbines	TJ	0	0	0
NG engines	TJ	520	499	508
Bituminous coal	TJ	362	362	362
Lignite	TJ	0	0	0
Biomass	TJ	20'293	16'775	18'467
Gasoline (gardening)	TJ	154	151	148

The table above documents the use of gas oil (55%), natural gas (35%) and biomass (10%) as fuels consumed in source category 1A4a Commercial/Institutional. Since 1990, fuel consumption in this source category 1A4a reduced by 10%. Within the fuel consumption, a major fuel swich can be observed in this source category from gas oil (-34%) to natural gas (+50%) and biomass (+142%).

Regarding source category 1A4b Residential, the major fuels consumed are gas oil (60%), natural gas (28%) and biomass (11%). Since 1990, fuel consumption in this source category 1A4b reduced by 11%. Also in this source category, a fuel switch from gas oil (-28%) to natural gas (+86%) can be observed. Biomass consumption for heating purposes of residential buildings diminued from 1990 to 2012 by 16%.

This shift in fuel mix is the reason for CO_2 emissions from the use of natural gas and liquid fuels in category 1A4a and 1A4b being key categories regarding trend.

Underlying data for the activity data on mobile off-road sources (1A4aii and 1A4bii) like vehicle stock and operating hours are shown in Annex A3.1.6. A slight modification of the activity data was carried out in 2013 (Prognos 2012a, see also Chapter 3.2.9.5). The consumption of gasoline (gardening) has been recalculated accordingly. Numbers from 2005 onwards are affected.

Table 3-44 Activity data in 1A4bi charcoal consumption.

1A4bi	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
use of charcoal	TJ	311	315	318	322	292	291	292	272	302	282
bonfires	TJ	160	160	160	160	160	160	160	160	160	160

1A4bi	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
use of charcoal	TJ	292	362	332	302	282	313	303	313	353	343
bonfires	TJ	160	160	160	160	160	160	160	160	160	160

1A4bi	Unit	2010	2011	2012
use of charcoal	TJ	343	343	343
bonfires	TJ	160	160	160

Charcoal consumption has slightly increased from 1990 to 2009 and since 2009, a stable consumption of charcoal is assumed (SFOE 2013, see documentation in EMIS 2014/1A4bi Holzkohle-Verbrauch). Bonfires are assumed constant over the whole time series as there are no official numbers available. As charcoal consumption is more or less constant, it is assumed, that bonfires also are constant over time and correspond to an estimation of 2kg of wood for bonfires per habitant (see documentation in EMIS 2014/1A4bi Lagerfeuer).

For source category 1A4ci, the following activity data is reported:

Drying of grass: Activity data on grass drying (in tons of dried grass) is extracted from the EMIS database (EMIS 2014/1A4ci).

Off-road machinery: Activity data is shown in Annex A3.1.6 (INFRAS 2008, Prognos 2012a, Keller/INFRAS 2013).

Biomass: Activity data is based on Swiss wood energy statistics (SFOE 2013b) as explained in 3.2.5.1.

Table 3-45 Activity data in 1A4c Agriculture/Forestry.

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A4c Agriculture/Forestry	TJ	8'597	8'623	8'568	8'546	8'489	8'494	8'518	8'423	8'415	8'391
Drying of Grass	TJ	1'895	1'828	1'748	1'683	1'620	1'544	1'482	1'409	1'349	1'291
gas oil	TJ	1'156	1'115	1'066	1'027	988	942	904	860	823	787
natural gas	TJ	739	713	682	657	632	602	578	550	526	503
Machinery (diesel, gasoline)	TJ	6'275	6'308	6'342	6'375	6'409	6'443	6'471	6'500	6'529	6'558
Biomass	TJ	427	487	478	488	461	508	564	514	536	542

Source/Fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1A4c Agriculture/Forestry	TJ	8'316	8'211	8'174	8'211	8'212	8'240	8'099	8'233	8'237	8'344
Drying of Grass	TJ	1'223	1'077	1'061	1'055	1'039	994	845	948	822	856
gas oil	TJ	746	657	647	644	634	607	516	579	502	522
natural gas	TJ	477	420	414	412	405	388	330	370	321	334
Machinery (diesel, gasoline)	TJ	6'587	6'588	6'589	6'590	6'591	6'592	6'658	6'724	6'791	6'857
Biomass	TJ	506	546	524	566	582	654	596	560	624	631

Source/Fuel	Unit	2010	2011	2012
1A4c Agriculture/Forestry	TJ	8'361	8'332	8'376
Drying of Grass	TJ	739	891	845
gas oil	TJ	451	543	515
natural gas	TJ	288	347	329
Machinery (diesel, gasoline)	TJ	6'923	6'871	6'818
Biomass	TJ	699	571	714

The table above documents the fuel use in source category 1A4c Agriculture/Forestry. Machinery is the major source with 81% fuel consumption of the source category 1A4c compared to grass drying with 10% and biomass with 9%. Fuel consumption in machinery increased by 8.7% since 1990. For grass drying, fuel consumption is divided in gas oil (61%) and natural gas (39%). Since 1990, the fuel consumption significantly decreased by 55% for gas oil as well as natural gas. Biomass consumption increased by 67%.

In the last submission in 2013 a mistake occured in the table above as the year 2011 had the same values as in the year 2001 for the line “gas oil”, “natural gas” and “machinery” and there was one process not calculated under “machinery”. This error is now corrected in current Table 3-44.

3.2.9.3 Uncertainties and Time-Series Consistency

The uncertainty of CO_2 emissions from fuel combustions is described in the uncertainty analysis of the Energy Industries (1A1) in Chapter 3.2.6.3. Uncertainty in emissions of other non-CO_2 gases are estimated to be medium: 30% for CH_4 and 80% for N_2O (see Table 1-14).

A general description of the time series consistency of the Energy Sector is provided in Chapter 3.2.6.3.

3.2.9.4 Source-specific QA/QC and Verification

a) General

See Chapter 3.2.6.4.

b) Specific: Other sectors (1A4)

The time series have been compared between the current and the previous submission as well as available energy data. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables.

- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of the last submission 2013.
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of the last submission 2013.

For A4ci grass drying: The fuel consumption was verified in 2003 by a statistical analysis of 20 typical grass drying plants (VSTB 2003).

3.2.9.5 Source-Specific Recalculations

- **1A all fuels:** Activity data of all fuels of the overall time series have been recalculated based on the new data from SFOE 2013. This includes data on 2011 for fossil fuels and waste, data for biomass on 1997, 2009 – 2011 and data of other fuels 1990 – 2011.
- **1A gaseous fuels:** Activity data have been recalculated based on new data of from SFOE 2013.
- **1A wood consumption:** Activity data have been recalculated for the overall time series based on the new data from SFOE 2013b.
- **1A gas oil:** SO_x emission factor value has been updated for 2010 based on sulphur analyses of the gas oil for the year 2010 (Directorate General of Customs) resulting in a revised value for 2011 as well.
- **1A bituminous coal:** CO_2 emission factor has been corrected from 94t CO_2/TJ to 92.7 t CO_2/TJ for the entire time series.
- **1A4a/1A4b engines and gasturbines:** Activity data in 1A4 households and services have been updated for 2011 based on updated statistical data.
- **1A4a engines, natural gas:** Activity data for natural gas in the commercial and institutional sector have been updated for 1990, 1995, 1997, 1998 and 2011 based on recalculations in SFOE 2013.
- **1A4a engines, natural gas:** Activity data for natural gas have been updated based on a recalculation of SFOE 2013 for the year 2011.
- **1A4a engines, gas oil and natural gas:** Activity data for gas oil and natural gas consumption have been updated for the overall time series based on changes in the energy model resulting from changes in the non-road transport model for boats and natural gas consumption in industry.
- **1A4b engines, natural gas:** Activity data have been updated for 1990, 1995, 1997, 1998 and 2011 based on recalculations in SFOE 2013.
- **1A4b engines, gas oil:** Activity data for gas oil have been updated for the whole time series based on recalculations in the energy consumption.
- **1A4b gas oil and natural gas:** CO and SO_2 emission factors for gas oil and natural gas of 2011 have been corrected in the energy model.
- **1A4b charcoal consumption:** Reporting of charcoal consumption has been shifted to sector 1A4b. Before, it was reported under 2D3. (Please note that the reporting of the CH_4 emissions from the charcoal production has already been shifted from 2D3 to 1A1c within the resubmission of Switzerland's Greenhouse Gas Inventory 1990–2011(FOEN2013g).)
- **1A4b bonfires:** A new process has been introduced in this sumbmission.
- **1A4aii, 1A4bii, 1A4cii mobile off-road machinery:** The activity data have so far been taken from INFRAS (2008). For this submission, the latest numbers on growth of population and economy (Prognos 2012a, Keller/INFRAS 2013) have been integrated

in the off-road model. This leads to an increase of the fuel consumption from 2005 onwards.

3.2.9.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

3.2.10 Source Category 1A5b - Military

3.2.10.1 Source Category Description

Tier 1 Key categories 1A5
CO_2 from the combustion of Liquid Fuels (trend)

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

Table 3-46 Specification of Swiss source category 1A5 Other (Military).

1A5	Source	Specification	Data Source
1A5a	Stationary	Not occurring in Switzerland (NO)	
1A5b	Mobile Military off-road sources	Tanks and similar off-road vehicles (emissions from military road vehicles are included in 1A3b Road Transportation)	Method, AD, EF: INFRAS 2008, AD: Prognos 2012, Keller/INFRAS 2013
1A5b	Military Aviation		VTG 2013

3.2.10.2 Methodological Issues

a) Military off-road vehicles

The emissions of military off-road machinery (excluding aviation) are modelled by the same approach as all other mobile off-road sources using the off-road model developed by INFRAS (2008). For details refer to Chapter 3.2.5.1 (paragraph on source category 1A2fii).

b) Military aviation

To calculate the emissions from military aviation, a Tier 1 method is used. The fuel consumption 1990–2012 is known on an annual basis (VTG 2013). A very small fraction of fuel is consumed for training abroad and might be allocated under “International Bunkers” (less than 3% of total military aviation consumption). Since the exact number is not known, it is not subtracted from the total consumption but included under national military aviation, as recommended by the IPCC Good Practice Guidance (IPCC 2000, chapter 2.5.1.3).
Emissions of NOx, CO and VOC have been modelled in detail by the Federal Office for Military Aviation (Bundesamt für Betriebe der Luftwaffe) for 1990 and 1995. From these inputs, FOEN determined average emission factors 1990 and 1995. For 1991-1994 the emission factors are linearly interpolated between 1990 and 1995. For 1996-2011, the factors for 1995 are used. The emissions are then calculated yearly by multiplying the average emission factors with the activity data.

The extension of the emission modelling to CO_2, CH_4, N_2O, NMVOC and SO_2 is also accomplished by FOEN.

Emission factors for military off-road vehicles

- The emission factors for CO_2 are country specific and are assumed to be constant in the period 1990-2012 with values 73.6 t/TJ for diesel oil, 73.9 t/TJ for gasoline and 55.0 t/TJ for CNG (equal to natural gas), see Table 3-9.
- For SO_2 the emission factors are country specific and are given in Table A - 6 in Annex A2.
- The emission factors for all other gases are country specific and shown in Table A - 15 to Table A - 18 in the Annex A3.1.6 (INFRAS 2008) The NMVOC emissions are calculated as the difference of VOC and CH_4 emissions.

Note that emission factors in the unit of kg/h may be downloaded by query from the public part of the off-road database INFRAS (2008), see footnote 7 on page 111.

Emission factors for 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 3-9, SFOE 2001, FOEN 2011k, Intertek 2008).
- NO_x, VOC, CO: Engine producer information is used (CORINAIR, for details see SAEFL 1996: p. 202) for calculation of the emission factors in 1990 and 1995. For 1991-1994 the values are linearly interpolated between 1990 and 1995. For 1996-2012, the values 1995 are used.
- CH_4, NMVOC: For VOC, aircraft-specific information used for calculation of the emission factors in 1990 and 1995. For 1991-1994 the values are linearly interpolated between 1990 and 1995. For 1996-2012, the values 1995 are used. The division of VOC into CH_4 and NMVOC is carried out by a constant split of 53%: 47% (country specific).
- N_2O: The implemented emission factor for N_2O is 2.356 kg/TJ. By mistake, in previous submissions the emission factor was defined as 23 kg/TJ.
- SO_2: The emission factor is taken from the IPCC Guidelines 1996, 23.3 kg/TJ, and is assumed to be constant over the period 1990–2012 (IPCC 1997c, Table 1-50)

Activity data for military off-road vehicles and military aviation

Fuel consumption data is shown in Table 3-47. The underlying data for military off-road such as vehicle stock and operating hours are shown in Table A - 24 and Table A - 25 in Annex A3.1.6.

Fuel consumption of military aviation is copied from the logbooks of the military aircrafts and summed up yearly (VTG 2013).

Table 3-47 Activity data (fuel consumption) for military off-road vehicles and military aviation

1A5	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		fuel consumption in TJ									
Military off-road	Diesel	48	48	48	48	49	49	49	49	50	50
Military off-road	Gasoline	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Military aviation	Jet kerosene	2'733	2'495	2'382	2'268	2'192	1'955	1'806	1'941	1'927	1'734

1A5	Fuel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		fuel consumption in TJ									
Military off-road	Diesel	50	50	49	49	48	48	48	48	48	48
Military off-road	Gasoline	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Military aviation	Jet kerosene	1'793	1'755	1'837	1'641	1'488	1'621	1'672	1'572	1'500	1'524

1A5	Fuel	2010	2011	2012
		fuel consumption in TJ		
Military off-road	Diesel	48	48	47
Military off-road	Gasoline	0.6	0.6	0.6
Military aviation	Jet kerosene	1'586	1'414	1'521

3.2.10.3 Uncertainties and Time-Series Consistency

a) General

For a general description of the uncertainty analysis and time series consistency of the Energy Sector see Chapter 3.2.6.3 a).

b) Specific

See Chapter 3.2.6.3.

3.2.10.4 Source-specific QA/QC and Verification

The time series have been compared between the current and the previous submission as well as available energy data. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF.
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013.
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013.

The activity data of military aviation (kerosene consumption) are provided by the Federal Department of Defence, Civil Protection and Sport. For a compatibility check with the emission data base of civil aviation, they are sent to the FOCA (office of the Federal Department of the Environment, Transport, Energy and Communications). A further compatibility check is carried out by the NIR authors of the energy chapter. No peculiarities have been detected by the specialists in the time series of the kerosene consumption of military aviation.

3.2.10.5 Source-Specific Recalculations

- 1A5b: The activity data have so far been taken from INFRAS (2008). For this submission, the latest numbers on growth of population and economy (Prognos 2012a, Keller/INFRAS 2013) have been integrated in the off-road model. This leads to an increase of the fuel consumption from 2005 onwards**.**

3.2.10.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. To accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

3.3 Source Category 1B – Fugitive Emissions from Fuels

Fugitive emissions arise from the production, processing, transmission, storage and use of fuels. According to IPCC guidelines, emissions from venting and 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 (1B2a)
- Natural Gas (1B2b)

Tier 1 Key categories 1B2
CH_4 from fugitive emissions of Oil and Natural Gas (level and trend)

Tier 2 Key categories 1B2
CH_4 from fugitive emissions of Oil and Natural Gas (trend)

3.3.1 Source Category 1B1 - Solid Fuels

Coal mining is not occurring in Switzerland.

3.3.2 Source Category 1B2a - Oil

3.3.2.1 Source Category Description

In Switzerland, oil production is not occuring. Fugitive emissions in the oil industry result from two refining companies and several fuel handling stations. Production from the refining companies cover around 40% of the oil consumption in Switzerland. The other 60% are imports of final products. Oil pipelines are very short in Switzerland (approximately 40km and 70km) and are mainly underground.

The follwoing source categories occur in Switzerland:

- Transport (1B2a iii)
- Refining / Storage (1B2a iv)
- Distribution of Oil Products from storage tanks and gasoline stations (1B2a v)

Table 3-48 Specification of source category 1B2a Fugitive Emissions from Oil.
EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

1B2	Source	Specification	Data Source
1B2 a	Oil	Emissions from refining/storage of oil and the distribution of oil products	AD: EV 2013, SFOE 2013 EF: IPCC 2006, EMIS 2014/1B2a

3.3.2.2 Methodological Issues

For source 1B2a Oil, emissions of CO_2, CH_4 and NMVOC are reported. CO_2 emissions occur through the oxidation of volatile organic compounds in the athmosphere. CH_4 emissions only occur in 1B2a iii.

Emissions are calculated based on a Tier 1 approach. Fugitive emissions from fuels are calculated by multiplying level of activity by emission factor.

Emission factors

The following table presents the emission factors used in 1B2a Oil:

Table 3-49 Emission Factors for 1B2a Oil in 2012.

Source/fuel	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	g/t	g/t	kg/TJ	kg/TJ	kg/TJ	g/t	kg/TJ
1B2a Oil Products							
Oil Transport	0.60	6.59	NA	NA	NA	65.9	NA
Oil Refining and Storage	1356	45	NA	NA	NA	430	NA
Gasoline storage tank	893	NA	NA	NA	NA	283	NA
Gasoline station	1240	NA	NA	NA	NA	393	NA

For oil transport (1B2a iii), the default value from IPCC 2006 for pipeline transport is used to calculate emissions.

For oil refining and storage (1B2a iv), country specific emission factors for CH_4 and NMVOC are used. The conversion factor used to calculate the CO_2 emission factor bases on the NIR of the Netherlands.

For oil distribution from storage tanks and gasoline stations (1B2a v), CO_2 emission factors base on the conversion factor from the NIR of the Netherlands. NMVOC emission factor for oil distribution from tanks is taken from country specific calculations based on statistical information from the Energy Model based on data from SFOE 2013 (see documentation in EMIS 2014/1B2a v Benzinumschlag Tanklager). NMVOC emission factor from gasoline stations is calculated based on country specific information (see documentation in EMIS 2014/1B2a v Benzinumschlag Tankstellen).

Activity data

Table 3-50 Activity data (fuel consumption) for 1B2a Oil

1B2a Oil Products	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Crude oil	t	3127315	4671296	4317130	4763889	4879630	4657407	5289352	4830324	5069907	5093056
Gasoline transport	t	3682727	3834439	3972485	3682707	3682344	3568755	3660597	3800552	3829912	3956876

1B2a Oil Products	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Crude oil	t	4649074	4846065	4848380	4567130	5146296	4810417	5496528	4661806	5066898	4778472
Gasoline transport	t	3958527	3849300	3773347	3755292	3687960	3575627	3466291	3432200	3357092	3266530

1B2a Oil Products	Unit	2010	2011	2012
Crude oil	t	4490741	4402315	3408796
Gasoline transport	t	3151135	3029864	2922408

For oil transport (1B2a iii), crude oil used is based on annual statistics of the Swiss Petroleum Association (EV 2013).

For oil refining and storage (1B2a iv), crude oil used is based on annual statistics of the Swiss Petroleum Association (EV 2013).

For oil distribution from tanks and gasoline stations (1B2a v), data is provided by the Energy Model based on SFOE 2013 (see Section 3.2.5.1). As the statistics include also oil consumption of Liechtenstein, this is substracted from the data provided to represent oil consumption of Switzerland only.

Since 1990, Crude oil production increased slightly by 9% and Gasoline transport decreased by 21%.

3.3.2.3 Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment of all other sources in source category 1B2 based on expert judgement results in medium confidence in the emissions estimate (see Table 1-14).

The time series is consistent.

3.3.2.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission as well as available energy data. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of the last submission 2013.
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of the last submission 2013.

3.3.2.5 Source-Specific Recalculations

- **1B2a v distribution of oil products:** Emission factor for CO_2 and NMVOC were corrected to exclude emissions from Liechtenstein that overestimated emissions by 0.5%.

3.3.2.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

3.3.3 Source Category 1B2b - Natural Gas

3.3.3.1 Source Category Description

Emissions from natural gas production are only occurring for the years of operation of the single production plant in Switzerland from 1985 - 1994. Other emissions in this sector occur from natural gas transmission and distribution. Emission from transmission also include leakages from gas pipelines. Major accidents and isolated events are reported under other leakage.

The follwoing source categories occur in Switzerland:

- Production (1B2b ii) (only 1990-1994)
- Transmission (1B2b iii)
- Distribution (1B2b iv)
- Other leakage (1B2b v) (isolated events in single years)

Table 3-51 Specification of source category 1B2b Fugitive Emissions from Natural Gas.
EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

1B2	Source	Specification	Data Source
1B2 b	Natural Gas	Emissions from gas pipelines	AD: SFOE 2013, Quantis 2014 EF: IPCC 2006, Quantis 2014

3.3.3.2 Methodological Issues

For source 1B2b Natural Gas, emissions of CO_2, CH_4 and NMVOC are reported for natural gas production as well as transmission, distribution and related accidents. Emissions are calculated based on annual production data which is consistent with the IPCC Tier 1 approach. Emission from leakages from gas pipelines are calculated with a country specific method. The method considers the length, type and pressure of the gas pipelines as well as the annual gas consumption. The distribution network components (regulators, shut off fittings and gas meters), the losses from maintenance and extension as well as the end user losses are separately taken into account.

Fugitive emissions from fuels are calculated by multiplying level of activity by emission factor.

Emission factors

CO_2, CH_4 and NMVOC Emission factors for natural gas production is provided by the default values of IPCC 2006 Guidelines as documented in EMIS 2014/1B2b Gasproduktion.

Emission factors for gas transport and distribution losses (source 1B2b iii and 1b2 iv) are based on a new study realized by Quantis (Quantis 2014). Emission factors are provided by literature and base mostly on the study of Batelle 1994 that provides specific emission factors for different sources of fugitive emissions based on measurements of 1998 in Germany. Specific data for Switzerland is provided by a study of Xinmin (2004), but also these emission factors are mostly based on Batelle (1994).

Table 3-52 Emission factors for 1B2b Natural Gas and 1B2d Other (only occurring in 2010).

Source/fuel	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ	g/GJ
1B2b Natural Gas							
Production	NO	NO	NA	NA	NA	NO	NA
Transmission	312	17'938	NA	NA	NA	17'938	NA
Distribution	312	17'938	NA	NA	NA	0.002	NA
1B2d Other	312	17'938	NA	NA	NA	0.002	NA

Activity data

Table 3-53 Activity data (fuel consumption) for 1B2b Natural Gas and 1B2d Other (only occurring in 2010).

1B2b Natural Gas / 1B2d Other	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1B2b Natural Gas											
Production	GJ	130'000	110'000	100'000	80'000	30'000	0	0	0	0	0
Transmission	GJ	13'237	13'269	13'313	13'347	13'156	13'254	13'261	13'261	13'257	13'160
Distribution	GJ	676'096	714'632	749'911	783'021	804'621	835'693	863'669	890'494	910'730	838'810
1B2d Other	GJ	0	0	0	0	0	0	0	0	0	0

1B2b Natural Gas / 1B2d Other	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1B2b Natural Gas											
Production	GJ	0	0	0	0	0	0	0	0	0	0
Transmission	GJ	13'138	13'113	13'087	13'061	13'036	13'014	12'993	13'291	13'310	13'301
Distribution	GJ	772'213	711'334	656'231	606'938	563'463	525'790	493'880	478'854	459'030	443'559
1B2d Other	GJ	0	0	0	0	0	0	0	0	0	0

1B2b Natural Gas / 1B2d Other	Unit	2010	2011	2012
1B2b Natural Gas				
Production	GJ	0	0	0
Transmission	GJ	13'218	13'214	13'229
Distribution	GJ	431'079	426'425	426'145
1B2d Other	GJ	28'899	0	0

Activity data for natural gas production are extracted from the Swiss overall energy statistics (SFOE 2013).

Activity data for gas transport and distribution losses (source 1B2b iii and 1B2b iv) are based on information from the Swiss Gas and Water Industry Association (SGWA) as documented in the study realized by Quantis (Quantis 2014). Since 1990, the natural gas net increased by 73% from 142’000 km in 1990 to 246’000 km in 2012. In the same period, the natural gas consumption increased by 62% from 21’000 to 34’000 GWh.

Within the different sectors, continuous leakage emissions from pipelines are the mayor emission source followed by fugitive emissions from the end user losses that are dominated by the emissions from industry and power stations using natural gas. Fugitive emissions from damages and ruptures of the pipelines, maintenance of the pipelines and the components are very small (Quantis 2014).

It can be observed in the table above, that the fugitive emissions from gas transport and distribution losses strongly decreased between 1990 and 2012. Total CH_4 emissions decreased by 36% based on the strong decrease of fugitive emissions from the continuous leakage by more than 50% which can be explained by the change of material used for the pipelines from cast-iron pipes to polyethylene pipelines. Fugitive emission from the end user losses increased slightly. This switch is also visible in the respective contribution of these two sources between 1990 and 2012. While fugitive emissions from continuous leakage contributed with more than 80% to the total CH_4 emissions in 1990, it only contributes with 60% in 2012.

3.3.3.3 Uncertainties and Time-Series Consistency

a) Uncertainty in fugitive CH_4 emissions from natural gas pipelines in 1B2

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

b) Qualitative estimate of uncertainties of non-key category emissions in 1B2 Fugitive Emissions from Fuels

A preliminary uncertainty assessment of all other sources in source category 1B2 based on expert judgement results in medium confidence in the emissions estimate (see Table 1-14).

The time series is consistent.

3.3.3.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission as well as available energy data. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of the last submission 2013.
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of the last submission 2013.

3.3.3.5 Source-Specific Recalculations

- **1B2b natural gas production:** As recommended in ARR 2012 and 2013 Switzerland has included in his inventory the emissions from the only small plant for natural gas production (Finsterwald) from 1985-1994. The default emission factors from IPCC Guidelines 2006 is used.
- **1B2b natural gas production:** Activity data from 1990-1997 has been updated based on data from SFOE 2013.
- **1B2b natural gas production:** A new model for emissions in swiss gas transport system based on a new study realized by Quantis has been developed (Quantis 2014).

3.3.3.6 Source-Specific Planned Improvements

Regarding the emission factor of CH_4 emissions of natural gas pipelines, an error has been detected during the internal review that leads to an underestimation of the emissions based on a too low emission factor used for the calculation. The error will be corrected for the next submission.

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

3.3.4 Source Category 1B2c - Venting

3.3.4.1 Source Category Description

In Switzerland, oil or natural gas production is not occuring. The fugitive emissions from venting result only from the torches in the two refining companies (1B2c i Flaring).

Table 3-54 Specification of source category 1B2c Fugitive Emissions from Venting. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

1B2	Source	Specification	Data Source
1B2 c	Venting / Flaring	The release/combustion of excess gas at the oil refinery	AD: EV 2013 EF: EMIS 2014/1B2c

3.3.4.2 Methodological Issues

Fugitive emissions from fuels are calculated by multiplying level of activity by emission factor.

For source category 1B2c Venting/Flaring (Oil), CO_2 as well as CH_4, N_2O, NO_x, CO and NMVOC are considered. The emissions venting/flaring are calculated based on country specific annual production/consumption data.

Emission factors

Emission factors are based on data from the refining industry and expert estimates as documented in EMIS 2014/1B2c Raffinerie Abfackelung.

Table 3-55 Emission factors for 1B2c Venting/Flaring.

Source/fuel	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	g/t	g/t	g/t	g/t	g/t	g/t	g/t
1B2c Venting / Flaring	8300	3.5	0.64	43	10	3.5	62

Activity data

Table 3-56 Activity data for 1B2c Venting/Flaring.

1B2c Venting/Flaring	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Crude Oil used	t	3'127'315	4'671'296	4'317'130	4'763'889	4'879'630	4'657'407	5'289'352	4'830'324	5'069'907	5'093'056

1B2c Venting/Flaring	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Crude Oil used	t	4'649'074	4'846'065	4'848'380	4'567'130	5'146'296	4'810'417	5'496'528	4'661'806	5'066'898	4'778'472

1B2c Venting/Flaring	Unit	2010	2011	2012
Crude Oil used	t	4'490'741	4'402'315	3'408'796

For source category 1B2c, crude oil used is based on annual statistics of the Swiss Petroleum Association (EV 2012). This is the same activity data as for 1B2a Oil.

3.3.4.3 Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment of all other sources in source category 1B2 based on expert judgement results in medium confidence in the emissions estimate (see Table 1-14).

The time series is consistent.

3.3.4.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission as well as available energy data. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of the last submission 2013.
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of the last submission 2013.

3.3.4.5 Source-Specific Recalculations

No recalculations occured in 1B2c.

3.3.4.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

4 Industrial Processes

4.1 Overview

This chapter provides information on the estimation of the greenhouse gas emissions from sector 2 Industrial Processes. The following source categories are reported:

- 2A Mineral Products
- 2B Chemical Industry
- 2C Metal Production
- 2D Other Production
- *2E Production of Halocarbons and SF_6 is not occurring*
- 2F Consumption of Halocarbons and SF_6
- 2G Other

Emissions within this sector comprise greenhouse gas emissions as by-products from industrial processes and also emissions of F-gases during production, use and disposal. Emissions from fuel combustion in industry are reported in source category 1A2 under sector 1 Energy. Figure 4-1 shows the development of greenhouse gas emissions in source category 2 between 1990 and 2012.

Please note that for several industrial processes within source categories 2A Mineral Products and 2B Chemical Products data and information of emission factors and activity data is classified as confidential (C). For reviewers there is an additional version of chapter 4 Industrial Processes available, including all confidential data and information.

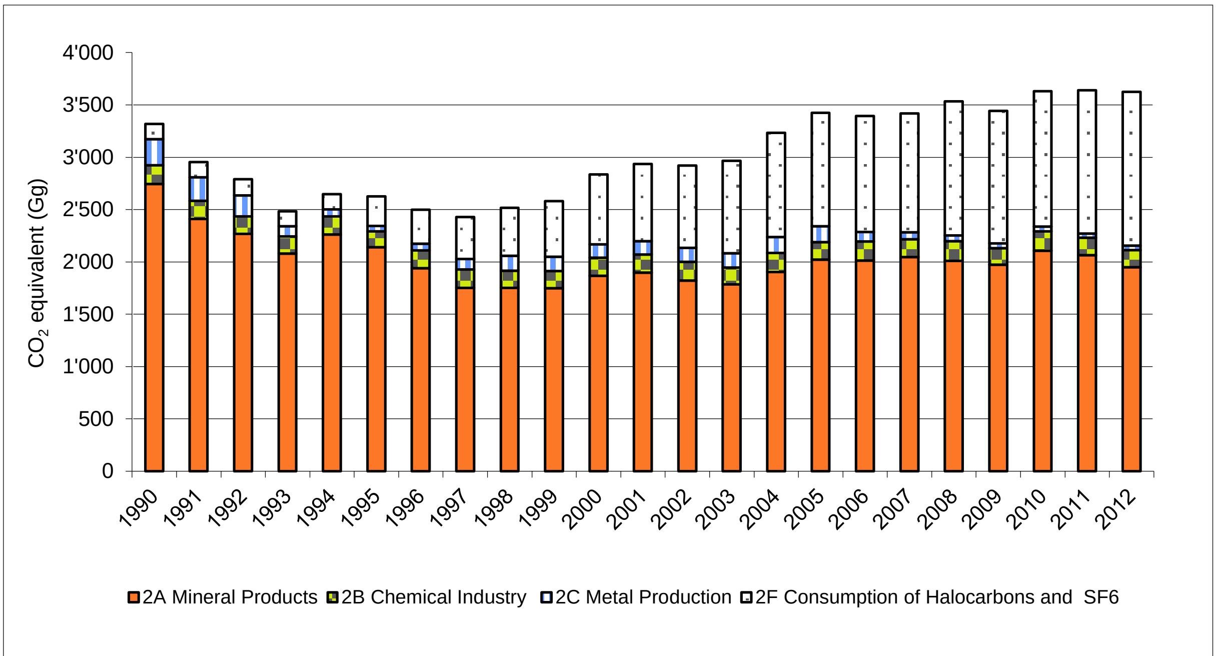

Figure 4-1 Switzerland's greenhouse gas emissions of sector 2 Industrial Processes 1990-2012. Source category 2D Other Production emits no direct greenhouse gas. The emissions of source category 2G Other are very small (2012: 0.9 Gg CO_2 eq) and are therefore not visible in this figure.

2A Mineral Products remain the dominant source of sector 2 with a share of 53.7% of the greenhouse gas emissions in 2012 although they have decreased by 29% since 1990. 2B

Chemical Industry accounts for 4.6% and has decreased by 8% since 1990. 2C Metal Production has decreased by 82.8% and accounts for 1.2% in 2012. 2F Consumption of Halocarbons and SF_6 is of increasing importance: The emissions have increased by a factor of 10.2 since 1990 and are currently responsible for 40.5% of total greenhouse gas emissions in sector 2. This is primarily due to the replacement of HFC for CFC in many technical applications.

In Table 4-1 the development of greenhouse gas emissions in sector 2 Industrial Processes are given by gases. Dominant gases are CO_2 and synthetic gases with shares of 57.1% and 41.4%, respectively, of the emissions in 2012 whereas N_2O and CH_4 contribute with 1.5% and less than one tenth of a per cent, respectively. The relative trend of these gases referring to the base year 1990 is shown in Figure 4-2 and 4-3.

Table 4-1 Greenhouse gas emissions of sector 2 Industrial Processes by gases in Gg CO_2 equivalent for the period 1990-2012.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	3'006	2'662	2'513	2'260	2'424	2'271	2'100	1'926	1'920	1'920
CH_4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.8	1.5	1.3
N_2O	68	62	54	52	61	60	58	51	54	55
Synth. gases	244	231	224	171	164	294	340	452	541	604
Sum	3'320	2'957	2'793	2'484	2'649	2'626	2'498	2'431	2'517	2'580

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (Gg)									
CO_2	2'046	2'073	2'011	1'968	2'108	2'219	2'165	2'169	2'139	2'081
CH_4	1.5	1.6	1.5	1.5	2.1	2.2	1.9	2.2	2.5	1.6
N_2O	60	63	66	59	62	52	60	58	67	58
Synth. gases	728	799	844	941	1'063	1'152	1'170	1'191	1'326	1'306
Sum	2'836	2'938	2'922	2'970	3'235	3'425	3'397	3'421	3'535	3'446

Gas	2010	2011	2012
	CO_2 eq (Gg)		
CO_2	2'241	2'186	2'070
CH_4	2.3	2.3	2.4
N_2O	60	54	54
Synth. gases	1'330	1'400	1'502
Sum	3'634	3'642	3'628

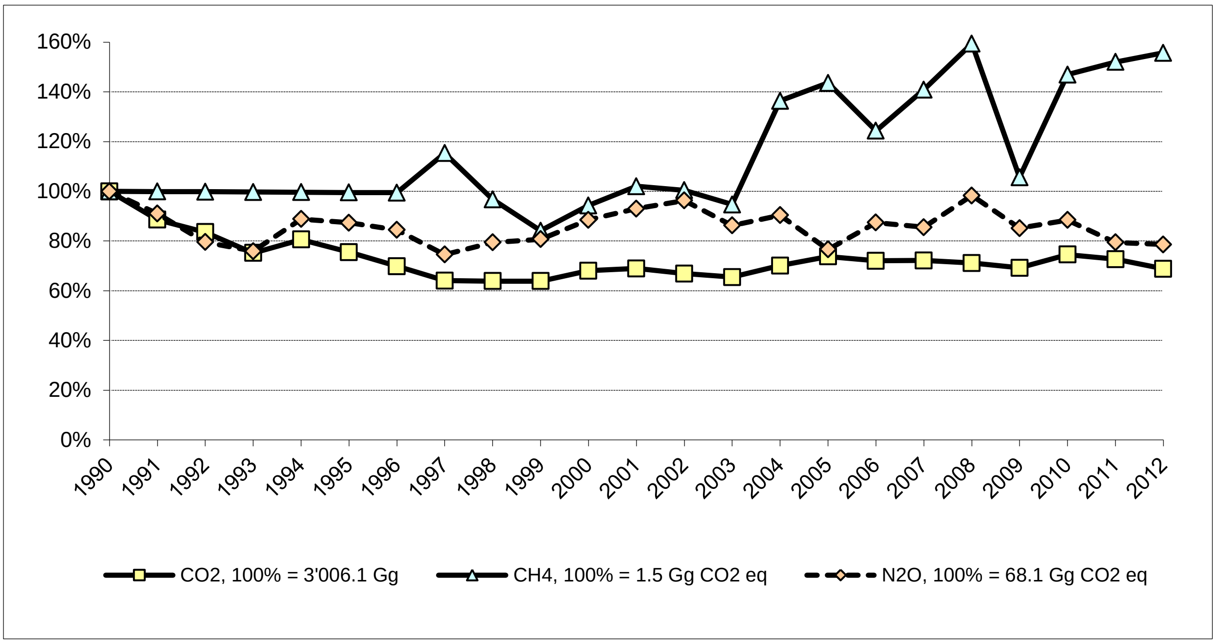

Figure 4-2 Relative trends of the greenhouse gases of sector 2 Industrial Processes in the period 1990-2012. The base year 1990 represents 100%.

Figure 4-2 shows that in the period 1990-2012 the emissions of CO_2 and N_2O from sector 2 Industrial Processes have decreased by 31.1% and 21.4% respectively compared to the base year 1990. Emissions of CH_4 have increased by 55.7% in the same time span.

Figure 4-3 shows that the emissions of F-gases have increased sixfold compared to the year 1990.

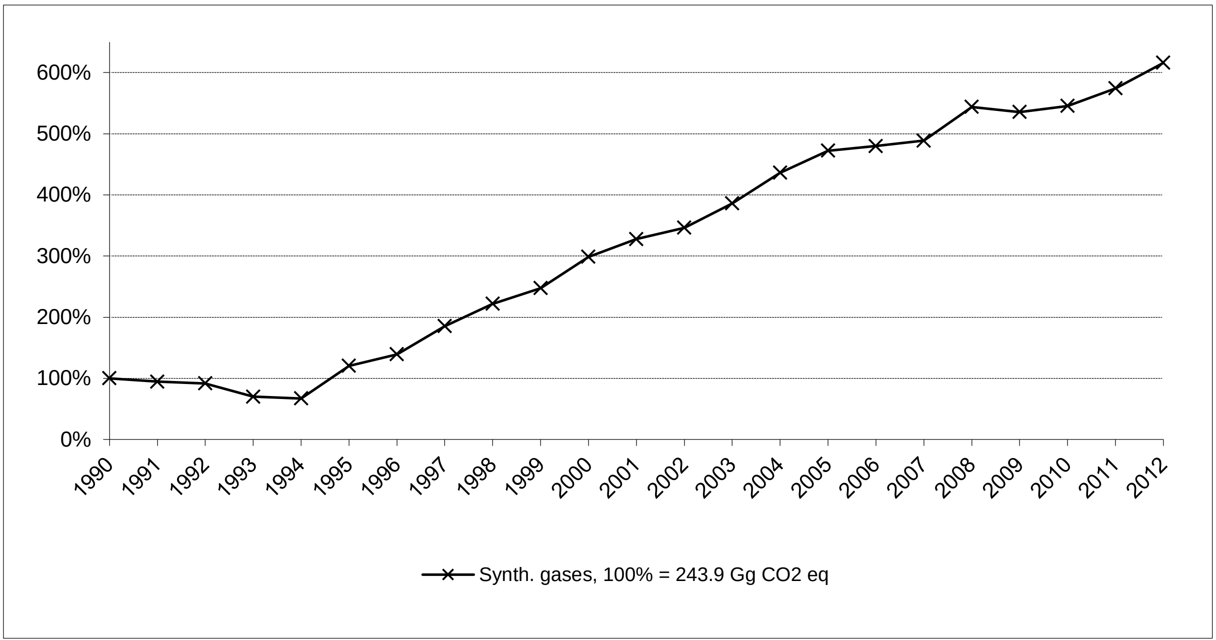

Figure 4-3 Relative trends of the F-gases of sector 2 Industrial Processes in the period 1990-2012. The base year 1990 represents 100%.

4.2 Source Category 2A – Mineral Products

4.2.1 Source Category Description

Tier 1 Key category 2A1
CO_2 emissions from Cement Production (level and trend).

Tier 2 Key category 2A1
CO_2 emissions from Cement Production (level).

Tier 2 Key category 2A3
CO_2 emissions from Limestone and Dolomite Use (trend).

Source category 2A Mineral Products comprises process emissions from production of cement and lime, limestone and dolomite use, asphalt roofing, road paving with asphalt and from production of plaster and glass.

Table 4-2 Specification of source category 2A Mineral Products. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

2A	Source	Specification	Data Source
2A1	Cement Production	Geogenic CO2 emissions from calcination process in cement production Emissions of CO2, NOx, CO, NMVOC and SO2 from blasting operations	AD, EF: EMIS 2014/2A1 Zementwerke Rohmaterial AD, EF: EMIS 2014/2A1 Zementwerke übriger Betrieb
2A2	Lime Production	Geogenic CO2 emissions from calcination process in lime production Emissions of CO2, NOx, CO, NMVOC and SO2 from blasting operations	AD, EF: EMIS 2014/2A2 Kalkproduktion, Rohmaterial AD, EF: EMIS 2014/2A2 Kalkproduktion, übriger Betrieb
2A3	Limestone and Dolomite Use	Geogenic CO2 emissions from fine ceramics, rock wool, and brick and tile production	EF: IPCC 2006, EMIS 2014/2A3 Ziegeleien AD: EMIS 2014/2A3 Feinkeramik Produktion, EMIS 2014/2A3 Steinwolle Produktion, EMIS 2014/2A3 Ziegeleien
2A4	Soda Ash Production and Use	Production is not occurring in Switzerland. Geogenic CO2 emissions from the use of soda ash in fine ceramics and glass production is reported in 2A3 Limestone and Dolomite Use and 2A7 Other respectively	
2A5	Asphalt Roofing	Emissions of CO and NMVOC from asphalt roofing	AD, EF: EMIS 2014/2A5 Dachpappenproduktion und Verlegung
2A6	Road Paving with Asphalt	Emissions of NMVOC from road paving	AD, EF: EMIS 2014/2A6 Strassenbelagsarbeiten
2A7	Other	Emissions of CO2, NOx, CO, NMVOC and SO2 from the production of plaster Geogenic CO2 emissions from production of container and tableware glass, and glass wool	AD, EF: EMIS 2014/2A7 Gips-Produktion übriger Betrieb EF: IPCC 2006 AD, EF: EMIS 2014/2A7 Hohlglas Produktion, EMIS 2014/2A7 Glas übrige Produktion, EMIS 2014/2A7 Glaswolle Produktion Rohprodukt

4.2.2 Methodological Issues

4.2.2.1 Cement production (2A1)

Emissions of geogenic CO_2 occur during the production of clinker which is an intermediate component in the cement manufacturing process. During the production of clinker, limestone, which is mainly calcium carbonate ($CaCO_3$) is heated (calcined) to produce lime (CaO) and CO_2 as by-product. The CaO reacts subsequently with minerals in the raw materials and yields clinker. During this reaction step no further CO_2 is emitted. Clinker is then mixed with other components such as gypsum to make cement.

In Switzerland there are six plants producing clinker and cement. The Swiss plants are rather small and do not exceed a capacity of 3'000 tonnes of clinker per day. All of them use modern dry process technology.

Blasting operations in the limestone quarries are another source of emissions for both CO_2 and indirect greenhouse gases such as NO_x, CO, NMVOC and SO_2.

Methodology

Calcination process:

The geogenic CO_2 emissions from the calcination process in cement production are determined by a Tier 2 approach according to 2000 IPCC good practice guidance (IPCC 2000, chapter *3.1.1 Cement production*). For cement production in Switzerland this results in the following formula:

$$CO_2\ \text{Emissions} = M_{Clinker} \bullet EF_{Clinker} \bullet CKD_{Correction\ Faktor}$$

In Switzerland no long wet or long dry kilns but only modern preheater or precalciner kilns are used and also no so-called low-alkali cement is produced. Therefore there is no landfilling of calcined cement dust (CKD) in Switzerland. In the cement plants all the filter dust is collected in high performance electrostatic precipitator or bag filters (having an efficiency of more than 99.999%) and being recycled to the kiln feed. In some cases small portions of the CKD are added directly to the cement as filler. Due to the kiln technology used in Switzerland the decarbonating degree of the CKD is almost equal to that of the kiln feed, meaning, that this CKD has not been decarbonated yet. Therefore the CKD correction factor is 1.00.

Blasting operations:

The emissions resulting from blasting operations during the digging of limestone are included following a country specific method. Emissions of GHGs related to blasting operations are calculated by multiplying the annual *cement* output by emission factors. Please note that the CO_2 emissions from "blasting" are related to the usage of the explosive itself and are not related to fuel consumption of e.g. bulldozers etc. The amount of used explosive is reported to be 0.13 kg/t cement[12] (EMIS 2014/2A1 Zementwerke übriger Betrieb).

Total emissions reported for the production of cement are the sum of emissions from calcination process and blasting operations. The share of CO_2 emissions from blasting operations in limestone quarries is well below one tenth of a per cent of the geogenic CO_2 emissions from the calcination process.

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[12] The CO_2 emission factor for the use of blasting agents amounts to 600 kg CO_2/t of blasting agent. For the average amount on blasting agent used per kg cement measurement data for the year 2002 were taken. Measurement data were available for four Swiss cement plants, covering more than 60% of the Swiss cement production. Therefore this information is regarded as representative for the Swiss situation. The average blasting agent input per ton of cement amounts to 0.13 kg. The emission factor for CO_2 per ton of cement therefore amounts to 78 g/t cement.

Emission Factors

Calcination process:

The emission factor for CO_2 for calcination is a country specific value depending on the composition of the raw material. The emission factors for the entire time series are listed in Table 4-3. In 2012 it amounts to 530.56 kg CO_2 per ton of *clinker* produced. The IPCC approach neglects CO_2 emissions from decomposition of $MgCO_3$, which are taken into account in this country-specific value.

Table 4-3 CO_2 emission factor for calcination in 2A1 Cement Production 1990 to 2012 (EMIS 2014/2A1 Zementwerke Rohmaterial).

2A1 Cement production	Unit	1990 - 2004	2005	2006	2007	2008	2009	2010	2011 - 2012
Calcination, CO_2	kg/t clinker	525	530.6	527.9	528.58	529.26	531.00	532.15	530.56

Blasting operations:

The emission factors are country specific based on measurements and data from industry and expert estimates as documented in EMIS 2014/2A1 Zementwerke übriger Betrieb. They are given per ton of *cement*. All emission factors have been recalculated for the entire time series due to a calculation error resulting in about 20% lower values. For CO_2 the emission factor has been adjusted from 96 g/t cement to 78 g/t.

Table 4-4 Emission factors for CO_2, NO_x, CO, NMVOC and SO_2 from blasting operations in g/t cement from source category 2A1 Cement Production in 2012 (EMIS 2014/2A1 Zementwerke übriger Betrieb).

2A1 Cement production	Unit	CO_2	NO_X	CO	NMVOC	SO_2
Blasting operations	g/t cement	78	3	18	7.8	0.13

Activity Data

Activity data on annual clinker and cement production is provided by industry and documented in EMIS 2014/2A1 Zementwerke Rohmaterial and EMIS 2014/2A1 Zementwerke übriger Betrieb.

Table 4-5 Activity data of clinker and cement production in Switzerland for the period 1990-2012 in Gg (EMIS 2014/2A1 Zementwerke Rohmaterial and EMIS 2014/2A1 Zementwerke übriger Betrieb).

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

2A1 Cement production	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cement production	Gg	3'754	3'891	3'771	3'592	3'957	4'136	4'143	4'243	4'284	4'303
Clinker production	Gg	3'214	3'275	3'150	3'081	3'265	3'442	3'452	3'512	3'461	3'443

2A1 Cement production	Unit	2010	2011	2012
Cement production	Gg	4'553	4'577	4'359
Clinker production	Gg	3'642	3'587	3'368

4.2.2.2 Lime production (2A2)

During the production of lime calcium carbonate ($CaCO_3$) is heated (calcined) yielding burnt lime (CaO) and CO_2 as by-product. In Switzerland there is only one plant producing lime. There is no industry in Switzerland producing lime for its own requirements. A request to the sugar producing plants Aarberg and Frauenfeld confirmed that indeed they produce lime from limestone in own shaft kilns but that the CO_2 is re-captured in the sugar production process. Thus no CO_2 emissions occur.

Blasting operations in quarry is another source of emissions for both CO_2 and indirect emissions such as NO_x, CO, NMVOC and SO_2.

Methodology

Calcination process:

The geogenic CO_2 emissions from the calcination process in lime production are determined by a country specific approach according to 2000 IPCC good practice guidance (IPCC 2000, chapter *3.1.2 Lime production*). For lime production in Switzerland this results in the following formula:

CO_2 Emissions = $M_{Lime} \bullet EF_{Lime}$

Blasting operations:

The emissions resulting from blasting operations during the digging of limestone are included following a country specific method. They are calculated by multiplying the annual lime production by emission factors. Please note that the CO_2 emissions from "blasting" are related to the usage of the explosive itself and are not related to fuel consumption of e.g. bulldozers etc

Total emissions reported for the production of lime are the sum of emissions from calcination process and blasting operations. The share of CO_2 emissions from blasting operations in the quarry is well below one tenth of a per cent of the geogenic CO_2 emissions from the calcinations process.

Emission Factors

Calcination process:

The emission factor for CO_2 from calcination of limestone depends both on the purity of the limestone and the grade of calcination (i.e. amount of rest CO_2 remaining in the final lime). The plant specific value has been calculated based on industry declaration and is assumed to be constant over time (EMIS 2014/2A2 Kalkproduktion, Rohmaterial). The value is considered confidential, however, available to reviewers.

Blasting operations:

The emission factors are country specific as documented in EMIS 2014/2A1 Kalkproduktion, übriger Betrieb. The value is considered confidential, however, available to reviewers.

Table 4-6 CO_2 emission factor for calcination process and blasting operations in lime production in kg/t lime and emission factors for CO_2, NO_x, CO, NMVOC and SO_2 from blasting operations in g/t lime in 2012 (EMIS 2014/2A2 Kalkproduktion, Rohmaterial and EMIS 2014/2A1 Kalkproduktion übriger Betrieb**)**.

2A2 Lime production	**Unit**	**CO_2**	**NO_X**	**CO**	**NMVOC**	**SO_2**
Calcination	kg/t	C	NA	NA	NA	NA
Blasting operations	g/t	C	C	C	C	C

Activity Data

Activity data on annual lime production is based on data from the one existing plant in Switzerland, documented in the EMIS database (EMIS 2014/2A2 Kalkproduktion, Rohmaterial and EMIS 2014/2A1 Kalkproduktion übriger Betrieb). Detailed activity data is not reported as it is considered confidential, however, available to reviewers.

4.2.2.3 Limestone and dolomite use (2A3)

In Switzerland limestone and dolomite are used as raw material in the production of

- fine ceramics,
- rock wool and
- bricks and tiles.

When using limestone and dolomite in such production processes geogenic CO_2 is released to the atmosphere. The three different production processes are discussed consecutively in the following.

The use of limestone and dolomite as raw materials in glass production is reported in source category 2A7 Glass Production.

Fine ceramics (2A3)

In Switzerland the main production of fine ceramics is sanitary ware. The carbonate containing raw materials limestone and dolomite are used in product glazes only. The glazes contain small amounts of soda ash (Na_2CO_3) as well. All information on the fine ceramics production is documented in EMIS 2014/2A3 Feinkeramik Produktion.

Methodology

The geogenic CO_2 emissions from fine ceramics production are determined by a Tier 2 approach according to 2006 IPCC guidelines (IPCC 2006, chapter *2.5 Other process uses of carbonates)*. For fine ceramics production in Switzerland this results in the following formula:

$$CO_2 \text{ Emissions} = (M_{Limestone} \bullet EF_{Limestone}) + (M_{Dolomite} \bullet EF_{Dolomite}) + (M_{Soda\ Ash} \bullet EF_{Soda\ Ash})$$

Emission Factors

For fine ceramics production in Switzerland the CO_2 emission factors of limestone, dolomite and soda ash are taken from IPCC 2006 (chapter *2.5 Other process uses of carbonates, Table 2.1*). As these emission factors are material properties they remain constant over time.

Table 4-7 Geogenic CO_2 emission factors for 2012 used for fine ceramics, rock wool production and the production of brick and tile in g/t carbonate containing raw material and g/t product, respectively (IPPC 2006, EMIS 2014/2A3 Ziegeleien).

2A3 Limestone and dolomite use	Unit	CO_2 geogenic
fine ceramics and rock wool production		
limestone use	g/t limestone	439'710
dolomite use	g/t dolomite	477'320
soda use	g/t soda	414'920
brick and tile production	g/t	117'000

Activity Data

Activity data for carbonate containing raw materials, i.e. limestone, dolomite and soda ash used in the glazes of the fine ceramics production are extrapolated values based on industry data from the largest fine ceramics production plant in Switzerland. Detailed activity data on the carbonate containing raw materials is considered confidential; however, it is available to the reviewers.

Rock wool production (2A3)

In Switzerland there is one single producer of rock wool. The plant uses dolomite as raw material. No other carbonate containing raw material is used in the production process. All information of the rock wool production is documented in EMIS 2014/2A3 Steinwolle Produktion.

Methodology

The geogenic CO_2 emissions from rock wool production are determined by a Tier 2 approach according to IPCC 2006 (chapter *2.5 Other process uses of carbonates)*. For rock wool production in Switzerland this results in the following formula:

CO_2 Emissions = $M_{Dolomite} \bullet EF_{Dolomite}$

Emission Factors

For rock wool production in Switzerland the CO_2 emission factor of dolomite is taken from IPCC 2006 (chapter *2.5 Other process uses of carbonates, Table 2.1*). As the emission factor is a material property it remains constant over time (see Table 4-7).

Activity Data

Activity data is based on industry data from the single rock wool production plant in Switzerland.

Table 4-8 Activity data for the use of limestone and dolomite in fine ceramics and rock wool production and of the brick and tile production in Switzerland for the period 1990-2012 in Gg (EMIS 2014/2A3 Feinkeramik Produktion, EMIS 2014/2A3 Steinwolle Produktion, EMIS 2014/2A3 Ziegeleien).

2A3 Limestone and dolomite use	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
fine ceramics production											
limestone use	Gg	C	C	C	C	C	C	C	C	C	C
dolomite use	Gg	C	C	C	C	C	C	C	C	C	C
soda use	Gg	C	C	C	C	C	C	C	C	C	C
rock wool production											
dolomite use	Gg	2.8	2.9	2.8	2.6	2.7	2.9	2.8	2.6	3.0	3.3
brick and tile production	Gg	1'271	1'240	1'208	1'177	1'146	1'115	1'084	1'052	1'021	990

2A3 Limestone and dolomite use	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
fine ceramics production											
limestone use	Gg	C	C	C	C	C	C	C	C	C	C
dolomite use	Gg	C	C	C	C	C	C	C	C	C	C
soda use	Gg	C	C	C	C	C	C	C	C	C	C
rock wool production											
dolomite use	Gg	3.7	2.7	4.9	5.6	4.9	1.7	0.3	3.7	4.7	4.7
brick and tile production	Gg	959	945	875	859	1'023	1'086	1'065	975	865	701

2A3 Limestone and dolomite use	Unit	2010	2011	2012
fine ceramics production				
limestone use	Gg	C	C	C
dolomite use	Gg	C	C	C
soda use	Gg	C	C	C
rock wool production				
dolomite use	Gg	5.9	5.9	6.4
brick and tile production	Gg	879	800	818

Brick and tile production (2A3)

In Switzerland there are about 20 plants producing bricks and tiles. The manufacturing process uses limestone containing clay as main raw material.

Methodology

Concerning the release of geogenic CO_2 emissions from brick and tile production there has been no specific information on the employed raw materials available from Swiss industry in the past years. In 2013, again, a request to the Swiss association of brick and tile industry (Verband Schweizerische Ziegelindustrie VSZ) was made. Unfortunately without success.

Therefore, for submission 2014 data from a comparison of geogenic CO_2 emissions based on analyses of the carbonate content of the clay used for brick and tile production in a number of plants in Switzerland an the European Union are applied. This study was carried out by the VSZ in 2012 (see EMIS 2014/2A3 Ziegeleien).

In order to estimate the geogenic CO_2 emission from brick and tile production in Switzerland the following formula was used:

CO_2 Emissions = $M_{\text{brick and tile}} \bullet EF_{\text{brick and tile}}$

Emission Factors

According to this study, bricks emit a weighted average of 13.2% of geogenic CO_2 (variation range 5.4 - 24%) and roof tiles have a weighted average of 8.6% (variation range 5.6 - 13%). Based on the production shares of the largest Swiss brick producer a production ratio for bricks:tiles of 2:1 was assumed for the whole period from 1990 on. This results in an average geogenic CO_2 emission content of 11.7%.

For estimating the geogenic CO_2 emissions from Swiss brick and tile production, a constant emission factor of 117 kg CO_2/t brick and tile was assumed. This represents the mean value provided by the industry association as discussed above and is about 50% higher than the value of 80 kg CO_2/t brick and tile used before.

Activity Data

Activity Data is based on production data from the Swiss association of brick and tile industry (see Table 4-8).

4.2.2.4 Soda ash production and use (2A4)

There is no soda ash production in Switzerland.

The main use of soda ash is in the glass production which is reported separately in source category 2A7 Glass production. A very small amount of soda ash is also applied in glazes of fine ceramics and is thus included in source category 2A3.

4.2.2.5 Asphalt roofing (2A5)

This source category comprises emissions from production and use of asphalt roofing materials (saturated felt, roofing and siding shingles, roll roofing and sidings). These products are used in roofing and other building applications. From 2A5 Asphalt roofing only indirect greenhouse gas emissions of CO and NMVOC arise. CO is emitted during the production process of asphalt roofing materials whereas NMVOC emissions are released during the entire production and laying processes (primers included).

Methodology

Emissions of CO and NMVOC from asphalt roofing are calculated by multiplying the annual amounts of asphalt roofing products and primers produced and employed by the corresponding emission factors.

Emission Factors

The emission factors for CO and NMVOC emissions from asphalt roofing processes are country specific. They are based on measurements, industry data and expert estimates as documented in EMIS 2014/2A5 Dachpappenproduktion und Verlegung.

Table 4-9 Emission factors for 2012 for CO and NMVOC in kg/t asphalt sealing sheeting and asphalt concrete from 2A5 Asphalt roofing and 2A6 Road paving with asphalt, respectively (EMIS 2014/2A5 Dachpappenproduktion und Verlegung and EMIS 2014/2A6 Strassenbelagsarbeiten).

	Unit	CO	NMVOC
2A5 Asphalt roofing	kg/t asphalt sealing sheeting	121	21
2A6 Road paving	kg/t asphalt concrete	NA	0.49

Activity Data

Activity data on asphalt roofing products and primers produced is based on industry and expert estimates as documented in EMIS 2014/2A5 Dachpappen Produktion und Verlegung.

Table 4-10 Activity data for asphalt roofing and road paving with asphalt for the period 1990-2012 in Gg (EMIS 2014/2A5 Dachpappenproduktion und Verlegung and EMIS 2014/2A6 Strassenbelagsarbeiten).

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2A5 Asphalt roofing											
asphalt sealing sheeting	Gg	50	49	48	47	46	45	44	42	41	41
2A6 Road paving with asphalt											
asphalt concrete	Gg	5'500	5'360	5'220	5'080	4'940	4'800	4'763	4'727	4'690	5'070

	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2A5 Asphalt roofing											
asphalt sealing sheeting	Gg	41	41	38	35	32	30	28	26	25	25
2A6 Road paving with asphalt											
asphalt concrete	Gg	5'170	4'860	4'770	4'860	4'840	4'780	5'400	5'100	5'160	5'200

	Unit	2010	2011	2012
2A5 Asphalt roofing				
asphalt sealing sheeting	Gg	25	24	24
2A6 Road paving with asphalt				
asphalt concrete	Gg	5'250	5'300	4'770

4.2.2.6 Road paving with asphalt (2A6)

Asphalt road surfaces are composed of compacted aggregate and asphalt binder. From road surfacing operations NMVOC emissions occur only.

Methodology

The NMVOC emissions are determined by a country specific method as documented in EMIS 2014/2A5 Strassenbelagsarbeiten and calculated by multiplying the annual amount of asphalt products used for road paving by the corresponding emission factor.

Emission Factors

The emission factor for NMVOC emissions from road paving with asphalt is country specific. It consists of a EF for the NMVOC emissions from the bitumen content of asphalt products which is decreasing since 1990 and a variable EF from prime coatings. The values are based on industry data from 1990, 1998, 2007 and 2010. All other years are interpolated and complemented with expert estimates as documented in EMIS 2014/2A6 Strassenbelags-arbeiten (see Table 4-9).

Activity Data

Activity data on annual production of asphalt concrete is provided by the industry association on a yearly basis from 1998 on and for 1990 and 1995 (with expert estimates for the years in between) as documented in EMIS 2014/2A6 Strassenbelagsarbeiten (see Table 4-10).

4.2.2.7 Other (2A7)

Source category 2A7 Other comprises emissions from plaster production and from the production of container and table ware glass as well as glass wool.

Plaster Production (2A7)

Methodology

The emissions of CO_2, NO_x, CO, NMVOC and SO_2 from 2A7 Plaster production refer to emissions from blasting operations during the mining of gypsum, i.e. the raw material for plaster production. The emissions are calculated by multiplying the annual amount of processed rock by the emission factors. There are two plaster production sites in Switzerland.

Emission Factors

As there are no specific emission factors for gypsum mining, the emission factors for cement raw material mining are taken instead (with a rough estimate that 1.5 t of rocks are needed for 1 t of cement). This approach is documented in EMIS 2014/2A7 Gips-Produktion übriger Betrieb.

Table 4-11 Emission factors for plaster production in g/t mined rocks for 2012 (EMIS 2014/2A7 Gips-Produktion übriger Betrieb).

2A7 Plaster production	Unit	CO_2	NO_x	CO	NMVOC	SO_2
	g/t rocks	144	5.6	33	14.4	0.24

Activity Data

The activity data of the annual amount of rocks processed in the plaster production is based on industry data and expert estimates as documented in EMIS 2014/2A7 Gips-Produktion übriger Betrieb.

Table 4-12 Activity data for the mining of gypsum in Switzerland for the period 1990-2012 in Gg (EMIS 2014/2A7 Gips-Produktion übriger Betrieb).

2A7 Plaster production	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
rocks	Gg	319	316	313	310	307	304	300	297	294	291

2A7 Plaster production	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
rocks	Gg	288	285	290	296	301	327	323	314	295	293

2A7 Plaster production	Unit	2010	2011	2012
rocks	Gg	335	293	271

Glass production (2A7)

The carbonate containing raw materials in the glass production are soda ash, limestone and dolomite. In Switzerland the following three glass types are produced: container glass, tableware glass and glass wool. Today there is only one production plant for container glass and one for tableware glass in Switzerland after the other one closed in 2002 and 2006, respectively. Glass wool is produced in two plants.

Methodology

For determination of geogenic CO_2 emission from glass production a Tier 2 approach according to IPCC 2006 (chapter *2.4 Glass production)* is used. For glass production in Switzerland this results in the following formula:

CO_2 Emissions = $M_{Glass\ type} \bullet EF_{Glass\ type} \bullet (1 - \text{cullet ratio})$

The cullet ratio describes the share of recycled glass material which is used in the production. The melting of cullet causes no geogenic CO_2 emissions.

Emission Factors

The emission factor for glass production in Switzerland is taken from IPCC 2006 (chapter *2.4 Glass production, Table 2.6*). For the production of container glass, tableware glass and glass wool the values for glass type *container*, *tableware* and *fibreglass* are taken, respectively. As the emission factors are material properties they remain constant over the time.

Table 4-13 Geogenic CO_2 emission factor for glass production in g/t glass (IPPC 2006).

2A7 Glass production	Unit	CO_2 geogenic
container glass	g/t	210'000
glass wool (fibre glass insulation)	g/t	250'000
glass (speciality tableware)	g/t	100'000

Activity Data and Cullet Ratios

Activity data is based on industry data from Swiss glass producers. Detailed information on activity data for container glass production and tableware production is considered confidential as there is only one producing plant respectively. However, the detailed data is available to the reviewers. Activity data for glass wool production is based on industry data from the two glass wool production plants in Switzerland.

Table 4-14 Glass production in Switzerland for the period 1990-2012 in Gg and cullet ratio in % (EMIS 2014/2A7 Hohlglas Produktion, EMIS 2014/2A7 Glas übrige Produktion and EMIS 2014/2A7 Glaswolle Produktion Rohprodukt).

2A7 Glass production	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
container glass											
production	Gg	C	C	C	C	C	C	C	C	C	C
cullet ratio	%	C	C	C	C	C	C	C	C	C	C
glass (speciality tableware)											
production	Gg	C	C	C	C	C	C	C	C	C	C
cullet ratio	%	C	C	C	C	C	C	C	C	C	C
glass wool											
production	Gg	24.3	22.8	23.4	21.7	24.9	24.2	19.9	25.6	27.5	32.1
cullet ratio	%	21	26	49	53	65	45	61	66	65	67

2A7 Glass production	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
container glass											
production	Gg	C	C	C	C	C	C	C	C	C	C
cullet ratio	%	C	C	C	C	C	C	C	C	C	C
glass (speciality tableware)											
production	Gg	C	C	C	C	C	C	C	C	C	C
cullet ratio	%	C	C	C	C	C	C	C	C	C	C
glass wool											
production	Gg	31.1	25.2	19.9	25.9	32.7	37.5	38.1	44.5	44.4	33.5
cullet ratio	%	69	65	59	62	65	65	73	71	69	69

2A7 Glass production	Unit	2010	2011	2012
container glass				
production	Gg	C	C	C
cullet ratio	%	C	C	C
glass (speciality tableware)				
production	Gg	C	C	C
cullet ratio	%	C	C	C
glass wool				
production	Gg	35.7	41.4	38.7
cullet ratio	%	71	72	61

4.2.3 Uncertainties and Time-Series Consistency

The uncertainty for CO_2 emissions in cement production (2A1) which is key category regarding level and trend amounts to 2.8%. The uncertainty of CO_2 emissions was calculated following the steps in Table 3.2 in 2000 IPCC good practice guidance (IPCC 2000, p. 3.15). As CO_2 emissions are calculated based on plant level CaO contents of the clinker (Tier 2) an uncertainty of 2% is assumed both for activity data and emission factor (step 3 in table 3.2).

For non-key categories, the NIR provides qualitative estimates of uncertainties only. The terms high, medium and low data quality is used and a quantitative relative uncertainty is assigned to every uncertainty category (see Table 1-14 Semi-quantitative uncertainties for non-key categories). The uncertainties for CO_2 emissions from source categories 2A2 and 2A7 are estimated to be low and thus amount to 2%. For CO_2 emission in source category 2A3 an overall uncertainty of 51% is taken. The uncertainty of 51% corresponds to the uncertainty of brick and tile and is the highest among the three processes included in source category 2A3.

The time series is consistent.

4.2.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

In submission 2012 the emission factor of category 2A1 used in the Swiss Inventory was compared to the corresponding emission factors of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) and to the IPCC default value (INFRAS 2012). Switzerland's factor lies in the midfield of the other countries; see chpt. 4.2.2.1.

In submission 2012 the emission factor of category 2A2 used in the Swiss Inventory was compared to the corresponding emission factors of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) and to the IPCC default value (INFRAS 2012). Switzerland's factor lies in the midfield of the other countries, see chpt. 4.2.2.2.

In submission 2012 the emission factor of category 2A3 used in the Swiss Inventory was compared to the corresponding emission factors of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) and to the IPCC default value if available (INFRAS 2012). Switzerland's factor lies beyond the other countries. This is due to the fact, that the Swiss factor includes emissions from three different sources: fine ceramics, rock wool and brick and tile. The most dominant process in category 2A3 is brick and tile production. The emission factor amounts to 0.08 t CO_2/t brick and tile. Comparing this value to the German value which is 0.029 t CO_2/t bricks and tiles, shows that the Swiss value is rather high. The Swiss brick and tile industry has determined very recently the carbonate content of the clay raw material at several pits. A first comparison with the carbonate content of clay from pits in other European countries confirms that the Swiss values are indeed rather high.

4.2.5 Source-Specific Recalculations

2A1 Cement production: For blasting operations a calculation error has been corrected resulting in about 20% lower EF values for CO_2, NO_x, CO, NMVOC and SO_2 for 1990-2011.

2A3 Brick and tile production: So far interpolated activity data of the three brick and tile production plants which are not member of the industry association have been replaced by effective production data for 2001-2006 resulting thus in revised AD for these years. The EF for CO_2 has been revised based on some specifications of the carbonate content of the raw material and an assumed brick and tile production share yielding an about 50% higher EF value for the entire time series.

2A5 Asphalt roofing: Activity data for 2008-2011 has been revised due to updated projection values for 2015.

2A7 Glasswool production: Activity data of one of the two production plants have been revised for 1991-2004 based on effective production data for 1996-2004 resulting in revised EF values of CO_2 for 1991-2004 as well due to different cullet ratios of the two plants.

4.2.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

4.3 Source Category 2B – Chemical Industry

4.3.1 Source Category Description

Source category 2B Chemical Industry comprises process emissions from the production of ammonia, nitric acid, silicon carbide, ethylene, acetic acid and sulphuric acid.

Table 4-15 Specification of source category 2B Chemical Industry. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

2B	Source	Specification	Data Source
2B1	Ammonia Production	Emissions of CO2 and NMVOC are reported in 2B5 Ethylene production	AD, EF: EMIS 2014/2B1 Ammoniak-Produktion
2B2	Nitric Acid Production	Emissions of N2O and NOx from the production of nitric acid	AD, EF: EMIS 2014/2B2 Salpetersäure Produktion
2B3	Adipic Acid Production	Not occurring in Switzerland	
2B4	Carbide Production	Emissions of CO2, CH4 and SO2 from the production of silicon carbide	EF: IPCC 2006, EMIS 2014/2B4 Graphit und Siliziumkarbid Produktion AD: EMIS 2014/2B4 Graphit und Siliziumkarbid Produktion
2B5	Other Chemical Industry	Emissions of CO2 and NMVOC from ethylene production Emissions of CO2, CH4, CO and NMVOC from acetic acid production SO2 emissions from sulphuric acid production	AD, EF: EMIS 2014/2B5 ethylene production AD, EF: EMIS 2014/2B5 Essigsäure-Produktion AD, EF: EMIS 2014/2B5 Schwefelsäure-Produktion

4.3.2 Methodological Issues

4.3.2.1 Ammonia production (2B1)

Ammonia (NH_3) is produced in one single plant in Switzerland by catalytic reaction of nitrogen and synthetic hydrogen (see Figure 4-4). Ammonia is not produced in an isolated reaction plant but is part of an integrated production chain (see Figure 4-5).

The starting production process is the thermal cracking of liquefied petroleum gas (LPG) and light virgin naphtha yielding ethylene (ethene, C_2H_4), and a series of by-products such as e.g. synthetic hydrogen and methane, which are used as educts for further production steps. According to the Swiss ammonia producer it is not possible to split and allocate the emissions of the cracking process (CO_2 and NMVOC) to every single product such as, e.g., ethylene, acetylene (ethyne, C_2H_2), cyanic acid or ammonia. **Therefore, all CO_2 and NMVOC emissions of the cracking process are allocated to the *ethylene production*** and are reported under the category 2B5 Ethylene production. Thus, for source category 2B1 Ammonia production, CO_2 and NMVOC emissions are reported as included elsewhere (IE). All information on the ammonia production and the cracking process is documented in EMIS 2014/2B1 Ammoniak-Produktion and EMIS 2014/2B5 Ethen-Produktion, respectively.

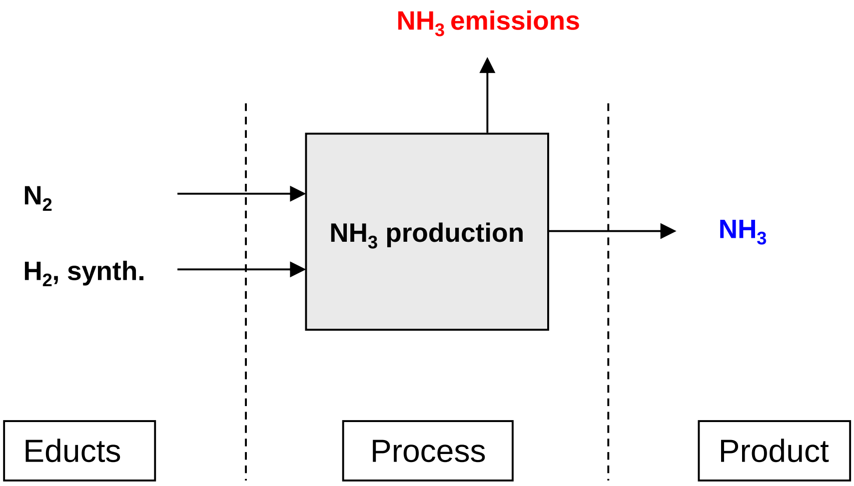

Figure 4-4 Process flow chart for the production of ammonia (NH_3) from nitrogen (N_2) and hydrogen (H_2, synth.). Hydrogen is derived from the thermal cracking process in the same plant (see Figure 4-5).

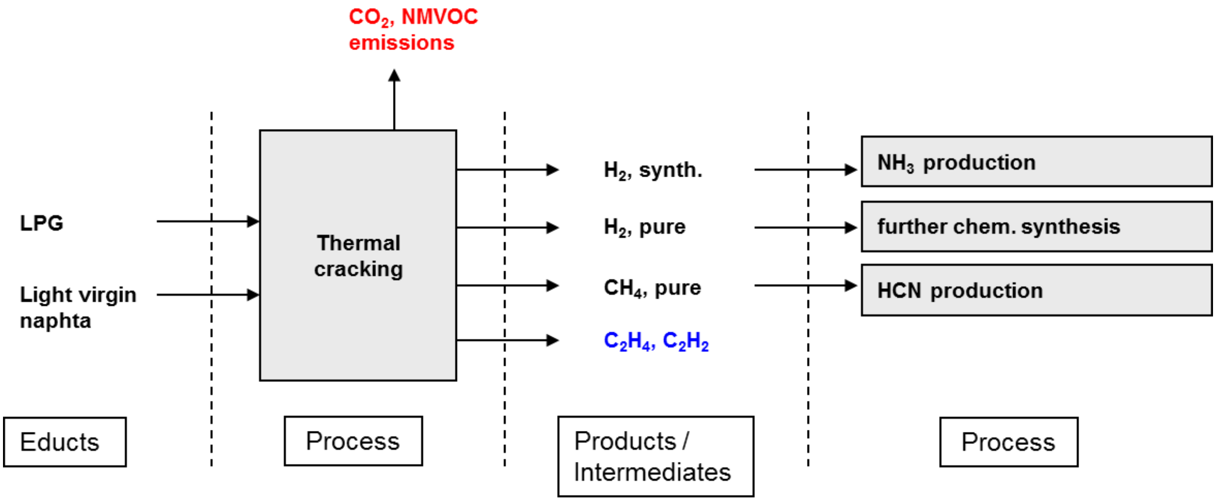

Figure 4-5 Process flow chart for the production of ethylene (C_2H_4) and acetylene (C_2H_2) by thermal cracking of liquefied petroleum gas (LPG) and light virgin naphta. The intermediate product H_2, synth. is used as educt in the ammonia production in the same plant (see Figure 4-4).

4.3.2.2 Nitric acid production (2B2)

In Switzerland there is one single plant producing nitric acid (HNO_3). Nitric acid is produced by catalytic oxidation of ammonia (NH_3) with air. At temperatures of 800 °C nitric monoxide (NO) is formed. During cooling, nitrogen monoxide reacts with excess oxygen to form nitrogen dioxide (NO_2). The nitrogen dioxide reacts with water to form 60% nitric acid (HNO_3). Today, two types of processes are used for nitric acid production: single pressure or dual pressure plants. In Switzerland a dual pressure plant is installed.

During the process nitrous oxide (N_2O) can be formed as an unintended by-product. In addition, also some nitrogen oxide (NO_x) is produced. In the Swiss production plant abatement of NO_x is done by selective catalytic reduction (SCR) which reduces NO_x to N_2 and O_2 (the SCR in this plant is also used for treatment of other flue gases and was not installed for the HNO_3 production specially). No additional abatement technique is installed to destroy N_2O. A decomposition of N_2O occurs, to some extent, simultaneously in the NO_x

reduction process. The production and abatement technology has essentially remained the same since 1990.

Methodology

The N_2O and NO_x emissions from nitric acid production are determined by a Tier 2 approach. The emissions are calculated by multiplying the annual nitric acid production output by the corresponding emission factors for N_2O and NO_x emissions respectively.

Emission Factors

The N_2O and NO_x emission factors for nitric acid production in Switzerland are based on measurements from the single nitric acid production plant. The measurement of N_2O was carried out according to the guideline VDI-Richtlinie 2469/Blatt 1 (Messen gasförmiger Emissionen - Messen von Distickstoffmonoxid - Manuelles gaschromatographisches Verfahren). The test gas is sucked in via a heated titanium sensor and then treated with a solution of potassium permanganate and hydrogen peroxide in order to remove nitrogen oxides and further disturbing components. The N_2O concentration is then measured using a gas chromatograph with an electron capture detector. The measurement uncertainty is ± 20% (minimum ± 0.5 mg/m^3). On repeated enquires the plant confirmed that since a denitrification system and an automatic control system for the ammonia addition was installed in 1988 and 1990, respectively, no modification has been made in the production line. The values are documented in EMIS 2014/2B2 Salpetersäure Produktion. They are considered confidential, however, available to reviewers on request.

Table 4-16 Emission factors for N_2O and NO_x for nitric acid production in Switzerland in kg/t nitric acid for 2012. Data refers to 100% nitric acid (EMIS 2014/2B2 Salpetersäure Produktion).

2B2 Nitric acid production	Unit	N_2O	NO_x
	kg/t	C	C

Activity Data

Activity data on annual production of nitric acid (100%) is provided on a yearly basis by the Swiss production plant for the entire time period 1990-2012. The data is confidential but available for reviewers (see EMIS 2014/2B2 Salpetersäure Produktion).

4.3.2.3 Carbide production (2B4)

In Switzerland there is one single plant producing carbide. The plant produces silicon carbide which is used in abrasives, refractories, metallurgy and anti-skid flooring. The Swiss silicon carbide is produced in an electric furnace at temperatures above 2000 ºC using the Acheson process. The starting materials are quartz sand (SiO_2), petroleum coke and anthracite (C) which yield silicon carbide (SiC) and carbon monoxide (CO). The CO is converted to CO_2 in excess oxygen and released to the atmosphere. Petroleum coke and anthracite – although to a lower portion – may contain volatile organic compounds which can form methane (CH_4) as an unintended by-product. There is no abatement techniques installed which could capture the CO_2 or CH_4 emissions.

Methodology

The CO_2, CH_4 and SO_2 emissions from silicon carbide production are determined by a Tier 2 approach. The emissions are calculated by multiplying the annual silicon carbide production output by the corresponding emission factors for CO_2, CH_4 and SO_2 emissions respectively.

Emission Factors

The CO_2, CH_4 and SO_2 emission factors are considered confidential, however, available to reviewers on request. The values base partly on measurements and data from the single silicon carbide production plant and are documented in EMIS 2014/2B2 Graphit und Siliziumkarbid Produktion.

Table 4-17 Emission factors for CO_2, CH_4 and SO_2 for carbide production in Switzerland for 2012 in kg/t silicon carbide respectively (EMIS 2014/2B4 Graphit und Siliziumkarbid Produktion).

2B4 Silicon carbide production	Unit	CO_2	CH_4	SO_2
	kg/t	C	C	C

Activity Data

Activity data on annual production of silicon carbide is provided on a yearly basis from 1997 onwards by the Swiss production plant. For the time period 1990-1996 activity data bases on industry data for 1990 and 1995 and interpolated values in between. The data is confidential but available for reviewers (see EMIS 2014/2B4 Graphit und Siliziumkarbid Produktion).

4.3.2.4 Other (2B5)

Source category Other (2B5) comprises emissions from production of ethylene, acetic acid and sulphuric acid.

4.3.2.5 Ethylene production (2B5)

Ethylene (ethene, C_2H_4) is produced by a single plant in Switzerland by thermal cracking of liquefied petroleum gas (LPG) and virgin naphta. Ethylene is not produced in an isolated process but is co-processed together with several other products such as H_2, CH_4, and C_2H_2 (see flow chart in Figure 4-5 in section 4.3.2.1). From the thermal cracking process emissions of CO_2 and NMVOC are released. They are both allocated entirely to the production of ethylene which is the first product within the integrated production chain. CH_4 emissions to atmosphere do not occur since CH_4 is completely used as an educt in the downstream production of cyanic acid (HCN) in the same facility (again, see Figure 4-5 and for further information see EMIS 2014/2B5 Ethen-Produktion). Therefore CH_4 emissions are reported as NA for ethylene production and only CO_2 and NMVOC emissions are reported.

Methodology

The CO_2 and NMVOC emissions from ethylene production are determined by a country-specific approach. The emissions are calculated by multiplying the annual ethylene production output by the corresponding emission factors for CO_2 and NMVOC emissions respectively.

Emission Factors

The CO_2 and NMVOC emission factors for ethylene production are based on industry data from the single ethylene production plant in Switzerland. Annual emission data was only available from the year 2000 onwards. For the period 1990-1999 a constant value, i.e. the mean value of the years 2000-2009 was assumed. The emission factors for ethylene production are considered confidential; however, they are available to reviewers on request.

Table 4-18 Emission factors for CO_2 and NMVOC in ethylene production, CH_4, CO and NMVOC in acetic acid production and SO_2 in sulphuric acid production for 2012 in kg/t product (EMIS 2014/2B5 Ethen-Produktion, EMIS 2014/2B5 Essigsäure-Produktion and EMIS 2014/2B5 Schwefelsäure-Produktion).

2B5 Chemical industry, other	Unit	CO_2	CH_4	CO	NMVOC	SO_2
ethylene production	kg/t	C	NA	NA	C	NA
acetic acid production	kg/t	12	0.023	0.014	0.25	NA
sulphuric acid production	kg/t	NA	NA	NA	NA	C

Activity Data

Activity data on the annual production of ethylene is provided on a yearly basis by the single ethylene production plant in Switzerland for the entire time period 1990-2012. The data is considered confidential but available for reviewers on request.

Table 4-19 Activity data for the production of ethylene, acetic acid and sulphuric acid in Switzerland for the period 1990-2012 in Gg (EMIS 2014/2B5 Ethen-Produktion, EMIS 2014/2B5 Essigsäure-Produktion and EMIS 2014/2B5 Schwefelsäure-Produktion).

2B5 Chemical industry, other	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
ethylene production	Gg	C	C	C	C	C	C	C	C	C	C
acetic acid production	Gg	30	29	29	28	28	27	27	26	26	25
sulphuric acid production	Gg	C	C	C	C	C	C	C	C	C	C

2B5 Chemical industry, other	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
ethylene production	Gg	C	C	C	C	C	C	C	C	C	C
acetic acid production	Gg	24	14	11	10	9	8	8	9	18	28
sulphuric acid production	Gg	C	C	C	C	C	C	C	C	C	C

2B5 Chemical industry, other	Unit	2010	2011	2012
ethylene production	Gg	C	C	C
acetic acid production	Gg	20	18	12
sulphuric acid production	Gg	C	C	C

4.3.2.6 Acetic and sulphuric acid production (2B5)

In Switzerland there are two plants producing acetic acid (CH_3COOH). From acetic acid production emissions of CO_2, CH_4, CO and NMVOC occur. For this year's submission all three so far known plants producing acetic acid were contacted directly for information on production data, process emissions and manufacturing processes. Thereby it turned out that one plant does not produce acetic acid but acetic acid occurs as a by-product only of esterifications using acetic anhydride.

Sulphuric acid (H_2SO_4) is produced by one plant only in Switzerland. From this production process SO_2 is emitted.

Methodology

In order to determine emissions of CO_2, CH_4, CO and NMVOC as well as of SO_2 from acetic acid and sulphuric acid production, respectively, a country specific approach is used. The emissions are calculated by multiplying the annual production of acetic acid and sulphuric acid, respectively, by the corresponding emission factor.

Emission Factors

The emission factors for CO_2, CH_4, CO and NMVOC from acetic acid production and for SO_2 from sulphuric acid production in Switzerland are country specific and base on measurements and data from industry and expert estimates documented in EMIS 2014/2B5 Essigsäure-Produktion and EMIS 2014/2B5 Schwefelsäure-Produktion (see Table 4-18).

For this year's submission emission factors of the acetic acid production have been revised for the entire time series in co-operation with industry. From one production plant NMVOC emissions are emitted only, whereas the other one reports emissions of CO_2, CH_4, CO and NMVOC. Usually the process emissions are treated in a flue gas incineration. Thus, the reported emissions of CH_4, CO and NMVOC only occur in case of malfunction resulting in strongly fluctuating plant-specific emission factors. In addition the resulting implied emission factors based on the emissions of both plants are modulated by considerable production fluctuations of one of the plants from 2000 onwards.

The data for sulphuric acid production is confidential but available for reviewers on request.

Activity Data

The annual amount of produced acetic acid and sulphuric acid base on data from industry and expert estimates documented in EMIS 2014/2B5 Essigsäure-Produktion and EMIS 2014/2B5 Schwefelsäure-Produktion (see Table 4-19). The data for sulphuric acid production is confidential but available for reviewers.

4.3.3 Uncertainties and Time-Series Consistency

For non-key categories, the NIR provides qualitative estimates of uncertainties only. The terms high, medium and low data quality are used and a quantitative relative uncertainty is assigned to every uncertainty category (see Table 1-14 Semi-quantitative uncertainties for non-key categories). The uncertainties for CO_2 and CH_4 in source category 2B are both estimated to be medium, resulting in a relative uncertainty of 10% for CO_2 and of 30% for CH_4. For N_2O emissions from 2B2 Nitric Acid Production which has been a key category in previous submissions the uncertainty was calculated to be 41%.

The time series is consistent.

4.3.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

In submission 2012 the N_2O emission factor of source category 2B2 Nitric Acid Production used in the Swiss Inventory was compared to the corresponding emission factors of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) and to the IPCC default value (INFRAS 2012). Switzerland's factor lies in the midfield of the other countries; see chpt. 4.3.2.2.

4.3.5 Source-Specific Recalculations

2B2 Nitric acid production: The EF values for NO_x have been revised for the entire time series based on measurement data of NO_x emissions for the years 2007, 2009 and 2012 from the production plant.

2B5 Acetic acid production: Based on information from the production plants the activity data has been revised from 1991-2011 (effective data from 2000 onwards and interpolated values 1991-1999). In addition also the EF values for CH_4, CO and NMVOC are revised and the one of CO_2 is newly introduced for the entire time series (except for NMVOC only from 2000-2011) based on measurement data from 2000 onwards.

2B5 Sulphuric acid production: The activity data has been updated for 2009-2011 based on corrected and new production data from the plant for 2009-2010 and 2011, respectively. The EF values for SO_2 have been revised for the entire time series based on new information from the producer for the years 2009-2012.

4.3.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

4.4 Source Category 2C – Metal Production

4.4.1 Source Category Description

Source category 2C Metal Production comprises process emissions from the production of iron and steel and aluminium, from the use of SF_6 in aluminium and magnesium foundries, as well as from battery recycling and non-ferrous metal foundries.

Table 4-20 Specification of source category 2C Metal Production. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

2C	Source	Specification	Data Source
2C1	Iron and Steel Production	Emissions of CO2, NOx, CO, NMVOC and SO2 from the production of iron and steel	AD, EF: EMIS 2014/2C1 Eisengiessereien Elektroschmelzofen/übriger Betrieb, EMIS 2014/2C1 Stahl-Produktion Elektroschmelzöfen/übriger Betrieb
2C2	Ferroalloys Production	Production is not occuring in Switzerland	
2C3	Aluminium Production	Emissions of PFC, CO2, NOx, CO, NMVOC and SO2 from the production of aluminium (ceased in 2006)	AD: EMIS 2014/2C3 Aluminium Produktion EF for PFC: Industry Data EF other gases: EMIS 2014/2C3 Aluminium Produktion
2C4	Use of SF_6 in Aluminium and Magnesium Foundries	Emissions from use of SF6 in aluminium and magnesium foundries	AD: Industry Data EF: IPCC 2006
2C5	Other	Emissions of CO2, NOx, CO and SO2 from battery recycling Emissions of CO and NMVOC from non-ferrous metal foundries	AD, EF: EMIS 2014/2C5e Batterie-Recycling, AD, EF: EMIS 2014/2C5e Buntmetallgiessereien Elektroöfen

4.4.2 Methodological Issues

4.4.2.1 Iron and Steel production (2C1)

There is no primary iron and steel production in Switzerland. Only secondary steel production occurs, which is steel production from recycled steel scrap. After closing down of two steel plants in 1994 there remain two plants in Switzerland. Both plants use electric arc furnaces (EAF) with a carbon electrode for melting the steel scrap. During the melting process CO_2 emissions occur mainly from scrap, electrodes and carburization coal. Indirect emissions such as NO_x, CO, NMVOC and SO_2 occur as well.

In Switzerland no production of pig iron occurs but iron is processed in foundries only. 14 iron foundries exist in Switzerland today. About 75% of the iron is processed in induction furnaces and 25% in cupola furnaces. From induction furnaces only indirect emissions occur. From cupola furnaces also CO_2 emissions occur. Those CO_2 emissions are accounted for in source category 1A2a.

Methodology

For determination of CO_2 emission from iron and steel production a mixture of a Tier 2 and a Tier 3 approach according to IPCC 2006 (chapter 4.2 *Iron & steel and metallurgical coke production)* is used since this year's submission. For the years 2005-2011 plant specific information is available (Tier 3). From this information data for the other years are interpolated for calculating an implied emission factor.

For steel production in Switzerland this results in the following formula:

$E_{CO2,\ non\text{-}energy} = EAF \bullet EF_{EAF}$

whereas EAF is the quantity of EAF crude steel produced in tonnes and EF_{EAF} the emission factor in tonnes CO_2/tonne steel produced. The same formula is also applied to calculate emissions of indirect greenhouse gases from iron and steel production. No CH_4 emissions occur in the Swiss EAF process.

Emission Factors

The emission factors for iron and steel production in Switzerland are country specific and base on measurement data from industry and expert estimates documented in EMIS 2014/2C1 Eisengiessereien Elektroschmelzofen/übriger Betrieb, EMIS 2014/2C1 Stahl-Produktion Elektroschmelzöfen and EMIS 2014/2C1 Stahlwerke Walzwerke.

For this year's submission the CO_2 emission factor was completely revised as new data from the two Swiss steel plants were available. For the calculations all carbon sources (graphite electrodes, steel scrap, alloy coal, etc.) and carbon sinks (steel, filter dust and slag) for the years 2005-2011 were taken into account. From these mass flows emission factors were calculated for both steel plants and weighted according to the production amount to yield overall CO_2 emission factors for Swiss steel industry for the entire time series, see Table 4-27 On average the revised values are about a factor of 16 (range: 12-21) lower than the ones used so far. The latter were based on measurements at the flue gas chimneys including emissions from gas burners which already are reported in source category 1A2a as well.

Table 4-21 CO_2 emission factor of electric arc furnaces in 2C1 Steel Production for the period 1990-2012 in kg/t (EMIS 2014/2C1 Stahl-Produktion Elektroschmelzöfen).

2C1 Steel production	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2	kg/t	8.3	8.2	8.1	8.1	8.1	8.0	8.0	7.8	7.5	7.5

2C1 Steel production	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2	kg/t	7.7	7.7	7.8	7.9	7.8	8.8	9.1	8.5	6.8	6.8

2C1 Steel production	Unit	2010	2011	2012
CO_2	kg/t	7.6	7.1	7.9

Table 4-22 Emission factors for NO_x, CO and NMVOC in iron production, for CO_2, NO_x, CO, NMVOC and SO_2 in steel production, for CO_2, NO_x, CO and SO_2 in battery recycling and for CO and NMVOC in non-ferrous metal production for 2012 (EMIS 2014/2C1 Eisengiessereien Elektroschmelzofen/übriger Betrieb, EMIS 2014/2C1 Stahl-Produktion Elektroschmelzöfen and EMIS 2014/2C1 Stahlwerke Walzwerke, EMIS 2014/2C5e Batterie-Recycling and 2014/2C5e Buntmetallgiessereien Elektroöfen).

2C Metal production	Unit	CO_2	NO_x	CO	NMVOC	SO_2
2C1 Iron	kg/t	NA	0.01	4.1	4.0	NA
2C1 Steel	kg/t	7.9	0.19	0.8	0.1	0.017
2C5 Battery recycling	kg/t	560	0.88	1.2	NA	0.01
2C5 Non-ferrous metals	kg/t	NA	NA	0.24	0.05	NA

Activity Data

Activity data on annual production of iron and steel is provided on a yearly basis by the Swiss production plants and the foundry association. Data is given in the following table:

Table 4-23 Production of iron, steel, aluminium and non-ferrous metals as well as amount of batteries recycled in Switzerland for the period 1990-2012 in Gg (EMIS 2014/2C1 Eisengiessereien Elektroschmelzofen/ übriger Betrieb, EMIS 2014/2C1 Stahl-Produktion Elektroschmelzöfen, EMIS 2014/2C3 Aluminium Produktion, EMIS 2014/2C5e Batterie-Recycling and 2014/2C5e Buntmetallgiessereien Elektroöfen).

2C Metal production	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2C1 Iron	Gg	170	140	136	110	115	130	111	114	123	122
2C1 Steel	Gg	1'108	1'155	1'245	1'276	1'230	716	738	789	880	918
2C3 Aluminium	Gg	87	82	75	36	24	21	27	27	32	34
2C5 Battery recycling	Gg	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
2C5 Non-ferrous metals	Gg	55	56	57	58	59	60	65	66	68	69

2C Metal production	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2C1 Iron	Gg	120	105	80	73	67	67	67	72	78	49
2C1 Steel	Gg	1'022	1'048	1'125	1'143	1'226	1'159	1'254	1'267	1'315	935
2C3 Aluminium	Gg	36	36	40	44	45	45	12	0	0	0
2C5 Battery recycling	Gg	3.0	3.0	3.0	2.9	3.3	2.8	2.4	2.4	2.5	3.4
2C5 Non-ferrous metals	Gg	70	60	49	43	38	33	30	28	21	15

2C Metal production	Unit	2010	2011	2012
2C1 Iron	Gg	53	61	46
2C1 Steel	Gg	1'218	1'322	1'252
2C3 Aluminium	Gg	0	0	0
2C5 Battery recycling	Gg	3.3	2.4	2.4
2C5 Non-ferrous metals	Gg	20	12	18

4.4.2.2 Aluminium Production (2C3)

Methodology

The last production site for aluminium in Switzerland closed down in April 2006. Both CO_2 and PFC emissions were based on a country specific approach. More specific for PFC emissions a Tier 3b approach according to 2000 IPCC good practice guidance (IPCC 2000) was used. Operating smelter emissions have been monitored periodically by the industry for selected years. The emissions were calculated by multiplying annual production by emission factors.

Emission Factors

The emission factor for CO_2 per ton of metal product is country specific. It is based on measurements and data from industry and expert estimates, documented in EMIS 2014/2C3 Aluminium Produktion. For CO_2 emissions from aluminium production, an emission factor of 1.6 ton CO_2 per ton of aluminium is used (EMIS 2014/2C3 Aluminium Produktion). This CO_2 stems from the oxidation of the anode in the electrolysis process. The value is based on an estimate of the amount of anode material used. In Switzerland only pre-backed anodes are used. The emissions for CO_2 are calculated with 0.43 tons of anode per ton of aluminium; it is assumed that the anode consists completely of carbon and that it is fully oxidized during the process (value from Swiss foundries, value for 1990, assumed to be constant over the time series).

For PFC emissions from aluminium production, operating smelter EF have been monitored periodically by the industry for selected years. The only Swiss factory provided own measurements for 1990, 1999 and 2000 yielding smaller EFs than the European average (by factors of 3.9, 4.7 and 5.1, respectively) (Alcan 2003). The comparison with these data and data from IAI (2005) on global PFC emissions from aluminium production showed that the emissions from the smelter in Switzerland are lower by a factor of about 4. This seems to be plausible because they used point feed prebake (PFPB) technology and it is known that this technology has the lowest emissions per tonne of aluminium. Therefore a “general reduction factor” of 4.0 for both PFC gases (CF_4 and C_2F_6) is adopted based on the average European values as reported from the European Aluminium Association (Alcan 2002) for the years with no measured emission data available. The resulting emission factors for Switzerland are still within the uncertainty range according to IPCC GPG 2000. In order to calculate the emissions factors for the years 2001 to 2006 — without any measurements in Switzerland — the data has been interpolated from the European data. E.g. for the year 2006 a value of 0.035 kgPFC/tAL, results with a European average emission factor of 0.14 kgPFC/tAL and a correction factor of 0.25. For the ratio of CF_4 to C_2F_6 a value of 90% to 10% is applied. As it was not possible to perform industry independent measurements, and because of the fact that aluminium production was closed in 2006 it is not possible to redo any measurements or to collect any information about the process details retroactively. The emission factors have decreased by a factor of about 4.9 between 1990 and 2006 due to technical efforts to reduce emissions (Alcan 2003).

The factors according to Table 4-24 are used. The large difference between the emission factors of the year 1999 and 2000 is based on measured data given by the company.

Table 4-24 PFC emissions factors for aluminium production in Switzerland. Aluminium production in Switzerland ceased in the year 2006. Data beyond 2009 is not presented (emissions are not ocurring).

Gas	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CF_4	kg/t	0.1530	0.1373	0.1215	0.1058	0.0900	0.0833	0.0765	0.0698	0.0630	0.0540
C_2F_6	kg/t	0.0170	0.0153	0.0135	0.0118	0.0100	0.0093	0.0085	0.0078	0.0070	0.0060

Gas	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CF_4	kg/t	0.0360	0.0360	0.0360	0.0360	0.0338	0.0315	0.0315	NO	NO	NO
C_2F_6	kg/t	0.0040	0.0040	0.0040	0.0040	0.0038	0.0035	0.0035	NO	NO	NO

Gas	Unit	2010	2011	2012
CF_4	kg/t	NO	NO	NO
C_2F_6	kg/t	NO	NO	NO

Activity Data

In 2006 the last production site of aluminium in Switzerland was closed. Activity data on aluminium production from 1997 to 2006 is based on annual data published by the Swiss Aluminium Association. For earlier years, the data was provided directly by the aluminium industry. Activity data for aluminium production in Switzerland is given in Table 4-23.

4.4.2.3 Use of SF_6 in Aluminium and Magnesium Foundries (2C4)

Methodology

SF_6 is used in aluminium and magnesium foundries in the cleaning process as inert gas to fill casting forms. The Swiss Foundry Association (GVS) has not provided information on emission factors and hence a Tier 1 based approach is used. The inventory data on SF_6 used in aluminium and magnesium foundries (2C4) is based on the total imported amount of SF_6 according to the import statistic. It is assumed that the total imported amount is emitted within one year. For the inventory of any particular year the mean value of the imports in the present and the previous year is used to account for possible time lag between import and consumption (e.g. for 2012 inventory the mean value of 2012 and 2013 import data is used).

Emission Factors

For SF_6 used in aluminium and magnesium foundries (2C4) it is assumed that the total imported amount is emitted (IPCC 2006, default emission factor of 1000 kg per ton of imported substance).

Activity Data

Activity data on SF_6 used in aluminium and magnesium foundries (2C4) is based on import data. For the activity data of any particular year the mean value of the imports in the present and the previous year is used to account for possible time lag between import and consumption (e.g. for 2012 the mean value of 2011 and 2012 import data is used). SF_6 is used in Swiss aluminium and magnesium foundries since 1997. There have been two magnesium foundries known to be using SF_6. In 2007 one of them closed down production which led to a reduction in activity data for magnesium foundries by 25% from 2007 to 2008. The remaining magnesium foundry reported activity data for 2008 to 2012 to the SWISSMEM statistics. The fact that only one magnesium foundry uses SF_6 was confirmed by a survey which has been carried out in 2011 within members of the Swiss Foundry Association (GVS). Use of SF_6 in Aluminium foundries is not occuring in 2012. The import amount for aluminium cleaning is extrapolated from an estimate value given in the year 2003 by an import company. Details on the imported amount are not available for later years. A steady decrease since 2003 is assumed for import of SF_6 used for aluminium cleaning. This assumption is based on the above mentioned survey and on information which was obtained on other applications within the category 'others' from FOEN import statistics which indicates that decreasing amounts of SF_6 are used for aluminum cleaning.

4.4.2.4 Other (2C5)

Battery recycling and non-ferrous metal foundries (2C5)

There is one plant recycling batteries in Switzerland. The recycling is done applying the Sumitomo process. The batteries are first pyrolised at temperatures of 700 °C in reducing atmosphere in a shaft kiln. The gas with the carbonised components then goes to a post-combustion step where it is completely oxidised at temperatures of 1000 °C. The flue gas is then led to flue gas cleaning. The metal fraction from the pyrolysis goes to a melting furnace where it is reduced by addition of coal and magnesium oxide. As reducing agent coke and Carburit is used.

In Switzerland there are one large and several small plants operating non-ferrous metal foundries. During the melting process emissions of CO and NMVOC occur.

Methodology

To determine emissions of CO_2, NO_x, CO and SO_2 from battery recycling and of CO and NMVOC from non-ferrous metal foundries, a country specific approach is used. The emissions are calculated by multiplying the annual amount of recycled batteries and produced non-ferrous metals by the corresponding emission factors.

Emission Factors

The emission factors of CO_2, NO_x, CO and SO_2 from battery recycling and of CO and NMVOC from non-ferrous metal foundries in Switzerland are country specific and base on measurements from industry and expert estimates documented in EMIS 2014/2C5e Batterie-Recycling and 2014/2C5e Buntmetallgiessereien Elektroöfen (see Table 4-22).

Activity Data

The annual amount of recycled batteries and produced non-ferrous metals in Switzerland is reported from industry and the foundry association as documented in EMIS 2014/2C5e Batterie-Recycling and 2014/2C5e Buntmetallgiessereien Elektroöfen (see Table 4-21).

4.4.3 Uncertainties and Time-Series Consistency

4.4.3.1 Uncertainty for key category 2C1 Iron and Steel Production

The uncertainty for CO_2 emissions in steel production amounts to 40.3 %. Production data of the steel industry has a high confidence and its uncertainty is estimated to 5% (EMIS 2014/2C1 Stahl-Produktion Elektroschmelzöfen). The uncertainty for the CO_2 emission factor is estimated to be 40% (EMIS 2014/2C1 Stahl-Produktion Elektroschmelzöfen).

4.4.3.2 Uncertainty for source category 2C4 Use of SF_6 in Aluminium and Magnesium Foundries

For the use of SF_6 in Aluminium and Magnesium Foundries, an uncertainty of 15% (with normal distribution) is assumed, which is a result of a Monte Carlo simulation of the emissions of F-gases (Carbotech 2014).

4.4.3.3 Qualitative estimate of uncertainties for non-key category 2C5 Other

For non-key categories, the NIR provides qualitative estimates of uncertainties. The terms high, medium and low data quality are used and a quantitative relative uncertainty is assigned to every uncertainty category (see Table 1-14, semi-quantitative uncertainties for non-key categories). The uncertainty for CO_2 emissions from source category 2C5 is estimated to be medium and thus amounts to 10%.

The time series is consistent.

4.4.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

In submission 2012 the CO_2 emission factor of source category 2C1 Steel Production used in the Swiss Inventory was compared with the corresponding emission factors of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) and the IPCC default value (INFRAS 2012). Switzerland’s factor lies in the lower end of the countries. This is due to the fact that in Switzerland only secondary steel making occurs; see chpt. 4.4.2.1.

For source category 2C4 Use of SF_6 in Aluminium and Magnesium Foundries the data received from SWISSMEM and import firms has been checked for double counting.

4.4.5 Source-Specific Recalculations

2C1 Iron foundries: The activity data has been revised due to corrected production shares of cupola and electric furnaces in iron foundries for 2010 and 2011. The EF value for NMVOC for 2012 has been updated resulting in revised interpolated values 1991-2011 as well.

2C1 Steel production: The EF values for CO_2 have been revised for the entire time series based on effective data of the carbon content of the consumed electrodes, the steel scrap and the alloying elements of the years 2005-2011 (emission reduction of about one order of magnitude).

2C5e Battery recycling: Activity data for 2011 has been revised due to corrected data from the plant operator.

4.4.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines..

4.5 Source Category 2D – Other Production

4.5.1 Source Category Description

Source category 2D Other Production comprises process emissions of indirect greenhouse gases from the production of pulp and paper including chipboard, fibreboard and cellulose, of food and drink as well as of charcoal. Biogenic CO_2 emissions from the production of beer, brandy, bread and wine within source category 2D2 Food and Drink are not reported. From this year's submission on charcoal production is no longer reported in source category 2D3 Wood Processing but in source category 1A1c (see section 3.2.6.2)[13)].

Table 4-25 Specification of source category 2D Other Production. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

2D	Source	Specification	Data Source
2D1	Pulp and Paper	Emissions from NMVOC from pulp and paper including chipboard, fibreboard and cellulose production (ceased in 2008)	AD, EF: EMIS 2014/2D1
2D2	Food and Drink	Emissions of CO and NMVOC from production of food and drink	AD, EF: EMIS 2014/2D2

4.5.2 Methodological Issues

4.5.2.1 Pulp and paper production (2D1)

Methodology

To determine NMVOC emissions from pulp and paper production a country specific approach is used. The emissions are calculated by multiplying the annual amount of processed pulp and paper by the corresponding emission factors. Please note that the cellulose production in Switzerland closed down in 2008.

[13] The CH_4 emissions from charcoal production have already been shifted to sector 1A1c in the NIR submission from September 2013 (FOEN 2013g).

Emission Factors

The emission factors for NMVOC emissions from pulp and paper production in Switzerland are country specific and base on measurements and data from industry and expert estimates documented in EMIS 2014/2D1.

Table 4-26 Emission factors for CO and NMVOC in pulp and paper production, food and drink production and charcoal production for 2012 (EMIS 2014/2D1, EMIS 2014/2D2 and EMIS 2014/2D3).

2D Other production	Unit	CO	NMVOC
2D1 Pulp and paper	g/t	NA	580
2D2 Food and drink (exc. beer, wine, spirits)	g/t	250	1'200
2D2 Food and drink (beer, wine, spirits)	g/m3	NA	360

Activity Data

The annual amount of pulp and paper produced in Switzerland bases on data from industry and expert estimates documented in EMIS 2014/2D1.

Table 4-27 Production of pulp and paper, food and drink and charcoal in Switzerland for the period 1990-2012 in Gg (EMIS 2014/2D1, EMIS 2014/2D2 and EMIS 2014/2D3).

2D Other production	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2D1 Pulp and paper	Gg	604	608	663	668	632	593	567	586	615	629
2D2 Food and drink (exc. beer, wine, spirits)	Gg	2'254	2'253	2110	2186	2092	2116	2240	2167	2177	2061
2D2 Food and drink (beer, wine, spirits)	m3	560'972	581'643	579'714	546'882	531'068	516'519	497'401	505'873	461'979	476'067

2D Other production	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2D1 Pulp and paper	Gg	641	640	645	634	652	660	696	752	728	514
2D2 Food and drink (exc. beer, wine, spirits)	Gg	2'301	2'083	2'276	2'246	2'153	2'138	2'167	2'344	2'370	2'467
2D2 Food and drink (beer, wine, spirits)	m3	492'208	481'114	466'112	461'071	475'754	452'877	451'924	462'141	479'293	465'753

2D Other production	Unit	2010	2011	2012
2D1 Pulp and paper	Gg	570	534	538
2D2 Food and drink (exc. beer, wine, spirits)	Gg	2'433	2'484	2'415
2D2 Food and drink (beer, wine, spirits)	m3	467'699	462'446	454'903

4.5.2.2 Food and drink production (2D2)

Methodology

To determine CO and NMVOC emissions from food and drink production a country specific approach is used. The emissions are calculated by multiplying the annual amount of produced food and drink by the corresponding emission factors.

Emission Factors

The emission factors for CO and NMVOC emissions from food and drink production in Switzerland are country specific and base on measurements and data from industry and expert estimates documented in EMIS 2014/2D2 (see Table 4-26).

Activity Data

The annual amount of food and drink produced in Switzerland base on data from industry, farmers'association and expert estimates documented in EMIS 2014/2D2 (see Table 4-27).

4.5.3 Uncertainties and Time-Series Consistency

The time series is consistent.

4.5.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

4.5.5 Source-Specific Recalculations

2D2 Food and Drink: Activity data of meat smokehouses has been updated for the years 2007-2011.

4.5.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

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

Tier 1 Key Category 2F1
HFC from the consumption of halocarbons and SF_6; Refrigeration and Air Conditioning Equipment (level and trend).

Tier 2 Key Category 2F1
HFC from the consumption of halocarbons and SF_6; Refrigeration and Air Conditioning Equipment (level and trend).

Tier 2 Key Categories 2F9
SF_6 from the consumption of halocarbons and SF_6; Other (level and trend).

HFC from the consumption of halocarbons and SF_6; Other (level and trend).

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

Table 4-28 Specification of source category 2F Consumption of Halocarbons and SF_6. Data source: Carbotech (2014).

2F	Source	Specification	Data Source
2F1	Refrigeration and Air Conditioning Equipment	Emissions from Refrigeration and Air Conditioning Equipment	AD: Various national statistics [1] and industry data EF: Industry data and expert estimates
2F2	Foam Blowing	Emissions from Foam Blowing, incl. Polyurethane Spray	AD: Industry data and import statistics EF: Expert estimates
2F3	Fire Extinguishers	Not occurring in Switzerland	-
2F4	Aerosol / Metered Dose Inhalers	Emissions from use as aerosols, incl. metered dose inhalers	AD: Import statistics EF: IPCC default values
2F5	Solvents	Emissions from use as solvents	AD: Import statistics EF: IPCC default values
2F6	Other applications using ODS substitutes	Not occurring in Switzerland	-
2F7	Semiconductor Manufacturing	Emissions from use in semiconductor manufacturing	AD: Import statistics and industry data[2] EF: IPCC default values and industry data
2F8	Electrical	Emissions from use in	AD: Industry data EF: Industry data
2F9	Other	Emissions of SF_6 which are not yet	AD: Import statistics and Industry data EF: Industry data and estimates

[1] e.g. statistics on registration of cars and trucks, import statistics on F-gases (Carbotech 2014).
[2] e.g. import amount of some substance for specific company with known application type.

The following graph shows emissions in source category 2F by sub-sector and by different groups of gases. Refrigeration and air conditioning equipment account by far for the highest emissions in this source category with a share of 80% of the total emissions in the source category 2F.

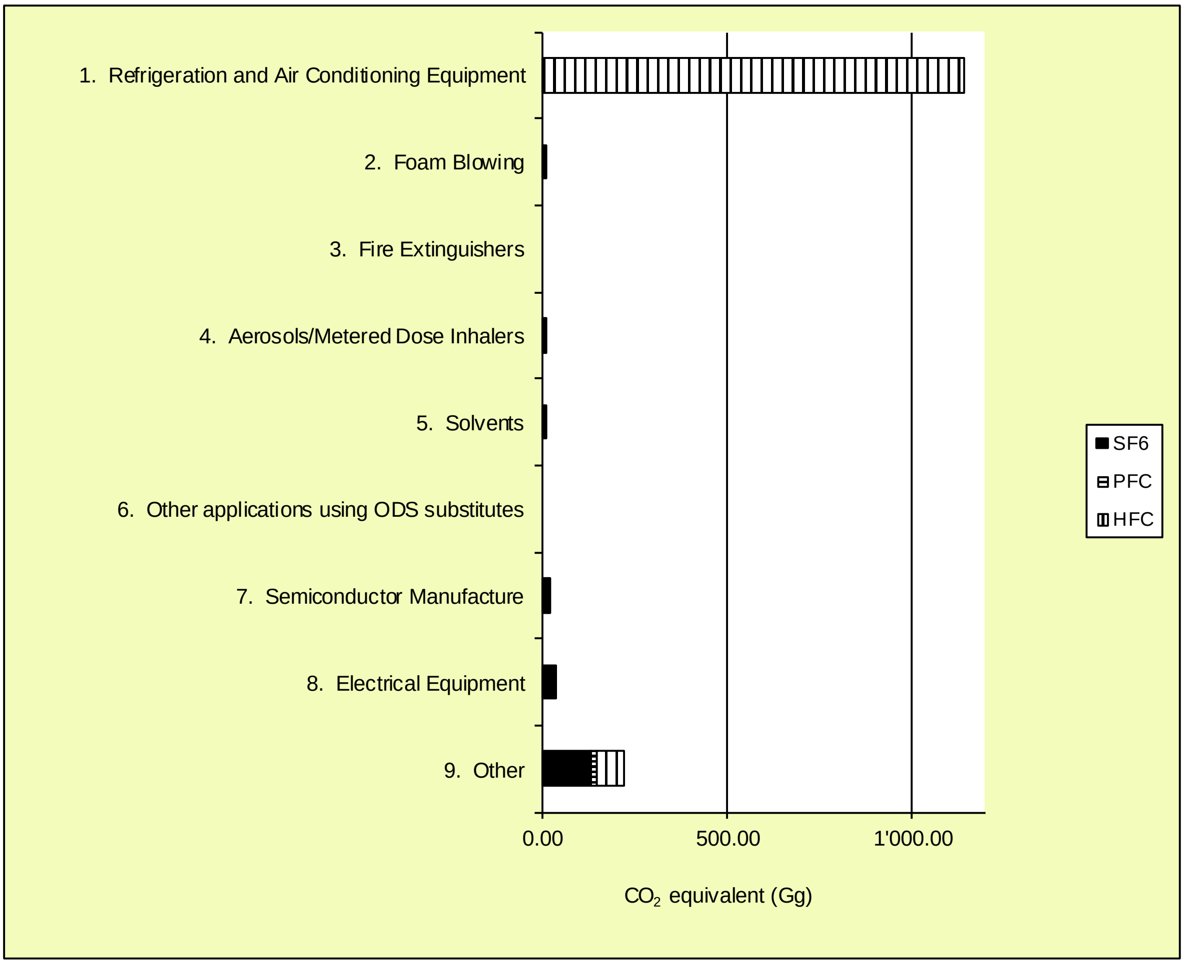

Figure 4-6 Distribution of emissions under source category 2F Consumption of Halocarbons and SF_6 (2012 data).

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 within the framework of the NIR. Annex A3.2 shows an illustrative example of the model structure and parameters used for calculating emissions from mobile air-conditioning in cars. Where possible, the most important assumptions for the data model are documented (e.g. Table 4-29). Detailed documentation of the individual data models is available from Carbotech (2014) as well as related background documents. This information is FOEN internal due to confidentiality of data, but is open for consultation by reviewers.

4.7.2.1 Refrigeration and Air Conditioning Equipment (2F1)

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.

The import data as reported to FOEN was adjusted for imported substances to be used in Liechtenstein. This is to eliminate double counting with the inventory data of Liechtenstein. Under source category 2F1 import data from the year 2008 onwards which is related to commercial and industrial refrigeration equipment are split between Switzerland and Liechtenstein. The split factor is based on the proportion of employees in the industrial and service sector (share of import for Liechtenstein < 1%). For other equipment types no scope for double counting with the inventory of Liechtenstein was identified and therefore no adjustment is required.

For the present submission also a number of minor improvements and corrections have been made to the model assumptions on emissions factors and activity data for source category 2F1. Further details can be seen from the section on recaclulations.

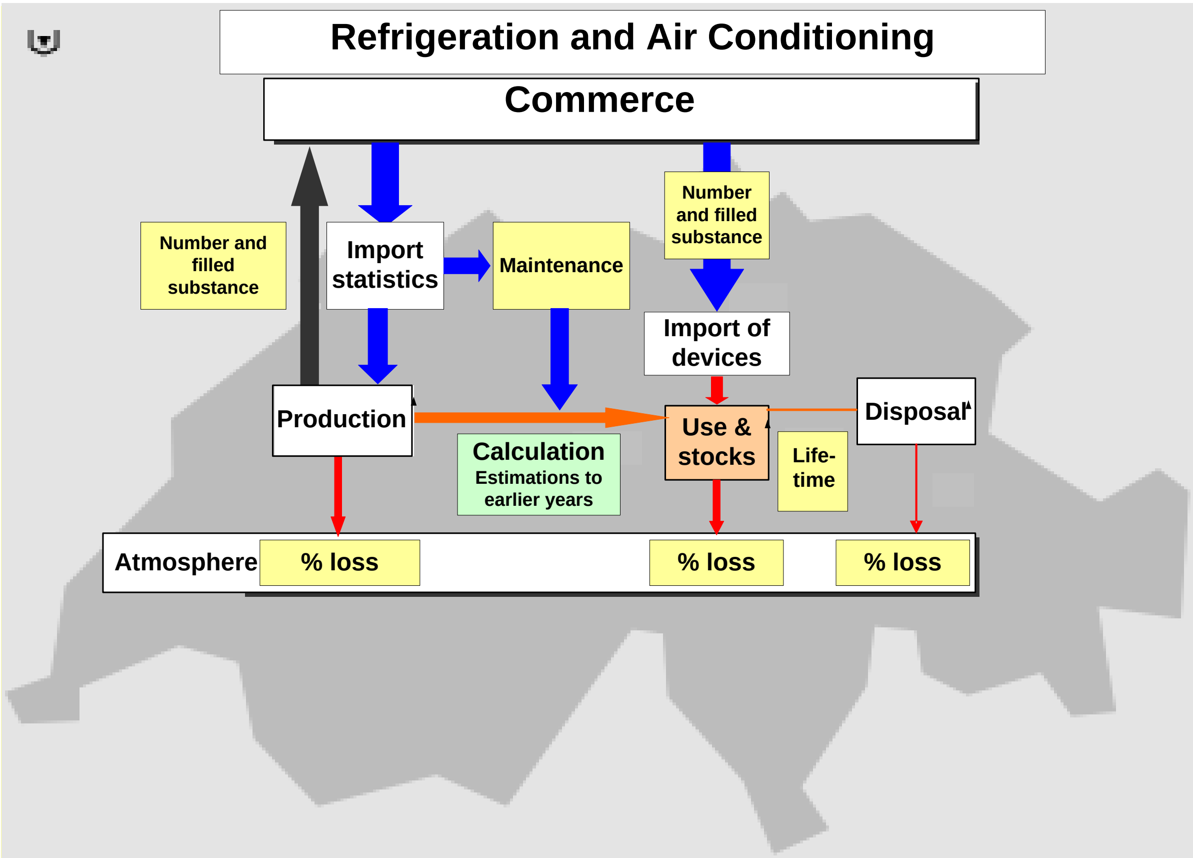

Figure 4-7: Required data for the model calculation of refrigeration and Air Conditioning in Switzerland

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 and literature. Direct monitoring of the product life emission factors is only done at company level (i.e. retailers such as Coop and Migros). The product life factors are used to make the allocation of imported F-gases to new products and maintenance activities.

In 2008 a revised ordinance on chemical risk reduction (Swiss Confederation 2005) was introduced. As part of this revision an obligation for operators handling equippment containing more than 3 kg HFCs was introduced to provide information to FOEN on the date of operation start, type of equipment, type and amount of refrigerant and date of dispoal. Today the statistics on equipment containing more than 3kg are comprehensive. However, these figures only cover about 50% to 70% of the Refrigeration and Air Conditioning Equipment reported under source category 2F1, since there are many types of equipment containing less than 3kg HFCs. Furthermore, there is no information available from the statistics regarding the emissions due to operation losses from the registered equipment. This data source provides valuable information to improve the estimates used for modelling emissions under source catogery 2F. However, it will not allow to directly draw the stock data or emission factors for the national inventory from this database in the near future.

Table 4-29 displays the detailed model parameters used for the present inventory. For product life emission factors of some equipment types a dynamic model is applied which implies that emission losses improve linearly between 1995 and 2012 (respectively 2020 for some equipment types) due to better production technologies and the continuous sensitisation of service technicians. The start/end values are based on expert statements, UBA (2005, 2007) and Schwarz (2001, 2005). The charge at end of life for different applications has been analysed considering the technical minimal charge of equipment and the expected frequency of maintenance (UBA/Ökorecherche 2012).

Table 4-29 Typical values on life time, charge and emission factors used in model calculations for Refrigeration and Air Conditioning Equipment. Data between 1995 and 2012 respectively 2020 is linearly interpolated.

Equipment type	Product life time	Initial charge of new product	Manufacturing emission factor	Product life emission factor	Charge at end of life [% of initial charge of new product] *)	Disposal loss emission factor
	[a]	[kg]	[% of initial charge]	[% per annum]		[% of remaining charge]
Domestic Refrigeration	16	0.1	NO	0.5	92	19 **)
Commercial and Industrial Refrigeration	10	NR	0.5	12 (2012: 7.2) (2020: 5)	87	20
Transport Refrigeration / Trucks	10	1.8-7.8 (various types)	1.5	15	86	20
Transport Refrigeration / Railway	16	NR	NO	10	100	20
Stationary Air Conditioning (direct / indirect cooling system)	15	NR	direct: 3 indirect: 1	direct: 10 (2010: 4) indirect: 6 (2010: 4)	85-90 (direct 89%, indirect 86%)	direct: 28 indirect: 19
Heat Pumps	15	(1999: 4.7-7.5) decreasing to (2010: 2.8-4.5)	3	2	86	20
Mobile Air Conditioning / Cars	15	0.7 (0.84) ***)	NO	8.5	58	50 ****)
Mobile Air Conditioning / Trucks	12	8.5	NO	10 until year 2000 decreasing to 8.35 in 2011	69	50 ****)
Mobile Air Conditioning / Buses	12	7.5	NO	10 until year 2010 8.5 for 2011 onwards	100	50 ****)
Mobile Air Conditioning / Railway	16	NR	NO	5.5	100	10

*) takes into account refill of losses during product life where applicable.

**) takes into account R134a content in foams, based on information from the national recycling organisation SENS.

***) Assumed constant since 2002. 0.84 kg in 1990. Linear interpolation between 1990 and 2002.

****) HFC disposal losses occur from 2003 onwards for Trucks/Buses resp. from 2006 for Cars (introduction of HFCs in MAC from 1991 only and 12 resp. 15 years lifetime). Value of 50% is based on UBA 2005 and expert assumptions on share of total refrigerant loss, e.g. due to road accident.

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

Activity Data

Activity data is taken from industry information and national statistics such as for admission of new cars and trucks. Stock data is modelled dynamically. Due to the large number of sub-models used for modelling the total emissions for sub-source category 2F1, no table on time series of activity data is provided here, despite 2F1 being a key category. For illustration, the detailed calculation model for car air-conditioning including the time series for the activity data for this particular sub-model can be seen from Annex A3.2. Mobile air-conditioning accounts for approx. 32% of the total emissions (CO_2 eq) of sub-source category 2F1 Refrigeration and Air Conditioning Equipment.

For the inventory report 2012 (FOEN 2012) a cross check has been performed for results from model calculation and FOEN statistics on disposal and recycling of HFCs. This has indicated a significant gap. Some of the gap is explained by the onsite reuse and recycling of refrigerants, which is not reflected by the FOEN statistics and with other factors as for example the not accounted export of refrigeration equipment (only export of vehicles with air-conditioning considered).

To avoid double counting with the inventory data of Liechtenstein, the activity data for the equipment type commercial and industrial refrigeration from the year 2008 onward is reduced by 0.9%, based on the share of imports of substances to be used in Liechtenstein. The reduction factor is based on the proportion of employees in the industrial and service sector in these two countries. For other equipment types no scope for double counting with the inventory of Liechtenstein was identified and therefore no correction factor is applied.

4.7.2.2 Foam Blowing (2F2)

Methodology

In Switzerland no production of open cell foam based on HFCs is reported by the industry. Therefore only closed cell PU and XPS foams, PU spray applications and sandwich elements are relevant under this source category.

The emission model (Tier 2) for foam blowing has been developed ‘top down’ based on import statistics for products, industry information and expert assumptions for market volumes and emission factors. Emissions for sandwich elements have been calculated as residual balance between SAEFL import statistics and consumption in PU spray, PU and XPS foams.

Emission Factors

For emission factors and lifetime of XPS and PU foam, expert estimates and general default values according to IPCC are being used (IPCC 2000: p. 3.95). For PU spray, expert estimates and specific default values according to IPCC are being used (IPCC 2000: p. 3.96).

Table 4-30 Typical values on life time, charge and emission factors used in model calculations for foam blowing.

	Product life time	**Charge of new product**	**Manufacturing emission factor**	**Product life emission factor**	**Charge at end of life**
	years	% of product weight	% of initial charge	% per annum	% charge of new product
PU foam	50	4.5	NR	NR	NR
XPS foam HFC 134a	50	6.5	NR	10 / 0.66**	100
HFC 152a				100 / 0**	100
PU spray	50	13.6 / 0 *	95	95 / 2.5 **	100
Sandwich Elements HFC 134a, HFC 227ea, HFC 365 mfc	50	NR	10	0.7	100
HFC 152a			100	0	100

* Data for 1990 / since 2009

** Data for 1st year / following years

NR Not relevant (PU foam: no substances according to this protocol have been used; XPS foam: emissions occur outside Switzerland; Sandwich elements: calculations are based on the remaining propellant import amount)..

Activity Data

HFCs have been used till 2008 in the Swiss production of PU spray. The export rate of PU spray from Swiss production is about 96.5% of total production volume. About one third of PU spray sold in Switzerland originates from local production, the rest is import. For PU rigid foams no HFCs are used as foam blowing agent (only Pentane and CO_2). From 2000 onwards until 2010 there is no production of XPS in Switzerland with HFC. XPS foams were 100% imported until 2010. In 2011 a new production facility was started which does not use HFCs. The HFC import not related to the main applications above has been allocated to the production of sandwich elements.

Detailed activity data for this sub-source category is available at FOEN but not reported due to confidentiality.

4.7.2.3 Fire Extinguishers (2F3)

No emissions occurring in this sector within Switzerland. The application of HFC, PFC and SF_6 in fire extinguishers is prohibited by law.

4.7.2.4 Aerosol / Metered Dose Inhalers (2F4)

Methodology

The Tier 2 emission model for Aerosol / MDI is based on a ‘top down’ approach using import statistics for HFCs.

Emission Factors

A manufacturing emission factor of 1% is applied. For product life emission factor the model assumes that 50% of the remaining substance is emitted in the first year and 50% in the second year respectively, which is in line with IPCC GPG. To account for variations in imports and stocks, the average figure from imports for the actual year (t) and for the past year (t-1) is reported. This emission model can lead to implied product life emission factors of > 100% in case of decreasing imports.

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. The export and import of filled products is unknown and assumed to be in a similar range. Detailed activity data for this sub-source category is available at FOEN but not reported due to confidentiality.

4.7.2.5 Solvents (2F5)

Methodology

HFC and PFC are used as solvents. Emissions are calculated according to Tier 1 method according to IPCC GPG on basis of a ‘top down’ approach using import statistics and industry information on allocation of the imported HFC and PFC amounts to different applications.

The import data as reported to FOEN was adjusted for imported substances to be used in Liechtenstein. This is to eliminate double counting with the inventory data of Liechtenstein. Under source category 2F5 import data from the year 2008 onwards are split between Switzerland and Liechtenstein. The split factor is based on the proportion of inhabitants.

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 source category is available at FOEN but not reported due to confidentiality. For the inventory report of the year 2011 (FOEN 2011) interviews were made with industry to get in-depth information on allocation of imported HFC and PFC volumes to different applications. This resulted that most PFC import declared as Solvents (2F5) or Other (2F9) until 2010 are related to the semiconductor manufacturing and thus the model for allocation of imported PFC volumes was adjusted accordingly. Since 2011 imports for semiconductors manufacturing and further etching process are registered separately.

To account for double counting with the inventory data of Liechtenstein, the import data reported to FOEN which is assigned to source category 2F5 in the inventory of Switzerland is adjusted by 0.5%. The adjustment factor is based on the proportion of inhabitants in these two countries.

4.7.2.6 Other applications using ODS substitutes (2F6)

No emissions occurring in this sector within Switzerland.

4.7.2.7 Semiconductor Manufacturing (2F7)

Methodology

A Tier 2 approach with process gas-specific parameters was used for emission calculations. General default values for gas-specific transformation rate and general values for exhaust treatment were applied.

Up to the inventory report 2010 (FOEN 2010), HFC, PFC and SF_6 emissions under 2F7 Semiconductor Manufacturing were calculated according to Tier 1 method according to IPCC GPG on basis of a 'top down' approach using import statistics. For the inventory report 2011 (FOEN 2011) interviews had been made with industry to get in-depth information on allocation of imported PFC volumes to different applications and to obtain process specific information from consumers. This resulted that until 2010 most PFC import declared as Solvents (2F5) or Other (2F9) are related to the semiconductor manufacturing and thus the model for allocation of imported PFC volumes was adjusted accordingly which leads to increased emissions under source category 2F7 Semiconductor Manufacturing. Since 2011 PFCs import declarations have been improved and information is provided for the source category 2F7 separately.

Emission Factors

Default emission factors as per IPCC GPG are used. Since the inventory report 2011 (FOEN 2012) the rate of exhaust treatment is assumed to be higher due to legislation under the Chemical Risk Reduction Ordinance (Swiss Confederation 2005) which limits emissions for industrial applications such as semiconductor manufacturing to 5%. For some large users the presence of exhaust treatment was confirmed in a survey.

Activity Data

Activity data is based on import statistics and industry information.

4.7.2.8 Electrical Equipment (2F8)

Methodology

Under an agreement with FOEN, the industry association SWISSMEM is reporting actual emissions of SF_6 on basis of a mass balance approach (Tier 3a). The balance includes mainly data for the production, installation, operation and disposal of electrical equipment, but included in past years also small amounts of SF_6 for other applications (i.e. research, magnesium foundry). SWISSMEM is collecting data from its members and is cross-checking the reported SF_6 consumption data with data from importers of the SF_6. Installations in operation with electrical equipment containing SF_6 are periodically inspected for leakage and losses are refilled (topping up). The refilled quantities and any SF_6 charge required for during repair are reported as emissions at the time of filling. A product lifetime of 35 years is applied.

Emission Factors

Emission factors for this sub-source category are based on industry information and are calculated values based on the mass balance data. For 2012 the calculated product life emission factor is 0.12%. The calculated product life emission factor is varying between 0.5%/a (2005) and 0.12%/a (2012). The discontinuity in emission factor from 2005 to 2006 data is partly due to the inspection intervals, optimised data collection system and technical optimisation of equipment. The continued trend for reduced emission factors can be linked to the existing agreement of SWISSMEM and FOEN on reduction of SF_6 emissions.

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 as well as variations in inspection intervals and equipment break-down requiring topping up of SF_6 charge in the equipment. Also for inventory report 2012 (FOEN 2012) the split factors for allocation of imported amounts to different applications were checked through industry interviews and in-depth analysis in order to eliminate double counting between SWISSMEM data and other import declarations.

4.7.2.9 Other (2F9)

Methodology

The emissions reported under 2F9 relate to a small amount of unallocated SF_6 from the FOEN import statistics and since 2003 to further applications of halocarbons such as laboratory and research use. In the past years an increasing amount of CF_4 and HFC 134a was registered to be used as trace gas, particularly in nuclear research. The unallocated difference for SF_6 between the FOEN import statistics and the SWISSMEM mass balance (see 2F8) have been assigned to cables and electrical control systems using a Tier 2 approach. Some imports of HFC 134a were declared for medical use, and small import amount of HFC 23 was declared for electronics and refrigeration technology.

Emission Factors

For the unallocated amount of SF6 assigned to cables and electrical control systems the manufacturing emission factor is assumed at 4% and the product life emission factor at 1%. 1% of the remaining charge is emitted at time of disposal after 40 years lifetime. Because of the long life time the disposal emissions are not relevant for the given results.

According to the IPCC guidelines (IPCC 2000) the emission factors for HFC 134a (medical and research use) and for HFC 23 (electronics and refrigeration technology) were chosen as 50% in the first year and 50% in the second year.

For the CF_4 and SF6 related to analytics, laboratory and research use a 50% lower emission factor was assumed considering a transformation and an exhaust treatment in some of the applications.

Activity Data

Activity data is based on import statistics and industry information. For the unallocated amount of SF6 assigned to cables and electrical control systems an export rate of 80% was assumed comparable to electrical equipment 2F8. Also for inventory report 2012 (FOEN 2012) the split factors for allocation of imported amounts to different applications was checked through industry interviews and in-depth analysis in order to eliminate double counting between SWISSMEM data and other import declarations. The quality check of import declarations and information obtained from import companies and SWISSMEM lead to a shift of SF_6 within different applications.

4.7.3 Uncertainties and Time-Series Consistency

For refrigeration equipment, air-conditioning equipment as well as for the foam blowing source category, a Monte Carlo analysis according to IPCC Good Practice Guidance for the evaluation of uncertainties of model calculations according to Tier 2 has been carried out. The Monte Carlo Analysis was performed on the inventory data of the current GHG inventory (submission April 2014). For the purpose of the Monte Carlo Analysis, uncertainty of all relevant parameters (e.g. initial appliance charge, product life emission factor, import and export volumes, etc.) used in the emission models for the applications as per Table 4-31 below has been characterised by a statistical distribution. Frequently a triangular distribution was chosen, defined by the three parameters: minimum, maximum and most likely value. Some uniform distributions were chosen where the spectrum was assumed to have the same probability. In the other cases normal or lognormal distribution has been chosen. The analysis was carried out with 10’000 cycles. Some details on the distributions of parameters used (i.e. type of distribution, minimum, maximum, likeliest value) are documented in the report Carbotech (2014).

For the submission of 12 April 2006 the uncertainty for the import statistic data had been estimated for the first time. Discussions with the persons responsible for data collection in the years 1997–2012 led to the estimations given in Table 4-31.

Table 4-31 Estimated uncertainty for the data of the imported substances

Year	Minimal	Maximal	Remarks
Up to 1999	-10%	30%	Assumed that the data is not complete
2000 – 2003	-10%	15%	Data can be incomplete or possible double declaration
2004 – 2012	-10%	10%	Data can be incomplete or possible double declaration

The following table summarises the results for the application-specific emission models. The “value 2012” represents the actual emissions in Gg CO_2 equivalent for the specific application as used for calculating the 2012 CRF-tables. The average, median, uncertainty, minimum and maximum values are output values of the Monte Carlo Analysis. The uncertainty of the resulting total emissions from the consumption of halocarbons and SF_6 is about 10.4%. Higher values result for the contributions of single applications.

Uncertainties of more than 20% have been calculated for the following applications:

- Sationary Airconditioning
- Transport Refrigeration
- Domestic Refrigeration
- Foam Blowing
- Aerosols
- Solvents
- Semiconductors
- Others

Uncertainties of 15% to 20% have been calculated for the following applications:

- Mobile Airconditioning

- Commercial and Industrial refrigeration

Low uncertainties of less than 15% have been calculated for the following applications:.

- Electric Equipment

For the model calculations of stocks, uncertainties result with a maximum of 35.2% for R134a in PU/XPS Foam Blowing. For the model calculations of stocks in domestic refrigeration no uncertainties value is given due to very asymmetric distribution. Calculation of stocks is not reported in detail here because the uncertainties for stock and new filled refrigerant related to the split of refrigerant on different applications is of less relevance for the overall emissions. This is because different applications show similar characteristics for the building of stocks and related emissions. Detailed data is available with FOEN.

Relevant parameters for the building of stock in PU-foam are the PU-foam import and export rate and the PU-Spray first year emission factor. The data base for PU-Sprays has been significantly improved with effect from the 2007 submission (FOEN 2007). This is attributed to improved models which are elaborated by the main producer and its blowing agent import firm. However, the following three factors lead to a small amount remaining in the stock with a relative high uncertainty: high import and export rate of PU-Spray, incompleteness of information on import volumes of PU-Spray and about propellant used in import products and finally high emission factor of the first year.

Table 4-32 Summary of results for model parameter “emissions” from Monte Carlo Analysis for 2012 data on selected emission sources.

Application	Model para-meter	Value 2012 Gg CO2 eq.	Average Gg CO2 eq.	Median Gg CO2 eq.	min. Gg CO2 eq.	max. Gg CO2 eq.	Uncer-tainty %
2F1 Refrigeration and Airconditioning	Emissions in Gg CO2 eq.	1142	1165	1163	943	1770	11.2
- Commercial / Industrial Refrigeration		602	621	618	422	852	19.4
- Mobile Air-Conditioning		366	340	356	264	474	20
- Stationary Air-Conditioning		134	149	149	100	679	25
- Transport Conditioning		25.1	28.7	28.5	18.7	44.8	25
- Domestic Refrigeration		15.5	8.7	6.7	0.2	35.9	*)
2F2 Foam Blowing		14.5 **)	16.7	16.4	7.1	37.8	43.2
2F4 Aerosol		13.2	13.3	13.3	5	23	41
2F5 Solvents		11.9	12	12	8.8	15.9	23.2
2F7 Semiconductors		26	27.5	27.4	9.9	45.5	39.2
2F8 Electrical equipment		36.8	36.8	36.8	27	46	14.4
2F9 Other		212	190	206	113	282	41.6
Total HFC, PFC and SF_6 from 2F		1470	1473	1473	1174	2037	10.4

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

**) incl. HFC 365mfc

The time series is consistent for all source categories, with exception of the sub-source category Electrical Equipment (2F8) where from 2000 onwards the data is based on a Tier 3a approach instead of model calculations according to Tier 2 as applied for data before 2000. Due to lack of basic information it is not possible to provide a consistent time series for category Electrical Equipment (2F8) retroactively.

4.7.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables.
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013.

- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013.

Recalculations were identified and explained. Detailed controls of all modelling results produced by Carbotech (2014) have been carried out firstly by FOEN specialists and secondly by the author for the NIR chapters containing F-gases.

The assumption of decreasing emissions factors for the different equipment types under sub-source category 2F1 Refrigeration and Air Conditioning Equipment have been cross-checked with the inventories of Austria and Germany and have found to be in line with the assumptions made for these inventories.

The emission factor of category 2F used in the Swiss Inventory has been compared to the corresponding emission factors of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) and to the IPCC default value if available (INFRAS 2012). Concerning the consumption of halocarbons and SF_6 the following sources of emissions are deemed relevant: HFC-125, HFC-134a and HFC-143a from stationary and commercial refrigeration as well as mobile air-conditioning. The product life factor is relevant, since there is no production of neither halocarbons or SF_6 in Switzerland. For all these sources Switzerland's emission factors lie in the midfield of the other countries except for the life factor in mobile air-conditioning. However when compared to neighbouring countries such as Germany, very similar values are used. The Swiss product life factors are often lower than the average for the following reasons. Since 2005 the ordinance on Chemical Risk Reduction (Swiss Confederation 2005) is in place that ensures the proper handling and disposal of halocarbons and SF_6. Furthermore the decommissioning sector is well organized by the SENS foundation and recycling is taxed in advance. Finally servicing staff is well trained to proper handling and disposal of respective appliances.

The FOEN supports a monitoring campaign at the high altitude research station Jungfraujoch, where various greenhouse gases are measured continuously. The location of the research station normally provides for analysis of tropospheric background concentrations. However, under special meteorological conditions, an estimate of Swiss emissions can be derived from the measurements. For HFC-134a, HFC-125, HFC-152a HFC-143a and HFC-32, a comparison of the inventory data with the inferred emissions is presented in Annex A6.1.

Special effort was undertaken to verify the underlying reasons for the discontinuity in emission factor of SF_6 in source category 2F8 Electrical equipment from 2005 to 2006 data. It however was not possible to find new supporting facts. With the change of personell at the data supplier SWISSMEM the basis for historical in-depth investigations has ceased.

4.7.5 Source-Specific Recalculations

In the data files used for calculating the emissions from Mobile Air-Conditioning / Buses in source category 2F1 an error has been discovered. Accordingly all emissions in Submission 2013 related to the equipment type Mobile Air-Conditioning / Buses were not taken into account in the total figure for emissions under source category 2F1. The emissions from mobile air-conditioning have been recalculated now, including emissions from buses. The recalculation results in additional emissions of HFC 134a of the order of 25-28 Gg CO_2eq per year for the years 2008-2011.

Further Source-specific recalculations for the time series 1990 to 2011 are summarized in Table 4-33. The different improvements carried out in the present inventory are related to the sub-source categories with the highest emissions.

The recalculation of the emissions 2011 delivers about 3.8% higher total emissions under source category 2F than reported in the previous submission.

Table 4-33 Summary of recalculations in source category 2F.

NFR code	Sector/ Process	AD/EF	Year	Gas	Specification
2 IIA F 1 (all sources)	Refrigeration and Air-Conditioning	AD	1991-2011	HFC 32 HFC 125 HFC 134a HFC 143a HFC 152a PFC 218 HFC23	Improvement of model calculations of stock. Recharge of equipment considering minimal technical charge and related frequency of service (resulting average charge between initial charge and minimal technical charge). The improvement has an impact on the calculation of stocks, emissions from stock and on the required in bulk refrigerant used in different applications (calculation of remaining in bulk refrigerant for industrial/commercial refrigeration)
2 IIA F 1 6	Refrigeration: Mobile Air-conditioning	AD/EF	1991-2011	HFC 134a	Bus air-conditioning added to the calculation of mobile air-conditioning (related evaluations delivered for review process)
2 IIA F 1 3	Transport refrigeration	AD	2000-2011	HFC 125 HFC 134a HFC 143a PFKW 218 (=C3F8)	Export of retiring equipment included in model calculations of trucks, lifetime of railway elevated (so far first HFC containing equipment still in use)
2 F 4	Aerosols	AD/EF	1998-2012	HFC 134a HFC 152a	Use of spray products not considering the earlier aerosol loss of production (1% double counting of aerosol emissions).

4.7.6 Source-Specific Planned Improvements

Gradual improvement of the data quality in co-operation with industry is on-going. As in the past years, methodologies and emission models will be updated during the yearly process of F-gas inquiry. The focus will be on improvements of HFC-emission calculations from refrigeration and air-conditioning equipment.

4.8 Source Category 2G – Other

4.8.1 Source Category Description

Source category 2G Other comprises process emissions from blasting and shooting and Claus units in refineries.

Table 4-34 Specification of source category 2G Other. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

2G	Source	Specification	Data Source
2G	Other	Emissions of CO2, NOx, CO, NMVOC and SO2 from blasting and shooting Emissions of SO2 from Claus units in refineries	AD, EF: EMIS 2014/2G Sprengen und Schiessen AD, EF: SFOE 2013, expert estimates

4.8.2 Methodological Issues

Blasting and shooting and Claus units in refineries (2G)

Methodology

For determination of emissions of CO_2, NO_x, CO, NMVOC and SO_2 from blasting and shooting a country specific method is used as documented in EMIS 2014/2G Sprengen und Schiessen. The emissions are calculated by multiplying the annual amount of used explosive by the corresponding emission factors. The SO_2 emissions from Claus units are calculated by multiplying the annual amount of processed crude oil by the emission factor.

Emission Factors

The emission factors for CO_2, NO_x, CO, NMVOC and SO_2 from blasting and shooting activities in Switzerland and for SO_2 emissions from Claus units in refineries are country specific and base on measurements and data from industry and expert estimates documented in EMIS 2014/2G Sprengen und Schiessen.

Table 4-35 Emission factors for CO_2, NO_x, CO, NMVOC and SO_2 from blasting and shooting and SO_2 from Claus units in refineries for 2012 (EMIS 2014/2G Sprengen und Schiessen).

2G Other	Unit	CO_2	NO_x	CO	NMVOC	SO_2
Blasting and shooting	kg/t	400	35	310	60	0.5
Claus units in refineries	g/t	NA	NA	NA	NA	38

Activity Data

The annual amount of used explosives and of processed crude oil in Clause units base on the Federal statistics on explosives as documented in EMIS 2014/2G Sprengen und Schiessen and the Swiss overall energy statistics (SFOE 2013), respectively.

Table 4-36 Amount of used explosives and processed crude oil in Switzerland for the period 1990-2012 in Gg (EMIS 2014/2G Sprengen und Schiessen and SFOE 2013).

2G Other	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Blasting and shooting											
blasting agent and powder	Gg	2.6	2.3	2.1	1.8	1.6	1.3	0.5	0.8	1.1	1.6
Claus units in refineries											
crude oil	Gg	3'127	4'671	4'317	4'764	4'880	4'657	5'289	4'830	5'070	5'093

2G Other	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Blasting and shooting											
blasting agent and powder	Gg	1.9	2.0	3.3	4.1	3.6	0.8	1.5	1.1	1.4	2.1
Claus units in refineries											
crude oil	Gg	4'649	4'846	4'848	4'567	5'146	4'810	5'497	4'662	5'067	4'778

2G Other	Unit	2010	2011	2012
Blasting and shooting				
blasting agent and powder	Gg	2.4	2.9	2.3
Claus units in refineries				
crude oil	Gg	4'491	4'402	3'409

4.8.3 Uncertainties and Time-Series Consistency

For non-key categories, the NIR provides qualitative estimates of uncertainties. The terms high, medium and low data quality are used and a quantitative relative uncertainty is assigned to every uncertainty category (see Table 1-14, semi-quantitative uncertainties for non-key categories). The uncertainty for CO_2 emissions from 2G is rated medium and thus amounts to 10%.

The time series is consistent.

4.8.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables

- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

4.8.5 Source-Specific Recalculations

2G Claus units in refineries: Activity data of the years 1990–1997 has been revised due to recalculations in the Swiss overall energy statistics.

4.8.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

5 Solvent and Other Product Use

5.1 Overview

This chapter provides information on the calculation of the greenhouse gas emissions from solvent and other product use. The emissions contain NMVOC emissions from the use of solvents in different applications. Also, it includes direct CO_2 emissions resulting from post-combustion of NMVOC to reduce NMVOC in exhaust gases and indirect CO_2 emissions due to decomposition of NMVOC in the atmosphere. Further included are emissions of CO_2, NO_x, CO and SO_2 arising from the use of firework and N_2O emissions from medical and private use.

Emissions of biogenic CO_2 from the use of tobacco products are not reported. The disposal of solvents is reported in the waste sector (Chapter 8). Emissions from the use of halocarbons and sulphur hexafluoride are reported in the Industrial Processes Chapter under 2F.

Tier 1 Key category 3
CO_2 emissions from Solvent and Other Product Use (trend).

Tier 2 Key category 3
CO_2 emissions from Solvent and Other Product Use (trend).
N_2O emissions from Solvent and Other Product Use (trend).

5.1.1 Emissions of CO_2 and N_2O

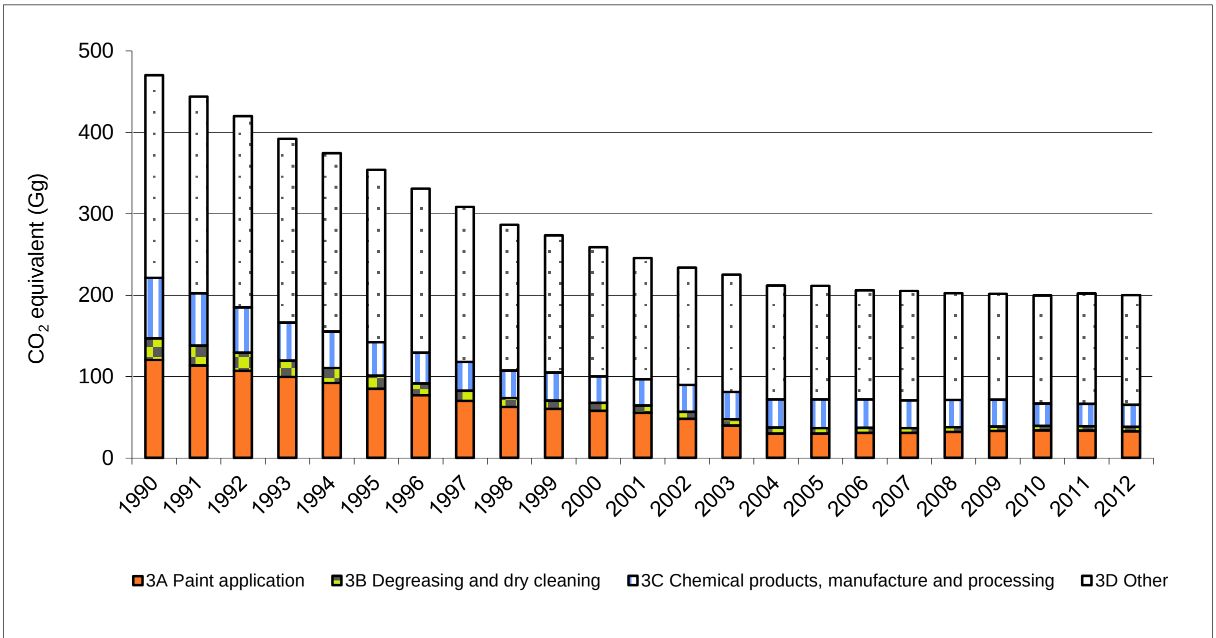

Figure 5-1 Switzerland's GHG emissions of sector 3 Solvent and Other Product Use 1990-2012 in Gg CO_2 eq.

In 2012 200 Gg of CO_2 eq emissions were released from sector 3 Solvent and Other Product Use as shown in Figure 5-1 and Table 5-1. This is a decline of 57.5% between 1990 and 2012. Source category 3D Other remains the dominant source within sector 3 Solvent and Other Product Use although its emissions have decreased by 45.8% since 1990. Source category 3A Paint Application has decreased by 73.0% since 1990, source category 3B Degreasing and Dry Cleaning has decreased by 80.3% and source category 3C Chemical Products has decreased by 63.2%.

Table 5-1 Emissions of sector 3 Solvent and Other Product Use 1990-2012 in Gg CO_2 eq.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	360	338	318	295	283	267	250	233	216	209
N_2O	110	106	101	96	92	86	81	75	70	65
Sum	470	444	420	392	374	354	331	308	286	273

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (Gg)									
CO_2	200	191	181	172	160	159	157	158	156	157
N_2O	59	54	52	53	51	52	49	47	46	45
Sum	259	245	234	225	212	211	206	205	202	201

Gas	2010	2011	2012
	CO_2 eq. (Gg)		
CO_2	153	158	155
N_2O	46	44	45
Sum	199	202	200

The relative trends of the emissions of CO_2 and N_2O are shown in Figure 5-2. The base year 1990 represents 100%.

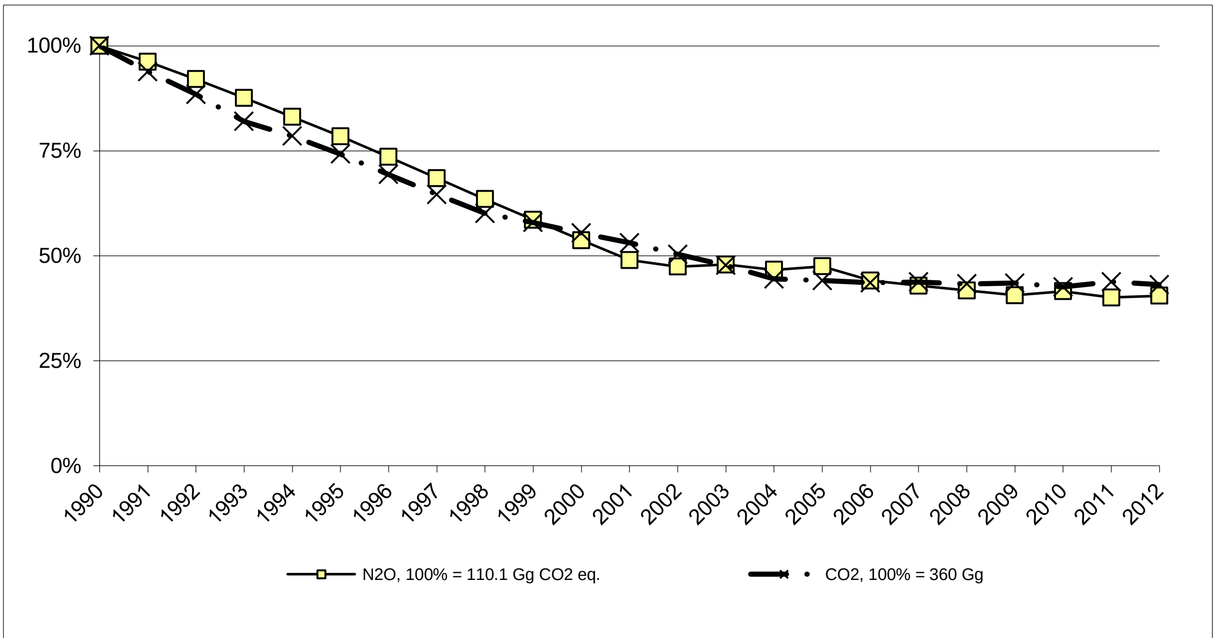

Figure 5-2 Relative trends of the greenhouse gases of sector 3 Solvent and Other Product Use in the period 1990-2012.

5.1.2 Emissions of NMVOC

Due to the importance of NMVOC emissions in sector 3 Solvent and Other Product Use they are given separately in Table 5-2.

Table 5-2 Emissions of NMVOC in sector 3 Solvent and Other Product Use 1990-2012 in Gg.

NMVOC	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Gg									
3A Paint application	54	51	47	44	40	37	34	30	27	26
3B Degreasing and dry cleaning	12	11	10	9	8	7	7	6	5	5
3C Chemical products, manufacture and processing	28	23	18	13	12	11	9	8	7	6
3D Other	60	57	55	52	49	46	43	41	38	35
Sum	155	142	130	118	110	101	92	84	76	72

NMVOC	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	Gg									
3A Paint application	25	23	20	16	12	12	12	12	12	13
3B Degreasing and dry cleaning	4	4	4	4	3	3	3	3	3	2
3C Chemical products, manufacture and processing	6	5	5	5	4	4	4	4	4	4
3D Other	32	29	28	27	26	25	24	24	24	24
Sum	67	62	57	51	45	44	43	43	43	43

NMVOC	2010	2011	2012
	Gg		
3A Paint application	13	13	12
3B Degreasing and dry cleaning	2	2	2
3C Chemical products, manufacture and processing	4	4	4
3D Other	24	24	25
Sum	44	44	43

NMVOC emissions have decreased by 72.0 % between 1990 and 2012. This is mainly due to two reduction efforts: The introduction of NMVOC emission limit values by the ordinance on Air Pollution Control (Swiss Confederation 1985) and the introduction of the VOC-tax in 2000 (Swiss Confederation 1997).

5.2 Source Category 3A – Paint Application

5.2.1 Source Category Description

Source category 3A Paint Application comprises NMVOC emissions from paints, lacquers, thinners and related materials used in coatings in industrial, commercial and household applications. Also, it includes indirect CO_2 emissions due to decomposition of NMVOC in the atmosphere and direct CO_2 emissions resulting from post-combustion of NMVOC in exhaust gases.

Table 5-3 Specification of source category 3A Paint Application. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

	Source	Specification	Data Source
3A	Paint Application	Emissions of CO2 and NMVOC from paint application in households, industry and construction	AD, EF: EMIS 2014/3A1, 3A2 and 3A3

5.2.2 Methodological Issues

Methodology

For determination of NMVOC emissions from paint application a country specific method based on the consumption of paint and its solvent content is used. Switzerland's Informative Inventory Report 2014 contains a description of the country-specific methods used for estimating the NMVOC emissions from the most important sources within source category 3A (FOEN 2014e, section 5.2.2).

The indirect CO_2 emissions due to decomposition of NMVOC in the atmosphere are calculated using a carbon content fraction of 0.6 according to the 2006 IPCC Guidelines (IPCC 2006).

Also, several industrial plants use facilities and equipment to reduce NMVOC in exhaust gases and room ventilation output. Often, this implies the feeding of air with high NMVOC content into the burning chamber of boilers or other facilities to incinerate NMVOC. This post-combustion of NMVOC leads to additional direct CO_2 emissions. They are estimated based on industry data and expert estimates.

Emission Factors

Emission factors for NMVOC emissions base on data from the Swiss association for coating and paint applications (VSLF) and from relevant retailers (source category 3A1 Paint Applications in Households), documented in the EMIS database (EMIS 2014/3A).

For paint application in construction, which is the most important NMVOC source in 3A Paint Application, the emission factor amounts to 59 kg NMVOC per ton of paint in 2012 (EMIS 2014/3A1 Farben-Anwendung Bau).

The emission factor for indirect CO_2 emissions from decomposition of NMVOC in the atmosphere is 2.2 Gg CO_2/Gg NMVOC (carbon content fraction * molecular weight of carbon dioxide / molecular weight of carbon).

Activity Data

Activity data corresponds to the annual consumption of paints. Data on paint consumption is taken from the Swiss association for coating and paint applications (VSLF) and from relevant retailers (source category 3A1 Paint Applications in Households), documented in the EMIS database (EMIS 2014/3A).

For paint application in construction, which is the most important NMVOC source in source category 3A Paint Application, the activity data equals the consumption of 54'000 t paint in 2012 (EMIS 2014/3A1 Farben-Anwendung Bau).

5.2.3 Uncertainties and Time-Series Consistency

The uncertainty of total CO_2 emissions from the entire source category Solvent and Other Product Use is estimated to be 50% (expert estimate).

Time series is consistent.

5.2.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

5.2.5 Source-Specific Recalculations

3A1 Paint applications in households: Activity data has been revised due to updated projection for 2015. This has led to a revision of the AD for 2011.

5.2.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

5.3 Source Category 3B – Degreasing and Dry Cleaning

5.3.1 Source Category Description

Source category 3B Degreasing and Dry Cleaning comprises NMVOC emissions from degreasing, dry cleaning and cleaning in electronic industry. Also, it includes indirect CO_2 emissions due to decomposition of NMVOC in the atmosphere and direct CO_2 emissions resulting from post-combustion of NMVOC in exhaust gases.

Table 5-4 Specification of source category 3B Degreasing and Dry Cleaning. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

	Source	Specification	Data Source
3B	Degreasing and Dry Cleaning	Emissions of CO2 and NMVOC from degreasing; dry cleaning; cleaning of electronic components; cleaning of parts in metal processing; other industrial cleaning	AD, EF: EMIS 2014/3B1 and 3B2

5.3.2 Methodological Issues

Methodology

For determination of NMVOC emissions from degreasing and dry cleaning a country specific method based on the consumption of solvents is used. Switzerland's Informative Inventory Report 2014 contains a description of the country-specific methods used for estimating the NMVOC emissions from the most important sources within source category 3B (FOEN 2014e, section 5.3.2).

The indirect CO_2 emissions due to decomposition of NMVOC in the atmosphere are calculated using a carbon content fraction of 0.6 according to the 2006 IPCC Guidelines (IPCC 2006).

The direct CO_2 emissions resulting from post-combustion of NMVOC in exhaust gases is estimated based on industry data and expert estimates.

Emission Factors

Emission factors for NMVOC emissions are based on data from Swiss industry and expert estimates, documented in the EMIS database (EMIS 2014/3B).

For degreasing of metal, which is the most important NMVOC source in source category 3B Degreasing and Dry Cleaning, the emission factor amounts to 550 kg NMVOC per ton of solvent in 2012 (EMIS 2014/3B1 Metallreinigung).

The emission factor for indirect CO_2 emissions from decomposition of NMVOC in the atmosphere is 2.2 Gg CO_2/Gg NMVOC (carbon content fraction * molecular weight of carbon dioxide / molecular weight of carbon).

Activity Data

Activity data corresponds to the annual consumption of solvents for degreasing and dry cleaning. Data bases on industry data and expert estimates, documented in the EMIS database (EMIS 2014/3B).

For degreasing of metal, which is the most important NMVOC source in source category 3B Degreasing and Dry Cleaning, the activity data equals to 2'272 t solvent in 2012 (EMIS 2014/3B1 Metallreinigung).

5.3.3 Uncertainties and Time-Series Consistency

The uncertainty of total CO_2 emissions from the entire source category 3 Solvent and Other Product Use is estimated to be 50% (expert estimate).

The time series is consistent.

5.3.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

5.3.5 Source-Specific Recalculations

3B2 Dry cleaning: Activity data and EF value have been updated for 2012 resulting as well in revised interpolated values for 2007-2011 and 1991-2011, respectively.

5.3.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

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

5.4.1 Source Category Description

Source category 3C Chemical Products, Manufacture and Processing comprises NMVOC emissions from manufacturing and processing chemical products. Also, it includes indirect CO_2 emissions due to decomposition of NMVOC in the atmosphere and direct CO_2 emissions resulting from post-combustion of NMVOC in exhaust gases.

Table 5-5 Specification of source category 3C Chemical Products, Manufacture and Processing. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

	Source	Specification	Data Source
3C	Chemical Products, Manufacture and Processing	Emissions of CO2 and NMVOC from handling and storage of solvents; fine chemical production; production of pharmaceuticals; manufacturing of paint, inks, glues, adhesive tape, rubber; processing of PVC, polystyrene foam, polyurethane and polyester	AD, EF: EMIS 2014/3C

5.4.2 Methodological Issues

Methodology

For determination of NMVOC emissions from chemical products, manufacture and processing a country specific method is used. The emissions from fine chemical and pharmaceutical production are based on production data and expert estimates. The emissions of handling and storage of solvents are calculated based on the imported quantities. The emissions from manufacturing paint, glues, inks, adhesive tape, rubber and polyurethane as well as the processing of PVC are calculated based on production data. The emissions from processing of polystyrene foam and polyester are calculated based on consumption data. Switzerland's Informative Inventory Report 2014 contains a description of the country-specific methods used for estimating the NMVOC emissions from the most important sources within source category 3C (FOEN 2014e, section 5.4.2).

The indirect CO_2 emissions due to decomposition of NMVOC in the atmosphere are calculated using a carbon content fraction of 0.6 according to the 2006 IPCC Guidelines (IPCC 2006).

Direct CO_2 emissions result from post-combustion of NMVOC. Those emissions are estimated based on industry data and expert estimates.

Emission Factors

Emission factors for NMVOC emissions are based on data from Swiss industry, industry associations and expert estimates, documented in the EMIS database (EMIS 2014/3C). Emission factors for handling and storage of solvents are estimated according to the solvent vapour pressure.

For fine chemical production, which is the most important NMVOC source in source category 3C Chemical Products, Manufacture and Processing, the emission factor amounts to 3.7 ton NMVOC per production index in 2012 (EMIS 2014/3C Feinchemikalien-Produktion).

The emission factor for indirect CO_2 emissions from decomposition of NMVOC in the atmosphere is 2.2 Gg CO_2/Gg NMVOC (carbon content fraction * molecular weight of carbon dioxide / molecular weight of carbon).

Activity Data

Activity data corresponds to the annual consumption of solvents and bases on data from industry, industry associations and expert estimates, documented in the EMIS database (EMIS 2014/3C).

For fine chemical production, which is the most important NMVOC source in source category 3C Chemical Products, Manufacture and Processing, the activity data equals to a production index of 303 in 2012 (EMIS 2014/3C Feinchemikalien-Produktion). For activity data the index of production according to the Swiss Federal Office of Statistics is used.

5.4.3 Uncertainties and Time-Series Consistency

The uncertainty of total CO_2 emissions from the entire source category 3 Solvent and Other Product Use is estimated to be 50% (expert estimate).

Time series is consistent.

5.4.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-tables
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

5.4.5 Source-Specific Recalculations

3C Paint and ink manufacturing: Activity data has been revised due to updated projection for 2015. This has led to a revision of the AD for 2011.

3C Manufacturing of rubber: Activity data has been updated for 2011 and EF value has been updated for 2012 resulting as well in revised interpolated values for 2008-2010 and 1998-2011, respectively.

3C Manufacturing of polyester: Activity data has been updated for 2010 and 2011 and EF values have been updated for 2010 and 2012 resulting as well in revised interpolated values for 2008-2009 and 2008, 2009 and 2011, respectively.

3C Manufacturing of polystyrene: Activity data has been updated for 2011 resulting in revised interpolated values for 2008-2010 as well.

3C Manufacturing of PVC: Activity data has been updated for 2010 and 2011 and EF values have been updated for 2004 and 2012 resulting as well in revised interpolated values for 2009 and 1991-2003 and 2005- 2011, respectively.

5.4.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

5.5 Source Category 3D – Other

5.5.1 Source Category Description

Source category 3D Other comprises emissions from the application of N_2O in households and hospitals as well as of NMVOC from many different solvent applications. Also, it includes indirect CO_2 emissions due to decomposition of NMVOC in the atmosphere and direct CO_2 emissions resulting from post-combustion of NMVOC in exhaust gases.

Additional emissions of CO_2, NO_x, CO and SO_2 result from the use of firework.

Table 5-6 Specification of source category 3D Other. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

	Source	**Specification**	**Data Source**
3D1	Use of N2O for Anaesthesia	Emissions of N2O from the use of N2O in hospitals	AD, EF: EMIS 2014/3D1
3D3	N2O from Aerosol Cans	Emissions of N2O from the use of aerosol cans	AD, EF: EMIS 2014/3D3
3D5	Other	Emissions of CO2 and NMVOC from use of spray cans in industry and households; domestic solvent use; print industry; application of glues and adhesives; use of concrete additives; removal of paint and lacquer; car underbody sealant; de-icing of airplanes; tanning of leather; impregnating of glass and mineral wool; use of cooling and other lubricants; extraction of oils and fats; use of pesticides; use of pharmaceutical products in households; house cleaning industry/craft/services; hairdressers; scientific laboratories; textile production; paper and paper board production; clothing production; cosmetic institutions; production and use of tobacco products; vehicles dewaxing; wood preservation; medical practitioners; other health care institutions; not attributable solvent emissions Emissions of CO2, NOx, CO and SO2 from use of fireworks	AD, EF: EMIS 2014/3D5

5.5.2 Methodological Issues

Methodology

Emissions of N_2O from source category 3D1 occur from anaesthesia use in hospitals and in source category 3D3 from the use of aerosol cans in households. For both categories a country specific method based on the production/consumption of N_2O and of the different solvent applications is used.

The emissions from source category 3D5 Domestic solvent use, which is the most important NMVOC emission source in 3D5 Other, is calculated proportional to the number of inhabitants in Switzerland. Switzerland's Informative Inventory Report 2014 contains a description of the country-specific methods used for estimating the NMVOC emissions from the most important sources within source category 3D (FOEN 2014e, section 5.5.2).

The indirect CO_2 emissions due to decomposition of NMVOC in the atmosphere are calculated using a carbon content fraction of 0.6 according to the 2006 IPCC Guidelines (IPCC 2006).

Direct CO_2 emissions result from post-combustion of NMVOC. Those emissions are estimated based on industry data and expert estimates.

Emission Factors

For source category 3D1 Use of N_2O for anaesthesia the emission factor is calculated based on the amount on N_2O sold in Switzerland divided by the number of inhabitants. The yearly amount of N_2O sold for anaesthesia purpose is provided from sales information from the companies concerned and has been updated for the NIR submission 2013 based on annual data from 2005 onwards (EMIS 2014/3D1 Lachgasanwendung Spitäler).

Source 3D3 N_2O from aerosol cans include N_2O emissions from whipped cream makers using gas capsules from private households and restaurants. The emission factor is calculated based on the amount of gas capsules sold in Switzerland divided by the number of inhabitants The emission factor has been updated for the NIR submission 2013 based on sales figures and N2O content of aerosol cans in 2011 (EMIS 2014/3D3 Lachgasanwendung Haushalt).

In Table 5-7 emission factors for the emission of N_2O is given for source categories 3D1 Use of N_2O for anaesthesia and 3D3 N_2O from aerosol cans.

Table 5-7 Emission factors for N_2O for source category 3D1 and 3D3 in g/inhabitant in 2012 (EMIS 2014/3D1 Lachgasanwendung Spitäler; EMIS 2014/3D3 Lachgasanwendung Haushalt).

3D1 Use of N_2O for anaesthesia	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N_2O	g/inhabitant	43	40.4	37.7	35.1	32.5	29.8	27.2	24.5	21.9	19.3
3D3 N_2O from aerosol cans											
N_2O	g/inhabitant	9.3	9.3	9.4	9.4	9.5	9.6	9.6	9.7	9.7	9.8

3D1 Use of N_2O for anaesthesia	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N_2O	g/inhabitant	16.6	14	13	13	12	12	10	9	8	7
3D3 N_2O from aerosol cans											
N_2O	g/inhabitant	9.8	9.9	9.9	10	10.3	10.5	10.8	11.0	11.3	11.5

3D1 Use of N_2O for anaesthesia	Unit	2010	2011	2012
N_2O	g/inhabitant	7	6	5.8
3D3 N_2O from aerosol cans				
N_2O	g/inhabitant	11.8	12	12.2

For source category 3D5 Other the emission factors for NMVOC as well as the emission factors for CO_2, NO_x, CO and SO_2 from the use of fireworks emissions are based on data from Swiss industry and expert estimates, documented in the EMIS database (EMIS 2014/3D). For house cleaning, which is the most important emission source in source category 3D5 Other, the emission factor for NMVOC amounts to 892 g per inhabitant in 2012 (EMIS 2014/3D5 Reinigungs- und Lösemittel, Haushalte).

The emission factor for indirect CO_2 emissions from decomposition of NMVOC in the atmosphere is 2.2 Gg CO_2/Gg NMVOC (carbon content fraction * molecular weight of carbon dioxide / molecular weight of carbon).

Activity Data

For source categories 3D1 Use of N_2O for anaesthesia and 3D3 N_2O from aerosol cans the activity data corresponds to the number of inhabitants in Switzerland and amounts to

7'997'000 in 2012 (EMIS 2014/3D1 Lachgasanwendung Spitäler and EMIS 2014/3D3 Lachgasanwendung Haushalt).

For source category 3D5 Other the activity data corresponds to the annual production/ consumption of solvents. Data bases on industry data and expert estimates, documented in the EMIS database (EMIS 2014/3D5). For house cleaning, which is the most important emission source in source category 3D Other, the activity data is the number of inhabitants in Switzerland and amounts to 7'997'000 in 2012 (EMIS 2014/3D5 Reinigungs- und Lösemittel, Haushalte).

5.5.3 Uncertainties and Time-Series Consistency

The uncertainty of total CO_2 emissions from the entire source category 3 Solvent and Other Product Use is estimated to be 50% (expert estimate).

The uncertainty of N_2O emissions is estimated to be 80% (expert estimate, see table Table 1-14).

Time series is consistent.

5.5.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF-table
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

5.5.5 Source-Specific Recalculations

3D5 Print industry: Activity data has been revised due to updated projection for 2015. This has led to a revision of the AD for 2011.

3D5 Impregnating of glass and mineral wool: Activity data of one of the two production plants has been revised for 1991-2004 based on effective production data for 1996-2004.

3D5 Production and use of tobacco products: The estimation of consumption of tobacco products has been improved and updated for the years 2005-2011.

3D5 Use of concrete additives: Activity data has been revised and updated for 1990, 1998, 2001 and 2008-2011, respectively. This has resulted in revised interpolated values in between. EF values have been corrected to interpolated values and updated for 1999-2006 and 2008-2011, respectively.

3D5 Car underbody sealant: Activity data has been revised and updated for 1990, 1998 and 2012, respectively, resulting in revised interpolated values in between. EF values have been corrected to interpolated values and updated for 1999-2003 and 2012, respectively, resulting in revised interpolated values for 2005-2011 as well.

3D5 De-icing of airplanes and other de-icing: Activity data and EF values have been updated for 2012 resulting in revised interpolated values for 2008-2011 as well.

3D5 Use of cooling and other lubricants: Activity data and EF values have been updated for 2008-2011 and 2012, respectively, resulting as well in revised interpolated values from 2005 onwards.

3D5 Use lubricants: Activity data has been updated for 2008-2011 resulting in revised interpolated values for 2005-2007 as well. EF values have been corrected to interpolated values and updated for 1999-2003 and 2012, respectively resulting in revised interpolated values for 2008-2011 as well.

5.5.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

6 Agriculture

6.1 Overview

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

- 4A Enteric Fermentation, CH_4 emissions from domestic livestock,
- 4B Manure Management, emissions of CH_4 and N_2O,
- 4D Agricultural Soils, emissions of N_2O, NO_x and NMVOC,

Categories 4C Rice Cultivation and 4E Burning of Savannahs are not occurring and therefore not reported in Switzerland.

Emissions from field burning of agricultural residues, formerly reported under Source Category 4F, have been moved to Source Category 6C (Waste Incineration, Chap. 8.4), in accordance with the EMEP Guidebook 2009 (EEA 2010).

Total greenhouse gas emissions from agriculture in 2012 were 5'539 Gg CO_2 equivalents in total which is a contribution of 10.9% to the total of Swiss greenhouse gas emissions. Main agricultural sources of greenhouse gases in 2012 were enteric fermentation emitting 2'497 Gg CO_2 equivalents (45% of all agricultural greenhouse gases), followed by agricultural soils with 2'060 Gg CO_2 equivalents (37%) and Manure Management with 982 Gg CO_2 equivalents (18%).

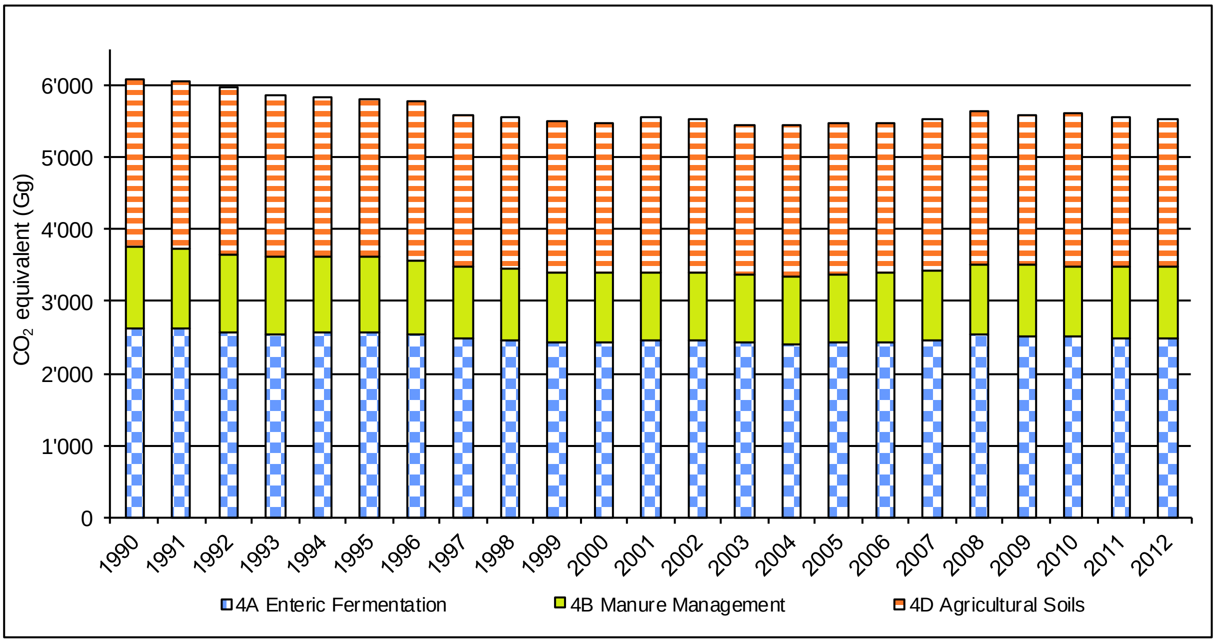

Figure 6-1 Greenhouse gas emissions of agriculture in Gg CO_2 equivalents 1990-2012.

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

Table 6-1 Greenhouse gas emissions in Gg CO_2 equivalents from agriculture 1990-2012.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	0	0	0	0	0	0	0	0	0	0
CH_4	3'307	3'298	3'236	3'200	3'213	3'201	3'171	3'107	3'092	3'055
N_2O	2'785	2'772	2'743	2'678	2'630	2'618	2'609	2'499	2'486	2'456
Sum	6'092	6'069	5'979	5'877	5'843	5'819	5'780	5'606	5'578	5'511

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (Gg)									
CO_2	0	0	0	0	0	0	0	0	0	0
CH_4	3'047	3'080	3'069	3'042	3'031	3'060	3'088	3'118	3'203	3'175
N_2O	2'449	2'481	2'466	2'418	2'417	2'414	2'405	2'437	2'442	2'412
Sum	5'496	5'561	5'536	5'461	5'447	5'474	5'493	5'556	5'645	5'587

Gas	2010	2011	2012
	CO_2 eq. (Gg)		
CO_2	0	0	0
CH_4	3'166	3'155	3'143
N_2O	2'470	2'417	2'395
Sum	5'637	5'572	5'539

CH_4 and N_2O emissions were declining from 1990 until 2004. This general trend can be explained by a reduction of the number of cattle and a reduced input of mineral fertilisers due to the introduction of the “Proof of Ecological Performance (PEP)” (ART 2013a, Leifeld and Fuhrer 2005). From 2004 to 2008 CH_4 emissions increased again due to higher livestock numbers (mainly cattle). Since 2008 total emissions seem to be fluctuating on a rather stable level possibly due to a more or less stable cattle population due to the suspension of the milk quotation. Most emission factors did not change significantly.

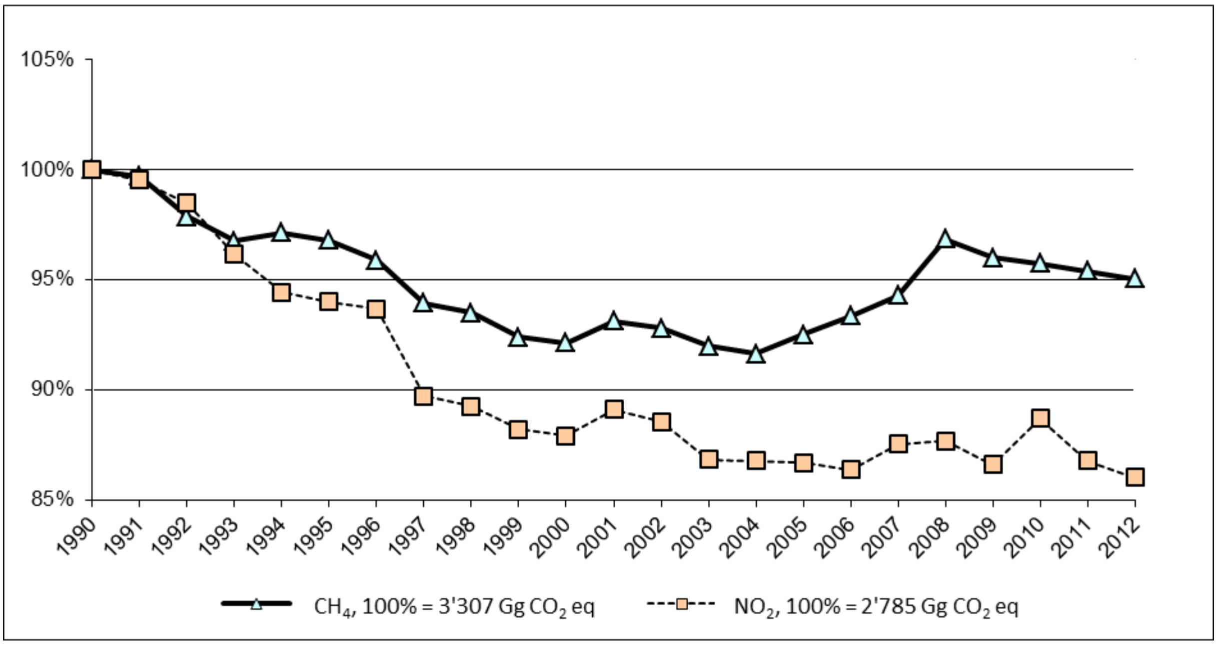

Figure 6-2 Trend of the greenhouse gases of the agricultural sector 1990-2012. The base year 1990 represents 100%.

Among the key categories of the Swiss inventory, six are from the agricultural sector:

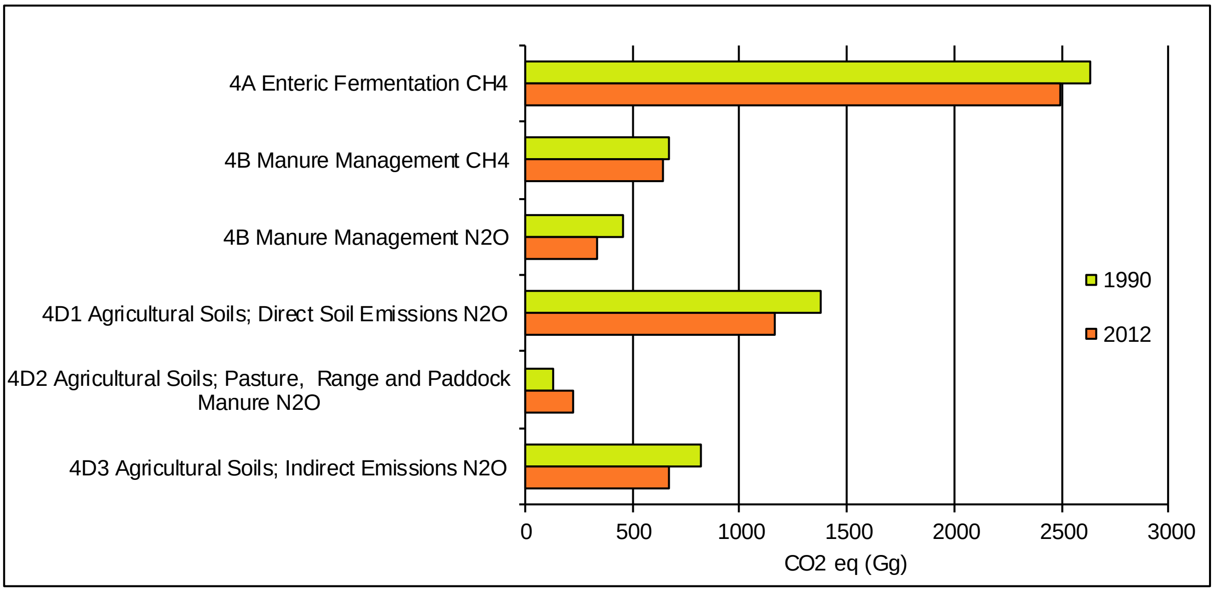

Figure 6-3 Key sources (Tier 1 and Tier 2) in Agriculture, emissions 1990 and 2012 in CO_2 equivalents (Gg).

6.2 *Source Category 4A – Enteric Fermentation*

6.2.1 Source Category Description

Tier 1 Key Category 4A CH_4 emissions from Enteric Fermentation (level)
Tier 2 Key category 4A CH_4 emissions from Enteric Fermentation (level)

The emission source is the domestic livestock population broken down into 3 cattle categories (mature dairy cattle, mature non-dairy cattle, young cattle), sheep, goats, horses, mules and asses, swine and poultry. Emissions from enteric fermentation were declining from 1990 until 2004, mainly due to a reduction of the number of cattle. However, between 2004 and 2008 cattle livestock numbers and subsequently CH_4 emissions were increasing again, whereas since 2008 they are decreasing. Emissions from cattle contribute to over 90% of the emissions from enteric fermentation.

Table 6-2 Specification of source category 4A Enteric Fermentation. (AD: Activity data; EF: Emission factor).

4A	Source	Specification	Data Source
4A1	Cattle	Mature dairy cattle Mature non-dairy cattle Young cattle (fattening calves, pre-weaned calves, breeding cattle 1st year (breeding calves + breeding cattle 4-12 months), breeding cattle > 1 year, fattening cattle (fattening calves 0-4 months, fattening cattle 4-12 months)	AD: Livestock data from SBV 2013, ART/SHL 2012, SFSO 2013d; Net energy and metabolisable energy (calves) from RAP 1999; EF: Soliva 2006
4A3 4A4	Sheep Goats		AD: Livestock data from SBV 2013 and ART/SHL 2012; net energy data from Giuliani 2013; EF: Soliva 2006
4A6 4A7	Horses Mules and asses		AD: Livestock data from SBV 2013 and ART/SHL 2012; digestible energy data from Stricker 2012; EF: Soliva 2006
4A8	Swine		AD: Livestock data from SBV 2013 and ART/SHL 2012; net energy data from Giuliani 2013; EF: Soliva 2006
4A9	Poultry		AD: Livestock data from SBV 2013 and ART/SHL 2012; net energy data from Giuliani 2013; EF: Hadorn and Wenk 1996 cited in Soliva 2006

6.2.2 Methodological Issues

Methodology

The calculation is based on methods described in the IPCC Good Practice Guidance (IPCC 2000, equation 4.14). CH_4 emissions from enteric fermentation of the livestock population have been estimated using Tier 2 methodology. This means that detailed country specific data on nutrient requirements, feed intake and CH_4 conversion rates for specific feed types are required.

For calculating the gross energy intake, a country specific method based on available data on requirements of net energy (lactation, growth), digestible energy and metabolisable energy has been applied. Data on energy intake is based on RAP (1999) and SBV (2013) as well as on Stricker 2012. The method is described in detail in Soliva (2006) and is realised in Agroscope (2014).

Different energy levels (Figure 6-4) are used to express the energy conversion from energy required for maintenance and performance to gross energy intake.

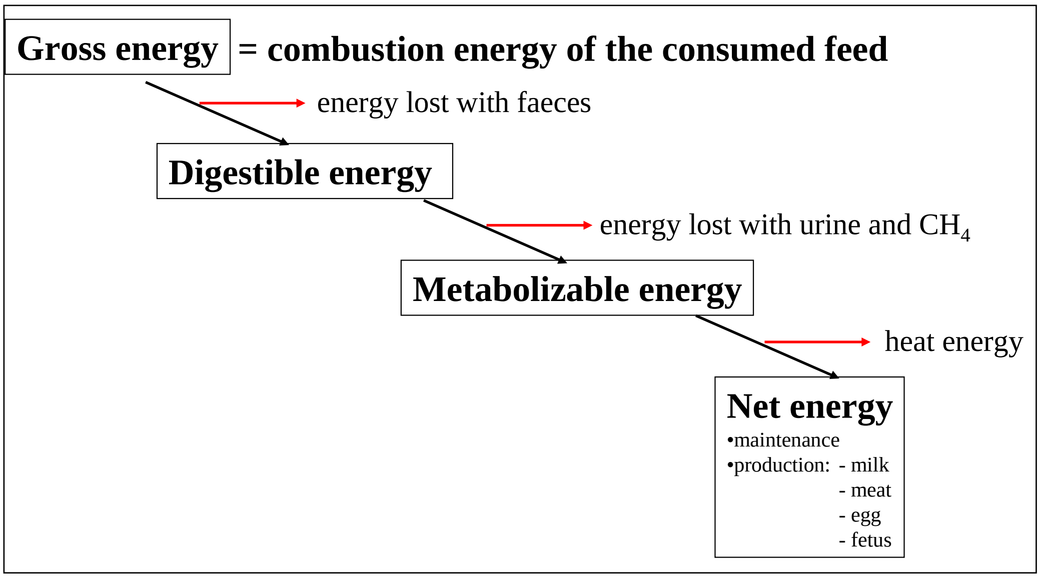

Figure 6-4 Levels of feed energy conversion. Reference: Soliva 2006.

Net energy (NE) is used to express the energy required by the ruminants such as cattle, sheep and goats. NE in cattle feeding is further sub-divided into NE for lactation (NEL) and NE for growth (NEV). For some of the young cattle categories NEL is used rather than NEV what would seem natural. However, cattle raising is often coupled with dairy cattle activities and therefore the same energy unit (NEL) is used in these cases (RAP 1999). Exceptions are the fattening calves (milk-fed calves), whose requirements for energy are expressed as metabolisable energy (ME). Horses, mules, asses and swine are fed on the basis of digestible energy (DE), whereas poultry are fed according to metabolisable energy (ME).

For the cattle categories detailed estimations for NE requirements are necessary. As the Swiss Farmers Union (SBV) does not calculate the NE for detailed cattle sub-categories, NE data for each cattle source category was calculated individually according to the animal's requirements following the feeding recommendations of RAP (1999). These RAP recommendations are also used by the Swiss farmers as basis for their cattle feeding regime and for filling in application forms for subsidies for ecological services, and are therefore highly appropriate. In the calculation of the NE data, the animal's weight, daily growth rate, daily feed intake (dry matter), daily feed energy intake, and energy required for milk production and pregnancy for the respective sub-categories were considered (Soliva 2006).

For estimating the gross energy intake out of the available data on net energy, metabolisable energy and digestible energy, the following conversion factors were applied:

Table 6-3 Conversion factors used for calculation of energy requirements of individual livestock categories. Reference: Soliva 2006: p.3. GE: Gross energy; DE: Digestible Energy; ME: Metabolisable Energy; NEL: Net energy for lactation; NEV: Net energy for growth.

Livestock Category		**Conversion Factors**	
Mature Dairy Cattle		NEL to GE	0.318
Mature Non-Dairy Cattle		NEL to GE	0.275
Young Cattle	Fattening Calves	ME to GE	0.930
	Pre-Weaned Calves	NEL to GE	0.291
	Breeding Calves	NEL to GE	0.341
	Breeding Cattle (4-12 months)	NEL to GE	0.322
	Breeding Cattle (> 1 year)	NEL to GE	0.313
	Fattening Calves (0-4 months)	NEV to GE	0.350
	Fattening Cattle (4-12 months)	NEV to GE	0.401
Milksheep		NEL to GE	0.287
Fattening Sheep		NEV to GE	0.350
Goats		NEL to GE	0.283
Horses		DE to GE	0.700
Mules and Asses		DE to GE	0.700
Swine		DE to GE	0.682
Poultry		ME to GE	0.700

Emission factors

All emission factors for enteric fermentation are country specific, based on IPCC equation 4.14 IPCC 2000: p. 4.26.

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

GE = Gross energy intake (MJ/head/day)

Y_m = Methane conversion rate, which is the fraction of gross energy in feed converted to methane

55.65 MJ/kg = energy content of methane.

The following input data are used:

Table 6-4 Gross energy intake per head of different livestock groups. Calculation is based on the above mentioned parameters net energy, digestible energy, metabolisable energy according to the method described in Soliva (2006). Input data on net energy, digestible energy and metabolisable energy is taken from Giuliani (2013), RAP (1999) and Stricker (2012). All sub-categories displayed in italic.

Gross Energy Intake	1990-1999									
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	MJ/head/day									
Mature Dairy Cattle	258.0	260.3	260.6	263.9	263.6	266.4	265.4	269.6	273.7	277.2
Mature Non-Dairy Cattle	205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1
Young Cattle Average (weighted)	93.6	93.5	93.6	93.4	94.0	94.3	93.7	94.1	93.1	92.1
Fattening Calves	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*
Pre-Weaned Calves	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*
Breeding Calves	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*
Breeding Cattle (4-12 months)	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*
Breeding Cattle (> 1 year)	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*
Fattening Calves (0-4 months)	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*
Fattening Cattle (4-12 months)	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*
Sheep	21.2	21.7	22.2	22.4	23.8	24.0	22.0	22.1	21.5	22.9
Goats	25.0	24.6	25.0	25.4	25.5	27.9	25.3	25.6	26.9	25.8
Horses	107.3	107.3	107.3	107.3	107.1	106.9	107.1	107.3	107.3	107.2
Mules and Asses	39.2	39.2	39.2	39.2	39.5	39.7	39.7	39.8	39.6	39.8
Swine	28.3	28.9	29.0	29.1	28.5	31.9	29.8	29.9	27.9	29.0
Poultry 1)	1.5	1.5	1.6	1.3	1.4	1.3	1.4	1.4	1.3	1.4

Gross Energy Intake	2000-2009									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	MJ/head/day									
Mature Dairy Cattle	280.1	282.0	285.0	288.6	294.0	294.1	295.1	300.5	304.1	309.2
Mature Non-Dairy Cattle	205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1
Young Cattle Average (weighted)	93.4	92.3	91.9	91.6	91.3	90.8	90.9	90.7	90.8	90.4
Fattening Calves	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*
Pre-Weaned Calves	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*
Breeding Calves	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*
Breeding Cattle (4-12 months)	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*
Breeding Cattle (> 1 year)	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*
Fattening Calves (0-4 months)	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*
Fattening Cattle (4-12 months)	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*
Sheep	22.4	22.9	22.8	22.7	23.3	22.8	22.6	22.2	22.0	22.7
Goats	25.7	26.0	25.2	25.4	25.2	25.4	25.3	25.0	25.0	25.3
Horses	107.4	107.5	107.6	107.6	107.6	107.7	107.7	107.7	107.7	107.8
Mules and Asses	39.5	39.6	39.6	39.6	39.5	39.4	39.5	39.3	39.2	40.0
Swine	28.0	27.7	27.1	27.0	27.2	26.6	26.3	26.9	26.7	27.0
Poultry 1)	1.4	1.4	1.3	1.3	1.3	1.2	1.2	1.3	1.3	1.3

Gross Energy Intake	2010-2012		
	2010	2011	2012
	MJ/h./d.		
Mature Dairy Cattle	310.8	312.1	311.5
Mature Non-Dairy Cattle	205.1	205.1	205.1
Young Cattle Average (weighted)	90.4	90.1	89.8
Fattening Calves	*47.6*	*47.6*	*47.6*
Pre-Weaned Calves	*55.7*	*55.7*	*55.7*
Breeding Calves	*26.9*	*26.9*	*26.9*
Breeding Cattle (4-12 months)	*89.2*	*89.2*	*89.2*
Breeding Cattle (> 1 year)	*129.1*	*129.1*	*129.1*
Fattening Calves (0-4 months)	*55.6*	*55.6*	*55.6*
Fattening Cattle (4-12 months)	*124.6*	*124.6*	*124.6*
Sheep	22.6	22.6	22.6
Goats	25.1	25.6	25.6
Horses	107.9	107.9	107.9
Mules and Asses	40.2	39.9	39.9
Swine	27.2	26.9	26.9
Poultry 1)	1.3	1.3	1.3

1) Poultry data is not Gross Energy intake (GE) but Metabolizable Energy intake (ME)

The **gross energy intake** per head for some animal categories revealed some fluctuations during the inventory period. The value for mature dairy cattle increased which is mainly a result of higher milk production (Table 6-5). Milk production of mature dairy cattle increased from 4’900 kg per head and year in 1990 to 6’879 kg per head and year in 2012. Statistics of annual milk production are provided by the Swiss Farmers Union (SBV 2013). Milk production includes marketed milk, milk consumed by calves on farms and milk sold outside the commercial industry (MISTA 2013). It should be noted that daily milk yield refers to milk production during lactation (305 days) and not during the whole year (365 days). Accordingly, energy requirement for lactation is excluded from the two remaining months when the cows are dry.

Table 6-5: Annual milk production in Switzerland

Milk Production Cattle		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Population Size Mature Dairy Cattle	head	783'100	780'500	763'500	744'450	749'700	739'641	736'043	711'613	701'343	683'545
Lactation Period	day	305	305	305	305	305	305	305	305	305	305
Milk Yield Mature Dairy Cattle	kg/head/day	16.06	16.35	16.39	16.78	16.75	17.09	16.96	17.48	17.97	18.40
Milk Yield Mature Non-Dairy Cattle	kg/head/day	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20

Milk Production Cattle		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Population Size Mature Dairy Cattle	head	669'410	669'410	657'924	638'288	621'008	620'708	618'065	614'795	628'516	599'361
Lactation Period	day	305	305	305	305	305	305	305	305	305	305
Milk Yield Mature Dairy Cattle	kg/head/day	18.75	18.97	19.34	19.77	20.43	20.45	20.57	21.21	21.66	22.27
Milk Yield Mature Non-Dairy Cattle	kg/head/day	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20	8.20

Milk Production Cattle		2010	2011	2012
Population Size Mature Dairy Cattle	head	589'024	589'239	591'212
Lactation Period	day	305	305	305
Milk Yield Mature Dairy Cattle	kg/head/day	22.46	22.63	22.55
Milk Yield Mature Non-Dairy Cattle	kg/head/day	8.20	8.20	8.20

The gross energy intake for mature non-dairy cattle is significantly higher than IPCC default values, since this category only comprehends mature cows to produce offspring for meat (so called suckler cows or mother cows). Milk production of mature non-dairy cattle is 2500kg per head and year (305 days of lactation) and does not change over the inventory time period (RAP 1999).

The gross energy intake of young cattle was calculated separately for all sub-categories displayed in Table 6-4 (in italics) and subsequently averaged (weighted average). The values for all the 7 sub-categories summarized under young cattle are constant over time. Since the composition of the young cattle category is changing over time (e.g. more pre-weaned calves, less fattening calves, see Table 6-6) the average gross energy intake for young cattle is also slightly changing. To calculate an annual emission factor, the categories breeding calves and breeding cattle 4-12 months are combined in the category breeding cattle 1st year (not shown in Table 6-4 and Table 6-6). Subsequently the respective animals have two separate gross energy intake values, i.e. 26.9 MJ/head/day for the first 4 month and 89.2 MJ/head/day for the later 8 months. The same procedure is applied for fattening calves 0-4 months and fattening cattle 4-12 months summing up to the category fattening cattle.

For the **methane conversion rate Y_m** (%) only few country specific data exist. Therefore mainly default values recommended by the IPCC for developed countries in Western Europe were used (IPCC 1997b: Reference Manual: p. 4.32–4.35 and IPCC 2000: p. 4.27). For all juveniles consuming only milk (i.e. fattening calves) the CH_4 conversion rate is assumed to be zero (IPCC 2000). For poultry a country specific value ($Y_{poultry}$ = 0.1631% of metabolisable energy) was used since no default value is given by the IPCC. This value was evaluated in an in vivo trial with broilers (Hadorn and Wenk 1996).

Activity data

The activity data input has been obtained from statistics published by the Swiss Farmers Union (SBV 2013) and the Swiss Federal Statistical Office (SFSO 2013d). All activity data has been revised and harmonized during a joint effort of the Agroscope Reckenholz Tänikon

Research Station (ART) and the Swiss College of Agriculture (SHL) in 2011 (ART/SHL 2012).

The following data were used:

Table 6-6 Activity data for calculating methane emissions from enteric fermentation (ART/SHL 2012, SBV 2013, SFSO 2013d).

Population Size		1990-1999									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		1'000 head									
Total cattle		1'855	1'829	1'783	1'745	1'755	1'748	1'747	1'673	1'641	1'609
Mature Dairy Cattle		783	781	764	744	750	740	736	712	701	684
Mature Non-Dairy Cattle		12	14	17	18	20	23	28	32	36	41
Young Cattle		1'060	1'034	1'002	983	986	986	983	929	904	884
	Fattening Calves	*112*	*111*	*110*	*111*	*101*	*102*	*112*	*106*	*108*	*116*
	Pre-Weaned Calves	*10*	*11*	*14*	*14*	*16*	*18*	*22*	*26*	*29*	*33*
	Breeding Calves	*214*	*204*	*197*	*184*	*182*	*166*	*155*	*139*	*136*	*72*
	Breeding Cattle (4-12 months)	*132*	*133*	*127*	*125*	*124*	*129*	*131*	*121*	*118*	*147*
	Breeding Cattle (> 1 year)	*404*	*400*	*397*	*381*	*379*	*378*	*383*	*372*	*350*	*305*
	Fattening Calves (0-4 months)	*88*	*79*	*71*	*76*	*83*	*82*	*75*	*68*	*66*	*48*
	Fattening Cattle (4-12 months)	*100*	*96*	*87*	*92*	*101*	*110*	*105*	*97*	*97*	*162*
Sheep		395	409	415	424	405	387	419	420	422	424
Goats		68	65	58	57	55	53	57	58	60	62
Horses		51	52	53	54	58	62	62	65	64	65
Mules and Asses		11	11	11	11	11	11	12	13	14	15
Swine		1'787	1'723	1'706	1'692	1'569	1'446	1'379	1'395	1'487	1'453
Poultry		5'938	5'647	5'502	6'410	6'330	6'251	6'440	6'553	6'740	6'908

Population Size		2000-2009									
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		1'000 head									
Total cattle		1'588	1'611	1'594	1'570	1'545	1'555	1'567	1'572	1'604	1'597
Mature Dairy Cattle		669	669	658	638	621	621	618	615	629	599
Mature Non-Dairy Cattle		45	51	58	65	70	78	87	94	98	108
Young Cattle		874	891	878	867	854	856	862	863	877	890
	Fattening Calves	*103*	*115*	*114*	*114*	*111*	*106*	*101*	*100*	*95*	*101*
	Pre-Weaned Calves	*36*	*40*	*47*	*52*	*57*	*62*	*67*	*72*	*76*	*86*
	Breeding Calves	*76*	*78*	*76*	*73*	*71*	*75*	*77*	*76*	*80*	*77*
	Breeding Cattle (4-12 months)	*161*	*160*	*154*	*147*	*143*	*147*	*147*	*147*	*152*	*149*
	Breeding Cattle (> 1 year)	*352*	*350*	*345*	*337*	*326*	*318*	*320*	*320*	*322*	*331*
	Fattening Calves (0-4 months)	*43*	*40*	*38*	*39*	*36*	*35*	*35*	*34*	*36*	*35*
	Fattening Cattle (4-12 months)	*105*	*109*	*104*	*105*	*109*	*112*	*114*	*114*	*116*	*112*
Sheep		421	420	430	445	441	446	448	444	446	432
Goats		62	63	66	67	71	74	76	79	81	81
Horses		66	64	64	65	65	65	66	67	68	69
Mules and Asses		16	16	17	17	18	19	19	20	20	22
Swine		1'498	1'548	1'557	1'529	1'538	1'609	1'635	1'573	1'540	1'557
Poultry		6'983	6'939	7'339	7'587	8'061	8'260	7'670	8'228	8'543	8'809

Population Size		2010-2012		
		2010	2011	2012
		1'000 head		
Total cattle		1'591	1'577	1'565
Mature Dairy Cattle		589	589	591
Mature Non-Dairy Cattle		111	111	114
Young Cattle		891	877	859
	Fattening Calves	*99*	*101*	*99*
	Pre-Weaned Calves	*88*	*88*	*91*
	Breeding Calves	*77*	*75*	*73*
	Breeding Cattle (4-12 months)	*149*	*145*	*140*
	Breeding Cattle (> 1 year)	*332*	*324*	*311*
	Fattening Calves (0-4 months)	*34*	*34*	*34*
	Fattening Cattle (4-12 months)	*111*	*111*	*112*
Sheep		434	424	417
Goats		83	83	85
Horses		71	66	67
Mules and Asses		23	22	23
Swine		1'589	1'579	1'544
Poultry		9'025	9'478	9'955

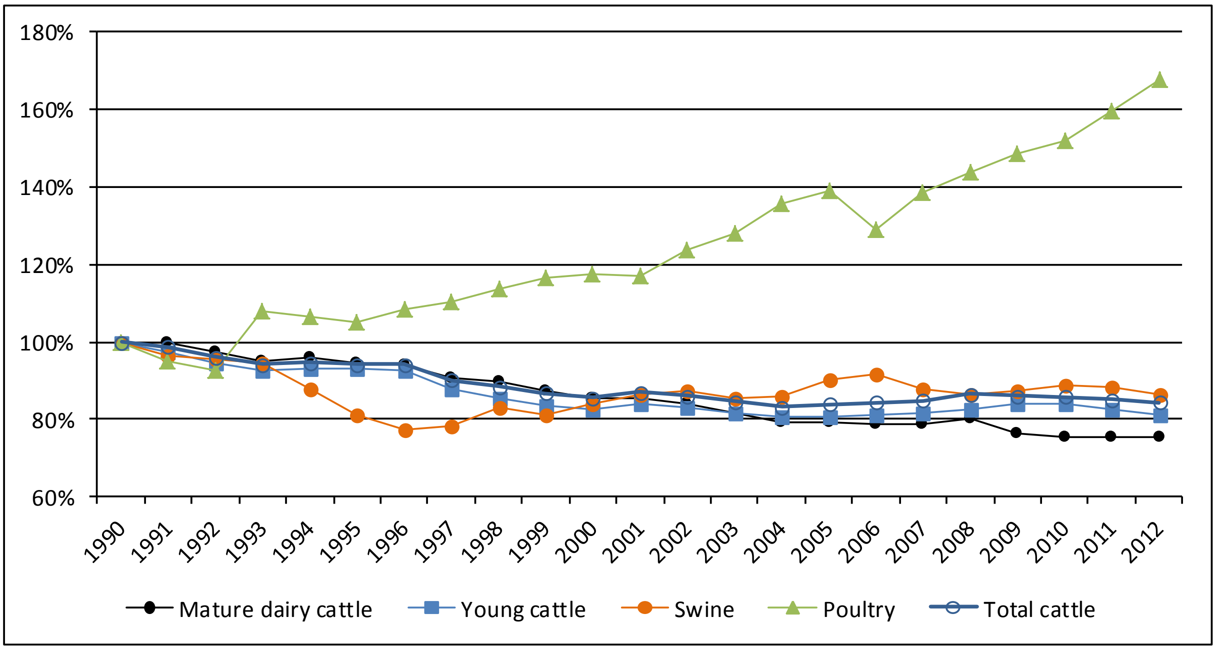

Figure 6-5 Relative development of main animal categories 1990-2012. The category with the strongest increase, mature non-dairy cattle, is not displayed, as it increases to over 950% of the 1990 value by 2012.

Emission estimation for cattle has been conducted at a more disaggregated level than the one displayed in the CRF. The category Mature non-dairy cattle only includes mature cows used to produce offspring for meat. The CRF livestock category Young cattle includes the sub-categories fattening calves, pre-weaned calves, breeding calves, breeding cattle 4-12 months, breeding cattle > 1 year, fattening calves 0-4 months and fattening cattle 4-12 months. Although not young cattle in the proper sense, bulls are contained in the categories Breeding Cattle (> 1 year) and Fattening Cattle (4-12 months) according to their purposes. This regrouping of the cattle category enhances the consistency and transparency of the emission estimation procedure from livestock activities (also refer to chapter 6.3).

The number of cattle was slightly declining until the year 2004, which is a result of an on-going process to a less intensive form of animal husbandry due to ecological and economic reasons. However, cattle livestock numbers were slightly increasing again between 2004 and 2008 mainly due to an increase of the number of young cattle. Since 2008 the cattle population is more or less stable possibly due to the suspension of the milk quotation.

After a decrease until 1996 the number of swine was increasing again until 2006 – a process that could be observed also in many other European countries (SBV 2004: p.69). Since then the number of swine has been fluctuating slightly below the level of 2006. The number of poultry shows a rapid increase between 1990 and 2012 with only a distinct dip between 2005 and 2006, a consequence of changed human consumption patterns as a result of the avian flu in 2006.

The number of sheep has been more or less constant while the number of goats is increasing after a decline between 1990 and 1995.

6.2.3 Uncertainties and Time-Series Consistency

For the uncertainty analysis the input data from ART (2008a) was used and was wheighted with current activity and emission data. The arithmetic mean of the lower and upper bound uncertainty is used for activity data (6.4%) and for emission factors (17.2%), resulting in a combined uncertainty of 18.4% for Tier 1 analysis. Tier 2 analysis results in a slightly different and asymmetric result: The uncertainty interval lies between -18.1% and +18.5% corresponding to a mean uncertainty of 18.3%. For further results see Section 1.7.

The time series 1990–2012 is generally consistent, with two issues that should be considered:

- Between 1998 and 1999 the questionnaire for the collection of livestock data was modified. In some animal categories this led to minor ruptures in the time series. Consequences for overall emissions are, however, of minor importance. While the average absolute trend for the years 1990–2011 over all animal categories excluding mature non-dairy cattle was 3.3%, the average absolute trend for the years 1998-1999 was 3.8% (ART/SHL 2012).
- For the last four inventory years cattle population statistics were not available in the usual format. Data for 2009 to 2012 is based on the animal traffic database. Aggregation has been adapted to the format necessary for the AGRAMMON and greenhouse gas inventories by the Swiss College of Agriculture SHL (SHL 2010). Data in the animal traffic database is considered more complete than the data from the survey of the SFSO because it includes also animals held outside agricultural enterprises.

6.2.4 Source-Specific QA/QC and Verification

All QA/QC activities are further described in a separate document (ART 2013a). General information on agricultural structures and policies is provided and eventual differences between national and (IPCC) standard values are being analysed and discussed. Furthermore, comparisons with data from other countries have been conducted and discussed where possible.

The documentation about the data set and calculation method assures transparency and traceability of the calculation methods (Soliva 2006). Additionally a document in German lists all the methodological differences between the former calculations and the current methodology (Soliva 2006a).

Livestock data was compared with the livestock data provided by the FAO and checked for plausibility. In all cases the new recalculated data according to ART/SHL (2012) is considered more reliable than the FAO data. Small inconsistencies (usually in the order of ± 2%) are due to updates of provisional data that are not considered by the FAO. For horses, mules and asses disagreements are due to the different accounting of agricultural and non-agricultural horses. The Swiss inventory systems accounts for all animals no matter whether they are held on agricultural or non-agricultural enterprises. Moreover, the numbers of mules and asses is higher in the Swiss GHG-Inventory because unlike the FAO, Switzerland accounts also for ponies and lesser horses. The total number for poultry also shows some minor discrepancies due to different accounting of turkeys, geese, ducks and quails. Seasonal fluctuation of the cattle population has been analysed for the years 2005-2007 based on detailed information from the Swiss Farmers Union (SBV 2007a). Fluctuations are usually in the order of ±3% with census data (April) always slightly above the annual mean.

Total NE-intake of the cattle population as calculated in the Swiss GHG- Inventory is in accordance with an independent calculation of the Swiss farmers union (SBV 2007). In a check during the submission 2010 the average absolute difference for the time period 1990-2004 was ±1.2%.

IPCC tables with data for estimating emission factors for cattle (such as weight, weight gain, milk production) were filled in, checked for consistency and confidence and compared with IPCC default values (refer to Table A - 27 in Annex A3.3). Methane conversion rates (Y_m) and feed digestibilities were compared to literature values representative for Swiss conditions.

The emission factors of category 4A were compared to the corresponding emission factors of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) and to the IPCC default value if available for submission 2013 (INFRAS 2012). Furthermore, emission factors have been calculated according to the original IPCC Tier 2 method. Implied emission factors for enteric fermentation for mature dairy and non-dairy cattle in Switzerland are generally higher than IPCC Tier 1 default due to relatively high gross energy intake (ART 2013a). This can be explained by the high performance of animal livestock in Switzerland (weight, weight gain, milk production). However, the IPCC Tier 2 analysis yields even higher energy intake levels and hence emission factors for all cattle animals. High feed quality together with high genetic standard i.e. high energy use efficiency of Swiss cattle might be a reason for these differences (ART 2013a). In general a straightforward comparison is difficult due to the country specific feeding regime and the inconsistent categorization of immature cattle.

During the years 2009-2012 the group of animal nutrition from the Swiss Federal Institute of Technology Zürich investigated the effect of different feeding and management strategies on methane and nitrous oxide emissions from enteric fermentation and manure management of cattle held under typical Swiss management conditions (Kreuzer 2012). Measured values of various parameters such as Y_m or MCF were compared to IPCC default values and values in the Swiss greenhouse gas inventory. Preliminary analysis suggests that overall emissions are neither over- nor underestimated (Zeitz et al. 2012). Further investigations have to show to what extent the preliminary estimates will be confirmed to provide a basis for implementation in Switzerland's GHG inventory after 2014.

During the past years a couple of studies have been conducted to verify methane emissions at regional scale comparing bottom up estimates with atmospherical measurements. While Hiller et al. (2014a) found that methane emissions could be underestimated by the inventory method, Stieger (2014) reported a very good accordance of bottom up estimates and flux measurements. Generally the methodological approaches of atmospherical measurements as conducted by Hiller et al. (2014a) still rely on a number of rather uncertain basic assumptions and are therefor not beyond doubts. Furthermore, it hase been stated, that the differences between bottom up and top down estimates are possibly due to the limitations of the geografical emission allocation within the spatial explicit inventory (Hiller et al. 2014).

The time series of activity data and emission factors have been compared between the current and the previous submission. All activity data, implied emission factors and emissions estimates undergo the following triple check:

- the results for 2012 are compared with the results for 2011 within the current CRF,
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of the submission 2013,
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission the 2013.

Additionally an independent quality control was conducted by INFRAS by a countercheck of the data and calculation sheets elaborated by Agroscope (Agroscope 2014).

6.2.5 Source-Specific Recalculations

New more precise activity data have been used for the years 1994 and 2006. Previously only rounded values have been available. The effects on overall emissions is negligible.

Preliminary estimates for energy requirements for non cattle populations for the years 2010 and 2011 have been revised. A new dataset has been received from the Swiss Farmers Union (Giuliani 2013). The estimates are based on the same method as earlier energy requirement statistics published until 2007 by the Swiss Farmers Union. The effect of the recalculation on overall greenhouse gas emissions is considered negligible.

Milk yield of mature dairy cattle in the year 2011 has been slightly revised due to an update of the provisional number from the Swiss Farmers Union.

6.2.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. All methods will be adapted to the 2006 IPCC Guidelines (IPCC 2006). Within this general recalculation a number of optional country specific methods will be explored and eventually implemented. Other projects are eventually postponed in order to give first priority to changes related to the new reporting guidelines.

6.3 Source Category 4B – Manure Management

6.3.1 Source Category Description

Tier 1 and Tier2 Key categories 4B
CH_4 emissions from Manure Management (level)
N_2O emissions from Manure Management (level and trend)

CH_4 and N_2O emissions from manure management are reported. The total emissions from manure management closely follow the development of the cattle population. Emissions declined from 1990 until 2004, increased again until 2008 and remained more or less stable since then.

Table 6-7 Specification of source category 4B Manure Management (CH_4). (AD: Activity data; EF: Emission factor).

4B	Source	Specification	Data Source
4B1	Cattle	Mature dairy cattle Mature non-dairy cattle Young cattle	AD: SBV 2013, ART/SHL 2012, SFSO 2013d; EF: RAP 1999, IPCC 2000, IPCC 1997c, Soliva 2006, Kupper et al. 2013
4B3 4B4	Sheep Goats		AD: SBV 2013, ART/SHL 2012, SFSO 2013d; EF: IPCC 2000, IPCC 1997c, Flisch et al. 2009, Kupper et al. 2013, Giuliani 2013, Soliva 2006
4B6 4B7	Horses Mules and Asses		AD: SBV 2013, ART/SHL 2012, SFSO 2013d; EF: IPCC 2000, IPCC 1997c, Flisch et al. 2009, Kupper et al. 2013, Stricker 2012, Soliva 2006
4B8	Swine		AD: SBV 2013, ART/SHL 2012, SFSO 2013d; EF: IPCC 2000, IPCC 1997c, Flisch et al. 2009, Kupper et al. 2013, Giuliani 2013, Soliva 2006
4B9	Poultry		AD: SBV 2013, ART/SHL 2012, SFSO 2013d; EF: IPCC 2000, IPCC 1997c, Flisch et al. 2009, Kupper et al. 2013, Giuliani 2013, Soliva 2006

Table 6-8 Specification of source category 4B Manure Management (N_2O). (AD: Activity data; EF: Emission factor).

4B	Source	Specification	Data Source
4B11 4B12	Liquid systems Solid storage and dry lot	Mature dairy cattle	AD: SBV 2013, ART/SHL 2012, SFSO 2013d, Flisch et al. 2009, Kupper et al. 2013; EF: IPCC 1997c, IPCC 2000

6.3.2 Methodological Issues

For calculation of CH_4 and N_2O emissions slightly different livestock sub-categories are used. The livestock categories reported in the CRF-tables are the same, but the respective sub-categories as a basis for the calculation are different. Nevertheless, there is no inconsistency in the total number of animals as they are the same both for CH_4 and N_2O emissions. The calculation of CH_4 and N_2O emissions is realised in Agroscope (2014).

Calculation of CH_4 emissions is based on the domestic livestock populations mature dairy cattle, mature non-dairy cattle, young cattle (fattening calves, pre-weaned calves, breeding calves, breeding cattle 4-12 months, breeding cattle > 1 year, fattening calves 0-4 months, fattening cattle 4-12 months), sheep, goats, horses, mules and asses, swine and poultry as reported for enteric fermentation.

Calculation of N_2O emissions are based on a different livestock population break down:

- Cattle: Mature dairy cattle, mature non-dairy cattle and young cattle (fattening calves, pre-weaned calves, breeding cattle 1st year, breeding cattle 2nd year, breeding cattle 3rd year, fattening cattle). Although not young cattle in the proper sense, bulls are contained in the categories Breeding Cattle 3rd Year and Fattening Cattle according to their purposes.
- Sheep: fattening sheep, milk sheep
- Goats: goat places
- Horses: horses < 3 years, horses > 3 years
- Mules and asses: mules, asses
- Swine: piglets, fattening pig over 25 kg, dry sows, nursing sows, boars
- Poultry: growers, layers, broilers, turkey, other poultry (geese, ducks, ostriches, quails)

This calculation is chosen because more detailed data on parameters such as N excretion or manure management system distribution for the particular animal categories are available (Flisch et al. 2009, Kupper et al. 2013). The nitrogen excretion rates are given on a yearly basis, considering replacement of animals (young cattle, swine and poultry) and including excretions from corresponding offspring and other associated animals (sheep, goats, swine) (ART/SHL 2012).

a) CH_4 Emissions

Methodology

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

$$EF_i = VS_i \bullet 365\ days/year \bullet Bo_i \bullet 0.67\ kg/m^3 \bullet \sum_{ijk} MCF_{jk} \bullet MS_{ijk}$$

EF_i: annual emission factor for livestock population i
VS_i: daily volatile solids (VS) excreted for an animal within population i
B_{0i}: maximum CH_4 producing capacity for manure produced by an animal within population i
MCF_{jk}: CH_4 conversion factors for each manure management system j by climate region k
MS_{ijk}: fraction of animal species / category i's manure handled using manure system j in climate region k

Emission factor

Calculation of the emission factor is based on the parameters volatile solids excreted (VS), the maximum CH_4 producing capacity for manure (B_o) and the CH_4 conversion factors for each manure management system (MCF).

The **daily excretions of VS** for cattle sub-categories were estimated according to the IPCC Guidelines and GPG (2000: equation 4.16: p. 4.31). Gross energy intake is calculated according to the method described in Chapter 6.2.2. For the livestock categories swine, sheep, goats, horses, mules and asses, and poultry default values from IPCC (1997c: Reference Manual: p. 4.39 to 4.47) were taken.

The **ash content** of cattle manure is assumed to amount 8% on average (IPCC 1997c: Reference Manual: p. 4.47).

The **digestible energy** of the feed for cattle is assumed to be 60% on average, except for calves with 65% (IPCC 1997c: Reference Manual: p. 4.39).

For the Methane Producing Potential (**B_o**) default values are used (IPCC 1997c: Reference Manual: p. 4.39 to 4.47).

For the Methane Conversion Factor (**MCF**) mainly IPCC default values are used (IPCC 2000, p. 4.36 and IPCC 1997c: Reference Manual: p. 4.25). In Switzerland mainly two manure management systems exist, solid storage and liquid/slurry storage. Fattening calves, sheep and goats are mainly kept in deep litter systems and there are also specific MCF values for pasture and poultry systems: The following MCF's were used:

Table 6-9 Manure management systems and Methane conversion factors (MCFs). References: IPCC 2000, p. 4.36 and IPCC 1997b: p. 4.25 (for liquid/slurry and deep litter).

Manure Management System	Description	MCF [%]
Solid manure	Dung and urine are excreted in a barn. The solids (with and without litter) are collected and stored in bulk for a long time (months) before disposal.	1.0%
Liquid/slurry	Combined storage of dung and urine under animal confinements for longer than 1 month.	10.0%
Pasture	Manure is allowed to lie as it is, and is not managed (distributed, etc.).	1.0%
Deep litter	Dung and urine is excreted in a barn with lots of litter and is not removed for a long time (months). This is applied for the cattle sub-categories of Fattening Calves, Fattening Calves (0-4 months) and for sheep and goats.	10.0%
Poultry system	Manure is excreted on the floor with or without bedding.	1.5%

For the MCF for deep litter the 2000 IPCC good practice guidance suggest a value of 39%. However, this would lead to a rather large overestimation of methane emissions from deep litter manure management systems in Switzerland. Since the 2000 IPCC good practice guidance state that the MCF's for cattle and swine deep litter are similar to liquid/slurry, the respective value from the 1996 IPCC guidelines (IPCC 1997b) has been adopted. The choice of a MCF of 10% for deep litter is supported by the specific feeding and manure management regime in Switzerland (especially cold winter temperatures) and confirmed by a number of studies representative for the country specific management conditions (Amon et al. 2001, Külling et al. 2002, Külling et al. 2003, Moller et al. 2004, Hindrichsen et al. 2006, Park et al. 2006 and Sommer et al. 2007). For further details see FOEN 2011 (16.5 attachment E).

The fraction of animal manure handled using different manure management systems (**MS**) as well as the percentages of the grazing time was separately calculated for each livestock category. The fractions are based on Flisch et al. (2009) and calculated within the Swiss ammonium model AGRAMMON (Kupper et al. 2013). Input data for the AGRAMMON-model for the years 1990 and 1995 is based on expert judgement and literature whereas data for 2002, 2007 and 2010 is based on extensive farm surveys. Values in between the assessment years have been interpolated linearly (Table 6-10) while values beyond 2010 are kept constant until new survey results are available. The data clearly reflects the shift towards an increased use of pasture, range and paddocks and a decrease in solid storage. The changes of the manure management system distribution reflects the shift to a more animal friendly livestock husbandry in the course of the agricultural policy reform during the 1990th and the early 20th century. One of the most important programs in this context is called "RAUS" and implies at least 156 days of pasture per year (Schweizerischer Bundesrat, 2008). Accordingly the share of mature dairy cows (and other animals) going to pastures increased substantially and the length of stay on the pasture increased by 50%. In the year

2007 78% of the dairy cows were held on farms who participated in the RAUS program. The number of pasture days was 181 whereas it was 177 in 2010. It can be assumed, that already in the early years of the new millennium most farms accomplished the transition to RAUS and that accordingly a new management standard was reached that did not change significantly afterwards.

Emissions from deep litter and poultry systems have been calculated together with solid storage and are thus reported under solid storage in CRF-table 4.B(a)s2 and 4.B(b).

Table 6-10 Manure management system distribution.

MS Distribution	1990			1995			2002			2007			2010		
	%			%			%			%			%		
	Solid manure/ Deep litter	Liquid/ Slurry	Pasture range and paddock	Solid manure/ Deep litter	Liquid/ Slurry	Pasture range and paddock	Solid manure/ Deep litter	Liquid/ Slurry	Pasture range and paddock	Solid manure/ Deep litter	Liquid/ Slurry	Pasture range and paddock	Solid manure/ Deep litter	Liquid/ Slurry	Pasture range and paddock
Mature Dairy Cattle	27.70	64.04	8.26	24.53	65.93	9.54	16.38	65.66	17.96	13.94	68.35	17.72	14.84	68.22	16.94
Mature Non-Dairy Cattle	32.20	41.49	26.30	34.22	39.53	26.25	20.82	40.08	39.11	20.59	50.42	28.98	18.41	49.15	32.44
Young Cattle Average (weighted)	36.38	47.84	15.78	35.47	48.67	15.86	30.02	42.47	27.51	28.23	46.52	25.26	30.18	46.47	23.35
Fattening Calves	*85.36*	*14.64*	*0.00*	*84.72*	*15.28*	*0.00*	*77.70*	*21.96*	*0.33*	*77.10*	*22.74*	*0.16*	*81.64*	*18.13*	*0.23*
Pre-Weaned Calves	*32.20*	*41.49*	*26.30*	*34.22*	*39.53*	*26.25*	*21.20*	*41.54*	*37.27*	*18.98*	*50.88*	*30.14*	*33.27*	*45.86*	*20.87*
Breeding Cattle 1st Year	*48.63*	*37.31*	*14.06*	*47.52*	*38.25*	*14.22*	*38.92*	*34.05*	*27.03*	*34.86*	*41.88*	*23.26*	*33.89*	*44.61*	*21.50*
Breeding Cattle 2nd Year	*29.00*	*45.63*	*25.37*	*26.82*	*47.54*	*25.64*	*23.49*	*38.12*	*38.38*	*21.14*	*42.32*	*36.54*	*21.25*	*44.45*	*34.30*
Breeding Cattle 3rd Year	*29.17*	*50.81*	*20.02*	*28.03*	*51.66*	*20.31*	*22.65*	*42.54*	*34.81*	*21.70*	*46.52*	*31.78*	*21.92*	*47.48*	*30.60*
Fattening Cattle	*29.65*	*70.35*	*0.00*	*33.36*	*66.64*	*0.00*	*30.13*	*67.67*	*2.20*	*32.46*	*63.21*	*4.33*	*37.14*	*58.90*	*3.96*
Sheep	69.90	0.00	30.10	69.73	0.00	30.27	66.82	0.00	33.18	60.78	0.00	39.22	66.32	0.00	33.68
Fattening Sheep	*69.32*	*0.00*	*30.68*	*69.32*	*0.00*	*30.68*	*66.50*	*0.00*	*33.50*	*59.84*	*0.00*	*40.16*	*65.50*	*0.00*	*34.50*
Milksheep	*88.57*	*0.00*	*11.43*	*88.57*	*0.00*	*11.43*	*73.94*	*0.00*	*26.06*	*75.92*	*0.00*	*24.08*	*77.15*	*0.00*	*22.85*
Goats	86.39	0.00	13.61	86.39	0.00	13.61	87.82	0.00	12.18	92.88	0.00	7.12	90.00	0.00	10.00
Goat Places	*86.39*	*0.00*	*13.61*	*86.39*	*0.00*	*13.61*	*87.82*	*0.00*	*12.18*	*92.88*	*0.00*	*7.12*	*90.00*	*0.00*	*10.00*
Horses	93.15	0.00	6.85	93.15	0.00	6.85	76.14	0.00	23.86	78.66	0.00	21.34	74.38	0.00	25.62
Horses <3 years	*93.15*	*0.00*	*6.85*	*93.15*	*0.00*	*6.85*	*61.77*	*0.00*	*38.23*	*61.71*	*0.00*	*38.29*	*66.37*	*0.00*	*33.63*
Horses >3 years	*93.15*	*0.00*	*6.85*	*93.15*	*0.00*	*6.85*	*79.27*	*0.00*	*20.73*	*81.90*	*0.00*	*18.10*	*75.62*	*0.00*	*24.38*
Mules and Asses	93.15	0.00	6.85	93.15	0.00	6.85	76.93	0.00	23.07	75.21	0.00	24.79	79.31	0.00	20.69
Mules	*93.15*	*0.00*	*6.85*	*93.15*	*0.00*	*6.85*	*76.93*	*0.00*	*23.07*	*75.21*	*0.00*	*24.79*	*79.31*	*0.00*	*20.69*
Asses	*93.15*	*0.00*	*6.85*	*93.15*	*0.00*	*6.85*	*76.93*	*0.00*	*23.07*	*75.21*	*0.00*	*24.79*	*79.31*	*0.00*	*20.69*
Swine	0.00	100.00	0.00	0.00	100.00	0.00	0.34	99.54	0.12	0.14	98.68	1.18	0.27	99.61	0.13
Piglets	*0.00*	*100.00*	*0.00*	*0.00*	*100.00*	*0.00*	*0.84*	*99.16*	*0.00*	*0.67*	*98.97*	*0.36*	*2.34*	*97.66*	*0.00*
Fattening Pig over 25 kg	*0.00*	*100.00*	*0.00*	*0.00*	*100.00*	*0.00*	*0.27*	*99.56*	*0.17*	*0.00*	*98.51*	*1.49*	*0.00*	*99.85*	*0.15*
Dry Sows	*0.00*	*100.00*	*0.00*	*0.00*	*100.00*	*0.00*	*0.03*	*99.90*	*0.07*	*0.08*	*98.90*	*1.03*	*0.00*	*99.82*	*0.17*
Nursing Sows	*0.00*	*100.00*	*0.00*	*0.00*	*100.00*	*0.00*	*0.70*	*99.30*	*0.00*	*0.55*	*99.11*	*0.34*	*0.17*	*99.83*	*0.00*
Boars	*0.00*	*100.00*	*0.00*	*0.00*	*100.00*	*0.00*	*0.54*	*99.23*	*0.23*	*0.00*	*98.84*	*1.16*	*1.23*	*98.13*	*0.64*
Poultry	100.00	0.00	0.00	99.50	0.00	0.50	97.38	0.00	2.62	96.33	0.00	3.67	97.31	0.00	2.69
Growers	*100.00*	*0.00*	*0.00*	*99.41*	*0.00*	*0.59*	*99.81*	*0.00*	*0.19*	*98.54*	*0.00*	*1.46*	*98.80*	*0.00*	*1.20*
Layers	*100.00*	*0.00*	*0.00*	*99.41*	*0.00*	*0.59*	*94.86*	*0.00*	*5.14*	*92.69*	*0.00*	*7.31*	*93.91*	*0.00*	*6.09*
Broilers	*100.00*	*0.00*	*0.00*	*99.61*	*0.00*	*0.39*	*99.38*	*0.00*	*0.62*	*98.84*	*0.00*	*1.16*	*99.74*	*0.00*	*0.26*
Turkey	*100.00*	*0.00*	*0.00*	*99.61*	*0.00*	*0.39*	*96.94*	*0.00*	*3.06*	*96.93*	*0.00*	*3.07*	*98.09*	*0.00*	*1.91*
Other Poultry (Geese, Ducks, Ostriches, Quails)	*100.00*	*0.00*	*0.00*	*100.00*	*0.00*	*0.00*	*96.93*	*0.00*	*3.07*	*96.93*	*0.00*	*3.07*	*98.81*	*0.00*	*1.19*

Activity data

Activity data on all livestock categories is taken from SBV (2013) and the Swiss Federal Statistical Office (SFSO 2013d). All activity data has been revised and harmonized during a joint effort of the Agroscope Reckenholz Tänikon Research Station (ART) and the Swiss College of Agriculture (SHL) in 2011 (ART/SHL 2012) (refer to chapter 6.2.2 for details).

b) N_2O Emissions

Methodology

For the calculation of N_2O emissions from manure management a country specific method based on the Swiss ammonia model AGRAMMON is applied (Kupper et al. 2013). Basically the IPCC emission factors are used, but activity data is adjusted to the particular situation of Switzerland.

For calculation of emissions from manure management AGRAMMON applies other values for the nitrogen excretion per animal category than IPCC and differentiates the animal waste management systems Liquid systems and Solid storage. N_2O emissions from pasture, range and paddock appear under the category 4D Agricultural Soils, source category 2 Animal Production. IPCC categories Daily Spread and Other Systems are not occurring. The basic animal waste management systems are defined in Flisch et al. (2009) and Menzi et al. (1997).

Emission factors

IPCC default emission factors are used for the two animal waste management systems (IPCC 1997c: Reference Manual: p. 4.104).

Table 6-11 Emission factors for calculating N_2O emissions from manure management (IPCC 1997c: p. 4.104).

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

Activity data

Livestock population data of all categories are taken from the Swiss Farmers Union (SBV 2013) and the Swiss Federal Statistical Office (SFSO 2013d). All activity data has been revised and harmonized during a joint effort of the Agroscope Reckenholz Tänikon Research Station (ART) and the Swiss College of Agriculture (SHL) in 2011 (ART/SHL 2012). Input data is subdivided into the following livestock categories:

Table 6-12 Activity data for calculating N_2O emissions from manure management (ART/SHL 2012, SBV 2013).

Population Size		**1990-1999**									
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
		1000 head/places									
Cattle		1855	1829	1783	1745	1755	1748	1747	1673	1641	1609
Mature Dairy Cattle		783	781	764	744	750	740	736	712	701	684
Mature Non-Dairy Cattle		12	14	17	18	20	23	28	32	36	41
Young Cattle		1060	1034	1002	983	986	986	983	929	904	884
	Fattening Calves	*112*	*111*	*110*	*111*	*101*	*102*	*112*	*106*	*108*	*116*
	Pre-Weaned Calves	*10*	*11*	*14*	*14*	*16*	*18*	*22*	*26*	*29*	*33*
	Breeding Cattle 1st Year	*346*	*337*	*324*	*308*	*306*	*295*	*286*	*260*	*254*	*219*
	Breeding Cattle 2nd Year	*253*	*252*	*251*	*239*	*237*	*239*	*243*	*233*	*217*	*188*
	Breeding Cattle 3rd Year	*151*	*148*	*147*	*142*	*141*	*139*	*140*	*139*	*133*	*118*
	Fattening Cattle	*188*	*175*	*158*	*168*	*184*	*193*	*180*	*165*	*163*	*210*
Sheep		395	409	415	424	405	387	419	420	422	424
	Fattening Sheep	*191*	*201*	*201*	*211*	*201*	*191*	*208*	*208*	*209*	*222*
	Milksheep	*4*	*4*	*4*	*4*	*3*	*3*	*3*	*3*	*4*	*6*
Goats		68	65	58	57	55	53	57	58	60	62
	Goat Places	*45*	*43*	*38*	*37*	*36*	*35*	*37*	*38*	*40*	*41*
Horses		51	52	53	54	58	62	62	65	64	65
	Horses <3 years	*11*	*11*	*11*	*12*	*14*	*16*	*16*	*14*	*14*	*15*
	Horses >3 years	*40*	*41*	*42*	*43*	*44*	*45*	*47*	*51*	*50*	*51*
Mules and Asses		11	11	11	11	11	11	12	13	14	15
	Mules	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*1*
	Asses	*10*	*11*	*11*	*11*	*11*	*11*	*12*	*13*	*13*	*15*
Swine		1787	1723	1706	1692	1569	1446	1379	1395	1487	1453
	Piglets	*299*	*283*	*291*	*300*	*287*	*275*	*241*	*252*	*262*	*281*
	Fattening Pig over 25 kg	*1025*	*990*	*973*	*943*	*855*	*768*	*779*	*780*	*837*	*734*
	Dry Sows	*129*	*126*	*125*	*125*	*117*	*109*	*99*	*104*	*111*	*101*
	Nursing Sows	*37*	*37*	*37*	*37*	*35*	*33*	*30*	*30*	*31*	*35*
	Boars	*8*	*8*	*8*	*8*	*8*	*7*	*6*	*6*	*6*	*6*
Poultry		5938	5647	5502	6410	6330	6251	6440	6553	6740	6908
	Growers	*719*	*664*	*710*	*719*	*717*	*714*	*732*	*733*	*793*	*761*
	Layers	*3083*	*2645*	*2536*	*2518*	*2318*	*2118*	*2226*	*2278*	*2270*	*2223*
	Broilers	*2020*	*2199*	*2096*	*2990*	*3111*	*3231*	*3293*	*3342*	*3502*	*3747*
	Turkey	*95*	*117*	*140*	*163*	*166*	*170*	*174*	*184*	*158*	*155*
	Other Poultry (Geese, Ducks, Ostriches, Quails)	*22*	*21*	*21*	*20*	*18*	*17*	*15*	*16*	*16*	*22*

Table continued from last page:

Population Size		**2000-2009**									
		2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
		1000 head/places									
Cattle		1588	1611	1594	1570	1545	1555	1567	1572	1604	1597
Mature Dairy Cattle		669	669	658	638	621	621	618	615	629	599
Mature Non-Dairy Cattle		45	51	58	65	70	78	87	94	98	108
Young Cattle		874	891	878	867	854	856	862	863	877	890
	Fattening Calves	*103*	*115*	*114*	*114*	*111*	*106*	*101*	*100*	*95*	*101*
	Pre-Weaned Calves	*36*	*40*	*47*	*52*	*57*	*62*	*67*	*72*	*76*	*86*
	Breeding Cattle 1st Year	*236*	*238*	*230*	*220*	*215*	*222*	*223*	*223*	*232*	*226*
	Breeding Cattle 2nd Year	*222*	*219*	*219*	*213*	*205*	*205*	*210*	*210*	*213*	*212*
	Breeding Cattle 3rd Year	*130*	*130*	*126*	*124*	*121*	*113*	*110*	*109*	*110*	*119*
	Fattening Cattle	*147*	*148*	*142*	*144*	*145*	*147*	*149*	*148*	*152*	*147*
Sheep		421	420	430	445	441	446	448	444	446	432
	Fattening Sheep	*217*	*217*	*220*	*229*	*227*	*229*	*231*	*230*	*229*	*227*
	Milksheep	*7*	*7*	*7*	*8*	*8*	*9*	*10*	*10*	*11*	*12*
Goats		62	63	66	67	71	74	76	79	81	81
	Goat Places	*41*	*42*	*43*	*45*	*46*	*48*	*51*	*52*	*53*	*54*
Horses		66	64	64	65	65	65	66	67	68	69
	Horses <3 years	*13*	*12*	*12*	*11*	*11*	*11*	*11*	*11*	*11*	*10*
	Horses >3 years	*53*	*52*	*52*	*53*	*53*	*54*	*55*	*56*	*57*	*59*
Mules and Asses		16	16	17	17	18	19	19	20	20	22
	Mules	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
	Asses	*15*	*15*	*16*	*17*	*17*	*18*	*19*	*19*	*20*	*21*
Swine		1498	1548	1557	1529	1538	1609	1635	1573	1540	1557
	Piglets	*297*	*319*	*327*	*323*	*328*	*338*	*367*	*345*	*336*	*338*
	Fattening Pig over 25 kg	*751*	*763*	*768*	*752*	*753*	*797*	*786*	*767*	*763*	*779*
	Dry Sows	*105*	*108*	*109*	*105*	*108*	*113*	*115*	*106*	*105*	*105*
	Nursing Sows	*37*	*38*	*36*	*36*	*35*	*36*	*37*	*35*	*33*	*33*
	Boars	*6*	*6*	*6*	*5*	*5*	*5*	*5*	*4*	*4*	*4*
Poultry		6983	6939	7339	7587	8061	8260	7670	8228	8543	8809
	Growers	*832*	*745*	*754*	*809*	*853*	*868*	*888*	*902*	*919*	*967*
	Layers	*2150*	*2069*	*2154*	*2117*	*2089*	*2189*	*2147*	*2198*	*2255*	*2318*
	Broilers	*3808*	*3993*	*4298*	*4518*	*4971*	*5060*	*4481*	*5002*	*5300*	*5456*
	Turkey	*173*	*123*	*124*	*134*	*139*	*132*	*137*	*112*	*54*	*52*
	Other Poultry (Geese, Ducks, Ostriches, Quails)	*21*	*9*	*8*	*9*	*9*	*11*	*16*	*14*	*15*	*16*

Population Size		**2010-2012**		
		2010	**2011**	**2012**
		1000 head/places		
Cattle		1591	1577	1565
Mature Dairy Cattle		589	589	591
Mature Non-Dairy Cattle		111	111	114
Young Cattle		891	877	859
	Fattening Calves	*99*	*101*	*99*
	Pre-Weaned Calves	*88*	*88*	*91*
	Breeding Cattle 1st Year	*226*	*221*	*212*
	Breeding Cattle 2nd Year	*213*	*207*	*200*
	Breeding Cattle 3rd Year	*119*	*116*	*112*
	Fattening Cattle	*145*	*145*	*146*
Sheep		434	424	417
	Fattening Sheep	*228*	*222*	*219*
	Milksheep	*12*	*12*	*13*
Goats		83	83	85
	Goat Places	*55*	*56*	*57*
Horses		71	66	67
	Horses <3 years	*10*	*10*	*9*
	Horses >3 years	*61*	*56*	*58*
Mules and Asses		23	22	23
	Mules	*1*	*1*	*1*
	Asses	*22*	*21*	*22*
Swine		1589	1579	1544
	Piglets	*351*	*353*	*345*
	Fattening Pig over 25 kg	*788*	*787*	*776*
	Dry Sows	*106*	*103*	*97*
	Nursing Sows	*34*	*32*	*31*
	Boars	*4*	*3*	*3*
Poultry		9025	9478	9955
	Growers	*926*	*970*	*1076*
	Layers	*2438*	*2437*	*2521*
	Broilers	*5580*	*5984*	*6282*
	Turkey	*58*	*58*	*51*
	Other Poultry (Geese, Ducks, Ostriches, Quails)	*23*	*29*	*25*

Data on nitrogen excretion per animal category (kg N/head/year) is taken from Kupper et al. (2013) (see Table 6-13). These values are based on Flisch et al. (2009) and adjusted according to the Swiss ammonia model AGRAMMON. Unlike IPCC, the age structure of the animals and the different use of the animals (e.g. fattening and breeding) are considered. Standard nitrogen excretion rates are modified within the AGRAMMON model to accounts for changing agricultural structures and production techniques along the years (e.g. milk yield, protein reduced animal feed, use of feed concentrates etc.). Calculation of nitrogen excretion of mature dairy cattle is dependent on milk production and is therefore increasing from 1990 to 2007. In the year 2007 milk yield reaches 6500 liter per head and year. To reach higher milk yields farmers usually apply higher shares of energy rich feed concentrates. Consequently increases in nitrogen excretion rates are lower or nonexistent beyond a milk yield of 6500 liter per head and year (Flisch et al. 2009). In accordance with the AGRAMMON model the same nitrogen excretion rates as in 2010 have been used for the years 2011 and 2012 due to the lack of further survey results. Sheep in Switzerland are fed mainly according to a regime based on roughage from extensive pasture and meadows (Flisch et al. 2009) and are estimated to excrete approximately 8.0 kg N per head and year. This is considerably lower than IPCC default. However, nitrogen excretion is averaged over the whole population of which roughly 50% are lambs and other immature animals. Swine show a significant decrease in nitrogen excretion per head over almost the whole inventory time period which can be explained by the increasing use of protein reduced fodder.

The consideration of adopted nitrogen excretion values is one of the major advantages of the country specific method in Switzerland. The more disaggregated approach leads to considerable lower calculated nitrogen excretion rates compared to IPCC, which therefore also implies lower total N_2O emissions from manure management.

Table 6-13 Nitrogen excretion per animal category, 1990-2012 (Kupper et al. 2013).

Nitrogen Excretion		**Unit**	**1990-1999**									
			1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
			kg N / unit / year									
Mature Dairy Cattle		head	96.06	96.57	97.09	97.61	98.13	98.65	99.35	100.05	100.75	101.45
Mature Non-Dairy Cattle		head	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
Young Cattle Average (weighted)		head	33.08	33.11	33.21	33.13	33.31	33.37	33.28	33.56	33.31	32.85
	Fattening Calves	*place*	*13.00*	*13.00*	*13.00*	*13.00*	*13.00*	*13.00*	*13.00*	*13.00*	*13.00*	*13.00*
	Pre-Weaned Calves	*head*	*34.00*	*34.00*	*34.00*	*34.00*	*34.00*	*34.00*	*34.00*	*34.00*	*34.00*	*34.00*
	Breeding Cattle 1st Year	*head*	*25.00*	*25.00*	*25.00*	*25.00*	*25.00*	*25.00*	*25.00*	*25.00*	*25.00*	*25.00*
	Breeding Cattle 2nd Year	*head*	*40.00*	*40.00*	*40.00*	*40.00*	*40.00*	*40.00*	*40.00*	*40.00*	*40.00*	*40.00*
	Breeding Cattle 3rd Year	*head*	*55.00*	*55.00*	*55.00*	*55.00*	*55.00*	*55.00*	*55.00*	*55.00*	*55.00*	*55.00*
	Fattening Cattle	*place*	*33.00*	*33.00*	*33.00*	*33.00*	*33.00*	*33.00*	*33.00*	*33.00*	*33.00*	*33.00*
Sheep		head	7.46	7.56	7.46	7.64	7.62	7.59	7.58	7.58	7.63	8.14
	Fattening Sheep	*place*	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*
	Milksheep	*place*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*
Goats		head	10.49	10.58	10.56	10.53	10.47	10.41	10.43	10.42	10.58	10.59
	Goat Places	*place*	*16.00*	*16.00*	*16.00*	*16.00*	*16.00*	*16.00*	*16.00*	*16.00*	*16.00*	*16.00*
Horses		head	43.57	43.57	43.57	43.57	43.51	43.47	43.50	43.56	43.57	43.55
	Horses <3 years	*head*	*42.00*	*42.00*	*42.00*	*42.00*	*42.00*	*42.00*	*42.00*	*42.00*	*42.00*	*42.00*
	Horses >3 years	*head*	*44.00*	*44.00*	*44.00*	*44.00*	*44.00*	*44.00*	*44.00*	*44.00*	*44.00*	*44.00*
Mules and Asses		head	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70
	Mules	*head*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*
	Asses	*head*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*
Swine		head	13.37	13.38	13.31	13.13	12.95	12.75	12.72	12.35	11.99	10.88
	Piglets	*place*	*4.60*	*4.60*	*4.60*	*4.60*	*4.60*	*4.60*	*4.60*	*4.60*	*4.60*	*4.60*
	Fattening Pig over 25 kg	*place*	*17.01*	*16.95*	*16.88*	*16.81*	*16.75*	*16.68*	*16.15*	*15.63*	*15.10*	*14.58*
	Dry Sows	*place*	*24.28*	*24.28*	*24.28*	*24.28*	*24.28*	*24.28*	*23.53*	*22.77*	*22.02*	*21.26*
	Nursing Sows	*place*	*47.57*	*47.57*	*47.57*	*47.57*	*47.57*	*47.57*	*46.77*	*45.98*	*45.18*	*44.39*
	Boars	*head*	*20.50*	*20.50*	*20.50*	*20.50*	*20.50*	*20.50*	*20.02*	*19.53*	*19.04*	*18.56*
Poultry		head	0.57	0.56	0.56	0.54	0.53	0.53	0.54	0.54	0.54	0.55
	Growers	*place*	*0.34*	*0.34*	*0.34*	*0.34*	*0.34*	*0.34*	*0.34*	*0.33*	*0.33*	*0.32*
	Layers	*place*	*0.71*	*0.71*	*0.71*	*0.71*	*0.71*	*0.71*	*0.72*	*0.74*	*0.75*	*0.76*
	Broilers	*place*	*0.40*	*0.40*	*0.40*	*0.40*	*0.40*	*0.40*	*0.41*	*0.41*	*0.42*	*0.43*
	Turkey	*place*	*1.40*	*1.40*	*1.40*	*1.40*	*1.40*	*1.40*	*1.40*	*1.40*	*1.40*	*1.40*
	Other Poultry (Geese, Ducks, Ostriches, Quails)	*place*	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*

Nitrogen Excretion		**Unit**	**2000-2009**									
			2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
			kg N / unit / year									
Mature Dairy Cattle		head	102.15	102.85	103.55	104.49	105.42	106.35	107.28	108.21	108.20	108.18
Mature Non-Dairy Cattle		head	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
Young Cattle Average (weighted)		head	33.56	33.27	33.26	33.27	33.25	33.12	33.18	33.17	33.25	33.42
	Fattening Calves	*place*	*13.00*	*13.00*	*13.00*	*13.00*	*13.00*	*13.00*	*13.00*	*13.00*	*13.00*	*13.00*
	Pre-Weaned Calves	*head*	*34.00*	*34.00*	*34.00*	*34.00*	*34.00*	*34.00*	*34.00*	*34.00*	*34.00*	*34.00*
	Breeding Cattle 1st Year	*head*	*25.00*	*25.00*	*25.00*	*25.00*	*25.00*	*25.00*	*25.00*	*25.00*	*25.00*	*25.00*
	Breeding Cattle 2nd Year	*head*	*40.00*	*40.00*	*40.00*	*40.00*	*40.00*	*40.00*	*40.00*	*40.00*	*40.00*	*40.00*
	Breeding Cattle 3rd Year	*head*	*55.00*	*55.00*	*55.00*	*55.00*	*55.00*	*55.00*	*55.00*	*55.00*	*55.00*	*55.00*
	Fattening Cattle	*place*	*33.00*	*33.00*	*33.00*	*33.00*	*33.00*	*33.00*	*33.00*	*33.00*	*33.00*	*33.00*
Sheep		head	8.06	8.08	8.03	8.09	8.13	8.13	8.18	8.26	8.22	8.47
	Fattening Sheep	*place*	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*
	Milksheep	*place*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*	*21.00*
Goats		head	10.60	10.69	10.43	10.66	10.47	10.49	10.59	10.50	10.49	10.70
	Goat Places	*place*	*16.00*	*16.00*	*16.00*	*16.00*	*16.00*	*16.00*	*16.00*	*16.00*	*16.00*	*16.00*
Horses		head	43.60	43.61	43.63	43.64	43.65	43.66	43.66	43.67	43.67	43.70
	Horses <3 years	*head*	*42.00*	*42.00*	*42.00*	*42.00*	*42.00*	*42.00*	*42.00*	*42.00*	*42.00*	*42.00*
	Horses >3 years	*head*	*44.00*	*44.00*	*44.00*	*44.00*	*44.00*	*44.00*	*44.00*	*44.00*	*44.00*	*44.00*
Mules and Asses		head	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70
	Mules	*head*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*
	Asses	*head*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*	*15.70*
Swine		head	10.53	10.10	9.75	9.61	9.50	9.42	9.21	9.09	9.18	9.23
	Piglets	*place*	*4.60*	*4.60*	*4.60*	*4.56*	*4.53*	*4.49*	*4.45*	*4.42*	*4.40*	*4.38*
	Fattening Pig over 25 kg	*place*	*14.05*	*13.53*	*13.00*	*12.78*	*12.55*	*12.33*	*12.11*	*11.89*	*11.95*	*12.02*
	Dry Sows	*place*	*20.51*	*19.75*	*19.00*	*19.08*	*19.16*	*19.24*	*19.33*	*19.41*	*19.51*	*19.62*
	Nursing Sows	*place*	*43.59*	*42.80*	*42.00*	*42.43*	*42.86*	*43.30*	*43.73*	*44.16*	*43.17*	*42.18*
	Boars	*head*	*18.07*	*17.58*	*17.10*	*17.18*	*17.27*	*17.35*	*17.43*	*17.52*	*17.73*	*17.94*
Poultry		head	0.55	0.55	0.55	0.55	0.54	0.54	0.55	0.54	0.53	0.53
	Growers	*place*	*0.32*	*0.31*	*0.31*	*0.31*	*0.31*	*0.31*	*0.31*	*0.31*	*0.31*	*0.31*
	Layers	*place*	*0.77*	*0.79*	*0.80*	*0.80*	*0.80*	*0.80*	*0.80*	*0.80*	*0.80*	*0.80*
	Broilers	*place*	*0.44*	*0.44*	*0.45*	*0.45*	*0.45*	*0.45*	*0.45*	*0.45*	*0.45*	*0.45*
	Turkey	*place*	*1.40*	*1.40*	*1.40*	*1.40*	*1.40*	*1.40*	*1.40*	*1.40*	*1.40*	*1.40*
	Other Poultry (Geese, Ducks, Ostriches, Quails)	*place*	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*

Table continued from last page:

Nitrogen Excretion		Unit	2010-2012		
			2010	2011	2012
			kg N / unit / year		
Mature Dairy Cattle		head	108.17	108.17	108.17
Mature Non-Dairy Cattle		head	80.00	80.00	80.00
Young Cattle Average (weighted)		head	33.45	33.36	33.32
	Fattening Calves	*place*	*13.00*	*13.00*	*13.00*
	Pre-Weaned Calves	*head*	*34.00*	*34.00*	*34.00*
	Breeding Cattle 1st Year	*head*	*25.00*	*25.00*	*25.00*
	Breeding Cattle 2nd Year	*head*	*40.00*	*40.00*	*40.00*
	Breeding Cattle 3rd Year	*head*	*55.00*	*55.00*	*55.00*
	Fattening Cattle	*place*	*33.00*	*33.00*	*33.00*
Sheep		head	8.48	8.46	8.53
	Fattening Sheep	*place*	*15.00*	*15.00*	*15.00*
	Milksheep	*place*	*21.00*	*21.00*	*21.00*
Goats		head	10.57	10.76	10.83
	Goat Places	*place*	*16.00*	*16.00*	*16.00*
Horses		head	43.72	43.71	43.73
	Horses <3 years	*head*	*42.00*	*42.00*	*42.00*
	Horses >3 years	*head*	*44.00*	*44.00*	*44.00*
Mules and Asses		head	15.70	15.70	15.70
	Mules	*head*	*15.70*	*15.70*	*15.70*
	Asses	*head*	*15.70*	*15.70*	*15.70*
Swine		head	9.18	9.17	9.15
	Piglets	*place*	*4.36*	*4.36*	*4.36*
	Fattening Pig over 25 kg	*place*	*12.09*	*12.09*	*12.09*
	Dry Sows	*place*	*19.73*	*19.73*	*19.73*
	Nursing Sows	*place*	*41.19*	*41.19*	*41.19*
	Boars	*head*	*18.16*	*18.16*	*18.16*
Poultry		head	0.54	0.53	0.53
	Growers	*place*	*0.31*	*0.31*	*0.31*
	Layers	*place*	*0.80*	*0.80*	*0.80*
	Broilers	*place*	*0.45*	*0.45*	*0.45*
	Turkey	*place*	*1.40*	*1.40*	*1.40*
	Other Poultry (Geese, Ducks, Ostriches, Quails)	*place*	*0.56*	*0.56*	*0.56*

The split of nitrogen flows into the different animal waste management systems and its temporal dynamic is based on Kupper et al. (2013). The distribution is consistent with the allocation of volatile solids used for the calculation of CH_4 emissions (for further information refer to the previous section on CH_4 emissions).

6.3.3 Uncertainties and Time-Series Consistency

For the uncertainty analysis the input data from ART (2008a) was used and was weighted with current activity and emission data. The arithmetic mean of the lower and upper bound is used for activity data and for emission factors resulting in a combined uncertainty of 55% for CH_4 and 64% for N_2O in Tier 1 analysis, where N_2O includes the sum of liquid and solid storage. For Tier 2 analysis, liquid and solid storage are treated separately giving the following results for the uncertainty intervals and the mean uncertainties:

- 4B CH_4 [-54.5%; 55.1%], mean uncertainty 54.7%
- 4B N_2O liquid: [-86.4%; 69.3%], mean uncertainty 77.9%
- 4B N_2O solid: [-60.7%; 58.0%], mean uncertainty 59.4%

Further results of Tier 2 uncertainty analysis are shown in Table 1-18.

Time series consistency of livestock population data and gross energy intake: See Chapter 6.2.3.)

Input data from the AGRAMMON-model are available for the years 1990 and 1995 (expert judgement and literature) as well as for 2002, 2007 and 2010 (extensive farm surveys).

Values in between the assessment years were interpolated linearly while values beyond 2010 are kept constant until new survey results are available.

6.3.4 Source-Specific QA/QC and Verification

All QA/QC activities are further described in a separate document (ART 2013a). General information on agricultural structures and policies is provided and eventual differences between national and (IPCC) standard values are being analysed and discussed.

For quality of livestock population data and animal energy intake please consult Chapter 6.2.4.

The time series of activity data and emission factors have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the following triple check:

- the results for 2012 are compared with the results for 2011 within the current CRF
- the results for 2011 are compared between the current CRF-tables and the CRF-tables of the submission 2013
- the results for the base year 1990 are compared between the current CRF-tables and the CRF-tables of the submission 2013.

Additionally an independent quality control was conducted by INFRAS by a countercheck of the data and calculation sheets elaborated by Agroscope (Agroscope 2014).

a) CH_4

For CH_4 the documentation about the data set and calculation method assures transparency and traceability of the calculation methods (Soliva 2006). Additionally a document in German lists all the methodological differences between the former calculations and the current methodology regarding CH_4 estimations (Soliva 2006a).

IPCC tables with data for estimating emission factors for all livestock categories (such as weight, feed digestibility, maximum CH_4 producing capacity (B_0) or daily excretion of volatile solids) were filled in, checked for consistency and confidence and compared with IPCC default values (refer to Table A - 28 in Annex A3.3). Factors for methane conversion (MCF) and manure management distribution (MS) were analysed considering the Swiss national agricultural context.

The emission factors of 4B CH_4 were compared to the corresponding emission factors of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) and to the IPCC default value if available for submission 2013 (ART 2013a, INFRAS 2012). Most implied emission factors for CH_4 emissions from manure management in Switzerland are considerably above IPCC default. Differences are mainly due to different allocations to manure management systems i.e., a higher share of manure stored in liquid systems and as deep litter.

During the years 2009-2012 the group of animal nutrition from the Swiss Federal Institute of Technology Zürich investigated the effect of different feeding and management strategies on methane and nitrous oxide emissions from enteric fermentation and manure management of cattle held under typical Swiss management conditions (Kreuzer 2012). Measured values of various parameters such as digestible energy, B_0 or MCF have been compared to IPCC default values and values in the Swiss greenhouse gas inventory. Preliminary analysis suggests that overall emissions are neither over- nor underestimated (Zeitz et al. 2012). Further investigations have to show to what extent the preliminary estimates will be confirmed to provide a basis for implementation in Switzerland’s GHG inventory.

During the past years a couple of studies have been conducted to verify methane emissions at regional scale comparing bottom up estimates with atmospherical measurements (Hiller et al. 2014, Hiller et al. 2014a, Stieger 2014). For further information see section 6.2.4.

b) N_2O

N_2O estimation is based on the Swiss ammonium emission model AGRAMMON that is documented in Kupper et al. (2013).

All relevant data needed for the calculation of N_2O emissions such as nitrogen excretion, manure management system distribution and N_2O emission factors have been checked for consistency and have been compared to the corresponding values of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) and to the IPCC default value if available (ART 2013a). As one of the most important parameters, nitrogen excretion has been analysed in more detail. A comparison in 2011 revealed that bottom up calculations of total nitrogen excretion in the Swiss GHG inventory are only 5-8% below the values of an independent top down approach subtracting all nitrogen contained in animal products from the total amount of nitrogen in animal feedstuff produced in or imported to the country (Peter et al. 2006, Spiess 2005). Furthermore N_{ex} values for the most important animal categories (mature dairy cattle, mature non-dairy cattle and swine), being responsible for almost 70% of total nitrogen excretion, are very well in line with the alternative gross energy approach suggested in the 2006 IPCC guidelines.

6.3.5 Source-Specific Recalculations

For recalculation of livestock numbers, energy requirements and milk yield see chapter 6.2.5.

The nitrogen excretion rate of mature dairy cattle of the year 2011 has been revised in order to be consistent with the AGRAMMON model (Kupper et al. 2013). The reduced nitrogen excretion rate resulted in an overall emission reduction (including source category 4B and 4D) of less than 10 Gg CO_2 equivalent.

6.3.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. All methods will be adapted to the 2006 IPCC Guidelines (IPCC 2006). Within this general recalculation a number of optional country specific methods will be explored and eventually implemented.

Currently manure used for biogas production as reported under 1A1a and 6D is not subtracted from animal manure in sector 4B. It is planned to improve the respective cross sectoral reporting in future submissions to avoid double counting of emissions. The regulations for national compensation projects in the field of anaerobic manure treatment are still under revision. These regulations will be an important basis for the respective estimates in the national inventory as the issued emission reduction certificates should correspond to emission reductions in the inventory. The regulations should be finalized during 2014, so that the respective recalculations will be included in the GHG-Inventory submission 2015. Currently the agriculture expert is in contact with Ökostrom Schweiz, the association of approximately 100 energy-producing farmers in order to get the required data on manure processed in the digesters.

Other projects are eventually postponed in order to give first priority to changes related to the new reporting guidelines.

6.4 Source Category 4C – Rice Cultivation

Rice Cultivation is of minor importance in Switzerland. The agricultural land used for rice cultivation and the annual yield of rice are not estimated by the Swiss Farmers Union (SBV 2013). There is only some insignificant upland rice cultivation. CH_4 Emissions are assumed to be zero. They are therefore not considered in the emission calculation.

6.5 Source Category 4D – Agricultural Soils

6.5.1 Source Category Description

Tier 1 and Tier 2 Key category 4D:
4D1: N_2O emissions from Agricultural Soils; Direct Soil Emissions (level and trend)
4D2: N_2O emissions from Agric.Soils; Pasture, Range and Paddock Manure (level and trend)
4D3: N_2O emissions from Agricultural Soils; Indirect Soil Emissions (level and trend)

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

Direct and indirect N_2O emissions are decreasing since 1990 in almost all sub-categories. Contrarily N_2O emissions from animal production have been increasing due to a higher share of manure excreted on pasture, range and paddock. NO_x emissions declined by more than 18% since 1990.

The general trend can be explained by a reduction of the number of cattle and a reduced input of mineral fertilisers due to the introduction of the “Proof of Ecological Performance (PEP)” (ART 2013a, Leifeld and Fuhrer 2005). From 2004 on the cattle population increased again which lead to higher total animal manure nitrogen excretion.

Table 6-14 Specification of source category 4D Agricultural Soils. (AD: Activity data; EF: Emission factor).

4D	Source	Specification	Data Source
4D1	Direct soil emissions	Includes emissions from synthetic fertilizer, animal manure and crop residues, N-fixing crops, organic soils, residues from meadows and pasture, N-fixation on meadows and pasture	AD: SBV 2013, ART/SHL 2012, Agricura 2012, Flisch et al. 2009, FAL/RAC 2001, Kupper et al. 2013, Leifeld et al. 2003, Schmid et al. 2000, Walther et al. 1994; EF: IPCC 1997c (N_2O), IPCC 2000
4D2	Pasture, range and paddock manure	Emissions from pasture, range and paddock	AD: SBV 2013, ART/SHL 2012, Flisch et al. 2009, Kupper et al. 2013; EF: IPCC 1997c
4D3	Indirect emissions	Leaching and runoff, N deposition air to soil	AD: SBV 2013, ART/SHL 2012, Flisch et al. 2009, Kupper et al. 2013, Prasuhn and Braun 1994, Braun et al. 1994, Schmid et al. 2000, EEA 2007; EF: IPCC 2000
4D4	Other (sewage sludge and compost used for fertilizing)		AD: SBV 2013, Kupper et al. 2013; EF: IPCC 1997c

6.5.2 Methodological Issues

Methodology

For calculation of N_2O emissions from agricultural soils the national method IULIA is applied. IULIA is an IPCC-derived method for the calculation of N_2O emissions from agriculture that basically uses the same emission factors, but adjusts the activity data to the particular situation of Switzerland (Schmid et al. 2000). According to Schmid et al. (2000) IULIA is better adapted to the conditions of Swiss agriculture, compared to the IPCC method.

IULIA has been updated with new parameters derived from the Swiss ammonium model AGRAMMON (Kupper et al. 2013). New values for nitrogen excretion, manure system distribution and ammonium emission factors have been adopted. Furthermore the updated version of the "Principles of Fertilization in Arable and Forage Crop Production" (GruDAF; Flisch et al. 2009) has been used instead of obsolete data from FAL/RAC 2001 and Walther et al. 1994.

The modelling of the N_2O emissions is realised in Agroscope (2014). The model structure is displayed in the following figure.

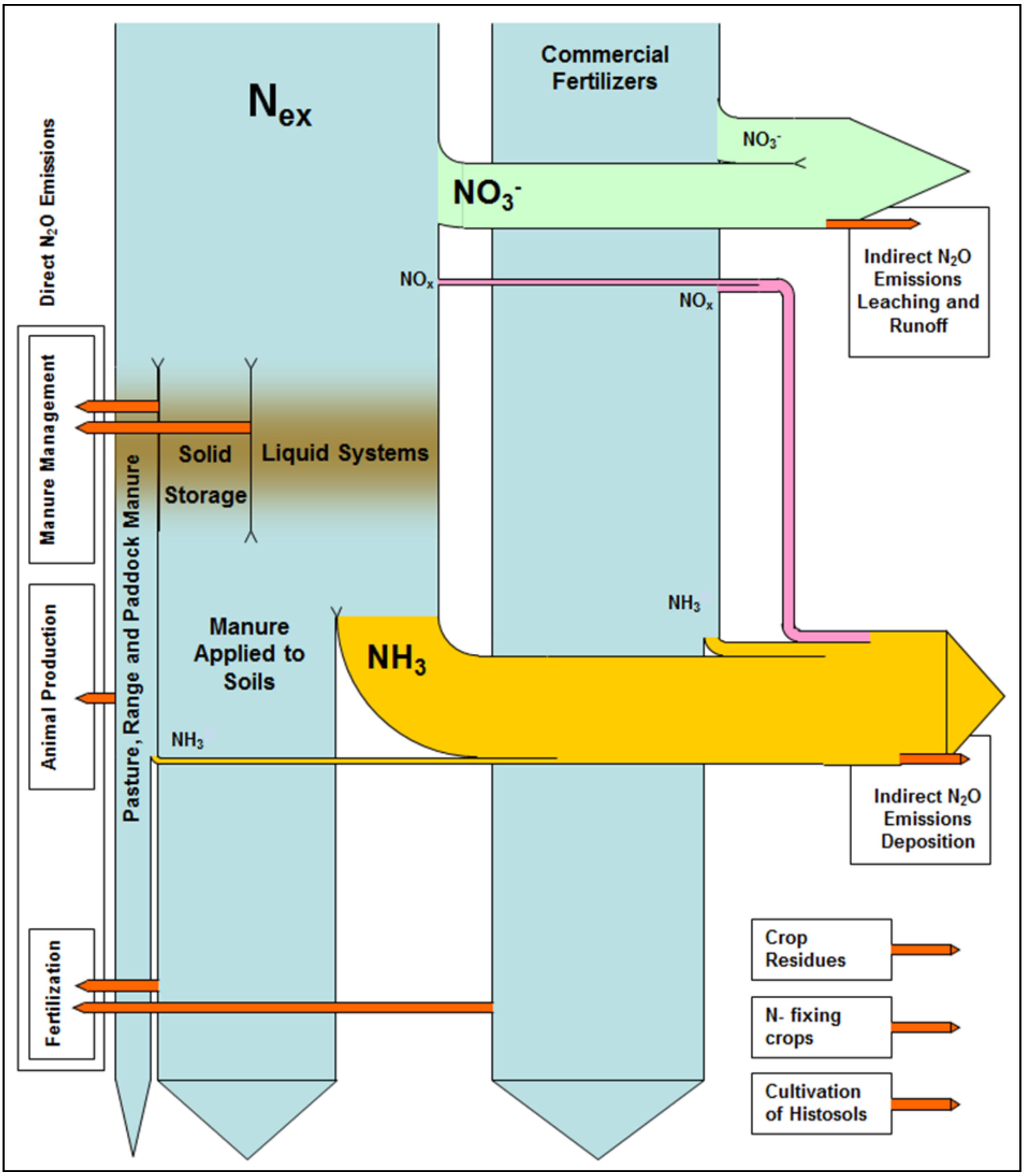

Figure 6-6 Diagram depicting the methodology of the approach to calculate the N_2O emissions in Agriculture. Note that the figure shows explicitly the methodology of the approach and not the physical nitrogen flow.

Main differences between the IULIA/AGRAMMON method and IPCC are (Schmid et al. 2000: p. 74):

- IULIA/AGRAMMON estimates lower nitrogen excretion per animal category, especially due to the lower excretions of young cattle (refer to chapter 6.3.2.b).
- The amount of losses to the atmosphere from the excreted nitrogen is almost 50% higher compared to IPCC.
- The amount of leaching (of manure nitrogen and of synthetic fertilizers) is lower by 1/3 compared to IPCC.

- Compared to the IPCC default method more manure is managed in liquid systems and less manure is excreted on pasture, range and paddock. Furthermore the manure management system distribution is not constant over the time series.
- The nitrogen inputs from biological fixation are higher by more than a factor of 30 since fixation on meadows and pastures are also considered. The consideration of nitrogen fixation from grassland is one of the major advantages of the method IULIA as the grassland accounts for the majority of nitrogen fixed in Swiss Agriculture.
- The nitrogen inputs from crop residues are only 25% higher although emissions from plant residue on grasslands are considered. This is explained by the fact that the emissions from plant residues returned to soils on cropland are estimated 50% below the IPCC defaults (see Schmid et al. 2000 p. 68).

Despite the different assumptions of the two methods, differences at the level of the N_2O emissions are quite moderate. In a comparison of the 1996 N_2O inventory, IULIA estimations of the N_2O emissions from agriculture were approximately 15% lower than the IPCC estimations (Schmid et al. 2000: p. 75). This comparison has been made with the original IULIA model in the year 2000. Since then the model has been developed further (e.g. implementation of the AGRAMMON model). A comprehensive comparison as conducted by Schmid et al. 2000 has not been made since.

Direct emissions from soil (4D1)

Calculation of direct N_2O emissions from soil is based on IPCC 2000 Tier 1b.

- Emissions from **synthetic fertilizer** include urea and other mineral fertilizers (mainly ammonium-nitrate). The amount of nitrogen input due to these fertilizers is taken from SBV (2013), Agricura (2012) and Kupper et al. (2013). Fertilizer statistics is based on sales statistics by the compulsory storekeepers of fertilizers (Pflichtlagerhalter) and small importers. Agricura conducts plausibility checks with import-data received by the Directorate General of Customs (Oberzolldirektion). From the amount of nitrogen in fertilizer, losses to the atmosphere in form of NH_3 are subtracted and the rest is multiplied with the corresponding N_2O emission factor. According to AGRAMMON NH_3 losses to the atmosphere are 15% for urea and 2% for other synthetic fertilizers (van der Weerden and Jarvis 1997) instead of the IPCC value of 10% for NH_3 and NO_x (see Table 6-16). For more information on ammonia volatilization from synthetic fertilizers see the paragraph on Indirect emissions (4D3). NO_x emissions are not subtracted since they occur mainly after the fertilizer application. Thus, the basis for N_2O-emissions is the synthetic fertilizer including the nitrogen that will be lost as NO_x later (Berthoud 2004).
- To model the emissions of **animal manure applied to soils**, nitrogen input from manure is calculated as the total N excretion minus N excreted on pasture, range and paddock minus ammonia volatilization from solid and liquid manure. The losses (to the atmosphere) as ammonia are specified for each animal category separately instead of using a fixed ratio of 20% (Kupper et al. 2013). For more information on ammonia volatilization from animal manure see the paragraph on indirect emissions (4D3). NO_x emissions are not subtracted since they occur after the application of animal wastes (Berthoud 2004). $Frac_{GASM}$ in CRF-table 4.Ds2 represents the amount of nitrogen volatilized as NH_3 from housing, manure storage and manure application divided by the manure excreted in the stable. The nitrogen input from manure applied to soils in CRF-table 4.Ds1 can thus be calculated with the numbers given in CRF-table 4.B(b) and 4.Ds2. For further details regarding the volatized N refer to Table 6-16.
- Emissions from **crop residues** are based on the amount of nitrogen in crop residues returned to soil. According to IULIA (Schmid et al. 2000: p. 68 and p. 100) the calculation of nitrogen in crop residues is based on data reported on crop yields (SBV

2013), the standard values for arable crop yields (FAL/RAC 2001 and Flisch et al. 2009) and standard amounts of nitrogen in crop residues returned to soils (FAL/RAC 2001 and Flisch et al. 2009). The calculation of the amount of nitrogen in crop residues returned to soil according to IULIA is as follows (Schmid et al. 2000: p. 101):

$$F_{CR} = \sum_{Cr} (E_{Cr} * \frac{NR_{Cr}}{Y_{Cr}})$$

F_{CR}: Amount of nitrogen in crop residues returned to soils (t N)
E_{Cr}: Amount of crop yields for culture Cr (t)
Y_{Cr}: Standard values for arable crop yields for culture Cr (t/ha)
NR_{Cr}: Standard amount of nitrogen in crop residues returned to soils (t/ha)

In addition to the N transfer from crop residues, IULIA also takes into account the plant residue returned to soils on meadows and pastures (Schmid et al. 2000). Three quarters of the agricultural land use consists of grassland which underscores the importance of this source for Switzerland. Input data on the managed area of meadows and pastures are taken from SBV (2013) and the Swiss Federal Statistical Office (SFSO 2013d). Estimated values of total crop production, nitrogen incorporated with crop residues $F_{(CR)}$, residue/crop ratio, dry matter (dm) fraction of residues and nitrogen content of residues are provided in Annex A3.3.

- For calculation of emissions from **N-fixing crops**, IULIA assumes that 60% of the nitrogen in leguminous crops originates from biological nitrogen fixation (Schmid et al. 2000: p. 70). This is in line with the IPCC Guidelines that state that biological nitrogen fixation supplies 50-60 per cent of the nitrogen in grain legumes (IPCC 1997c, p. 4.89). The total amount of nitrogen is calculated according to the calculation of nitrogen in crop residues, additionally taking into account the nitrogen contained in the crop product. In addition, IULIA takes biological nitrogen fixation on meadows and pastures into account, assuming a nitrogen concentration of 3.5% in the dry matter from which 80% derives from biological nitrogen fixation. For the dry matter production of clover on pastures and meadows statistical data were used (Schmid et al. 2000: p. 70). The following table gives an overview of the calculation of emissions from N-fixing crops.

Table 6-15 Input values for calculation of emissions from N-fixing crops according to IULIA (Schmid et al. 2000: p. 70).

Fixation	Share of N caused by fixation	Share of N in dry matter
Leguminous (N-fixing crops)	0.6	crop-specific
Clover (Fixation meadows and pasture)	0.8	0.035

Estimates of total crop production and nitrogen fixed per kg crop dry matter are provided in Annex A3.3.

- Emissions from **cultivated organic soils** are based on estimations on the area of cultivated organic soils and the IPCC default emission factor for N_2O emissions from cultivated organic soils (IPCC 1997b). The area of cultivated organic soils corresponds to the total area of organic soils under Cropland and Grassland as reported in CRF-table 5.B and 5.C (see also chapter 7.2.3).

Emissions from animal production (4D2)

Calculation of emissions from animal production is based on AGRAMMON (Kupper et al. 2013). IPCC equation 4.18, IPCC 2000: p. 4.42 is used, but country specific N excretion rates and manure management system distribution fractions (MS) are used (refer to chapter

6.3.2). The relevant input data are based on Flisch et al. (2009) and calculated within the Swiss ammonium model AGRAMMON.

Only emissions of pasture, range and paddock are to be reported under agricultural soils. Other emissions from animal production are reported under Manure Management.

Indirect emissions (4D3)

Calculation of the indirect emissions is based on IPCC 2000 Tier 1b.

- For calculation of N_2O emissions from **leaching and run-off**, N-leaching from commercial fertilizers (including synthetic fertilizers, sewage sludge and compost) and animal manure has to be estimated. The relevant input data is based on Flisch et al. 2009, Prasuhn and Braun (1994), Braun et al. (1994) and Prasuhn and Mohni (2003). $Frac_{Leach}$ is set as 0.2 instead of the IPCC default of 0.3. This country specific value is extrapolated from long-term monitoring and modelling studies from the canton of Berne (Prasuhn and Mohni 2003) while the default value is based on a global model which assumes that 30% of nitrogen from synthetic fertilizer and atmospheric deposition is reaching water bodies. According to Schmid et al. (2000: p.71) this later amount is not representative for N-excretion of livestock animals in Switzerland and would lead to a significant overestimation.
- N_2O emissions from **deposition** are based on NH_3 and NO_x emissions. NH_3-losses to the atmosphere are calculated according to the Swiss ammonium emission model AGRAMMON (Kupper et al. 2013). Input data for AGRAMMON for the years 1990 and 1995 are mainly based on expert judgements and literature studies whereas data for 2002, 2007 and 2010 include extensive farm surveys. Values in between the assessment years have been interpolated linearly while values beyond 2010 are kept constant until new survey results are available. For the calculation of NH_3 emissions changes of agricultural structures (changes to more animal friendly housing systems) and techniques (manure management, measures to reduce NH_3 emissions) are considered and explain temporal dynamics. Specific losses for all livestock categories are estimated. Ammonium volatilization of nitrogen in synthetic fertilizers is 15% for urea and 2% for other synthetic fertilizers. These estimates are based on a literature review by van der Weerden and Jarvis (1997) who examined ammonia emission factors for ammonium nitrate and urea for grassland and cropland soils. The emission factors for all other applied synthetic nitrogen (as straight and compound fertilizers) were assumed to be similar to that for ammonium nitrate. Ammonia emission factors for recycling fertilizers (sewage sludge and compost) are between 10 and 20% depending on the relative share of the individual fertilizer types (Kupper et al. 2013). Total $Frac_{GASF}$[14] has declined considerably due to a change in the shares of the different components that contribute to $Frac_{GASF}$ (weighted mean): the use of urea and sewage sludge (which both have high NH_3 emission factors) has been declining since 1990. Furthermore, volatilization of 2.0 kg NH_3 -N/ha agricultural soil is assumed due to processes in the vegetation cover (Kupper et al. 2013). Details about the amount of volatized NH_3 are provided in the following table.

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[14] The concepts of $Frac_{GASF}$ and $Frac_{GASM}$ in the Swiss GHG-Inventory are not used as straight-forward as in the IPCC Guidelines and GPG. The Swiss Model applies two respective data sets: one for the estimation of nitrogen applied to agricultural soils and another used for the estimation of atmospheric nitrogen deposition. $Frac_{GASM}$ as reported in CRF-table 4.Ds2 represents the amount of nitrogen volatilized as NH_3 from housing, manure storage and manure application divided by the manure excreted in the stable. The nitrogen input from manure applied to soils in CRF-table 4.Ds1 can thus be calculated with the numbers given in CRF-table 4.B(b) and 4.Ds2. For the calculation of indirect N_2O emissions from atmospherical deposition all nitrogen volatilizations are considered inculding NO_x emissions and ammonia volatilization on pasture, range and paddock.

Table 6-16 Overview of Ammonia emission factors 1990–2010. Data source: Kupper et al. (2013)

Ammonia Emission Factor		**1990**	**1995**	**2002**	**2007**	**2010**
		%				
Mature Dairy Cattle		35.12	35.25	32.74	33.69	33.33
Mature Non-Dairy Cattle		31.47	32.08	28.17	33.63	31.24
Young Cattle Average (weighted)		33.94	34.43	30.99	33.21	33.07
	Fattening Calves	*39.58*	*39.97*	*38.66*	*40.83*	*40.54*
	Pre-Weaned Calves	*31.47*	*32.08*	*29.04*	*33.24*	*35.01*
	Breeding Cattle 1st Year	*33.94*	*34.45*	*31.05*	*33.86*	*33.80*
	Breeding Cattle 2nd Year	*30.23*	*30.63*	*27.14*	*29.33*	*29.47*
	Breeding Cattle 3rd Year	*32.09*	*32.55*	*28.46*	*31.17*	*31.10*
	Fattening Cattle	*41.31*	*41.46*	*40.14*	*39.61*	*38.11*
Sheep		21.20	21.21	20.32	19.14	20.51
	Fattening Sheep	*21.08*	*21.13*	*20.31*	*18.91*	*20.35*
	Milksheep	*24.86*	*24.92*	*20.53*	*22.88*	*22.65*
Goats		24.64	24.71	24.32	24.88	24.25
	Goat Places	*24.64*	*24.71*	*24.32*	*24.88*	*24.25*
Horses		25.77	25.84	22.12	23.36	21.90
	Horses <3 years	*25.77*	*25.84*	*19.14*	*18.83*	*19.84*
	Horses >3 years	*25.77*	*25.84*	*22.77*	*24.22*	*22.22*
Mules and Asses		25.77	25.84	21.86	22.18	23.24
	Mules	*25.77*	*25.84*	*21.86*	*22.18*	*23.24*
	Asses	*25.77*	*25.84*	*21.86*	*22.18*	*23.24*
Swine		38.26	38.87	45.01	45.34	44.40
	Piglets	*38.26*	*38.39*	*38.24*	*39.94*	*43.37*
	Fattening Pig over 25 kg	*38.26*	*38.96*	*46.68*	*46.60*	*44.07*
	Dry Sows	*38.26*	*38.99*	*46.30*	*47.47*	*48.36*
	Nursing Sows	*38.26*	*38.39*	*38.94*	*40.27*	*41.69*
	Boars	*38.26*	*38.39*	*46.53*	*47.78*	*47.28*
Poultry		41.77	38.93	32.48	30.65	30.86
	Growers	*48.76*	*46.29*	*44.96*	*35.39*	*31.95*
	Layers	*44.93*	*44.40*	*36.55*	*35.54*	*35.62*
	Broilers	*32.72*	*32.32*	*27.59*	*25.96*	*27.12*
	Turkey	*32.72*	*33.07*	*29.66*	*34.40*	*27.11*
	Other Poultry (Geese, Ducks, Ostriches, Quails)	*32.72*	*32.99*	*32.53*	*33.34*	*36.70*
Fertilizer		6.10	5.83	4.99	4.61	4.11
	Urea	*15.00*	*15.00*	*15.00*	*15.00*	*15.00*
	Other Mineral Fertilizers	*2.00*	*2.00*	*2.00*	*2.00*	*2.00*
	Recycling Fertilizers	*17.58*	*19.74*	*18.03*	*12.32*	*9.58*
Other: Vegetation cover (kg/ha/year)		2.00	2.00	2.00	2.00	2.00

Other (sewage sludge and compost used for fertilizing) (4D4)

This source category covers N_2O emissions from sewage sludge and from compost used for fertilization. The calculation of the emissions corresponds to the one for synthetic fertilizer. Both direct soil emissions as well as indirect soil emissions (atmospherical deposition and leaching and runoff) are considerd. Since 2003 the use of sewage sludge as fertilizer is prohibited in Switzerland. However, a transition period applies for some areas. Accordingly the cantons could prolong this period until 2008 in individual cases (UVEK 2003).

Activity data is based on Kupper et al. (2013) and has been consolidated by the responsible persons at the School of Agricultural, Forest and Food Science (HAFL, Kupper et al. 2013). Estimates are available for the years 1990, 1995, 2000, 2005, 2007 and 2010 and years in between have been interpolated linearly. Beyond 2010 constant values as in 2010 are used until further survey results are available.

NO_x emissions

NO_x emissions are estimated to be 0.7% of total nitrogen from animal manure and synthetic fertilizer, sewage sludge and compost. This factor is based on the CORINAIR Emission Inventory Guidebook 2003 (EEA 2007). Data on N-excretion (kg N/head/yr) is based on

Flisch et al. (2009) and calculated within AGRAMMON (Kupper et al. 2013). The amount of nitrogen from synthetic fertilizer, sewage sludge and compost is taken from Agricura (2012), Kupper et al. (2013) and SBV (2013).

NMVOC emissions

Estimation of NMVOC emissions of meadows and arable land is based on Spirig and Neftel (2002). VOC flows are estimated in Warneke et al. (2002) (for meadows) and König et al. (1995) (for arable land). Emissions were measured in a field trial in Austria (Karl et al. 2001).

Emission factors

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

Table 6-17 Emission factors for calculating N_2O emissions from agricultural soils (IPCC 1997c: tables 4.18 (direct emissions), 4.22 (pasture, range and paddock) and 4.23 (indirect emissions); IPCC 2000: table 4.17 (organic soils).

Emission Source	Emission factor
Direct Emissions	
Synthetic fertilizer (kg N_2O-N/kg)	0.0125
Animal manure nitrogen used as fertilizer (kg N_2O-N/kg)	0.0125
Crop residue (kg N_2O-N/kg)	0.0125
N-fixing crops (kg N_2O-N/kg)	0.0125
Organic soils (kg N_2O-N/ha)	8
Residues meadows and pasture (kg N_2O-N/kg)	0.0125
N-fixing meadows and pasture (kg N_2O-N/kg)	0.0125
Animal production	
Pasture, range and paddock (kg N_2O-N/kg)	0.0200
Indirect emissions	
Leaching and run-off (kg N_2O-N/kg)	0.0250
Deposition (kg N_2O-N/kg)	0.01
Other	
Other (sewage sludge and compost used for fertilizing) (kg N_2O-N/kg)	0.0125

Activity data

Activity data for calculation of direct soil emissions has been provided by ART/SHL (2012; animal livestock population), SBV (2013; use of synthetic fertilizer, crop yields, area of meadows and pasture), Agricura (2012; use of synthetic fertilizer), FAL/RAC (2001: p. 48/49), Schmid et al. (2000), Walther et al. (1994), Flisch et al. (2009) and Kupper et al. (2013).

Use of synthetic fertilizers in public green areas, sports grounds and home gardens (domestic synthetic fertilizer use) is 4% of all synthetic fertilizers (Kupper et al. 2013) and reported under 4D1.6 Other Direct Emissions.

The relevant activity data for calculating N_2O emissions from soils is displayed in the following table. Additional information is given in Table A - 29 and Table A - 30 in Annex A3.3.

Table 6-18 Activity data for calculating N_2O emissions from agricultural soils.

Related Activity Data		1990-1999									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		Value									
Direct Emissions											
Fertilizers (t N/yr)	Total commercial fertilizers	70'744	71'611	71'543	66'869	63'272	63'399	61'050	53'460	53'581	55'667
	Mineral fertilizer (t N/yr)	66'096	66'877	66'724	61'964	58'283	58'326	56'213	48'855	49'207	51'521
	Sewage sludge (t N/yr)	3'852	3'834	3'816	3'797	3'778	3'758	3'497	3'239	2'984	2'731
	Compost (t N/yr)	796	900	1'003	1'107	1'211	1'315	1'340	1'365	1'390	1'416
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	81'496	80'382	78'701	77'379	76'677	75'041	73'762	70'902	69'587	66'873
N-fixation	N fixation peas, dry beans, soybeans and leguminous vegetables (t N/yr)	681	774	909	796	811	861	931	1'131	1'107	1'049
	N fixation meadows and pasture (t N/yr)	29'027	29'325	29'728	29'602	28'913	30'270	30'645	30'862	30'868	30'852
Crop residue	N from crop residues (t N/yr)	11'335	11'170	11'053	11'249	10'634	10'838	12'145	11'742	11'803	10'555
	N from residues meadows and pasture (t N/yr)	21'473	21'574	21'713	21'677	21'461	21'903	22'032	22'080	22'156	22'069
	Area of meadows and pasture (ha)	784'867	788'089	792'338	791'387	785'006	798'550	802'514	803'722	807'945	805'131
Organic soils	Area of cultivated organic soils (ha)	18'493	18'458	18'423	18'391	18'353	18'314	18'276	18'241	18'205	18'170
Animal production											
Pasture, range and paddock	N excretion on pasture range and paddock (t N/yr)	13'148	13'399	13'498	13'421	13'691	13'833	15'615	16'805	18'040	18'800
Indirect emissions											
	N excretion of all animals (t N/yr)	144'593	143'184	140'768	138'724	138'066	135'756	135'750	132'553	131'987	128'452
	Fertilizer (t N/yr)	75'339	75'675	75'612	70'848	67'185	67'321	64'841	56'660	56'580	58'699
Leaching and run-off	N from fertilizers and animal manure that is lost through leaching and run off (t N/yr)	43'986	43'772	43'276	41'914	41'050	40'615	40'118	37'843	37'713	37'430
Deposition	Emissions NH_3 from fertilizers, animal manure and agricultural soils (tN/yr)	57'331	56'274	55'455	54'723	54'449	53'655	53'113	51'045	50'426	48'908
	Emissions NO_x from fertilizers and animal manure (t N/yr)	1'540	1'532	1'515	1'467	1'437	1'422	1'404	1'324	1'320	1'310
	Area of agricultural soils (ha)	1'066'981	1'069'630	1'072'279	1'074'928	1'077'577	1'080'226	1'082'875	1'075'727	1'078'405	1'071'899

Related Activity Data		2000-2009									
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		Value									
Direct Emissions											
Fertilizers (t N/yr)	Total commercial fertilizers	54'824	58'660	57'102	54'666	54'749	53'587	52'708	54'859	52'121	49'542
	Mineral fertilizer (t N/yr)	50'903	54'896	53'496	51'217	51'458	50'454	49'559	51'694	48'886	46'220
	Sewage sludge (t N/yr)	2'481	2'169	1'858	1'546	1'235	923	779	635	423	212
	Compost (t N/yr)	1'441	1'595	1'749	1'903	2'056	2'210	2'370	2'530	2'812	3'110
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	65'209	64'609	63'125	62'268	61'606	62'443	62'667	62'702	64'371	64'117
N-fixation	N fixation peas, dry beans, soybeans and leguminous vegetables (t N/yr)	840	734	1'144	1'256	1'322	1'179	1'107	1'093	1'069	1'028
	N fixation meadows and pasture (t N/yr)	30'817	31'120	31'143	31'485	31'623	31'089	31'204	31'639	31'671	31'872
Crop residue	N from crop residues (t N/yr)	11'887	10'386	11'446	9'737	11'814	11'513	10'529	11'508	11'492	11'874
	N from residues meadows and pasture (t N/yr)	22'055	22'217	22'220	22'321	22'334	22'174	22'199	22'267	22'249	22'269
	Area of meadows and pasture (ha)	806'369	809'441	809'597	812'624	812'370	807'793	808'416	809'187	808'300	807'927
Organic soils	Area of cultivated organic soils (ha)	18'134	18'098	18'063	18'027	17'991	17'970	17'937	17'904	17'883	17'853
Animal production											
Pasture, range and paddock	N excretion on pasture range and paddock (t N/yr)	20'921	22'643	24'166	23'858	23'432	23'555	23'719	23'718	23'868	23'402
Indirect emissions											
	N excretion of all animals (t N/yr)	128'095	129'120	128'423	127'016	125'842	127'797	128'785	129'136	131'539	130'195
	Fertilizer (t N/yr)	57'919	61'759	60'100	57'340	57'481	56'021	55'015	57'510	54'469	51'628
Leaching and run-off	N from fertilizers and animal manure that is lost through leaching and run off (t N/yr)	37'203	38'176	37'705	36'871	36'664	36'764	36'760	37'329	37'202	36'365
Deposition	Emissions NH_3 from fertilizers, animal manure and agricultural soils (tN/yr)	48'265	48'259	47'499	46'918	46'869	47'582	48'067	48'724	48'999	48'077
	Emissions NO_x from fertilizers and animal manure (t N/yr)	1'302	1'336	1'320	1'290	1'283	1'287	1'287	1'307	1'302	1'273
	Area of agricultural soils (ha)	1'072'492	1'071'130	1'069'770	1'067'055	1'064'573	1'065'118	1'065'199	1'060'242	1'058'100	1'055'648

Related Activity Data		2010-2012		
		2010	2011	2012
		Value		
Direct Emissions				
Fertilizers (t N/yr)	Total commercial fertilizers	56'849	50'464	48'954
	Mineral fertilizer (t N/yr)	53'425	47'040	45'529
	Sewage sludge (t N/yr)	0	0	0
	Compost (t N/yr)	3'424	3'424	3'424
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	64'504	64'187	64'145
N-fixation	N fixation peas, dry beans, soybeans and leguminous vegetables (t N/yr)	1'037	1'096	1'014
	N fixation meadows and pasture (t N/yr)	31'983	32'164	32'117
Crop residue	N from crop residues (t N/yr)	10'442	12'178	11'251
	N from residues meadows and pasture (t N/yr)	22'266	22'332	22'299
	Area of meadows and pasture (ha)	807'226	809'513	808'355
Organic soils	Area of cultivated organic soils (ha)	17'822	17'790	17'759
Animal production				
Pasture, range and paddock	N excretion on pasture range and paddock (t N/yr)	22'992	22'726	22'662
Indirect emissions				
	N excretion of all animals (t N/yr)	129'900	129'089	128'871
	Fertilizer (t N/yr)	59'287	52'687	50'987
Leaching and run-off	N from fertilizers and animal manure that is lost through leaching and run off (t N/yr)	37'838	36'355	35'972
Deposition	Emissions NH_3 from fertilizers, animal manure and agricultural soils (tN/yr)	48'122	47'666	47'361
	Emissions NO_x from fertilizers and animal manure (t N/yr)	1'324	1'272	1'259
	Area of agricultural soils (ha)	1'051'748	1'051'866	1'051'063

6.5.3 Uncertainties and Time-Series Consistency

For the uncertainty analysis the input data from ART (2008a) was used and was weighted with current activity and emission data. The arithmetic mean of the lower and upper bound uncertainty is used for activity data and for emission factors, resulting in the following combined uncertainties for Tier 1 analysis: 4D1: 83%, 4D2: 85%, 4D3: 166% and 4D4 80%. To aggregate fertilizer and organic soils to a single category 4D1 and atmospheric deposition, leaching and run-off to 4D3 (as required for input into Tier 1 analysis), the combined uncertainty of the emissions is determined by using Tier 1 error propagation for the sub-systems.

For Tier 2 analysis the uncertainties are shown in Table 6-19. For further results see Section 1.7 and Annex 7.

Table 6-19 Combined uncertainties for N_2O emissions from 4D Agricultural Soils.

Source categories 4D			gas	lower bound 2.5% (in %)	upper bound 97.5% (in %)	mean uncertainty %
4D1	D. Agricultural Soils; Direct Soil Emissions	fertilizer	N_2O	-6	242	124
4D1		organic soils	N_2O	41	171	65
4D2	D. Agricultural Soils; Pasture, Range and Paddock Manure		N_2O	40	151	55
4D3	D. Agricultural Soils; Indirect Emissions	deposition	N_2O	37	182	72
4D3		leaching and runoff	N_2O	39	224	92
4D4	D. Agricultural Soils; Sewage sludge and compost		N_2O	20	180	80

For details on time-series consistency see Chapter 6.2.3 and 6.3.3.

6.5.4 Source-Specific QA/QC and Verification

All QA/QC activities are further described in a separate document (ART 2013a). General information on agricultural structures and policies is provided and eventual differences between national and (IPCC) standard values are being analysed and discussed.

An internal documentation of the Agroscope Research Station about the calculation of the greenhouse gas emissions in agriculture assures transparency and traceability of the calculation methods (Berthoud 2004). IULIA is described in Schmid et al. (2000) and the Swiss ammonium emission model AGRAMMON is documented in Kupper et al. (2013) and Agrammon 2010.

All relevant data needed for the calculation of direct and indirect nitrogen inputs to agricultural soils (e.g. F_{SN}, MS-distribution, $Frac_{GASF}$, N_{ex}, $Frac_{GASM}$, F_{BN}, F_{CR}) have been checked for consistency and confidence and have been compared (where possible) to IPCC default values, values of other countries as well as literature values. As one of the most important parameters, nitrogen excretion has been analysed in more detail as described in Chapter 6.3.4.

For quality of livestock population data consult Chapter 6.2.4.

The implied emission factors have been compared to the corresponding emission factors of other countries (UNFCCC http://unfccc.int/di/FlexibleQueries.do) (INFRAS 2012). Additionally, N_2O emission factors have been compared to literature values to assure plausibility. Implied emission factors are generally in line with measurements representative for Swiss conditions (ART 2013a).

The estimate for cultivated histosols in the agricultural sector is consistent with the estimates reported under Cropland and Grassland in the LULUCF sector. A literature study conducted by Leifeld et al. (2003) comes up with an estimate of 17'000 ± 5'000 ha which is close to the numbers reported in the LULUCF sector (18'100 ha on average).

The time series of activity data and emission factors have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the following triple check:

- the results for 2012 are compared with the results for 2011 within the current CRF

- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of the submission 2013.
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of the submission 2013

Additionally an independent quality control was conducted by INFRAS by a countercheck of the data and calculation sheets elaborated by Agroscope (Agroscope 2014).

6.5.5 Source-Specific Recalculations

For recalculation of livestock numbers see chapter 6.2.5.

For recalculation of the nitrogen excretion rate of mature dairy cattle of the year 2011 see chapter 6.3.5.

The area of cultivated organic soils has been revised due to new projections in the LULUCF-sector. Average absolute difference in area of organic soils are only 0.03% and the mean change of overal greenhouse gas emissions is below 0.02 Gg CO_2 equivalent.

Activity data for compost for the years 2008-2011 has been revised due to an error correction. New emission estimates are lower by approximately 7-8 Gg CO_2 equivalent.

The ammonia emission factor for recycling fertilizers (liquid digestate) has been adjusted for the years 2008 - 2011 due to the increasing use of trailing hoses during land application as fertilizer. Due to the low quantities of applied nitrogen from this source, impact on $Frac_{GASF}$ and on overall emissions is negligible.

A general recalculation for the year 2011 has been carried out due to some updates of crop yield data from the Swiss Farmers Union (SBV 2012). The respective changes are only of minor importance for total emission estimates.

6.5.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. All methods will be adapted to the 2006 IPCC Guidelines (IPCC 2006). Within this general recalculation a number of optional country specific methods will be explored and eventually implemented. Other projects are eventually postponed in order to give first priority to changes related to the new reporting guidelines.

6.6 Source Category 4E – Burning of savannahs

Burning of savannahs does not occur (NO) in Switzerland.

6.7 Source Category 4F – Field Burning of Agricultural Residues

Source category 4F Field Burning of Agricultural Residues has been moved to sector 6 Waste. Emissions from open burning of branches in agriculture and forestry have been reported here in the past. However, since branches in agriculture and forestry are burned only after they have been translocated from their place of origin, they should be reported under sector 6 Waste in accordance to the EMEP guidebook 2009 (EEA 2010). Accordingly the source category has been moved to 6C1 and is now reported under 6.C Waste Incineration, a. biogenic.

7 LULUCF

7.1 Overview of LULUCF

7.1.1 Methodology

Chapter 7 presents estimates of greenhouse gas emissions by sources and removals by sinks from land use, land-use change and forestry (LULUCF). Data acquisition and calculations are based on the Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003) and are completed by country specific methodologies.

The land areas in the period 1990-2012 are represented by geographically explicit land-use data with a resolution of one hectare (following approach 3 for representing land areas; IPCC 2003). Direct and repeated assessment of land use with full spatial coverage also enables to calculate spatially explicit land-use change matrices. In 2004, the Swiss Land Use Statistics AREA was launched. Simultaneously, aerial photos from two earlier Swiss Land Use Statistics (1979/85 and 1992/97) were re-evaluated, applying the same approach. At the editorial deadline AREA had been completed and the interpretation of the entire Swiss territory was available for three time slices.

The six main land-use categories required by IPCC (2003) are: A. Forest Land, B. Cropland, C. Grassland, D. Wetlands, E. Settlements and F. Other Land. These categories were divided in 18 sub-divisions of land use. A further spatial stratification reflects the criteria “altitude” (3 zones),”geomorphologic and climatic conditions” (adopting the five production regions of the National Forest Inventory; NFI) and ”soil type” (mineral, organic).

Country specific emission factors and carbon stocks for Forest Land were derived from four Swiss National Forest Inventories (NFI 1 – NFI 4a+), which had been finalised in 1985, 1995, 2006 and 2012, respectively. The inventories comprehended ca. 2'600 (2012), 6'000 (1995, 2006) and 12'000 (1985) terrestrial sampling plots (see Table 7-11), where biomass stock, growth, harvesting and mortality had been measured.

For the remaining land-use categories, carbon stocks and GHG emissions/removals were derived from particular research activities, domestic surveys and measurements in the fields of agriculture (cropland, grassland) and nature conservation (wetlands). Partially, also IPCC default values and expert estimates were used.

7.1.2 Emissions and Removals

Table 7-1 and Figure 7-1 summarize the CO_2 emissions and removals as a result of carbon losses and gains for the years 1990-2012. The total net emissions and removals of CO_2 from 1990 to 2012 vary between -3'331 Gg (1993) and 1'266 Gg (2001).

In Table 7-1 and Figure 7-1, four components of the CO_2 balance are differentiated:

- Gains in carbon stock of living biomass on all land uses and due to land-use changes; it represents the largest sink of carbon.
- Losses in carbon stock of living biomass on all land uses and due to land-use changes; it represents the largest source of carbon. The highest losses are observed in the years following a heavy storm with windfall in December 1999.
- Net carbon stock changes in dead organic matter (DOM) on forest land remaining forest land as well as on forest land converted to non-forest land: it represents a sink of carbon in most years from 1990-2006. Since 2007 this item is a source.
- Balance of carbon emissions and removals (1) in soils due to the use of soils (especially of organic soils) and due to land-use changes, (2) by agricultural lime application, and (3)

by wildfires. In the period under investigation this accumulative component persistently represents a source of carbon.

In forests, growth of biomass exceeds the harvesting and mortality rate except for the years 2000-2002. Compared to CO_2 fluxes involved in forest biomass dynamics, the net CO_2 emissions arising from the use of soils, from agricultural lime application, wildfires, and from all land-use changes are relatively small. Overall, the LULUCF sector was a sink of -1'702 Gg CO_2 on the average between 1990 and 2012 (see Table 7-1 and Figure 7-2).

Table 7-1 Switzerland's CO_2 emissions and removals (Gg) of category 5 Land Use, Land-Use Change and Forestry 1990-2012. Positive values refer to emissions; negative values refer to removals. In this data set, emissions of CH_4 and N_2O are not included. Land-use changes include Afforestation and Deforestation.

LULUCF	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	Gg CO_2									
Gains of living biomass	-12'690	-12'627	-12'772	-12'725	-12'665	-12'913	-12'962	-12'906	-12'552	-12'562
Losses of living biomass	9'886	10'054	10'018	8'903	9'392	9'032	9'829	9'703	10'008	10'777
Net change in dead organic matter	136	-123	-74	-193	141	9	-326	-787	-1'154	-1'098
Net change in soil, liming, wildfires	706	683	680	683	701	708	707	733	719	713
Total Sector 5: LULUCF	-1'962	-2'013	-2'147	-3'331	-2'432	-3'164	-2'752	-3'257	-2'979	-2'169

LULUCF	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	Gg CO_2									
Gains of living biomass	-12'981	-12'579	-12'635	-12'597	-13'303	-12'718	-12'846	-13'599	-13'383	-13'419
Losses of living biomass	13'306	14'002	13'543	11'272	10'743	11'166	11'105	11'071	11'057	10'783
Net change in dead organic matter	-1'041	-868	-667	-838	-832	-1'131	-662	22	856	1'143
Net change in soil, liming, wildfires	712	711	718	721	709	730	730	720	681	667
Total Sector 5: LULUCF	-3	1'266	961	-1'441	-2'683	-1'953	-1'672	-1'785	-789	-827

LULUCF	**2010**	**2011**	**2012**	**Mean**
	Gg CO_2			
Gains of living biomass	-13'348	-13'995	-13'361	-12'962
Losses of living biomass	10'865	10'539	10'733	10'773
Net change in dead organic matter	859	863	809	-215
Net change in soil, liming, wildfires	677	680	677	703
Total Sector 5: LULUCF	-948	-1'914	-1'142	-1'702

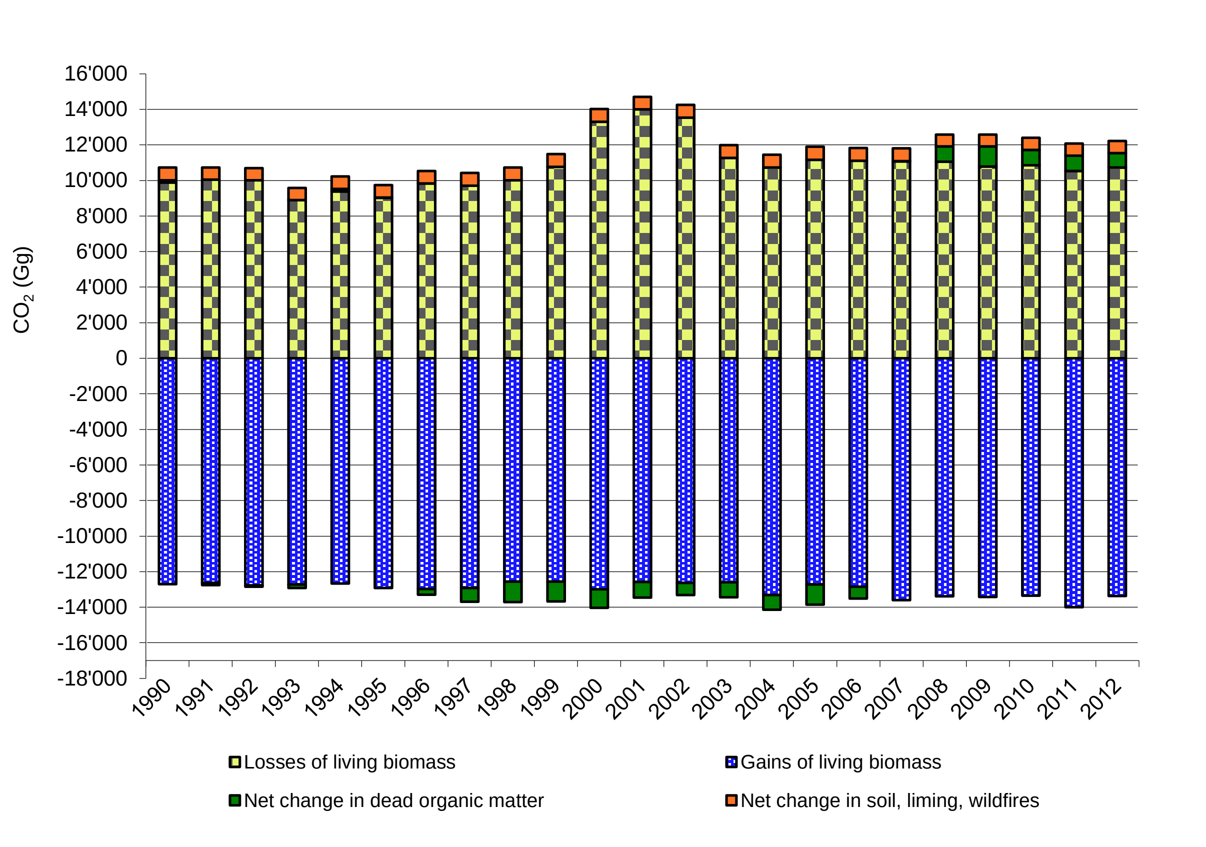

Figure 7-1 (i) CO_2 removals due to the gain (growth) of living biomass, (ii) CO_2 emissions due to the loss (harvest and mortality) of living biomass, (iii) net CO_2 emissions and removals due to changes in dead organic matter, and (iv) net CO_2 emissions from soils, due to liming and wildfires, 1990–2012.

The non-CO_2 emissions associated with land use, land-use change and forestry are very small. Between 1990 and 2012 annual CH_4 emissions add up to less than 1.81 Gg, and annual N_2O emissions equal at maximum 0.04 Gg. Those emissions arise from flooded land/reservoirs (CH_4; CRF-table 5(II)), soil disturbance associated with land-conversion to cropland (N_2O; CRF-table 5(III)), and wildfires on forest land (CH_4 and N_2O; CRF-table 5(V)). The calculation methods are based on default procedures of IPCC (2003; Chapter 3) and are summarized in Chapters 7.3.4.13, 7.4.4.4 and 7.6.4.4, respectively.

Figure 7-2 shows the resulting net GHG balances of LULUCF 1990–2012 including all CO_2 and non-CO_2 fluxes. Further representations of LULUCF CO_2 eq data can be found in Chapter 2 “Trends in Greenhouse Gas Emissions and Removals”.

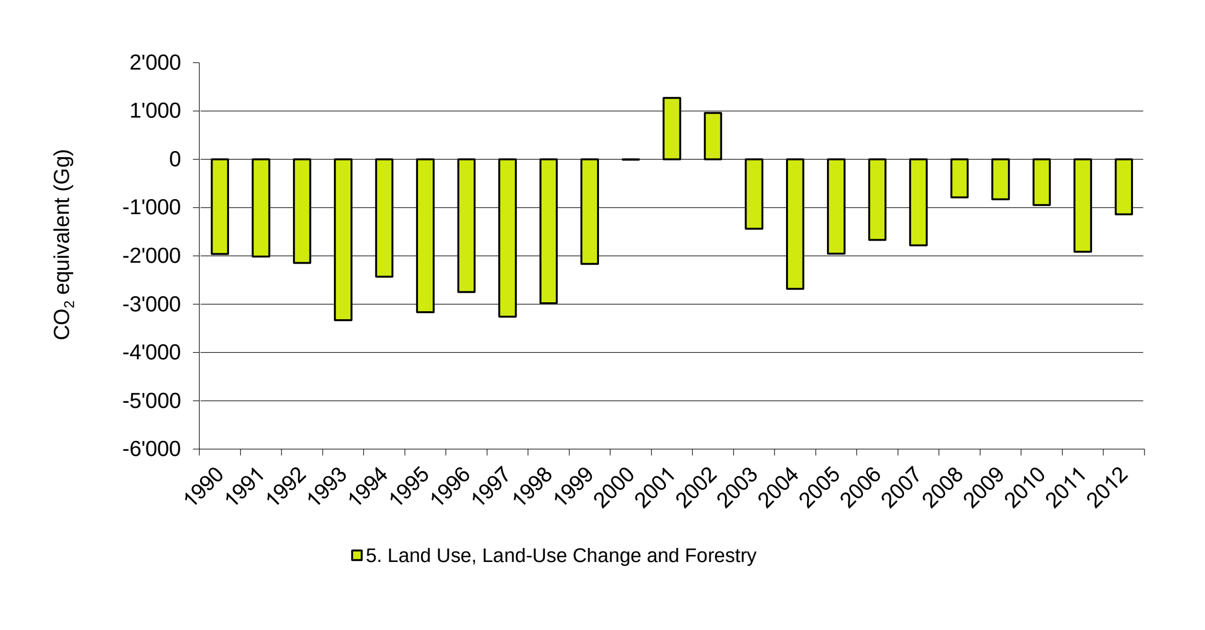

Figure 7-2 Switzerland's net GHG balance of category 5 Land Use, Land-Use Change and Forestry 1990–2012 (in Gg CO_2 eq). Positive values refer to emissions, negative values refer to removals.

7.1.3 Approach for Calculating Carbon Emissions and Removals

7.1.3.1 Work Steps

The selected procedure for calculating carbon emissions and removals in the LULUCF sector corresponds to a Tier 2 approach as described in IPCC (2003; Chapter 3). It can be summarised as follows:

- Define land use categories and sub-divisions with respect to available land-use data (see Table 7-2). For the present study, so-called combination categories (CC) were defined on the basis of the AREA land-use and land-cover categories (Table 7-6; SFSO 2006a).
- Define criteria and collect data for the spatial stratification of the land-use categories.
- Measure or estimate the carbon stocks and carbon stock changes for each spatial stratum of the land-use categories.
- Calculate the land use and the land-use change matrix in each spatial stratum.
- Calculate the carbon stock changes in living biomass (deltaC$_l$), in dead organic matter (deltaC$_d$) and in soil (deltaC$_s$) for all cells of the land-use change matrix.
- Finally, aggregate the results by summarising the carbon stock changes over land-use categories and strata according to the level of disaggregation displayed in the CRF-tables.

Table 7-2 Land-use categories used in this report (so-called combination categories CC): 6 main land-use categories (identical to the UNFCCC land-use categories) and 18 sub-divisions. Additionally, descriptive remarks, abbreviations used in the CRF-tables, and CC codes are given. For a detailed definition of the combination categories see Table 7-6 (FOEN 2007f) and SFSO (2006a).

CC Main category	CC Sub-division	Remarks	Terminology in CRF tables	CC code
A. Forest Land	Afforestations	areas converted to forest by active measures, e.g. planting	afforestation	11
	Productive Forest	dense and open forest meeting the criteria of forest land	productive	12
	Unproductive Forest	brush forest and forest on unproductive areas meeting the criteria of forest land	unproductive	13
B. Cropland		arable and tillage land (annual crops and leys in arable rotations)		21
C. Grassland	Permanent Grassland	meadows, pastures (low-land and alpine)	permanent	31
	Shrub Vegetation	agricultural and unproductive areas predominantly covered by shrubs	woody, shrub	32
	Vineyards, Low-Stem Orchards, Tree Nurseries	perennial agricultural plants with woody biomass (no trees)	woody, vine	33
	Copse	agricultural and unproductive areas covered by perennial woody biomass including trees	woody, copse	34
	Orchards	permanent grassland with fruit trees	woody, orchard	35
	Stony Grassland	grass, herbs and shrubs on stony surfaces	unproductive, stony	36
	Unproductive Grassland	unmanaged grass vegetation	unproductive	37
D. Wetlands	Surface Waters	lakes and rivers	surface	41
	Unproductive Wetland	reed, unmanaged wetland	unproductive	42
E. Settlements	Buildings and Constructions	areas without vegetation such as houses, roads, construction sites, dumps	building	51
	Herbaceous Biomass in Settlements	areas with low vegetation, e.g. lawns	herb	52
	Shrubs in Settlements	areas with perennial woody biomass (no trees)	shrub	53
	Trees in Settlements	areas with perennial woody biomass including trees	tree	54
F. Other Land		areas without soil and vegetation: rocks, sand, scree, glaciers		61

The sub-categories listed in Table 7-2 were defined with respect to optimal distinction of biomass and soil carbon contents and dynamics (see Chapter 7.2.2.2, Table 7-6). The underlying criteria to include land-use sub-categories such as Shrub vegetation, Vineyards, Low-stem Orchards, Tree Nurseries, Copse and Orchards under Grassland with woody biomass are: (1) They do not fulfil the criteria for forests; (2) There is an agricultural management in general; (3) They all have woody biomass (i.e. perennial vegetation) with grass understory. Under Cropland there are no perennial crops, but only annual crops and leys in arable rotations. All perennial crops are included in the grassland sub-categories.

7.1.3.2 Calculating Carbon Stock Changes

For calculating carbon stock changes, the following input parameters (mean values per hectare) must be quantified for all combination categories (CC) and spatial strata (i):

$stockC_{l,i,CC}$ carbon stock in living biomass (t C ha^{-1})
$stockC_{d,i,CC}$ carbon stock in dead organic matter (t C ha^{-1})
$stockC_{s,i,CC}$ carbon stock in soil (t C ha^{-1})
$gainC_{l,i,CC}$ annual gain (growth) of carbon in living biomass (t C ha^{-1} yr^{-1})
$lossC_{l,i,CC}$ annual loss (harvesting and mortality) of carbon in living

	biomass (t C ha^{-1} yr^{-1})
$changeC_{d,i,CC}$	annual net carbon stock change in dead organic matter (t C ha^{-1} yr^{-1})
$changeC_{s,i,CC}$	annual net carbon stock change in soil (t C ha^{-1} yr^{-1})

For the reporting under the UNFCCC, the carbon content of litter (organic soil horizons) is included in $stockC_{d,i,CC}$. For the reporting under the Kyoto Protocol, litter is calculated and reported separately (see Chapter 11.3.1.1).

On this basis, the total carbon fluxes (t C yr^{-1}) in living biomass ($deltaC_l$), in dead organic matter ($deltaC_d$) and in soil ($deltaC_s$) are calculated for all cells of the land-use change matrix. Each cell is characterized by a land-use category before the reporting year (b), a land-use category at the end of the reporting year (a), and the area of converted land within the spatial stratum (i). It includes the case without any land-use change (a = b).

Equations 7.1.-7.6 show, according to the IPCC good practice guidance (GPG) for LULUCF (IPCC 2003), two approaches and their application for calculating carbon emissions and removals: (1) the gain-loss approach (GPG Equation 3.1.1) and (2) the stock-change approach (GPG Equation 3.1.2).

The gain-loss aproach takes into account the net carbon stock changes in living biomass (l), dead organic matter (d) and soils (s) of solely the land-use category after the conversion. The gain-loss approach is also used in cases of no land-use change. The stock-change approach takes into account the stock changes due to conversion of land use (difference of the stocks before and after the conversion).

The gain-loss approach is defined as:

$$deltaC_{l,i,ba} = (gainC_{l,i,a} – lossC_{l,i,a}) * A_{i,ba} \quad (7.1)$$

$$deltaC_{d,i,ba} = changeC_{d,i,a} * A_{i,ba} \quad (7.2)$$

$$deltaC_{s,i,ba} = changeC_{s,i,a} * A_{i,ba} \quad (7.3)$$

The formulation of the stock-change approach is:

$$deltaC_{l,i,ba} = [(stockC_{l,i,a} – stockC_{l,i,b}) / CT] * A_{i,ba} \quad (7.4)$$

$$deltaC_{d,i,ba} = [(stockC_{d,i,a} – stockC_{d,i,b}) / CT] * A_{i,ba} \quad (7.5)$$

$$deltaC_{s,i,ba} = [(stockC_{s,i,a} – stockC_{s,i,b}) / CT] * A_{i,ba} \quad (7.6)$$

where:

a	land-use category after conversion (CC = a)
b	land-use category before conversion (CC = b)
ba	land use conversion from b to a
i	spatial stratum
$A_{i,ba}$	area of land (ha) converted from b to a in the spatial stratum i (activity data from the land-use change matrix)
CT	conversion time (yr), see Chapter 7.1.3.3

Table 7-3 pinpoints which approach is used for calculating the carbon fluxes for the various types of land-use conversion and carbon pools (living biomass, dead organic matter and soil): The gain-loss approach is generally used for smooth transitions, e.g. the growth of living biomass on land converted to forest land; the stock-change approach is used for quick changes (e.g. loss of biomass by deforestation, CT = 1 year) as well as slow processes such as the change in soil carbon content (CT = 20 years, see Chapter 7.1.3.3).

For the conversions between different forest categories (e.g. CC12 to CC13 and CC13 to CC12) the method is choosen in such a way that no potential carbon losses are underestimated.

In case of land-use changes involving "Buildings and Constructions" (CC51), 50% of the difference between carbon stocks before and after the conversion is reported as a source or sink, respectively; for a detailed documentation see Chapter 7.7.4.2 and Chapter 11.3.1.1.

Table 7-3 Calculation approach (gain-loss or stock-change) and conversion time periods (CT, years) applied for different land-use transitions and carbon pools. KP = corresponding activity under the Kyoto Protocol; NF = non-forest category. Combination categories CC11 to CC61 are introduced in Table 7-2.

Change in main land-use category or sub-division	**Living biomass**	**UNFCCC: Dead organic matter KP: Deadwood, Litter**	**Soil**	**Remarks**
No change in category KP and UNFCCC	gain-loss	gain-loss	gain-loss	
CC13 to CC12 UNFCCC: 5A1 KP: forest management	gain-loss	stock-change, 20	stock-change, 20	
CC12 to CC13 UNFCCC: 5A1 KP: forest management	stock-change, 20	stock-change, 20	stock-change, 20	
CC11 to CC12 UNFCCC: 5A1 KP: afforestation >20 years	gain-loss	gain-loss	gain-loss	
Change to CC11 UNFCCC: 5A2 KP: afforestation ≤20 years	gain-loss	stock-change, 20	stock-change, 20	Dead organic matter is 0 in CC11 and in NF; directly human-induced
NF to CC12/CC13 UNFCCC: 5A2 KP: forest management	gain-loss	stock-change, 20	stock-change, 20	
Change to CC51 UNFCCC: 5E2 KP: deforestation	stock-change, 1	stock-change, 1	stock-change, 20	Buildings/constructions; soil: carbon stock reduced by 50%
Change to CC52-54 UNFCCC: 5E2	stock-change, 1	stock-change, 1	stock-change, 20	Green settlement areas
Change to CC21 UNFCCC: 5B2	stock-change, 1	stock-change, 1	stock-change, 20	Cropland
Change to CC31-37 UNFCCC: 5C2	stock-change, 1	stock-change, 1	stock-change, 20	Grassland
Change to CC41 UNFCCC: 5D2	stock-change, 1	stock-change, 1	stock-change, 1	Surface water
Change to CC42 UNFCCC: 5D2	stock-change, 1	stock-change, 1	stock-change, 20	Unproductive wetland
Change to CC61 UNFCCC: 5F2	stock-change, 1	stock-change, 1	stock-change, 20	Other land

7.1.3.3 Considering the Conversion Time (CT)

Changes in the soil carbon stock – this is also true for the increase of woody biomass – as a result of land-use changes are slow processes that might take decades. Therefore, IPCC (2003) suggests implementing a conversion time (CT). Following the IPCC default value (CT = 20 years), the carbon emission or removal due to a soil carbon stock difference ($stockC_{s,i,a}$ – $stockC_{s,i,b}$) does not occur in one year but is distributed evenly over the 20 years following the land-use conversion.

A conversion time of 20 years has been applied to all soil carbon stock changes (except land converted to surface water). Accordingly, the CRF-tables 5A2, 5B2, 5C2, 5D2, 5E2 and 5F2 contain the cumulative area remaining in the respective category in the reporting year.

In addition, the default conversion time of 20 years has been assumed for carbon stock changes in biomass (living and dead) for land converted from productive forest to unproductive forest (CC12 to CC13).

The land-use category Aafforestations (CC11) is inherently a transitional category by definition in the land-use survey. Areas converted to afforestations are reported in the CRF-table 5A2 with the same conversion time as for other forest sub-categories (20 years). However, afforestations remaining afforestations (according to the land-use survey) are reported in CRF-table 5A1 and are merged with source category Productive Forest (CC12) after having been reported 20 years under land converted to forest land.

Table 7-3 summarises the conversion times applied to carbon stock changes in living biomass, in dead organic matter, and in soils for all types of land-use transitions.

There is no consistent data on land-use changes before 1990, but it is well known (ARE/SAEFL 2001, FOEN 2013g) that the main trends of the Swiss land-use dynamics (e.g. increase of forests and settlements) did arise before 1970. Therefore, it was assumed that between 1971 and 1989 the annual rate of all land-use changes was the same as in 1990. Based on this assumption it has been possible to produce the land-use data required for the consideration of the conversion time in that period.

7.1.3.4 Displaying Results in the Common Reporting Format (CRF)

In the CRF-tables 5A to 5F, a part of the combination categories (CC) and associated spatial strata are shown at an aggregated level for optimal documentation and overview. The values of deltaC are accordingly summarised. Positive values of deltaCl,i,ba are inserted in the column “Gains” and negative values in the column “Losses”, respectively. The values of deltaCd,i,ba and deltaCs,i,ba are inserted in column "Net carbon stock change in dead organic matter" and "Net carbon stock change in soils", respectively.

The CRF-tables 5A to 5F are subdivided in two parts: (1) X Land remaining X Land and (2) Land converted to X Land. Unchanged areas as well as changes occurring from one combination category to another belonging to the same main land-use category are reported in the first part of the CRF. For example, the area of ”shrub vegetation” (CC32) converted to ”permanent grassland” (CC31) is reported in CRF-table 5C1 in the sub-division “permanent” in the respective altitude zone. As CC31 and CC32 do have different carbon stocks in biomass, a carbon stock change is calculated according to the equations presented in Chapter 7.1.3.2.

7.1.4 Carbon Stocks, Emission Factors, and Net Changes at a Glance

Table 7-4 lists all values of carbon stocks, gains, losses and net changes of carbon specified for combination category (CC) and associated spatial strata for the year 1990. These values remain constant during the period 1990-2012 with the following exceptions (highlighted cells):

- Carbon stock, gain and loss of living biomass, carbon stock and net change in dead organic matter as well as net change in mineral soils of productive forest (CC12): Deduction and values of the annually changing data of CC12 are described in Chapters 7.3.4.6, 7.3.4.7 and 7.3.4.8.
- Carbon stock, gain and loss of living biomass of cropland (CC21): Annual data of CC21 are listed in Chapter 7.4.4.

The deduction of the individual carbon stocks and emission factors is explained in detail in the Chapters 7.3 to 7.8.

Table 7-4 Carbon stocks and changes in living biomass, in dead organic matter and in soils for the combination categories (CC), disaggregated for altitude, NFI region, and soil type. The values are valid for the period 1990-2012 with the exception of the values in the highlighted cells, which change annually (numbers given here are for the year 1990); cf. main text.

land-use code CC	NFI region	altitude zone z	carbon stock in living biomass (stockCl,i)	carbon stock in dead org. matter (stockCd,i)	carbon stock in mineral soil (stockCs,i)	carbon stock in organic soil (stockCs,i)	gain of living biomass (gainCl,i)	loss of living biomass (lossCl,i)	net change in dead org. matter (changeCd,i)	net change in mineral soil (changeCs,i)	net change in organic soil (changeCs,i)
	Strata		[t C ha^{-1}]				[t C ha^{-1} yr^{-1}]				
11 Afforestations	1	1	7.84	0	82.65	240	1.63	0	0	0	-0.68
	1	2	4.30	0	102.03	240	1.09	0	0	0	-0.68
	1	3	1.61	0	121.34	240	0.57	0	0	0	-0.68
	2	1	7.84	0	55.40	240	1.63	0	0	0	-0.68
	2	2	4.30	0	62.12	240	1.09	0	0	0	-0.68
	2	3	1.61	0	122.00	240	0.57	0	0	0	-0.68
	3	1	7.84	0	66.10	240	1.63	0	0	0	-0.68
	3	2	4.30	0	75.91	240	1.09	0	0	0	-0.68
	3	3	1.61	0	95.78	240	0.57	0	0	0	-0.68
	4	1	7.84	0	66.47	240	1.63	0	0	0	-0.68
	4	2	4.30	0	74.39	240	1.09	0	0	0	-0.68
	4	3	1.61	0	69.48	240	0.57	0	0	0	-0.68
	5	1	7.84	0	102.37	240	1.63	0	0	0	-0.68
	5	2	4.30	0	108.99	240	1.09	0	0	0	-0.68
	5	3	1.61	0	107.08	240	0.57	0	0	0	-0.68
12 Productive forest	1	1	126.87	14.95	82.65	240	3.60	-2.41	-0.01	0.00	-0.68
	1	2	124.88	14.32	102.03	240	3.21	-2.27	-0.15	0.00	-0.68
	1	3	84.73	13.66	121.34	240	1.95	-1.34	-0.10	0.00	-0.68
	2	1	134.18	17.82	55.40	240	4.63	-4.13	-0.16	0.00	-0.68
	2	2	146.77	20.33	62.12	240	4.63	-3.93	-0.04	0.00	-0.68
	2	3	101.21	20.33	122.00	240	1.60	-0.86	-0.04	0.00	-0.68
	3	1	135.06	18.29	66.10	240	4.56	-3.04	0.83	0.00	-0.68
	3	2	147.43	24.23	75.91	240	4.15	-3.06	-0.09	0.00	-0.68
	3	3	119.32	35.36	95.78	240	2.48	-2.11	-0.38	0.00	-0.68
	4	1	94.81	11.46	66.47	240	3.24	-2.71	0.59	0.00	-0.68
	4	2	104.42	27.27	74.39	240	2.49	-1.81	-0.07	0.00	-0.68
	4	3	96.41	41.36	69.48	240	1.81	-1.62	-0.05	0.00	-0.68
	5	1	70.67	11.05	102.37	240	2.74	-1.01	-0.39	0.00	-0.68
	5	2	76.70	13.95	108.99	240	2.20	-0.71	-0.33	0.00	-0.68
	5	3	76.70	33.60	107.08	240	1.61	-0.48	-0.03	0.00	-0.68
13 Unproductive forest	1	1	45.90	9.51	82.65	240	0	0	0	0	-0.68
	1	2	48.20	7.53	102.03	240	0	0	0	0	-0.68
	1	3	48.03	7.76	121.34	240	0	0	0	0	-0.68
	2	1	46.64	8.70	55.40	240	0	0	0	0	-0.68
	2	2	45.90	11.42	62.12	240	0	0	0	0	-0.68
	2	3	12.86	11.42	122.00	240	0	0	0	0	-0.68
	3	1	45.90	7.51	66.10	240	0	0	0	0	-0.68
	3	2	47.68	16.29	75.91	240	0	0	0	0	-0.68
	3	3	29.08	26.21	95.78	240	0	0	0	0	-0.68
	4	1	40.47	3.15	66.47	240	0	0	0	0	-0.68
	4	2	38.37	19.99	74.39	240	0	0	0	0	-0.68
	4	3	18.58	33.37	69.48	240	0	0	0	0	-0.68
	5	1	38.59	8.22	102.37	240	0	0	0	0	-0.68
	5	2	33.46	11.03	108.99	240	0	0	0	0	-0.68
	5	3	21.14	30.77	107.08	240	0	0	0	0	-0.68

(Table 7-4 continued)

21 Cropland	n.s.	n.s.	4.34	0	53.40	240	0.05	0.00	0	0	-9.52
31 Permanent Grassland	n.s.	1	7.08	0	62.02	240	0	0	0	0	-9.52
	n.s.	2	6.00	0	67.50	240	0	0	0	0	-9.52
	n.s.	3	7.95	0	75.18	240	0	0	0	0	-9.52
32 Shrub Vegetation	n.s.	1	12.90	0	62.02	240	0	0	0	0	-5.3
	n.s.	2	12.90	0	67.50	240	0	0	0	0	-5.3
	n.s.	3	12.90	0	75.18	240	0	0	0	0	-5.3
33 Vineyards et al.	n.s.	n.s.	3.74	0	53.40	240	0	0	0	0	-9.52
34 Copse	n.s.	1	12.90	0	62.02	240	0	0	0	0	-5.3
	n.s.	2	12.90	0	67.50	240	0	0	0	0	-5.3
	n.s.	3	12.90	0	75.18	240	0	0	0	0	-5.3
35 Orchards	n.s.	n.s.	24.32	0	64.76	240	0	0	0	0	-9.52
36 Stony Grassland	n.s.	n.s.	4.52	0	26.31	240	0	0	0	0	-5.3
37 Unproductive Grassland	n.s.	n.s.	7.01	0	68.23	240	0	0	0	0	-5.3
41 Surface Waters	n.s.	n.s.	0	0	0	240	0	0	0	0	0
42 Unproductive Wetland	n.s.	n.s.	6.50	0	68.23	240	0	0	0	0	-5.3
51 Buildings, Constructions	n.s.	n.s.	0	0	0	0	0	0	0	0	0
52 Herbaceous Biomass in S.	n.s.	n.s.	9.54	0	53.40	240	0	0	0	0	-9.52
53 Shrubs in Settlements	n.s.	n.s.	15.43	0	53.40	240	0	0	0	0	-5.3
54 Trees in Settlements	n.s.	n.s.	20.72	0	53.40	240	0	0	0	0	-5.3
61 Other Land	n.s.	n.s.	0	0	0	0	0	0	0	0	0

Legend

altitude zones:		*NFI-regions:*		
1	< 601 m	1	Jura	n.s. = no stratification
2	601 - 1200 m	2	Central Plateau	annually changing data
3	> 1200 m	3	Pre-Alps	
		4	Alps	
		5	Southern Alps	

7.1.5 Uncertainty Estimates

Table 7-5 gives an overview of uncertainty estimates of activity data (AD) and of emission factors (EF). In most cases (highlighted in yellow; reasons for exceptions are indicated in column “Remark”), the uncertainty of AD depends on the quality of the AREA survey data.

In general, AD uncertainty is lower than EF uncertainty, because AD are based on a systematic survey with high spatial resolution (AREA, see Chapter 7.2), while EF include parameters that are difficult to measure or model such as carbon stocks in biomass, growth rates and other biological processes.

Uncertainty estimates of AD are presented in Chapter 7.2.5, while uncertainty estimates of EF are presented in detail in the respective chapters (7.X.5) of the LULUCF source categories.

Table 7-5 Uncertainty estimates in the LULUCF sector, expressed as half of the 95% confidence intervals.

IPCC category		Gas	Activity data uncertainty	Emission factor uncertainty	Remark
			%	%	
5A1	1. Forest Land remaining Forest Land	CO_2	2	63	
5A2	2. Land converted to Forest Land	CO_2	2	63	
5B1	1. Cropland remaining Cropland	CO_2	5	110	
5B2	2. Land converted to Cropland	CO_2	6	143	
5B2	2. Land converted to Cropland	N_2O	6	90	
5C1	1. Grassland remaining Grassland	CO_2	6	2084	
5C2	2. Land converted to Grassland	CO_2	6	67	
5D1	1. Wetlands remaining Wetlands	CO_2	30	100	organic soil
5D2	2. Land converted to Wetlands	CO_2	5	50	
5E1	1. Settlements remaining Settlements	CO_2	5	50	
5E2	2. Land converted to Settlements	CO_2	5	50	
5F2	2. Land converted to Other Land	CO_2	4	50	
5(IV)	Agricultural lime application	CO_2	40	25	
5(V)	Forest Land	CO_2	10	70	wildfire
5(V)	Forest Land and Grasland	CH_4	10	70	wildfire
5(V)	Forest Land and Grasland	N_2O	10	70	wildfire

7.2 Activity Data – Land Areas

7.2.1 Description

Chapter 7.2 presents information related to activity data that is valid for all LULUCF categories, including information on land-use databases, approaches used for representing land areas, classification systems, uncertainties of land-use data as well as land-use related QA/QC, recalculations and planned improvements. The chapter, hence, is structured in a similar way as the subsequent category-specific Chapters 7.3 – 7.8.

7.2.2 Information on Approaches Used for Representing Land Areas and on Land-use Databases Used for Inventory Preparation

7.2.2.1 Swiss Land Use Statistics (AREA)

Data of the Swiss Land Use Statistics (AREA) evaluated by the Swiss Federal Statistical Office (SFSO 2013) are the basis of activity data. In the course of the AREA surveys, every hectare of Switzerland's territory (4'128 kha) was assigned to one of 46 land-use categories and to one of 27 land-cover categories by means of stereographic interpretation of aerial photos (SFSO 2006a). The AREA surveys were launched in 2004 and completed in 2013.

For the reconstruction of the land use conditions in Switzerland during the period 1990-2012 three datasets are used:

- Land Use Statistics “1979/85” (AREA1)
- Land Use Statistics “1992/97” (AREA2)
- Land Use Statistics “2004/09” (AREA3)

The aerial photos for AREA1, AREA2 and AREA3 were taken 1977-1986, 1990-1998 and 2004-2009, respectively. They were simultaneously evaluated according to the newly designed AREA set of land-use and land-cover categories based on the nomenclature 'NOAS04' (SFSO 2006a).

The inter-survey period is not identical throughout the Swiss territory, but varies regionally. It averages approximately 12 years. This methodical characteristic needs to be considered when reconstructing the annual country-wide status of land use or when calculating annual rates of land-use change.

7.2.2.2 Combination Categories (CC) as derived from AREA Land Use Statistics

The 46 land-use categories and 27 land-cover categories of AREA were aggregated to 18 combination categories (CC) as shown in Table 7-6 (FOEN 2007f), thus implementing the main categories proposed by IPCC as well as country specific sub-divisions (see Table 7-2). The sub-divisions were defined with respect to optimal distinction of biomass densities, carbon turnover, and soil carbon contents.

The first digit of the CC code represents the land-use category according to IPCC, whereas the second digit stands for sub-divisions of the land-use categories.

Table 7-6 Derivation of 18 combination categories (CC) from AREA land-use and land-cover categories (FOEN 2007f).

18 Combination Categories (CC) — Land Cover (NOLC04) acc. to AREA × Land use: Settlement and urban areas

Land Cover (NOLC04) acc. to AREA	101 Industrial and commercial areas > 1 ha	102 Industrial and commercial areas < 1 ha	103 Residential areas (one and two-family house	104 Residential areas (terraced houses)	105 Residential areas (blocks of flats)	106 Public buildings and surroundings	107 Agricultural buildings and surroundings	108 Unspecified buildings and surroundings	121 Motorways	122 Roads	123 Parking areas	124 Railway surface	125 Airports and airfields	141 Energy supply plants	142 Waste treatment plants	143 Other supply or waste treatment plants	144 Dumps	145 Quarries, mines	146 Construction sites	147 Unexploited urban areas	161 Public parks	162 Sport facilities	163 Golf courses	164 Camping areas	165 Garden allotments	166 Cemeteries
	Building areas								Transport surfaces					Special urban areas							Recreational areas and cemeteries					
10 Artificial areas																										
11 Sealed surfaces	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
12 Buildings	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
13 Greenhouses	52	52	52	52	52	52	52	52			52	52	52						52	52	52	52	52	52	52	52
14 Gardens with border and patch structures	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52			52	52	52	52	52	52	52	52
15 Lawns	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52			52	52	52	52	52	52	52	52
16 Trees in artificial areas	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54			54	54	54	54	54	54	54	54
17 Mix of small structures	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52			52	52	52	52	52	52	52	52
20 Grass and herb vegetation																										
21 Grass and herb vegetation	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
30 Brush vegetation																										
31 Shrub	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53
32 Brush meadows	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53
33 Short-stem fruit trees	53	53	53	53	53	53	53	53	53	53	53	53								53	53				53	53
34 Vines	53	53	53	53	53	53	53	53	53	53	53	53								53	53				53	53
35 Permanent garden plants and brush crops	52	52	52	52	52	52	52	52	52	52	52	52								52	52				52	52
40 Tree vegetation																										
41 Closed forest	54	54	54	54	54	54	54	54	54		54									54	54	54		54	54	54
42 Forest edges	54	54	54	54	54	54	54	54	54		54			54	54	54				54	54	54	54	54	54	54
43 Forest strips	54	54	54	54	54	54	54	54	54		54			54	54	54				54	54	54		54	54	54
44 Open forest	54	54	54	54	54	54	54	54	54		54			54	54	54				54	54	54		54	54	54
45 Brush forest																					53			53		
46 Linear woods	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54
47 Clusters of trees	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54
50 Bare land																										
51 Solid rock	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
52 Granular soil	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
53 Rocky areas	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
60 Watery areas																										
61 Water	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
62 Glacier, perpetual snow																										
63 Wetlands	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
64 Reedy marshes	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42

Land use: Agricultural areas, Forest areas, Unproductive areas

Land Cover (NOLC04) acc. to AREA	201 Orchards	202 Vineyards	203 Horticulture	221 Arable land, in general	222 Semi-natural grassland, in general	223 Farm pastures, in general	241 Alpine meadows, in general	242 Alpine pastures, in general	243 Alpine sheep grazing pastures, in general	301 Forest	302 Afforestation	303 Lumbering areas	304 Damaged forest	401 Lakes	402 Streams, rivers	403 Flood protection structures	421 Unused	422 Avalanche and rockfall protection structures	423 Alpine sports facilities	424 Landscape intervention
	Orchards, vineyards, horticulture			Arable and grassland			Alpine grazing areas			Forest (not used for agriculture)				Lakes and rivers			Unproductive land			
10 Artificial areas																				
11 Sealed surfaces		51	51											51	51	51		51	51	51
12 Buildings																				
13 Greenhouses			21																	
14 Gardens with border and patch structures		21	21	21	21		21			12										
15 Lawns		31	31																	
16 Trees in artificial areas																				
17 Mix of small structures		21	21																	
20 Grass and herb vegetation																				
21 Grass and herb vegetation	31	31	31	21	31	31	31	31	31		11	12	12	37	37	37	37	37	37	31
30 Brush vegetation																				
31 Shrub		32	32								11	12	12	32	32	32	32	32	32	32
32 Brush meadows		32	32		32	32	32	32			11	12	12	32	32	32	32	32	32	32
33 Short-stem fruit trees	33		33																	
34 Vines		33	33																	
35 Permanent garden plants and brush crops			33							12										
40 Tree vegetation																				
41 Closed forest	35									12	11					12		12		
42 Forest edges	35									12	11	12	12			12		12		
43 Forest strips	35									12	11					12		12		
44 Open forest	35				12	12	12	12	13	12	11	12	12			12		12	12	12
45 Brush forest										13						13		13		
46 Linear woods	34	34	34	34	34	34	34	34	34		11	12	12	34	34	34	34	34	34	34
47 Clusters of trees	34	34	34	34	34	34	34	13	34		11	12	12	34	34	34	34	34	34	34
50 Bare land																				
51 Solid rock												13	13	61	61	61	61	61	61	61
52 Granular soil		61	61									12	12	61	61	61	61	61	61	61
53 Rocky areas		36	36			36	36	36			11	13	13	36	36	36	36	36	36	36
60 Watery areas																				
61 Water														41	41	41				41
62 Glacier, perpetual snow																	61			
63 Wetlands					42	42	42	42	42			12	13	42	42	42	42	42	42	42
64 Reedy marshes				21	42	42	42	42	42					42	42	42	42			

Combination Categories (CC):

- 11 Afforestations
- 12 Productive forest
- 13 Unproductive forest
- 21 Cropland
- 31 Permanent grassland
- 32 Shrub vegetation
- 33 Vineyards, Low-stem Orchards, Tree nurseries
- 34 Copse
- 35 Orchards
- 36 Stony grassland
- 37 Unproductive grassland
- 41 Surface waters
- 42 Unproductive wetland
- 51 Buildings and construction
- 52 Herbaceous biomass in settlements
- 53 Shrubs in settlements
- 54 Trees in settlements
- 61 Other land

7.2.2.3 Interpolation of the Status for each Year

The exact dates of aerial photo shootings are known for each hectare. However, the exact occurrence date (year) of a land-use change on a specific hectare is unknown. The actual change can have taken place in any year between two AREA surveys. In this study, it is assumed that the probability of a land-use change from AREA1 to AREA2 and from AREA2 to AREA3 is uniformly distributed over the respective interim period between two surveys. Therefore, the land-use change of each hectare has to be equally distributed over its specific interim period.

Thus, the land-use status for the years between two data collection dates can be calculated by linear interpolation. Dates of aerial photo shootings (i.e. starting and ending year of the inter-survey period) and the land-use categories of AREA1, AREA2 and AREA3 for every hectare are used for these calculations. An example is shown in Figure 7-3: A hectare has been assigned to the land-use category Cropland in AREA1 (aerial photo in 1980). A land-use change to Surrounding of Buildings has been discovered 10 years later (1990) in AREA2.

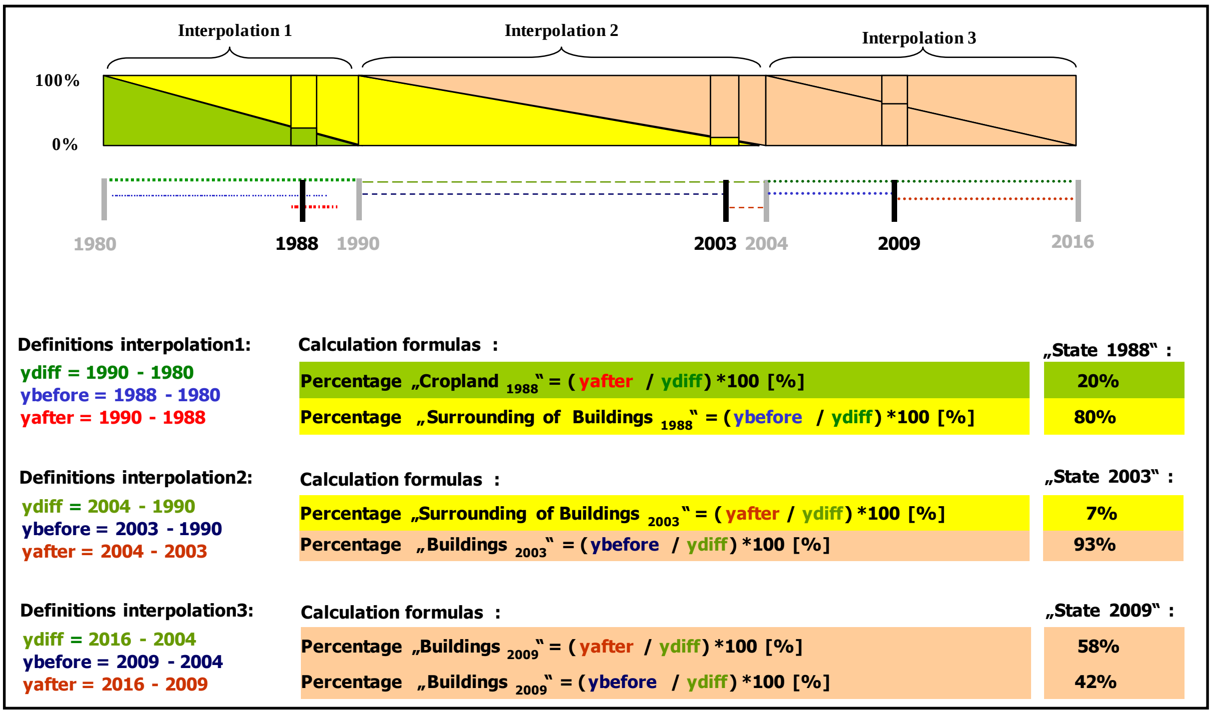

Figure 7-3 Hypothetical linear development of land-use changes between AREA1, AREA2 and AREA3 considering as example a hectare changing from "Cropland" to "Surrounding of Buildings" and then from "Surrounding of Buildings" to "Buildings". For 2009, a linear interpolation has been carried out between AREA3 and a virtual fourth survey modelled for the year 2016 (here resulting in no change of land use).

The "state 1988" of that hectare is determined by calculating the fractions of the two land-use categories for the year 1988. A linear development from "Cropland" to "Surrounding of Buildings" during the whole interim period is assumed. Thus, in 1988 the hectare is split up in two fractions: 80% is "Surrounding of Buildings" and 20% is "Cropland". The same procedure can be applied for two survey dates between AREA2 and AREA3 (here exemplarily shown for the period 1990-2004, highlighting "state 2003").

AREA3 comprehends aerial photos from six years (2004-2009). Therefore, the land-use changes occurring after AREA3 are calculated from the linear development detected between AREA3 and a virtual fourth survey, AREA4 (see Figure 7-3: example "state 2009"). AREA4 was modeled for each sample plot using a Markov-chain approach, where transition probabilities between AREA3 and AREA4 were assessed based on transition distribution between AREA2 and AREA3 within each spatial stratum (Sigmaplan 2014). This approach was evaluated successfully by modeling a virtual AREA3 from transition probabilities between AREA1 and AREA2 and comparing the results to the actual interpretation of AREA3.

The status for each individual year in the period 1990-2012 for the whole Swiss territory results from the summation of the fractions of all hectares per combination category CC, additionally considering the spatial strata where appropriate.

7.2.3 Land-use Definitions and the Classification Systems Used and their Correspondence to the LULUCF Categories

7.2.3.1 Spatial Stratification

In order to quantify carbon stocks and GHG emissions by sources and removals by sinks in the LULUCF sector as accurately as possible, Switzerland's territory was stratified by means of three site criteria: soil type (mineral or organic), altitude and forest production region.

Most soils in Switzerland are mineral soil types. For mapping the occurrence of organic soils, two datasets were used: (i) the digital soil map "BEK" (SFSO 2000a) and (ii) the Inventory of Raised Bogs of National Importance (Appendix to Swiss Confederation 1991a).

Two units of the digital soil map contain mainly organic soils (Figure 7-4): The codes F1 and Q3, representing Histosols in the Central Plateau and in Alpine valleys, respectively, are good indicators for organic soils in the lowlands. As the soil map has no appropriate unit for organic soils in mountainous areas the maps of the Inventory of Raised Bogs (with a scale of 1:25'000) were used in addition. All areas covered by this inventory were assumed to have organic soils (see Figure 7-4).

For Forest Land and – in part – Grassland, three altitudinal belts were differentiated: <601 m a.s.l. (meters above sea level), 601-1200 m a.s.l., and >1200 m a.s.l. (Figure 7-4). Altitude data are available on a hectare-grid from the Swiss Federal Statistical Office (SFSO 1997).

Forest Land was furthermore differentiated into the five production regions of the National Forest Inventory NFI (EAFV/BFL 1988; Brassel and Brändli 1999; Brändli 2010). The NFI regions were adopted from EAFV/BFL (1988) as shown in Figure 7-4:

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

Applying all spatial stratifications, 30 different strata (referred to as subscript i in Chapter 7.1.3.2) would be theoretically possible. Not all of them, but altogether 28 have been actually realised and applied for the calculation of LULUCF-associated carbon emissions and removals.

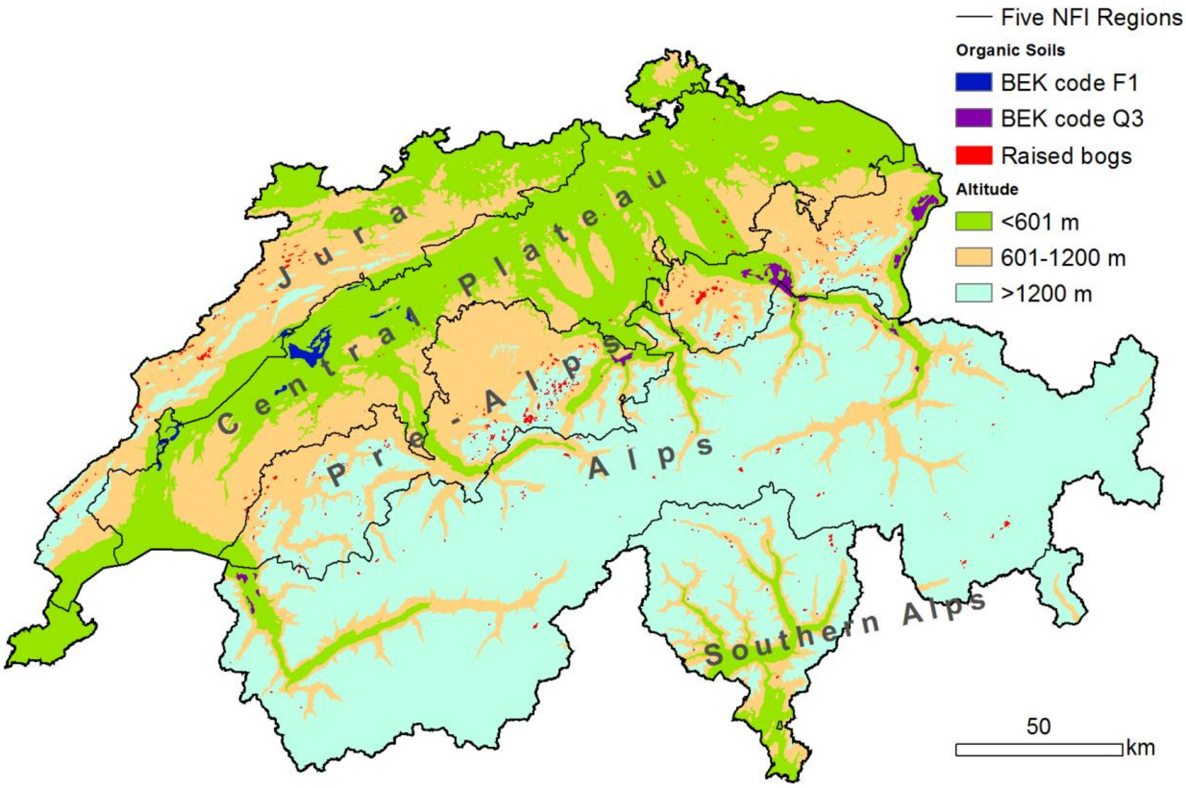

Figure 7-4 Map showing the spatial stratification according to NFI region, altitude, and soil type.

7.2.3.2 The Land-use Tables and Change Matrices

In Table 7-7 the land-use statistics resulting from spatial stratification (Chapter 7.2.3.1) and interpolation in time (Chapter 7.2.2.3) are exemplarily shown for the year 1990. This table gives also an overview of the size of the individual spatial strata. The combination categories (CC) have been introduced in Table 7-2.

Table 7-7 Land use (in terms of combination categories CC) projection by the end of 1990, stratified separately for altitude (3 zones), soil type (mineral or organic) and NFI region (1-5), in kha.

CC:	11	12	13	21	31	32	33	34	35	36	37	41	42	51	52	53	54	61	Sum
Altitude																			
<601	1.1	222.7	0.5	299.5	152.0	2.6	22.7	37.8	1.2	0.5	2.9	137.5	5.2	116.2	47.4	2.8	18.6	1.9	1072.6
601-1200	1.5	501.4	8.0	132.3	360.0	8.6	3.8	40.1	0.4	2.4	1.5	10.0	5.6	47.0	17.1	1.0	5.4	7.7	1153.8
>1200	1.4	382.8	77.1	0.4	425.4	144.5	0.0	30.0	0.0	148.8	61.9	13.5	14.4	11.4	3.7	0.2	1.0	585.6	1902.0
	4.0	1106.8	85.6	432.2	937.4	155.7	26.5	107.8	1.6	151.6	66.3	160.9	25.1	174.5	68.2	3.9	24.9	595.2	4128.4
Soil																			
mineral	4.0	1103.5	85.6	420.4	931.8	155.6	26.4	107.3	1.6	151.6	66.0	160.4	21.9	172.7	67.5	3.9	24.8	595.2	4100.1
organic	0.0	3.3	0.1	11.8	5.6	0.1	0.1	0.5	0.0	0.0	0.3	0.5	3.2	1.8	0.7	0.1	0.1	0.027	28.3
	4.0	1106.8	85.6	432.2	937.4	155.7	26.5	107.8	1.6	151.6	66.3	160.9	25.1	174.5	68.2	3.9	24.9	595.2	4128.4
NFI-region																			
1	0.7	197.2	5.3	78.0	122.6	0.9	4.7	14.8	0.3	0.2	0.6	23.6	1.2	26.8	10.9	0.5	4.7	0.5	493.5
2	0.8	227.1	0.4	306.9	152.4	0.9	9.9	31.1	1.0	0.2	1.6	70.3	4.1	84.9	34.7	1.6	12.6	0.7	941.2
3	1.0	214.3	9.2	30.4	261.3	10.4	0.8	21.7	0.1	8.5	6.8	30.2	12.0	26.8	9.2	0.5	2.9	15.0	661.0
4	1.2	331.6	49.5	13.8	365.4	110.2	9.5	31.0	0.2	118.0	49.2	26.2	7.2	26.9	9.8	0.8	3.0	524.7	1678.1
5	0.3	136.6	21.2	3.0	35.7	33.3	1.5	9.2	0.0	24.6	8.1	10.7	0.7	9.2	3.7	0.6	1.9	54.2	354.6
	4.0	1106.8	85.6	432.2	937.4	155.7	26.5	107.8	1.6	151.6	66.3	160.9	25.1	174.5	68.2	3.9	24.9	595.2	4128.4

Table 7-8 shows the overall trends of land-use changes between 1990 and 2012. For example, the area of afforestations (CC11) decreased by 76% during this period, while the area of unproductive forests (CC13) increased by 7%. CC11 is decreasing because the area of new afforestations has been decreasing during this period and because most of the afforestation areas develop to productive forests after a certain time period.

Table 7-8 Statistics of land use (in terms of combination categories CC) and relative change (%) between 1990 and 2012, in kha.

CC:	11	12	13	21	31	32	33	34	35	36	37	41	42	51	52	53	54	61	Sum
Year:																			
1990	4.0	1106.8	85.6	432.2	937.4	155.7	26.5	107.8	1.6	151.6	66.3	160.9	25.1	174.5	68.2	3.9	24.9	595.2	4128.4
1991	3.9	1109.0	86.0	431.4	935.5	155.2	26.5	106.6	1.5	151.4	66.1	160.9	25.1	176.2	68.7	4.0	25.3	594.9	4128.4
1992	3.8	1111.2	86.4	430.6	933.7	154.7	26.6	105.4	1.4	151.1	66.0	160.9	25.1	177.9	69.3	4.0	25.6	594.5	4128.4
1993	3.7	1113.3	86.8	429.8	932.1	154.2	26.5	104.2	1.4	150.9	65.8	160.9	25.1	179.5	69.8	4.1	25.9	594.2	4128.4
1994	3.5	1115.3	87.1	428.6	931.1	153.6	26.5	103.1	1.3	150.7	65.7	161.0	25.1	181.1	70.4	4.1	26.1	594.0	4128.4
1995	3.3	1117.1	87.5	427.0	930.7	153.0	26.5	102.0	1.3	150.5	65.6	161.0	25.2	182.7	71.1	4.2	26.1	593.7	4128.4
1996	3.1	1118.6	87.8	425.4	930.5	152.5	26.4	101.0	1.3	150.4	65.5	161.0	25.2	184.2	71.8	4.2	26.1	593.4	4128.4
1997	2.9	1120.1	88.1	423.7	930.5	152.0	26.3	99.9	1.3	150.3	65.4	161.0	25.2	185.7	72.6	4.2	25.9	593.1	4128.4
1998	2.7	1121.4	88.4	421.9	930.5	151.8	26.2	98.9	1.2	150.2	65.3	161.1	25.2	187.3	73.4	4.2	25.8	592.9	4128.4
1999	2.5	1122.7	88.6	420.2	930.5	151.5	26.1	97.8	1.2	150.3	65.2	161.1	25.2	188.8	74.3	4.2	25.6	592.6	4128.4
2000	2.2	1123.9	88.9	418.5	930.4	151.3	26.1	96.7	1.2	150.3	65.1	161.1	25.2	190.3	75.1	4.2	25.5	592.4	4128.4
2001	2.0	1125.2	89.2	416.8	930.4	151.0	26.0	95.6	1.1	150.3	65.0	161.2	25.2	191.9	75.9	4.2	25.3	592.2	4128.4
2002	1.8	1126.5	89.4	415.0	930.4	150.8	25.9	94.6	1.1	150.3	64.9	161.2	25.3	193.4	76.7	4.2	25.2	591.9	4128.4
2003	1.6	1127.8	89.7	413.3	930.3	150.6	25.8	93.5	1.1	150.3	64.8	161.2	25.3	194.9	77.5	4.2	25.0	591.7	4128.4
2004	1.3	1129.1	89.9	411.6	930.3	150.3	25.7	92.4	1.0	150.3	64.6	161.3	25.3	196.5	78.3	4.2	24.8	591.4	4128.4
2005	1.2	1131.1	90.2	411.1	930.4	149.9	25.5	90.7	1.0	150.2	64.4	161.3	25.3	197.9	78.8	4.1	24.3	591.0	4128.4
2006	1.1	1133.1	90.5	411.0	930.5	149.6	25.2	88.9	1.0	150.2	64.2	161.4	25.3	199.1	79.1	4.0	23.8	590.5	4128.4
2007	1.1	1135.0	90.6	411.2	930.5	149.3	25.0	87.1	0.9	150.1	63.9	161.5	25.2	200.1	79.4	3.9	23.3	590.0	4128.4
2008	1.0	1137.2	90.9	411.4	930.9	148.7	24.8	85.6	0.9	150.1	63.7	161.6	25.2	200.8	79.5	3.8	22.9	589.3	4128.4
2009	1.0	1138.8	91.2	409.9	930.9	148.3	24.7	84.5	0.9	150.1	63.5	161.7	25.2	202.2	80.2	3.9	22.7	588.9	4128.4
2010	1.0	1139.8	91.4	408.4	930.6	148.1	24.6	83.6	0.9	150.1	63.4	161.7	25.2	203.7	80.9	3.9	22.6	588.7	4128.4
2011	1.0	1140.7	91.6	406.8	930.3	147.9	24.5	82.8	0.8	150.1	63.3	161.7	25.3	205.1	81.5	3.9	22.5	588.4	4128.4
2012	1.0	1141.7	91.8	405.2	930.0	147.7	24.4	82.0	0.8	150.1	63.2	161.8	25.3	206.6	82.2	3.9	22.4	588.2	4128.4
Change:	-76	3	7	-6	-1	-5	-8	-24	-48	-1	-5	0	1	18	21	-1	-10	-1	0

The annual rates of change in the entire territory of Switzerland (change-matrices, Table 7-9) are achieved by adding up the annual change rates of all hectares per combination category (CC). For calculating the carbon stock changes, fully stratified (up to 28 strata, cf. Chapter 7.2.3.1) land-use change tables are used for each year (Meteotest 2014).

It is worth noting that in general the numbers given in the tables above cannot be directly compared with the numbers reported in the CRF-tables: The CRF-tables 5A2–5F2 contain the cumulative area remaining in the respective category in the reporting year. As described in Chapter 7.1.3.3, a conversion time of 20 years is applied to those land-use transitions and during the conversion time, the converted areas are reported under CRF-tables 5X2. In contrast, the change matrices present the land-use changes occurring in the specified year alone.

Table 7-9 Annual rates of land-use change in 1990 and in 2012 (change matrices). Units: ha/year, rounded values. Empty cells indicate that no change has occurred.

1990	change to CC																		
change from CC	11	12	13	21	31	32	33	34	35	36	37	41	42	51	52	53	54	61	decrease
11		369	1	0	0	0		0						0	0	0		0	372
12			135	5	125	86	6	82		12	19	11	7	117	27	11	17	49	709
13		534			128	37	0	45		3	2	1	1	5	0	0	1	9	767
21	8	1			663	6	181	40	1	4	4	4	4	632	317	21	18	22	1926
31	136	166	231	718		1007	123	560	4	46	43	9	11	870	490	27	44	68	4554
32	24	1022	687	2	126		9	337		14	14	6	0	24	8	5	3	30	2312
33	1	2		126	65	4		33	2	0	1	0		50	26	4	3	5	323
34	30	680	33	151	1091	60	40		11	10	24	4	4	207	114	8	54	15	2537
35		0		8	13	0	4	47						4	2	0	0	0	80
36	3	27	25	2	162	243	1	41			89	4	0	8	1	0		45	652
37	7	26	6	1	8	234	1	68		10		3	0	6	1		0	13	384
41	0	4	1	2	2	6	0	4		4	1		17	11	2	1	0	99	156
42	5	27	5	1	3	2	0	3		0	0	6		4	1	0	0	1	59
51	38	18	1	86	158	11	5	11		3	5	6	4		271	58	46	5	726
52	7	4		16	32	3	1	2		0	1	1	2	349		68	387	0	874
53	5	9	0	6	7	2	0	2				0	2	45	28		46	0	150
54	2	6		1	2	0	0	3			0	0	1	78	152	8		0	253
61	4	41	16	16	67	93	8	32		287	33	96	2	13	1	0	1		709
increase	271	2936	1141	1140	2652	1794	381	1310	18	394	236	152	55	2425	1443	211	621	362	17543

2012	change to CC																		
change from CC	11	12	13	21	31	32	33	34	35	36	37	41	42	51	52	53	54	61	decrease
11		71	0			0								0					72
12			224	1	178	140	2	107		31	21	15	12	90	26	12	9	73	943
13		515			158	58		27		4	2	1	1	3	0	0	0	10	779
21	2	0			1287	5	140	17	0	4	11	8	9	496	286	13	5	12	2294
31	17	77	176	444		725	73	319	2	71	30	7	9	756	403	14	9	81	3215
32	3	646	510	2	127		3	288		18	11	5	0	13	4	2	1	32	1664
33	0	1		135	95	5		20	1	1	0		0	35	23	1	2	6	326
34	3	523	31	53	770	67	15		4	10	23	6	1	126	70	3	22	18	1745
35				1	6		2	16						1	0				26
36	0	17	20	3	80	195	1	44			51	4		3	0			40	460
37	2	14	3	1	2	181		47		13		3	0	4	1			12	283
41	0	2	0	0	1	5		2		3	3		9	6	1	0		100	133
42	0	18	4		0	0		1		1		7		2	0			1	36
51	17	9	0	63	144	8	3	6		6	6	6	2		287	51	21	5	635
52	6	3	0	16	41	3	1	3		1	2	1	2	411		51	216	0	757
53	2	10		3	11	2	0	1		0	1	0	0	49	39		38	0	156
54	1	3		0	2	0		2			0		0	96	302	18			425
61	1	28	11	16	46	73	4	28		285	16	101	1	6	1	0			618
increase	55	1938	981	740	2947	1467	244	928	6	449	177	164	49	2098	1445	165	323	391	14568

7.2.4 Methodological Issues

No further remarks.

7.2.5 Uncertainties and Time-series Consistency of Activity Data

An overview of uncertainty estimates for activity data (AD) and emission factors (or biomass parameters) is shown in Table 7-5. Details related to uncertainties of AD are presented in this chapter, while uncertainties of the emission factors are presented in the respective chapters (7.X.5) of the LULUCF source categories.

In most cases (as highlighted in yellow in Table 7-5), the uncertainty of AD depends on the quality of the AREA survey data. However, in the following cases the uncertainty is determined mainly by other parameters:

- CO_2 emissions of category 5D1 (Wetland remaining wetland) are due to net carbon stock losses in organic soils. The uncertainty of the area of organic soils is around 30% according to Leifeld et al. (2003: 61).

- CO_2 emissions of category 5(IV): Agricultural lime application. The uncertainty of the amount of lime (40%) was estimated based on a poll among the main producers in Switzerland (Agroscope 2014a; see Chapter 7.4.4.5).
- CO_2, CH_4 and N_2O emissions from category 5(V) are due to wildfires on Forest Land and Grassland. The burnt area is surveyed by cantonal authorities. An uncertainty of 10% is assumed as it is a complete survey and not a sampling approach.

The uncertainty of AREA-based activity data has two main sources (Table 7-10). They have been quantified on the basis of the AREA data (SFSO 2013) as follows:

1) Interpretation error: In the AREA survey, the interpretation of the aerial photos is checked by a second independent interpreter. The portion of sampling points with a mismatch of the first and the second interpretation is used as the uncertainty of the interpretation. This uncertainty of interpretation integrates all errors related to the manual interpretation of land-use and land-cover classes on aerial photographs. While it is clear that this is rather an estimate of the maximum potential interpretation error than of the actual interpretation error, it is reported hereafter unless more accurate information is available.

2) Statistical sampling error: In the AREA survey, the land-use types are interpreted on points situated on a regular 100x100 m grid. Thus, the uncertainty of the surface area covered by a certain land-use type or land-use change decreases with increasing numbers of sampling points. Assuming a binomial distribution of the errors, this uncertainty is calculated as

$$U_{sampling} = 100 * 1.96 * (\text{number of points})^{-0.5}$$

The number of sampling points lies between 2'472 (for 5D2) and 1'374'367 (for 5C1) leading to values of $U_{sampling}$ between 3.9% and 0.2%.

The overall uncertainty was calculated as:

$$U_{overall} = (U_{interpret}^2 + U_{sampling}^2)^{0.5}$$

Finally, conservatively rounded values of the calculated overall uncertainties were chosen for further processing in the uncertainty analysis.

Table 7-10 Sources of AD uncertainty and overall uncertainties in the area calculations, expressed as half of the 95% confidence intervals. Exception for source category 5D1 is mentioned in the main text above. Calculations are based on AREA data from SFSO (2013).

IPCC	Description	Interpretation uncertainty	Sampling uncertainty	Overall uncertainty, calculated value	Overall uncertainty, rounded value
5A1	Forest Land remaining Forest Land	1.1	0.2	1.09	2
5A2	Land converted to Forest Land	1.1	1.2	1.60	2
5B1	Cropland remaining Cropland	4.9	0.3	4.89	5
5B2	Land converted to Cropland	4.9	2.1	5.31	6
5C1	Grassland remaining Grassland	5.2	0.2	5.23	6
5C2	Land converted to Grassland	5.2	1.0	5.33	6
5D1	Wetlands remaining Wetlands	0.9	0.5	1.02	2
5D2	Land converted to Wetlands	0.9	3.9	4.05	5
5E1	Settlements remaining Settlements	4.4	0.4	4.41	5
5E2	Land converted to Settlements	4.4	1.1	4.54	5
5F1	Other Land remaining Other Land	1.4	0.3	1.40	NA
5F2	Land converted to Other Land	1.4	2.8	3.16	4

7.2.6 QA/QC and Verification of Activity Data

The AREA survey is a well-defined and controlled, long-term process in the responsibility of the Swiss Federal Statistical Office (SFSO 2006a). The data supplied by SFSO (2013) have been checked for suitability and consistency (Sigmaplan 2014).

The temporal interpolation and extrapolation of the AREA sample is quite a complex procedure, whose internal consistency is checked systematically as described in Sigmaplan (2014). Further checks (interannual comparisons, plausibility) are carried out after producing the land-use change tables presented in Chapter 7.2.3.2.

In response to UNFCCC (2012: §115) a systematic cross-check between the activity data reported under LULUCF category 5A and under the KP activity Forest management was carried out (Meteotest 2013a). It revealed that the difference between activity data used for emission and removal estimates under the Convention and under the KP can be consistently explained. The cross-check was updated for the present submission (see Chapter 11.2.3).

7.2.7 Recalculations of Activity Data

In the previous submission (FOEN 2013), AREA coverage has been restricted to 83%. The completion of the AREA surveys in 2013 led to a recalculation in the LULUCF sector for the period 1990-2011.

The borders of the NFI regions used to define the spatial strata (see Chapter 7.2.3.1) have been updated using new, more precise data (Meteotest 2013b). As a consequence, the size of the strata changed slightly.

7.2.8 Planned Improvements for Activity Data

No improvements are planned for the compilation and deduction of activity data.

7.3 Category 5A – Forest Land

7.3.1 Description

Tier 2 Key category 5A1 CO_2 from Forest Land remaining Forest Land (2012: level and trend) **Tier 2 Key category 5A2** CO_2 from Land converted to Forest Land (2012: level and trend)

Only temperate forests are occurring in Switzerland. Forest is defined as a minimum area of land of 0.0625 ha with crown cover of at least 20% and a minimum width of 25 m. The minimum height of the dominant trees must be 3 m or have the potential to reach 3 m at maturity in situ (FOEN 2006h). The following forest areas are not subject of the criteria of minimum stand height and minimum crown cover, but must have the potential to achieve it: afforested, regenerated, as well as burned, cut or damaged areas. Although orchards, parks, camping grounds, open tree formations in settlements, gardens, cemeteries, sports and parking fields may fulfil the (quantitative) forest definition, they are not considered as forests (FOEN 2006h).

For reporting in the CRF-tables, the different forest types are allocated to afforestations (CC11), productive forest (CC12) and unproductive forest (CC13) based on AREA categories (see Table 7-2; Table 7-6; SFSO 2006a). A detailed description of the category unproductive forest can be found in Chapter 7.3.4.9.

7.3.2 Information on Approaches Used for Representing Land Areas and on Land-use Databases Used for the Inventory Preparation

See Chapter 7.2.

7.3.3 Land-use Definitions and the Classification Systems Used and their Correspondence to the LULUCF Categories

See Chapter 7.2.

7.3.4 Methodological Issues

7.3.4.1 Choice of Method and National Forest Inventories

For calculating annual changes in carbon stocks changes, the general approach was used (see IPCC 2003 Eq. 3.1.1).

Data for growing stock, gross growth, cut (harvesting) and mortality were derived from the first, second, third and first phase a of the fourth Swiss National Forest Inventories (NFI, see Table 7-11). A description of NFI 1 and NFI 2 methodologies can be found in EAFV/BFL (1988) and in Brassel and Brändli (1999). Data and methodology of NFI 3 are described in Brändli (2010). Data of NFI 4a are described in Abegg et al. (2012). The methodology remained identical to Brändli (2010).

The inventories NFI 1, 2 and 3 are based on full surveys that were repeated in intervals of approximately 10 years. Since 2009, the inventory interval has been changed: a continuous survey is being conducted (NFI 4, 2009-2017). This means that a rotating subsample of approximately 12% will be surveyed and evaluated every year. NFI 4 data for the years 2009-2012 are implemented in this submission. Abegg et al. (2012) with NFI4a data covering 2009-2011 is an official NFI release. On request, NFI4a+ data for 2009-2012 have been provided exclusively for this submission by Thürig (2014).

Table 7-11: Characteristics of the National Forest Inventories 1, 2, 3 and 4a+.

	NFI 1	NFI 2	NFI 3	NFI 4a+
Inventory cycle	1983-1985	1993-1995	2004-2006	2009-2012
Grid size	1 x 1 km	1.4 x 1.4 km	1.4 x 1.4 km	1.4 x 1.4 km
Terrestrial sample plots	~12'000	~6'000	~6'000	~2'600
Measured single trees	~130'000	~70'000	~70'000	~30'000

7.3.4.2 Three-year Averaging of Forest Carbon Pools

The Revised 1996 IPCC Guidelines (IPCC 1997a) recommend working with three-year averages to report carbon changes in “Forest and Other Woody Biomass Stocks”. Further, the 2003 IPCC GPG (IPCC 2003) describes how to deal with interannual variability and states that “it is good practice to consistently report emissions using longer-term averages of environmental conditions or actual annual estimates of emissions when estimating stock changes”.

Changes in the carbon pools reported for the Swiss forest sector reflect annual fluctuations in management, weather conditions and natural disturbances. Therefore, three-year moving averages are calculated for all changes in forest carbon pools in order to smooth out high interannual fluctuations.

Three-year moving averages for the inventory year X are calculated as the average of the years X, X-1 and X-2. For example, the value for the inventory year 2004 is the average value of the years 2002-2004.This “backward-averaging” was used instead of calculating the arithmetic mean (mean of the years X-1, X, X+1), because

- if X is the most recent inventory year, X+1 data generally are not available in time (for submission in year X+2);
- we argue, that growth of living biomass, cut and mortality and the amount of dead wood is more influenced by the previous years than by the following year.

This “backward-averaging” introduces a certain time-lag in the calculated values and can complicate the interpretation of the resulting CO_2 emissions and removals.

7.3.4.3 Stratification

Spatial Strata

Forests in Switzerland reveal a high heterogeneity in terms of elevation, growth conditions, tree species composition, and inter-annual growth variability.

To combine the activity data of the Swiss land use statistics (see Chapter 7.2) with the emission factors from the Swiss forest inventory, Switzerland was divided into different strata. To find explanatory variables that significantly reduce the variance of gross growth an analysis of variance was done (Table 7-12).

Table 7-12 Analysis of variance of gross growth. Explanatory variables: Tree species, NFI production region, and altitude.

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

The analysis of variance indicated that production region, elevation, and tree species all significantly explain differences in gross growth. Therefore, the explanatory variables considered in this study are:

- tree species (coniferous and deciduous species).
- the five NFI production regions
  (1. Jura, 2. Central Plateau, 3. Pre-Alps, 4. Alps, 5. Southern Alps)
- altitude (<601 m, 601-1200 m, >1200 m)

Values for growing stock, gross growth, harvesting and mortality were calculated and applied for each of these 30 strata.

Separating Mixed Forests into Coniferous and Deciduous Sites

In Switzerland, most forests are mixed stands. However, the forest area derived by the Swiss land use statistics does not allow separating coniferous and deciduous sites.

To derive species specific measures for growing stock, gross growth, harvesting and mortality, the total forest area has to be divided according to the species mixture. The emission factor per stratum is then calculated as the weighted mean of both species. The required ratio of coniferous forest area (R_c) per spatial stratum was calculated by dividing the sum of the biomass of the conifers (B_c) over the sum of the biomass of all trees (B).

$R_{ci} = B_{ci} / B_i$ i = spatial strata

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

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

The weights for each spatial stratum are displayed in Table 7-13.

Table 7-13 Ratio of coniferous and deciduous species for 1985-1994 (derived from NFI 1 and NFI 2; source: Brassel and Brändli 1999), for 1995-2005 (derived from NFI 2 and NFI 3 data; source: Brändli 2010) and for 2006-2012 (derived from NFI 3 and NFI 4a+ data; source: Abegg et al. 2012 and Thürig 2014).

		1985 - 1994		**1995 – 2005**		**2006-2012**	
NFI region	**Altitude [m]**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**
1	<601	0.31	0.69	0.31	0.69	0.30	0.70
	601-1200	0.54	0.46	0.52	0.48	0.52	0.48
	>1200	0.74	0.26	0.72	0.28	0.74	0.26
2	<601	0.56	0.47	0.50	0.50	0.40	0.60
	601-1200	0.60	0.40	0.58	0.42	0.48	0.52
	>1200	0.90	0.10	0.90	0.10	0.96	0.40
3	<601	0.40	0.60	0.40	0.60	0.26	0.74
	601-1200	0.70	0.30	0.69	0.31	0.63	0.37
	>1200	0.92	0.08	0.91	0.09	0.87	0.13
4	<601	0.33	0.67	0.33	0.67	0.17	0.83
	601-1200	0.64	0.36	0.63	0.37	0.54	0.46
	>1200	0.97	0.03	0.96	0.04	0.95	0.05
5	<601	0.07	0.93	0.06	0.94	0.03	0.97
	601-1200	0.18	0.82	0.17	0.83	0.16	0.84
	>1200	0.84	0.16	0.83	0.17	0.84	0.16

Additional Stratification: Eastern and Western Alps

In the Swiss Alps (NFI region 4) below an altitude of 1200 m, climate between the eastern and the western part differs substantially. We therefore included an additional stratification for the eastern and the western part of the Alps below 1200 m (Alps < 601 m east, Alps < 601 m west, Alps 601-1200 m east, Alps 601-1200 m west; see Thürig et al. 2005a for details). This additional stratification resulted in very small datasets per stratum.

Gains and losses of living biomass were estimated for the eastern and western Alps separately. The emission factors for the Alps below 1200 m were then calculated as a weighted mean of the percentage of forest biomass situated in the western and in the eastern Alps. The weights for the pooled emission factors derived from the NFI 1, NFI 2,NFI 3 and NFI 4 are listed in Table 7-14.

Table 7-14 Ratio of biomass in the eastern and western Alps (NFI production region 4) for 1985-1994 (derived from NFI 1 and NFI 2; source: Brassel and Brändli 1999), for 1995-2005 (derived from NFI 2 and NFI 3 data; source: Brändli 2010) and for 2006-2012 (derived from NFI 3 and NFI 4a+ data; source: Abegg et al. 2012, Thürig 2014).

	1985 - 1994		**1995 – 2005**		**2006-2012**	
Altitude [m]	**NFI 2 Eastern**	**NFI 2 Western**	**NFI 3 Eastern**	**NFI 3 Western**	**NFI 4a+ Eastern**	**NFI 4a+ Western**
<601	0.56	0.44	0.53	0.47	0.60	0.40
601-1200	0.62	0.38	0.61	0.39	0.62	0.38

7.3.4.4 Estimation of Growing Stock in Biomass

The biomass of all tree compartments (stem-wood over bark including stock, coarse and small branches, needles/leaves, and roots) were estimated based on established allometries to tree-dimensions (Table 7-15; Thürig and Herold 2013). Estimates for branches, foliage and roots were derived from tree diameter at breast height (DBH). For stem-wood over bark including stock, additionally, diameter at tree height 7 m (D7) and total tree height were required. Except for roots, the biomass functions were empirically derived from a large number of single-tree data from Swiss forest sites (see references in Table 7-15).

Table 7-15 Applied allometric biomass functions, dependencies and references. DBH: tree diameter at breast height; D7: diameter at tree height 7 m.

Tree parts	Input parameter	Nr. of trees	References
Stem-wood over bark incl. stock	DBH, D7, height	12’000	Kaufmann et al. 2001
Coarse branches (>= 7 cm)	DBH	40’000	Kaufmann et al. 2001
Small branches (< 7 cm)	DBH	40’000	Kaufmann et al. 2001
Needles, Leaves	DBH	400	Perruchoud et al. 1999
Broadleaved Roots	DBH	443	Wutzler et al. 2008
Coniferous Roots	DBH	80	Zell and Thürig 2012

The biomass of all individual trees was calculated and, in a second step, single-tree estimates of gains and losses were obtained as the difference in biomass between subsequent NFIs (Thürig and Herold 2013).

7.3.4.5 Carbon Content

The IPCC default carbon content of solid wood of 50% was applied (IPCC 2003; p. 3.25).

7.3.4.6 Productive Forests (CC12): Growing Stock, Gross Growth and Cut and Mortality

Values for growing stock, gross growth, cut and mortality for productive forests (CC12, without afforestations) were derived from 5’425 common sample plots measured during NFI 1 and NFI 2 (Kaufmann 2001), 5’581 samples measured during NFI 2 and NFI 3 (Brändli 2010) and 2613 samples measured during NFI 3 and NFI 4 2009-2012 (Abegg et al. 2012; Thürig 2014). All values derived from the national forest inventories are related to above- and below-ground biomass in mass units (t C ha^{-1}) per spatial stratum. Annual values for growing stock are shown in Table 7-19 as "carbon stock in living biomass". Table 7-16 and Table 7-17 show gross growth and cut and mortality (in Table 7-19 marked as "gain of living biomass" and "loss of living biomass") for the four NFIs for coniferous and deciduous trees, respectively.

Table 7-16 Gross growth and cut and mortality for coniferous trees (related to coniferous forest biomass). In the Alps (NFI production region 4) below 1200 m, data are additionally stratified for eastern and western Alps. Data sources: Brassel and Brändli (1999), Brändli (2010), Abegg et al. (2012) and Thürig (2014).

NFI region	Altitude [m]	Gross growth [10^3 kg ha-1 yr^{-1}] NFI 1-2	Cut and mortality [10^3 kg ha^{-1} yr-1] NFI 1-2	Gross growth [10^3 kg ha^{-1} yr^{-1}] NFI 2-3	Cut and mortality [10^3 kg ha^{-1} yr^{-1}] NFI 2-3	Gross growth [10^3 kg ha^{-1} yr^{-1}] NFI 3-4a+	Cut and mortality [10^3 kg ha^{-1} yr^{-1}] NFI 3-4a+
	<601	2.13	1.42	2.26	2.82	2.07	2.95
1	601-1200	3.15	2.52	3.16	2.80	3.60	3.05
	>1200	2.68	2.16	2.67	1.71	3.34	1.19
	<601	4.51	4.28	4.21	6.28	3.93	5.68
2	601-1200	5.29	4.60	4.85	7.21	5.14	6.54
	>1200	2.40	1.40	1.49	2.20	5.14	6.54
	<601	3.27	1.91	3.01	3.01	4.92	4.47
3	601-1200	5.52	4.10	5.39	6.38	4.92	4.47
	>1200	4.50	3.57	4.52	4.64	5.23	3.61
4 east	<601	2.75	1.29	2.90	1.59	3.22	2.65
4 west	<601	0.72	0.84	1.23	0.92	2.22	1.27
4 east	601-1200	3.44	2.86	3.44	2.31	3.22	2.65
4 west	601-1200	2.40	2.02	2.17	1.76	2.22	1.27
4	>1200	3.36	5.59	3.50	2.43	3.47	1.71
	<601	0.08	0.06	0.12	0.02	0.78	0.00
5	601-1200	0.43	0.23	0.56	0.15	0.34	0.84
	>1200	2.38	0.75	2.46	0.78	3.28	1.15

Table 7-17 Gross growth, cut and mortality for deciduous trees (related to deciduous forest biomass). In the Alps (NFI production region 4) below 1200 m, data are additionally stratified for eastern and western Alps. Data sources: Brassel and Brändli (1999); Brändli (2010), Abegg et al. (2012) and Thürig (2014).

NFI region	Altitude [m]	Gross growth [10^3 kg ha-1 yr^{-1}] NFI 1-2	Cut and mortality [10^3 kg ha^{-1} yr-1] NFI 1-2	Gross growth [10^3 kg ha^{-1} yr^{-1}] NFI 2-3	Cut and mortality [10^3 kg ha^{-1} yr^{-1}] NFI 2-3	Gross growth [10^3 kg ha^{-1} yr^{-1}] NFI 3-4a+	Cut and mortality [10^3 kg ha^{-1} yr^{-1}] NFI 3-4a+
1	<601	5.08	3.30	4.48	5.11	4.37	3.52
	601-1200	3.27	1.80	2.91	2.13	3.60	2.95
	>1200	1.22	0.31	0.93	0.57	3.34	0.21
2	<601	4.75	3.36	4.87	3.93	3.93	4.17
	601-1200	3.98	2.65	4.27	2.79	4.20	3.21
	>1200	0.80	0.16	1.07	0.40	4.20	3.21
3	<601	5.84	3.85	5.46	2.61	2.91	1.55
	601-1200	2.77	1.41	2.92	1.61	2.91	1.55
	>1200	0.46	0.12	0.48	0.11	0.54	0.23
4 east	<601	4.66	6.41	5.09	2.18	2.93	1.96
4 west	<601	5.20	3.08	4.95	2.11	2.26	1.25
4 east	601-1200	2.11	0.95	2.05	1.10	2.93	4.60
4 west	601-1200	1.93	0.73	2.27	1.03	2.26	2.52
4	>1200	0.25	0.14	0.34	0.13	0.50	0.09
5	<601	5.39	2.29	3.96	2.72	4.98	2.58
	601-1200	3.97	1.40	3.79	1.11	4.70	2.00
	>1200	0.83	0.26	1.12	0.16	0.48	0.28

Annual Gross Growth

Annual values of gross growth have been derived from the NFI 1 and NFI 2 datasets for the period 1985-1994,from the NFI 2 and NFI 3 datasets for the period 1995-2005 and from the NFI 3 and NFI 4a+ dataset for the period 2006-2012. Annual values of gross growth are constant in the intersurvey periods of NFI 1 to NFI 2, NFI 2 to NFI 3 and of NFI 3 to NFI 4a+, respectively. These annual values are averaged over 3 years (see Chapter 7.3.4.2), thereby affecting the values of gross growth of the years 1996, 1997 and 2006, 2007, respectively (see Table 7-19).

Annual Cut and Mortality

An average value for cut and mortality (CM) is derived from the NFI 1 and NFI 2 dataset for the period 1985-1994,from the NFI 2 and NFI 3 datasets for the period 1995-2005 and from the NFI 3 and NFI 4a+ dataset for the period 2006-2012. To calculate annual values of cut and mortality (CMy) for the years 1985 to 1994, 1995 to 2005 and 2006 to 2012, respectively, the average amount of cut and mortality was weighted by the percentage of the relative harvesting amounts taken from the forest statistics (Table 7-18; SFSO 2013c; FOEN 2013k, and former editions 1985-2012). Relative harvesting amouns were calculated for each year per LFI-interservey period. As recommended in the Revised 1996 IPCC Guidelines (IPCC 1997a), moving three-year averages of the harvesting amounts from the forest statistics were calculated in order to level out extreme events such as storm Vivian in 1990 and storm Lothar in 1999 (see Chapter 7.3.4.2).

Table 7-18 Annual harvesting amount in m^3 merchantable timber specified for NFI production region as well as for coniferous and deciduous tree species for the period 1990-2012 as derived from forest statistics (SFSO 2013c; FOEN 2013k, and former editions 1985-2012). All values were averaged over three years as recommended in the revised 1996 IPCC guidelines (IPCC 1997a).

Year	1. Jura		2. Central plateau		3. Pre-Alps		4. Alps		5. Southern Alps	
	Conif.	**Dec.**	**Conif.**	**Dec.**	**Conif.**	**Dec.**	**Conif.**	**Dec.**	**Conif.**	**Dec.**
	[m^3]	[m^3]	[m^3]	[m^3]	[m^3]	[m^3]	[m^3]	[m^3]	[m^3]	[m^3]
1990	669'756	364'296	1'400'390	582'340	963'683	138'833	851'765	65'707	38'790	24'026
1991	616'629	360'660	1'348'951	557'776	967'684	135'699	1'002'608	68'221	31'210	24'093
1992	573'269	361'633	1'328'880	556'023	966'390	133'405	1'034'064	71'000	31'106	25'943
1993	527'672	366'516	1'141'041	541'195	779'032	131'588	816'939	68'958	38'085	29'386
1994	575'928	379'505	1'225'395	554'916	752'565	132'571	701'336	67'181	43'628	31'723
1995	607'611	391'128	1'288'507	554'563	765'351	140'962	652'879	62'517	45'047	33'467
1996	597'544	393'817	1'241'999	556'409	742'348	147'125	604'935	61'095	46'972	35'501
1997	590'296	394'443	1'210'678	571'579	723'808	152'997	557'039	60'013	53'658	37'649
1998	575'006	399'476	1'191'359	590'606	744'730	156'410	579'223	77'391	53'319	40'188
1999	602'445	405'237	1'283'404	614'399	801'259	163'971	608'468	80'428	52'075	40'285
2000	733'872	402'682	2'196'853	733'718	1'300'811	184'017	562'665	78'246	38'806	38'572
2001	680'175	374'861	2'426'715	722'713	1'514'372	181'804	513'772	62'014	29'343	36'651
2002	626'798	351'805	2'448'000	674'298	1'603'283	168'724	491'872	60'187	24'903	35'522
2003	481'195	327'776	1'698'975	535'598	1'254'485	144'789	542'312	62'065	30'195	35'667
2004	551'910	316'752	1'617'068	509'352	1'135'069	147'134	534'976	65'377	32'781	35'617
2005	622’087	326’862	1’751’762	549’665	1’108’437	162’449	530’563	67’811	34’189	34’890
2006	681'354	357'113	1'788'551	606'050	1'082'363	191'691	524'433	75'116	36'300	39'261
2007	727'255	397'149	1'726'102	667'116	1'090'739	213'537	568'604	79'224	47'235	41'950
2008	744’843	430’545	1’549’750	704’695	1’093’245	228’233	618’331	83’231	53’102	45’453
2009	699’189	448’946	1’339’493	709’282	1’013’811	226’469	654’511	85’013	57’413	43’359
2010	650'428	471'929	1'173'993	717'138	963'166	232'425	687'652	90'799	56'610	46'159
2011	621'118	489'838	1'100'727	721'806	951'347	241'980	695'223	97'139	59'529	49'219
2012	566'782	488'626	970'748	719'003	825'019	225'988	665'506	94'480	51'475	50'757

Growing Stock: Calculation of Time Series

In order to develop a consistent time series, annual growing stocks (GS) are calculated backward or forward starting from the growing stock 2005, determined from NFI 3.

A backward calculation is used for the time period 1985-2004, meaning that the annual growing stock equals the growing stock 2005 minus the cumulated gains of the annual gross growths and plus the cumulated annual amounts of cut and mortality (CM_y).

Growing stocks for inventory years after 2005 are determined using a forward calculation, i.e. adding the cumulated annual gross growths to the growing stock 2005, and subtracting the cumulated annual amounts of cut and mortality (CM_y).

$$GS_{iy} = GS2005 - \Sigma_y\,[\text{annual gross growth}_y] + \Sigma_y\,[CM_y] \qquad \text{for iy} < 2005$$

$$GS_{iy} = GS2005 \qquad \text{for iy} = 2005$$

$$GS_{iy} = GS2005 + \Sigma_y\,[\text{annual gross growth}_y] - \Sigma_y\,[CM_y] \qquad \text{for iy} > 2005$$

where the “iy” indicates the inventory year and “y” refers to the years between 2005 and the inventory year.

An overview of the values of gross growth, cut & mortality and calculated growing stock for the period 1990 to 2012 specified for all spatial strata are displayed in Table 7-19.

All work steps and data required to reproduce the calculation of emission factors for productive forests (CC12) in the period 1990-2012 are summarized in FOEN (2014b).

Table 7-19 Annual carbon data of living biomass for productive forest (CC12) disaggregated for NFI region (NFI) and altitude zone (Alt.), 1990-2012, three-year-averages. Highlighted data for 1990 as displayed in Table 7-4.

NFI	Alt.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		CC12: carbon stock in living biomass (stockCl,i) [t C ha^{-1}]									
1	1	126.87	128.07	129.34	130.66	132.01	133.24	134.39	133.80	133.14	132.41
1	2	124.88	125.82	126.88	128.02	129.25	130.35	131.35	131.98	132.58	133.13
1	3	84.73	85.35	86.06	86.85	87.72	88.50	89.21	89.97	90.68	91.36
2	1	134.18	134.69	135.35	136.06	137.13	138.01	138.79	139.29	139.78	140.21
2	2	146.77	147.47	148.33	149.22	150.49	151.58	152.55	153.26	153.97	154.66
2	3	101.21	101.95	102.72	103.51	104.40	105.24	106.05	106.56	106.97	107.29
3	1	135.06	136.58	138.13	139.71	141.54	143.38	145.08	147.32	149.42	151.36
3	2	147.43	148.52	149.61	150.72	152.30	153.93	155.49	156.74	158.01	159.21
3	3	119.32	119.69	120.06	120.43	121.20	122.02	122.82	123.67	124.57	125.44
4	1	94.81	95.34	95.69	95.92	96.37	96.96	97.88	99.57	101.40	102.99
4	2	104.42	105.10	105.52	105.87	106.59	107.51	108.45	109.33	110.32	111.14
4	3	96.41	96.60	96.50	96.34	96.59	97.06	97.61	98.11	98.75	99.35
5	1	70.67	72.40	74.13	75.78	77.29	78.70	80.03	81.22	82.10	82.65
5	2	76.70	78.18	79.69	81.15	82.50	83.78	85.01	86.58	88.10	89.58
5	3	76.70	77.83	79.03	80.22	81.33	82.38	83.40	84.53	85.65	86.82

NFI	Alt.	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		CC12: carbon stock in living biomass (stockCl,i) [t C ha^{-1}]									
1	1	131.57	130.45	129.64	129.12	129.10	128.99	129.41	129.51	129.39	129.30
1	2	133.61	133.79	134.17	134.74	135.72	136.57	136.97	137.22	137.41	137.64
1	3	92.00	92.46	93.01	93.66	94.52	95.30	96.49	97.71	98.99	100.29
2	1	140.40	138.51	136.24	134.09	133.77	133.68	132.77	131.83	131.17	130.93
2	2	155.10	153.34	151.11	148.95	148.70	148.67	147.52	146.40	145.65	145.40
2	3	107.54	107.16	106.64	106.12	106.12	106.19	108.05	111.06	115.25	119.51
3	1	153.16	154.11	154.78	155.44	156.77	158.25	159.20	159.80	160.12	160.54
3	2	160.20	159.64	158.47	157.10	156.87	156.97	158.02	158.91	159.67	160.61
3	3	126.18	125.85	125.07	124.10	123.89	123.92	124.53	125.25	126.08	127.05
4	1	104.50	106.09	107.99	109.95	111.82	113.65	114.67	114.93	114.73	114.44
4	2	111.87	112.71	113.77	114.88	115.89	116.88	119.01	120.10	121.15	122.11
4	3	99.89	100.53	101.29	102.09	102.78	103.49	104.73	106.01	107.30	108.54
5	1	83.20	83.82	84.51	85.24	85.97	86.70	87.90	89.31	90.90	92.55
5	2	91.06	92.59	94.16	95.76	97.35	98.93	100.07	101.17	102.27	103.37
5	3	88.01	89.33	90.75	92.22	93.63	95.02	96.32	97.52	98.68	99.80

NFI	Alt.	2010	2011	2012							
		CC12: carbon stock in living biomass (stockCl,i) [t C ha^{-1}]									
1	1	129.22	129.14	129.04							
1	2	137.90	138.17	138.44							
1	3	101.64	103.01	104.38							
2	1	131.00	131.21	131.52							
2	2	145.53	145.82	146.25							
2	3	123.81	128.14	132.49							
3	1	160.94	161.24	161.55							
3	2	161.65	162.69	163.77							
3	3	128.10	129.18	130.28							
4	1	113.98	113.36	112.71							
4	2	122.98	123.79	124.59							
4	3	109.73	110.91	112.10							
5	1	94.11	95.59	96.99							
5	2	104.43	105.39	106.30							
5	3	100.92	101.99	103.08							

(Table 7-19 continued)

NFI	Alt.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		CC12: gain of living biomass (gainCl,i) [t C ha^{-1} yr^{-1}]									
1	1	3.60	3.60	3.60	3.60	3.60	3.60	3.53	3.45	3.37	3.37
1	2	3.21	3.21	3.21	3.21	3.21	3.21	3.15	3.09	3.04	3.04
1	3	1.95	1.95	1.95	1.95	1.95	1.95	1.90	1.85	1.80	1.80
2	1	4.63	4.63	4.63	4.63	4.63	4.63	4.60	4.57	4.54	4.54
2	2	4.63	4.63	4.63	4.63	4.63	4.63	4.61	4.59	4.56	4.56
2	3	1.60	1.60	1.60	1.60	1.60	1.60	1.49	1.39	1.28	1.28
3	1	4.56	4.56	4.56	4.56	4.56	4.56	4.45	4.34	4.23	4.23
3	2	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15	4.15
3	3	2.48	2.48	2.48	2.48	2.48	2.48	2.49	2.49	2.50	2.50
4	1	3.24	3.24	3.24	3.24	3.24	3.24	3.31	3.37	3.44	3.44
4	2	2.49	2.49	2.49	2.49	2.49	2.49	2.50	2.50	2.50	2.50
4	3	1.81	1.81	1.81	1.81	1.81	1.81	1.84	1.87	1.90	1.90
5	1	2.74	2.74	2.74	2.74	2.74	2.74	2.51	2.27	2.04	2.04
5	2	2.20	2.20	2.20	2.20	2.20	2.20	2.19	2.18	2.18	2.18
5	3	1.61	1.61	1.61	1.61	1.61	1.61	1.67	1.73	1.79	1.79

NFI	Alt.	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		CC12: gain of living biomass (gainCl,i) [t C ha^{-1} yr^{-1}]									
1	1	3.37	3.37	3.37	3.37	3.37	3.37	3.32	3.27	3.22	3.22
1	2	3.04	3.04	3.04	3.04	3.04	3.04	3.13	3.22	3.31	3.31
1	3	1.80	1.80	1.80	1.80	1.80	1.80	1.88	1.96	2.03	2.03
2	1	4.54	4.54	4.54	4.54	4.54	4.54	4.57	4.60	4.63	4.63
2	2	4.56	4.56	4.56	4.56	4.56	4.56	4.60	4.63	4.67	4.67
2	3	1.28	1.28	1.28	1.28	1.28	1.28	2.41	3.54	4.67	4.67
3	1	4.23	4.23	4.23	4.23	4.23	4.23	4.13	4.02	3.92	3.92
3	2	4.15	4.15	4.15	4.15	4.15	4.15	4.08	4.00	3.92	3.92
3	3	2.50	2.50	2.50	2.50	2.50	2.50	2.63	2.75	2.88	2.88
4	1	3.44	3.44	3.44	3.44	3.44	3.44	3.15	2.86	2.57	2.57
4	2	2.50	2.50	2.50	2.50	2.50	2.50	2.64	2.72	2.80	2.80
4	3	1.90	1.90	1.90	1.90	1.90	1.90	1.99	2.07	2.16	2.16
5	1	2.04	2.04	2.04	2.04	2.04	2.04	2.32	2.60	2.88	2.88
5	2	2.18	2.18	2.18	2.18	2.18	2.18	2.29	2.41	2.52	2.52
5	3	1.79	1.79	1.79	1.79	1.79	1.79	1.82	1.85	1.88	1.88

NFI	Alt.	2010	2011	2012							
		CC12: gain of living biomass (gainCl,i) [t C ha^{-1} yr^{-1}]									
1	1	3.22	3.22	3.22							
1	2	3.31	3.31	3.31							
1	3	2.03	2.03	2.03							
2	1	4.63	4.63	4.63							
2	2	4.67	4.67	4.67							
2	3	4.67	4.67	4.67							
3	1	3.92	3.92	3.92							
3	2	3.92	3.92	3.92							
3	3	2.88	2.88	2.88							
4	1	2.57	2.57	2.57							
4	2	2.80	2.80	2.80							
4	3	2.16	2.16	2.16							
5	1	2.88	2.88	2.88							
5	2	2.52	2.52	2.52							
5	3	1.88	1.88	1.88							

(Table 7-19 continued)

NFI	Alt.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		CC12: loss of living biomass (lossCl,i) [t C ha^{-1} yr^{-1}]									
1	1	-2.41	-2.33	-2.29	-2.25	-2.37	-2.46	-4.12	-4.10	-4.10	-4.21
1	2	-2.27	-2.15	-2.07	-1.98	-2.11	-2.21	-2.52	-2.50	-2.48	-2.56
1	3	-1.34	-1.24	-1.16	-1.09	-1.18	-1.24	-1.15	-1.14	-1.12	-1.16
2	1	-4.13	-3.97	-3.93	-3.56	-3.75	-3.85	-4.09	-4.08	-4.11	-4.36
2	2	-3.93	-3.78	-3.74	-3.36	-3.55	-3.66	-3.90	-3.87	-3.88	-4.12
2	3	-0.86	-0.82	-0.81	-0.71	-0.76	-0.79	-0.98	-0.97	-0.96	-1.03
3	1	-3.04	-3.00	-2.97	-2.73	-2.72	-2.85	-2.22	-2.24	-2.29	-2.43
3	2	-3.06	-3.05	-3.04	-2.57	-2.51	-2.59	-2.90	-2.88	-2.96	-3.16
3	3	-2.11	-2.11	-2.11	-1.71	-1.66	-1.69	-1.63	-1.59	-1.64	-1.76
4	1	-2.71	-2.89	-3.01	-2.79	-2.66	-2.47	-1.62	-1.55	-1.85	-1.93
4	2	-1.81	-2.07	-2.14	-1.77	-1.57	-1.47	-1.61	-1.51	-1.69	-1.77
4	3	-1.62	-1.91	-1.97	-1.56	-1.34	-1.25	-1.34	-1.23	-1.29	-1.36
5	1	-1.01	-1.01	-1.08	-1.23	-1.33	-1.40	-1.32	-1.40	-1.49	-1.49
5	2	-0.71	-0.69	-0.74	-0.84	-0.92	-0.97	-0.62	-0.66	-0.70	-0.70
5	3	-0.48	-0.41	-0.41	-0.50	-0.56	-0.58	-0.54	-0.61	-0.61	-0.60

NFI	Alt.	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		CC12: loss of living biomass (lossCl,i) [t C ha^{-1} yr^{-1}]									
1	1	-4.49	-4.18	-3.89	-3.39	-3.48	-3.71	-2.91	-3.17	-3.34	-3.31
1	2	-2.86	-2.65	-2.46	-2.06	-2.19	-2.38	-2.73	-2.97	-3.12	-3.08
1	3	-1.35	-1.25	-1.16	-0.93	-1.02	-1.13	-0.69	-0.74	-0.76	-0.72
2	1	-6.42	-6.81	-6.69	-4.86	-4.63	-5.01	-5.48	-5.54	-5.29	-4.87
2	2	-6.33	-6.79	-6.72	-4.82	-4.59	-4.96	-5.76	-5.75	-5.41	-4.92
2	3	-1.66	-1.80	-1.80	-1.27	-1.21	-1.31	-0.55	-0.53	-0.48	-0.41
3	1	-3.28	-3.56	-3.58	-2.90	-2.76	-2.84	-3.17	-3.43	-3.59	-3.50
3	2	-4.72	-5.33	-5.52	-4.39	-4.05	-4.05	-3.03	-3.11	-3.16	-2.98
3	3	-2.83	-3.28	-3.46	-2.72	-2.46	-2.41	-2.02	-2.04	-2.05	-1.91
4	1	-1.84	-1.53	-1.48	-1.56	-1.61	-1.64	-2.45	-2.60	-2.76	-2.85
4	2	-1.66	-1.44	-1.39	-1.50	-1.51	-1.52	-1.46	-1.56	-1.68	-1.75
4	3	-1.26	-1.14	-1.09	-1.20	-1.19	-1.18	-0.74	-0.80	-0.87	-0.92
5	1	-1.43	-1.35	-1.31	-1.32	-1.32	-1.29	-1.12	-1.19	-1.29	-1.23
5	2	-0.65	-0.60	-0.58	-0.59	-0.59	-0.59	-1.15	-1.30	-1.43	-1.41
5	3	-0.47	-0.37	-0.32	-0.38	-0.40	-0.41	-0.52	-0.65	-0.72	-0.76

NFI	Alt.	2010	2011	2012							
		CC12: loss of living biomass (lossCl,i) [t C ha^{-1} yr^{-1}]									
1	1	-3.30	-3.31	-3.32							
1	2	-3.05	-3.04	-3.05							
1	3	-0.69	-0.67	-0.66							
2	1	-4.56	-4.42	-4.32							
2	2	-4.54	-4.37	-4.24							
2	3	-0.36	-0.34	-0.32							
3	1	-3.52	-3.62	-3.61							
3	2	-2.88	-2.88	-2.84							
3	3	-1.83	-1.81	-1.78							
4	1	-3.03	-3.19	-3.22							
4	2	-1.85	-1.91	-1.92							
4	3	-0.97	-0.98	-0.98							
5	1	-1.31	-1.40	-1.48							
5	2	-1.47	-1.56	-1.61							
5	3	-0.76	-0.80	-0.79							

Separation of Above and Belowground Living Biomass

Carbon stock of total living biomass can be seperated using the ratios listed in Table 7-20. Under the UNFCCC both pools are merged, under the Kyoto Protocol the pools are reported seperatly (see Chapter 11.3.1.1).

Table 7-20: Ratio the seperate total living biomass into above and belowground living biomass. The ratios are retrieved from the NFI (Brändli 2010).

NFI region	Altitude [m]	Ratio above-/belowground Living Biomass
1	<601	0.22
	601-1200	0.27
	>1200	0.35
2	<601	0.22
	601-1200	0.24
	>1200	0.40
3	<601	0.23
	601-1200	0.28
	>1200	0.37
4	<601	0.25
	601-1200	0.30
	>1200	0.40
5	<601	0.28
	601-1200	0.32
	>1200	0.40
Switzerland	<601	0.23
	601-1200	0.27
	>1200	0.39

7.3.4.7 Productive Forests (CC12): Carbon Stocks in Dead Wood, Litter and in Soils

Dead Wood - Carbon Stock

The influence of wood decay on wood density and on carbon content of dead wood has been investigated by Dobbertin and Jüngling (2009) for two dominant tree species in Swiss forests: Norway spruce (Picea abies) and beech (Fagus sylvatica). They found a significant decrease in relative wood density with increasing decay stage for Norway spruce (30%) and beech (60%) compared to fresh wood. Only small differences in carbon content in dry matter were found between tree species and between fresh wood and dead wood (1.2 - 1.4%), but carbon content remained stable for dead wood across the four decay classes for each species

The total amount of carbon in the total dead wood pool (TDW) in Switzerland consists of three components:

TDW = CWD + LIS + DRoots

where

- CWD (coarse woody debris) contains all wood of dead trees with a diameter of at least 12 cm,
- LIS contains lying small diameter dead wood with a diameter of at least 7 cm determined with the line intersect method and
- DRoots consist of dead coarse roots.

A time series of carbon stocks in dead wood is derived from the soil carbon model Yasso07 (see descritption in Chapter 7.3.4.8). The value for dead wood stock for 2012 is shown in Table 7-21. Values for dead wood stocks since 1990 are displayed in Table 7-22 under dead organic matter, encompassing dead wood and litter.

Soil and Litter (Organic Soil Horizons) in Mineral Soils - Carbon Stock

Nussbaum et al. (2012) provided updated data for carbon stocks of litter (organic soil horizons L - litter, F - fermentation and H - humus) and soil organic carbon in Swiss forests.

1033 sites of a database stored at WSL distributed among different forest types throughout Switzerland were chosen for this study. Further information on the C content of L horizons was taken from Moeri (2007). By using this dataset and robust geostatistical methods, the authors produced a map of organic carbon stocks of Swiss forest soils. The data for litter and soil carbon stocks are stratified for the five NFI production regions and three elevation levels (Table 7-21).

In the organic soil horizons (litter) of mineral soils in productive and unproductive forests an average carbon stock of 16.7 t C ha^{-1} was estimated.

In the same study, an average carbon stock in mineral forest soils of 79.9 t C ha^{-1} in 0-30 cm topsoil was estimated.

Table 7-21 Total dead wood (TDW) stock in Swiss productive forests (CC12) with diameter>7 cm per spatial stratum in t C ha^{-1} for 1990 (Didion et al. 2013) and carbon stock in organic soil horizons (litter; used for CC12, CC13) and in soil organic carbon (SOC) of forest soils (used for CC11, CC12, CC13) in mineral soil horizons (0-30 cm) stratified for five NFI production regions and three altitudinal levels (Nussbaum et al. 2012). The average values ± standard error are given.

NFI region	Altitude [m]	Carbon in dead wood TDW 1990 [t C ha^{-1}]	Carbon in organic soil horizon (litter) [t C ha^{-1}]	SOC of mineral topsoil 0-30 cm [t C ha^{-1}]
1	<601	5.44 ± 0.09	9.51 ± 1.57	82.65 ± 3.34
1	601-1200	6.79 ± 0.27	7.53 ± 0.70	102.03 ± 3.56
1	>1200	5.90 ± 0.08	7.76 ± 1.74	121.34 ± 5.39
2	<601	9.12 ± 0.11	8.70 ± 0.68	55.40 ± 1.55
2	601-1200	8.91 ± 0.13	11.42 ± 1.45	62.12 ± 1.68
2	>1200	8.91 ± 0.13	11.42 ± 1.45	122.00 ± 7.07
3	<601	10.78 ± 0.49	7.51 ± 1.25	66.10 ± 2.06
3	601-1200	7.94 ± 0.15	16.29 ± 1.55	57.91 ± 2.00
3	>1200	9.14 ± 0.11	26.21 ± 4.77	95.78 ± 3.27
4	<601	8.31 ± 0.36	3.15 ± 0.47	66.47 ± 2.44
4	601-1200	7.29 ± 0.09	19.99 ± 2.64	74.39 ± 2.42
4	>1200	7.99 ± 0.12	33.37 ± 3.53	69.48 ± 1.85
5	<601	2.83 ± 0.08	8.22 ± 1.62	102.37 ± 4.07
5	601-1200	2.92 ± 0.06	11.03 ± 2.11	108.99 ± 4.09
5	>1200	2.82 ± 0.06	30.77 ± 5.43	107.08 ± 4.11
Switzerland		7.30 ± 0.03	16.73 ± 0.83	79.93 ± 1.52

Total Dead Organic Matter DOM- Carbon Stock

According to the Good Practice Guidance LULUCF (IPCC 2003) annual values of carbon stock in dead organic matter are calculated as the sum of carbon in dead wood and of carbon in the organic soil horizons (litter) of mineral forest soils.

Table 7-22 shows annual data of DOM in productive forests (CC12) for 1990-2012. This dataset combines annual estimates of dead wood and litter in productive forests. A time series of litter is derived by adding the temporal changes derived from Yasso07 to the estimates of Nussbaum et al. (2012) as described in Chapter 7.3.4.8 (see also Table 7-21).

Table 7-22 Carbon stock in dead organic matter for CC12, 1990-2012. Highlighted data for 1990 as displayed in Table 7-4.

NFI	Alt.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		CC12: carbon stock in dead organic matter (stockCd,i) [t C ha-1]									
1	1	14.95	14.97	14.99	15.01	15.01	15.00	15.06	15.22	15.51	15.86
1	2	14.32	14.53	14.73	14.91	15.06	15.21	15.31	15.33	15.23	15.06
1	3	13.66	13.60	13.55	13.50	13.44	13.39	13.35	13.34	13.35	13.35
2	1	17.82	17.81	17.80	17.80	17.77	17.74	17.76	17.87	18.09	18.35
2	2	20.33	20.29	20.25	20.21	20.16	20.11	20.13	20.28	20.58	20.95
2	3	20.33	20.29	20.25	20.21	20.16	20.11	20.13	20.28	20.58	20.95
3	1	18.29	18.74	19.14	19.51	19.81	20.08	20.27	20.32	20.15	19.84
3	2	24.23	24.02	23.84	23.67	23.50	23.35	23.22	23.10	23.00	22.90
3	3	35.36	35.38	35.41	35.44	35.44	35.44	35.53	35.78	36.23	36.79
4	1	11.46	11.74	12.00	12.23	12.43	12.60	12.79	13.01	13.26	13.51
4	2	27.27	27.29	27.29	27.30	27.30	27.30	27.32	27.34	27.37	27.40
4	3	41.36	41.37	41.37	41.37	41.35	41.35	41.36	41.38	41.43	41.47
5	1	11.05	10.96	10.87	10.79	10.72	10.65	10.60	10.57	10.55	10.55
5	2	13.95	13.94	13.92	13.91	13.90	13.89	13.88	13.85	13.79	13.73
5	3	33.60	33.60	33.61	33.62	33.61	33.62	33.60	33.54	33.43	33.28

NFI	Alt.	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		CC12: carbon stock in dead organic matter (stockCd,i) [t C ha-1]									
1	1	16.21	16.52	16.80	17.07	17.33	17.58	17.74	17.75	17.58	17.31
1	2	14.86	14.69	14.52	14.37	14.24	14.13	13.99	13.78	13.48	13.13
1	3	13.36	13.37	13.37	13.38	13.38	13.41	13.40	13.35	13.26	13.14
2	1	18.59	18.80	18.99	19.19	19.38	19.58	19.68	19.62	19.35	18.98
2	2	21.33	21.66	21.96	22.25	22.53	22.80	22.98	23.00	22.82	22.54
2	3	21.33	21.66	21.96	22.25	22.53	22.80	22.98	23.00	22.82	22.54
3	1	19.48	19.15	18.85	18.61	18.39	18.22	18.07	17.96	17.89	17.86
3	2	22.81	22.73	22.64	22.56	22.49	22.43	22.37	22.28	22.15	22.02
3	3	37.37	37.89	38.35	38.79	39.19	39.58	39.83	39.80	39.42	38.86
4	1	13.75	13.97	14.17	14.36	14.55	14.76	14.87	14.83	14.59	14.24
4	2	27.42	27.44	27.44	27.46	27.48	27.52	27.52	27.44	27.26	27.03
4	3	41.52	41.55	41.58	41.61	41.64	41.69	41.68	41.58	41.34	41.03
5	1	10.56	10.56	10.56	10.56	10.57	10.57	10.57	10.55	10.50	10.45
5	2	13.65	13.59	13.53	13.48	13.43	13.39	13.37	13.36	13.39	13.44
5	3	33.14	33.01	32.89	32.79	32.69	32.61	32.54	32.49	32.45	32.43

NFI	Alt.	2010	2011	2012							
		CC12: carbon stock in dead organic matter (stockCd,i) [t C ha-1]									
1	1	17.04	16.81	16.59							
1	2	12.79	12.48	12.20							
1	3	13.03	12.93	12.84							
2	1	18.62	18.29	17.99							
2	2	22.26	22.01	21.78							
2	3	22.26	22.01	21.78							
3	1	17.86	17.85	17.84							
3	2	21.89	21.77	21.66							
3	3	38.26	37.71	37.22							
4	1	13.90	13.58	13.29							
4	2	26.80	26.58	26.37							
4	3	40.72	40.43	40.16							
5	1	10.39	10.34	10.30							
5	2	13.50	13.55	13.60							
5	3	32.43	32.42	32.42							

7.3.4.8 Productive Forests (CC12): Changes in Carbon stocks in Dead Wood, in Litter and in Soils

Switzerland used the soil carbon model Yasso07 to estimate temporal changes in carbon stocks in soil organic carbon, organic soil horizons (LFH; litter) and in dead wood (TDW) for productive forests (CC12). The implementation of Yasso07 (Tuomi et al. 2009, 2011) in the Swiss GHG inventory is described in detail in Didion et al. (2012, 2013). Didion et al. (2014) demonstrated the validity of the model for application in Swiss forests.

Yasso07 is a model of C cycling in mineral soil, litter and dead wood. For estimating stocks of organic C in mineral soil up to a depth of ca. 100 cm and the temporal dynamics of the C stocks, Yasso07 requires information on C inputs from dead organic matter (i.e. non-woody inputs, including foliage and fine roots, woody inputs, including standing and lying dead wood and dead roots) and climate (temperature, temperature amplitude and precipitation).

By default, Yasso07 does not provide separate estimates of carbon pool sizes for dead wood, litter and soil. In order to report estimates for each pool, the structure of Yasso07 was examined for deriving separate estimates (Didion et al. 2012). Dead wood, litter and soil pools could be correlated with modeled data based on the category of carbon input, i.e., non-woody and woody material, and the five carbon compartments in Yasso07, i.e. four chemical partitions (insoluble, soluble in ethanol, soluble in water or in acid and humus). The approach was validated using independent, measured data (see Didion et al. 2012).

Using annual data for climate and for C inputs obtained from the Swiss NFIs, Yasso07 was used for estimating the annual C stocks in soil, litter and dead wood. Annual C stock changes were calculated from C stocks that were averaged over three years following the recommendation in IPCC (2003; Chapter 7.3.4.2). For an overview, Figure 7-5 shows the mean stock change in Swiss forests for these three carbon pools (soil, litter, dead wood) and the aggregated Yasso total. Annual and stratified values for CC12 can be found in Table 7-23, where net change in dead organic matter encompasses changes in dead wood and in litter. Stocks and stock changes were validated as described in Didion et al. (2013).

Table 7-23 Net carbon stock change in dead organic matter (dead wood and litter) and in mineral soils for CC12, 1990-2012. Highlighted data for 1990 as displayed in Table 7-4.

NFI	Alt.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		CC12: net change in dead organic matter (changeCd,i) [t C ha^{-1} yr^{-1}]									
1	1	-0.01	0.08	0.03	0.06	-0.05	-0.05	0.05	0.22	0.35	0.33
1	2	-0.15	-0.07	-0.08	-0.04	-0.12	-0.10	-0.02	0.07	0.13	0.09
1	3	-0.10	-0.03	0.00	0.04	0.00	0.03	0.02	-0.05	-0.18	-0.29
2	1	-0.16	-0.03	-0.05	-0.01	-0.13	-0.12	0.00	0.19	0.32	0.29
2	2	-0.04	0.03	0.00	0.03	-0.09	-0.08	0.04	0.22	0.39	0.39
2	3	-0.04	0.03	0.00	0.03	-0.09	-0.08	0.04	0.22	0.39	0.39
3	1	0.83	0.78	0.66	0.58	0.38	0.33	0.26	0.12	-0.17	-0.40
3	2	-0.09	-0.02	-0.01	0.02	-0.08	-0.05	0.10	0.32	0.56	0.64
3	3	-0.38	-0.31	-0.26	-0.21	-0.27	-0.21	-0.12	-0.03	0.05	0.06
4	1	0.59	0.56	0.45	0.40	0.25	0.22	0.27	0.36	0.44	0.41
4	2	-0.07	-0.03	-0.05	-0.03	-0.10	-0.05	0.00	0.06	0.10	0.07
4	3	-0.05	-0.02	-0.06	-0.02	-0.10	-0.04	0.02	0.11	0.17	0.14
5	1	-0.39	-0.29	-0.24	-0.20	-0.19	-0.15	-0.08	0.02	0.12	0.17
5	2	-0.33	-0.24	-0.19	-0.15	-0.15	-0.10	-0.06	-0.02	0.01	0.01
5	3	-0.03	-0.01	-0.02	-0.01	-0.06	-0.01	0.06	0.13	0.20	0.19

NFI	Alt.	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		CC12: net change in dead organic matter (changeCd,i) [t C ha^{-1} yr^{-1}]									
1	1	0.30	0.25	0.22	0.31	0.30	0.35	0.14	-0.07	-0.33	-0.41
1	2	0.07	0.05	0.01	0.07	0.06	0.11	0.03	-0.05	-0.13	-0.12
1	3	-0.29	-0.25	-0.24	-0.20	-0.17	-0.11	-0.15	-0.22	-0.31	-0.33
2	1	0.25	0.19	0.15	0.25	0.25	0.30	0.10	-0.14	-0.43	-0.53
2	2	0.37	0.31	0.26	0.32	0.31	0.36	0.18	-0.06	-0.35	-0.45
2	3	0.37	0.31	0.26	0.32	0.31	0.36	0.18	-0.06	-0.35	-0.45
3	1	-0.47	-0.42	-0.40	-0.27	-0.23	-0.12	-0.12	-0.12	-0.09	-0.07
3	2	0.65	0.58	0.48	0.47	0.43	0.48	0.27	-0.09	-0.54	-0.73
3	3	0.08	0.04	-0.02	-0.02	-0.02	0.05	0.00	-0.11	-0.22	-0.22
4	1	0.38	0.31	0.23	0.27	0.26	0.34	0.18	-0.07	-0.37	-0.48
4	2	0.06	0.04	0.00	0.05	0.06	0.15	0.06	-0.11	-0.32	-0.38
4	3	0.11	0.07	0.02	0.06	0.10	0.20	0.10	-0.07	-0.28	-0.31
5	1	0.16	0.13	0.09	0.11	0.07	0.12	0.09	0.05	-0.02	-0.04
5	2	0.00	-0.01	-0.04	-0.01	-0.03	0.03	0.03	0.03	0.01	0.03
5	3	0.18	0.15	0.08	0.09	0.06	0.16	0.13	0.11	0.06	0.09

NFI	Alt.	2010	2011	2012							
		CC12: net change in dead organic matter (changeCd,i) [t C ha^{-1} yr^{-1}]									
1	1	-0.34	-0.29	-0.28							
1	2	-0.04	-0.07	-0.07							
1	3	-0.28	-0.29	-0.26							
2	1	-0.45	-0.38	-0.35							
2	2	-0.36	-0.32	-0.29							
2	3	-0.36	-0.32	-0.29							
3	1	0.05	0.01	0.00							
3	2	-0.69	-0.65	-0.58							
3	3	-0.13	-0.19	-0.17							
4	1	-0.39	-0.37	-0.33							
4	2	-0.30	-0.31	-0.29							
4	3	-0.23	-0.25	-0.26							
5	1	0.00	-0.01	-0.01							
5	2	0.09	0.05	0.04							
5	3	0.19	0.12	0.10							

(Table 7-23 continued)

NFI	Alt.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		CC12: net change in mineral soil (changeCs,i) [t C ha^{-1} yr^{-1}]									
1	1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	3	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002
2	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	2	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2	3	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
3	1	0.003	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.005
3	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001
3	3	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	0.000
4	1	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005
4	2	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	3	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
5	1	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.003	-0.003	-0.002	-0.002
5	2	-0.001	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
5	3	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002

NFI	Alt.	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		CC12: net change in mineral soil (changeCs,i) [t C ha^{-1} yr^{-1}]									
1	1	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.001
1	2	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001
1	3	-0.002	-0.002	-0.002	-0.002	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
2	1	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.000
2	2	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
2	3	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
3	1	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
3	2	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.002	0.002
3	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	1	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
4	2	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000
4	3	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002
5	1	-0.002	-0.002	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
5	2	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	-0.001
5	3	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003

NFI	Alt.	2010	2011	2012							
		CC12: net change in mineral soil (changeCs,i) [t C ha^{-1} yr^{-1}]									
1	1	0.001	0.001	0.001							
1	2	0.001	0.001	0.001							
1	3	-0.003	-0.003	-0.003							
2	1	0.000	-0.001	-0.001							
2	2	0.001	0.001	0.001							
2	3	0.001	0.001	0.001							
3	1	0.004	0.004	0.004							
3	2	0.001	0.001	0.001							
3	3	0.000	0.000	-0.001							
4	1	0.005	0.005	0.005							
4	2	0.000	0.000	0.000							
4	3	0.001	0.001	0.001							
5	1	-0.001	-0.001	-0.001							
5	2	-0.001	-0.001	-0.001							
5	3	0.003	0.004	0.004							

A large source of uncertainties in simulated estimates of litter and soil carbon stocks is related to the calculation of the litter production of trees (de Wit et al. 2006), which determines the C inputs that drive the Yasso07 simulation. Data for soil and litter carbon are retrieved from Nussbaum et al. 2012 (Table 7-21). Deadwood (TDW) stocks are reported based on estimates obtained with Yasso07 (annual values integrated in DOM in Table 7-23).

Carbon stock changes in the soil pool are small (Figure 7-5 SO_{csc} and Table 7-23), which corresponds to information from measurements (see Chapter 7.3.6). Carbon stock changes in litter are higher and more erratic than changes in the dead wood and soil pools (Figure 7-5 LFH_{csc}). This is expected since non-woody material decomposes faster than dead wood (Tuomi et al. 2011), and there is a higher interannual variability in the production of foliage (Etzold et al. 2011). The C stock change in the dead wood pool is to a large extend driven by the increase in the dead wood volume following the hurricane Lothar (1999). As Lothar occurred between the NFI2 (1993-1995) and NFI3 (2004-2007), it strongly affects the results of the change analysis for dead wood volume in the periode NFI2-3 and also between NFI3-4, where the mortality rate decreased again. Large-scale disturbance events like Lothar that occur between two consecutive NFIs strongly affect the estimates of annually accumulating mass of carbon in dead wood that drives the Yasso07 simulation This bias is expected to disappear following the switch to a continuous sampling approach in the NFI4 (Braendli und Speich 2011).

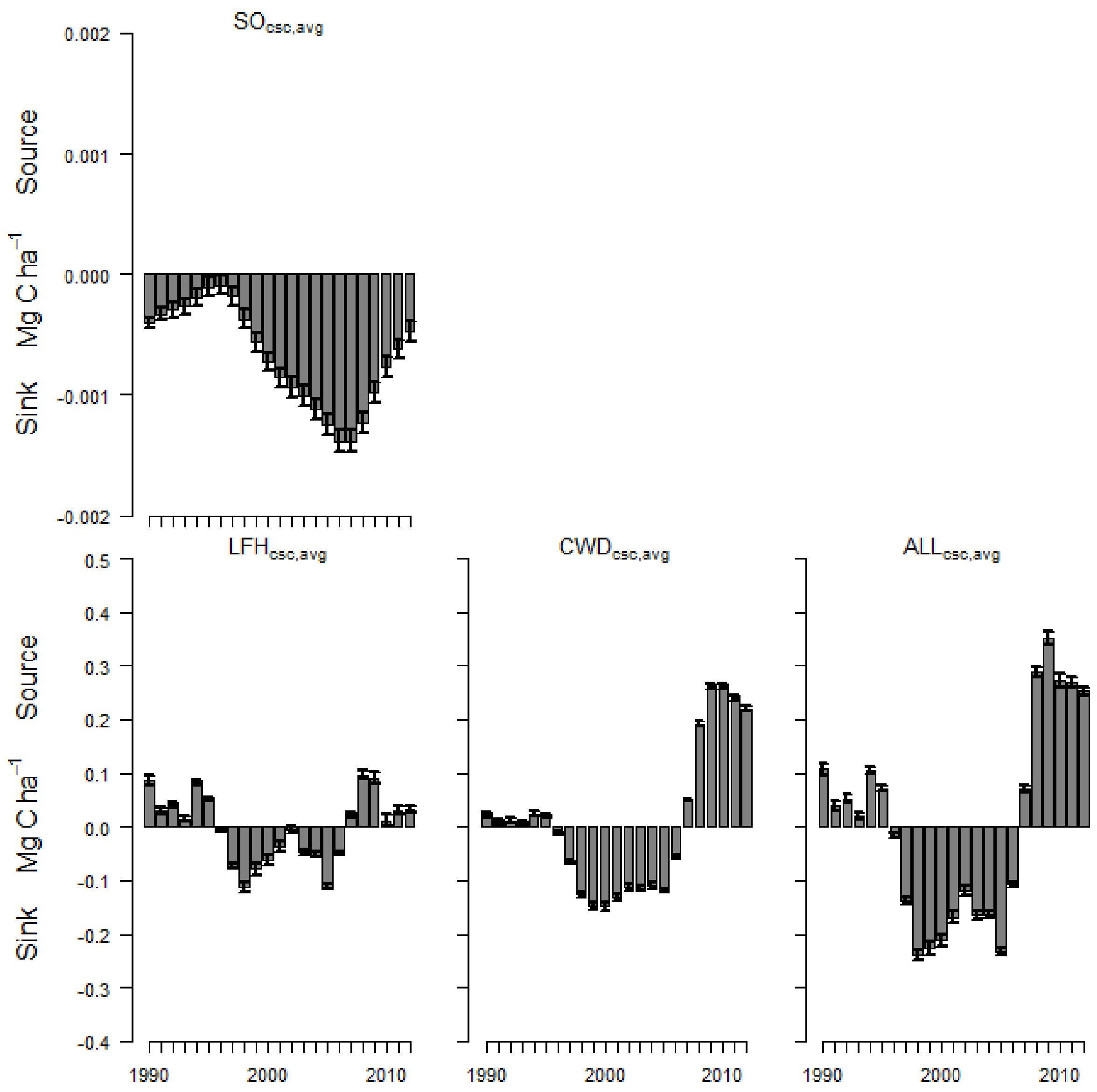

Figure 7-5: Mean carbon stock change (CSC) based on averaged (avg) annual carbon stocks for soil organic carbon (SO). Litter (LFH), dead wood (CWD) and their sum (ALL). Note the different scale of the y-axis for SOcsc,avg in comparison to LFHcsc,avg, CWDcsc,avg and ALLcsc,avg. Negative values indicate a sink of carbon, positive values a carbon source.

7.3.4.9 Unproductive Forests (CC13): Stocks and Changes in Stocks of Living Biomass, Dead wood, Litter and Soil Carbon

Unproductive forests consist of brush forests and forest on unproductive areas. FOEN (2014f) shows some examples of unproductive forests in Switzerland.

For transparency reasons, both productive and unproductive forest areas are reported separately. However, there is only scarce information available about unproductive forests. In unproductive forests, wood is not harvested for economical reasons. Only in exceptional cases (e.g. wood log blocks a hiking trail) there can be an intervention where the log is moved, but not removed from the stand. Moreover, since yearly harvesting amounts from forest statistics (FOEN 2013k) are divided over the productive forests, total harvesting in Swiss forests is accounted for under CC12 remaining, thus all havesting amounts are accounted for.

The national forest inventory does not incorporate unproductive stands in its regular inventory scheme because 1) the plots are difficult to access or it is not possible to carry out precise measurements (brush forests), (2) the plots are inaccessible or the NFI forest definition is not fulfilled (forest on unproductive areas).

- Brush forests: Since brush forests have no direct economical value in terms of wood harvest, an inventory of these stands has not been attributed high priority. During NFI3, some plots in brush forests have been visited for the first time, but only a limited number of parameters like tree species, stem diameter and crown cover have been determined. There are no NFI estimates available on carbon stocks of living biomass, since the allometric functions to calculate biomass from stem diameter in brush forests are not established yet.
- Forest on unproductive areas:

  a) Inaccessible stands are forests which cannot be visited because of safety reasons (see description in Brändli 2010, p. 89). They are mainly located in the Alps and often grow on sites of low productivity: rocky sites, sites at high altitude near the tree line with a short vegetation period and low biological activity;

  b) Unproductive forests not covered by NFI: after the review of its Initial Report (FOEN 2006h), Switzerland had to apply a forest definition for reporting activities under KP Art. 3.3 and Art. 3.4, which is different from the definition applied by the Swiss NFI and the Land Use Statistics AREA. The same definition is used for reporting under the UNFCCC and under the Kyoto Protocol. Because the country definition (NFI and AREA) was not in line with the specific requirements of the Kyoto Protocol forest definition, Switzerland had to develop an approach to classify certain AREA categories as forest. Those areas are not covered by the regular NFI and are situated in the threshold range between forests and alpine pastures with woody biomass of very low productivity. More specifically, it concerns the combination category “alpine pastures with a cluster of trees” in Table 7-6 (LU=242 and LC 47).

Unproductive Forests (CC13): Carbon Stocks in Living Biomass

Brush Forest

Brush forests in Switzerland mainly consist of *Alnus viridis* and horizontal *Pinus mugo var. prostrata*. No NFI data are available to derive their growing stock. Therefore, following assumptions were met to describe the stocks: 4’000 trees per ha, average height of 2.5 m and an average diameter at 1.3 m of 10 cm. Hence, an average growing stock (> 7 cm diameter) of 40 m3 ha^{-1} was estimated. Multiplied by the mean BCEF for coniferous trees of 0.64 (see Table 7-28; Thürig and Herold 2013), an average biomass for brush forest of 25.7 t ha^{-1}, which translates to 12.9 t C ha^{-1} (using the IPCC default carbon content of 50%) was estimated.

Forest on Unproductive Areas

Forest on unproductive areas in Switzerland is mainly located in the Alps and the Southern Alps. In those forests, no NFI data are available to derive growing stocks. As those forests are assumed to grow preferably on bad site conditions, we assume an average growing stock (> 7 cm diameter) of 150 m^3 ha^{-1}. Multiplied by the mean BCEF for coniferous trees of 0.64 (see Table 7-28; Thürig and Herold 2013), an average biomass for forest on unproductive areas of 96.4 t ha^{-1} was estimated, which translates to 48.2 t C ha^{-1} (using the IPCC default carbon content of 50%).

Carbon Stocks of Living Biomass at CC13: Weighted Means

The carbon content of unproductive forest was calculated as a weighted average of brush forest and forest on unproductive areas per spatial stratum:

[weighted C content]i = RSi * CS + (1- RSi) * CI

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

CS is the carbon content of brush forest (12.9 t C ha^{-1}),

CI is the carbon content of forest on unproductive areas (48.2 t C ha^{-1}).

Table 7-24 shows the carbon content per spatial stratum in t C ha^{-1}.

Table 7-24 Rate of brush forest and forest on unproductive areas and the resulting weighted carbon content in t C ha-1 of Swiss unproductive forests (CC13) specified for all spatial strata. The area of forest on unproductive sites is derived from NFI 2 (Brassel and Brändli 1999).

NFI region	Altitude [m]	Brush forest [ha]	Forest on unproductive area [ha]	Total unproductive forest [ha]	Rate of brush forest	Weighted C content [t C ha^{-1}]
1	<601	25	356	381	0.07	45.90
	601-1200	1	1'780	1'781	0.00	48.20
	>1200	1	178	179	0.01	48.03
2	<601	25	534	559	0.05	46.64
	601-1200	25	356	381	0.07	45.90
	>1200	1	0	1	1.00	12.86
3	<601	25	356	381	0.07	45.90
	601-1200	50	3'204	3'254	0.02	47.68
	>1200	2'100	1'780	3'880	0.54	29.08
4	<601	100	356	456	0.22	40.47
	601-1200	1'925	4'984	6'909	0.28	38.37
	>1200	36'925	7'120	44'045	0.84	18.58
5	<601	200	534	734	0.27	38.59
	601-1200	2'550	3'560	6'110	0.42	33.46
	>1200	16'875	5'162	22'037	0.77	21.14

Unproductive Forests (CC13): Carbon Stocks in Litter, Soil and Dead Wood

As stated on previous page CC13, consists of very different forests and data are hardly available. Carbon stocks in litter and mineral soil under unproductive forests reveal therefore a very high spatial heterogeneity. Brush forests are mainly situated on soils comparable to the ones under productive forests, others are situated at stony sites with very thin layers of organic material. Data on carbon stocks of litter and soil are not available. We therefore assumed carbon stocks of soil carbon and litter to be the same as for productive forests CC12 and are derived from Nussbaum et al. (2012; Table 7-21).

So far, there are no data available for dead wood stocks in unproductive forests (CC13). We conservatively assume no dead wood on CC13 sites. Therefore, the amount of dead organic matter (litter and dead wood) on CC13 sites equals the carbon stock in litter of mineral forest soils. Dead organic matter values for CC13 are listed in Table 7-4.

Unproductive Forests (CC13): Changes in Carbon Stocks of Living Biomass

There are a few case studies on carbon stocks, but just like in neighboring countries with forests in mountainous regions, there are no repeated forest inventory data available for these unproductive forests (also known as “mountain forest without harvest”) available.

As no harvesting is conducted in unproductive forests, gross growth and cut and mortality of unproductive forest are assumed to be in balance. This approach is confirmed by two studies in which basal area and crown cover is used as a proxy for the stock of living biomass. An increase in basal area or crown cover, respectively, is positively correlated with an increase in living biomass (e.g. Nowak and Crane 2002). Living biomass in brush forests is increasing during the stage of establishment: the stand develops from a stand with grasses, herbs and some shrubs towards a stand dominated by shrubs and with a denser crown cover. A decrease in crown cover in unproductive forests is observed when natural disturbances like avalanches or rock fall partially damage the stand.

- Huber and Thürig (2014) analyzed the available data on diameters of the terrestrial inventory NFI3 and NFI4a+. The authors found that the number of trees has increased over this 6 years period. Since no allometric functions are available for these stands, it is not possible to calculate stocks from these data. The authors calculated an increase in the mean basal area from 4.59 m^2 ha^{-1} in 2006 to 5.47 m^2 ha^{-1} in 2012.

- Ginzler (2014) analyzed the crown cover density of 135 aerial photographs between 2006 (NFI3) and 2011 (NFI4a) and found no statistical change in crown cover density of well-established, existing shrub forests. The terrestrial NFI data, however, showed a slight increase in the basal area of trees in brush forests.

- In addition, the study of Huber and Frehner (2013) shows that the expansion of *Green Alder* in eastern Switzerland has doubled in the past 75 years. Especially in the Alps or at unproductive sites, brush forests are expanding as summer pastures are abandoned. At these sites, an increase in crown cover is observed which correlates with an increment in carbon stocks. A literature review by Huber and Frehner (2012; for an overview see FOEN 2014f) shows that *Green Alder* has in general a strong annual gross growth, not only in very young stands, and that stands of *Green Alder* can be very vital at an age of over 100 years.

Considering the observed dynamics in brush forests, we conclude that living biomass in unproductive forests is not a net source of carbon and report living biomass to be in balance (conservative estimate, Tier 1 approach). In Table 7-3 and in the CRF-tables, this is transcribed into gains = losses = 0.

Unproductive Forests (CC13): Changes in Carbon Stocks of Litter, Mineral Soils, Dead Wood and organic soils

There are no repeated measurements of carbon stocks in litter, mineral soils and dead wood.

Above, transparent and verifiable information has been given that in Switzerland living biomass in brush forest is increasing. An increase in biomass leads to an increase in litter and dead wood production, which again can lead to an accumulation in soil carbon. Based on that, we can conclude that litter, mineral soils and dead wood are not a net source of carbon. Carbon changes in litter, mineral soils and dead wood are conservatively reported to be zero (Tier 1 approach). This assumption is further supported by the following arguments:

- The areas of CC13 occur on higher altitudes where microbiological processes in soils are slow (Hagedorn et al. 2010; Davidson and Janssens 2006).

- In addition, unproductive forests grow on poor or rocky sites with thin or no organic lay-er. Brush forest protect the soils; in particular, Alder brush is not even destroyed by avalanches, rock fall when rock size is small or medium (Huber and Frehner 2014). By stabilizing soils, brush forests act as a perfect protection against soil erosion (Richard 1995; Stangle 2004).

- Further, by fixing nitrogen with its nitrogen-fixing root nodules, *Green Alder* has an ameliorative effect on the soil. Amelioration of soils enables an increase in biomass production which on the other hand increases the amount of litter and dead wood and finally leads to accumulation of soil carbon.
- Since there is no active logging on these unproductive stands, there is also no human impact on the soils, litter and dead wood.

By providing this transparent and verifiable information (survey of peer-reviewed literature and reasoning based on sound knowledge of likely system responses; as requested by the ERT, see Table 1-12), we conclude that the requirements of IPCC GPG Chapter 4.2.3.1 (IPCCC 2003) application of Tier 1 are fulfilled.

For conversions within forest land (CC13 to CC12 and CC12 to CC13), no changes in carbon stocks of litter and soil carbon of mineral soils are calculated because carbon stocks of litter and soil carbon are equal for CC12 and CC13. The reason why these stocks are assumed to be equal is (1) because data are not available (see above) and (2) because it leads to a conservative estimate of changes in these pools. With the exception of brush forests, it is very likely that carbon stocks of litter and soil carbon are smaller under unproductive forests CC13 than under productive forests CC12. As the area changing from CC13 to CC12 is larger than from CC12 to CC13 (see Table 7-9), applying the stock-change method (see Table 7-3) with equal stocks for litter and soil carbon under CC12 and CC13 is a conservative estimate.

Emissions from organic soils are accounted for using a Tier 1 approach. A conservative estimate (Tier 1; no changes) is applied for all pools of unproductive forests.

7.3.4.10 Afforestations (CC11)

Living Biomass: Growing Stock and Changes in Growing Stock

The average growing stock and growth of afforestations were empirically assessed from NFI 1 and NFI 2 data, specifically with those stands that were approximately 10 years old in the first NFI and 20 years old in the second NFI. The average growing stock of those 20 year old stands was derived from NFI 2. The NFI data were therefore stratified per altitudinal level. The growing stock of forest stands below 600 m was on average 90 $m^3 ha^{-1}$. The growing stock on sites between 600 and 1200 m was assumed to be one-third smaller (60 $m^3 ha^{-1}$) than on sites below 600 m, and two-thirds smaller on sites above 1200 m (30 $m^3 ha^{-1}$). As trees below 12 cm diameter at breast height (DBH) were not measured in the NFI, the growing stock of 10 year old stands below 600 m was assumed to be 2 $m^3 ha^{-1}$. Within the first few years of stand age, the growing stock was assumed to develop exponentially. The development of the growing stock between 10 and 20 years on sites below 600 m was simulated by calibrating a logistical growth function. To simulate the development of growing stock on intermediate and poor sites, growing stock was assumed to develop one-third slower on intermediate, and two-thirds slower on poor sites. The annual growth was calculated as the difference between growing stocks of two following years. These assumptions are not valid for single stands, but can be applied as a rough simplification. Table 7-25 shows the simulated growing stock and growth for the three altitudinal levels.

Table 7-25 Estimated average growing stock and annual growth of forest stands in stem-wood over bark including stock up to 20 years (CC11) specified per altitudinal zone. Bench marks derived from NFI 1 and NFI 2 (see text above) in bold letters.

Stand age	< 601 m altitude		601 - 1200 m altitude		> 1200 m altitude	
	Growing stock	Growth	Growing stock	Growth	Growing stock	Growth
[yr]	[m^3 ha^{-1}]	[m^3 ha^{-1} $year^{-1}$]	[m^3 ha^{-1}]	[m^3 ha^{-1} $year^{-1}$]	[m^3 ha^{-1}]	[m^3 ha^{-1} $year^{-1}$]
0-9	0	0	0	0	0	0
10	2	2	0	0	0	0
11	7	5	0	0	0	0
12	13	6	1	1	0	0
13	19	6	5	4	0	0
14	27	8	10	5	0	0
15	35	8	16	6	1	1
16	44	9	23	7	5	4
17	54	10	31	8	10	5
18	66	12	40	9	16	6
19	78	12	50	10	23	7
20	**90**	12	**60**	10	**30**	7

To convert the estimated growing stock (m^3 ha^{-1}) and growth (m^3 ha^{-1} $year^{-1}$), both expressed in volume units, into tonnes of carbon, the following equations were applied:

Carbon stock in living biomass = Average growing stock * BCEF * C content

Growth of living biomass = Average growth * BCEF * C content

Where

- C content: Carbon to total biomass ratio. The IPCC default of 50% was applied (IPCC 2003; p 3.25)
- BCEF: Biomass conversion and expansion factor converting the volume of growing stock and the volume of net annual increment to total tree biomass and total tree biomass growth, respectively; an average value for coniferous and deciduous trees is taken from Burschel et al. (1993).

Table 7-26 Carbon stock in living biomass (stem-wood over bark including stock without branches) and growth of living biomass in afforestations (CC11) specified per altitudinal zone. BCEF taken from Burschel et al. (1993).

Altitude	Average growing stock	Average growth	BCEF	Carbon content	Carbon stock in living biomass	Growth of living biomass
[m]	[m^3 ha^{-1}]	[m^3 ha^{-1} yr^{-1}]			[t C ha^{-1}]	[t C ha^{-1} yr^{-1}]
<601	21.7	4.5	0.7	0.5	7.84	1.63
601-1200	11.8	3	0.7	0.5	4.3	1.09
>1200	4.25	1.5	0.7	0.5	1.61	0.57

Litter and Dead Wood (DOM): Carbon Stock and Carbon Stock Changes

In Switzerland, afforestations (CC11) occur mostly on grasslands and settlements (see Table 7-9 in Chapter 7.2.3) where there is no litter and no dead wood (IPCC 2003, p. 3.105). Therefore, assuming no carbon stock in dead organic matter on afforestation sites, we follow the Tier 1 approach in terms of IPCC good practice (IPCC 2003, Sect. 3.1.5) and consistently report no changes in the litter and dead wood pool after a land-use change to afforestation (see Chapter 11.3.1.2 for a deepened discussion)

Soil: Carbon Stock and Carbon Stock Changes

The estimates for soil carbon stocks from Nussbaum et al. (2012) are used for afforestations (CC11; see Table 7-4 and Table 7-21). Based on these carbon stocks, carbon stock changes are calculated with the stock-change method (see 7.1.3.2 and Table 7-3).

7.3.4.11 Organic Soils

Organic Soils - Carbon Stock

No specific information is available related to carbon stocks in organic soils under forest land. Therefore, the value calculated for cropland and permanent grassland based on Leifeld et al. (2003, 2005) is adopted for forest land, including CC11, CC12 and CC13. The approach uses measured carbon stocks in Swiss organic soils. The mean soil organic carbon stock (0-30 cm) for organic soils is 240 ± 48 t C ha^{-1}.

Organic Soils - Changes in Carbon Stocks due to Drainage

Drainage of forests is not a permitted practice in Switzerland (Swiss Confederation 1991). There are no nation-wide survey data available. It is possible that small parts of the Swiss forest have been drained before 1990 or have been established on drained areas. We conservatively report all organic forest soils to be drained (which is definitely an overestimation).

In order to calculate CO_2 emissions due to drainage, we used equation 3.2.15 of the GPG for LULUCF (IPCC 2003) and applied the default emission factor of 0.68 t C ha^{-1} yr^{-1}.

7.3.4.12 N_2O Emissions from N Fertilization and Drainage of Soils

Fertilization of forests is prohibited by the Swiss forest law and adherent ordinances (Swiss Confederation 1991, 1992). Additionally, the “Ordinance on Chemical Risk Reduction“ (Swiss Confederation 2005) prohibits the application of fertilizers, including liming, in forests. Therefore, no emissions are reported in CRF-table 5(I A).

There are no data available on non-CO_2 emissions from organic soils in Switzerland. As in IPCC (2003) only a basis for future methodological development is included, Switzerland does not provide such estimates.No non-CO_2 emissions are estimated (“NE”) in CRF-table 5(II A) (see also Chapter 7.6.4.4).

7.3.4.13 Emissions from Wildfires

Data on wildfires affecting Swiss forest land are obtained from cantonal authorities and are compiled by FOEN (FOEN 2013k). Table 7-27 shows the annual number of fires and the burnt area from 1990 to 2012.

As controlled burning is not allowed in Switzerland all fires are assigned to “wildfires”. The number and area of the fires are assigned to productive forests. This is a conservative estimate, since the "available fuel" of productive forests is higher than the carbon stocks of afforestations and unproductive forests.

Using the default emission factor of 7.10 g (kg combusted biomass)$^{-1}$, an emission factor for CH_4 of 0.903 Mg CH_4 ha^{-1} is cacluated (IPCC 2003, equation 3.2.20 and table 3A.1.16).

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

The mass of available fuel considered for calculating the emissions, depends on the greenhouse gas reported:

(1) For reporting CH_4 and N_2O emissions from wildfires, the mass of available fuel encompasses carbon stock of living biomass, litter and dead wood.

(2) For reporting CO_2 emissions from wildfires, the mass of available fuel only encompasses carbon stock of litter. Losses in living biomass and dead wood due to wildfires are already reflected in the NFI dataset and included in CRF-table 5A. Yearly values of these losses are included in the data shown in Table 7-19 under “loss of living biomass" and in Table 7-23 under "net change in dead organic matter", respectively.

On average, the amount of living biomass amounts to 119.40 t C ha^{-1}or 238.81 t biomass ha^{-1}. This value has been derived from the mean growing stock in NFI 1, NFI 2, NFI 3 and NFI 4a (Brassel and Brändli 1999, Brändli 2010, Abegg et al. 2012).

On average in Swiss forests, the amount of litter amounts to 16.7 t C ha^{-1} or 33.40 t biomass ha^{-1} (Nussbaum et al. 2012). The amount of dead wood amounts on average to 5.23 t C ha^{-1} or 10.46 t biomass ha^{-1}. These values are derived from Table 7-21 as weighted averages over all spatial strata.

The fraction of the biomass combusted is 0.45 (IPCC 2003, Table 3A.1.12). Inserting these values in equation 3.2.20 of IPCC (2003), the emissions shown in Table 7-27 are calculated.

CH_4 and and N_2O emissions caused by wildfires are reported in CRF-table 5(V). CO_2 emissions caused by wildfires are included in CRF-table 5A (as described above) and 5(V). In Table 5(V), the emissions from all forest fires are reported under 5(V)A1, because it is not known which fires occur on forest land remaining forest land and which on land converted to forest land. Consequently, 5(V)A2 has the notation key "IE".

Table 7-27 Productive forest land affected by wildfires (FOEN 2013k) and resulting GHG emissions 1990-2012.

Year	Number	Area burnt [ha]	CH_4 [Mg]	N_2O [Mg]	CO_2 [Mg]
1990	216	1102	995.24	15.42	25'358.04
1991	157	148	133.66	2.07	3'405.62
1992	111	52	46.96	0.73	1'196.57
1993	99	42	37.93	0.59	966.46
1994	52	293	264.62	4.10	6'742.20
1995	56	438	395.57	6.13	10'078.79
1996	61	233	210.43	3.26	5'361.55
1997	77	1511	1364.62	21.14	34'769.52
1998	88	249	224.88	3.48	5'729.72
1999	31	9	8.13	0.13	207.10
2000	41	36	32.51	0.50	828.39
2001	39	37	33.42	0.52	851.40
2002	75	410	370.28	5.74	9'434.48
2003	189	564	509.36	7.89	12'978.16
2004	46	20	18.06	0.28	460.22
2005	97	47	42.45	0.66	1'081.51
2006	70	101	91.22	1.41	2'324.10
2007	64	234	211.33	3.27	5'384.56
2008	47	53	47.87	0.74	1'219.58
2009	52	42	37.93	0.59	966.46
2010	59	25	22.58	0.35	575.27
2011	77	167	150.82	2.34	3'842.83
2012	56	22	19.87	0.31	506.24

7.3.4.14 NMVOC Emissions

Estimates for annual biogenic emissions of NMVOC in Switzerland for forests (and natural grassland) are available in SAEFL (1996a): The values are 92.0 Gg for coniferous forests, 2.4 Gg for deciduous forests and 0.61 Gg for forest fires. These numbers are based on a study from Andreani-Aksoyoglu and Keller (1995). Approximately 97% of the total emissions are monoterpene and the rest consists of isoprene (Keller et al. 1995).

7.3.5 Uncertainties and Time-Series Consistency

Uncertainties

For living biomass, the following information on uncertainty related to 2012 was used:

- Stem wood of growth and cut & mortality (C&M) in NFI 4a+ and differences NFI 3-4a+:

  mean growth 11.38 m^3 ha^{-1}, mean C&M -8.97 m^3 ha^{-1}, resulting mean net change in stem volume 2.41 m^3 ha^{-1}

  relative uncertainty: 2% for growth and 5% for C&M (Thürig 2014)

  resulting relative uncertainty of mean net change in volume: 20.9%

- Carbon content in solid wood: 5-10% (background: Lamlom and Savidge 2003, assessment of carbon content in wood; Monni et al. 2007, 2%)
- Wood density: guess 10-20% (background: Lamlom and Savidge 2003)
- Biomass expansion function (for the Swiss GHGI, allometric functions for individual trees are applied): The uncertainty is estimated to be 30% (Monni et al. 2007, Appendix 1, 2.7-21.3%; Vanninen and Mäkelä 1999; Cronan 2003; Helmisaari and Hallbäcken 1998).

Thus, the total uncertainty of net carbon stock change in living biomass ($U_{liv.biom}$) in terms of carbon per unit area can be calculated as:

- addition of relative uncertainties to derive uncertainty for gains and losses following equation 6.4 in chapter 'Quantifying Uncertainties in Practice' (IPCC 2000)

  $U_{liv.biom} = (20.9^2 + 10^2 + 15^2 + 30^2)^{0.5} = 40.7\%$

- calculation of the absolute uncertainty, based on the mean gain of 0.72 t C ha^{-1} yr^{-1}:

  $U_{liv.biom} = 0.29$ t C ha^{-1} yr^{-1}.

The uncertainty in the estimates of annual stock changes derived with the Yasso07 model originates from the following sources:

- spatial climate data interpolation
- C input estimates obtained from the NFI (measurement errors, allometries, etc.)
- decomposition parameters used in the Yasso07 model

The uncertainty associated with the climate data could not be estimated.

The uncertainty associated with C inputs (dead wood production and litterfall) was estimated based on estimates of uncertainty in a) litter turnover rates (Wutzler and Mund 2007), b) wood densities of deadwood in different decay stages (Dobbertin and Jüngling 2009), and c) spatial uncertainty in the NFI data approximated based on the estimation error for tree volume reported for the NFI (see chapter 1.4 in Brändli 2010). Based on the mean C inputs and the estimated uncertainty, a distribution of possible values was obtained. Finally, the combined uncertainty from these sources was calculated:

- The uncertainty in the Yasso07 parameters was estimated based on a Markov Chain Monte Carlo approach (see also Tuomi et al. 2011). A distribution of possible parameter values was provided by A. Lehtonen, Finnish Forest Research Institute METLA .
- The uncertainty of Yasso07 estimates on C stocks and C stock changes in different pools, resulting from the uncertainty of C inputs and of model parameters, was obtained through Monte Carlo simulations: 30 values for C inputs and 30 parameter combinations were selected randomly and the combined uncertainty in Yasso07 estimates of C stocks and C stock changes in the soil, litter, and dead wood pools was calculated as (described in Didion et al. 2013).

- Based on this approach the absolute uncertainty of the estimates of C stock changes are (Didion et al. 2013):

  U_{Soil} = 0.000081, U_{Litter} = 0.0065 and $U_{Deadwood}$ = 0.0047 t C ha^{-1} yr^{-1}.

The absolute uncertainty of the total C stock change is:

- $U_{tot} = (U_{liv.biom}^2 + U_{Soil}^2 + U_{Litter}^2 + U_{Deadwood}^2)^{0.5}$ = 0.29 t C ha^{-1} yr^{-1}.

The mean total C stock change in 2012 is the sum of the mean changes of living biomass, soil, litter and deadwood: 0.72 + 0.00 - 0.03 - 0.22 = 0.47 t C ha^{-1} yr^{-1}. Thus, the resulting relative uncertainty of the C stock changes for forest land is 63%.

Combined uncertainties of the activities under the Kyoto Protocol are shown in Table 11-8.

The emission factor uncertainty for wildfires is 70%. This is the default value given for non-CO_2 emissions in the Good Practice Guidance (IPCC 2003, section 3.2.1.4.2.4). It is used here also for the CO_2 emissions as the fraction of the biomass combusted is quite uncertain for temperate forests (IPCC 2003, Table 3A.1.12): mean=0.45, SD=0.16.

Uncertainties of activity data of Forest land are described in Chapter 7.2.5. Table 7-5 lists the relative uncertainties in the LULUCF sector: an uncertainty of 63% was calculated for Afforestations, 50% for Deforestations and 63% for Forest Management.

Time-Series Consistency

Consistent time series of annual growing stocks were calculated backward or forward starting from the growing stock 2005, as derived from NFI 3 (see Chapter 7.3.4.6).

Consistent time series of dead wood, litter and soil carbon were calculated with the model Yasso07 (see Didion et al. 2013 and Chapter 7.3.4.8).

7.3.6 Category-Specific QA/QC and Verification

Estimation of Growing Stock, Gains and Losses of Living Biomass

Biomass Conversion and Expansion Factors

For transparency reasons and for comparison with the Biomass Conversion and Expansion Factors (BCEFs) used in former submissions (FOEN 2012 and before), updated BCEFs were calculated. Please note: These BCEFs (Table 7-28) were not used for the calculations but are only provided for verification purposes and transparancy. BCEFs for gains and losses vary between the four inventories NFI 1-4a (Table 7-28). The values for gains range from 0.59 to 0.62 for conifers and from 0.82 to 0.86 for broadleaves. The values for losses show a similar range: 0.59 to 0.60 for conifers and 0.79 to 0.83 for broadleaves. The BCEFs and the differences between gains and losses, respectively, are in the same range as those reported in the Austrian NIR 2012 (Umweltbundesamt 2012).

Table 7-28 Comparison of BCEFs used in FOEN (2012 and before: 'BCEF 2012') and BCEFs 2013 (weighted averages, not used for calculation) for conifers and broadleaves, NFI 1-4a.

		BCEF 2012 Growing stock	BCEF 2013 Growing stock	BCEF 2013 Gains	BCEF 2013 Losses	Difference
Conifers	NFI 1		0.62			
	NFI 1-2			0.59	0.60	-0.01
	NFI 2		0.61			
	NFI 2-3			0.61	0.59	0.02
	NFI 3*	0.64	0.62			
	NFI 3-4			0.62	0.60	0.02
	NFI 4a		0.63			
	Austria**			0.62	0.61	0.01
Broadleaves	NFI 1		0.81			
	NFI 1-2			0.82	0.79	0.03
	NFI 2		0.82			
	NFI 2-3			0.85	0.81	0.04
	NFI 3	0.83	0.83			
	NFI 3-4			0.86	0.83	0.03
	NFI 4a		0.83			

* For conifers, BCEFs 2013 for growing stock is smaller than BCEF 2012 because of the new parameters for coniferous roots (cf. Thürig and Herold 2013).

** In Umweltbundesamt (2012), only BEFs are published. For comparison in this report, BEFs are converted to BCEFs by multiplication with wood densities (0.38 for conifers, 0.54 for broadleaves as given in Umweltbundesamt 2012: Table 215).

Brush Forests

Düggelin and Abegg (2011) calculated values of total growing stock (also < 7 cm) for brush forest. They measured an average growing stock of 166 m^3 ha^{-1} for *Pinus mugo* stands and 74 m^3 ha^{-1} for stands with *Alnus viridis.*

Litter of Afforstations CC11

In an experiment by Zimmermann and Hiltbrunner (2012; COST E639-project “Turnover and stabilization of soil organic matter: effect of land-use change in alpine regions”) litter accumulation in a 40 year old afforestation with Norway Spruce was determined. The authors found accumalation rates of 0.17-0.20 t C ha^{-1} yr^{-1}. An overview of other studies is given in Chapter 11.3.1.2.

Carbon Balance of two Mountain Forest Ecosystems in Switzerland: Net Ecosystem Exchange and Soil Respiration

Measurements of the net ecosystem exchange (NEE) and of soil respiration were conducted at a montane mixed forest over 5 years (Lägeren; 2005–2009; NFI production region 2), and at a subalpine coniferous forest over 12 years (Davos; 1997–2009; Swiss Plateau, NFI production region 4).

(1) Etzold et al. (2011) determined the net ecosystem exchange (NEE) by eddy covariance (EC) measurements. EC measurements, as well as biometric estimates indicate that both sites with two different mountain forest types were significant C sinks in the respective periods. During 2005 to 2009 NEE of the Lägeren forest ranged from -366 to -662 g C m^{-2} yr^{-1} (mean: -415 g C m^{-2} yr^{-1}), and of the Davos forest from -47 to -274 g C m^{-2} yr^{-1} (mean: -154 g C m^{-2} yr^{-1}).

(2) Rühr and Eugster (2009) measured soil respiration rates at these two Swiss forest sites. Modeled changes in soil C storage with the dynamic soil carbon model Yasso07 (see also Thürig et al. 2005) gave comparable results with measured soil respiration. The authors found that soils at the alpine site Davos acted as a significant C sink. Soils at the Lägeren site were neither a significant C sink nor a significant C source. This domestic study confirms the broadly spread knowledge that it is very difficult to detect short term changes in soil C stocks, since the uncertainty of the measurement is often higher than the actual change of the annual estimates (e.g. Falloon and Smith 2003).

Changes in Soil Carbon Stocks

SOC Dataset of the Swiss Soil Monitoring Network

The objective of the Swiss Soil Monitoring Network (http://www.nabo.admin.ch/?lang=en; NABO) is to assess soil quality in the long term and to validate appropriate soil protection measures. The network was established in 1985. Currently, it comprises 105 observation sites throughout Switzerland. For the statements below, the NABO sites had been classified according to the 18 LULUCF combination categories (CC).

Changes in SOC content of forest soils are being measured since 1985 at soil monitoring benchmark sites in the Swiss Soil Monitoring Network (SAEFL 1993). Repeated soil inventories at the soil monitoring sites are carried out every 5 years. Four replicate bulked soil samples from the upper soil layer 0-20 cm are taken at the monitoring sites (10m x 10m). For each bulked sample 25 single cores are taken at the site according to a stratified random sampling scheme. Further details can be found in SAEFL (2000a).

SOC of the archived soil samples was measured with a modified Walkley and Black method (ACW/ART 1998) in the same laboratory since 2006. Since 2012 we introduced in parallel the SOC analysis by a C/N- Analyser (ThruSpec, Leco company) and measured soil samples of almost all sites with both methods. Strong correlations between both methods were found, with slightly higher values measured by the C/N-Analyser as this analytical method provides total organic carbon (TOC). The resulting regression to transfer SOC-Walkley and Black measurements to TOC showed a high coefficient of determination of 97%. Therefore, we harmonized the dataset correcting the SOC values (Walkely and Black) to the measurements of the C/N-Analyser. For further SOC analysis of the 5th and 6th soil campaign we will only use the C/N-Analyser method. Thus, the SOC dataset (n = 1'884 measurements) presented here and in Chapters 7.4.6 and 7.5.6 is not subject to systematic methodological errors caused by different laboratories or methods. To assure the reliability and accuracy of the measurements, sampling quality, sampling preparation, chemical extraction, analysis and sample storage in the soil archive is evaluated. SOC measurements of a soil sample were repeated if a SOC value deviated more than a certain degree from the values of the other three bulked soil samples of the same sampling campaign.

The spatial variation of bulk density is included in calculating the carbon pools. Bulk density measurements and soil skeleton (> 2mm) were measured at the monitoring sites in the 4th (2000-04) and 5th (2005-09) re-sampling campaign (n=4 in each campaign per site), but not in the previous campaigns. As the mass of the fine earth (FE) is the relevant fraction for the element pools in the soil, the bulk density refers to the mass FE. The measured skeleton fraction of the volume sample is substracted before. The temporal changes of the top soil bulk density between the 4th and 5th campaign were quite small and they differ between -0.2 and 0.1 g/cm^3. We presumed that the bulk density of the first three sampling campaigns ranged within the values measured in the 4th and 5th re-sampling campaign, i.e. propagated the variability of the measurements through Latin Hypercube sampling (n = 1000 simulation runs) assuming a normal distribution of the bulk density and SOC measurements for each site.

The SOC pools for the forest top soils (0-20 cm) ranged between 35.4 t C ha^{-1} (min) and 135.8 t C ha^{-1} (max) and were in average 70.6 t C ha^{-1}. In these numbers we exclude one coniferous forest site that revealed large SOC pools up to 191 t C ha^{-1}. Figure 7-6 shows that in average, SOC pools did not change monotonously during the measurement period between 1989 and 2009 in the sampled forest soils. At some of the forest monitoring sites higher values were found in the 3rd re-sampling campaign.

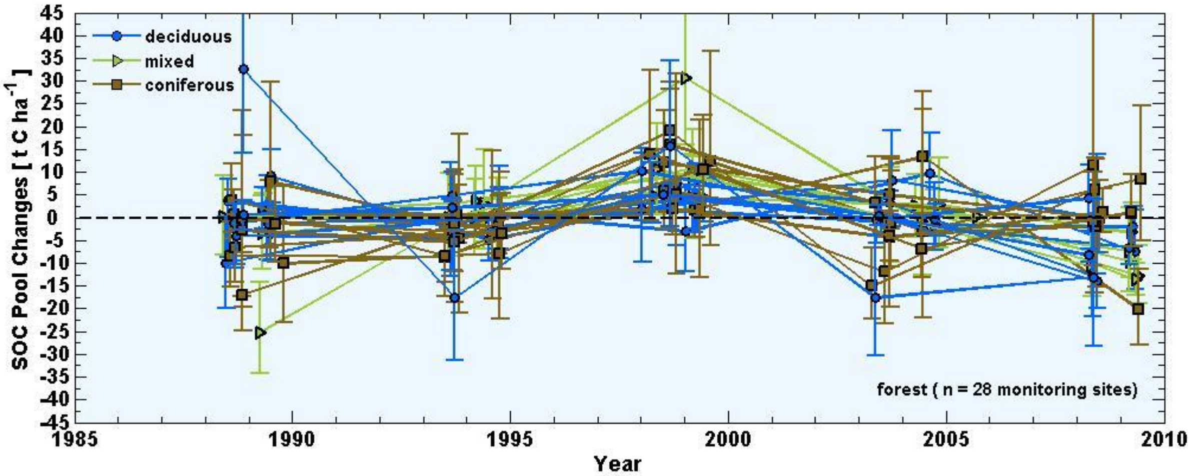

Figure 7-6 Time series of measured SOC pool changes in the top soil (0-20 cm) at the 28 NABO forest sites from the 1st to the 5th re-sampling campaigns. SOC pools were centred by the median SOC pool of all re-samplings of the monitoring site. Each pool value presents the median of four bulked soil samples per campaign with measured SOC and bulk density. The error bars indicate the 25% and 75% percentiles resulting from the spatial variation of the sites and the errors along the measurement chain. The altitude of the forest sites ranges between 380 and 1690 m a.s.l.

Detailed studies at monitoring sites showed that short-term temporal variation of soil properties can result from different site conditions at the sampling date, e.g. regarding soil moisture, soil temperature and bulk density (Keller et al. 2006). For instance, at two forest sites six re-samplings within three years revealed short-term variation of the SOC content between ± 1.8 % and ± 0.6 %. Therefore, the majority of the measured temporal variation for all forest sites is interpreted as natural variation (noise) and not as real SOC changes (signal). This hypotheses is also supported by the fact that the soil samples in the 3rd resampling campaign were taken earlier in spring time as in the other sampling campaigns and hence, soil moisture content of the samples was higher in average. This might explain the large temporal variation, in particular at coniferous forest sites with a pronounced organic layer. Using a robust linear regression approach for the SOC pool data of the forest soils, the 95% confidence interval for the SOC pool was ± 1.5 t C ha^{-1}. In order to capture as good as possible the natural variation of these site-specific characteristics, standard operation procedures and quality assurance were implemented since the 4th soil campaign. Further work will focus on the correction of the measured C pools to equivalent mass of the fine earth < 2 mm. In this way, we presume that the 95% confidence interval of the mean SOC pool can be reduced to some degree.

The 95% confidence interval obtained for the 28 forest monitoring sites is an order of magnitude larger than the modelled SOC pool changes for Swiss forest soils (Chapter 7.3.4.8). Didion et al. (2013), who applied the Yasso07 model to Swiss forest soils, estimated a soil sink effect of -0.0008 t C ha^{-1} yr^{-1} for 2009 to 2010. For the monitoring period of 20 years this rate of change would correspond to -0.016 t C ha^{-1}.Modeled SOC pool changes are not inconsistent with with the repeated soil inventories in the NABO network. As indicated by the 95% confidence interval for the 28 forest monitoring sites, the noise is about hundred times larger than the modeled signal.

Uncertainty Estimates

For comparison, the uncertainty for the stock of litter amounts to approximately 60% (Moeri 2007). The uncertainty of mortality data from the Finnish GHG inventory was assessed to be 30% (Monni et al. 2007). The uncertainty reported by Finland, where the Yasso07 model is also applied, was 46.8% for the 2010 emission factor in South Finland, 26.2% in North Finland, and 24.1% for the net change in the whole country (Statistics Finland 2012: Chapter 7.2.4.2).

7.3.7 Category-Specific Recalculations

The completion of the AREA surveys in 2013 (see Chapter 7.2) led to a recalculation in category 5A.

For this submission, NFI4a+ data covering the period 2009-2012 were applied as described in Thürig (2014; see Chapter 7.3.4.1). These data are an update of Abegg et al. (2012) which had been used in the previous submission (FOEN 2013).

The calculation of carbon stock changes in the different pools has been adapted such that it is harmonized for reporting under UNFCCC and under the KP, that no double counting is possible and that the most conservative accounting method is applied. The calculation approach is explained in 7.1.3.2 and Chapter 11.3.1. and transparently shown in Table 7-3 and Table 11-7. The V- and W-factors are no longer used for describing the calculation methods. Instead, the terms 'gain-loss' approach and 'stock-change' approach were introduced in line with the GPG LULUCF in order to be more clear and comprehensible. The calculation procedure was modified in the following transitions and C pools:

- Land-use type conversions from non-forest to CC12 (productive forest), from non-forest to CC13 (unproductive forest) and from CC13 to CC12; living biomass:
  Previous submission: stock-change.
  This submission: gain-loss.
  Rationale: The stock differences being dispersed over a conversion time of 20 years led to very high growth rates (Implied Emission Factor for gains). With this modification the C sink on areas converted from non-forest to forest land strongly decreased.
- Land-use type conversion from afforestation CC11 to CC12: living biomass, dead organic matter and soil:
  Previous submission: stock-change.
  This submission: gain-loss.
  Rationale: Afforestation is a transient land-use type by definition. It is supposed that it converts smoothly to CC12 during the 20 years.

Updated estimates of yearly changes in carbon stocks of soil organic carbon, dead wood and litter, modeled with Yasso07, are described in Didion et al. (2013). The accuracy of the estimates of C stocks and CSC was improved. As a result the a posteriori calibration of deadwood stocks (Chapter 7.3.4.9 in FOEN 2013) became redundant and, hence, a source of uncertainty was eliminated.

For wildfires on forest land, the emission factor for CH_4 was revised (see description in Chapter 7.3.4.13). Now, the default emission factor is used.

7.3.8 Category-Specific Planned Improvements

In the course of the next inventory preparation, the implementation of the new reporting guidelines (IPCC 2006) represents the largest improvement. To accomplish this transition, other projects or planned improvements may be postponed in order to give first priority to changes related to the new reporting guidelines.

In 2011, Agroscope started a three-year running research project that aims to identify (drained) fens and raised bogs under different land uses beyond the national inventories of bogs and fens in order to improve the AD estimates of organic soils ("Area and location of organic soils and peatlands in Switzerland"'). An ongoing study at Agroscope measures soil carbon stocks in organic soils under forest of three different vegetation units. These data will become available during 2014 and will help to validate the results of the above-mentioned project (ground truthing).

Further research is underway to estimate yearly values for gross growth. First results of a study investigating the relationship between climate and gross growth (Thürig et al. 2009) are expected in the course of 2014.

Switzerland intends to make better use of the SOC data provided by the Swiss Soil Monitoring Network in forthcoming submissions. A contract was signed in 2011 that arranges a close collaboration for the period 2012-2014.

The application and the parametrization of the model Yasso07 to get better estimates of temporal changes in soil carbon, LFH layer and dead wood will be further improved. Contact with researchers from other countries also applying Yasso07 for LULUCF reporting has been established.

Projects in a new national research programme (Sustainable Use of Soil as a Resource: "SOM control", http://www.nfp68.ch/E) aims at identifying the drivers of soil organic matter storage in Swiss forest soils. The objectives are to assess how forest productivity and tree species composition affect SOM storage, to investigate if and how land-use history affects C pools in soils, to estimate the influence of climate, temperature and precipitation on SOM stocks, to link SOM stocks to physico-chemical parameters controlling SOM stabilization and to model SOM and evaluate the residuals to measured SOM stocks.

7.4 *Category 5B – Cropland*

7.4.1 Description

Tier 2 Key category 5B1 CO_2 from 5B1 Cropland remaining Cropland (2012: level and trend). **Tier 2 Key category 5B2** CO2 from 5B2 Land converted to Cropland (2012: trend).

Swiss croplands belong to the cold temperate wet climatic zone. Carbon stocks in aboveground living biomass and carbon stocks in mineral and organic soils are considered. Croplands (CC21) include annual crops and leys in arable rotations (see Table 7-2 and Table 7-6). Because arable cropping mainly occurs in the temperate Swiss Central Plateau and no elevation-dependent soil carbon stocks are available for Swiss croplands (Leifeld et al. 2005), no stratification of carbon stocks has been applied.

In 2012, 5B1 Cropland remaining Cropland was a net source of 674.69 Gg CO_2 due to (I) a decrease in living biomass between 2011 and 2012 and due to (II) emissions from organic soils. Average living biomass was increasing slightly over the period 1990-2012. However, annual fluctutations in net carbon stock changes of biomass are considerable (see Table 7-30). Since carbon stocks on mineral soils are assumed to be in balance (i.e. no carbon stock changes occur on mineral soils) all soil emissions in 5B1 were generated by carbon mineralization in organic soils, mainly in the lowest altitudinal zone (z1: 98%). Overall, organic soils account for 2.7% of cropland area in Switzerland.

5B2 Land converted to Cropland was a small net source of 22.26 Gg CO_2 in 2012.

7.4.2 Information on Approaches Used for Representing Land Areas and on Land-use Databases Used for the Inventory Preparation

See Chapter 7.2.

7.4.3 Land-use Definitions and the Classification Systems Used and their Correspondence to the LULUCF Categories

See Chapter 7.2.

7.4.4 Methodological Issues

7.4.4.1 Carbon in Living Biomass

Annual biomass carbon stocks are shown in Table 7-29. They are calculated as area-weighted means of standing stocks at harvest for the seven most important annual crops (wheat, barley, maize, silage maize, sugar beet, fodder beet, potatoes) and as cumulated annual harvested biomass for leys.

The annual mean standing biomass carbon stock per hectare is calculated as:

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

where A_f = Area of crop type f, A_t = total cropping area and C_f = yield (annual crops, leys) for the particular crop (t C ha^{-1}). Annual values for A_f, A_t and C_f were published by the Swiss Farmers Union (SBV 2013).

The resulting mean biomass stock for Swiss cropland over the inventory time period is 4.69 ± 0.34 (1 SD) t C ha^{-1}.

Table 7-29 Annual values for arable crop yields (i.e. carbon stocks) and area-weighted mean (t C ha^{-1}) (SBV 2013), assuming a carbon fraction of 0.5 (IPCC default).

crop	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CC21: yield [t C ha^{-1}]									
Barley	2.36	2.47	2.48	2.54	2.19	2.29	2.69	2.69	2.86	2.18
Wheat	2.36	2.54	2.35	2.53	2.34	2.56	2.84	2.55	2.63	2.24
Maize	3.51	3.42	3.53	3.78	3.72	3.55	3.64	3.94	3.87	3.78
Silage maize	7.37	6.59	7.15	6.72	6.11	6.03	4.98	7.08	6.88	6.49
Sugar beet	7.41	6.91	7.04	7.63	6.72	6.78	7.83	7.76	7.42	7.48
Fodder beet	6.70	6.51	6.64	6.77	5.66	5.49	6.41	6.53	6.06	5.79
Potatoes	4.47	4.39	4.65	4.83	3.65	3.88	5.36	5.05	4.44	3.87
Leys	6.11	6.11	6.11	6.11	6.11	6.11	6.11	6.11	6.11	6.11
Mean	4.34	4.30	4.39	4.44	4.12	4.28	4.51	4.72	4.67	4.43

crop	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CC21: yield [t C ha^{-1}]									
Barley	2.55	2.38	2.68	2.35	2.92	2.61	2.64	2.57	2.58	2.73
Wheat	2.53	2.35	2.42	2.16	2.62	2.46	2.49	2.57	2.58	2.60
Maize	4.10	3.80	3.92	1.83	4.09	4.10	3.30	4.32	4.12	4.42
Silage maize	6.68	6.45	4.93	5.96	6.52	8.23	7.01	8.02	8.09	7.60
Sugar beet	8.74	6.51	8.52	7.89	8.60	8.50	7.30	8.37	8.73	9.37
Fodder beet	6.71	5.75	5.95	5.67	6.13	6.15	6.25	6.21	6.30	6.72
Potatoes	4.67	4.13	4.30	3.71	4.34	4.26	3.60	4.59	4.71	5.12
Leys	6.11	6.11	6.11	6.11	6.11	6.11	6.11	6.11	6.11	6.11
Mean	4.71	4.51	4.54	4.41	4.89	4.97	4.70	5.07	5.13	5.19

crop	2010	2011	2012	mean 1990-2012
	CC21: yield [t C ha^{-1}]			
Barley	2.56	2.75	2.76	2.56
Wheat	2.48	2.72	2.50	2.50
Maize	3.61	4.13	3.86	3.76
Silage maize	7.47	8.42	8.06	6.91
Sugar beet	8.03	10.38	9.58	7.98
Fodder beet	6.49	6.65	5.58	6.22
Potatoes	4.26	5.04	4.56	4.43
Leys	6.11	6.11	6.11	6.11
Mean	4.99	5.44	5.23	4.69

7.4.4.2 Carbon in Soils

Soil carbon stocks in mineral soils under cropland are calculated based on Leifeld et al. (2003, 2005). The approach correlates measured soil organic carbon stocks (t ha^{-1}) for arable land and leys with soil texture after correction for soil depth and stone content. Area upscaling uses the Swiss digital soil map (SFSO 2000a), and average stocks are calculated as weighted means using the area of arable land and leys. The mean soil organic carbon stock (0-30 cm) for cropland is 53.40 ± 5 t C ha^{-1}.

It should be noted that current carbon stocks are not only the result of the conditions for productivity and carbon turnover under different land-use types, but are also determined by farmers' decisions to use a site in a specific way due to the demands of a crop or the suitability of a site, e.g. regarding machine use (see Leifeld et al. 2003: 65).

Soil carbon stocks in organic soils under cropland are calculated based on Leifeld et al. (2003, 2005). The approach uses measured carbon stocks in Swiss organic soils. The mean soil organic carbon stock (0-30 cm) for cultivated organic soils is 240 ± 48 t C ha^{-1}.

7.4.4.3 Changes in Carbon Stocks

Carbon stocks in living biomass intermittently increased from 4.34 t C ha^{-1} in 1990 to 5.23 t C ha^{-1} in 2012 (Table 7-29; SBV 2013). The difference in biomass stock between a specific year and the preceding year is reported as gain or loss of carbon (see Table 7-30: "change"). The resulting values are in the range between -0.32 and 0.49 t C ha^{-1} yr^{-1} with an average of 0.041 t C ha^{-1} yr^{-1} for the inventory time period.

Changes of carbon stocks in mineral soils are assumed to be zero for cropland remaining cropland.

The annual net carbon stock change in organic soils was estimated to -9.52 t C ha^{-1} according to measurements in Europe including Switzerland as compiled by Leifeld et al. (2003, 2005) and rechecked by ART (2009b).

In the case of land-use change, the net changes in biomass and soil are calculated as described in Chapter 7.1.3.

Table 7-30 Annual carbon data for cropland (CC21), 1990-2012. Annual carbon stocks are broken down for arable crops in Table 7-29. Highlighted data for 1990 as displayed in Table 7-4.

cropland	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CC21: carbon stocks and changes in living biomass [t C ha^{-1}]									
stock	4.34	4.30	4.39	4.44	4.11	4.28	4.51	4.72	4.67	4.43
change	0.053	-0.033	0.086	0.047	-0.321	0.165	0.227	0.215	-0.051	-0.239

cropland	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CC21: carbon stocks and changes in living biomass [t C ha^{-1}]									
stock	4.71	4.51	4.54	4.41	4.89	4.97	4.70	5.07	5.13	5.19
change	0.282	-0.206	0.033	-0.131	0.486	0.075	-0.269	0.368	0.061	0.056

cropland	2010	2011	2012	mean 1990-2012
	CC21: carbon stocks and changes in living biomass [t C ha^{-1}]			
stock	4.99	5.44	5.23	4.69
change	-0.198	0.450	-0.206	0.041

7.4.4.4 N_2O Emissions from Land-Use Conversion to Cropland

N_2O emissions as a result of the disturbance associated with land-use conversion to cropland are reported in CRF-table 5(III). The emissions are calculated with default values proposed by IPCC (2003, following Equations 3.3.14 and 3.3.15, and Chapter 3.3.2.3.1.2):

$$\text{Emission}(N_2O) = -\,\text{delta}C_s * 1 / (C : N) * EF1 * 44 / 28 \qquad [Gg\ N_2O]$$

where:

- $\text{delta}C_s$: soil carbon change induced by land-use conversion to cropland [Gg C]
- C:N: C:N ratio = 9.8 in grassland soils (Leifeld et al. 2007)
- EF1: IPCC default emission factor = 0.0125 kg N_2O-N (kg N)$^{-1}$

$\text{delta}C_s$ is calculated according to the methodology described in Chapter 7.1.3. If $\text{delta}C_s$ is zero or positive (carbon gain) there are no N_2O emissions provoked by a land-use conversion to cropland.

On mineral soils this is the case for wetlands converted to cropland and other land converted to cropland (see CRF-table 5B2); consequently, NO is reported in CRF-table 5(III) for these land-use conversions.

On organic soils the carbon stock differences for land-use conversions to cropland are zero or – in the case of other land) – positive (cf. Table 7-4). No N_2O emissions are generated.

The country specific C/N ratio of 9.8 for grassland proposed by Leifeld et al. (2007) is used because the largest part of the area converted to cropland consisted of grassland (cf. CRF-table 5B2).

7.4.4.5 Carbon Emissions from Agricultural Lime Application

The total annual amount of limestone input to agricultural soils (CRF-table 5(IV)) is between 51’300 Mg and 74'050 Mg. It was estimated by Agroscope in 2009 for the period 1990-2008 (see Table 7-31). For 2009–2012 the same value as for 2008 is used: An inquiry in 2013 including the most important producers of lime products suggests that the consumption of limestone remained constant in this period (Agroscope 2014a).

Dolomite is probably applied only in small quantities. The available data do not allow to differentiate $Ca(CO_3)$ and $CaMg(CO_3)_2$.

The availability of a country specific emission factor for agricultural lime application has been investigated, but no domestic measurement data could be found. Consequently, the IPCC default carbon conversion factor for carbonate containing lime of 0.12 Mg C per Mg $Ca(CO_3)$ or $CaMg(CO_3)_2$ (IPCC 2003) has been used. The resulting carbon emissions associated with liming range from 22.57 to 32.58 Gg CO_2 yr^{-1}.

In the CRF-table 5(IV) all emissions are reported under Cropland and for Grassland the notation key IE is used because it is not known on which areas the lime was applied.

Table 7-31 Amount of limestone applied on agricultural soils and resulting CO_2 emissions 1990-2012 (Agroscope 2014a).

Year	Limestone	Emission
	Mg	Gg CO_2
1990	51'300	22.57
1991	51'342	22.59
1992	52'383	23.05
1993	53'425	23.51
1994	54'467	23.97
1995	55'508	24.42
1996	56'550	24.88
1997	57'592	25.34
1998	58'633	25.80
1999	59'675	26.26
2000	60'717	26.72
2001	61'758	27.17
2002	62'800	27.63
2003	63'842	28.09
2004	69'883	30.75
2005	70'925	31.21
2006	71'967	31.67
2007	73'008	32.12
2008	74'050	32.58
2009	74'050	32.58
2010	74'050	32.58
2011	74'050	32.58
2012	74'050	32.58

7.4.5 Uncertainties and Time-Series Consistency

A range of possible carbon stock changes in mineral soils has been determined by the Swiss Soil Monitoring Network (NABO). The upper and lower margin of the 95% confidence interval for carbon stock changes under cropland is 0 ± 0.52 t C ha^{-1} (Keller 2013). This absolute uncertainty is used to calculate relative uncertainties for 5B1 and 5B2 by dividing with the mean net emission per hectare of 5B1 and 5B2, respectively. In 2012, the mean net emissions were 0.474 t C ha^{-1} for 5B1 and 0.363 t C ha^{-1} for 5B2 (calculated from CRF-table 5B). The resulting relative uncertainties are 110% for 5B1 and 143% for 5B2, respectively (Table 7-5).

In the uncertainty analysis, these values were chosen for the overall emission factor uncertainties for CO_2 in sectors 5B1 and 5B2 as they dominate the other sources of uncertainty by far.

- Uncertainties for soil carbon stocks are given together with the mean value in the text above: 9% for mineral soils and 20% for cultivated organic soils. They take into account uncertainties in measured carbon contents and predicted soil bulk densities, i.e., they consider only uncertainties in emission factors.
- The relative uncertainty in yield determination has been estimated at 13% for biomass carbon from agricultural land (Leifeld and Fuhrer 2005). Data on biomass yields for different elevations and management intensities as published by FAL/RAC (2001) are based on many agricultural field experiments and have a high reliability.
- The uncertainty of the carbon stock change in organic soils is 23% as reported by Leifeld et al. (2003: 56).

For the uncertainty of the emission factor for N_2O on land converted to cropland a default value of 90% is used (Table 7-5).

The amount of total lime application in agriculture is mainly based on expert judgement; the resulting number is uncertain. A relative uncertainty of ± 40% can be used as an approximation (Agroscope 2014a). For the emission factor of lime a lower uncertainty of ± 25% was chosen, because it is a plain chemical process.

Uncertainties of activity data of Cropland are described in Chapter 7.2.5.

7.4.6 Category-Specific QA/QC and Verification

Changes in Living Biomass

In 2012 an assessment of the appropriateness of the estimated pools of carbon in living biomass was conducted (ART 2012a). It came to the conclusion that almost all carbon stocks and carbon stock changes are in the expected range of the IPCC Guidelines and Good Practice Guidance. Nevertheless there is room for improvements. However, given the relatively low significance of the respective emissions a major effort in this area is hardly justified. Consequently, the biomass carbon pools will eventually be recalculated only in the course of the new planned Tier 3 approach for quantification of carbon stocks and carbon stock changes in agricultural soils (see also Chapter 7.4.8).

Changes in SOC Pools

A SOC pool dataset provided by the Swiss Soil Monitoring Network (NABO; see Chapter 7.3.6) supports the Tier 1 assumption that changes of carbon stocks in mineral soils are zero for cropland remaining cropland (cf. UNFCCC 2009: §79; UNFCCC 2010: §72; UNFCCC 2011: §94). The SOC pool changes measured at 38 cropland monitoring sites in the Swiss Soil Monitoring Network show a slight trend towards decreasing SOC pools since 1985 (Figure 7-7). However, this trend is not statistical significant yet. The range of the calculated SOC pools is quite large (27.7-598 t C ha^{-1}), as three cropland soil monitoring sites are on peat soils. These three sites are excluded in Figure 7-7. Average SOC pool in the topsoils (0-20 cm) of the remaining 35 cropland monitoring sites for all soil sampling campaigns was 45.4 t C ha^{-1}. At the three cropland sites on peat soils the temporal variation of SOC content during the last 20 years ranged between ± 0.4%, corresponding to SOC pool changes larger than ± 10 t C ha^{-1}. However, for the majority of cropland sites the temporal variation found was smaller (± 0.2%), the confidence intervall of the SOC pool changes calculated by robust regression was ± 0.4 t C ha^{-1} over the last 20 years. This finding is in agreement with the detailed study mentioned in Chapter 7.3.6 (Keller et al. 2006), where six re-samplings of two cropland sites within three years revealed natural SOC content variation of ± 0.23% in the topsoil. The temporal variation of the SOC content and SOC pools at the cropland sites are rather small and possible future changes can be detected by this soil monitoring design.

Yet, the results suggest that Swiss cropland mineral soils did not act as a net carbon source or sink during the last 20 years. The results of the 6th soil campaign (2010-2014), that will be available in 2015 for the majority of the monitoring sites, will provide more evidence if the slight trend of decreasing SOC in cropland soils will be confirmed. In addition, SOC pools of the whole soil profile have to be determined as top soil SOC pools might be changed from changing land management practices such as the ploughing depth.

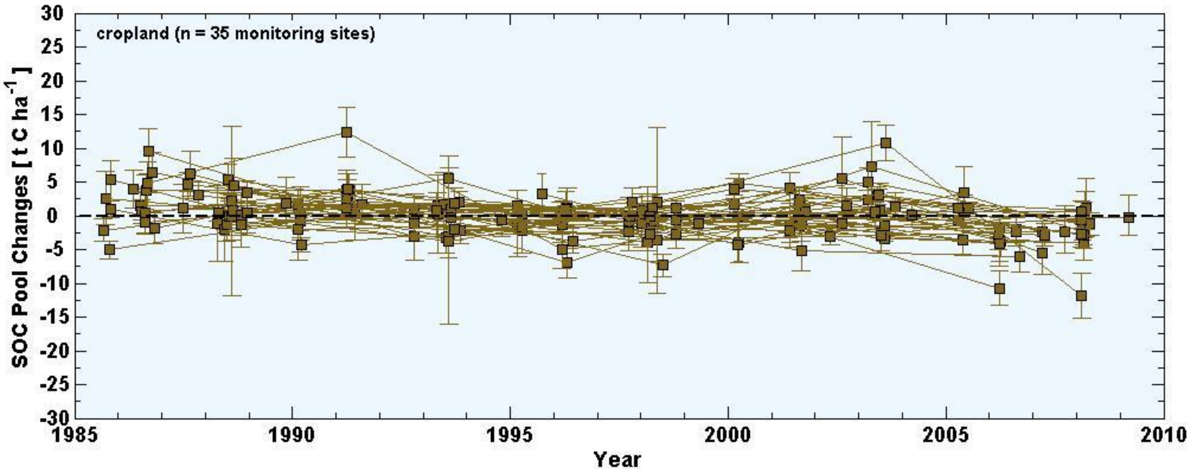

Figure 7-7 Time series of measured SOC pool changes in the top soil (0-20 cm) at 35 NABO cropland sites from the 1st to the 5th re-sampling campaigns. SOC pools were centred by the median SOC pool of all re-samplings of the monitoring site. Each pool value presents the median of four bulked soil samples per campaign with measured SOC and bulk density. The error bars indicate the 25% and 75% percentiles resulting from the spatial variation of the sites and the errors along the measurement chain. The altitude of the cropland sites ranges between 209 and 945 m a.s.l.

Short-term Land-Use Changes in Arable Rotations

Short-term land-use changes between "grassland" and cropland are to be expected for leys in arable rotations. However, leys are allocated to cropland by the Swiss Land Use Statistics (AREA) and are thus not considered grasslands in the common sense (i.e. permanent grassland). Furthermore, only long-term changes between cropland and grassland are considered relevant for carbon stock changes in soils. Since only long-term land-use changes are registered by the Swiss Land Use Statistics (AREA), carbon stock changes in soils associated with land-use changes between cropland and grassland and vice versa are adequately reported in the GHG inventory.

7.4.7 Category-Specific Recalculations

The completion of the AREA surveys in 2013 (see Chapter 7.2) led to a recalculation in category 5B.

7.4.8 Category-Specific Planned Improvements

In the course of the next inventory preparation, the implementation of the new reporting guidelines represents the largest improvement. All methods will be adapted to the 2006 IPCC Guidelines (IPCC 2006). Within this general recalculation a number of optional country specific methods will be explored and eventually implemented. Other projects and planned improvements may be postponed in order to give first priority to changes related to the new reporting guidelines.

In 2011, Agroscope started a three-year running research project that aims to identify (drained) fens and raised bogs under different land uses beyond the national inventories of bogs and fens in order to improve the AD estimates of organic soils ("Area and location of organic soils and peatlands in Switzerland"').

Switzerland intends to make better use of the SOC data provided by the Swiss Soil Monitoring Network (NABO) in forthcoming submissions. A contract was signed in 2011 that arranges a close collaboration for the period 2012-2014.

Furthermore, information about carbon stock changes in soils for cropland remaining cropland will become available from Agroscope research activities. A pilot study to evaluate possible Tier 3 methodological approaches for quantification of carbon stocks and carbon stock changes in agricultural soils (cf. UNFCCC 2009: §79; UNFCCC 2010: §72; UNFCCC 2011: §94) has recently been terminated (Köck et al. 2013).

Ongoing efforts to combine SOC measurements on the level of soil fractions with modelled pools (Zimmermann et al. 2007; Leifeld et al. 2009) will be combined with the planned Tier 3 approach for an independent check of emission and removal rates for cropland and grassland conversions.

The Research Institute of Organic Agriculture FiBL in CH-Frick runs a project with focus on the determination of sources and sinks of greenhouse gases in Swiss arable soils (project duration 2012-2014; co-funded by FOEN).

A new study on GHG emissions from peatlands and organic soils under different land use (Agroscope in collaboration with the University of Basel, 2013-2016, financed by FOEN) will improve the robustness of domestic emission factor estimates for soils rich in organic matter in the medium term.

Projects in a new national research programme ("Sustainable Use of Soil as a Resource", http://www.nfp68.ch/E) focus on (1) sustainable management of organic soils, (2) agricultural management and below ground carbon inputs, and (3) an integrated modelling framework to monitor and predict trends of agricultural management and their impact on soil functions at multiple scales. In the long term, results from these studies are expected to improve the reporting of emissions by sources and removals by sinks in category 5B.

7.5 Category 5C – Grassland

7.5.1 Description

Tier 2 Key category 5C1
CO_2 from Grassland remaining Grassland
(2012: level and trend).

Tier 2 Key category 5C2
CO_2 from Land converted to Grassland
(2012: level and trend)

Swiss grasslands belong to the cold temperate wet climatic zone.

Grasslands are subdivided into permanent grassland (CC31), shrub vegetation (CC32), vineyards, low-stem orchards (‘Niederstammobst’) and tree nurseries (CC33), copse (CC34), orchards (‘Hochstammobst’; CC35), stony grassland (CC36), and unproductive grassland (CC37), see Table 7-2 and Table 7-6. Carbon stocks in living biomass and carbon stocks in soils have been estimated for every subclass and have been considered accordingly in the calculation scheme.

In the CRF-table 5C2, the land-use types CC32, CC33, CC34 and CC35 are merged under the notation ‘woody’ and CC36 and CC37 are merged under ‘unproductive’ (see Table 7-2).

In 2012, 5C1 Grassland remaining Grassland was a net source of 134.74 Gg CO_2. Carbon stocks in mineral soils and carbon stocks in living biomass under constant land use are considered to be in balance (i.e. no carbon stock changes do occur). The highest contribution were thus generated by carbon mineralization in organic soils under permanent grasslands in the lowest altitudinal zone (z1: 173.2 Gg CO_2), although only 0.47% of all grassland soils in Switzerland are organic soils. Contributions of other grassland source categories remaining grassland were of minor importance.

5C2 Land converted to Grassland was a net source of 169.07 Gg CO_2 in 2012. The highest individual contribution came from 5C2.1 Forest Land converted to Grassland being responsible for a net source of 323.19 Gg CO_2. Most of this source (68%) is due to net changes in living biomass from deforestation. Land-use change source categories 5C2.2 to 5C2.5 were small net sinks due to sequestration of CO_2 in soils and biomass in the course of the conversion to grassland.

7.5.2 Information on Approaches Used for Representing Land Areas and on Land-use Databases Used for the Inventory Preparation

See Chapter 7.2.

7.5.3 Land-use Definitions and the Classification Systems Used and their Correspondence to the LULUCF Categories

See Chapter 7.2.

7.5.4 Methodological Issues

7.5.4.1 Carbon in Living Biomass

Permanent Grassland (CC31)

Permanent grasslands range in altitude from < 300 m to 3000 m above sea level. Because both biomass productivity and soil carbon rely on the prevailing climatic and pedogenic conditions, grassland stocks were calculated separately for three altitude zones (corresponding to those used in category 5A Forest Land).

Standing stocks for permanent grasslands (t C ha^{-1}) are calculated as the annual cumulative yield of differentially managed grasslands (meadows, pastures, alpine meadows and pastures) based on FAL/RAC (2001; Table 7-32), assuming a carbon fraction of 0.5 (IPCC default). Mean standing above-ground biomass stocks were taken for each of the altitudinal zones because the spatial distribution of grassland management types is not known.

Table 7-32 Annual yields of differentially managed permanent grassland (CC31). Each value represents the mean of two fertilization levels.

Management	Altitude [m]	Annual yield [t C ha-1]
Meadow	<601	5.88
	601-1200	4.38
	>1200	3.25
Pasture	<601	4.63
	601-1200	3.75
	>1200	2.75
Alpine pasture and meadow	601-1200	3.75
	>1200	0.75

Data for root biomass C was compiled by ART (2011a) based on published data of Swiss grassland. Carbon stocks in roots are in the range of 1.82–5.70 t C ha^{-1} depending on altitude. Root biomass is added to above-ground biomass to derive the total living biomass for CC31. Table 7-33 shows the living biomass of permanent grassland for the three altitudinal zones presented as the cumulated annual yield including roots.

Table 7-33 Root biomass C_{root} and total living biomass C_l of permanent grassland (CC31).

Altitude [m]	Croot [t C ha-1]	Cl [t C ha-1]
<601	1.82	7.08
601-1200	2.04	6.00
>1200	5.70	7.95

Shrub Vegetation (CC32) and Copse (CC34)

Due to the lack of more precise data, the living biomass of shrub vegetation and copse was assumed to be equal to the living biomass of brush forest as described in Chapter 7.3.4.9, where brush forest is assumed to contain 12.9 t C ha^{-1}.

Vineyards, Low-stem Orchards and Tree Nurseries (CC33)

Low-stem orchards are small fruit trees distinguished from CC35 ('orchards') by a maximum stem-height of 1 m and a much higher stand density. Only low-stem orchards and vineyards are considered in the following because no stand densities for tree nurseries are available. Data from SFSO (2002) indicate a very small contribution of tree nurseries (1'378 ha) as compared to the sum of vineyards (15'436 ha, SFSO 2005) and low-stem orchards (240 ha, based on Widmer 2006).

The standing carbon stock of living biomass per ha (Cl) for CC33 is therefore calculated as:

Cl = [(Cl vineyards * area vineyards) + (Cl low-stem orchards * area low-stem orchards)] / (area vineyards + area low-stem orchards)

Cl of vineyards is 3.61 t C ha^{-1}, calculated based on the mean stand density (5'556 vines ha^{-1}) and woody biomass of a plant including roots (0.65 kg C; Ruffner 2005).

For small fruit trees on low-stem orchards, no literature value was found for biomass expansion factors. Therefore, following assumptions were met. Diameter at breast height (DBH) of such trees was assumed to be around 10 cm and the stem height was assumed to be around 1 m. The bole shape of low-stem apple trees can be approximated by a cylinder shape.

Stem wood volume = r^2 * π * height = $(5\ cm)^2$ * 3.1 * 100 cm = 7.75 dm^3

Based on expert knowledge (Kaufmann 2005), the percentage of branches was estimated as 100%, and the percentage of roots was estimated as 30% of the stem wood volume. This results in a BEF of 2.3. A wood density of 0.55 kg dm^{-3} (Vorreiter 1949) and the default carbon content of 50% were assumed. With these assumptions the carbon content of a tree of the type low-stem ('Niederstamm') is calculated as follows:

C low-stem = stem wood volume * BEF * wood density * carbon content
= 7.75 dm^3 * 2.3 * 0.55 kg/dm^3 * 50% C-content = 4.9 kg C

The mean stand density of low-stem orchards is estimated at 2500 ha^{-1} (Widmer 2006), resulting in a Cl of 12.25 t C ha^{-1}.

The resulting Cl for CC33 is 3.74 t C ha^{-1}.

Orchards (CC35)

Orchards are loosely planted larger fruit trees ('Hochstammobst') with grass understory. Cl of orchards trees is calculated as:

Cl biomass = (carbon per fruit tree [t] * number of fruit trees / area orchards [ha]) + carbon in grass [t ha^{-1}]

The carbon content of a large fruit tree with a DBH of 25 - 35 cm was calculated as follows:

C (Hochstamm) = Stem wood volume * KE-Factor = 225 kg C

where:

Stem wood volume of an apple tree assuming a cylindrical stem with mean DBH of 30 cm and a stem height of 7 m amounts to 0.5 m^3;

KE-Factor [t C m^{-3}]= BEF * Density * C-content = 0.45, (Wirth et al. 2004: 68, Table 16).

From the total fruit-growing area of 41'480 ha (SFSO 2005), the area of small fruit trees (240 ha, see CC33) was subtracted, and the remaining area was divided by the number of large fruit trees. Large fruit trees were counted in 1991 (3'616'301) and 2001 (2'900'000; SFSO 2002), and the mean value was divided by 41'240 ha to obtain a mean stand density of 79 trees ha^{-1}. The resulting woody biomass of CC35 is thus 17.78 t C ha^{-1}. Because orchards typically have a grass understory, the biomass of CC31 was added to the woody biomass. Orchards are located below 1000 m a.s.l., so the mean of grass biomass of the classes <601 and 601-1200 m a.s.l. (i.e. 6.54 t C ha^{-1}; cf. Table 7-33) was taken to obtain a total biomass stock of 24.32 t C ha^{-1} for CC35.

Stony Grassland (CC36)

Approximately 35% of the surface of CC36 (herbs and shrubs on stony surfaces) is covered by vegetation. No accurate data were available for this category. Therefore, the carbon content of brush forest (12.9 t C ha^{-1}) was multiplied by 0.35 to account for the 35% vegetation coverage. This results in a carbon content of 4.52 t C ha^{-1}.

Unproductive Grassland (CC37)

The category CC37 includes grass and herbaceous plants at watersides of lakes and rivers including dams and other flood protection structures, constructions to protect against avalanches and rock slides, and alpine infrastructure (e.g. for skiing). For none of these land-use types, biomass data are currently available. Therefore, the mean value of permanent grasslands in all altitude zones, 7.01 t C ha^{-1} (cf. Table 7-33), is arbitrarily chosen as the preliminary biomass value for CC37.

7.5.4.2 Carbon in Soils

Permanent Grassland (CC31)

Carbon stocks in grassland soil refer to a depth of 0-30 cm.

Soil carbon stocks in mineral soils under permanent grassland CC31 are calculated based on Leifeld et al. (2003, 2005). The approach correlates measured soil organic carbon stocks (t ha^{-1}) for permanent grasslands with soil texture and elevation after correction for soil depth and stone content. Area upscaling makes use of the Swiss digital soil map (SFSO 2000a) and topography. Mean Cs values calculated for grasslands CC31 are given in Table 7-34. It should be noted that the current C stocks are not only the result of the conditions for productivity and C turnover under different land-use types, but are also determined by farmers' decisions to use a site in a specific way due to the demands of a crop or the suitability of a site, e.g. regarding machine use (see Leifeld et al. 2003: 65).

Table 7-34 Mean carbon stocks under permanent grassland on mineral soils (0-30 cm).

Altitude [m]	**Cs [t C ha-1]**
<601	62.02 ± 13
601-1200	67.50 ± 12
>1200	75.18 ± 9

Soil carbon stocks in organic soils under permanent grassland are calculated based on Leifeld et al. (2003, 2005). The approach uses measured carbon stocks in Swiss organic soils without differentiation among cropland and grassland. The mean soil organic carbon stock (0-30 cm) for organic soils is 240 ± 48 t C ha^{-1}.

Shrub Vegetation (CC32)

Due to the lack of data, the values of CC31 (Table 7-34) were used as the mineral soil carbon stocks for this category (0-30 cm).

The mean soil organic carbon stock (0-30 cm) for organic soils is 240 t C ha^{-1}.

Vineyards, Low-stem Orchards and Tree Nurseries (CC33)

The category includes carbon stocks in soils of vineyards, low-stem orchards and tree nurseries. In accordance to carbon stocks in biomass, only vineyards and low-stem orchards are considered. Both land-use types are assumed to have no grass undercover. Therefore, the soil carbon values of cropland, i.e. 53.40 t C ha^{-1} (mineral soils, 0-30 cm) and 240 t ha^{-1} (organic soils, 0-30 cm) are taken for CC33 (see Chapter 7.4.4.2).

Copse (CC34)

Due to the lack of data, the values of CC31 (Table 7-34) were used as the mineral soil carbon stocks for this category (0-30 cm).

The mean soil organic carbon stock (0-30 cm) for organic soils is 240 t C ha^{-1}.

Orchards (CC35)

Cs of orchards was calculated in accordance to the biomass calculation. No specific Cs orchards values are available, and the mean value of grassland mineral soil carbon stocks from the two lower altitudinal zones (i.e. 64.76 t C ha^{-1}; cf. Table 7-34) was taken for mineral soils (0-30 cm), and the value of 240 t ha^{-1} for organic soils (0-30 cm).

Stony Grassland (CC36)

Soil organic carbon stocks under herbs and shrubs on stony surfaces were calculated according to the procedure described in Chapter 7.5.4.1, i.e. it is assumed that not more than 35% of the area of CC36 is covered with vegetation and thus only 35% of the area bears a mineral soil while the remainder is bare rock. Land use of this category mostly belongs to ‘grassland’ and ‘unproductive land’ and likely includes many of the former alpine grasslands (SFSO 2005). These grasslands are mainly located at altitudes > 1200m a.s.l. Thus, using the respective value from Table 7-34, the carbon stock Cs of CC36 is calculated as:

Cs of CC36 = 0.35 * Cs permanent grassland > 1200 m = 26.31 t C ha^{-1} (0-30 cm)

The mean soil organic carbon stock (0-30 cm) for organic soils is 240 t C ha^{-1}. It is assumed that the small area covered by organic soils in CC36 (cf. CRF 5C1 ‘stony’), albeit entitled ‘stony grassland’, does not contain significant contributions from stones because bogs are free of stones as a matter of nature and fens usually contain, if any, only fine mineral sediments.

Unproductive Grassland (CC37)

The category CC37 ‚unproductive grasslands’ includes grass and herbaceous plants at watersides of lakes and rivers including dams and other flood protection structures, constructions to protect against avalanches and rock slides, and alpine infrastructure (e.g. for skiing). For none of these land-use types, Cs data are currently available. Soil carbon stocks of CC37 ‘unproductive grassland’ were arbitrarily set as the mean value of carbon stocks under permanent grassland on mineral soils (Table 7-34) in accordance to the procedure followed for biomass. Cs of CC37 is thus 68.23 t C ha^{-1}.

The mean soil organic carbon stock (0-30 cm) for organic soils is 240 t C ha^{-1}.

7.5.4.3 Changes in Carbon Stocks

Changes of carbon stock in biomass and in mineral soils are assumed to be zero for constant land use.

The annual net carbon stock change in organic soils on managed grassland (CC31, CC33 and CC35) was estimated to -9.52 t C ha^{-1} according to measurements in Europe including Switzerland as compiled by Leifeld et al. (2003, 2005) and rechecked by ART (2009b). For weakly managed grasslands (CC32, CC34, CC36 and CC37) the emission from organic soils was estimated to 5.30 t C ha^{-1} yr^{-1} according to available domestic data (ART 2011b).

In the case of land-use change, the net changes in biomass and soil of CC31, CC32, CC33, CC34, CC35, CC36, and CC37 are calculated as described in Chapter 7.1.3.

7.5.4.4 Carbon Emissions from Agricultural Lime Application

All CO_2 emissions caused by agricultural lime application are included under the category 5B Cropland (see Chapter 7.4.4.5, CRF-table 5(IV)).

7.5.4.5 NMVOC Emissions

Estimates for annual biogenic emissions of NMVOC (CRF-table 5) for forests and natural grassland in Switzerland are available in SAEFL (1996a): the value for natural grassland (unproductive vegetation) is 0.51 Gg.

7.5.4.6 Emissions from Wild Fires

Data on wildfires affecting Swiss grassland are obtained from cantonal authorities and are compiled by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL 2013). Table 7-35 shows the annual burnt area from 1990 to 2012. The Swissfire database differentiates between 'grassland' and 'unmanaged land'. As a conservative assumption the sum of both categories is reported. Controlled burning is no common practice in Switzerland. Therefore, all fires are assigned to “wildfires”.

The resulting CH_4 and N_2O emissions were calculated according to Equations 3.2.19/3.2.20 of IPCC (2003):

Emission CH_4 = (carbon released) * (emission ratio) * 16/12
Emission N_2O = (carbon released) * (emission ratio) * 28/12
carbon released = (burnt area) * (available fuel) * (combustion efficiency)

The "available fuel" was calculated as the area-weighted carbon stock in living biomass for all grassland categories (CC31 to CC37) in 2012: 7.68 Mg C ha^{-1}. Applying a default combustion efficiency of 0.74 (IPCC 2003, Table 3A.1.12, savanna grassland) the average amount of carbon that could be released by wildfires on grasslands is 5.68 Mg C ha^{-1}.

For CH_4, the emission ratio of savannas was used: 0.004 (IPCC 1996, Table 4-15). The resulting mean emission is 0.030 Mg CH_4 ha^{-1}.

For N_2O, a N/C ratio of 0.015 (IPCC 1996, pp. 4.83) and an emission ratio of 0.007 (IPCC 2003, Table 3A.1.15) result in a mean emission of 0.00094 Mg N_2O ha^{-1}.

The resulting annual emissions 1990-2012 on burnt areas in 5C grasslands are shown in Table 7-35 and are reported in CRF-table 5(V).

Table 7-35 Area of Grassland affected by wildfires (WSL 2013) and resulting CH_4 and N_2O emissions, 1990-2012.

Year	Area burnt	CH_4	N_2O
	ha	Mg yr^{-1}	Mg yr^{-1}
1990	637	19.315	0.598
1991	22	0.676	0.021
1992	6	0.183	0.006
1993	17	0.513	0.016
1994	175	5.292	0.164
1995	82	2.485	0.077
1996	43	1.297	0.040
1997	373	11.302	0.350
1998	73	2.203	0.068
1999	19	0.574	0.018
2000	22	0.662	0.020
2001	8	0.227	0.007
2002	257	7.799	0.241
2003	138	4.181	0.129
2004	4	0.130	0.004
2005	4	0.116	0.004
2006	6	0.171	0.005
2007	88	2.656	0.082
2008	29	0.879	0.027
2009	3	0.083	0.003
2010	1	0.040	0.001
2011	56	1.706	0.053
2012	4	0.133	0.004

7.5.5 Uncertainties and Time-Series Consistency

A range of possible carbon stock changes in mineral soils has been determined by the Swiss Soil Monitoring Network (NABO). The upper and lower margin of the 95% confidence interval for carbon stock changes under grassland is 0 ± 0.57 t C ha^{-1} (Keller 2013). This absolute uncertainty is used to calculate relative uncertainties for 5C1 and 5C2 by dividing with the mean net emission per hectare of 5C1 and 5C2, respectively. In 2012, the mean net emissions were 0.027 t C ha^{-1} for 5C1 and 0.846 t C ha^{-1} for 5C2 (calculated from CRF-table 5C). The resulting relative uncertainties are 2084% for 5C1 and 67% for 5C2, respectively (Table 7-5).

In the uncertainty analysis, these values were chosen for the overall emission factor uncertainties for CO_2 in sectors 5C1 and 5C2 as they dominate the other sources of uncertainty by far:

- Uncertainties for soil carbon stocks are given together with the mean value in the text above: 12-21% for mineral soils and 20% for organic soils. They take into account uncertainties in measured carbon contents and predicted soil bulk densities, i.e., they consider only uncertainties in emission factors.
- The uncertainty of the carbon stock change in organic soils of intensly managed grassland is 23% as reported by Leifeld et al. (2003: 56). For weakly managed grassland this uncertainty is 117% according to ART 2011b.
- The relative uncertainty in yield determination has been estimated at 13% for biomass carbon from both cropland and grassland (Leifeld and Fuhrer 2005). Data on biomass yields for different elevations and management intensities as published by FAL/RAC (2001) are based on many agricultural field experiments and have a high reliability.

Uncertainties of activity data of Grassland are described in Chapter 7.2.5. For wildfires, the emission factor uncertainties of CH_4 and N_2O were set to 70% (identical to forest land).

7.5.6 Category-Specific QA/QC and Verification

Changes in Living Biomass

The assumption of a constant carbon stock in living biomass has been reconsidered (UNFCCC 2007: §97). According to Schneider (2010) yields on meadows and pastures did not increase since 1990. Neither management nor the share of clover did significantly change over the past 20 years. Consequently, the current approach has been reconfirmed.

In 2012 an assessment of the appropriateness of the estimated pools of carbon in living biomass was conducted (ART 2012a). It came to the conclusion that almost all carbon stocks and carbon stock changes are in the expected range of the IPCC Guidelines and Good Practice Guidance. Nevertheless there is room for improvements. However, given the relatively low significance of the respective emissions a major effort in this area is hardly justified. Consequently, the biomass carbon pools will eventually be recalculated only in the course of the new planned Tier 3 approach for quantification of carbon stocks and carbon stock changes in agricultural soils (see also Chapter 7.5.8).

Changes in SOC Pools

A SOC pool dataset provided by the Swiss Soil Monitoring Network (NABO; see Chapter 7.3.6) supports the Tier 1 assumption that changes of carbon stocks in mineral soils are zero for grassland remaining grassland (cf. UNFCCC 2007: §97). The SOC pool measured at 33 grassland monitoring sites in the Swiss Soil Monitoring Network showed in average a slight increase during the period 1985 to 2000 and a slight decrease thereafter (Figure 7-8). SOC pools ranged between 20.9 and 183.2 t C ha^{-1}, the average SOC pool for the 33 grassland monitoring sites was 77.9 t C ha^{-1} (0-20 cm). Two alpine grassland sites above 1200 m a.s.l showed remarkable SOC pools of about 120 and 173 t C ha^{-1} (0-20 cm). The confidence interval of the mean SOC pool versus time was ± 0.9 t C ha^{-1}. In total, the results of the soil monitoring data indicate that Swiss grassland mineral soils did not act as a net source or sink of carbon during the last 20 years.

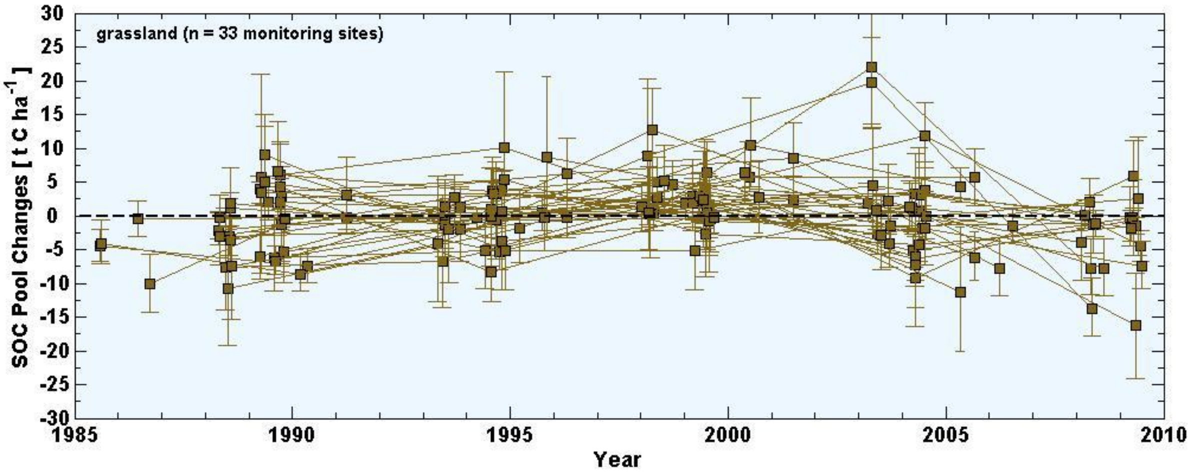

Figure 7-8 Time series of measured SOC pool changes in the top soil (0-20 cm) at the 33 NABO grassland sites from the 1st to the 5th re-sampling campaigns. SOC pools were centred by the median SOC pool of all re-samplings of the monitoring site. Each pool value presents the median of four bulked soil samples per campaign with measured SOC and bulk density. The error bars indicate the 25% and 75% percentiles resulting from the spatial variation of the sites and the errors along the measurement chain. The altitude of the grassland sites ranges between 265 and 2340 m a.s.l.

The slight increase and decrease will be subject for further detailed analysis. Partly, it may be attributed to natural variation of soil sampling (see Chapter 7.3.6). Furthermore, we presume that at grassland sites with intensive management and large manure application the temporal change of the SOC content is partly related to the nitrogen input fluxes and nitrogen content in soil. Therefore, the total nitrogen content of the archived soil samples will be measured and the correlation to the SOC content analysed. Moreover, management data of the monitoring sites gathered directly from the farmers since 1985 permit the calculation of annual nutrient fluxes of the sites (Keller et al. 2005). In this way temporal changes in nutrient management of the grassland sites can be separated from other effects that may cause temporal changes of SOC contents in grassland soils.

Short-term Land-Use Changes between Grassland and Cropland

See comments in Chapter 7.4.6.

7.5.7 Category-Specific Recalculations

The completion of the AREA surveys in 2013 (see Chapter 7.2) led to a recalculation in the category 5C.

Emissions from wildfires on grassland are reported the first time (see Chapter 7.5.4.6).

7.5.8 Category-Specific Planned Improvements

In the course of the next inventory preparation, the implementation of the new reporting guidelines represents the largest improvement. All methods will be adapted to the 2006 IPCC Guidelines (IPCC 2006). Within this general recalculation a number of optional country specific methods will be explored and eventually implemented. Other projects and planned improvements may be postponed in order to give first priority to changes related to the new reporting guidelines.

In 2011, Agroscope started a three-year running research project that aims to identify (drained) fens and raised bogs under different land uses beyond the national inventories of bogs and fens in order to improve the AD estimates of organic soils ("Area and location of organic soils and peatlands in Switzerland").

Switzerland intends to make better use of the SOC data provided by the Swiss Soil Monitoring Network (NABO) in forthcoming submissions. A contract was signed in 2011 that arranges a close collaboration for the period 2012-2014.

Furthermore, information about carbon stock changes in soils for grassland remaining grassland will become available from Agroscope research activities. A pilot study to evaluate possible Tier 3 methodological approaches for quantification of carbon stocks and carbon stock changes in agricultural soils (including meadows and pastures) (cf. UNFCCC 2007: §97) has recently been terminated (Köck et al. 2013).

Ongoing efforts to combine SOC measurements on the level of soil fractions with modelled pools (Zimmermann et al. 2007; Leifeld et al. 2009) will be combined with the planned Tier 3 approach for an independent check of emission and removal rates for cropland and grassland conversions.

A new study on GHG emissions from peatlands and organic soils under different land use (Agroscope in collaboration with the University of Basel, 2013-2016, financed by FOEN) will improve the robustness of domestic emission factor estimates for soils rich in organic matter in the medium term.

Projects in a new national research programme ("Sustainable Use of Soil as a Resource", http://www.nfp68.ch/E) focus on (1) sustainable management of organic soils, (2) agricultural management and below ground carbon inputs, and (3) an integrated modelling framework to monitor and predict trends of agricultural management and their impact on soil functions at multiple scales. In the long term, results from these studies are expected to improve the reporting of emissions by sources and removals by sinks in category 5C.

7.6 Category 5D – Wetlands

7.6.1 Description

The categories 5D1 Wetlands remaining Wetlands and 5D2 Land converted to Wetlands are not key categories.

Wetlands consist of surface waters (CC41) and unproductive wet areas such as shore vegetation, fens or (raised) bogs (CC42), see Table 7-2 and Table 7-6.

7.6.2 Information on Approaches Used for Representing Land Areas and on Land-use Databases Used for the Inventory Preparation

See Chapter 7.2.

7.6.3 Land-use Definitions and the Classification Systems Used and their Correspondence to the LULUCF Categories

See Chapter 7.2.

7.6.4 Methodological Issues

7.6.4.1 Carbon in Living Biomass

Surface Waters (CC41)

Surface waters have no carbon stocks by definition.

Unproductive Wetland (CC42)

CC42 consists of unmanaged or weakly managed grassland, bushes or tree groups. The pool of living biomass was estimated to 6.50 t C ha^{-1} (Mathys and Thürig 2010).

7.6.4.2 Carbon in Soils

In general, the soil carbon stock for surface waters (CC41) is zero. However, for CC41 situated in areas with organic soil (see Chapter 7.2.3.1 and Table 7-7), the soil carbon stock is set to 240 t C ha^{-1} (0-30 cm). These surface waters are assumed to be shallow ponds as integrated parts of fens or bogs.

Land cover in CC42 explicitly includes peatlands protected by Federal Legislation (Swiss Confederation 1991a, 1994) as well as reed. More than 10% of the unproductive wetland are located on organic soils (cf. Table 7-7) as defined in Chapter 7.2.3.1. In this case the carbon stock in soils is 240 t C ha^{-1} (0-30 cm). Currently, no specific soil data are available for CC42 on mineral soils. As a first guess, it is suggested that the soil carbon stock of unproductive wetlands is similar to permanent grassland on mineral soils (mean value: 68.23 t C ha^{-1}; 0-30 cm).

7.6.4.3 Changes in Carbon Stocks

Changes of carbon stock in biomass and in mineral soils are assumed to be zero for wetlands remaining wetlands.

The emission from organic soils under CC41 is assumed to be zero because the respective areas are not drained.

The emission from organic soils under CC42 was estimated to 5.30 t C ha^{-1} yr^{-1} according to domestic data (ART 2011b). This value is used for weakly managed ecosystems such as fens and unmanaged ecosystems such as raised bogs. Bogs and fens are protected to a large part by Federal Ordinances (Swiss Confederation 1991a, 1994) and drainage is therefore not allowed. However, the impact of old drainages constructed before 1990 probably leads to a certain emission.

In the case of land-use change, the net changes in biomass and soil of both CC41 and CC42 are calculated as described in Chapter 7.1.3.

For land converted to unproductive wetland (CC42) a conversion time of one year was chosen for the carbon stock change in living biomass and in dead organic matter (see Table 7-3). This was done because at the moment when the land-use change is detected in the sense of changes in the vegetation cover on the AREA aerial photographs the land-use change has already occurred (cf. UNFCCC 2009: §82). For carbon stock changes in soil the conversion time is 20 years.

7.6.4.4 Non CO_2 Emissions from Drainage of Soils and Wetlands

The reporting of non-CO_2 emissions from drainage of soils and wetlands is not mandatory. Due to the lack of data Switzerland decided not to prepare emission estimates for drainage of soils.

An estimate of 0.43 Gg CH_4 yr^{-1} emitted by reservoirs (flooded lands) is given by Hiller et al. (2014). The estimate encompasses 97 artificial lakes covering a total area of 10.6 kha. This emission is reported in CRF-table 5(II)D.

7.6.5 Uncertainties and Time-Series Consistency

As a best guess, a value of 50% was chosen for the overall emission factor uncertainty in sector 5D (Table 7-5).

The uncertainty of the emission factor for carbon stock losses in organic soils is 100% based on monitoring values compiled by ART (2011b).

Uncertainties of activity data of Wetlands are described in Chapter 7.2.5.

7.6.6 Category-Specific QA/QC and Verification

No category-specific QA/QC activities have been carried out.

7.6.7 Category-Specific Recalculations

The completion of the AREA surveys in 2013 (see Chapter 7.2) led to a recalculation in the category 5D.

Emissions of CH_4 are reported for flooded lands (reservoirs) in CRF-table 5(II)D (Chapter 7.6.4.4). In former submissions, this emission source was not reported.

7.6.8 Category-Specific Planned Improvements

In the course of the next inventory preparation, the implementation of the new reporting guidelines (IPCC 2006) represents the largest improvement. To accomplish this transition, other projects or planned improvements may be postponed in order to give first priority to changes related to the new reporting guidelines.

In 2011, Agroscope started a three-year running research project that aims to identify (drained) fens and raised bogs under different land uses beyond the national inventories of bogs and fens in order to improve the AD estimates of organic soils ("Area and location of organic soils and peatlands in Switzerland").

A new study on GHG emissions from peatlands and organic soils under different land use (Agroscope in collaboration with the University of Basel, 2013-2016, financed by FOEN) will improve the robustness of domestic emission factor estimates for soils rich in organic matter in the medium term.

Lake Wohlen, a hydroelectric reservoir on the Swiss Plateau, has been shown to be a large emitter of CH_4 (DelSontro et al. 2010). Sediments cores from the reservoir were sampled in March 2014 by the University of Bern. The project (2014-2015, co-financed by FOEN) focuses on the question if Lake Wohlen is a representative system within Switzerland.

7.7 *Category 5E – Settlements*

7.7.1 Category Description

Tier 2 Key category 5E2 CO_2 from Land converted to Settlements (2012: level and trend)

The category 5E1 Settlements remaining Settlements is not a key category.

Settlements consist of buildings/constructions (CC51), herbaceous biomass in settlements (CC52), shrubs in settlements (CC53), and trees in settlements (CC54) as shown in Table 7-2 and Table 7-6.

7.7.2 Information on Approaches Used for Representing Land Areas and on Land-use Databases Used for the Inventory Preparation

See Chapter 7.2.

7.7.3 Land-use Definitions and the Classification Systems Used and their Correspondence to the LULUCF Categories

See Chapter 7.2.

7.7.4 Methodological Issues

7.7.4.1 Carbon in Living Biomass

Buildings and Constructions (CC51)

Buildings/constructions contain no carbon by default.

Herbaceous Biomass, Shrubs and Trees in Settlements (CC52, CC53, CC54)

Results of the research project “Baumbiomasse in der Landschaft” are used for carbon stocks in living biomass as follows: 9.54 t C ha^{-1} for CC52, 15.43 t C ha^{-1} for CC53 and 20.72 t C ha^{-1} for CC54 (Mathys and Thürig 2010: Table 7).

7.7.4.2 Carbon in Soils

The carbon stock in soil for CC51 (buildings and construction) was set to zero.

In case of land-use changes to CC51 or from CC51, only 50% of the difference between carbon stocks before and after the change is reported as a source or sink, respectively. The reason for this is that the soil organic matter on construction sites is stored temporarily and is later used for replanting the surroundings or for vegetating dumps, for example. According to paragraph 7 of the "Ordinance against deterioration of soils" (Swiss Confederation 1998) the soil material excavated on a construction site must be treated in such a way that it can be used as a soil again. When the material is re-used (e.g. for re-cultivations) the fertility of the soil must not be affected. This regulation ensures that a large part of the soil organic matter is preserved on land converted to and from CC51. Switzerland has chosen the factor 0.5 (i.e.

50% stabilised SOC fraction which is not likely to be oxidised in the medium term) to reflect this domestic soil protection measure (see discussion in Leifeld et al. 2003: 67). Thus, the equation 7.6 presented in Chapter 7.1.3.2 is adjusted as follows if a=CC51 or b=CC51:

$$deltaC_{s,i,ba} = [\ 0.5 * (stockC_{s,i,a} - stockC_{s,i,b}\ ) / CT\ ] * A_{i,ba}$$

where:

a	land-use category after conversion (CC = a)
b	land-use category before conversion (CC = b)
ba	land use conversion from b to a
i	spatial stratum
$A_{i,ba}$	area of land (ha) converted from b to a in the spatial stratum i
CT	conversion time (yr), see Table 7-3.

The carbon stock in mineral soil for CC52, CC53 and CC54 is 53.40 t C ha^{-1} (0-30 cm, same value as for cropland).

For organic soils the carbon stock is 240 t C ha^{-1} (0-30 cm, same value as for the other land-use categories on organic soils).

7.7.4.3 Changes in Carbon Stocks

Changes of carbon stock in biomass and in mineral soils are assumed to be zero for settlements remaining settlements.

On organic soils, the following emission factors were applied:

- 9.52 t C ha^{-1} yr^{-1} for CC52. This corresponds to the value used for cropland because CC52 areas are managed (gardens, parks) (Leifeld et al. 2003, 2005 and rechecked by ART 2009b).
- 5.30 t C ha^{-1} yr^{-1} for CC53 and CC54. This corresponds to the value used for weakly managed grasslands (ART 2011b).

In the case of land-use change, the net changes in biomass and soil of CC51, CC52, CC53, and CC54 are calculated as described in Chapter 7.1.3.

7.7.5 Uncertainties and Time-Series Consistency

As a best guess, a value of 50% was chosen for the overall emission factor uncertainty in sector 5E (Table 7-5).

Uncertainties of activity data of Settlements are described in Chapter 7.2.5.

7.7.6 Category-Specific QA/QC and Verification

No.

7.7.7 Category-Specific Recalculations

The completion of the AREA surveys in 2013 (see Chapter 7.2) led to a recalculation in the category 5E.

7.7.8 Category-Specific Planned Improvements

In the course of the next inventory preparation, the implementation of the new reporting guidelines (IPCC 2006) represents the largest improvement. To accomplish this transition, other projects or planned improvements may be postponed in order to give first priority to changes related to the new reporting guidelines.

7.8 Category 5F – Other Land

7.8.1 Description

The categories 5F1 Other Land remaining Other Land and 5F2 Land converted to Other Land are not key categories.

As shown in Table 7-2 and Table 7-6 other land (CC61) covers non-vegetated areas such as glaciers, rocks and shores.

7.8.2 Information on Approaches Used for Representing Land Areas and on Land-use Databases Used for the Inventory Preparation

See Chapter 7.2.

7.8.3 Land-use Definitions and the Classification Systems Used and their Correspondence to the LULUCF Categories

See Chapter 7.2.

7.8.4 Methodological Issues

By definition, other land has no carbon stocks. Coherently, changes of carbon stock in biomass and in soil are assumed to be zero for other land remaining other land.

In the case of land-use change, the net C changes in biomass and soil are calculated as described in Chapter 7.1.3.

7.8.5 Uncertainties and Time-Series Consistency

As a first guess, a value of 50% was chosen for the overall emission factor uncertainty in sector 5F2 (Table 7-5).

Uncertainties of activity data of Other Land are described in Chapter 7.2.5.

7.8.6 Category-Specific QA/QC and Verification

No.

7.8.7 Category-Specific Recalculations

The completion of the AREA surveys in 2013 (see Chapter 7.2) led to a recalculation in the category 5F.

7.8.8 Category-Specific Planned Improvements

In the course of the next inventory preparation, the implementation of the new reporting guidelines (IPCC 2006) represents the largest improvement.

8 Waste

8.1 Overview

8.1.1 Greenhouse Gas Emissions

Within the waste sector, emissions from four source categories are considered:

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

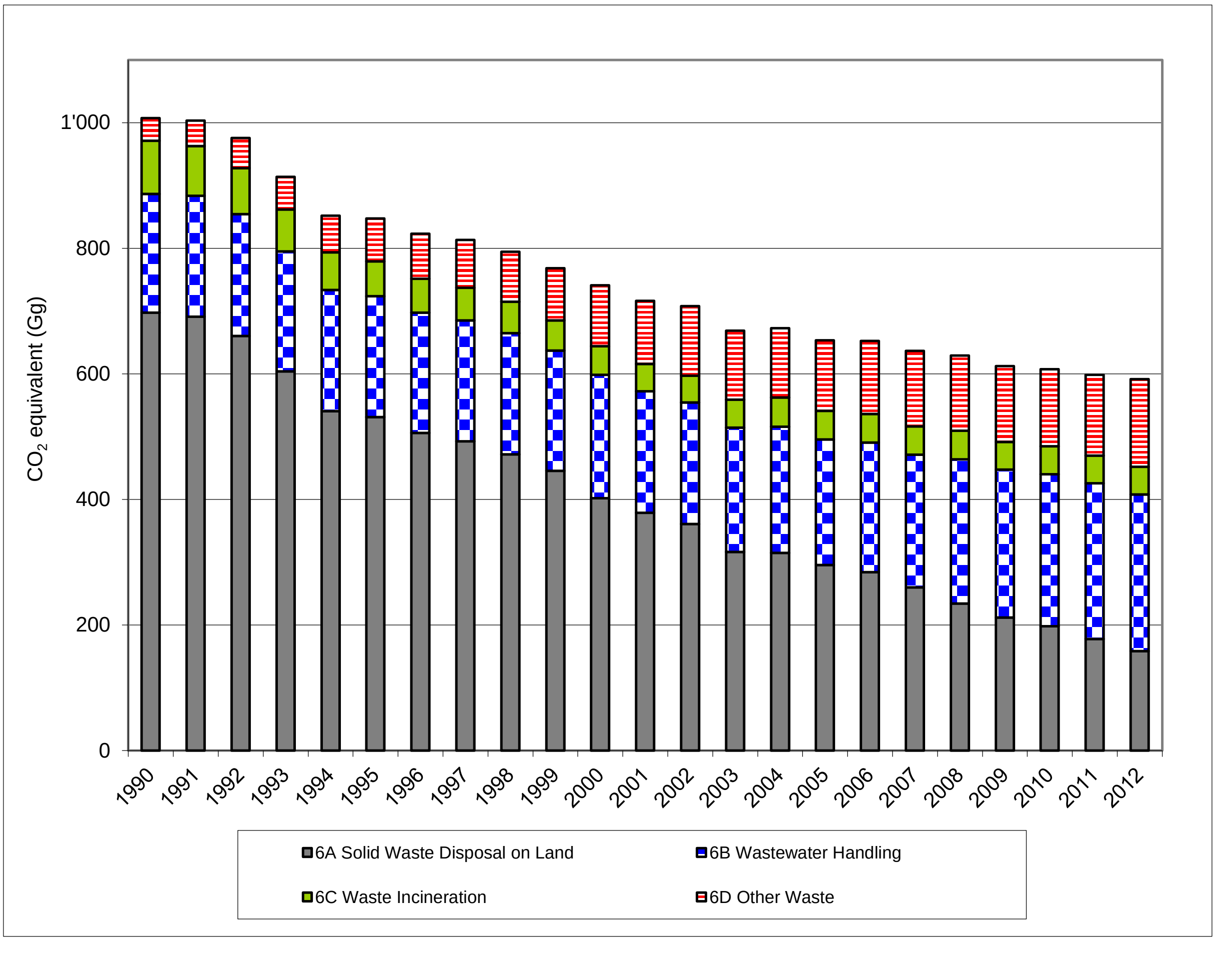

Figure 8-1 Switzerland's greenhouse gas emissions in the waste sector 1990–2012.

Table 8-1 Trend of total GHG emissions from waste management in Switzerland 1990-2012.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	63	60	56	50	40	35	31	28	26	23
CH_4	734	731	706	654	600	600	578	569	550	528
N_2O	210	213	214	210	211	213	214	217	219	218
Sum	1007	1004	976	914	852	847	823	814	795	768

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (Gg)									
CO_2	19	16	13	12	12	12	12	12	13	12
CH_4	497	477	468	422	421	404	396	375	349	326
N_2O	225	224	227	234	239	238	244	249	268	274
Sum	741	717	708	669	673	654	653	637	629	612

Gas	2010	2011	2012
	CO_2 eq (Gg)		
CO_2	13	12	12
CH_4	314	299	287
N_2O	281	287	292
Sum	608	598	591

As illustrated in Table 8-1, in the waste sector a total of 591 Gg CO_2 equivalents were emitted in the year 2012. 29.3% stem from category 6A Solid Waste Disposal on Land, 40.8% of the emissions stem from category 6B Wastewater Handling, 7.3% from 6C Waste Incineration and 21.2% from 6D Others.

The total greenhouse gas emissions in the waste sector show a decrease of 41.3% from 1990 until 2012. From 1990 – 2007, the greenhouse gas emissions had been clearly dominated by the ones from the source category 6A Solid Waste Disposal on Land. In 2008, emissions of 6A Solid Waste Disposal on Land and 6B Wastewater Handling became equivalent. Since 2009 6B Wastewater Handling has been the most important source category.

While CO_2 and CH_4 emissions in the waste sector are decreasing since 1990, N_2O emission continue to augment, mainly due to the increasing number of inhabitants and related emissione caused by waste water hanlding. CH_4 emissions have decreased from 1990 until 2012 by 60.9%. N_2O emissions increased by 39.2% from 1990 until 2012. In 2012, N_2O has replaced CH_4 as the most important greenhouse gas in the waste sector. CO_2 is of minor importance in the waste sector. CO_2 emissions have remained rather constant since 2003 at a low level of about 12Gg. Since 1990 they have been reduced by 80.5%.

The relative trends of the gases can be seen in Figure 8-2.

Please note that according to IPCC Good Practice Guide all emissions from waste-to-energy, where waste material is used directly as fuel or converted into a fuel, are reported under the sector 1 Energy (see also Figure 8-4). Therefore the largest share of waste-related emissions in Switzerland is not reported under sector 6 Waste, as the box below shows.

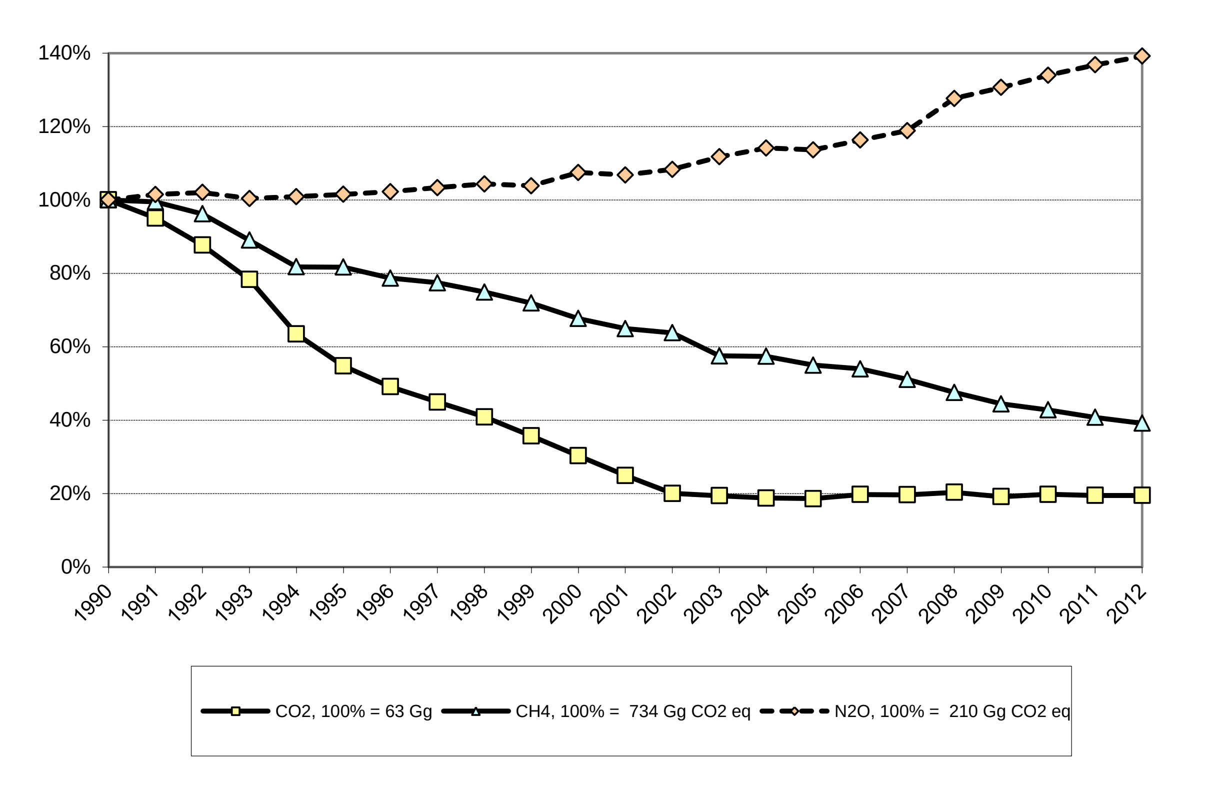

Figure 8-2 Trend of total GHG emissions from waste management in Switzerland 1990-2012.

Box: Waste related GHG emissions in Switzerland

The respective GHG emissions are reported in different chapters within the National Inventory. The following figure provides an overview on all waste related GHG emissions in Switzerland, not only the ones reported in the present Chapter 8 (see also Figure 8-4).

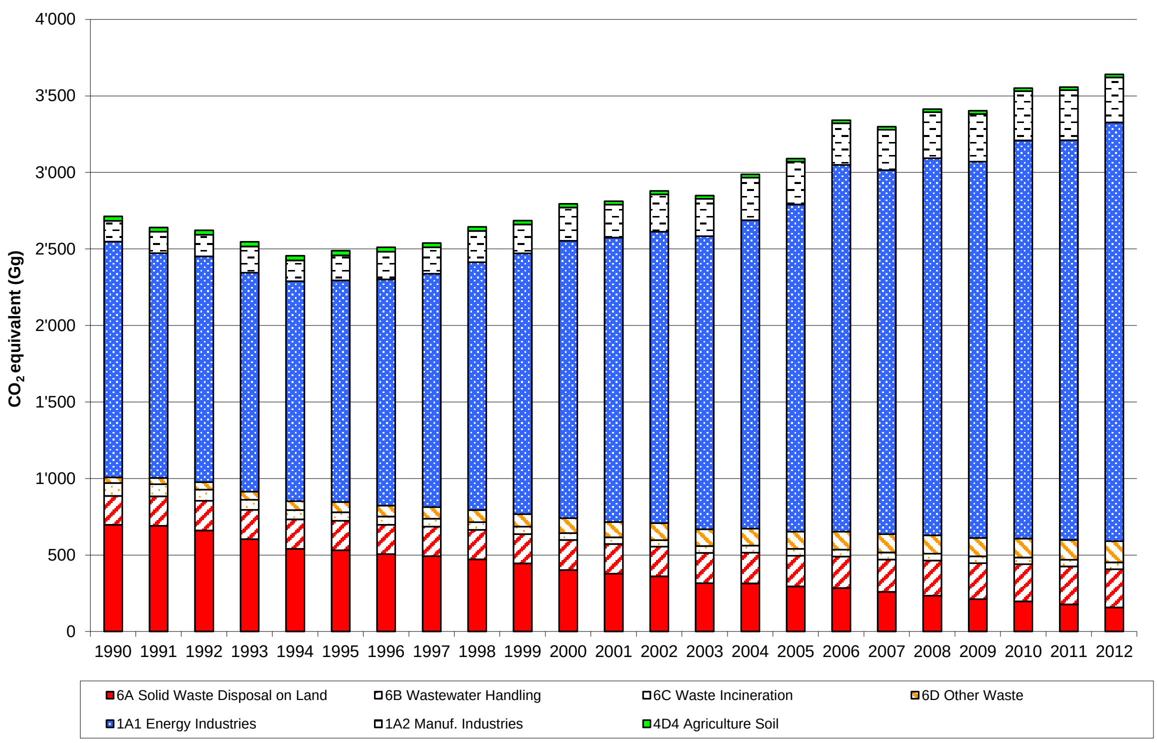

Figure 8-3 Waste related GHG emissions from 1990-2012.

8.1.2 Overview on Waste Management in Switzerland

The goals and principles regarding waste management in Switzerland are stated in the Guidelines on Swiss Waste Management (BUS 1986) and in the Waste Concept for Switzerland (SAEFL 1992). The four principles are:

- The generation of waste shall be avoided as far as possible.
- Pollutants from manufacturing processes and in products shall be reduced as far as possible.
- Waste shall be recycled wherever this is environmentally beneficial and economically feasible.
- Waste shall be treated in an environmentally sound way. In the long term only materials of final storage quality shall be disposed of in landfills.

Figure 8-4 gives a general overview of the type of treatment and amounts of waste fractions treated in the respective sectors in the NIR of Switzerland in 2012 including imports and exports. Only waste fractions that are emission-relevant are shown. It illustrates where the processes related to the waste management system are reported in the NIR.

1 Energy: In accordance with the IPCC provisions (IPCC 1997c) emissions from the combustion of waste-to-energy activities, if waste is used as an alternative fuel or used for energy production, emissions are are reported in 1A Fuel Combustion Activities. This applies for municipal solid waste incineration plants (MSWIP), special waste incineration plants (SWIP) where energy is being recovered, as well as the cement industry where special waste and sewage sludge are used as an alternative fuel in the cement production. The fermentation of biomass is also reported in sector 1 Energy, as biogas is used for co-generation of heat and electricity. The energy production from renewable goods, such as the use of waste wood in wood-fired power stations is reported under 1A4ai and 1A4bi.

4 Agriculture: Since 2003 it is forbidden to use sewage sludge as a fertilizer. In 2012, whithin sector 4 Agriculture only compost used as fertilizer was emission–relevant (due to N_2O emissions as described in chapter 6.5.2 table 6-18).

6 Waste: Only if waste is not used for energy production purposes, it is reported under the sector 6 Waste. Solid waste disposal on land does not ocurr anymore in Switzerland as incineration is the mandatory disposal option for burnable waste since 2000. The emissions related to the waste water management are reported under 6B. Emissions related to the digestion process which stem from processes that are not related to the energy production, such as the storage of fermented biomass are reported under 6D. 6D also describes emissions related to composting. 6C is only a small fraction, consisting of illegal waste incineration, sewage sludge incineration and burning of residues in agriculture and forestry. Special waste incineration withouth energy recovery such as cable incineration or hospital waste incineration no longer takes place. For this reason it is crossed out in the figure. These waste fractions are also incinerated in MWSIP and therefore reported under the sector 1 Energy.

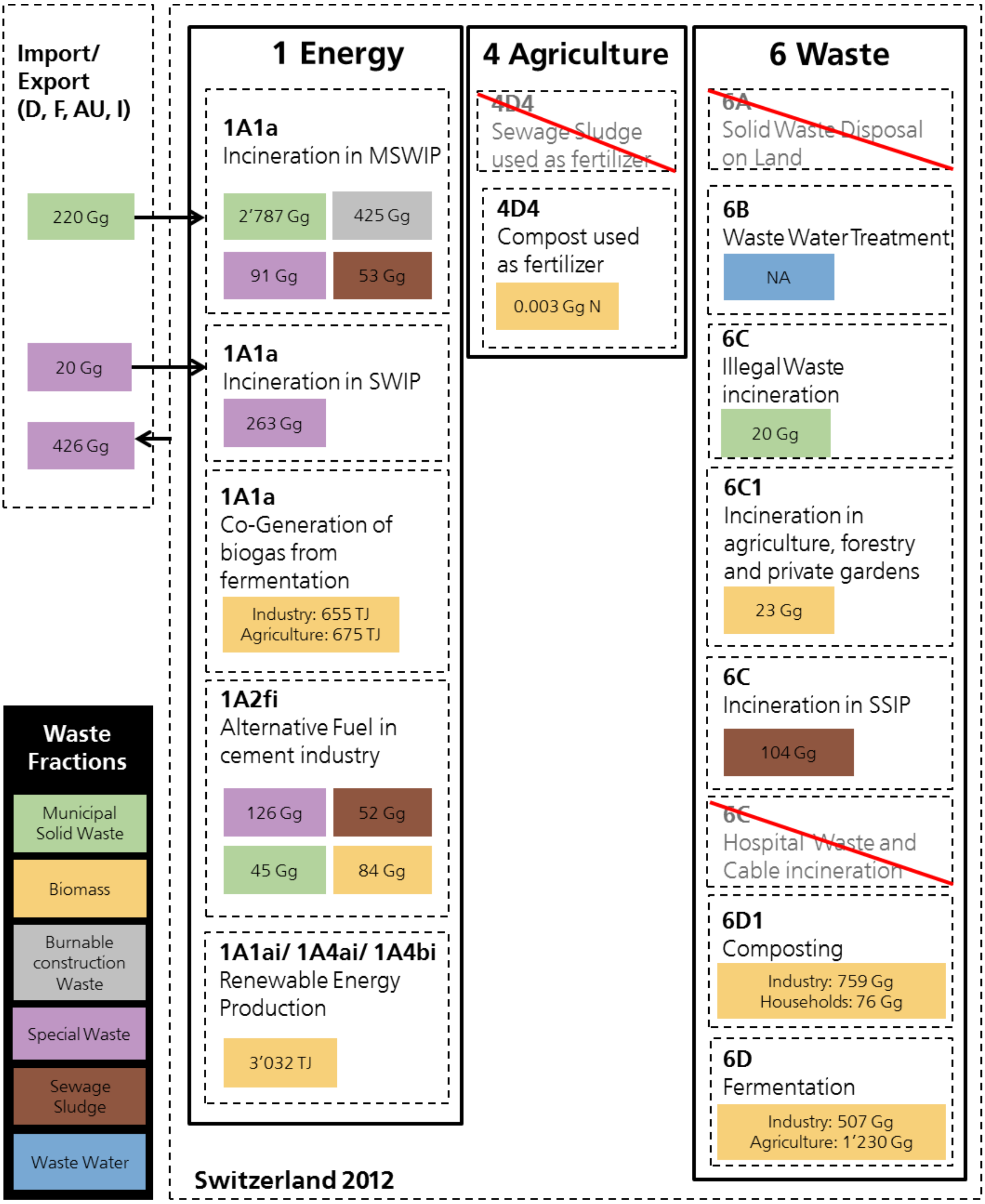

Figure 8-4 Overview on the type of treatment and amounts of waste fractions treated in the respective sectors in Switzerland in 2012
Abbreviations: MSWIP: Municipal Solid Waste Incineration Plant, SWIP: Special Waste Incineration Plant, SSIP: Sewage Sludge Incineration Plant

In the following the treatment and amounts of relevant waste fractions of Switzerland in 2012 are outlined (see also Figure 8-4). Recycled amounts are not shown in the figure because they are not emission-relevant.

- **Municipal Solid Waste:** Switzerland has a very high recycling rate, 50% of the municipal solid waste is collected separately and recycled (FOEN 2013h). While 2'790 Gg MSW were recycled, 2'787 Gg were incinerated in 2012. Additional 220 Gg MSW were imported into Switzerland for incineration (in the first place from neighbouring countries such as Germany, France, Austria and Italy). The import of waste into Switzerland needs to be authorized by the Federal Office for the Environment. A part of the separately collected plastic fractions from households and industry which can not be recycled, is used as a alternative fuel in the cement production (45 Gg in 2012).

- **Construction Waste:** It is assumed that about 1.5t construction waste is produced per inhabitant[15]. Thus, about 12'000 Ggconstruction waste was generated in Switzerland in 2012[16]. From this quantity 8’400Gg (about 70%) was recycled. About half of the recycling took place at the construction site, e.g. by reusing material left after breaking up the road cover. The other half was separated at the construction site and recycled individually, e.g. used glass, used metals, used concrete etc, EMPA 2004a A minor amount e.g. 425 Gg reflecting the burnable part of construction waste was incinerated in MSWIPas shown in Figure 8-4 (internal numbers provided by the waste section of FOEN). The remaining, inert construction waste (about 3’125 Gg) was disposed of in landfills for inert waste.
- **Special Waste:** Special waste refers to a highly divers waste fraction containing hospital wastes, batteries, electronic waste, hazardous industrial sludges, contaminated soils, etc.). According to the yearly reported special waste statistics (FOEN 2013i) about 1’749 Gg special waste was generated in Switzerland in 2012. About 326 Gg special waste was recycled, 294 Gg were biologically treated, 522 Gg landfilled and approximately 426 Gg exported for landfilling (FOEN 2013i). Only the amount of incinerated special waste is emission-relevant and therefore shown in figure 8-4. In 2012, 91 Gg were incinerated in MWSIP (EMIS 2014/1 A 1 a_Kehrichtverbrennungsanlagen), 263 Gg in SWIP (EMIS 2014/1 A 1 a_Sondermüllverbrennungsanlagen 20140123). In 2012 126 Gg special waste was used as an alternative fuel in the cement production (EMIS 2014/ 1 A 2 f i_Zementwerke Feuerung).
- **Sewage Sludge:** Since 2006 it is forbidden to use sewage sludge as a fertilizer in agriculture due to the content of organic contaminants, heavy metals and other substances. About 210 Gg (dry matter) sewage sludge was generated in 2012 (FOEN 2013h). 56 Gg were incinerated in MSWIP, 104 Gg incinerated in SWIP (without energy recovery) (internal numbers provided by the waste section of FOEN) and 52 Gg used as a fuel in the cement industry (EMIS 2014/ 1 A 2 f i_Zementwerke Feuerung) .
- **Biomass:** the term biomass refers to a broad range of materials such as garden waste, grass, waste wood, liquid manure and production from the food industry or further fractions, depending on the process concerned. In 2012 23 Gg residues from agriculture, forestry and private gardens were burned without energy recovery (EMIS 2014/6C1 Abfallverbrennung in der Land- und Forstwirtschaft). 1'737 Gg biomass was fermented (EMIS 2014/ 1 A 1 a und 6 D_Vergärung IG und LW). The amount of biomass composted in large-scale composting facilities (industrial composting) was 759 Gg wet matter in 2012. It is assumed that composted households waste adds up to 10 percent of industrial composting. (EMIS 2014/ 6 D_Kompostierung Industrie and EMIS 2014/ 6 D_Kompostierung Haushalte). Quantities of biomass refer to the wet matter. 84 Gg of biomass such as used wood or animal fat, was used as an alternative fuel in the cement industry (EMIS 2014/ 1 A 2 f i_Zementwerke Feuerung). Compost used as a fertilizer amounted to 3.424t N (see chapter). 3’032 TJ wood was used for energy production purposes, for example in wood-fired power stations, chimneys, or pellets heatings systems (SFOE 2013b).

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[15] It is assumed that this estimation in FOEN 2010j still applies for the year 2012.

[16] Inhabitants in Switzerland in 2012: 7.997 million (SFSO 2013a)

8.2 *Source Category 6A – Solid Waste Disposal on Land*

8.2.1 Source Category Description

Tier 1 key category 6A CH_4 emissions from managed waste disposal on land (trend) **Tier 2 key category 6A** CH4 CH_4 emissions from managed waste disposal on land (level and trend)

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

As incineration is the mandatory disposal option for burnable waste since 2000, input into managed solid waste landfill sites have dropped down to zero. Emissions thus stem from landfillling before 2000. Emissions from the source category 6A2 Unmanaged Waste Disposal Sites are included in source category 6A1 Managed Waste Disposal on Land. This is motivated by the fact that in Switzerland officially no unmanaged waste disposal sites exist. The effective quantity of waste not properly treated in landfills is estimated to be very small. However, no reliable data is available.

In Switzerland, in 2012 six managed biogenic active landfills are equipped to recover landfill gas (SFOE 2013a). The landfill gas is generally used in co-generation plants in order to produce electricity and heat. Some landfill gas is used to generate heat only. A very small amount of the landfill gas is flared.

Table 8-2 Specification of source category 6A Solid Waste Disposal on Land. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

6A	Source	Specification	Data Source
6A1	Managed Waste Disposal on Land	Emissions from managed solid waste landfill sites.	EMIS 2014/1A1a & 6A1 Kehrichtdeponien
6A2	Unmanaged Waste Disposal Sites	Emissions from all other waste disposal sites not included in source category 6A1. (included in 6A1)	
6A3	Others	Not ocurring in Switzerland	

8.2.2 Methodological Issues, Managed Waste Disposal on Land (6A1)

Methodology

The emissions are calculated in four steps:

i) The rate of CH_4 generation over time is based on the First Order Decay model (FOD) according to IPCC (IPCC 1997a-c). The following equation is applied to calculate the CH_4 generation in the year t:

$$CH_4 \text{ generated in the year t [Gg/year]} = \sum_x [A \cdot k \cdot M(x) \cdot L_0(x) \cdot e^{-k(t-x)}] \cdot (1-OX)$$

where

t = current year

x = the year of waste input, $x \leq t$

A = (1-k)/k, norm factor (fraction)

k = methane generation rate [1/yr]

M(x) = the amount of waste disposed in year x

$L_0(x)$ = methane generation potential (MCF(x) • DOC(x) • DOC_F • F • 16/12) [Gg CH_4 / Gg waste]

MCF(x) = methane correction factor (fraction)

DOC(x) = degradable organic carbon [Gg C/ Gg waste]

DOC_F = portion of DOC, that is converted to landfill gas (fraction)

F = portion of CH_4 in landfill gas (fraction)

16/12 = factor to convert C to CH_4.

OX = oxidation factor (fraction)

The following general assumptions are made:

MCF(x) = constant = 1 (default value according to IPCC for managed solid waste disposal sites)

OX = 0.1 (default value according to IPCC 1997a-c)

DOC_F = 0.6 (default value according to IPCC 1997a-c)

F = 0.5 (default value according to IPCC 1997a-c)

The degradable organic carbon DOC(x) is calculated based on country specific waste composition for municipal solid waste, construction waste and sewage sludge and default values for DOC (x) adopted from IPCC Guidelines, table 6-3. Assumptions for the composition are summarized in Table 8-3.

Table 8-3 Composition of landfilled Municipal Solid Waste (MSW), Construction Waste (CW) and Sewage Sludge (SS) used to derive DOC (Source 1A1 a / 6A1 EMIS Kehrichtdeponien)

Fraction IPCC	MSW 1993	MSW 2003	CW 1993	CW2003	SS1993	SS2003
Paper, textiles and cardboard %	28	20	0	0	0	0
Garden waste and non-food organic putrescible %	5	2	0	0	100	100
Food waste %	22	27	0	0	0	0
Wood and straw %	0	0	67	67	0	0
Other (glass, metals, plastics, minerals, etc.) do not contribute to methane generation)%	45	49	33	33	0	0

The methane generation rate k is based on expert judgement taking into account the country specific conditions as well as the type of waste disposed of in landfills (EMIS 2014/1A1a & 6A1 Kehrichtdeponien).

For the calculation of CH_4 generation three different categories of waste are distinguished. The three categories are i) municipal solid waste, ii) construction waste, and iii) sewage sludge.

The following parameters are applied for the calculation of CH_4 generated.

Table 8-4 Parameters used for FOD model

	k [1/yr]	L0 [Gg CH4 / Gg waste]	resulting DOC [-]
municipal solid waste	0.139	0.050	1990-1992: 0.15 1993-2002: linear interpolation 2003-2012: 0.12
construction waste	0.046	0.080	0.20
sewage sludge	0.069	0.068	0.17

ii) In a second step, the amount of CH_4 that is recovered and used as fuel for co-generation units as well as for flaring is subtracted from the CH_4 generated in landfills (resulting from step 1).

CH_4 emissions $_{step\ ii)}$ = CH_4 emissions $_{step\ i)}$ – (CH_4 emissions $_{step\ i)}$ * Fl(t)) – Qco-gen(t)

where

Fl(t) = portion of generated methane that is flared in the present year (fraction)

Qco-gen(t) = CH_4 which is recovered in co-generation units in the present (Gg)

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

CH_4 emissions $_{step\ iii)}$ = CH_4 emissions $_{step\ ii)}$ + Qopen(t)

where

Qopen(t) = CH_4 which is emitted from open burning in the present year (Gg)

iv) In the fourth and last step the emissions of the other gases are calculated. The respective emissions are considered as proportional to the CH_4 burnt (co-generation and flaring), or to the waste quantity burnt (open burning), respectively.

Emission Factors

Emission factors for CO_2, CH_4, CO, NMVOC and SO_2 are country specific based on measurements and expert estimates, documented in EMIS 2014/1A1a & 6A1 Kehrichtdeponien. CO_2 emissions from non-biogenic waste are included, while the CO_2 emissions from biogenic waste are excluded from total emissions.

The following table presents the emission factors used in 6A1:

Table 8-5 Emission Factors for 6A1 Managed Waste Disposal Sites on Land in 2012.

Source	**CO_2 biogen**	**CO_2 fossil**	**CH_4**	**NO_x**	**CO**	**NMVOC**	**SO_2**
6A1 Managed Waste Disposal on Land	t / t CH_4 produced						
Direct emisions from landfill	3.00	0	1				
	kg / t CH_4 burned						
Flaring	2750	0		1	17		
	kg / t waste burned						
Open burning	663	608	6	2.5	50	16	0.8

Activity data

One set of activity data for Managed Waste Disposal on Land (6A1) are the waste quantities disposed on landfills and the municipal solid waste burnt on-site.

Activity data for Managed Waste Disposal on Land (6A1) are taken from EMIS 2014/1A1a & 6A1 Kehrichtdeponien.

Table 8-6 Activity data in 6A1: Waste disposed of on Managed Landfill Sites from 1990 to 2012 (source EMIS 2014/1A1a & 6A1 Kehrichtdeponien).

Source / Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
6A1 Managed Waste Disposal on Land											
Municipal solid waste (MSW)	Gg	637.0	637.0	637.0	637.0	581.2	531.9	482.7	472.8	463.0	465.3
Construction waste	Gg	147.0	170.5	170.5	123.5	59.1	47.3	35.5	35.5	41.4	41.6
Sewage sludge	Gg (dry)	58.8	58.8	58.8	48.8	39.0	27.7	16.3	12.2	8.1	6.1
Open burned waste	Gg	17.2	20.0	20.0	18.2	10.9	9.7	8.5	8.3	8.2	5.5
Total waste quantity	Gg	860.0	886.3	886.3	827.5	690.2	616.6	542.9	528.7	520.6	518.5

Source / Parameter	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
6A1 Managed Waste Disposal on Land											
Municipal solid waste (MSW)	Gg	288.8	184.8	80.8	52.2	23.7	13.6	3.5	1.5	1.2	0.0
Construction waste	Gg	30.7	17.7	4.8	3.4	2.0	1.4	0.8	0.0	0.0	0.0
Sewage sludge	Gg (dry)	4.1	3.9	3.6	2.6	1.6	1.0	0.3	0.0	0.0	0.0
Open burned waste	Gg	3.5	2.2	0.9	0.6	0.1	0.1	0.0	0.0	0.0	0.0
Total waste quantity	Gg	327.0	208.6	90.1	58.8	27.5	16.1	4.7	1.5	1.2	0.0

Source / Parameter	Unit	2010	2011	2012
6A1 Managed Waste Disposal on Land				
Municipal solid waste (MSW)	Gg	0.0	0.0	0.0
Construction waste	Gg	0.0	0.0	0.0
Sewage sludge	Gg (dry)	0.0	0.0	0.0
Open burned waste	Gg	0.0	0.0	0.0
Total waste quantity	Gg	0.0	0.0	0.0

Table 8-6 documents the amounts of municipal solid waste, construction waste, sewage sludge and open burnt waste disposed of on managed waste disposal sites over the time period 1990 – 2012.

The continuous reduction happened due to changes in the legislative framework, making incineration the mandatory disposal option for burnable waste and banning its disposal on landfills from 1 January 2000. The amounts of burnable waste disposed of on managed waste diposal sites dropped down to zero in 2009.

The other activity data for Managed Waste Disposal on Land (6A1) are CH_4 direct emissions and CH_4 flared (Table 8-7). The landfill gas recovered and used as fuel for co-generation units is reported under 1A1 Energy in accordance to the IPCC Good Practice Guide. The sum of landfill gas flared and landfill gas used in co-generation units is reported as being recovered in CRF-table 6.A,C.

Table 8-7 Activity data in 6A1: CH_4 direct emissions and CH_4 flared from 1990 to 2012 (source EMIS 2014/1A1a & 6A1 Kehrichtdeponien).

Source / Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
6A1 Managed Waste Disposal on Land											
CH_4 direct emissions	Gg	32.7	32.3	30.8	28.2	25.4	25.0	23.8	23.2	22.2	21.0
CH_4 flared	Gg	4.2	4.2	4.3	4.3	4.2	4.1	4.0	3.9	3.7	3.6
CH_4 used in co-generation units (reported under 1A1a)	Gg	4.9	5.7	7.6	10.4	12.6	12.1	12.1	11.5	11.3	11.4

Source / Parameter	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
6A1 Managed Waste Disposal on Land											
CH_4 direct emissions	Gg	19.0	18.0	17.2	15.0	15.0	14.1	13.5	12.4	11.1	10.1
CH_4 flared	Gg	3.4	3.1	2.8	2.5	2.3	2.0	1.8	1.6	1.4	1.3
CH_4 used in co-generation units (reported under 1A1a)	Gg	11.3	10.0	8.1	7.7	5.3	4.1	2.7	2.1	1.8	1.5

Source / Parameter	Unit	2010	2011	2012
6A1 Managed Waste Disposal on Land				
CH_4 direct emissions	Gg	9.4	8.5	7.5
CH_4 flared	Gg	1.2	1.0	0.9
CH_4 used in co-generation units (reported under 1A1a)	Gg	1.0	0.9	0.9

The CH_4 generated in landfills decreased since 1990 due to the fact that waste quantities disposed of in landfills have been decreasing. Together with the relative increase of CH_4 recovery from 1990 until 2012 this is the reason for CH_4 emissions from the source category 6A being a key source regarding trend.

8.2.3 Uncertainties and Time-Series Consistency

Uncertainty in CH4 emissions from Solid Waste disposal on land in 6A

Uncertainty of direct CH_4 emissions from sanitary landfills is estimated to be 58.3%.

For the amount of waste disposed of on a landfill an uncertainty of 30% is assumed. This is because most of the emissions in the nineties stem from waste disposed of in the eighties, when waste statistics were reported less accurately. An uncertainty of 50% is assumed for the emission factor (EMIS 2014/1A1a & 6A1 Kehrichtdeponien).

Combined uncertainty of CO_2 emissions is estimated to be 40% in emissions estimates according to an uncertainty assessment based on expert judgments.

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

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

Consistency: The time series is consistent.

8.2.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission as well as available energy data. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013.
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

8.2.5 Source-Specific Recalculations

Value for 2011 of sewage gas production has changed in SFOE 2013a. The AD of 2011 (CH_4 direct emissions and CH_4 flared) have been recalculated.

8.2.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

8.3 Source Category 6B – Wastewater Handling

8.3.1 Source Category Description

Tier 1 Key category 6B
N_2O emissions from waste water handling (level).

Tier 2 Key category 6B
N_2O emissions from waste water handling (level and trend).

The source category 6B1 Industrial Waste Water comprises all emissions from liquid waste handling and sludge from industrial processes such as food processing, textiles, or pulp and paper production. Food processing may result in effluents with a high load of organics. In order to reduce the load of polluted waste water (and to meet the regulatory standards as well as to reduce discharge fee) the effluent is pre-treated on site. The treatment is generally anaerobic, in order to use the biogas as source for heat and power generation. Currently, there are 22 industrial waste water pre-treatment plants. For emission calculations, industrial waste water is not identified as separate waste water stream, but joined to the domestic waste water treatment. Industrial waste water comprises, for example, metal-containing waste waters from electroplating plants, waste water from the food processing industry or waste water from car-washing places. Depending on the contaminants, an on-site pre-treatment is necessary so that the legal threshold values are met and that disruptions on the public sewage treatment plant can be precluded. After the pre-treatment process, the industrial wastewater is discharged in the sewage system and cleaned in a public wastewater treatment plant.

The source category 6B2 Domestic and Commercial Waste Water comprises all emissions from liquid waste handling and sludge from housing and commercial sources (including gray water and night soil). In Switzerland, MWWTP treat waste water from single cities or several cities/municipalities together. Waste water in general is treated in three steps: 1. Mechanical treatment, 2. Biological treatment, and 3. Chemical treatment. The treated waste water flows into a receiving system (lake, river or stream). As mentioned above, the pre-treated effluents from industries are also handled for final treatment in these waste water treatment plants. Switzerland's wastewater management infrastructure - comprising 849 sewage plants and 40’000-50’000 km of public sewers - is now practically complete (FOEN 2012g). In 2012, 285 waste water treatment plants use sewage gas for energy production.

Table 8-8 Specification of source category 6B Wastewater Handling. "EMIS 2014/…" refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

6B	Source	Specification	Data Source
6B1	Industrial Waste Water	Emissions from handling of liquid wastes and sludge from industrial processes.	AD: EMIS 2014/6B1 Kläranlagen Industriell and SFOE 2013 EF: EMIS 2014/6B1 Kläranlagen Industriell
6B2	Domestic and Commercial Waste Water	Emissions from liquid waste handling and sludge from housing and commercial sources	AD: EMIS 2014/6B2 Kläranlagen Kommunal and SFOE 2013 EF: EMIS 2014/6B2 Kläranlagen Kommunal
6B3	Others	Not occurring in Switzerland	

The emissions related to waste water treatment are included in various categories as illustrated in Figure 8-5 below. The system boundaries of category 6B contain all emissions from direct waste water handling including direct emissions of sewage gas (leakage), torching, combined heat and power production (CHP), furnaces (only heat production), emissions from the combustion of heating oil in boilers and engines, and natural upgrading into gas quality (intended for introduction into the natural gas network and/or use as fuel).

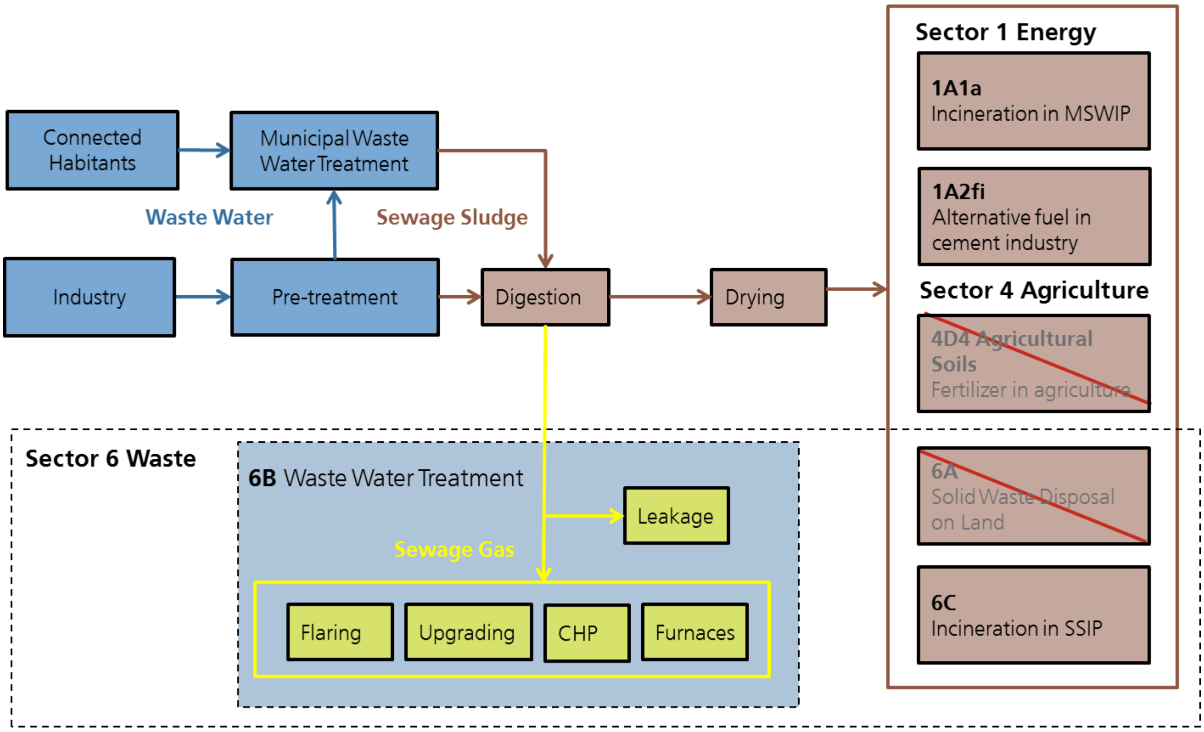


Figure 8-5 System boundaries of emissions related to wastewater treatment. CHP= Combined Heat and Power Production

Sewage sludge is usually dried in sewage plants in Switzerland before being disposed of. Emissions associated with sewage sludge drying are assumed to be negligible. The discharge of sewage sludge in agriculture has been phased out since 2003 and is generally forbidden since 2008, therefore this process is crossed out in the figure. The same applies to the disposal on land (6A). All sewage sludge is incinerated either in MSW incineration plants (1A1a), SS incineration plants (6C) or used as alternative fuel in the cement industry (1A2f).

8.3.2 Methodological Issues, Wastewater Handling (6B)

Methodology

For industrial waste water treatment (6B1) a country specific method is used. For domestic and commercial waste water treatment (6B2), a country specific method is used, with the exception of N_2O. The N_2O emissions are calculated based on the national protein consumption according to the IPCC default method. The GHG emissions are calculated by multiplying the number of inhabitants connected to waste water treatment plants by emission factors.

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 2014/6B1 Industrielle Abwässer and EMIS 2014/6B2 Kommunale Kläranlagen. To calculate emission factors, the total sewage gas production for Switzerland is taken into account. It is assumed that 2% of the total amount of sewage gas is flared and 0.75% of the total amount is leaking. It is further assumed that 5% of the upgraded gas leaks as well. With these assumptions EF in kg/TJ are calculated. All emission factors have been converted and standardized into g/inhabitants.

In case of emissions related to industrial waste water treatment, total mass flows of emissions are divided by the population “artificially”, because activity data in our database correspond to the connected population.

Emission factors are adapted on a yearly basis due to respective changes in the amounts of total production of sewage gas produced, population growth and eventual changes in the fraction of inhabitants connected to waste water treatment plants.

EF for N_2O is derived based on the IPCC-default method (EMIS 2014 6B2 Kläranlage kommunal. The IPCC standard values were used for the percentage of nitrogen in proteins and the emission factor of N_2O in waste water. The annual protein consumption in Switzerland is taken from the statistics of the Secretariat of the Swiss Farmers Association (SBV 2013). As these numbers take into account swiss conditions, results seem to be more accurate for national conditions than by applying the FAOSTAT database.

The following formula taken from the revised 1996 IPCC GL is used (adjusted for per capita emissions):

$N_2O(s)$ = Protein * FracNPR * EF6

According to the Swiss Farmer's Union, total protein consumption in Switzerland raised from 236'000 t in 1990 to 305'000 t in 2011 (SBV 2012). The value for 2012 has not been published yet and is therefore extrapolated by using the value of 2011 and the population in 2012. Protein consumption factors thus range around 34 kg/ inhabitant and year. Using an N fraction of 0.16 kg N per kg protein (FracNPR; IPCCdefault) an emission factor of around 97 g N_2O per inhabitant results for the year 2012. N_2O-emissions are thus only an approximation. Expert interviews reveal that currently there is no better data or more accurate values available for Switzerland[17]. Measurements of emissions have only been carried out for certain processes in specific waste water treatment plants and results are not transferable to other plants. There might be more specific values available in the future.

CH_4 emissions reported are due to flaring, leakage from sewage gas upgrading as well as leakage from piping systems. As mentioned before it is assumed that 5% of the upgraded gas is lost. A specific EF for the amount of upgraded biogas of 19'945 kg/TJ is assumed. This results in an EF for the amount of upgraded biogas of 19’945 kg/TJ x 0.05 = 997.25 kg/TJ. The total amount of biogas lost is allocated to the (connected) inhabitants, which results in an EF of 51.4 [g/connected inhabitant] or 49.8 [g/inhabitant] in 2012.

Although the emission factor for CH_4 in kg/ TJ has not changed since 2007, rather abrupt changes in EF [g/ inhabitant] can be observed since 2007. This is related to the changes in input mass flows, i.e. sewage gas produced in each year. Additionally, the amount of sewage gas fed into the natural gas pipes has increased significantly from 2007 to 2012 from 4.6 GWh in 2007 to 26.0 GWh in 2012 (SFOE 2013a). Thus, higher emissions are mainly related to the growing amounts of upgraded sewage gas.

The emission factors used in 6B1 and 6B2 are summarized in the following table.

Table 8-9 Emission Factors for 6B1 Industrial Waste Water and 6B2 Domestic and Commercial Waste Water in 2012.

Source	CO_2 biog.	N_2O	CH_4	NO_x	CO	NMVOC	SO_2
	kg/inhabitant	g/inhabitant					
6B1 Industrial Waste Water	2.2	NO	5.5	2.5	3.6	0.07	0.23
6B2 Municipal Waste Water	14.8	97	50	24	42	0.5	3

The activity data for N_2O emissions of municipal waste water is the total number of inhabitants (not connected inhabitants), in line with IPCC. For industrial waste water it is assumed that N_2O emissions are not occurring (EMIS 2014/6B1 Industrielle Abwässer).

[17] Telephone interview Denise Fussen with Pascal Wunderlin, PhD EAWAG, 11.09.2012

In 2012, 96.8 % of inhabitants are connected to to public waste water treatment. Emissions from waste water of the inhabitants not connected to public waste water treatment are not considered, as their contribution is of minor importance.

Several waste water treatment plants also accept co-substrates (organic wastes from the food processing industry) and add them to the digestion process. As they are rich in energy content a considerable part of the sewage gas stems therefrom. A part of the emissions are thus related to the addition of co-substrates.

Activity data

Activity data in 6B correspond to the number of connected inhabitants (except for N_2O as mentioned above). The number of inhabitants connected to the system (ICS) is calculated as a product of number of inhabitants and the service level. The latter is assumed to rise from 96.7% in 2007 to 97% in 2020 with interpolated values in between. Activity data for Domestic and Commercial Waste Water (6B2) are extracted from EMIS 2014/6B2 Kläranlage kommunal from SFOE 2013a. For 6B1 the same activity data were adopted.

Table 8-10 Activity data 6B2 Domestic and Commercial Waste Water; Population and fraction connected to waste water treatment plants.

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
6B2 Domestic and Commercial Waste Water											
Population	inhabitants in 1000	6'796	6'880	6'943	6'989	7'037	7'081	7'105	7'113	7'132	7'167
Fraction connected to waste water treatment plants	%	90.0	91.0	91.5	92.0	93.0	93.5	94.0	94.5	95.0	95.3
connected inhabitants	inhabitants in 1000	6'116	6'261	6'353	6'430	6'544	6'621	6'679	6'722	6'775	6'830

Source/Parameter	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
6B2 Domestic and Commercial Waste Water											
Population	inhabitants in 1000	7'209	7'285	7'343	7'405	7'454	7'501	7'558	7'619	7'711	7'801
Fraction connected to waste water treatment plants	%	95.4	95.7	96.0	96.3	96.6	96.7	96.7	96.7	96.7	96.7
connected inhabitants	inhabitants in 1000	6'877	6'972	7'049	7'131	7'201	7'253	7'309	7'368	7'458	7'547

Source/Parameter	Unit	2010	2011	2012
6B2 Domestic and Commercial Waste Water				
Population	inhabitants in 1000	7'878	7'912	7'997
Fraction connected to waste water treatment plants	%	96.8	96.8	96.8
connected inhabitants	inhabitants in 1000	7'623	7'658	7'742

8.3.3 Uncertainties and Time-Series Consistency

Uncertainty in N_2O emissions from 6B2

Activity data is highly reliable (estimated uncertainty 1.3%). The uncertainty for the emission factor is estimated to be 50%, according to EMIS 2014/6B1 Kläranlage Industriell.

Qualitative estimate of uncertainties of non-key category emissions in 6B

A preliminary uncertainty assessment based on expert judgment results in medium uncertainty of emissions estimates for CH_4 and low uncertainty for N_2O.

The time series is consistent.

8.3.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission as well as available energy data. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013.
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

8.3.5 Source-Specific Recalculations

Values of connected inhabitants (AD) have not been correctly interpolated from 2008-2011. Recalculations for those years were carried out.

The amount of sewage gas produced has been updated for the years 2007-2011 (SFOE 2013a). Updated values have been used in the model to calculate EF for all pollutants.

The Swiss Farmers Association (SBV) has changed its method of calculation for protein consumption for the years 2008 onwards. The EF of N_2O been recalculated for the years 2008-2011.

8.3.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

8.4 Source Category 6C – Waste Incineration

8.4.1 Source Category Description

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

There is a long tradition in Switzerland to incinerate waste. The waste heat generated during the incineration has to be recovered if technically and economically feasible. In accordance with the IPCC provisions (IPCC 1997c) emissions from the combustion of waste-to-energy activities are dealt with in 1A Fuel Combustion Activities.

Emissions from open burning of branches in agriculture and forestry have formerly (before Submission 2013) been reported in category 4F. However field burning of agricultural residues does not occur in Switzerland. Concerned waste fractions related to agriculture and forestry are burned only after they have been translocated from their place of origin. Therefore they are now reported under sector 6 Waste. Accordingly, the source category has been moved to 6C1 and is now reported under waste incineration as Burning of Residues in Agriculture and Forestry.

The following sources are included in source category 6C:

Table 8-11 Overview on waste incineration sources reported under 6C. "EMIS 2014/…" refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

Waste incineration	Specification	Data Source
Hospital waste incineration	Emissions from incinerating hospital waste in hospital incinerators	AD, EF: EMIS 2014/6C2 Spitalabfall-Verbrennung
Illegal waste incineration	Emissions from illegal incineration of municipal solid wastes at home Emissions from waste incineration at construction sites (open burning)	AD, EF: EMIS 2014/6C2Abfallverbrennung illegal
Insulation material from cables	Emissions from incinerating cable insulation materials	AD, EF: EMIS 2014/6C2 Kabelabbrand
Sewage sludge	Emissions from sewage sludge incineration plants	AD, EF: EMIS 2014/6C2 Klärschlamm-Verbrennung
Crematoria	Emissions from the burning of bodies in crematoria	AD, EF: EMIS 2014/6C Krematorien
Burning of residues in agriculture and forestry	Emissions from burning of agricultural and silvicultural waste	AD, EF: EMIS 2014/6C1 Abfallverbrennung in der Land- und Forstwirtschaft

8.4.2 Methodological Issues

Methodology

For the calculation of the greenhouse gas emissions a country specific Tier 2 method is used. In general, the GHG emissions are calculated by multiplying the waste quantity incinerated by emission factors. For crematoria, the GHG emissions are calculated by multiplying the number of cremations by emission factors.

For sewage sludge incineration plants the respective waste quantities are based on reliable statistical data (updated every two years until 2006). The emission factors are based on emission declarations from an incineration plant in 2002 that covered approx. one third of the Swiss capacities. Due to the lack of better or newer data these EF are kept constant since then and no increase in flue gas cleaning standards is assumed.

For hospital waste incineration, illegal waste incineration and incineration of insulation material, the waste quantities used are based on rough expert estimates.

The emissions of burning of residues in agriculture and forestry are calculated by multiplying the annual estimate of branches burned (in Gg of wood equivalent) by emission factors (IPCC default method).

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 2014/6C database. The emission factors of burning of residues in agriculture and forestry are calculated based on EMEP/EEA 2013 except for CH_4 und N_2O which are based on EMEP/CORINAIR (EEA 2002), EMIS 2014/6C1 Abfallverbrennung in der Land- und Forstwirtschaft.

In the years with no specific data for activity data or emission factors the respective data are interpolated.

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

Table 8-12 Emission Factors for 6C Waste Incineration in 2012 (source EMIS 2014/6C, EEA 2007 several EMIS comments see Table 8-11).

6C Waste Incineration							
Source	**CO_2** t/t	**CH_4** kg/t	**N_2O** g/t	**NO_x** kg/t	**CO** kg/t	**NMVOC** kg/t	**SO_2** kg/t
Hospital waste incineration	0.9	0	60	1.5	1.4	0.3	1.3
Illegal waste incineration	0.61	6	150	2.5	50.0	16	0.75
Insulation material cables	1.3	0	0	1.3	2.5	0.5	6
Sewage sludge plants	0	0.10	800	0.7	0.19	0.0050	0.47
Burning of natural residues in agriculture	NA	6.8	180	1.38	48.8	1.5	0.03
Burning of natural residues in forestry	NA	6.8	180	1.38	48.8	1.5	0.03
Burning of natural residues in private households	NA	6.8	180	1.38	48.8	1.5	0.03
	CO_2 t/crem.	**CH_4** kg/crem.	**N_2O** g/crem.	**NO_x** kg/crem.	**CO** kg/crem.	**NMVOC** kg/crem.	**SO_2** kg/crem.
Crematoria	NA	0	0	0.21	0.16	0.013	0

Additional information on the emission factor CO_2:

For all waste incineration options, the CO_2 emissions only from non-biodegradable waste are taken into account.

- Hospital waste incineration plants: Mainly waste of fossil origin. Default value for the CO_2 emission factor taken from CORINAIR (1992). Since 2002, no emissions from hospital waste incineration occur, as all special hospital waste incinerator plants have been closed and hospital waste is incinerated in municipal solid waste incineration plants (accounted for in 1A1).
- Illegal waste incineration: The main source of non-biodegradable CO_2 emissions is plastic. Until 2002 it is assumed that 40% of the waste mix is of fossil origin. In the FOCAWIN study by EMPA (Mohn 2011), the share of fossil matter in municipal waste in 2011 has been measured to be 47.8% on average. It is assumed that the same share applies for illegal waste burning. The value of 47.8% is implemented for the year 2011. Until 2002 the value is assumed to be 40%. In between 2002 and 2011 the values are linearly interpolated. The assumptions for the share of fossil/biogenic and C-content of waste are the same as for MSW incineration plants (EMIS 2014/6 C 2 (6 C c UNECE)_ Abfallverbrennung illegal). According to EMIS 2014/ 1A1 a_Kehrichtverbrennungsanlagen, p. 5, the emission factors for CO_2 were estimated for 1990 and 2004 by the Waste Division of the FOEN.
- Insulation materials: The CO_2 emission factor is based on measurements of the flue gas treatment of a cable dissassembling site where O_2 was measured in the flue gas. Assuming that the ratio of CO_2/O_2 is the same as in municipal solid waste incineration plants, a fraction of 7% of CO_2 results. Based on these assumptions, an EF of 1.3kg/cable can be derived. Since 1995, no emissions from incinerating cable insulation materials occur.
- Sewage sludge plants: Sewage sludge is biodegradable waste. Emission factor for CO_2 is 0. It is assumed that the share of fossil fuel used during the start-ups is negligible.

Additional information on other emission factors:

- Sewage sludge plants: Gradual technical improvements lead to reductions in NMVOC, CO, SO_2 and CH_4 emissions. Since 2002, emission factors are being kept constant because there is no newer data available (EMIS 2014 6C 2 Klärschlammverbrennung).
- Crematoria: NMVOC and CO emissions were reduced by technical improvements. Emission factors therefore depend on the number of technically improved crematoria.

The emission factors of 2011 were calculated by linearly extrapolating estimations for 2008 by taking into account an increase in the number of technically improved crematoria (EMIS 2014 6C Krematorien).

Activity Data

The activity data for Waste Incineration (6C) are the quantities of waste incinerated.

Table 8-13 Activity data for the different emission sources within source category 6C Waste Incineration.

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hospital Waste Incineration	Gg	30.0	27.5	25.0	22.5	20.0	17.5	15.0	12.5	10.0	7.5
Illegal waste	Gg	32.3	31.7	31.0	29.7	27.3	26.2	25.0	24.6	24.2	25.1
Insulation material cables	Gg	7.5	6.0	4.5	3.0	1.5	0.0	0.0	0.0	0.0	0.0
Sewage sludge	Gg dry	57.0	53.9	50.7	47.6	44.4	50.2	56.0	59.6	63.2	63.8
Burning of natural residues in agriculture	Gg	16.5	16.2	16.0	15.7	15.5	15.2	15.0	14.7	14.5	14.2
Burning of natural residues in forestry	Gg	28.8	28.0	27.1	26.2	25.4	24.5	23.6	22.8	21.9	21.0
Burning of natural residues in private households	Gg	6.1	5.8	5.6	5.3	5.1	4.9	4.6	4.4	4.1	3.9
Total	Gg	178.2	169.1	159.9	150.1	139.1	138.5	139.2	138.6	137.9	135.5
Cremations	Numb.	37'513	37'407	37'939	38'884	39'620	40'968	41'932	43'468	43'456	44'180

Source/Parameter	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hospital Waste Incineration	Gg	5.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Illegal waste	Gg	24.9	24.1	23.8	22.9	22.3	21.7	22.6	22.1	22.4	20.7
Insulation material cables	Gg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sewage sludge	Gg dry	64.3	70.2	76.0	86.5	97.0	94.9	92.7	93.1	93.5	93.9
Burning of natural residues in agriculture	Gg	14.0	13.8	13.5	13.3	13.0	12.8	12.5	12.3	12.0	11.8
Burning of natural residues in forestry	Gg	20.2	19.3	18.4	17.6	16.7	15.9	15.0	14.1	13.3	12.4
Burning of natural residues in private households	Gg	3.6	3.4	3.2	2.9	2.7	2.4	2.2	1.9	1.7	1.5
Total	Gg	132.0	133.2	134.9	143.2	151.7	147.6	145.0	143.5	142.9	140.2
Cremations	Numb.	45'104	45'681	45'979	47'488	46'128	48'169	48'083	49'413	50'885	52'402

Source/Parameter	Unit	2010	2011	2012
Hospital Waste Incineration	Gg	0.0	0.0	0.0
Illegal waste	Gg	21.0	20.3	20.3
Insulation material cables	Gg	0.0	0.0	0.0
Sewage sludge	Gg dry	94.3	94.7	95.1
Burning of natural residues in agriculture	Gg	11.5	11.4	11.3
Burning of natural residues in forestry	Gg	11.5	11.4	11.3
Burning of natural residues in private households	Gg	1.2	1.2	1.2
Total	Gg	139.6	139.1	139.2
Cremations	Numb.	52'813	52'530	54'167

8.4.3 Uncertainties and Time-Series Consistency

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

A preliminary uncertainty assessment based on expert judgment results in high uncertainty for CO_2 und CH_4 and low uncertainty for N_2O of emissions estimates.

The time series is consistent.

8.4.4 Source-Specific QA/QC and Verification

In addition to the general QA/QC measures described in Section 1.6 the activity data and emission factors were verified.

The time series have been compared between the current and the previous submission as well as available energy data. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013.
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

8.4.5 Source-Specific Recalculations

Following recalulation were carried out in 6C:

Crematoria: The Swiss Cremations Association (SVFB) has corrected AD of the year 2010. Recalculations have been made.

Sewage Sludge Incineration: Emission factors are now being kept constant since 2002 because there are no new data available. Before, a linear decrease until 2020 has been assumed. This led to recalculation from 2003 - 2011.

Sewage Sludge Incineration: AD between 2007 and 2011 have changed due to revised projections. The projections of emissions of air pollutants in Switzerland have been fully revised over the past year in order to provide consistency with he recently established energy scenarios of Energieperspektiven 2050 (Prognos 2012a).

Forestry and Agriculture: The process „Field Burning of Agricultural and sivlicultural Residues“ has been remodeled. Previously only the open burning of branches was considered. The former process has been split up into three processes “Incineration of biomass, Agriculture“, „Incineration of biomass, Silviculture“ and „Incineration of biomass; Private gardens“. This led to recalculations of AD for the whole time series.

8.4.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

8.5 Source Category 6D – Other Waste

8.5.1 Source Category Description

Tier 1 Key category 6D
CH_4 from composting and digesting organic waste (trend)

Tier 2 Key Category 6D
CH_4 from composting and digesting organic waste (level and trend)

The source category 6D Other Waste comprises the GHG emissions from car shredding plants, and the process related GHG emissions from composting and from digesting organic waste.

Within the composting activity four types of composting means are distinguished, i.e. i) hall composting, ii) field edge composting, iii) box composting and iv) windrow composting. Composting covers the GHG emissions from centralized composting plants with a capacity of more than 100 tons of organic matter/year. Backyard composting is also common practice in Switzerland. It is assumed that the quantities treated in small composting facilities such as gardens, backyards etc., add up to 10% of those treated in industrial composting plants (EMIS 2014 6D Kompostierung Industrie and EMIS 2014 6D Kompostierung Haushalte).

The digestion of organic waste takes places under anaerobic conditions. The digested matter (solid left-overs after completion of a process of anaerobic microbial degradation of organic matter) is being composted. The biogas is used for comined heat and power generation or upgraded and used as fuel. In 6D Other Waste the emissions from the composting of the digested matter as well as the methane losses due to biogas up-grading are included. The emissions related to the use of biogas in co-generation plants and emissions from biogas-upgrading are reported under the sector 1 Energy.

Table 8-14 Specification of source category 6D Other Waste. "EMIS 2014/…" refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

6B	Source	Specification	Data Source
6D	Car shredding plants	Emissions from car shredding plants	AD, EF: EMIS 2014/6D Shredder Anlagen
6D	Composting and digesting	Process related emissions from composting and digesting organic waste	AD, EF: EMIS 2014/6D Kompostierung Industrie, EMIS 2014/6D Kompostierung Haushalte,EMIS 2014/1A1a und 6D Vergärung IG und EMIS 2014/1A1a und 6D Vergärung LW

8.5.2 Methodological Issues

Methodology

For the emissions from car shredding a country specific method is used. The GHG emissions are calculated by multiplying the quantity of scrap by the emission factors. For all years the same constant emission factors have been applied.

For the emissions from composting a country specific method is used. The GHG emissions are calculated by multiplying the quantity of waste by the emission factors. For all years, the same constant emission factors have been applied.

For the emissions from digesting a country specific method is used. Digestion plants lead to GHG emissions from the storage of fermentable waste, losses due to leakages and diffusion, power water (storage of liquid fermented waste), rotting (storage of solid fermented waste) and flaring. The GHG emissions are calculated by multiplying the quantity of fermented waste by the emission factors. For all years, constant emission factors have been applied, except for $CH_{4.}$ The methane emissions from biogas upgrading are calculated by multiplying the biogas quantity upgraded by the percentage of methane losses.

Because of the increase in composting and digesting organic waste the source category 6D Other Waste is a key source regarding trend.

Emission Factors

Emission factors for car shredding, composting and digestion are country specific based on measurements and expert estimates, documented in the EMIS 2014/6D database.

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

Table 8-15 Emission Factors for 6D Others in 2012.

Source	Unit	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Shredding	g/t scrap				5	200	
Composting	g/t composted waste	5'000	70			1'700	
Fermentation (industrial, storage)	g/t fermentable waste	95	12			70	
Fermentation (industrial, losses)	g/t biogas losses	426'903					
Fermentation (industrial, power water)	g/t fermented waste (liquid)	1'896	2			400	
Fermentation (industrial, rotting)	g/t fermented waste (solid)	1'043	98			230	
Fermentation (industrial, flaring)	g/t CH4	42		4'066	2'054	82	616
Fermentation (agricultural, losses)	g/t biogas losses	426'903					
Fermentation (agricultural, rotting)	g/t fermented waste (solid)	1'100	98			230	
Fermentation (agricultural, flaring)	g/t CH4	246		4'066	2'054	82	616
Biogas up-grade	g/GJ	1075					

The fermentation process is split into different activities for industrial and agricultural biogas plants, respectively. These are following activities: storage of fermentable waste, losses due to leakages and diffusion, power water (storage of liquid fermented waste), rotting (storage of solid fermented waste) and flaring. For agricultural plants, reliable data on the emission factors exist for the storage of fermentable waste and the storage of the liquid fermented waste. For the purposes of a very rough initial estimate, the emission factors given here are taken from the corresponding subprocesses of the industrial and trades biogas installations. For each activity, new AD and EF have been reported, based on the newest data available. However, uncertainties are relatively high (EMIS 2014/1A1a und 6D Vergärung Industrie und Gewerbe und EMIS 2014/1A1a und 6D Vergärung Landwirtschaft).

The NMVOC emissions from car shredding stem from residues of fuels in the tanks of shredded cars (EMIS 2014/6D Shredder). For emission factors of NMVOC constant values are used since 2005 (EMIS 2014/6D Shredder Anlagen).

CH_4 emissions from biogas–upgrading occur due to leakage and are assumed to be 5 % of the total biogas production (value for 1990 – 2007). Since no data or better estimates are available the emisson factor is being kept constant for the following years (until 2035).

Emissions from composting encompass CO_2, CH_4 NH_3, N_2O and NMVOC and are based on measured or estimated values reported in literature.

Activity data

Activity data for shredding and composting are extracted from EMIS 2014/6D Shredder Anlagen and Kompostierung Industrie. Activity data of fermentation are extracted from EMIS 2014/1A1a und 6D Vergärung IG und EMIS 2014/1A1a und 6D Vergärung LW.

Activity data for composting are based on periodically collected reliable statistical data, but latest available data is from the year 2007. Since then values have been interpolated. The quantities for backyard composting are estimated values, i.e. 10% of the amount of waste from composting plants.

Activity data of fermentation are based on information on the number of biogas plants (EMIS 2014/1A1a und 6D Vergärung IG und EMIS 2014/1A1a und 6D Vergärung LW) and encompass activity data of all relevant processes, e.g. storage of fermentable waste, losses due to leakages and diffusion, power water (storage of liquid fermented waste), rotting (storage of solid fermented waste) and flaring.

The biogas used as fuel for co-generation units is reported under 1A1 Energy in accordance to the IPCC Good Practice Guide.

Table 8-16 Activity data in 6D Other Waste.

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Shredding	Gg	280	284	288	292	296	300	300	300	300	300
Composting	Gg	260	300	320	350	370	400	450	480	500	510
Fermentation (ind., storage, fermentable waste)	Gg	0	0	9	9	17	27	26	33	40	56
Fermentation (ind., losses, biogas)	Gg	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.04	0.05	0.07
Fermentation (ind., power water, fermented waste liquid)	Gg	0	0	5	5	10	15	15	18	22	31
Fermentation (ind., rotting, fermented waste solid)	Gg	0	0	3	3	6	9	9	11	14	19
Fermentation (ind., flaring, CH4)	Gg	0.00	0.00	0.01	0.01	0.02	0.03	0.05	0.06	0.08	0.10
Fermentation (agr., losses, biogas)	Gg	0.28	0.28	0.27	0.26	0.25	0.23	0.22	0.21	0.22	0.25
Fermentation (agr., rotting, fermented waste solid)	Gg	6	6	6	5	5	5	5	5	5	5
Fermentation (agr., flaring, CH4)	Gg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biogas up-grade	GJ	0	0	0	0	0	0	0	3'053	5'684	8'526

Source/Parameter	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Shredding	Gg	300	300	300	300	300	300	300	300	300	300
Composting	Gg	640	650	730	732	733	735	737	739	742	746
Fermentation (ind., storage, fermentable waste)	Gg	60	74	83	82	90	107	137	163	176	224
Fermentation (ind., losses, biogas)	Gg	0.07	0.09	0.10	0.10	0.10	0.13	0.16	0.19	0.20	0.25
Fermentation (ind., power water, fermented waste liquid)	Gg	33	41	46	46	50	60	76	91	98	125
Fermentation (ind., rotting, fermented waste solid)	Gg	20	25	28	28	31	37	47	56	60	77
Fermentation (ind., flaring, CH4)	Gg	0.10	0.12	0.15	0.14	0.15	0.17	0.23	0.27	0.30	0.39
Fermentation (agr., losses, biogas)	Gg	0.30	0.33	0.36	0.40	0.47	0.62	0.80	1.01	0.92	0.74
Fermentation (agr., rotting, fermented waste solid)	Gg	7	7	7	8	9	12	18	28	33	37
Fermentation (agr., flaring, CH4)	Gg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biogas up-grade	GJ	20'084	25'768	20'842	23'116	33'347	41'305	42'442	51'916	73'137	86'779

Source/Parameter	Unit	2010	2011	2012
Shredding	Gg	300	300	300
Composting	Gg	750	753	757
Fermentation (ind., storage, fermentable waste)	Gg	307	371	507
Fermentation (ind., losses, biogas)	Gg	0.34	0.41	0.55
Fermentation (ind., power water, fermented waste liquid)	Gg	171	207	283
Fermentation (ind., rotting, fermented waste solid)	Gg	105	127	173
Fermentation (ind., flaring, CH4)	Gg	0.52	0.60	0.80
Fermentation (agr., losses, biogas)	Gg	0.57	0.62	0.72
Fermentation (agr., rotting, fermented waste solid)	Gg	45	49	59
Fermentation (agr., flaring, CH4)	Gg	0.12	0.13	0.16
Biogas up-grade	GJ	124'295	172'042	241'768

8.5.3 Uncertainties and Time-Series Consistency

Uncertainty in CH_4 emissions from composting and digestion 6D

The uncertainty of the CH_4 emissions in Category 6D from composting and digesting of organic waste is estimated to be 100% (expert estimate). The uncertainty of the related activity data is estimated to be 10% (expert estimate), because waste statistics are rather reliable.

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

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

The time series is consistent.

8.5.4 Source-Specific QA/QC and Verification

The time series have been compared between the current and the previous submission as well as available energy data. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2012 are compared with the results 2011 within the current CRF
- the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013.
- the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013

8.5.5 Source-Specific Recalculations

Following recalculations were made in 6D:

Biogas upgrading: Emission factor of CH_4 had been wrong by a factor of 1000 and has been corrected. Recalculations were made from 1997, when biogas-upgrading activities started, until 2011.

Fermentation: Until submission 2013, AD for the years 2009-2011 have been extrapolated based on the values of the years 2007/08. Now actual data from SFOE 2013a have been used for estimating AD. Furthermore, activity data for the years before 2009 have been recalculated due to updated data in SFOE 2013a. This led to recalculation of AD for the whole time series 1990-2011 (agricultural biogas production) and the years 1999-2011 (industrial biogas production).

8.5.6 Source-Specific Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. In order to accomplish this transition, other projects are postponed in order to give first priority to changes related to the new reporting guidelines.

9 Other

9.1 Overview

9.1.1 Greenhouse Gas Emissions

Within the sector 7 Other emissions from various sources are considered:

- Fire damage estates,
- Fire damage motor vehicles

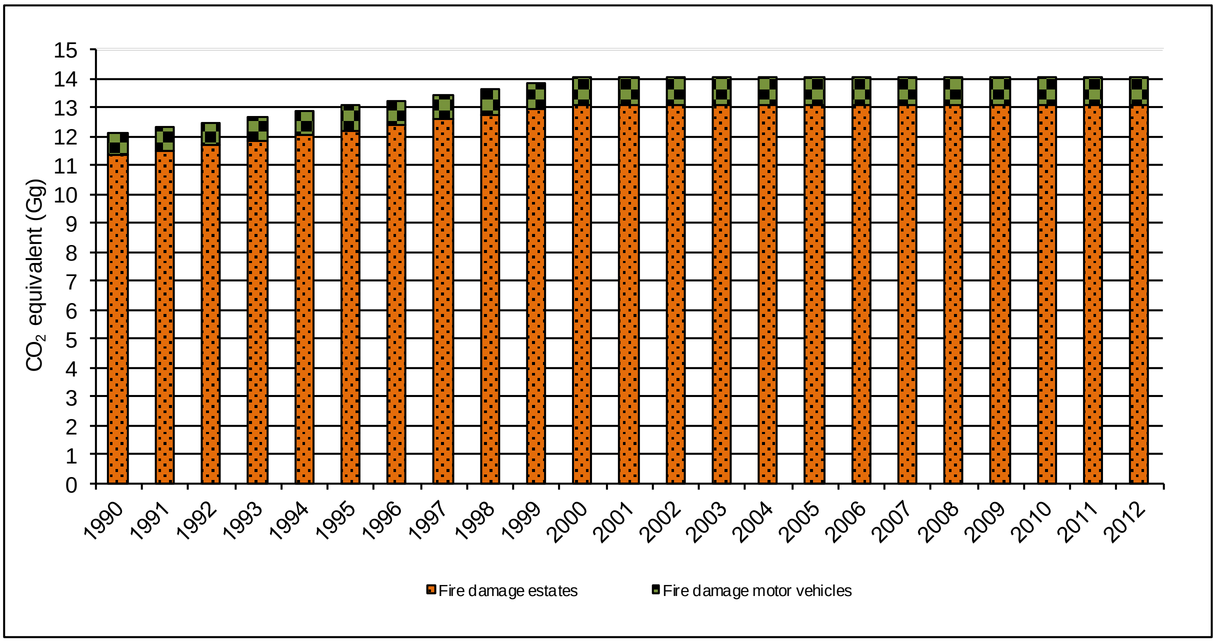


Figure 9-1 Switzerland's greenhouse gas emissions in the sector 7 Other 1990–2012.

Table 9-1 Trend of total GHG emissions from 7 Other in Switzerland 1990-2012.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	11.0	11.2	11.3	11.5	11.7	11.9	12.1	12.3	12.5	12.7
CH_4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
N_2O	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Sum	12.1	12.3	12.5	12.7	12.9	13.1	13.3	13.5	13.7	13.9

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO2 equivalent (Gg)									
CO_2	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9
CH_4	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
N_2O	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Sum	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1

Gas	2010	2011	2012
	CO_2 eq. (Gg)		
CO_2	12.9	12.9	12.9
CH_4	0.6	0.6	0.6
N_2O	0.6	0.6	0.6
Sum	14.1	14.1	14.1

In the sector Other a total of 14.1 Gg CO_2 equivalents was emitted in the year 2012. 93% of the emissions stem from “fire damage estates”, the rest from “fire damage motor vehicles”. The total greenhouse gas emissions of this sector show an increase of 16% from 1990 until 2012.

9.2 Source Category – Other non-specified

9.2.1 Source Category Description

Tier 1 and 2 key category 7
Source category 7 Other is **not a key category**.

The sources reported in 7 Other are depicted in Table 9-2.

Table 9-2 Specification of source category 7 Other N-specified. EMIS 2014/… refers to the internal documentation of the emission database and contains further references regarding specific AD and/or EF.

7	**Source**	**Specification**	**Data Source**
7D	Fire damage estates	Emissions from fires in buildings.	EMIS 2014/7D “Brand- und Feuerschäden Immobilien”
7D	Fire damage motor vehicles	Emissions from fires in motor vehicles.	EMIS 2014/7D “Brand- und Feuerschäden Motorfahrzeuge”

9.2.2 Methodological Issues: Fire damage estates and motor vehicles

Methodology

a) Fire damage estate

Based on average damage sums from insurances between 1992 and 2001, the average damage sum per fire case is estimated to be 15’600 CHF representing 780 kg of flammable material per fire case. Further assuming that not the whole amount burns down due to the intervention of the fire brigade, an amount of 400kg of burnt material per fire case is estimated. On average between 1992 and 2001, 20’650 cases of fire incidents happened each year. For emission calculation, a constant number of yearly 20’000 fire cases is assumed (EMIS 2014/7D “Brand- und Feuerschäden Immobilien”).

b) Fire damage motor vehicles

Based on data from a Swiss insurance company with 25% market share in 2002, the number of reported vehicle fires was extrapolated to 100%. Based on this estimate and the total vehicle number of Switzerland it was estimated that one fire case per 790 vehicles occurs per year and this was assumed to remain constant from 1990-2012. Multiplied with the actual vehicle number, the number of burnt vehicles in Switzerland per year is obtained (EMIS 2014/7D “Brand- und Feuerschäden Motorfahrzeuge”).

Emission Factors (Fire damages)

Fire damages in estates*:* Emission factors for CO_2, CO, NO_x and SO_2 are country specific based on measurements and expert estimates originally completed for illegal waste incineration. It is assumed that emissions are similar to emissions of fire damage in estates (EMIS 2014/7D “Brand- und Feuerschäden Immobilien”).

The fraction between fossil and biogenic CO_2 emissions is assumed to remain constant since 2000 with 80% being fossil and 20% biogenic CO_2 emissions. Before 2000, it is assumed that the fraction of fossil CO_2 emissions from burnt goods has been increasing linearly from 20% in 1950 to 80% in 2000.

Fire damages in motor vehicles: Emission factors for CO_2, CO, NO_x and SO_2 are country specific values based on measurements and expert estimates originally gained from the combustion of cables, documented in EMIS 2014/7D “Brand- und Feuerschäden Motorfahrzeuge”.

Emissions for CH_4 from fire damage in motor vehicles are reported as well, while N_2O emissions have not been estimated for this source.

Table 9-3 Emission Factors for fire damages in 2012 (EMIS 2014/7D).

Source 7 Other	CO_2 biogenic	CO_2 fossil	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	t / t burned good							
Fire damage estates	0.40	1.5	0.003	0.00025	0.0020	0.100	0.016	0.001
Fire damage motor vehicles	NO	1.5	0.005	NE	0.0013	0.002	0.002	0.005

Activity data (Fire damages)

Activity data is the weight of burnt goods, calculated according to the following rule of proportion: 400 kg of burnt goods per incidence of fire cases in estates (EMIS 2014/7D “Brand- und Feuerschäden Immobilien”) and 100 kg of burnt goods per incidence of burnt vehicles (EMIS 2014/7D “Brand- und Feuerschäden Motorfahrzeuge”). Activity data for estates is not estimated on a year to year basis but is assumed to be at a constant 8 Gg for the whole time period since 1990.

Table 9-4 Activity data: Burnt goods from 1990 to 2012 (source EMIS 2014/7D).

Source / Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
7 Burnt goods											
Fire damage estates	Gg	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Fire damage motor vehicles	Gg	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6

Source / Parameter	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
7 Burnt goods											
Fire damage estates	Gg	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Fire damage motor vehicles	Gg	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Source / Parameter	Unit	2010	2011	2012
7 Burnt goods				
Fire damage estates	Gg	8.0	8.0	8.0
Fire damage motor vehicles	Gg	0.6	0.6	0.6

9.2.3 Uncertainties and Time Series consistency

Uncertainty of CO_2, CH_4 and N_2O emissions is estimated to be high (according to Table 1-14).

9.2.4 Source-Specific QA/QC and Verification

In addition to the general QA/QC measures described in Section 1.6 subsequent source-specific activities have been carried out:

- Cross check of activity data in EMIS comments.
- Verification of NMVOC emission factor for car shredding. The time series have been compared between the current and the previous submission. All activity data, implied emission factors and emissions undergo the triple check.
    - the results for 2012 are compared with the results 2011 within the current CRF.
    - the CRF-tables for the year 2011 are compared between the current CRF-tables and the CRF-tables of submission 2013.
    - the CRF-tables for the base year 1990 are compared between the current CRF-tables and the CRF-tables of submission 2013.

9.2.5 Source-Specific Recalculations

7D Fire Damages Motor Vehicles: AD decreased in 2003-2015 due to revised projections in 2015 (linear interpolation between last set value in the year 2002 and projections for 2015).

9.2.6 Source-Specific Planned Improvements

There are no source-specific planned improvements in this category.

10 Recalculations

10.1 Explanations and Justifications for Recalculation

10.1.1 GHG Inventory

The Inventory Development Plan (IDP, see in FOEN 2014a) is regularly updated, mainly based on the various "Reports of the individual review of the greenhouse gas inventory of Switzerland" (e.g. UNFCCC 2010, 2011, 2012, 2013) and the outcome of domestic reviews. The IDP represents the main instrument for continuous improvement of the Swiss GHG inventory in subsequent inventory cycles. It includes suggestions and recommendations for recalculations that have an impact on emission levels in the corresponding sectors.

The processing of the expert review team's recommendations in the course of inventory preparation and compilation led to several recalculations (see also Table 1-12). Further recalculations had to be carried out due to improvements in some sectors. The details are explained below. An extensive list with all detailed recalculations and specifics of the recalculations is compiled by the EMIS experts and available to the reviewers (in German/French only).

1 Energy

- 1A: Activity data of all fuels of the overall time series have been recalculated based on the new data from SFOE 2013. This includes data on 2011 for fossil fuels and waste, data for biomass on 1997, 2009 – 2011 and data of other fuels 1990 – 2011.
- 1A: Activity data of wood consumption have been recalculated for the overall time series based on the new data from SFOE 2013b.
- 1A: SO_x emission factor value of gas oil has been updated for 2010 based on sulphur analyses of the gas oil for the year 2010 (Directorate General of Customs) resulting in a revised value for 2011 as well.
- 1A: CO_2 emission factor for bituminous coal has been corrected from 94t CO_2/TJ to 92.7 t CO_2/TJ for the entire time series.
- 1A1a: Activity data of biogas production from waste dumpsites have been recalculated for 2011 based on new values in the Swiss statistics of renewable energies SFOE 2013a.
- 1A1a: Emission factor of N_2O for waste incineration has been updated for the entire time series based on a new study realized by EMPA (2011).
- 1A1a: Emission factor of CH_4 for biomass fermentation has been corrected for the entire time series.
- 1A1a / 6D: Activity data for fermentation of biogenic waste in industrial and trades biogas installations and in agricultural biogas installations has been updated for the years 1999 to 2011 based on new data from the Swiss statistics of renewable energies SFOE 2013a.
- 1A1a: N_2O default emission factor from the IPCC guidelines has been introduced for the whole time series for fermentation of biogenic waste in industrial and trades biogas installations and in agricultural biogas installations.
- 1A1a: Activity data regarding bituminous coal has been corrected over the whole time series as it was not consistent with other years.

- 1A1a: Activity data regarding gas oil has been corrected over the whole time series based on data from the Swiss overall energy statistics (SFOE 2013).
- 1A1a: Activity data regarding other fuels has been corrected for 2007 and 2008 based on correction of the energy content of waste.
- 1A1b: Activity data for 2011 has been corrected for boilers refinery, residual fuel oil as there was a mistake in the database in Submission 2013.
- 1A1b: CO_2 Emission factor for 1990 to 2011 has been updated based on measurements that led to an average emission factor of 59'800 g/GJ compared to the previous emission factor of 59'300 g/GJ that was based on expert judgement.
- 1A1c: Reporting of the biogenic CO_2 and precursor emissions from the charcoal production has been shifted from source category 2D3 to 1A1c. (Please note that the reporting of the CH_4 emissions from the charcoal production has already been shifted from 2D3 to 1A1c within the resubmission of Switzerland's Greenhouse Gas Inventory 1990–2011(FOEN2013g).)
- 1A1c: Activity data from 2004 to 2012 has been corrected based on corrected data from small producers of charcoal.
- 1A1c: Emission factors for charcoal production have been corrected over the whole timeseries. The emission factors are newly based on Revised 1996 IPCC Guidelines for CO, NMVOC, CH_4, NO_x and USEPA (1995) for CO_2.
- 1A2: N_2O emission factor of liquefied petroleum gas has been changed for the whole time series from 0.6 g/GJ to the IPCC 2006 emission factor of 0.1 g/GJ. In previous submissions, the emission factor for gas oil was used for liquefied petroleum gas because they have been reported jointly. This has been corrected in the present submission.
- 1A2: Since SO_x emission factor values for 2010 and 2011 of gas oil have been updated based on sulphur analyses of gas oil for the year 2010 (Directorate General of Customs) also the SO_x emission factor values of liquefied petroleum gas for 2010 and 2011 have been revised as for all air pollutants the same EF are assumed as for gas oil.
- 1A2a: Activity data for bituminous coal in iron foundries has been revised due to corrected production shares of cupola and electric furnaces in iron foundries for 2010 and 2011. This change resulted in new activity data of bituminous coal in heat furnances for the same years.
- 1A2c: Activity data of steam production from the cracker-by-products has been updated for 1990 - 1999 based on new net calorific values. For calculation of the light virgin naphtha consumed as cracker feedstock the so far used net calorific value of gasoline has been replaced by the value for naphtha according to the 2006 IPCC guidelines resulting in revised activity data for 1990-1999.
- 1A2c: Activity data for liquefied petroleum gas has been updated for 1990-1999 and 2011 based on new activity data from the cracker process and resulting steam production.
- 1A2fi: Activity data of one of the two glass wool production plants have been revised for 1991-2004 based on effective production data for 1996-2004 resulting in revised gas consumption.
- 1A2fi: Activity data of all fuels for 1991-2011 have been updated based on new production data from brick and tile and glasswool production.

- 1A2fi: Activity data from gas oil and natural gas have been revised for 1990-2011 by the substraction of nonroad from "Heizkessel GLD, HEL" and "Heizkessel GLD, Gas" instead of "Industrie Heizkessel weitere, HEL" and "Industrie Heizkessel weitere, Gas" within the Energy model.
- 1A2fi: Newly also CH_4 emissions of the cement production are reported with a CH_4 emission factor of 5 g/t cement from 1990 to 1995 and 4 g/t cement from 2002 onwards.
- 1A2fi: Activity data of brick and tile production has been updated for 2001-2006 using effective production data instead of interpolated data. In addition, also so far interpolated fuel consumptions for these three plants have been replaced by effective values for 2000 and 2007-2011 resulting in overall revised fossil and biogenic fuel consumptions for 1991-2011 and 2000-2011.
- 1A2fi: Activity data of biogas from wastewater treatment plants has been updated for 2008, 2009 and 2011 based on recalculations in SFOE 2013a.
- 1A2fii: Diesel and gasoline consumption is based on INFRAS (2008) and on an update carried out in 2013 based on the latest numbers on growth of population and economy (Prognos 2012a, Keller/INFRAS 2013). The consumption has been recalculated accordingly. Numbers from 2005 onwards are affected.
- 1A3ai: The kerosene consumption (AD) for international flights (bunker fuels) has been recalculated in the Swiss energy statistics (SFOE 2012) for the year 2011. Therefore, all gases and pollutants have been recalculated for 2011 as well.
- 1A3b: The entire time series has been recalculated based on the latest numbers on growth of population and economy (Prognos 2012a, ARE 2012). Vehicle kilometres from 1993 are slightly lower in total; fleet compositions have changed, with slight impacts on implied emission factors; fuel consumption in tank tourism has been recalculated; the modelled share of biofuels has been reduced to be consistent with real-world developments. The overall impacts of these recalculations on emissions are low.
- 1A3c, 1A3d, 1A4aii, 1A4bii, 1A4cii, 1A5b (mobile off-road machinery): The activity data have so far been taken from INFRAS (2008). For this submission, the latest numbers on growth of population and economy (Prognos 2012a, Keller/INFRAS 2013) have been integrated in the off-road model. This leads to an increase of the fuel consumption from 2005 onwards.
- 1A3dii: The activity data of the international marine bunkers has been updated for all pollutants in 2011.
- 1A3dii: The emission factors have been recalculated for the year 2011 due to interpolation of the emission factors between 2010 and 2015 for the gases CH_4 and N_2O. The EF of 2015 has not been changed but the interpolation was by mistake not applied in former submissions.
- 1A3di: Recalculations due to new activity data in 2004, 2008 and 2011 have been made which also affects the "tank tourism" of diesel fuel in 1A3b.
- 1A4a/1A4b: Activity data for engines and gasturbines in 1A4 households and services have been updated for 2011 based on updated statistical data.
- 1A4a: Activity data for natural gas in the commercial and institutional sector has been updated for 1990, 1995, 1997, 1998 and 2011 based on recalculations in SFOE 2013.
- 1A4a: Activity data for natural gas has been updated based on a recalculation of SFOE 2013 for the year 2011.

- 1A4a: Activity data for gas oil and natural gas consumption has been updated for the overall time series based on changes in the energy model resulting from changes in the non-road transport model for boats and natural gas consumption in industry.
- 1A4b: Activity data for natural gas in the residential sector has been updated for 1990, 1995, 1997, 1998 and 2011 based on recalculations in SFOE 2013.
- 1A4b: Activity data for gas oil has been updated for the whole time series based on recalculations in the energy consumption.
- 1A4b: CO and SO_2 Emission factors for gas oil and natural gas of 2011 have been corrected in the energy model.
- 1A4b: Reporting of charcoal production has been shifted to sector 1A4b. Before, it was reported under 2D3.
- 1A4b: A new process for bonfires has been introduced in this sumbmission.
- 1B2a v: Emission factor for CO_2 and NMVOC were corrected to exclude emissions from Liechtenstein that overestimated emissions by 0.5%.
- 1B2b: As recommended in ARR 2012 and 2013 Switzerland has included in its inventory the emissions from the only small plant for natural gas production (Finsterwald) from 1985-1994. The default emission factors from IPCC Guidelines 2006 is used.
- 1B2b: Activity data from 1990-1997 has been updated based on data from SFOE 2013.
- 1B2b: A new model for emissions in swiss gas transport system based on a new study realized by Quantis has been developed.

2 Industrial Processes

- 2A1: A calculation error has been corrected resulting in new EFs for NO_x, CO, NMVOC and SO_2.
- 2A3 Brick and tile production: Interpolated activity data have been replaced by effective production data resulting in updated AD for 2001-2006. Revision of CO_2 EF for 1990-2011.
- 2A5: Activity data has been revised for 2008-2011due to updated projection values.
- 2A7 Glass wool production: Revision of activity data and cullet ratios resulting in revised EF values for CO_2 for 1991-2004.
- 2B2: Revision of NO_x EF values for the entire time series.
- 2B5 Acetic acid production: Revision of activity data from 1991-2011. In addition also revision of the EF values for CH_4, CO and NMVOC and introduction of an EF for CO_2 for the entire time series.
- 2B5 Sulphuric acid production: Updating of activity data for 2009-2011. Revision of EF values for SO_2 for the entire time series.
- 2C1 Iron foundries: Revision of activity data in iron foundries for 2010 and 2011. The EF value for NMVOC for 2012 has been updated resulting in revised interpolated values 1991-2011 as well.
- 2C1 Steel production: Revision of EF values for CO_2 for the entire time series.
- 2C5e Battery recycling: Activity data for 2011 has been revised due to corrected data from the plant operator.

- 2D2 Food and Drink: Activity data of meat smokehouses has been updated for the years 2007-2011.
- 2F1: Improvement of model calculations of stock for all gases from the Refrigeration and Air-conditioning source categories for the entire time series (recharge of equipment considering minimal technical charge and related frequency of service).
- 2F1: Bus air-conditioning added to the calculation of mobile air-conditioning and causes recalculations in the entire time series for HFC134a.
- 2F1: In Transport Refrigeration export of retiring equipment is now included in model calculations of trucks and the lifetime of railway is elevated. This affects date in the years 2000-2011.
- 2F4: The use of spray products consider now earlier aerosol loss of production to avoid 1% in double counting of aerosol emissions (HFC134a and HFC152a) in the years 1998-2011.
- 2G Claus units in refineries: Activity data of the years 1990–1997 has been revised due to recalculations in the Swiss overall energy statistics.

3 Solvent and Other Product Use

- 3A1: Activity data for paint applications in households has been revised due to updated projection for 2015. This has led to a revision of the AD for 2011.
- 3B2: Activity data and EF value for dry cleaning have been updated for 2012 resulting as well in revised interpolated values for 2007-2011 and 1991-2011, respectively.
- 3C: Activity data for paint and ink manufacturing has been revised due to updated projection for 2015. This has led to a revision of the AD for 2011.
- 3C: Activity data for manufacturing of rubber has been updated for 2011 and EF value has been updated for 2012 resulting as well in revised interpolated values for 2008-2010 and 1998-2011, respectively.
- 3C: Activity data for manufacturing of polyester has been updated for 2010 and 2011 and EF values have been updated for 2010 and 2012 resulting as well in revised interpolated values for 2008-2009 and 2008, 2009 and 2011, respectively.
- 3C: Activity data for manufacturing of polystyrene has been updated for 2011 resulting in revised interpolated values for 2008-2010 as well.
- 3C: Activity data for manufacturing of PVC has been updated for 2010 and 2011 and EF values have been updated for 2004 and 2012 resulting as well in revised interpolated values for 2009 and 1991-2003 and 2005- 2011, respectively.
- 3D5: Activity data for print industry has been revised due to updated projection for 2015. This has led to a revision of the AD for 2011.
- 3D5: Activity data for impregnating of glass wool have been revised for 1991-2004 based on effective production data for 1996-2004.
- 3D5: Activity data for production and use of tobacco products has been updated for the years 2005-2011.
- 3D5: Activity data for use of concrete additives has been revised and updated for 1990, 1998, 2001 and 2008-2011, respectively. This has resulted in revised interpolated values in between. EF values have been corrected to interpolated values and updated for 1999-2006 and 2008-2011, respectively.
- 3D5: Activity data for car underbody sealant has been revised and updated for 1990, 1998 and 2012, respectively, resulting in revised interpolated values in between. EF

values have been corrected to interpolated values and updated for 1999-2003 and 2012, respectively, resulting in revised interpolated values for 2005-2011 as well.

- 3D5: Activity data and EF value for de-icing of airplanes and other de-icing have been updated for 2012 resulting in revised interpolated values for 2008-2011 as well.
- 3D5: Activity data and EF values for use of cooling lubricants have been updated for 2008-2011 and 2012, respectively, resulting as well in revised interpolated values from 2005 onwards.
- 3D5: Activity data for use lubricants has been updated for 2008-2011 resulting in revised interpolated values for 2005-2007 as well. EF values have been corrected to interpolated values and updated for 1999-2003 and 2012, respectively resulting in revised interpolated values for 2008-2011 as well.

4 Agriculture

- 4A,B: New more precise livestock population data have been used for the years 1994 and 2006. Previously only rounded values have been available. The effects on overall emissions is negligible.
- 4A,B: Preliminary estimates for energy requirements for non cattle populations for the years 2010 and 2011 have been revised. The effect of the recalculation on overall greenhouse gas emissions is considered negligible.
- 4A,B: Milk yield of mature dairy cattle in the year 2011 has been slightly revised due to an update of the provisional number from the Swiss Farmers Union.
- 4B,D: The nitrogen excretion rate of mature dairy cattle of the year 2011 has been revised in order to be consistent with the AGRAMMON model (Kupper et al. 2013). The reduced nitrogen excretion rate resulted in an overall emission reduction (including source category 4B and 4D) of less than 10 Gg CO2 equivalent.
- 4D: The area of cultivated organic soils has been revised due to new projections in the LULUCF-sector. The mean change of overal greenhouse gas emissions is below 0.02 Gg CO2 equivalent.
- 4D: Activity data for compost for the years 2008-2011 has been revised due to an error correction. New emission estimates are lower by approximately 7-8 Gg CO2 equivalent.
- 4D: The ammonia emission factor for recycling fertilizers (liquid digestate) has been adjusted for the years 2008 - 2011 due to the increasing use of trailing hoses during land application as fertilizer. Impact on FracGASF and on overall emissions is negligible.
- 4D: A general recalculation for the year 2011 has been carried out due to some updates of crop yield data from the Swiss Farmers Union (SBV 2012). The respective changes are only of minor importance for total emission estimates.

5 Land Use, Land-Use change and Forestry and KP

- 5: The completion of the AREA surveys in 2013 (see Chapter 7.2.7, SFSO 2013) led to a recalculation in category 5 LULUCF.
- 5A1 and 5A2: The application of the gain-loss approach and the stock-change approach with regard to the calculation of carbon stock changes following land-use changes has been modified (see Chapter 7.1.3.2 and Chapter 7.3.7). This led to a large reduction of carbon sinks on land converted to forest land.

- 5A: New values of stocks, gains and losses of living biomass were derived from most recent NFI4a+ data (Thürig 2014). Implied emission factors for productive forests in the period 2006-2012 were affected (see Chapter 7.3.7).
- 5A: The Yasso07 values 1990-2012 for annual net changes in the dead wood pool, in the LFH litter pool and in mineral soils were updated (Didion et al. 2013). See Chapter 7.3.7.
- 5(II)D: Emissions of CH_4 are reported for flooded lands/reservoirs (was NO in former submissions). See Chapter 7.6.7.
- 5(V)A: For wildfires on forest land, the emission factor for CH_4 was revised. See Chapter 7.3.7.
- 5(V)C: Emissions of CH_4 and N_2O are reported due to wildfires on grassland (was NO in former submissions). See Chapter 7.5.7.

6 Waste

- 6A: Value for 2011 of sewage gas production has changed in SFOE 2013a. The AD of 2011 (CH_4 direct emissions and CH_4 flared) have been recalculated.
- 6B2 domestic waste water: Values of connected inhabitants (AD) have not been correctly interpolated from 2008-2011. Recalculations for those years were carried out.
- 6B2 domestic waste water: The amount of sewage gas produced has been updated for the years 2007-2011 (SFOE 2013a). Updated values have been used in the model to calculate EF for all pollutants.
- 6B2 domestic waste water: The Swiss Farmers Association (SBV) has changed its method of calculation for protein consumption for the years 2008 onwards. The EF of N2O been recalculated for the years 2008-2011.
- 6C Crematoria: The Swiss Cremations Association (SVFB) has corrected AD of the year 2010. Recalculations have been made.
- 6C Sewage Sludge Incineration: Emission factors are now being kept constant since 2002 because there are no new data available, instead of a linear decrease until 2020. This led to recalculation of emissions from 2003-2011.
- 6C Sewage Sludge Incineration: AD between 2007 and 2011 have changed due to revised projections.
- 6C1 Forestry and Agriculture: The process „Field Burning of Agricultural and sivlicultural Residues“ has been remodeled. Before, only the open burning of branches was considered. The former has been slipt up in three processes “Incineration of biomass, Agriculture“, „Incineration of biomass, Silviculture“ and „Incineration of biomass; Private gardens“. This led to recalculations of AD for the whole time series.
- 6D biogas upgrading: Emission factor of CH_4 had been wrong by a factor of 1000 and has been corrected. Recalculations were made from 1997, when biogas-upgrading activities started, until 2011.
- 6D Fermentation: Until submission 2013, AD for the years 2009-2011 have been extrapolated based on the values of the years 2007/08. Now actual data from SFOE 2013a have been used for estimating AD. Furthermore, activity data for the years before 2009 have been recalculated due to updated data in SFOE 2013a. This led to recalculation of AD for the whole time series 1990-2011 (agricultural biogas production) and the years 1999-2011 (industrial biogas production).

7 Other

- 7D: AD of Fire Damages Motor Vehicles decreased slightly in 2003-2015 due to revised projections in 2015 (linear interpolation between last set value in 2002 and 2015).

10.1.2 KP- LULUCF Inventory

A recalculation of the years 2008, 2009, 2010 and 2011 was carried out. The methodological improvements affect the activities reported under KP Art. 3.3 as well as under KP Art. 3.4. The improvements are described in detail in Chapter 7.3.7 (Recalculations 5A LULUCF Forest Land) and in Chapter 11.3.1.4 (Kyoto specific recalculations).

10.2 Implications for Emission Levels 1990 and 2011

10.2.1 GHG Inventory

Table 10-1 shows the recalculation results for the base year 1990. It results in a decrease of the total emissions in CO_2 equivalents (without emissions/removals from CO_2 from LULUCF) of 159.55 Gg CO_2 eq. This corresponds to a decrease of the latest submission compared to the previous submission (2012,v2.1) by 0.30% of the national total. If the LULUCF sector is included, there is a increase of 1074.77 Gg CO_2 eq (2.15%) due to substantial recalculations in the LULUCF sector.

Table 10-1 Overview of implications of recalculations on 1990 data. Emissions are shown before the recalculation according to the previous submission in 2013 "Prev." (FOEN 2013g) and after the recalculation according to the present submission "Latest". The differences "Differ." are defined as latest minus previous submission.

Recalculation	**CO_2**			**CH_4**			**N_2O**			**Sum (CO_2, CH_4 and N_2O)**		
Emissions for 1990	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
1 Energy	41'178	41'199	20.54	621.6	502.1	-119.49	283.2	287.6	4.38	42'083	41'989	-94.58
2 Ind. Processes (without F-gases)	3'059	3'006	-53.26	9.6	1.5	-8.09	68.1	68.1	0.00	3'137	3'076	-61.35
3 Solvent and Other Product Use	360	360	0.06				110.1	110.1	0.00	470	470	0.06
4 Agriculture				3'307.1	3'307.1	0.00	2'785.0	2'785.0	0.01	6'092	6'092	0.01
5 LULUCF	-3'174	-1'962	1'212.0	8.2	30.3	22.14	10.4	10.5	0.19	-3'156	-1'921	1'234.32
6 Waste	63	63	0.00	737.0	734.3	-2.66	210.6	209.6	-1.04	1'011	1'007	-3.70
7 Other	11	11	0.00	0.6	0.6	0.00	0.6	0.6	0.00	12	12	0.00
Sum (without F-gases)	41'498	42'677	1'179.3	4'684	4'576	-108.10	3'468	3'472	3.53	49'650	50'725	1'074.77

Recalculation	**HFC**			**PFC**			**SF6**			**Sum (synthetic gases)**		
Emissions for 1990	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
2 Ind. Processes (only syn. gases)	0.02	0.02	0.00	100.2	100.2	0.00	143.6	143.6	0.00	243.85	243.85	0.00

Recalculation		**Sum (all gases)**		
Emissions for 1990		Prev.	Latest	Differ.
Source and Sink Categories		CO_2 equivalent (Gg)		
Total CO_2 eq Em. with LULUCF		**49'894**	**50'969**	**1'074.77**
		100%	102.15%	2.15%
Total CO_2 eq Em. without LULUCF		**53'049**	**52'890**	**-159.55**
		100%	99.70%	-0.30%

For 2011, the recalculation results in a decrease of the total emissions in CO_2 equivalents (without emissions/removals from LULUCF) of 190.21 Gg CO_2 eq. This corresponds to an decrease of 0.38% of the national total in the latest submission compared to the previous submission. If the LULUCF sector is included, a decrease of 1323.31 Gg CO_2 eq. (2.83%) results due to major recalculations in the LULUCF sector.

Table 10-2 Overview of implications of recalculations on 2011 data. Emissions are shown before the recalculation according to the previous submission in 2013 “Prev.” (FOEN 2013) and after the recalculation according to the present submission “Latest”. The differences “Differ.” are defined as latest minus previous submission.

Recalculation	CO_2			CH_4			N_2O			Sum (CO_2, CH_4 and N_2O)		
Emissions for 2011	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
1 Energy	39'466	39'479	12.46	257.0	253.9	-3.16	266.3	212.4	-53.91	39'990	39'945	-44.62
2 Ind. Processes (without F-gases)	2'332	2'186	-145.81	8.6	2.3	-6.28	54.1	54.1	0.00	2'394	2'242	-152.08
3 Solvent and Other Product Use	155	158	2.45				44.1	44.1	0.00	199	202	2.45
4 Agriculture				3'159	3'155	-4.16	2'445	2'417	-27.77	5'604	5'572	-31.93
5 LULUCF	-3'417	-1'914	1'502.48	1.2	12.2	10.99	4.4	4.4	0.05	-3'411	-1'897	1'513.52
6 Waste	12	12	0.00	309.2	299.4	-9.83	265.4	286.7	21.26	587	598	11.43
7 Other	13	13	-0.11	0.6	0.6	-0.01	0.6	0.6	0.00	14	14	-0.12
Sum (without F-gases)	38'562	39'934	1'371.46	3'736	3'723	-12.44	3'080	3'019	-60.38	45'377	46'676	1'298.64

Recalculation	**HFC**			**PFC**			**SF6**			**Sum (synthetic gases)**		
Emissions for 2011	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)	1'171.45	1'195.50	24.05	39.4	40.0	0.62	164.4	164.4	0.00	1'375.18	1'399.85	24.67

Recalculation		**Sum (all gases)**		
Emissions for 2011		Prev.	Latest	Differ.
Source and Sink Categories		CO_2 equivalent (Gg)		
Total CO_2 eq Em. with LULUCF		**46'752**	**48'076**	**1'323.31**
		100%	102.83%	2.83%
Total CO_2 eq Em. without LULUCF		**50'163**	**49'973**	**-190.21**
		100%	99.62%	-0.38%

10.2.2 KP- LULUCF Inventory

The methodological improvements are described in Chapter 11.3.1.4. (Kyoto specific recalculations) and Chapter 7.3.7 (Recalculations LULUCF Forest Land).

10.3 Implications for Emissions Trends, including Time Series Consistency

10.3.1 GHG Inventory

Due to recalculations, the emission trend 1990–2011 reported in the present 2014 submission (FOEN 2014) has slightly changed. Compared to 1990, 2011 emissions (national total without emissions/removals from LULUCF) showed a decrease of 5.44% before recalculation (previous submission). After recalculation, the decrease turns out to be higher with a change 1990–2011 of 5.51% (latest submission).

Table 10-3 Change of the emission trend 1990–2011 due to recalculation. “Previous” refers to data reported in FOEN (2013g), whereas “latest” refers to the present submission.

Recalculation	**1990**		**2011**		**change 2011/1990**	
Submission	previous	latest	previous	latest	previous	latest
Unit	CO_2 eq (Gg)				%	
Total excl. LULUCF	53'049	52'890	50'163	49'973	-5.44%	-5.51%

All-time series in the present submission are consistent.

10.3.2 KP- LULUCF Inventory

As for KP-LULUCF 2008-2012 data is submitted, recalculations were done for 2008, 2009, 2010 and 2011 data and there are no implications for emission trends.

10.4 Recalculations, Including in Response to the Review Process, and Planned Improvements to the Inventory

10.4.1 Recalculations GHG Inventory

Many recalculations have been carried out in response to recommendations proposed in review reports. All relevant recalculations are listed in Chpt. 10.1.1. Further information on improvements due to the ERT recommendations are found in Table 1-12.

10.4.2 Recalculations KP-LULUCF Inventory

For recalculations see Chapter 10.1.2. Further information on improvements due to the ERT recommendations are found in Table 1-12. The methodological improvements are described in detail in Chapter 11.3.1.4. (Kyoto specific improvements) and Chapter 7.3.7 (Improvements LULUCF Forest Land).

10.4.3 Planned Improvements

In the coming year, the transition to the new reporting guidelines represents the largest improvement for the entire inventory. All methods will be adapted to the 2006 IPCC Guidelines (IPCC 2006). Within this general recalculation a number of optional country specific methods will be explored and eventually implemented. Other projects are eventually postponed in order to give first priority to changes related to the new reporting guidelines.

PART 2

11 KP-LULUCF

Switzerland has chosen to account annually for emissions and removals from the LULUCF sector (FOEN 2006h, Sect. G). In addition to the mandatory submission of the inventory years 2008, 2009, 2010, 2011 and 2012, data for the years 1999-2007 are available and shown in Switzerland's NIR on a voluntary basis. Switzerland has elected to account for Forest Management under the voluntary activities of Article 3, paragraph 4 of the Kyoto Protocol (FOEN 2006h, Sect. F). Switzerland applies the condition of "direct human-induced" in relation to Afforestation and Deforestation very strictly for both activities (see Chapter 11.1.3, FOEN 2010d, FOEN 2010h). Table 11-1 shows the activity coverage and the carbon pools reported for the mandatory activities under Article 3, paragraph 3 and for Forest Management under paragraph 4 of the Kyoto Protocol. The areas and change in areas between the previous and the current inventory year are shown in Table 11-2. Table 11-3 summarizes the results of the KCA for LULUCF activities under the Kyoto Protocol.

Table 11-1: NIR1 – Summary-Table.

TABLE NIR 1. SUMMARY TABLE
Activity coverage and other information relating to activities under Article 3.3 and elected activities under Article 3.4

Activity		Change in carbon pool reported[1]					Greenhouse gas sources reported[2]						
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil	Fertilization[3]	Drainage of soils under forest management	Disturbance associated with land-use conversion to croplands	Liming	Biomass burning[4]		
							N_2O	N_2O	N_2O	CO_2	CO_2	CH_4	N_2O
Article 3.3 activities	Afforestation and Reforestation	R	R	NR	NR	R	NO			NO	NO	NO	NO
	Deforestation	R	R	R	R	R			R	NO	NO	NO	NO
Article 3.4 activities	Forest Management	R	R	R	R	R	NO	NR		NO	R,IE	R	R
	Cropland Management	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA
	Grazing Land Management	NA	NA	NA	NA	NA				NA	NA	NA	NA
	Revegetation	NA	NA	NA	NA	NA				NA	NA	NA	NA

(1) Indicate R (reported), NR (not reported), IE (included elsewhere) or NO (not occurring), for each relevant activity under Article 3.3 or elected activity under Article 3.4. If changes in a carbon pool are not reported, it must be demonstrated in the NIR that this pool is not a net source of greenhouse gases. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

(2) Indicate R (reported), NE (not estimated), IE (included elsewhere) or NO (not occurring) for greenhouse gas sources reported, for each relevant activity under Article 3.3 or elected activity under Article 3.4. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

(3) N_2O emissions from fertilization for Cropland Management, Grazing Land Management and Revegetation should be reported in the Agriculture sector. If a Party is not able to separate fertilizer applied to Forest Land from Agriculture, it may report all N_2O emissions from fertilization in the Agriculture sector.

(4) If CO_2 emissions from biomass burning are not already included under changes in carbon stocks, they should be reported under biomass burning; this also includes the carbon component of CH_4. Parties that include CO_2 emissions from biomass burning in their carbon stock change estimates should report IE (included elsewhere).

Table NIR 1.1 Additional information
Selection of parameters for defining "Forest"under the Kyoto Protocol

Parameter	Range	Selected value
Minimum land area	0.05 - 1 ha	0.06
Minimum crown cover	10 - 30 %	20.00
Minimum height	2 - 5 m	3.00

Table 11-2: NIR 2 – Land Transition Matrix Inventory Year 2012: the total Swiss area amounts too 4'128.42 kha. A time series of the total values for Article 3.3 and Article 3.4 activities is displayed in Table 11-6.

Table NIR 2. LAND TRANSITION MATRIX

Areas and changes in areas between the previous and the current inventory year (1), (2), (3)

From previous inventory year / To current inventory year		Article 3.3 activities: Afforestation and Reforestation	Article 3.3 activities: Deforestation	Article 3.4 activities: Forest Management (if elected)	Article 3.4 activities: Cropland Management (if elected)	Article 3.4 activities: Grazing Land Management (if elected)	Article 3.4 activities: Revegetation (if elected)	Other (5)	Total area at the beginning of the current inventory year(6)
		(kha)							
Article 3.3 activities	Afforestation and Reforestation	2.44	NO						2.44
	Deforestation		6.81						6.81
Article 3.4 activities	Forest Management (if elected)		0.31	1'231.22					1'231.53
	Cropland Management(4) (if elected)	NA	NA		NA	NA	NA		NA
	Grazing Land Management(4) (if elected)	NA	NA		NA	NA	NA		NA
	Revegetation(4) (if elected)	NA			NA	NA	NA		NA
Other (5)		0.05	NA	1.44	NA	NA	NA	2'886.14	2'887.64
Total area at the end of the current inventory year		2.49	7.13	1'232.66	NA	NA	NA	2'886.14	4'128.42

(1) This table should be used to report land area and changes in land area subject to the various activities in the inventory year. For each activity it should be used to report area change between the previous year and the current inventory year. For example, the total area of land subject to Forest Management in the year preceding the inventory year, and which was deforested in the inventory year, should be reported in the cell in column of Deforestation and in the row of Forest Management.

(2) Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

(3) In accordance with section 4.2.3.2 of the IPCC good practice guidance for LULUCF, the value of the reported area subject to the various activities under Article 3.3 and 3.4 for the inventory year should be that on 31 December of that year.

(4) Lands subject to Cropland Management, Grazing Land Management or Revegetation which, after 2008, are subject to activities other than those under Article 3.3 and 3.4, should still be tracked and reported under Cropland Management, Grazing Land Management or Revegetation, respectively.

(5) "Other" includes the total area of the country that has not been reported under an Article 3.3 or an elected Article 3.4 activity.

(6) The value in the cell of row "Total area at the end of the current inventory year" corresponds to the total land area of a country and is constant for all years.

Table 11-3 NIR 3 – Summary Overview for Key Categories for LULUCF Activities under the KP in 2012. A detailed description of the KCA for Article 3.3 and 3.4 activities is given in Chapter 11.6.1.

TABLE NIR 3. SUMMARY OVERVIEW FOR KEY CATEGORIES FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL

KEY CATEGORIES OF EMISSIONS AND REMOVALS	GAS	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			COMMENTS [3]
		Associated category in UNFCCC inventory[1] is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory [1], [4] (including LULUCF)	Other [2]	
Specify key categories according to the national level of disaggregation used[1]					
Forest Management	CO2	Forest land remaining forest land	Yes	Since the total Swiss forest	Associated category in UNFCCC inventory is KC level and KC trend (Tier 2; 2012).
Afforestation and Reforestation	CO2	Conversion to forest land	No	Natural forest regeneration	
Deforestation	CO2	Conversion to settlements	Yes	see NIR Chapter 11.6.1	Associated category in UNFCCC inventory is KC level and KC trend (Tier 2; 2012).

(1) See section 5.4 of the IPCC good practice guidance for LULUCF.
(2) This should include qualitative consideration as per section 5.4.3 of the IPCC good practice guidance for LULUCF or any other criteria.
(3) Describe the criteria identifying the category as key.
(4) If the emissions or removals of the category exceed the emissions of the smallest category identified as key in the UNFCCC inventory (including LULUCF), Parties should indicate YES. If not, Parties should indicate NO.

An overview of net CO_2 eq emissions and removals of activities under Article 3, paragraph 3 and Forest Management under Article 3, paragraph 4 of the Kyoto Protocol is shown in Figure 11-1 and Table 11-4. Differences in the annual emissions from Deforestation can mainly be attributed to the changes in the area of Deforestations (see Table 11-6; Figure 11-2). Year-to-year differences in removals from Afforestations are mainly due to changes in the afforested area (see Table 11-6). Another relevant factor is the application of a logistical growth curve for Afforestations younger than 20 years (see Chapter 11.3.1.1; Figure 11-2; see Table 7-25). Fluctuations in the contribution of Forest Management can mainly be explained by changes in the losses of living biomass, dead wood and litter, whereas fluctuations in the area of managed forest are relatively small (see Table 11-6). In 2001 and 2002, Forest Management was a small source of CO_2 eq due to the damage caused by the storm Lothar.

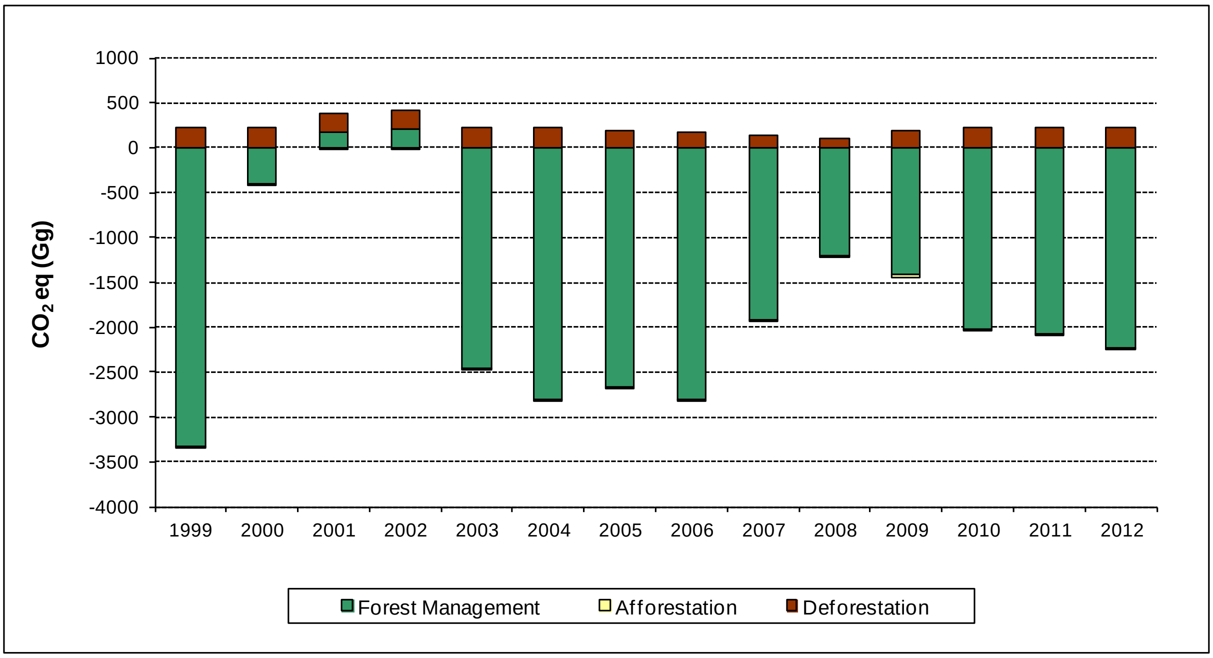


Figure 11-1 CO_2 eq emissions (positive sign) and removals (negative sign) from Afforestation and Deforestation under Article 3, paragraph 3 and Forest Management under Article 3, paragraph 4, 1999-2012.

Table 11-4 Overview on net CO_2 equivalent emissions (positive sign) and removals (negative sign) for activities under Article 3, paragraph 3 and Forest Management under Article 3, paragraph 4 of the Kyoto Protocol, 1999-2012.

Greenhouse gas source and sink activities	1999	2000	2001	2002	2003	2004	2005
	Net CO_2 equivalent emissions/removals (Gg CO_2 eq)						
A. Article 3.3 activities	**216.97**	**216.83**	**215.84**	**214.33**	**212.51**	**210.95**	**174.16**
A.1. Afforestation and Reforestation	-6.09	-6.82	-7.80	-9.17	-10.83	-12.60	-14.86
A.1.1. Units of land not harvested since the beginning of the commitment period	-6.09	-6.82	-7.80	-9.17	-10.83	-12.60	-14.86
A.1.2. Units of land harvested since the beginning of the commitment period	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.2. Deforestation	223.06	223.66	223.63	223.50	223.34	223.55	189.02
B. Article 3.4 activities	**-3330.01**	**-395.31**	**166.35**	**219.39**	**-2434.18**	**-2810.38**	**-2663.60**
B.1. Forest Management incl. biomass burning	-3330.01	-395.31	166.35	219.39	-2434.18	-2810.38	-2663.60
gains above ground living biomass	-9617.06	-9624.02	-9630.98	-9637.94	-9644.90	-9651.86	-9662.29
gains below ground living biomass	-2839.47	-2841.80	-2844.13	-2846.46	-2848.79	-2851.12	-2856.62
losses above ground living biomass	7758.43	10051.40	10371.01	10243.29	8273.08	8004.19	8365.83
losses below ground living biomass	2252.11	2847.55	2925.45	2894.29	2392.50	2319.62	2410.48
changes litter	-335.15	-271.92	-166.56	-34.20	-201.14	-218.05	-467.97
changes dead wood	-555.68	-563.91	-495.37	-423.47	-435.68	-418.28	-458.88
changes soil C min. soils	-2.28	-2.95	-3.46	-3.79	-4.07	-4.50	-5.04
changes soil C org. soils	8.68	8.68	8.68	8.69	8.69	8.69	8.70
sum forest management exl. biomass burning	-3330.43	-396.98	164.63	200.40	-2460.30	-2811.31	-2665.78
biomass burning	0.42	1.67	1.71	18.99	26.12	0.93	2.18
B.2. Cropland Management (if elected)	NA	NA	NA	NA	NA	NA	NA
B.3. Grazing Land Management (if elected)	NA	NA	NA	NA	NA	NA	NA
B.4. Revegetation (if elected)	NA	NA	NA	NA	NA	NA	NA

Greenhouse gas source and sink activities	2006	2007	2008	2009	2010	2011	2012
	Net CO_2 equivalent emissions/removals (Gg CO_2 eq)						
A. Article 3.3 activities	**147.05**	**117.04**	**81.74**	**162.22**	**197.10**	**201.52**	**204.74**
A.1. Afforestation and Reforestation	-17.18	-20.14	-22.17	-24.33	-23.34	-19.62	-17.13
A.1.1. Units of land not harvested since the beginning of the commitment period	-17.18	-20.14	-22.17	-24.33	-23.00	-18.89	-15.89
A.1.2. Units of land harvested since the beginning of the commitment period	0.00	0.00	0.00	0.00	-0.34	-0.73	-1.25
A.2. Deforestation	164.23	137.19	103.91	186.56	220.45	221.14	221.87
B. Article 3.4 activities	**-2804.38**	**-1901.42**	**-1202.77**	**-1419.28**	**-2020.23**	**-2063.62**	**-2236.38**
B.1. Forest Management incl. biomass burning	-2804.38	-1901.42	-1202.77	-1419.28	-2020.23	-2063.62	-2236.38
gains above ground living biomass	-9844.35	-10013.44	-10184.68	-10196.75	-10201.54	-10206.14	-10210.74
gains below ground living biomass	-2925.08	-2989.60	-3055.14	-3060.06	-3062.02	-3063.86	-3065.70
losses above ground living biomass	8106.69	8426.45	8467.86	8105.81	7882.81	7839.72	7757.11
losses below ground living biomass	2288.18	2387.54	2417.30	2332.60	2285.48	2283.19	2264.70
changes litter	-222.74	71.47	383.78	354.85	29.07	115.00	134.28
changes dead wood	-214.87	202.23	761.98	1037.66	1039.35	954.69	876.33
changes soil C min. soils	-5.60	-5.63	-5.05	-4.07	-3.27	-2.69	-2.12
changes soil C org. soils	8.71	8.72	8.73	8.74	8.74	8.74	8.74
sum forest management excl. Biomass burning	-2809.05	-1912.26	-1205.22	-1421.23	-2021.39	-2071.35	-2237.40
biomass burning	4.68	10.84	2.45	1.95	1.16	7.73	1.02
B.2. Cropland Management (if elected)	NA	NA	NA	NA	NA	NA	NA
B.3. Grazing Land Management (if elected)	NA	NA	NA	NA	NA	NA	NA
B.4. Revegetation (if elected)	NA	NA	NA	NA	NA	NA	NA

The KP-CRF-table “Information table on accounting for activities under Article 3, paragraph 3 and 4 of the Kyoto Protocol” gives an overview of the CO_2 eq emissions and removals from Afforestation and Deforestation under Article 3, paragraph 3 and Forest Management under Article 3, paragraph 4 and also provides information on the extent to which GHG removals by sinks offsets the debit incurred under Article 3.3.

- In 2008 Forest Management in Switzerland caused removals of -1202.77 Gg CO_2 eq. The debit incurred from activities under Article 3.3 is 81.74 Gg CO_2 eq.
- In 2009 Forest Management in Switzerland caused removals of -1419.28 Gg CO_2 eq. The debit incurred from activities under Article 3.3 is 162.22 Gg CO_2 eq.
- In 2010 Forest Management in Switzerland caused removals of -2020.23 Gg CO_2 eq. The debit incurred from activities under Article 3.3 is 197.10 Gg CO_2 eq.
- In 2011 Forest Management in Switzerland caused removals of -2063.62 Gg CO_2 eq. The debit incurred from activities under Article 3.3 is 201.52 Gg CO_2 eq.
- In 2012 Forest Management in Switzerland caused removals of -2236.38 Gg CO_2 eq. The debit incurred from activities under Article 3.3 is 204.74 Gg CO_2 eq.

11.1 General Information

The inventory datasets on which the calculations are based (Swiss Land Use Statistics AREA and National Forest Inventory NFI) are described in Chapters 7.2.2 and 7.3.4.1, respectively.

Methodological issues and assumptions concerning the calculation of activity data and emission factors used for the reporting under Article 3, paragraphs 3 and 4 of the Kyoto Protocol, follow the IPCC good practice guidance and are described in Chapter 7.3.4 and in FOEN (2014c).

11.1.1 Definition of Forest and any other Criteria

The forest definition used under the Kyoto Protocol is defined in Switzerland's Initial Report (FOEN 2006h, Sect. E and Chapter 7.3.1 in this submission). Forest is defined as a minimum area of land of 0.0625 ha with crown cover of at least 20% and a minimum width of 25 m. The minimum height of the dominant trees must be 3 m or have the potential to reach 3 m at maturity in situ. The selected values are also listed in KP LULUCF Table NIR1 (see Table 11-1).

Some source categories were explicitely excluded from the category “Forest Land”, although they may partly fulfil the requirements of the Swiss forest definition used under the Kyoto Protocol (see Chapter 7.2.2.2, Table 7-6). Those are:

- Vineyards, Low-Stem Orchards, Tree nurseries, Copses and Orchards in the land-use category “Grassland”;
- Cemeteries and public parks in the land-use category “Settlements”.

11.1.2 Elected Activities under Article 3, Paragraph 4, of the Kyoto Protocol

Switzerland has decided to account for Forest Management under the elective voluntary activities of Article 3, paragraph 4 of the Kyoto Protocol (FOEN 2006h, Sect. F). In accordance with the Annex to Decision 16/CMP.1, credits from Forest Management are capped in the first commitment period. For Switzerland the cap amounts to 1.83 Mt CO_2 yr^{-1} (0.5 Mt C yr^{-1}), or 9.15 Mt CO_2 for the whole commitment period 2008-2012.

11.1.3 Description of how the Definitions of each Activity under Article 3.3 and each elected Activity under Article 3.4 have been implemented and applied consistently over Time

The Swiss definitions of Afforestation, Deforestation and Forest Management are published in Switzerland's Initial Report (see FOEN 2006h, Sect. E and F). Switzerland applies the condition of “direct human-induced” in relation to Afforestation and Deforestation very strictly for both activities (see FOEN 2010d, FOEN 2010h).

Afforestation

Afforestation is the conversion to forest of an area not fulfilling the definition of forest for a period of at least 50 years if the definition of forest in terms of minimum area (625 m^2) is fulfilled, and the conversion is a direct human-induced activity.

Natural forest regeneration due to abandonment of land, mainly occurring in the Alpine area, is not considered to be a direct human-induced activity. Only Afforestations which can clearly be attributed as direct human-induced from aerial photographs (SFSO 2013; see also Chapter 7.2) are considered as Afforestation. Examples of direct human-induced Afforestations are shown in FOEN (2010h).

Deforestation

Deforestation is the permanent conversion of areas fulfilling the definition of forest in terms of minimum forest area (625 m^2) to areas not fulfilling the definition of forest as a consequence of direct human influence.

Temporary removals of tree stand (e.g. for the construction of high-tension lines and pipelines) are not reported as Deforestation under the Kyoto Protocol because in those cases the forest stand has to be re-established. In the NFI methodology (Brändli 2010: 91) “forest aisles” under high-tension are explicitly classified as forests. These forest aisles underlie however a specific management, i.e. maximum tree height is limited to a certain height. The NFI dataset thus covers such areas with a specific Forest Management practice.

After approximately 12 years (see Chapter 7.2.2.1) it is possible to check if deforestations or other land-use changes have been correctly classified. Sigmaplan (2012a) screened the classification of all land-use changes classified as Deforestation under the Kyoto Protocol. They found that 86% of all these Kyoto Deforestations are still deforested after 20 years, whereas 14% of these Kyoto Deforestations were in fact removals of crown coverage limited in time and should be classified as "management interventions" rather than as real land-use changes. As no reclassification was done the area of Deforestations reported under KP Art. 3.3 is in fact a slight overestimation. Accordingly, emissions are overestimated since implied emission factors for Deforestations are higher than for Forest Management (see Table 5(KP-I)A.2 for Deforestations and Table 5(KP-I)B.1 for Forest Management).

Reforestation

Reforestation does not occur in Switzerland (FOEN 2006h, Sect. E; see also Chapter 11.4.1).

Forest management

Forest Management includes all activities serving the purpose of fulfilling the Federal Law on Forests (Swiss Confederation 1991, Art. 1c), i.e. the obligation to conserve forests and to ensure forest functions – such as wood production, protection against natural hazards, preservation of biodiversity, purification of drinking water and maintenance of recreational value – in a sustainable manner.

11.1.4 Description of Precedence Conditions and/or Hierarchy among 3.4. Activities and how they have been consistently applied in determining how Land was classified.

Since Switzerland only elected Forest Management from the elective activities of Article 3, paragraph 4 of the Kyoto Protocol, the hierarchy among 3.4 activities does not affect Swiss reporting.

11.2 Land-related Information

11.2.1 Spatial Assessment Unit used for determining the Area of the units of Land

The spatial assessment unit for the submission of the KP LULUCF tables covers the entire territory of Switzerland, i.e. 4'128.42 kha (see).

All activity data for reporting the activities under the Kyoto Protocol are retrieved from the Swiss Land Use Statistics (SFSO 2013; see also Chapter 7.2). The Swiss Land Use Statistics AREA (SFSO 2006a) uses a regular sample grid with a grid size of 100 m to frame her fixed sample points with known coordinates. To each grid point a specific combination category (see Table 7-2) is assigned.

11.2.2 Methodology used to develop the Land Transition Matrix

The methodology used to develop the land transition matrix is described in detail in Chapter 7.2.3.2.

11.2.3 Maps / Database to identify the geographical Locations and the system of Identification Codes for the geographical Locations

All Afforestations and Deforestations are accounted for under Article 3, paragraph 3 and are not reported under Forest Management under Article 3, paragraph 4. Afforestations older than the general conversion period of 20 years, are still reported under Afforestations: CRF-table 5(KP-I)A.1.2. The calculation of changes in carbon stocks is described in Chapter 11.3.1.1. The changes in areas between the activities under Article 3, paragraph 3 and Article 3, paragraph 4 are listed in KP-Table NIR2 (see).

Forest areas under Forest Management are subdivided into productive forests (CC12) and unproductive forests (CC13; for a description see Chapter 7.3.4.9). Productive forests in Switzerland reveal a high heterogeneity in terms of elevation; growth conditions and tree species composition (see Chapter 7.2.3.1 and Figure 7-4). We therefore stratified Switzerland into five National Forestry Inventory production regions (L1: Jura, L2: Central Plateau, L3: Pre-Alps, L4: Alps, L5: Southern Alps), three altitudinal zones (Z1: <601 m, Z2: 601-1200 m, Z3: >1200 m) and two soil types (mineral soils and organic soils). In the KP CRF-tables, the stratification of the activity data into production region (L) and altitudinal level (Z) is indicated in the column “Subdivision”.

Afforestation

Activity data for Afforestations are derived from the Swiss Land Use Statistics (AREA) (SFSO 2006a, 2013; see also Chapter 7.2.2.1). A detailed description of the identification of Afforestations fulfilling the Kyoto definition is provided in FOEN (2010h).

Deforestation

Data for Deforestations are derived from the Swiss Land Use Statistics (AREA). A detailed description of the identification of Deforestations under the Kyoto Protocol from the AREA dataset is given in FOEN (2010d) and Sigmaplan (2010a).

Not all changes from a forest combination category (Afforestation CC11, productive forest CC12 and unproductive forest CC13) to a non-forest combination category do correspond to the definition of Deforestation according to the Kyoto Protocol Art. 3.3. The following criteria identify conversions from a forest combination category to a non-forest combination category, which are not classified as Deforestations under the Kyoto Protocol Art. 3.3 (FOEN 2010d):

1. Non-permanent conversions are due to Forest Management practices, natural dynamics or hazards:

- Tree loss is temporally limited: areas with loss of tree biomass, but where a change in land use cannot be identified. Natural regeneration, which is a common practice in Swiss Forest Management, is expected, but could not yet be recognized on the aerial photograph at the time the AREA survey (see Chapter 7.2.2.1) was conducted. Also, in the NFI methodology (Brändli 2010: 91) “forest aisles” under high-tension are explicitly classified as forests (see also Chapter 11.1.3). Further, a study by Sigmaplan (2012a) showed that, although the aspect of "temporal limitiation" was considered when classifying Deforestations, at the end still 14% of these Kyoto Deforestations were in fact "short-term reduction of crown coverage" and should be classified as "management interventions" rather than as real land-use changes (see 11.1.3).
- Tree loss is spatially limited: conversion is caused by an alteration of the surrounding stand, but the change does not affect the tree cover at the sample point.

2. Conversions of combination categories (see Table 7-2 and Table 7-6) not meeting the definition of Deforestation as defined under the Kyoto Protocol and in Switzerland’s Initial Report (FOEN 2006h).

- Areas smaller than the minimum area of 625 m^2.
- Areas with a reduction in forest cover on the grid point but still fulfilling the Kyoto definition of Forest, i.e. having the potential to reach 3 m at maturity in situ.

3. No change in land use took place: reduction of tree cover without land-use change; former land use was mainly pasture

4. Tree loss is not human-induced: Conversion due to natural hazards and dynamics.

Forest Management

Since all forests in Switzerland are subject to Forest Management, the area of managed forest corresponds to the forest area (see FOEN 2006h, Sect. E) as derived from the Swiss Land Use Statistics (AREA; SFSO 2006a, 2013; see also Chapter7.2). We report changes in pools for the following geographical locations:

- productive forest remaining productive forests (CC12 remaining)
- productive forest converted to unproductive forests (CC12 to CC13)
- unproductive forest remaining unproductive forests (CC13 remaining)

- unproductive forest converted to productive forests (CC13 to CC12).

Difference in area reported under KP Art. 3.4 Forest Management and area “Forest Land remaining Forest Land” reported under the UNFCCC

A direct comparison of the areas reported in the CRF-tables under the Convention "Forest Land remaining Forest Land" (Table 5A) and under "Forest Management" under the Kyoto Protocol (Table 5(KP-I)B.1) is not possible due to the different structure of these CRF-tables and due to different reporting requirements:

- Conversions to Forest Land which are not human-induced (natural regneration) are not accounted for as “Afforestations under the Kyoto Protocol”. These areas are reported under KP Art. 3.4 Forest Management in table 5(KP-I)B.1 as soon as the definition of Forest is fulfilled. Under the Convention, these Afforestations are reported under land-use category 5A2 with a conversion time of 20 years.
- Afforestations under the Kyoto Protocol which are older than 20 years are always reported under Art. 3.3 (KP-CRF-table 5(KP-I)A.1.2: units of land harvested since the beginning of the commitment period). Thus, there is no reclassification of the units of lands reported under Art. 3.3. In contrast, under the Convention, the Afforestations older than 20 years are moved to the land-use category 5A1 “Forest Land remaining forest land”.
- Not all changes from a forest combination category (CC11, 12, 13) to a non-forest combination category correspond to the definition of Deforestation according to the Kyoto Protocol Art. 3.3. (see above). These areas remain under the KP Art. 3.4 activity Forest Management and are included in the areas as reported in table 5(KP-I)B.1.
- Reporting of land-use changes LUC: Since only the KP activity “Forest Management” is chosen under KP Art. 3.4, changes from other KP activities to forest land are not reported as LUC but are reported as CC12 or CC13 as soon as the KP definition of forest is fulfilled. Only conversions within the activity “Forest Management” are reported under the Kyoto Protocol, i.e. CC12 to CC13 and CC13 to 12. Under the Convention, LUC to forest land are reported in land-use category 5A2.

In a study by Meteotest (2013a) the reported activity data have been checked and compared. It could be shown that the differences in the CRF-tables can be explained and that the resulting budget of areas reported under the Convention and the Kyoto Protocol are identical.

The cross-check was updated for the present submission:

Table 11-5 Area budget (in kha) of KP-LULUCF and LULUCF under the Convention (UNFCCC) in the year 2012 for forest land and afforestations.

activity	Table, Cells	area UNFCCC kha	area KP kha	Check Difference kha	remarks
All Forest Land					
Forest Management	5(KP-I)B.1, C9		1'232.660		a)
Afforestations <= 20 years	5(KP-I)A.1.1, C10		1.697		b)
Afforestations > 20 years	5(KP-I)A.1.2, C10		0.793		c)
Total area KP			1'235.150		
Non-Kyoto loss of forest cover			-0.670		d)
Forest Land UNFCCC	5.A, C10	1'234.480			e)
Total		1'234.480	1'234.480	0.000	
Afforestation, CC11					
UNFCCC	5.A, C31+C35+C39 +C43+C47	1.697			f)
KP	5(KP-I)A.1.1, C10		1.697	0.000	g)

Remarks:

a) KP forest management consists of CC12 and CC13 areas fulfilling the criteria of the KP.

b) KP afforestations are afforested areas since 1990 cumulated over 20 years at most.

c) KP afforestations "older than 20 years" (>20 years) is the area that has been afforested since more than 20 years. In the UNFCCC tables these areas belong to 5A1 (CC12 or CC13).

d) The non-Kyoto loss of forest cover is the part of the total area of forest loss (reported under UNFCCC) not fulfilling the definition of deforestations according to the Kyoto Protocol (see NIR Chapter 11.2.3). For the comparison this area must be subtracted from the KP forest area.

e) The total Forest Land in CRF 5A covers productive forests (CC12), unproductive forests (CC13) and afforestations (CC11). It is congruent with the forest area derived from the aerial photos of the AREA survey (NIR Chapter 7.2.2).

f) The CC11 area in UNFCCC can be taken from CRF 5A2 by summing up the afforestation source categories.

g) The cumulated (20 years) CC11 area of KP and UNFCCC are congruent.

Area reported under Afforestation, Deforestation and Forest Management

AREA data allow to clearly separate between the land areas subject to a specific activity. Absolute and cumulated activity data of Afforestations, Deforestations and forests under Forest Management are listed in Table 11-6. The total Swiss area remains constant and amounts to 4'128.42 kha.

Table 11-6 Activity data for activities under Article 3, paragraphs 3 and 4, 1990-2012. Afforestation, Deforestation data and values depicting the area of Forest Management are derived from the Swiss Land Use Statistics (AREA) (derived from SFSO 2006a, 2013). See also KP-CRF-Table NIR2 (Table 11-2).

Year	Deforested area [kha]	Cumulated deforested area since 1990 [kha]	Afforested area [kha]	Cumulated afforested area since 1990 [kha]	Area Forest Management [kha]
1990	0.31	0.31	0.27	0.27	1178.82
1991	0.31	0.62	0.26	0.53	1181.97
1992	0.31	0.93	0.26	0.79	1185.14
1993	0.31	1.24	0.23	1.02	1188.18
1994	0.33	1.58	0.18	1.20	1191.08
1995	0.34	1.92	0.13	1.33	1193.86
1996	0.34	2.26	0.12	1.44	1196.36
1997	0.35	2.61	0.09	1.53	1198.84
1998	0.38	2.98	0.06	1.59	1201.10
1999	0.37	3.36	0.06	1.65	1203.32
2000	0.37	3.73	0.06	1.71	1205.53
2001	0.36	4.09	0.06	1.77	1207.75
2002	0.36	4.44	0.06	1.82	1209.96
2003	0.35	4.79	0.06	1.88	1212.18
2004	0.34	5.14	0.06	1.94	1214.39
2005	0.28	5.41	0.10	2.04	1217.30
2006	0.23	5.64	0.08	2.12	1220.14
2007	0.18	5.82	0.08	2.20	1223.01
2008	0.12	5.93	0.07	2.27	1226.24
2009	0.25	6.19	0.06	2.33	1229.15
2010	0.31	6.50	0.05	2.38	1230.41
2011	0.31	6.81	0.05	2.44	1231.53
2012	0.31	7.13	0.05	2.49	1232.66

11.3 Activity-specific Information

11.3.1 Methods for Carbon Stock Change and GHG Emission and Removal estimates

11.3.1.1 Description of the Methodologies and the underlying Assumptions used

Emission factors for Afforestations, Deforestations and Forest Management were accounted for following the methodology described in chapter 7.1.3.2, Table 7-3 and using equations 7.1-7.6.

Annual values for carbon stocks and changes in the pools of living biomass (for a description of seperation in above and belowground living biomass see Chapter 7.3.4.6), dead wood, litter and soil carbon of afforestations (CC11), productive forests (CC 12) and unproductive forests (CC13) are displayed in Table 7-4,Table 7-19 and Table 7-23. The methodological approach is based on Table 7-3 and elaborated in detail for each pool in Table 11-7. Under the Kyoto Protocol, the pool “dead organic matter” is separated into dead wood and litter. Supplementary methodological information can be found in FOEN (2014c).

Table 11-7 Application of the methodolgy described in equations 7.1-7.6 in Chapter 7.1.3.2 and in Table 7-3 for calculating changes in carbon pools for the Kyoto activities Afforestations (CC11) younger than 20 years (≤ 20 yr) and older than 20 years (>20 yr), Deforestations (DEF) and Forest Management (FM) with the 4 geographical locations: CC12 remaining, CC13 remaining, conversions from CC12 to CC13 (FM CC1213) and conversions from CC13 to CC12 (FM CC1312). In the case of Deforestation (LUC to CC51), losses in soil carbon are accounted for by reducing the soil carbon pool by 50%. A conversion time CT of 20 years is applied for all pools except for the loss of living biomass, litter and dead wood after Deforestation (CT=1 year). Suffixes used: l for living biomass, dw for dead wood, s for soil, li for litter, i for spatial stratum. CC11 (afforestation), CC12 (productive forests) and CC13 (unproductive forests) refer to the specific combination category (see Table 7-2).

	Living biomass	Litter	Dead Wood	Soil-C
Afforestation CC11 ≤ 20 yr	gain-loss $gainC_{l,i,CC11}$ - $lossC_{l,i,CC11}$ = $gainC_{l,i,CC11}$ - 0 = $gainC_{l,i,CC11}$	stock-change, CT=20 ($stockC_{li,i,CC11}$ - $stockC_{li,i,CC31/51}$)/CT = (0 - 0)/ 20 = 0	stock-change, CT=20 ($stockC_{dw, i,CC11}$ - $stockC_{dw,i,CC31/51}$)/CT = (0 - 0)/20 = 0	stock-change, CT=20 ($stockC_{s,i,CC11}$ - $stockC_{s,i,CC31/51}$)/CT
Afforestation CC11 > 20 yr	gain-loss $gainC_{l,i,CC12}$ - $lossC_{l,i,CC12}$	gain-loss $changeC_{li,i,CC12}$	gain-loss $changeC_{dw,i,CC12}$	gain-loss $changeC_{s,i,CC12}$
Deforestation DEF	stock change, CT=1 (0-$stockC_{l,i,CC12}$)/CT = -$stockC_{l,i,CC12}$	stock change, CT=1 (0 - $stockC_{li,i,CC12}$)/CT = - $stockC_{li,i, CC12}$	stock change, CT=1 (0 - $stockC_{dw,i,CC12}$)/CT -$stockC_{dw,i,CC12}$	stock change, CT=20 (0.5*$stockC_{s,i,CC12}$ - $stockC_{s,i,CC12}$)/CT = -(0.5*$stockC_{s,i,CC12}$)/20
FM CC12 remaining	gain-loss $gainC_{l,i,CC12}$ - $lossC_{l,i,CC12}$	gain-loss $changeC_{li,i,CC12}$	gain-loss $changeC_{dw,i,CC12}$	gain-loss $changeC_{s,i,CC12}$
FM CC13 remaining	gain-loss $gainC_{l,i,CC13}$ - $lossC_{l,i,CC13}$ = 0	gain-loss $changeC_{li,i,CC13}$ = 0	gain-loss $changeC_{dw,i,CC13}$ = 0	gain-loss $changeC_{s,i,CC13}$ = 0
FM CC1213	stock change, CT=20 ($stockC_{l,i,CC13}$ - $stockC_{l,i,CC12}$)/CT	stock change, CT=20 ($stockC_{li,i,CC13}$ - $stockC_{li,i,CC12}$)/CT = 0	stock change, CT=20 ($stockC_{dw,i,CC13}$ - $stockC_{dw,i,CC12}$)/CT = (0 - $stockC_{dw,i,CC12}$)/20	stock change, CT=20 ($stockC_{s,i,CC13}$ - $stockC_{s,i,CC12}$)/CT = 0
FM CC1312	gain-loss $gainC_{l,i,CC12}$ - $lossC_{l,i,CC12}$	stock change, CT=20 ($stockC_{li,i,CC12}$ - $stockC_{li,i,CC13}$)/CT = 0	stock change, CT=20 ($stockC_{dw,i,CC12}$ - $stockC_{dw,i,CC13}$)/CT = $stockC_{dw,i,CC12}$/20	stock change, CT=20 ($stockC_{s,i,CC12}$ - $stockC_{s,i,CC13}$)/CT = 0

Reforestation

Reforestation does not occur in Switzerland (FOEN 2006h, Sect. E).

Afforestation ≤ 20 years: Units of Land not harvested since the beginning of the Commitment Period

Most of the afforestations occur on permanent grasslands CC31 and on settlements CC51 (see Table 7-9).

Living Biomass

- Gross growth of living biomass of Afforestations follows a logistical growth function. Values are available for three altitudinal levels (Table 7-25). The total gross growth of the cumulative afforested area was determined by multiplying the afforested area of a specific year with the corresponding age-specific growth values. For estimates under the UNFCCC, a simplified approach was chosen and mean growth values were applied.

Soil Carbon

- Organic soils: In the case of organic soils, emissions due to drainage are calculated as described in Chapter 11.3.1.2.
- Mineral soils: In the case of land-use conversions to Afforestations, the difference in soil carbon stocks between land use before the conversion (CC31 and CC51) and Afforestations CC11 is considered.

The fact that soils are acting as small sinks under afforestation is supported by Jandl et al. (2007) who reviewed several studies on the effect of different forest management systems (including afforestations) on soil carbon sequestration and concluded that a long-term consequence of afforestation is the gradual incorporation of C in the mineral associated soil C pool.

Dead Wood and Litter

- On grasslands and areas with settlements there are no dead wood and no litter available and a zero stock is attributed. Assuming no dead wood nor litter on Afforestations, the difference in the carbon stocks of these pools are zero. This is a conservative estimate (in terms of IPCC good practice: IPCC 2003, Sect. 3.1.5), since there actually is a small pool of dead wood and litter under Afforestations. This conservative approach is confirmed in a study by Zimmermann and Hiltbrunner (2012) and by other literature (see Chapter 11.3.1.2).

Afforestation > 20 years: Units of Land harvested since the beginning of the Commitment Period

In KP-CRF-Table A.1.2, changes in carbon stocks of Afforestations older than 20 years are reported. After 20 years, Afforestations are subject to normal Forest Management and the first thinnings and treatments are conducted. There is however no reclassification of these afforestated areas to Forest Management: all Afforesations after 1990 are reported under Article 3.3 (see Chapter 11.2.3). Emissions and removals for the carbon pools of Afforestations older than 20 years are calculated using the emission factors of productive (CC12) forests, since nearly all of the afforestations (99.9%) develop to productive forests (see methodological description under “Forest Management”).

Deforestation

- Change in carbon stock due to conversion: Total carbon stock of living biomass, dead wood and litter are immediately removed after Deforestation. Losses in soil carbon due to disturbance caused by Deforestation (conversion to buildings and constructions) are accounted for by reducing the soil carbon pool by 50% (Covington 1981; Rusch et al. 2009; see also Chapter 7.1.3.2) over a conversion period of 20 years (see Table 7-3).

Forest Management

Living biomass

- Total living biomass, calculated with single-tree allometric functuion, is separated into above- and belowground living biomass using the factors in Table 7-20 as described in Chapter 7.3.4.6.
- Gross growth of productive forests is used for “CC12 remaining”. Gross growth of unproductive forests is used for “CC13 remaining” and amounts to zero (see Chapter 7.3.4.9).
- Cut and mortality reflect yearly losses of living biomass in productive forests “CC12 remaining”. Unproductive forests are not systematically harvested (description Chapter 7.3.4.9). Thus losses of unproductive forests “CC13 remaining” are zero. More over, since yearly harvesting amounts from forest statistics (FOEN 2013k) are divided over the productive forests, total harvesting in Swiss forests is accounted for under CC12 remaining.

- For the conversions between different forest source categories (“CC13 to CC12” and “CC12 to CC13”) the method is choosen in such a way that no potential carbon losses are underestimated. For areas which changed from “CC12 to CC13” the difference in carbon stocks of living biomass was considered and a net loss in carbon stock of living biomass is reported; in the case of a conversion from “CC13 to CC12” a gain-loss approach has been applied, since applying a stock-change approach would lead to a considerable sink in living biomass in this category.

Dead wood, litter and soil

- A literature overview of the influence of forest management on soil carbon and litter is provided in Didion (2014) and summarized in Chapter 11.3.2.2.
- For productive forests “CC12 remaining”, values for yearly changes in carbon stock of dead wood, litter and soil are used (Table 7-23). Estimates of those yearly changes were derived from Yasso07 (see Chapter 7.3.4.8). For unproductive forests “CC13 remaining”, yearly changes in dead wood, litter and soil carbon stock are assumed to be zero (Chapter 7.3.4.9).
- For the conversions between different forest categories (“CC13 to CC12” and “CC12 to CC13”) the difference in carbon stock of dead wood, litter and soil carbon is taken into account (Table 7-23). For the conversion “CC12 to CC13”, we report a net loss in carbon stock for these pools, in the case of a conversion “CC13 to CC12”, we report a net gain (Table 7-4).
- In the case of organic soils, emissions due to drainage are calculated as described in Chapter 11.3.1.2.

Differences in accounting for “Forest Sector 5A1 and 5A2” under the UNFCCC and „Forest Management“ under KP Art. 3.4

For reporting changes in living biomass of Afforestations, under KP the age-specific growth value was multiplied with the afforested area of a specific year. For estimates under the UNFCCC, a simplified approach was chosen and mean growth values instead of age-speficic growth values were applied.

Under KP Art. 3.4, natural forest regeneration is reported under “Forest Management” as CC12 or CC13 as soon as the KP definition of Forest is fulfilled and management activities have taken place. Changes within the activity “Forest Management” are reported under the Kyoto Protocol in the source categories CC12 to CC13 and CC13 to 12.

Under the UNFCCC, all changes in land use from non-forest land to forest land are reported in the land-use category 5A2 for a conversion time of 20 years.

11.3.1.2 Justification when omitting any Carbon Pool or GHG Emissions/Removals from Activities under Article 3.3 and elected Activities under Article 3.4

KP LULUCF Table NIR1 (Table 11-1) summarizes the activity coverage and the carbon pools reported. When using the conservative Tier 1 approach (IPCC 2003, Sect. 3.1.5) assuming a specific carbon pool to be in balance, the carbon pool is indicated as not reported (NR). This is the case for litter and dead wood under Afforestation. Also for all pools of unproductive forests CC13, we report no changes.

Change in Carbon Pool not Reported

Afforestation: litter and dead wood

Figure 5.4.2 in the GPG LULUCF (IPCC 2003) illustrates the issue that, when data are not available, a “good practice method” should be used and that financial resources for key categories should not be jeopardized and an appropriate tier level should be used. Because Afforestation is not a key category (see Chapter 11.6.1), a conservative estimate (Tier 1) for the pools litter and dead wood is compliant to IPCC guidelines (IPCC 2003) for the first twenty years when no management activity takes place. We provide verifiable information to justify this approach:

for the pools litter and dead wood is compliant to IPCC guidelines (IPCC 2003). We provide verifiable information to justify this approach:

- **Changes in litter after Afforestation:** Under the Kyoto Protocol, we conservatively report no changes in the litter pool after Afforestations. In an experiment by Zimmermann and Hiltbrunner (2012) litter accumulation of an Afforestation with Norway Spruche was determined 40 years after Afforestation. The authors found accumalation rates of 0.17-0.20 t C ha^{-1} yr^{-1}. Other studies show even higher accumlation rates of 0.24-0.34 t C ha^{-1} yr^{-1} for Afforestations with Norway spruce in Southern Alps (Thuille and Schulze 2006), 0.24 t C ha^{-1} yr^{-1} for Afforestation with ash and maple (Alberti et al. 2008) and 0.36 t C ha^{-1} yr^{-1} for Scotch pine (Vesterdal et al. 2002). Karhu et al. (2011) determined for Finisch forest stands mean annual rate of carbon accumulation in the litter over 18 years was 0.28 and 0.15 Mg ha^{-1} for Scots pine and birch, respectively.

  In a literature overview, Jandl et al. (2007) showed, that the accumulation of a forest floor layer in, e.g., a conifer forest, is a C sink. The authors concluded that after afforestation, forest floors accumulate C quickly. A long-term consequence of afforestation is the gradual incorporation of C in the mineralassociated soil C pool.
- **Changes in dead wood after Afforestation**: Under the Kyoto Protocol, we conservatively report no changes in the litter pool after Afforestations. Zimmermann and Hiltbrunner (2012) showed that 40 years after Afforestation with Norway Spruce, dead wood volume ammounted to 10.4 t C ha^{-1}. Thus, an annual increase in dead wood of 0.26 t C ha^{-1} yr^{-1} for afforestations with Norway Spruce can be derived from this case study, considering the fact that on grassland, the starting point of most afforestations, there is no dead wood available.
- Besides the results of the case studies listed above, we provide a reasoning based on sound knowledge of likely system responses (Grassi and Blujdea 2011): At stand level, the pools dead wood and litter of Afforestation on cropland and grassland cannot be a source, especially if previous land use did not have perennial woody biomass. In Afforestations the stands development follow exponential patters, which can also be theoretically attributed to all other C pools.

Note that for afforestations older than 20 years, we report estimates of CSC in dead wood, litter and SOC.

Unproductive Forests CC13

These unproductive forests and the reasoning why these pools are not a source is described in detail in Chapter 7.3.4.9.

Based on the fact that unproductive forest land only covers 7.2% of the area under Forest Management (Table 7-10 LUC matrix and CRF-KP-Table 5(KP.I)B.2.) and based on the description of these stands given before, emissions or removals of any of the pools of unproductive forests cannot account for more than 25% of the activity Forest Management. According to IPCC 2003 Fig 3.1.1, note 4, 25% is the threshold that would require a higher

Tier. Since our resources are limited and we do not want to jeopardize financial resources for the key categories (IPCC 2003 Fig. 5.4.2.), Switzerland decided to use the Tier 1 approach and reports no changes in living biomass, litter, soil and dead wood of unproductive areas arguing that this is a conservative estimate. Emissions from organic soils are accounted for using default factors from IPCC 2013 (Tier 1).

Greenhouse Gas Sources Reported

- Fertilization of forests is prohibited by the Swiss forest law and adherent ordinances (Swiss Confederation 1991, 1992). Additionally, the “Ordinance on Chemical Risk Reduction“ (Swiss Confederation 2005) prohibits the application of fertilizers, including liming, in forests. Thus, emissions from fertilization are reported as “not occurring”.
- Drainage of forests is not a permitted practice in Switzerland and since 1991 not a permitted practice in Switzerland (Swiss Confederation 1991). There are no nation-wide survey data available. It is possible that a small part of the Swiss forest has been drained before 1990 or has been established on drained areas. We conservatively report all organic forest soils to be drained which is definitely an overestimation. In order to calculate CO2 emissions due to drainage, we used equation 3.2.15 of the GPG for LULUCF (IPCC 2003) and applied the default emission factor of 0.68 Mg ha^{-1} yr^{-1}. N_2O-emissions due to drainage are not estimated as no data are available. Moreover, reporting is not mandatory according to the Annex of chapter 3 of the IPCC GPG for LULUCF (reported as “NE” in KP-Table NIR1; Table 11-1).
- Biomass burning: emissions of CO_2, CH_4 and N_2O are reported. The calculation of these emissions is described in Chapter 7.3.4.13 according to the methodology of the GPG LULUCF (IPCC 2003).

11.3.1.3 Information on whether or not indirect and natural GHG Emissions and Removals have been factored out

No anthropogenic GHG emissions and removals from elevated carbon dioxide concentrations, indirect nitrogen deposition or the dynamic effects of the age structure resulting from LULUCF activities under Article 3, paragraphs 3 and 4 prior to 01 January 1990 have been factored out.

The IPCC does not give specific methods for factoring out these effects. Besides this, there are no reliable country specific data available. Investigations on elevated CO_2 concentrations on growth showed complex relationships in the middle term. Some species showed an increase others a decrease and some no change in growth (Bader el al. 2013). Until recently, researchers were convinced that there is a distinct positive effect of nitrogen deposition and gross growth (Spiecker 1999; Jarvis and Linder 2000). Recent scientific publications, however, question this relationship and even show that nitrogen deposition, while leading to soil acidification, even can cause a reduction in growth (Hyvönen et al. 2008; Högberg et al. 2006; Braun et al. 2010; Gschwantner 2006; Meining et al. 2008). Such acidification processes are widely detected in Swiss forest soils.

11.3.1.4 Changes in Data and Methods since the previous Submission (Recalculations)

Table 1-12 lists the improvements made since last year based on the questions or recommendations of the UNFCCC Expert Review Team.

A recalculation of the years 2008, 2009, 2010 and 2011 was carried out.

The completion of the AREA surveys (see Chapter 7.2.2.1, SFSO 2013) led to a recalculation of all areas reported under Art. 3.3 and Art 3.4 Forest Management.

In detail, the changes in the calculation of the emission factors calculated for all areas reported under Art. 3.3 and Art 3.4 Forest Management are described in Chapter 7.3.7 and in Chapter 10.1.2.

The following Kyoto-specific methodological modification was made for this submission:

- The calculation of carbon stock changes in the different pools has been adapted such that it is harmonized between reporting under the UNFCCC and under the KP, that no double counting is possible and that the most conservative accounting method is applied. The calculation approach is explained in Chapter 7.1.3.2 and in Chapter 11.3.1. and transparently shown in Table 7-3 and Table 11-7.
- New available NFI 4a+ data covering the period 2009-2012 have been used in the calculations for changes in living biomass (Thürig 2014). Total living biomass has been seperated into above- and belowground biomass (see Chapter 7.3.4.6)
- Updated estimates of yearly changes in carbon stocks of soil organic carbon, dead wood and litter, modeled with Yasso07, are described in Didion et al. (2013).

Additional information, references and documentation justifying not to report changes in litter and dead wood under afforestation is provided in Chapter 11.3.1.2.

The description of unproductive forests has been extended and also the reasoning why the carbon pools of the unproductive forest are not a source is supported with references (see section 7.3.4.9).

11.3.1.5 Uncertainty Estimates

An overview of the uncertainty estimates of activity data is discussed in detail in Chapter 7.2.5 and is shown in Table 7-10. Uncertainty estimates of emission factors for the reported activities under the Kyoto Protocol are shown in Table 7-5, overall uncertainties in Table 11-8.

A detailed description of the determination of the emission factor uncertainty of Forest Management can be found in Chapter 7.3.5. Table 7-5 lists the relative uncertainties in the LULUCF sector: an uncertainty of 63% was calculated for Afforestations, 50% for Deforestations and 63% for Forest Management.

Lands fulfilling the definition Forest (see Chapter 11.1.1) are accounted for under "Forest Management". This means, that lands under Forest Management wich are due to natural regeneration are attributed the uncertainty of Forest Management.

Table 11-8 Uncertainty estimates of activity data and emission factors and the overall uncertainty of activities reported under the Kyoto Protocol Article 3.3 and Article 3.4

Activity under KP	Associated category in UNFCCC inventory (Chapter 7.3)	Activity data uncertainty [%]	Emission factor uncertainty [%]	Combined uncertainty [%]
Afforestation	5A2 Land converted to Forest Land	2	63	63
Deforestation	mainly 5E2 Land converted to Settlements	5	50	50
Forest Management	5A1 Forest Land remaining Forest Land	2	63	63

11.3.1.6 Other methodological Issues

Methodology used for reporting under the Kyoto Protocol is described in detail in previous sections.

N_2O emissions as a result of the disturbance associated with land-use conversion (Deforestation) to Cropland are reported in KP-CRF-table 5(KP-II)3. The emissions are calculated according to the methodology described in Chapter 7.4.4.4.

11.3.1.7 The Year of the onset of an Activity, if after 2008

All activities reported started in 1990, i.e. before the beginning of the first commitment period.

11.3.2 Category-Specific QA/QC and Verification

In Chapter 7.3.6 category-specific QA/QC and verification items for forest land are described in detail. Differences between the forest areas reported in “Forest Sector 5A1 and 5A2” under UNFCCC and „Forest Management“ under KP Art. 3.4 are explained in Chapter 11.2.3.

11.3.2.1 Comparison of the Forest Areas reported in the CRF-tables and KP-CRF-tables

The relationship between forest land reported under LULUCF table 5.A and those reported for activities under KP-LULUCF forests has been documented in Meteotest (2013a) for the year 2010. An updated version of this study has been compiled in Table 11-5 in Chapter 11.2.3.

11.3.2.2 Impact of Forest Management on Changes in Carbon Stocks in Soil and in Litter

Accounting for forest management impacts on carbon storage in litter and soil in Swiss productive forests with Yasso07

To estimate C stocks and C stock changes in the reported litter and soil pools, Switzerland uses the C cycling model Yasso07 (cf. Didion et al. 2012, 2013). Inputs to the model include C deriving from the annually amount of leaves, fine-roots and fruits that are produced by living trees. The C inputs are obtained for each plot in the National Forest Inventory (NFI) that is simulated with Yasso07. The NFI plots have been repeatedly measured since the first inventory in 1985 and, hence, observed changes in the volume of living and dead biomass reflect, among other, the site-specific impact of forest management. Based on harvesting statistics and allometric relationships, the production of dead wood (incl. dead roots, stems, stumps and branches) and litter from living trees (i.e. controlled by forest management) and as harvest residues are estimated.

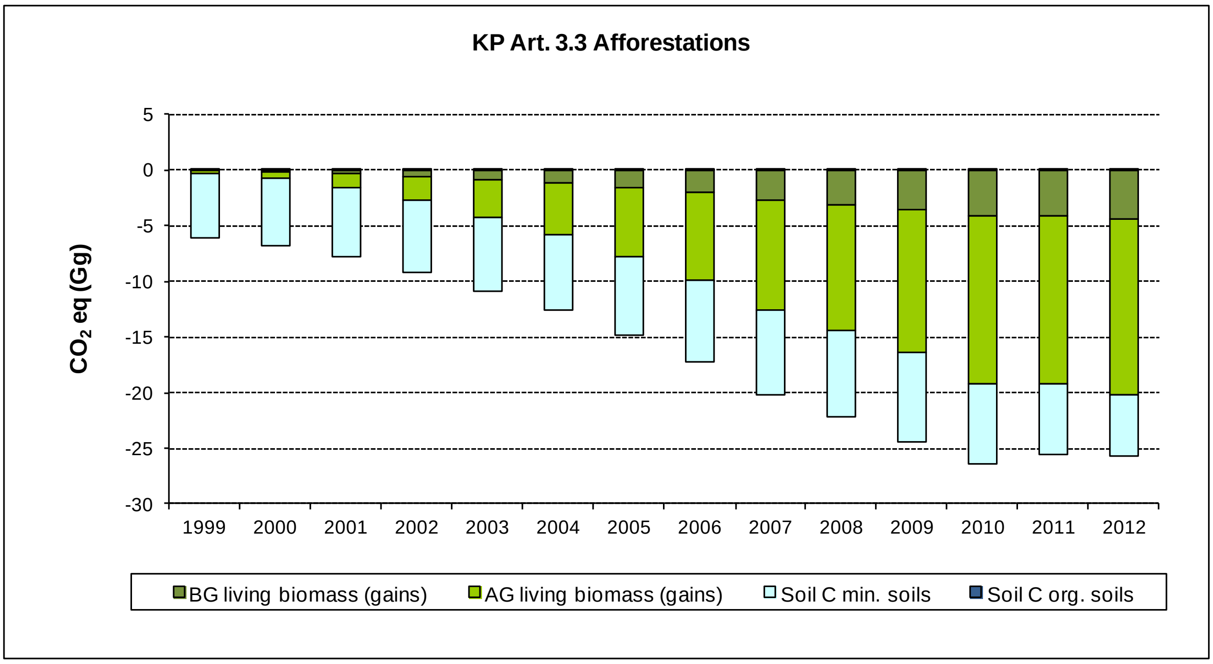
Thus, the Yasso07-model reflects the impact of forest management: forest management effects on C stocks in litter (including non-woody and woody material) and soil are fully accounted for in the Swiss GHGI (Didion 2014).

Literature Review

A detailed screening of the available scientific literature on the impact of forest management on carbon stock changes in litter and soils is provided in Didion (2014). The majority of studies indicated no significant effect of forest management on soil C stocks with the exception of clearcutting (e.g. Jandl et al. 2007). Since silvicultural practices in Switzerland are regulated by law and exclude intensive management options such as clearcuts, fertilization or liming (Swiss Confederation 1991, 1992), no or only minor forest management impacts on soil C stocks can be expected. The production of litter is directly affected by silvicultural practices since the removal of trees results in harvest residues and in a decrease in the amount of remaining foliage (e.g. Van Miegroet and Olsson 2011). Generally, the impact of forest management on litter production is temporary and losses of litter C can be rapidly replaced (Nave et al. 2010).

11.4 Article 3.3.

Figure 11-2 shows removals of CO_2 eq from Afforestations and emissions of CO_2 eq from Deforestations for the years 1999-2012. The corresponding values are listed inTable 11-4.



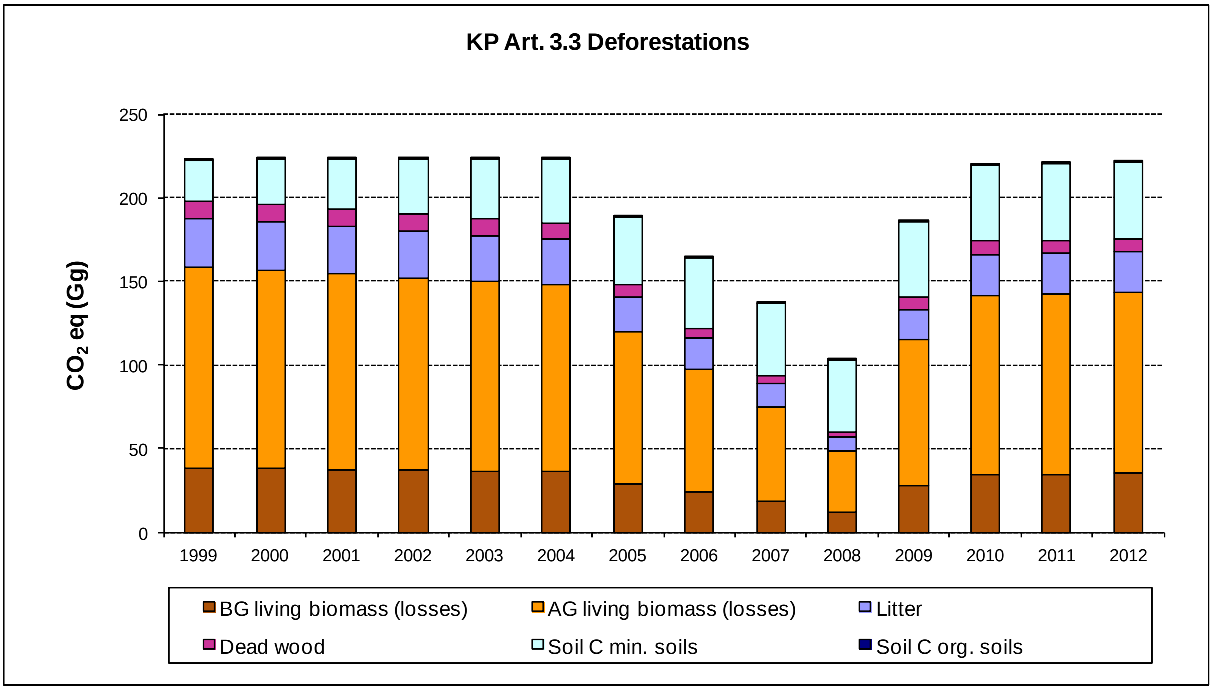


Figure 11-2 Removals (negative sign) and emissions (positive sign) of CO_2 eq from Afforestations (upper panel) and from Deforestations (lower panel) shown per carbon pool, 1999-2012. Belowground (BG) and aboveground (AG) living biomass is reported seperately.

The order of magnitude of total removals or emissions of CO_2 eq from Afforestations and Deforestations is considerably different (Figure 11-2, Figure 11-3). Since carbon from living biomass is immediately removed after clear-cutting, Deforestation can be seen as a “quick carbon-losing process”. In contrast, due to the slow increase of living biomass, Afforestation is a “slow process with increasing importance” in terms of carbon accumulation. CO_2 emissions on organic soils under Afforestations are due to drainage (see Chapter 11.3.1.2).

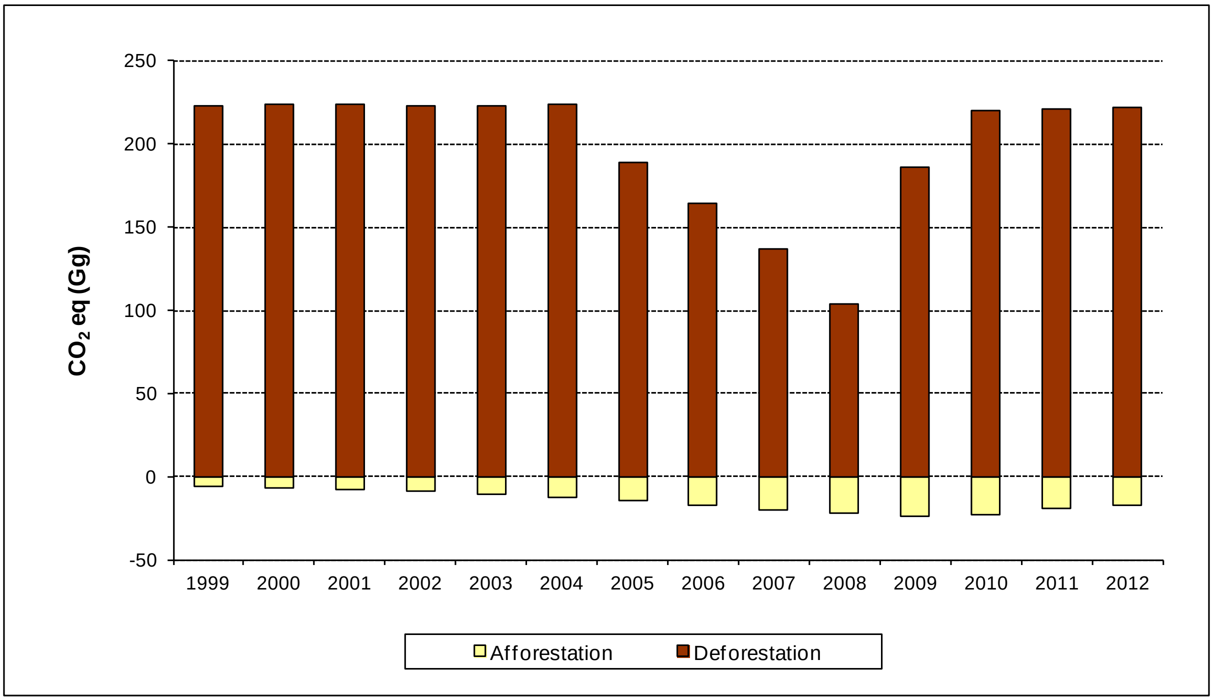


Figure 11-3 Removals (negative sign) and emissions (positive sign) of CO2 eq of Afforestations and Deforestations, 1999-2012.

11.4.1 Information that demonstrates that Activities under Article 3.3. began on or after 1 January 1990 and before December 2012 and are direct Human-induced.

The Swiss definitions of Afforestation and Deforestation only consider directly human-induced activities (see FOEN 2006h, Sect. E and FOEN 2010d).

Reforestation

For more than 100 years, the area of forest in Switzerland has been increasing (see Chapter 11.5.3), and a decrease in forest area as a result of Deforestation is prohibited by the Federal Law on Forests (Swiss Confederation 1991). Therefore, reforestation of areas not forested for a period of at least 50 years does not occur in Switzerland (FOEN 2006h, Sect. E). Switzerland only considers Afforestation and Deforestation under Article 3, paragraph 3.

Afforestation

Switzerland is very restrictive in reporting Afforestations under the Kyoto Protocol and only reports planted Afforestations (see Chapter 11.1.3; FOEN 2010h).

The annual rate of Afforestation since 1990 is assessed by AREA (Chapter 7.2.2). For reporting under the Kyoto Protocol, afforested areas since 1990 always remain in the "Afforestation" category. Therefore, the area of Afforestations is increasing since 1990 (see Table 11-6).

Afforestations older than 20 years are subject to normal Forest Management practices including harvesting (see Chapter 11.3.1.1). These areas are reported in CRF-tables 5(KP-I) A.1.2 and 5(KP-I)A.1.3.

Deforestation

In Switzerland, direct human-induced Deforestation is subject to authorization (Swiss Confederation 1991, Art. 5). For details concerning the classification of Deforestations under the Kyoto Protocol see Chapter 11.2.3). Only Deforestations carried out after 01 January 1990 are considered. For reporting under the Kyoto Protocol, deforested areas since 1990 remain in the Deforestation category. Therefore, the area of Deforestations is increasing since 1990 (see Table 11-6). Since Switzerland decided to only account for KP Art. 3.4 activity "Forest Management", these deforested areas are not subject to another KP Art. 3.4 activity.

11.4.2 Information on how Harvesting or Forest Disturbance that is followed by the Re-Establishment of Forest is distinguished from Deforestation

The Swiss definition of Deforestation only covers permanent conversions from forest land into non-forest land and is assessed by AREA applying the criteria discussed in chapter 11.2.3. This approach is confirmed by Sitmaplan (2012a).

They implicitly distinguish between permanent conversions and transient situations like harvesting or forest disturbance. Construction of e.g. pipelines and power supply lines within a forest area are transient situations (see Chapter 11.1.3 and 11.2.3; Brändli 2010). As described in FOEN (2010d), these non-permanent conversions are not classified as Deforestation under the Kyoto Protocol.

11.4.3 Information on the Size and Geographical Location of Forest Areas that have lost Forest Cover but which are not yet classified as Deforested

The AREA survey provides a detailed overview of land-use changes with regard to land cover and land use (see Chapter 7.2). Temporal changes of land cover can lead to a reclassification in AREA from a forest category to a non-forest category. In FOEN (2010d) and in Chapter 11.2.3 the criteria are listed which conversions from a forest combination category to a non-forest combination category are not identified as Kyoto Deforestation under the Kyoto Protocol.

11.5 Article 3.4

CO_2 eq emissions and removals from the reported pools and total CO_2 eq emissions and removals of the Kyoto Protocol activity Forest Management for the years 1999 until 2012 are shown in Figure 11-4. The corresponding values are listed in Table 11-4.

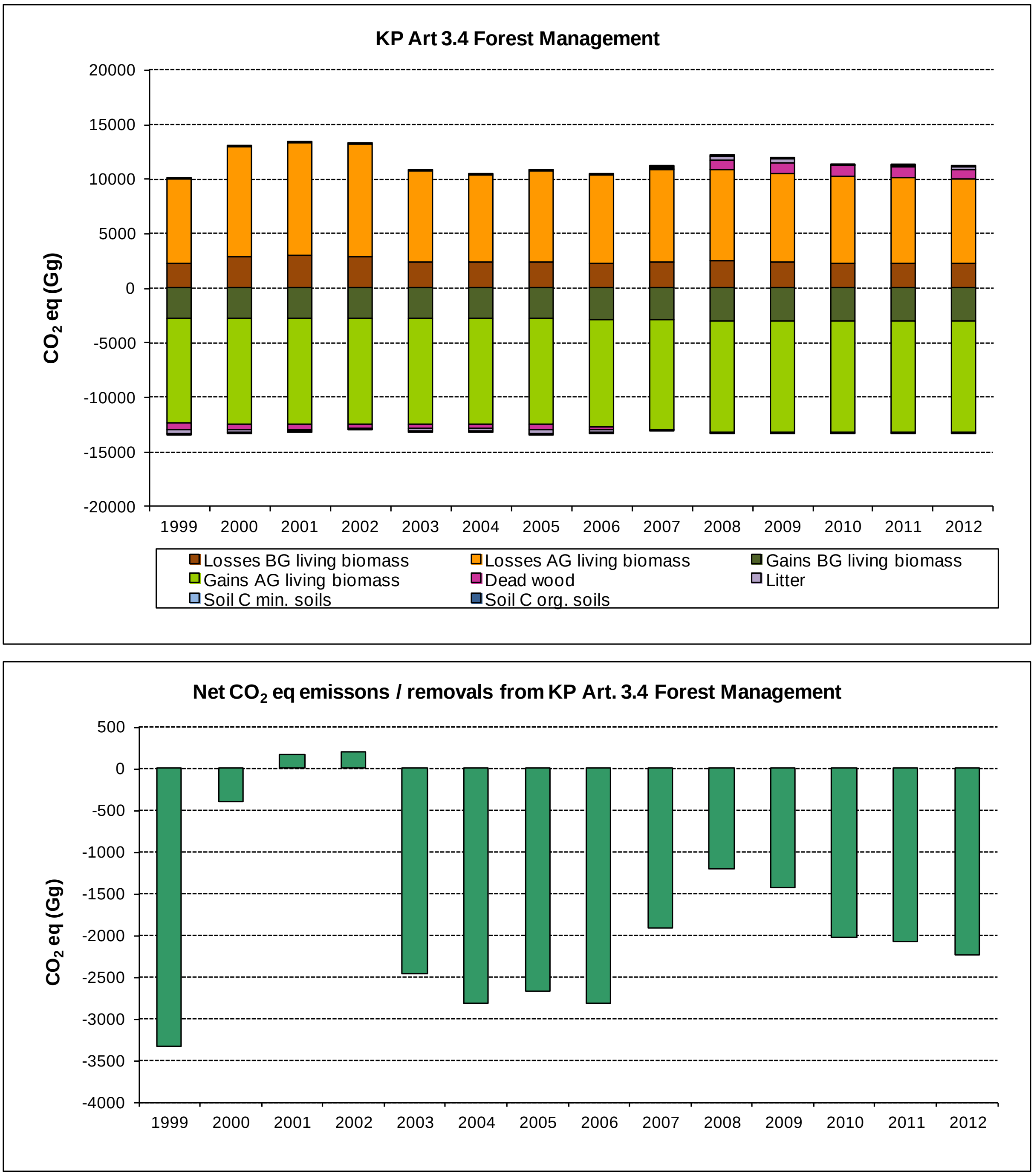


Figure 11-4 CO_2 eq emissions (positive sign) and removals (negative sign) from the reported carbon pools under Forest Management (upper panel) and the total CO_2 eq emissions and removals from Forest Management (lower panel), 1999-2012. Belowground (BG) and aboveground (AG) living biomass is reported seperately.

The yearly fluctuations in the GHG emissions and removals from Forest Management can mainly be explained by changes in the losses of living biomass, dead wood and litter (see Table 11-4). Changes in the area of managed forest are relatively small (Table 11-6). In 2001 and 2002 Forest Management was a small source of CO_2 eq. and in 2000 a small sink compared to previous and following years. This was due to an elevated amount of losses in living biomass after storm Lothar, which ravaged Swiss forests in December 1999.

11.5.1 Information that demonstrates that Activities under Article 3.4. have occurred since 1 January 1990 and are Human-induced

According to the Swiss Federal Law on Forests, the extent and the spatial distribution of the total forest area in Switzerland has to be preserved (Swiss Confederation 1991, Art. 1) and thus, any change of the forested area has to be authorized. All Swiss forests are under continuous observation of the Swiss Forest Service and monitored by the NFI. Therefore, all forests in Switzerland are subject to Forest Management (FOEN 2006h, Sect. F).

11.5.2 Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the Base Year

Not applicable.

11.5.3 Information Relating to Forest Management

There is a long tradition of forest protection in Switzerland. The first federal Forest Act came into force in 1876, but it only covered the Alpine region. Its aim was to put a halt to the depletion of forests, to manage the remaining forest areas in a sustainable way, and to promote Afforestation. The Forest Act of 1902 covered the whole country. The Forest Act as well as an enabling overall economic development resulted in an increase of the forested area in Switzerland by nearly 50% compared to the mid-19th century (Figure 11-5). Also growing stock increased significantly due to changes in Forest Management practices. The Forest Act (Swiss Confederation 1991) that came into force in 1993 reaffirms the long-standing Swiss tradition of preserving both forest area and forest as a natural ecosystem. It prescribes sustainable Forest Management, prohibits clearing, and bans Deforestation unless it is replaced by an equal area of afforested land or an equivalent measure to improve biodiversity.

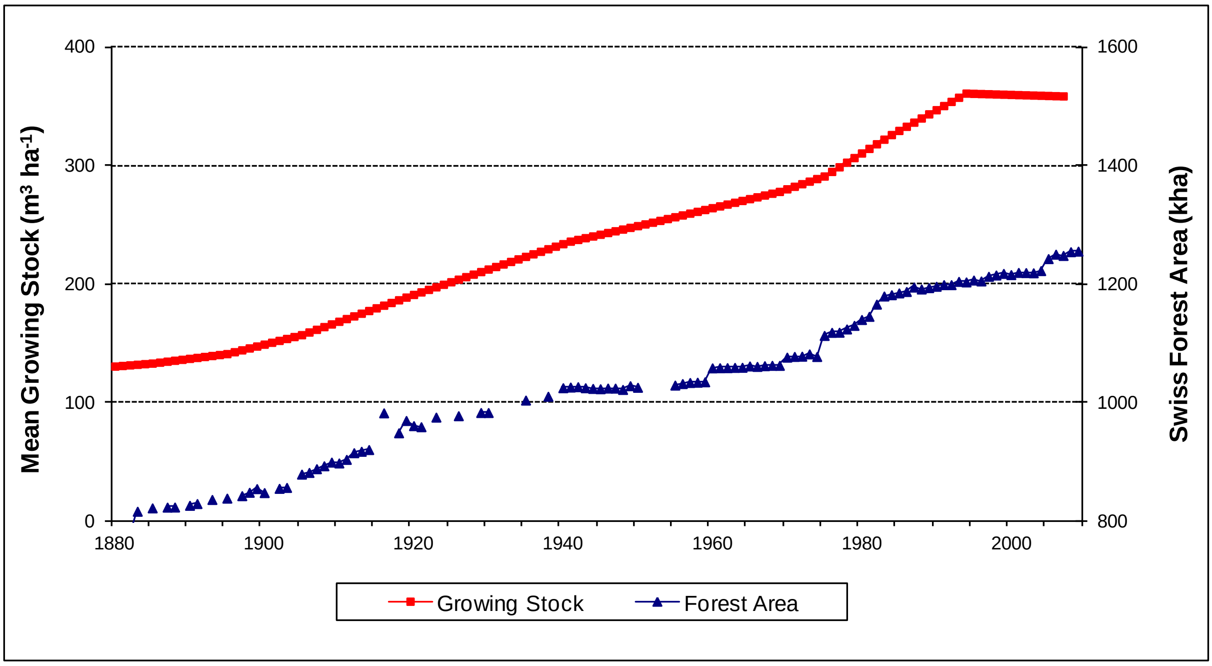


Figure 11-5: Historical mean growing stock and forest area in Switzerland since 1880.

In 2004, the Swiss national forest programme was published, outlining an action plan for the period 2004-2015 (SAEFL 2004b). It specifies five priority objectives: (1) the forest's protective function is guaranteed, (2) the economic viability of the forestry sector is improved, (3) the value-added chain for wood is strengthened, (4) biodiversity is conserved and (5) forest soils, trees and drinking water are not threatened. These objectives encompass that CO_2 removals by sinks and emissions by sources in the forests shall be recognized in terms of compliance with the Kyoto Protocol while making better use of the potential of forests for timber production and fuel wood through economic incentives and implementing new technologies.

In November 2006, the Swiss government communicated in its initial report to the UNFCCC that Switzerland will be accounting for Forest Management under Article 3.4 of the Kyoto Protocol (FOEN 2006h).

To implement the objectives of the national forest programme (SAEFL 2004b), FOEN has formulated its wood resource policy (FOEN 2008h) which is coordinated with the other relevant sectoral policies (e.g. energy policy, regional development policy). This wood resource policy defines, among other things, the direction to be taken by federal policy in relation to wood promotion on completion of the “Wood 21” wood promotion programme which was terminated at the end of 2008. Under this programme, a wood action plan was started in 2009. The main focus in the implementation of the action plan lies on the ecologically and economically effective use of wood. With a view to the efficient use of wood, cascade use is prioritized, i.e. wood is used as material prior to its use for energy. In the case of energy use, greater overall efficiency of the conversion technology should be targeted.

11.5.4 Information that demonstrates that Emissions and Removals resulting from elected Article 3, Paragraph 4, Activities are not accounted for under Activities under Article 3, Paragraph 3

This information is requested in the Annex to 15/CMP.1 paragraph 9.c.

The reporting of Forest Management under article 3, paragraph 4 is clearly separated from the reporting of the activities under article 3, paragraph 3.

Units of lands with ARD (Afforestation, Reforestation and Deforestation) activities, are reported under Article 3, paragraph 3. These areas always remain under Article 3, paragraph 3. Afforestations older than 20 years are attributed to emissions factors of mature forests under forest management. These units of lands are reported in Table 5(KP-I)A.1.2 and not under forest management. Thus, there is no double counting of untis of lands under article 3, paragraph 3 to Article 3, paragraph 4.

Table 11-5 Area budget (in kha) of KP-LULUCF and LULUCF under the Convention (UNFCCC) in the year 2012 for forest land and afforestations.Table 11-5 shows the clear distinction between units of land subject to activities under Article 3, paragraph 3 and Land subject to Forest Management under Article 3, paragraph 4.

11.5.5 Information that indicates to what extend Removals from Forest Management offsets the Debit incurred under Article 3, Paragraph 3

This information is requested in the Annex to 15/CMP.1 paragraph 9.d.

This information is shown in the summary KP-CRF-Table "Information table on accounting for activities under Articles 3.3 and 3.4 of the Kyoto Protocol.

11.6 Other Information

11.6.1 Key Category Analysis for Article 3.3. and 3.4. Activities

The results of the Tier 2 key category analysis including LULUCF are shown and explained in Chapter 1.5 and are displayed in Table 1-9 for the year 2012. The smallest UNFCCC category, and therefore also the smallest LULUCF category, considered key based on a Tier 2 level assessment is “6D Waste, Other, CH4” with a contribution of 113.76 Gg CO_2 eq.

The following LULUCF activities under the Kyoto Protocol are listed in Kyoto Table NIR 3 (Table 11-3) because their associated LULUCF categories in the UNFCCC inventory are key categories under the level or trend assessment:

- **Forest Management** (-2'236.38 Gg CO_2 eq, encompasses all greenhouse gass emissions) is a key category under the Kyoto Protocol because its absolute contribution is higher than the smallest category considered key (113.76 Gg CO_2 eq for Tier 2) in the UNFCCC inventory. This activity is associated with the UNFCCC category „Forest Land remaining Forest Land“ (-2'134.56 Gg CO_2 eq, encompasses only CO_2 emissions). Since the total Swiss forest is considered as managed, there is a good agreement between the category under the Kyoto Protocol and the UNFCCC inventory category. According to Table 1-9, the UNFCCC category ”Forest Land remaining Forest Land“ is both level and trend key category under a Tier 2 assessment in 2012.

- **Afforestation and Reforestation** (-17.13 Gg CO_2 eq) is not a key category under the Kyoto Protocol because its absolute contribution is substantially lower than the smallest category considered key (113.76 Gg CO_2 eq for Tier 2) in the UNFCCC inventory. Natural forest regeneration due to abandonment of land is not reported as Afforestation under the Kyoto Protocol. The contribution of the associated UNFCCC category “Land converted to Forest Land” is 518.61 Gg CO_2 eq. It includes converted areas after natural regenrations, which are not reported as Afforestation under the Kyoto Protocol. The UNFCCC category “Land converted to Forest Land” is both level and trend key category under a Tier 2 assessment in 2012 (Table 1-9).

- **Deforestation** (221.87 Gg CO_2 eq) is a key category under the Kyoto Protocol because its contribution is higher than the smallest UNFCCC category considered key (113.76 Gg CO_2 eq for Tier 2). The associated UNFCCC category is „Land converted to Settlements” (302.93 Gg CO_2 eq), but only a part of this UNFCCC category represents the activity Deforestation under the Kyoto Protocol. The UNFCCC category ”Land converted to Settlements” is both level and trend key category under a Tier 2 assessment in 2012 (Table 1-9).

11.7 Information Relating to Article 6

Switzerland does not host Joint Implementation projects.

12 Information on Accounting of Kyoto Units

12.1 Background Information

The Swiss Emissions Trading Registry completed the go-live process and got fully operational with the International Transaction Log (ITL) on December 4, 2007. As part of the go-live process the entire Assigned Amount of 242’838’402 has been issued as AAUs for the first commitment period.

The user interface is located on the Swiss Emissions Trading Registry website (www.national-registry.ch/). Switzerland uses the Seringas™ registry software, which has been developed by the French Caisse des Dépôts et Consignations, CDC and cooperates with Monaco by hosting the Registry of this Party on Swiss servers. However, both national registries are maintained as independent systems with independent registry administrators.

The following registry systems’ reporting includes the standard electronic format (SEF) tables and the standard independent assessment report (SIAR) tables in accordance with sections E and G of the annex to decision 15/CMP.1.

12.2 Summary of Information Reported in the SEF Tables

The Standard Electronic Format report for 2013 has been submitted to the UNFCCC Secretariat electronically.

By the end of the reporting year 2013 a total balance of 248,768,078 Assigned Amount Units (AAUs) were held in the Swiss Emissions Trading Registry (Fig. 1), which represents a decrease of approximately 22 million units compared to 2012. From the initial assigned amount of 242,838,402 AAUs, 16,872,850 units have been allocated to companies participating in the Swiss Emissions Trading System in the first commitment period 2008-2012. 13,155,455 of those allocated units, 69,679 ERUs, and 505,689 CERs have been surrendered by companies by the end of 2013.

50,005,622 Emission Reduction Units (ERUs) were held in the Swiss Emissions Trading Registry, a reduction of approx. 6.5 Mio. units compared to the previous reporting year. The amount of Certified Emission Reductions (CERs) has slightly increased to 44,352,490. A total of 108,968 AAUs, 108,727 ERUs and 1,053,996 CERs have been voluntarily cancelled in the period from 2008 to 2013.

Table 12-1 Total quantities of Kyoto Protocol units by account type at the end of 2013 (SEF table 4)

Party	Switzerland
Submission year	2014
Reported year	2013
Commitment period	1

Table 4. Total quantities of Kyoto Protocol units by account type at end of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	239651621	558645	2214606	14934060	NO	NO
Entity holding accounts	8834902	49338250	NO	28364434	106695	NO
Article 3.3/3.4 net source cancellation accounts	172587	NO	489589	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	108968	108727	NO	1053996	8098	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	248768078	50005622	2704195	44352490	114793	NO

12.3 Discrepancies and Notifications

Switzerland's reports on discrepancies (R-2), CDM notifications (R-3), non-replacements (R-4) including reversal of storage and failure of certification and invalid units (R-5) have been uploaded on the UNFCCC Submission Portal.

During the reported year 2013, the Swiss Emissions Trading Registry had no discrepancies, no CDM notifications, no non-replacements including reversal of storage and failure of certification and no invalid units. Therefore the SIAR tables R-2, R-3, R-4 and R-5 are empty and no actions and changes have been taken to address discrepancies.

12.4 Publicly Accessible Information

In accordance to section E of the annex to decision 13/CMP.1 the Swiss Emissions Trading Registry makes non-confidential information available to the public via webpage or user-interface.

Non-confidential information is publicly available on the Swiss Emissions Trading Registry website www.national-registry.ch. The national allocation plan is accessible under 'National Allocation Plan'. All other information can be downloaded by selecting the menu item 'Reports'. The reports 'List of legal entities holding an account in the national registry', 'List of installations created in the Swiss national registry', 'List of accounts opened in the national registry', 'Annual summary of quantity per type of operation made in the national registry', 'Summary statement on the quantity of surrendered Allowances', 'Verified emissions table', 'Surrendered allowances table', and 'Compliance statement status table' are publicly accessible.

Data of transfers and holdings of individual accounts are considered as business secrets and the disclosure may prejudice their competitiveness. Information on acquiring and transferring units of companies (as legal persons) is therefore regarded as personal data. Article 19 of the Federal Act on Data Protection (FADP, SR 235.1 Bundesgesetz vom 19. Juni 1992 über den Datenschutz (DSG) 2) enacts that Federal bodies may disclose personal data if there is a legal basis for doing so or if there is an overriding public interest. In the present case these conditions are not fulfilled. Therefore, the registry of Switzerland cannot make the information on acquiring and transferring accounts publicly available and considers them as confidential. A statement on which information is considered as confidential can be found on the public website www.national-registry.ch.

All other information referred to in paragraphs 44 to 48 to the annex to decision 13/CMP.1 are made publicly available by the Swiss Emissions Trading Registry, if they are not covered by the above mentioned articles.

Information related to Article 6 projects is publicly accessible on the website http://www.bafu.admin.ch/ji-e. Switzerland does not host JI-projects and therefore no issuance of ERUs has taken place.

12.5 Calculation of the Commitment Period Reserve (CPR)

The commitment period reserve remains unchanged and is the same as defined in the update of the Initial Report (submitted on 20 December 2007; FOEN 2006h). The calculation of the commitment period reserve is based on the assigned amount (Method 1 in Table 12-2).

Table 12-2 Calculation of the commitment period reserve

Method 1 (based on assigned amount)	Method 2 (based on latest reviewed submission)
90 % of the assigned amount [t CO_2 equivalent]	Total of 2011 emissions of sectors 1,2,3,4,6 times 5 [t CO_2 equivalent]
242 838 402 x 0.9 = **218 554 562**	50 149 216 x 5 = **250 746 080**

Method 1 results in the lower value. Accordingly the commitment period reserve of Switzerland is calculated as 218 554 562 tonnes CO_2 equivalent.

12.6 KP-LULUCF Accounting

According to the 'Report of the individual review of the annual submission of Switzerland submitted in 2012' (http://unfccc.int/resource/docs/2013/arr/che.pdf), Switzerland cancelled 144,158 Removal Units (RMUs) for its Deforestation activities into its Net Source Cancellation account (ITL notification ID: 1000340049), and subsequently issued 24,586 RMUs for its Afforestation and Reforestation activities, and 810,496 RMUs for its Forest Management activities in its Emissions Trading Registry. The transactions took place on 30 July 2013 (cancellation), and 8 August 2013 (issuance) respectively..

13 Information on Changes in National System

The initial Swiss national inventory system is described in detail in FOEN (2006h). The detailed description of the national inventory system is updated annually in the description of the quality management system (FOEN 2014a). Changes to the national system in accordance with 15/CMP.1, annex II, 30a-g are listed below.

Change of name or contact information (15/CMP.1 annex II.D 30a):
No changes.

Change of roles and responsibilities as well as change of the institutional, legal and procedural arrangements (15/CMP.1 annex II.D 30b):

The current arrangements for cooperation within the national inventory system are shown in Table 13-1. No changes.

Changes in the process of inventory compilation (15/CMP.1 annex II.D 30c):

No changes.

Change of key source identification and archiving (15/CMP.1 annex II.D 30d):

No changes.

Change of process for recalculations (15/CMP.1 annex II.D 30e):

No changes.

Changes to QA/QC plan, activities and procedures (15/CMP.1 annex II.D 30f):

No changes.

Change to official consideration and approval procedures (15/CMP.1 annex II.D 30g):

No changes.

Table 13-1: Formal arrangements for cooperation within the national inventory system. Items marked in bold have changed in the past year.

Partner	**Subject/Sector**	**Type of arrangement**	**Duration**
Institutions of the federal administration			
Swiss Federal Office of Energy (SFOE)	Energy statistics	Agreement	open-ended
Federal Office of Civil Aviation (FOCA)	Aviation emissions	Agreement	open-ended
Swiss Federal Statistical Office (SFSO)	LULUCF (area surveys)	Agreement	open-ended
Agroscope research station	Agriculture emissions and removals	Agreement with the FOAG	open-ended
FOEN air pollution control and chemicals division (new name of the division)	- EMIS inventory data base & archive - Energy emissions - Industrial process emissions (without F-gases) -Solvent and Other Product Use emissions - Waste emissions - Key category analysis	Documentation of roles and responsibilities	open-ended
FOEN forest division	Forestry emissions and removals	Documentation of roles and responsibilities	2014
Private companies			
Carbotech	F-gas emissions	Contract	renewed annually
Sigmaplan / Meteotest	LULUCF data compilation	Contract	renewed annually
EBP / INFRAS	- NIR - Uncertainty analysis	Contract	2009-2014
Prognos	Allocation of energy data to specific industrial and commercial sectors	Contract	renewed annually

14 Information on Changes in National Registry

Table 14-1: Changes in the national registry in accordance with §32 decision 15/CMP.1

Annual Submission Item	Reporting
15/CMP.1 annex II.E paragraph 32.(a): Change of name or contact	No change in the name or contact information of the registry administrator occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(b): Change of cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c): Change of the database or the capacity of National Registry	No change to the database or to the capacity of the national registry occurred during the reported period
15/CMP.1 annex II.E paragraph 32.(d): Change of conformance to technical standards	No change in the registry's conformance to technical standards occurred for the reported period
15/CMP.1 annex II.E paragraph 32.(e): Change of discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f): Change of Security	No change of security measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(g): Change of list of publicly available information	No change to the list of publicly available information occurred during the reporting period
15/CMP.1 annex II.E paragraph 32.(h): Change of Internet address	No change of the registry Internet address occurred during the reporting period
15/CMP.1 annex II.E paragraph 32.(i): Change of data integrity measures	No change of data integrity measures occurred during the reporting period
15/CMP.1 annex II.E paragraph 32.(j):	No change of test results occurred during the reporting period

15 Information on Minimization of Adverse Impacts in Accordance with Article 3, Paragraph 14

The Convention (Art. 4 §8 and §10) and its Kyoto Protocol (Art. 2 §3 and Art. 3 §14) commit Parties to strive to implement climate policies and measures in such a way as to minimize adverse economic, social and environmental impacts on developing countries when responding to climate change.

Context

Switzerland strives to design climate change policies and measures in a way as to ensure a balanced distribution of mitigation efforts by implementing climate change response measures in all sectors and for different gases. Indirectly, this approach is deemed to minimize also the scope of potential adverse impacts on concerned actors (including developing countries). Though, due to Switzerland's size and share related to international trade – mainly concentrated on the EU – and greenhouse gas emissions, it is not assumed that Swiss climate change policies have any significant adverse economic, social and environmental impacts in developing countries. Additionally, the policies and measures are very much compatible and consistent with those of the European Union in order to avoid trade distortion, non-tariff barriers to trade and to set similar incentives. All major projects of law in Switzerland are accompanied by impact assessments, inter alia including evaluation of trade-related issues. In accordance with international law, this approach strives at ensuring that Switzerland is implementing those climate change response measures, which are least trade distortive and do not create unnecessary barriers to trade. Consistently, Switzerland notifies all proposed non-tariff measures having a potential impact on trade to the WTO, where specific concerns can be raised by other parties. Moreover, Switzerland belongs to the most important donors in the area of Aid for Trade.

The impact assessment is accompanied by a broad internal and external consultation process, inter alia inviting competent actors to provide advice on international economic, social and environmental aspects of proposed policies and measures. The open public consultation process, together with regular policy dialogues with other countries guarantee that all domestic and foreign stakeholders can raise concerns and issues about new policy initiatives, i.e. including those concerns about possible adverse impacts on other countries.

Progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities

Environmental policy in Switzerland, including climate change policies, are guided by the "polluter pays" principles, as enshrined in the Federal Law on the Protection of the Environment. Accordingly, the internalization of external costs and adequate price signals are key aspects of Switzerland's climate change policy. Regarding greenhouse gas emissions, market-based instruments, such as the Swiss Emissions Trading Scheme, the supplemental use of Certified Emission Reductions from the Clean Development Mechanism or the levy for heating and process fuels are important measures to put a price on emissions of greenhouse gases (see Sixth National Communication for more details), that are then reflected in market prices and thus internalizing externalities.

Fiscal incentives, tax and duty exemptions and subsidies

Price-based measures are recognized as essential instruments for promoting the efficient use of resources and to reduce market imperfections. In 2001 Switzerland introduced a heavy vehicle fee (HVF). It is applied to passenger and freight transport vehicles of more than 3.5 tonnes gross weight. The impact of the HVF introduction was most clearly reflected by changes in traffic volume (truck-kilometres) but also in reduced air pollution, a renewal of the heavy vehicle fleet and an increase of load per vehicle, fewer trucks having transported more goods. Two thirds of the revenues are used to finance major railway infrastructure projects (such as the two base tunnels through the Alps), and one third is transferred to the cantons.

In 2008 Switzerland introduced a CO_2 levy on heating and process fuel to set an incentive for a more efficient use of fossil fuels, promote investment in energy-efficient technologies and the use of low-carbon or carbon-free energy sources. The 2013 amendment to the CO_2 act (Swiss Confederation 2012) still encompasses the imposition of a CO_2 levy on heating and process fuel. Companies, especially those industries with substantial CO_2 emissions from use of heating fuels, may apply for exemption from the CO_2 levy, provided the company commits to emission reductions. The company has to elaborate an emission reduction target, based on the technological potential and economic viability of various measures within the company. While the proceeds from the CO_2 levy were initially to be fully and equally refunded to the Swiss population and to the business community in proportion of wages paid, a parliamentary decision of June 2009 earmarked a third of the revenues from the CO_2 levy to CO_2 relevant measures in the building sector (Building refurbishment programme). The partial earmarking of revenues from the CO_2 tax is limited in the revised CO_2 act to a maximum of 300 million Swiss francs per year.

The economic impact of the Swiss climate policy was analysed in two studies[18]. The impact is considered to be very small.

Switzerland does not subsidize fossil fuels in general. There are some minor schemes in place though that may be regarded as fossil fuel subsidies. In international comparison, however, these schemes are limited: At the federal level, a few tax exemptions and reductions provide some form of support to users of fossil fuels. Farmers, foresters, fishermen and the fuel use of snow cats are exempt from the mineral oil tax that is normally levied on sales of mineral oils, while public transport companies benefit from a reduced rate. Some vehicles are also exempt from the performance-related Heavy Vehicle Fee (HFV), e.g. agricultural vehicles, vehicles used for the concessionary transport of persons or vehicles for police, fire brigade, oil and chemical emergency unit, civil protection and ambulances.

The need for energy prices reforms

World-wide subsidies for fossil fuels are estimated at 300-500 billion USD per annum, depending on the level of energy prices. This huge market distortion does not only produce severe fiscal problems for the countries concerned, it is also a major obstacle for enhanced investments in energy efficiency measures and renewable energies.

Switzerland as a member of the Friends of Fossil Fuels Subsidies Reform group supports the gradual and sustained reduction of unnecessary market-distortions. Switzerland under its Economic Development Cooperation supports partner countries in the design and implementation of energy tariff reforms, as an element of infrastructure financing programs. Switzerland has been an initiator of specialized international programs, including the World Bank's

[18] Ecoplan (2009): Volkswirtschaftliche Auswirkungen der Schweizer Post-Kyoto-Politik, im Auftrag des BAFU. BAFU (2010): Synthesebericht zur Volkswirtschaftlichen Beurteilung der Schweizer Klimapolitik nach 2012.

Energy Sector Management Program ESMAP. The Energy Efficiency Governance Handbook has been produced with Swiss financing (IEA/EBRD 2010).

Removing subsidies associated with the use of environmentally unsound and unsafe technologies

Switzerland doesn't subsidize the use of environmentally unsound and unsafe technologies.

Strengthening the capacity of developing country Parties for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities

Switzerland supports through different projects the enhancement of efficiency in industrial production, i.e. "cleaner production". These cleaner production projects promote eco-efficient means of production and better working conditions attained through technical improvements and behavioural changes in both management and staff in industrial companies and services. The resulting rise of economic and environmental efficiency and improved competitiveness is gained through the systematic optimisation of energy use, processing of raw material, more efficient use of resources and thus better protection of the environment.

Furthermore, there is a rising awareness and demand by consumers for environmentally sound products. In order to alleviate potential adverse economic impacts of corresponding national measures Switzerland promotes and supports the development of international standards, especially with regard to the sustainable use of natural resources (including agricultural commodities), e.g. through the creation of sustainability standards, financial incentives and favourable framework conditions in developing countries by consultancy services and technology transfer. Further information is contained in Chapter 7 of Switzerland's Sixth National Communication (FOEN 2014d).

Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies

Most developing and transition countries have, in recent years, taken important steps towards trade liberalisation, in order to align their trade policies with multilateral trade agreements. The Swiss State Secretariat for Economic Affairs (SECO) supports these efforts, because a multilaterally acknowledged and respected set of regulations for international transactions not only strengthens trade as such, but also creates more potent and legally secure markets to the benefit of all players.

The measures taken by SECO are aimed at creating the necessary conditions for earning additional income in the beneficiary countries and thereby contribute directly to the alleviation of poverty. SECO is focusing on three areas of intervention along the value chain: (i) International competitiveness (ii) Enabling framework conditions for trade (iii) Improving market access.

For example market access: Trade between developing and industrial countries is still insufficiently developed respectively not diversified enough. On one hand, the developing countries lack the necessary production capacities, transport infrastructure and know-how; on the other hand, tariff and non-tariff barriers to trade make direct access to markets more difficult.

Switzerland promotes access to Swiss markets by granting preferential tariffs on products from developing and emerging countries. In addition, SECO runs programmes for promoting imports to Switzerland and the rest of Europe. The easing of market entry for products from disadvantaged countries is an important contribution to the promotion and diversification of trade, the increase of export revenues and thus to the economic development of the partner countries. Switzerland supports developing and transition countries in the following areas:

- Generalized system of preferences (GSP)
- Swiss Import Promotion Program (www.sippo.ch)
- Development of new private voluntary social and environmental standards based on international multi-stakeholder approaches: private sustainability standards Better Cotton, 4C (Common Code for the Coffee Community), Roundtable for Sustainable Biofuels, etc.

Finally, Switzerland is a strong supporter of the EITI (Extractive Industries Transparency Initiative). We share a belief that the rational use of natural resource wealth is an important driving force for sustainable economic growth that contributes to sustainable development and poverty reduction. The sustainable management of natural resource wealth – as supported by EITI principle and criteria incl. regular publication and audit of revenues – is key to mobilize the funds for diversification strategies.

Changes compared to the latest submission

The reference regarding capacity-building and technology transfer has been updated and refers now to the 6th National Communication. Some minor editorial changes and clarifications have been done.

16 Other Information

This Chapter contains Switzerland's response to the Saturday Paper (UNFCCC 2013a). Together with this response, Switzerland has also submitted a resubmission of the CRFs to the UNFCCC in November 2013 (FOEN 2013g):

Bonn 07 September 2013

Potential Problems and Further Questions from the ERT formulated in the course of the 2013 review of the greenhouse gas inventories of Switzerland submitted in 2013

For the ERT,

Mr. Ole-Kenneth Nielsen, Lead Reviewer   Ms. Medea Inashvili, Lead Reviewer

Inventory related potential problems

With reference to the Guidelines for review under Article 8 of the Kyoto Protocol, the ERT requests that additional information and/or revised estimates for the 2011 greenhouse gas (GHG) inventory corresponding to the potential problems identified in this paper (see attached tables) be forwarded to the ERT, through the UNFCCC secretariat, not later than by 21 October 2013.

Should Switzerland decide to submit by 21 October 2013, in response to some or all potential problems, revised estimates of its GHG emissions, the ERT requests that the revised estimates contain the following:

- Relevant background information and a descriptive summary of the revisions made by Switzerland in its 2013 inventory submission with respect to CO2 emissions from fuel combustion, N2O emissions from public electricity and heat production, CH4 emissions from other energy industries, CH4 and N2O emissions from residential plants, fugitive CO2 and CH4 emissions from oil transport, all from the energy sector and HFC emissions from refrigeration and air conditioning equipment from the industrial processes sector;
- A complete resubmission of the 2013 CRF-tables, reflecting the revised estimates;
- Switzerland's revision of the calculation of the commitment period reserve, based on the recalculated emissions reported for 2011, if the calculation of the commitment period reserve is based on the inventory and not the assigned amount.

ATTACHMENT A

Overview of inventory potential problems identified for 2008-2011

Annex A sources

2013 GHG inventory review

Switzerland

Abbreviations:

GPG: IPCC good practice guidance

AD: activity data, EF: emission factor, IEF: implied emission factor

KC: key category, ERT: Expert Review Team

Sector, category, sub-category (with code)	Gas	KC / non-KC	Identified inventory problem in terms of:		
			Missing estimate	Estimate provided but not in line with GPG	Estimate provided but lack of transparency
1. Energy, 1.A Fuel combustion	CO_2	Level and trend		X	

Description of problem identified:

During the review the ERT identified that the CO_2 EF used for natural gas in Switzerland (55 t CO_2/TJ) was lower than that of all neighbouring countries as well as lower than the IPCC default value (56.1 t CO_2/TJ). The ERT required further information regarding the source of the EF that in the NIR was presented as a country-specific EF. Switzerland informed the ERT that the EF originally came from the 1992 version of the CORINAIR Guidebook. Considering that the EF was lower than the IPCC default and lower than all neighbouring countries and that the EF was not country-specific and backed up by documentation the ERT concluded that the estimate of CO_2 emissions from natural gas combustion in Switzerland is not in line with the IPCC GPG.

Recommendation by ERT:

The ERT recommends that Switzerland:

- Use a country-specific EF.
- If a country-specific EF is not available, the default value from the Revised 1996 IPCC Guidelines can be used.
- Recalculate emissions of CO_2 from natural gas combustion for 2008-2011
- Provide the ERT with the reference of the EF used in the recalculation

Response / Information by Party:

Emissions from natural gas combustion have been recalculated for the entire time period 1990-2011, using the CO2-EF of the 2006 IPCC guidelines of 56.1 t/TJ. The CO2-EF is the same as in the revised 1996 IPCC guidelines (15.3 tC/TJ).

CO2 emissions Sector 1A [t]	1990	2008	2009	2010	2011
Submission April 2013	3'731'116	6'448'315	6'186'794	6'909'500	6'129'790
Submission September 2013 Saturdaypaper	3'805'738	6'577'281	6'310'530	7'047'690	6'252'386

Potential problem unsolved? Rationale:

The ERT considered the response of Switzerland with regard to the potential underestimation of CO_2 emissions from natural gas combustion. Switzerland has revised the EF for natural gas combustion using the default EF from the IPCC guidelines. Estimations are performed in accordance to IPCC methodologies (Revised 1996 IPCC guidelines). The ERT concluded that this potential problem has been resolved in the course of the review.

Overview of inventory potential problems identified for <u>2009-2011</u>

Annex A sources

2013 GHG inventory review

Switzerland

Abbreviations:

GPG: IPCC good practice guidance

AD: activity data, EF: emission factor, IEF: implied emission factor

KC: key category, ERT: Expert Review Team

Sector, category, sub-category (with code)	Gas	KC / non-KC	Identified inventory problem in terms of:		
			Missing estimate	Estimate provided but not in line with GPG	Estimate provided but lack of transparency
1.Energy, 1.A.1 Energy industries, 1.A.1.a Public electricity and heat production	N_2O	**non-KC**		X	

Description of problem identified:

During the review the ERT raised a question regarding the N_2O IEF from waste incineration. In response, Switzerland informed the ERT that an error had been detected for the years 2009-2011. By mistake the N_2O EFs for fossil and biogenic municipal waste incineration are not identical for the year 2009 and onward. The N_2O EF used for biogenic waste is lower than the real EF.

Recommendation by ERT:

The ERT recommends that Switzerland:

- Correct the N_2O EF used for biogenic municipal waste incineration
- Recalculate emissions of N_2O from municipal waste incineration for 2009-2011

Response / Information by Party:

The N2O EF has been corrected so that for both the biogenic and the fossil fraction the same EF is used. This correction is reflected in the revised estimates of the N2O emissions of municipal waste incineration in 1A1a Public electricity and heat production Biomass.

N2O emissions 1A1a Biomass [t]	1990	2008	2009	2010	2011
Submission April 2013	89	179	158	150	137
Submission September 2013 Saturdaypaper	89	179	165	155	141

Potential problem unsolved? Rationale:

The ERT considered the response of Switzerland with regard to the potential underestimation of N_2O emissions from biogenic waste combustion. Switzerland has revised the EF for biogenic waste combustion correcting the error identified during the review. The recalculation is performed in accordance with IPCC good practice guidance. The ERT concluded that this potential problem has been resolved in the course of the review.

Overview of inventory potential problems identified for 2011

Annex A sources

2013 GHG inventory review

Switzerland

Abbreviations:

GPG: IPCC good practice guidance

AD: activity data, EF: emission factor, IEF: implied emission factor

KC: key category, ERT: Expert Review Team

Sector, category, sub-category (with code)	Gas	KC / non-KC	Identified inventory problem in terms of:		
			Missing estimate	Estimate provided but not in line with GPG	Estimate provided but lack of transparency
1.Energy, 1.A.1 Energy industries, 1.A.1.c Other energy industries	CH_4	**non-KC**	X		

Description of problem identified:

In the NIR, Switzerland states that emissions from charcoal production are not included in the inventory. The Revised 1996 IPCC Guidelines contain a default CH_4 EF for charcoal production. Also, the ERT noted that the charcoal production as reported in the NIR for 2011 (0.11 Gg) is significantly lower than the data available through the FAO statistical database (5.0 Gg).

Recommendation by ERT:

The ERT recommends that Switzerland:

- Provide explanations of any discrepancies between the activity data reported in the NIR and the FAO data.
- Estimate emissions of CH_4 from charcoal production.
- Report the activity data and EFs used and the reference for these.

Response / Information by Party:

The activity data on charcoal production (table 4-25 in the NIR) used for estimating emissions from charcoal production are based on enquiries with the charcoal producers directly. They are considered complete.

The FAO data seem to be a very inhomogeneous time series: Constant production of 5Gg for 1999-2011, 0 Gg for 1986-1993, and values between 4Gg and 16Gg in between. Enquiries with the Swiss Federal Statistical Office, the Federal Office for Agriculture, the Swiss Federal Office of Energy and the Forest Division of the Federal Office for the Environment all resulted in the same answer, that no charcoal production in Switzerland is reported. An enquiry with the FAO as to how their data on charcoal production for Switzerland were derived is pending. However, according to the "Joint Wood Energy Enquiry JWEE", a database hosted by UNECE and FAO, charcoal production was reported 0 Gg. It seems as if FAO databases contain contradicting information.

Activity data was reported before in 2D3 (see also chapter 4.5.2.3 "Charcoal production (2D3)" of the NIR 2013). It is now transferred to 1A1c. CH4 emissions from charcoal production were estimated based on the activity data provided in the NIR table 4-25 and the default CH4-EF of the revised 1996 guidelines (1tCH4/TJ).

CH4 emissions charcoal production 1A1c Biomass [t]	1990	2008	2009	2010	2011
Submission April 2013	-	-	-	-	-
Submission September 2013 Saturdaypaper	1	3	3	3	3

Potential problem unsolved? Rationale:

The ERT considered the response of Switzerland with regard to the potential underestimation of CH_4 emissions from charcoal production. Switzerland has estimated CH_4 emissions using the activity data reported in the NIR combined with the default EF from the revised 1996 IPCC guidelines. The ERT considers that the activity data used by Switzerland are appropriate. However, the ERT recommends that Switzerland continues the communication with FAO to revise the production data in the FAO database. The recalculation is performed in accordance with IPCC good practice guidance. The ERT concluded that this potential problem has been resolved in the course of the review.

Overview of inventory potential problems identified for 2008-2011

Annex A sources

2013 GHG inventory review

Switzerland

Abbreviations:

GPG: IPCC good practice guidance

AD: activity data, EF: emission factor, IEF: implied emission factor

KC: key category, ERT: Expert Review Team

Sector, category, sub-category (with code)	Gas	KC / non-KC	Identified inventory problem in terms of:		
			Missing estimate	Estimate provided but not in line with GPG	Estimate provided but lack of transparency
1.Energy, 1.A.4 Other sectors, 1.A.4.b Residential	CH_4 and N_2O	**non-KC**	X		

Description of problem identified:

In connection with the issue related to charcoal production, the ERT enquired whether emissions from charcoal use were included in the emission inventory. Switzerland informed the ERT that emissions from charcoal use were not included. In the FAO statistical database the consumption of charcoal is available in case national statistics do not provide this information.

Recommendation by ERT:

The ERT recommends that Switzerland:

- Estimate emissions of CH_4 and N_2O from charcoal use.
- Provide explanations to any discrepancies between the activity data chosen for the emission estimation and the FAO data.
- Report the activity data and EFs used and the reference for these.

Response / Information by Party:

Activity data for estimating emissions from charcoal combustion are based on production, import and export data. Production data are listed in table 4-25 of the NIR (see also above). Import and export data is based on the Swiss energy balance. Comparing the time series of the Swiss energy balance with the data of FAO provides similar numbers in terms of import for several years (of the order of 300-350 TJ), however, FAO data seems rather inhomogeneous, with production varying between 300 TJ and 1000 TJ. As discussed above, the data source for FAO data is currently unclear, while the energy balance is based on import/export statistics of the Federal Customs administration, which is considered a more reliable source.

Emission factors for CH4 and N2O are based on the 2006 IPCC guidelines (online version), being the same as those of the revised 1996 IPCC guidelines. CH4-EF: 200 kg/TJ N2O-EF: 1 kg/TJ.

CH4 emissions charcoal use 1A4b [t]	1990	2008	2009	2010	2011
Submission April 2013	-	-	-	-	-
Submission September 2013 Saturdaypaper	62	71	69	69	69

N2O emissions charcoal use 1A4b [t]	1990	2008	2009	2010	2011
Submission April 2013	-	-	-	-	-
Submission September 2013 Saturdaypaper	0.3	0.3	0.3	0.3	0.3

Potential problem unsolved? Rationale:

The ERT considered the response of Switzerland with regard to the potential underestimation of CH_4 and N_2O emissions from charcoal combustion. Switzerland has estimated the emissions using charcoal production data and data for import and export combined with the default EFs from the IPCC guidelines. The recalculation is performed in accordance with IPCC good practice guidance. The ERT concluded that this potential problem has been resolved in the course of the review.

Overview of inventory potential problems identified for 2011

Annex A sources

2013 GHG inventory review

Switzerland

Abbreviations:

GPG: IPCC good practice guidance

AD: activity data, EF: emission factor, IEF: implied emission factor

KC: key category, ERT: Expert Review Team

Sector, category, sub-category (with code)	Gas	KC / non-KC	Identified inventory problem in terms of:		
			Missing estimate	Estimate provided but not in line with GPG	Estimate provided but lack of transparency
1.Energy, 1.B.2 Fugitive emissions from oil and natural gas, 1.B.2.a iii Oil transport	CO_2 and CH_4	non-KC	X		

Description of problem identified:

Switzerland is reporting activity data and emissions from oil transport as not occurring (NO). However, due to oil refining activities in Switzerland the transport of crude oil does occur. The previous ERT recommended that Switzerland provide verifiable information that emissions from oil transport do not occur in Switzerland. The current ERT raised a question on this matter during the review. In response, Switzerland acknowledged that the emissions occur and indicated that they would be estimated and reported for the 2014 annual submission.

Recommendation by ERT:

The ERT recommends that Switzerland:

- Estimate emissions of CO_2 and CH_4 from oil transport using the imported amount of crude oil as activity data and either country-specific EFs or IPCC default values.
- Report the activity data and EFs used and the reference for these.

Response / Information by Party:

The emissions are estimated based on the default EF provided in Table 4.2.4 of the 2006 IPCC reporting guidelines (CH4 EF 5.4E-6 Gg/1000m3, CO2 EF 4.9E-7Gg/1000m3). The density of the crude oil is taken as 0.82 t/m3, based on the annual statistics of the Swiss Petroleum Association (EV, 2012). Activity data are crude oil use according to CRF-table 1.B.2.a.

CH4 emissions from oil transport [t]	1990	2008	2009	2010	2011
Submission April 2013	NO	NO	NO	NO	NO
Submission September 2013 Saturdaypaper	21	33	31	30	29

CO2 emissions from oil transport [t]	1990	2008	2009	2010	2011
Submission April 2013	NO	NO	NO	NO	NO
Submission September 2013 Saturdaypaper	2	3	3	3	3

Potential problem unsolved? Rationale:

The ERT considered the response of Switzerland with regard to the potential underestimation of CO_2 and CH_4 emissions from oil transport. Switzerland has estimated the emissions using the amount of crude oil transported combined with CO_2 and CH_4 EFs from the 2006 IPCC guidelines. The recalculation is performed in accordance with IPCC good practice guidance. The ERT concluded that this potential problem has been resolved in the course of the review.

Overview of inventory potential problems identified for 2008-2011

Annex A sources

2013 GHG inventory review

Switzerland

Abbreviations:

GPG: IPCC good practice guidance

AD: activity data, EF: emission factor, IEF: implied emission factor

KC: key category, ERT: Expert Review Team

Sector, category, sub-category (with code)	Gas	KC / non-KC	Identified inventory problem in terms of:		
			Missing estimate	Estimate provided but not in line with GPG	Estimate provided but lack of transparency
2.Industrial processes, 2.F Consumption of halocarbons and SF_6, 2.F.1 refrigeration and air-conditioning equipment	HFCs	Level and Trend	X (estimate existing, but not included in CRF)		

Description of problem identified:

Switzerland uses a tier 2 approach in line with the IPCC GPG by modelling emissions from refrigeration and air conditioning using national statistics and industry data. Activity data and country-specific emission factors used are provided by industry or through expert estimates. In the 2013 NIR, Switzerland states that in the data files used for calculating the emissions from mobile air-conditioning / buses in category 2.F.1 an error has occurred which results in emissions related to the equipment type mobile air-conditioning / buses not being taken into account in the total emission figure of the category 2.F.1. The Party estimates emissions from mobile air conditioning in buses to be between 25-28 Gg CO_2-eq annually. This leads to an underestimation of approximately 2 per cent for this category for the years 2008-2011. As this error was discovered very late in the inventory compilation process, the Party was not able to correct the data files in time for the 2013 annual submission. The NIR indicates that the correction of the calculation model is planned for the 2014 annual submission.

Recommendation by ERT:

The ERT recommends Switzerland to submit revised emission data for category 2.F.1 by including emission estimates from air conditioning in buses.

Response / Information by Party:

The emissions from mobile air-conditioning have been recalculated, including emissions from buses. The recalculation results in additional emissions of HFC 134a of the order of 25-28 Gg CO2eq per year for the years 2008-2011.

HFC 134a Emission Sector 2 [t]	1990	2008	2009	2010	2011
Submission April 2013	0.02	354.61	353.99	384.10	451.16
Submission September 2013 Saturdaypaper	0.02	375.34	374.20	403.26	472.44

Potential problem unsolved? Rationale:

The ERT considered the data resubmitted by Switzerland and concluded that this potential problem has been resolved in the course of the review.

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References to EMIS database comments

Table A - 1 Assignments of NFR Codes to titles of EMIS database comments. These internal documents will be made available, on request, to reviewers by the NIC.

NFR Code CRF [UNECE]	EMIS Title	NFR Code CRF [UNECE]	EMIS Title
1 A 1 a	Kehrichtverbrennungsanlagen	2 G	Sprengen und Schiessen
1 A 1 a	Sondermüllverbrennungsanlagen	3 A 1	Farben-Anwendung Bau
1 A 1 a & 6 A 1	Kehrichtdeponien	3 A 2	Farben-Anwendung andere industrielle
1 A 1 a & 6 D	Vergärung IG (industriell-gewerblich)	3 A 1	Farben-Anwendung Haushalte**
1 A 1 a & 6 D	Vergärung LW (landwirtschaftlich)	3 A 1	Farben-Anwendung Holz
1 A 2 a	Eisengiessereien Kupolöfen	3 A 2	Farben-Anwendung andere nicht industrielle
1 A 2 a	Stahl-Produktion Wärmeöfen**	3 A 2	Farben-Anwendung Autoreparatur
1 A 2 b	Buntmetallgiessereien übriger Betrieb**	3 B 1	Elektronik-Reinigung
1 A 2 b & 2 C 3	Aluminium Produktion	3 B 1	Metallreinigung
1 A 2 d	Zellulose-Produktion Feuerung*	3 B 1	Reinigung Industrie übrige
1 A 2 f i & 2 A 3	Feinkeramik Produktion*	3 B 2	Chemische Reinigung
1 A 2 f i & 2 A 7	Glas übrige Produktion*	3 C	Druckfarben Produktion
1 A 2 f i & 2 A 7	Glaswolle Produktion Rohprodukt*	3 C	Farben-Produktion
1 A 2 f i & 2 A 7	Hohlglas Produktion*	3 C	Feinchemikalien-Produktion**
1 A 2 f i	Kalkproduktion, Feuerung*	3 C	Gummi-Verarbeitung
1 A 2 f i	Mischgut Produktion	3 C	Klebband-Produktion
1 A 2 f i & 2 A 3	Steinwolle Produktion	3 C	Klebstoff-Produktion
1 A 2 f i & 2 A 3	Ziegeleien**	3 C	Lösungsmittel-Umschlag und -Lager
1 A 2 f i	Zementwerke Feuerung	3 C	Pharmazeutische Produktion**
1 A 2 f i	Faserplatten Produktion**	3 C	Polyester-Verarbeitung
1 A 3 a & 1 A 5	Flugverkehr	3 C	Polystyrol-Verarbeitung
1 A 3 b i-viii	Strassenverkehr	3 C	Polyurethan-Verarbeitung
1 A 3 c	Schienenverkehr	3 C	PVC-Verarbeitung
1 A 3 e	Gasverteilung Netzverluste	3 C	Gerben von Ledermaterialien
1 A 4 c i	Grastrocknung	3 D [3 D 3]	Korrosionsschutz im Freien
1 A 4 div.	Off-Road	3 D 1 [3 D 3]	Lachgasanwendung Spitäler**
1 Energy Model***	Energie New	3 D 5 [3 D 2]	Reinigungs- und Lösemittel; Haushalte
1A solid fuels/wood	Holzfeuerungen	3 D 5 [3 D 2]	Spraydosen Haushalte**
1 B 2 a iv	Raffinerie, Leckverluste	3 D 5 [3 D 3]	Betonzusatzmittel-Anwendung
1 B 2 a v	Benzinumschlag Tanklager	3 D 5 [3 D 3]	Coiffeursalons
1 B 2 a v	Benzinumschlag Tankstellen	3 D 5 [3 D 1]	Druckereien
1 B 2 c	Raffinerie, Abfackelung	3 D 5 [3 D 3]	Entfernung von Farben und Lacken
2 A 1	Zementwerke Rohmaterial	3 D 5 [3 D 3]	Entwachsung von Fahrzeugen
2 A 1	Zementwerke übriger Betrieb	3 D 5 [3 D 3]	Fahrzeug-Unterbodenschutz
2 A 2	Kalkproduktion, Rohmaterial*	3 D 5 [3 D 3]	Feuerwerke
2 A 2	Kalkproduktion, übriger Betrieb*	3 D 5 [3 D 3]	Flugzeug-Enteisung
2 A 5	Dachpappen Produktion Emissionen aus Bitumen	3 D 5 [3 D 3]	Gas-Anwendung
2 A 5	Dachpappen Produktion Voranstrich	3 D 5 [3 D 3]	Gesundheitswesen, übrige**
2 A 5	Dachpappen Verlegung Bitumen	3 D 5 [3 D 3]	Glaswolle Imprägnierung*
2 A 5	Dachpappen Verlegung Voranstrich	3 D 5 [3 D 3]	Holzschutzmittel-Anwendung
2 A 6	Strassenbelagsarbeiten**	3 D 5 [3 D 3]	Klebstoff-Anwendung
2 A 7	Gips-Produktion übriger Betrieb**	3 D 5 [3 D 3]	Kosmetika-Produktion**
2 B 1	Ammoniak-Produktion*	3 D 5 [3 D 3]	Kosmetik-Institute
2 B 2	Salpetersäure Produktion*	3 D 5 [3 D 3]	Kühlschmiermittel-Verwendung
2 B 4	Graphit und Siliziumkarbid Produktion*	3 D 5 [3 D 3]	Lachgasanwendung Haushalt**
2 B 5	Ammoniumnitrat-Produktion*	3 D 5 [3 D 3]	Lösungsmittel-Emissionen IG nicht zugeordnet
2 B 5	Chlorgas-Produktion	3 D 5 [3 D 3]	Medizinische Praxen**
2 B 5	Essigsäure-Produktion**	3 D 5 [3 D 3]	Öl- und Fettgewinnung
2 B 5	Ethen-Produktion*	3 D 5 [3 D 3]	Papier- und Karton-Produktion**
2 B 5	Formaldehyd-Produktion	3 D 5 [3 D 3]	Parfum- und Aromen-Produktion**
2 B 5	PVC-Produktion	3 D 5 [3 D 3]	Pflanzenschutzmittel-Verwendung
2 B 5	Salzsäure-Produktion**	3 D 5 [3 D 3]	Pharma-Produkte im Haushalt
2 B 5	Schwefelsäure-Produktion*	3 D 5 [3 D 3]	Reinigung Gebäude IGD**
2 C 1	Eisengiessereien Elektroschmelzöfen	3 D 5 [3 D 3]	Schmierstoff-Verwendung
2 C 1	Eisengiessereien übriger Betrieb	3 D 5 [3 D 3]	Spraydosen IndustrieGewerbe
2 C 1	Stahl-Produktion Elektroschmelzöfen**	3 D 5 [3 D 3]	Tabakwaren Konsum
2 C 1	Stahl-Produktion übriger Betrieb**	3 D 5 [3 D 3]	Tabakwaren Produktion**
2 C 1	Stahl-Produktion Walzwerke**	3 D 5 [3 D 3]	Textilien-Produktion
2 C 5 d	Verzinkereien	3 D 5 [3 D 3]	Wissenschaftliche Laboratorien
2 C 5 e	Buntmetallgiessereien Elektroöfen**	3 D 5 [3 D 3]	Steinwolle-Imprägnierung
2 C 5 e	Batterie-Recycling**	4 div.***	Landwirtschaft
2 D 1	Zellulose Produktion übriger Betrieb*	6 B 1 [6 B]	Kläranlagen Industriell
2 D 1	Faserplatten Produktion**	6 B 2 [6 B]	Kläranlagen Kommunal
2 D 1	Spanplatten Produktion*	6 C [6 C d]	Krematorien
2 D 2	Bierbrauereien	6 C 1 [6 C e]	Abfallverbrennung Land- und Forstwirtschaft
2 D 2	Branntwein Produktion	6 C 2 [6 C a]	Spitalabfallverbrennung
2 D 2	Brot Produktion	6 C 2 [6 C b]	Kabelabbrand
2 D 2	Fleischräuchereien	6 C 2 [6 C b]	Klärschlammverbrennung
2 D 2	Kaffeeröstereien	6 C 2 [6 C c]	Abfallverbrennung illegal
2 D 2	Müllereien	6 D	Kompostierung Industrie
2 D 2	Wein Produktion	6 D	Shredder Anlagen
2 D 2	Zucker Produktion	6 D	Biogasaufbereitung (Methanverlust)
2 D 3	Holzkohle Produktion	7 C 1	Kompostierung, Verbreitung als Dünger im Haushalt
2 F div.	Synthetische Gase	7 D	Brand- und Feuerschäden Immobilien
2 D 3	Holzbearbeitung	7 D	Brand- und Feuerschäden Motorfahrzeuge

* confidential process
** confidential EMIS comment
** work in progress

Annexes

Annex 1: Key Category Analysis (KCA)

A1.1 Methodology

The key category analysis is performed according to the IPCC Good Practice Guidance (IPCC 2000, chapter 7): A Tier 1 level and trend assessment is applied with the proposed threshold of 95%. A Tier 2 key category analysis has also been carried out for this submission with the proposed threshold of 90% of the sum of all level assessments weighted with their relative source uncertainty. All main source categories have been disaggregated into sub-sources (e.g. 2A, 2B, 2C etc.) and gases (CO2, CH4, N2O, HFCs, PFCs, and SF6).

For some important sources, an even more detailed level of disaggregation has been used in order to clearly identify and isolate the most important sources.

This is the case for the important source category 1A Energy Fuel Combustion sources, where the source categories have been disaggregated further to the level of sub-categories as for example 1A1 Fuel Combustion – Energy Industries, 1A2 Fuel Combustion – Manufacturing Industries, etc. Even further disaggregation has been realized for the source category Transport (1A3) and Other Sectors (1A4):

The source Transport (1A3) has been further split into Civil Aviation (1A3a), Road Transportation (1A3b), Railways (1A3c), and Navigation (1A3d).

A more detailed disaggregation has also been carried out for Other Sectors (1A4) which has been split into Commercial/Institutional (1A4a), Residential (1A4b) and Agriculture/Forestry (1A4c).

Also the categories Mineral Products (2A) and Metal Production (2C) have been disaggregated into source categories. Consumption of Halocarbons and SF6 (2F) has been split into its source categories 2F1 to 2F9.

Agricultural Soils (4D) have been split into its source categories 4D1 to 4D4.

Uncertainty data have been taken from the uncertainty analysis, where the disaggregation of source and sink categories is in accordance with the key category analysis.

A1.2 KCA Tier 1 2012 *without LULUCF categories.*

Results of Key Category Analysis Tier 1 – Level and Trend

Table A - 2 Key category analysis Tier 1 2012 (without LULUCF) regarding level and trend.

Tier 1 Key category analysis 2012 without LULUCF categories													
	A					B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (without LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Year 2012 Estimate [Gg CO2 eq]	Level Assessm	Trend Assessm	% Contrib. in Trend	Result level assessm	Result trend assessm
1	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11335.27	9016.58	17.53%	0.04013	9.5%	KC level	KC trend
2	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.79	7374.50	14.33%	0.05183	12.3%	KC level	KC trend
3	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2587.68	6767.05	13.15%	0.08494	20.1%	KC level	KC trend
4	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Liquid Fuels	CO2	4606.43	3038.51	5.91%	0.02881	6.8%	KC level	KC trend
5	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1519.73	2714.50	5.28%	0.02471	5.8%	KC level	KC trend
6	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1424.38	2649.60	5.15%	0.02527	6.0%	KC level	KC trend
7	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Liquid Fuels	CO2	3692.22	2640.18	5.13%	0.01900	4.5%	KC level	KC trend
8	4A	4. Agriculture	A. Enteric Fermentation			CH4	2635.45	2496.98	4.85%	0.00132	0.3%	KC level	-
9	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Gaseous Fuels	CO2	1074.09	2096.41	4.07%	0.02102	5.0%	KC level	KC trend
10	2A1	2. Industrial P	A. Mineral Products; Cement Production-CO2			CO2	2524.68	1787.11	3.47%	0.01336	3.2%	KC level	KC trend
11	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Gaseous Fuels	CO2	987.24	1482.76	2.88%	0.01044	2.5%	KC level	KC trend
12	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.48	1143.10	2.22%	0.00342	0.8%	KC level	KC trend
13	2F1	2. Industrial P	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	1137.81	2.21%	0.02274	5.4%	KC level	KC trend
14	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	693.69	805.16	1.56%	0.00261	0.6%	KC level	KC trend
15	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	822.48	674.93	1.31%	0.00250	0.6%	KC level	KC trend
16	4B	4. Agriculture	B. Manure Management			CH4	671.61	646.11	1.26%	0.00014	0.0%	KC level	-
17	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	547.34	540.01	1.05%	0.00015	0.0%	KC level	-
18	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	289.73	498.74	0.97%	0.00434	1.0%	KC level	KC trend
19	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Solid Fuels	CO2	1204.47	454.87	0.88%	0.01432	3.4%	KC level	KC trend
20	4B	4. Agriculture	B. Manure Management			N2O	454.68	335.81	0.65%	0.00213	0.5%	KC level	KC trend
21	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Other Fuels	CO2	134.15	288.60	0.56%	0.00316	0.7%	KC level	KC trend
22	6B	6. Waste	B. Wastewater Handling			N2O	184.72	240.28	0.47%	0.00121	0.3%	KC level	-
23	4D2	4. Agriculture	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	220.79	0.43%	0.00192	0.5%	KC level	KC trend
24	1B2	1. Energy	B. Fugitive Emissions fr	2. Oil and Natural Gas		CH4	263.72	169.45	0.33%	0.00174	0.4%	-	KC trend
25	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	158.26	0.31%	0.01021	2.4%	-	KC trend
26	3	3. Solvent and Other Product Use				CO2	360.04	155.28	0.30%	0.00389	0.9%	-	KC trend
27	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	136.65	0.27%	0.00218	0.5%	-	KC trend
28	2F9	2. Industrial P	F. Consumption of Halocarbons and SF6; Other			SF6	79.58	135.91	0.26%	0.00117	0.3%	-	-
29	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	111.93	121.14	0.24%	0.00025	0.1%	-	-
30	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	203.58	114.80	0.22%	0.00166	0.4%	-	KC trend
31	6D	6. Waste	D. Other			CH4	29.94	113.76	0.22%	0.00169	0.4%	-	KC trend
32	2B	2. Industrial P	B. Chemical Industry			CO2	111.22	110.47	0.21%	0.00005	0.0%	-	-
33	2A3	2. Industrial P	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2			CO2	150.39	98.48	0.19%	0.00096	0.2%	-	-
34	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	CO2	0.00	83.59	0.16%	0.00167	0.4%	-	KC trend
35	2F9	2. Industrial P	F. Consumption of Halocarbons and SF6; Other			HFC	0.00	76.14	0.15%	0.00152	0.4%	-	-
36	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	5.74	66.06	0.13%	0.00121	0.3%	-	-
37	2A2	2. Industrial P	A. Mineral Products; Lime Production-CO2			CO2	53.35	54.26	0.11%	0.00005	0.0%	-	-
38	2B	2. Industrial P	B. Chemical Industry			N2O	68.13	53.57	0.10%	0.00025	0.1%	-	-
39	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CO2	31.42	45.44	0.09%	0.00030	0.1%	-	-
40	3	3. Solvent and Other Product Use				N2O	110.14	44.62	0.09%	0.00125	0.3%	-	-
41	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	28.69	39.69	0.08%	0.00024	0.1%	-	-
42	1B2	1. Energy	B. Fugitive Emissions fr	2. Oil and Natural Gas		CO2	84.62	39.29	0.08%	0.00086	0.2%	-	-
43	2F8	2. Industrial P	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	36.81	0.07%	0.00051	0.1%	-	-
44	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	97.87	33.78	0.07%	0.00123	0.3%	-	-
45	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	54.59	33.60	0.07%	0.00039	0.1%	-	-
46	2C	2. Industrial P	C. Metal Production; Magnesium Foundries			SF6	0.00	31.72	0.06%	0.00063	0.2%	-	-
47	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	142.38	27.52	0.05%	0.00222	0.5%	-	KC trend
48	6C	6. Waste	C. Waste Incineration			N2O	19.06	25.86	0.05%	0.00015	0.0%	-	-
49	6D	6. Waste	D. Other			N2O	5.82	25.55	0.05%	0.00040	0.1%	-	-
50	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	20.85	20.96	0.04%	0.00001	0.0%	-	-
51	4D4	4. Agriculture	D. Agricultural Soils; Use of sewage sludge as fertilizers			N2O	28.30	20.85	0.04%	0.00013	0.0%	-	-
52	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	27.72	19.75	0.04%	0.00014	0.0%	-	-
53	2F7	2. Industrial P	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture			SF6	0.00	19.55	0.04%	0.00039	0.1%	-	-
54	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	97.47	18.82	0.04%	0.00152	0.4%	-	-
55	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.94	18.69	0.04%	0.00013	0.0%	-	-
56	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	41.45	18.48	0.04%	0.00044	0.1%	-	-
57	2F2	2. Industrial P	F. Consumption of Halocarbons and SF6; Hard Foam			HFC	0.00	13.27	0.03%	0.00027	0.1%	-	-
58	2F4	2. Industrial P	F. Consumption of Halocarbons and SF6; Metered Dose Inhalers and Other			HFC	0.00	13.22	0.03%	0.00026	0.1%	-	-
59	2F9	2. Industrial P	F. Consumption of Halocarbons and SF6; Other			PFC	0.00	13.10	0.03%	0.00026	0.1%	-	-
60	7	7. Other				CO2	10.96	12.92	0.03%	0.00005	0.0%	-	-
61	6C	6. Waste	C. Waste Incineration			CO2	54.10	12.34	0.02%	0.00080	0.2%	-	-
62	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Liquid Fuels	N2O	13.92	11.76	0.02%	0.00004	0.0%	-	-
63	2C1	2. Industrial P	C. Metal Production; Steel Production			CO2	9.20	9.89	0.02%	0.00002	0.0%	-	-
64	6B	6. Waste	B. Wastewater Handling			CH4	4.65	9.28	0.02%	0.00010	0.0%	-	-
65	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.79	9.07	0.02%	0.00003	0.0%	-	-
66	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Liquid Fuels	N2O	11.70	7.80	0.02%	0.00007	0.0%	-	-
67	2A7	2. Industrial P	A. Mineral Products; Other non-specified-CO2			CO2	15.30	7.68	0.01%	0.00014	0.0%	-	-
68	2F5	2. Industrial P	F. Consumption of Halocarbons and SF6; Solvents			PFC	0.00	7.29	0.01%	0.00015	0.0%	-	-
69	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Biomass	N2O	1.68	6.85	0.01%	0.00010	0.0%	-	-
70	2F7	2. Industrial P	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture			PFC	0.00	6.54	0.01%	0.00013	0.0%	-	-
71	6C	6. Waste	C. Waste Incineration			CH4	11.58	6.14	0.01%	0.00010	0.0%	-	-
72	2F1	2. Industrial P	F. Consumption of Halocarbons and SF6; Refrigeration			PFC	0.04	6.14	0.01%	0.00012	0.0%	-	-
73	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.24	6.10	0.01%	0.00006	0.0%	-	-
74	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	4.96	5.54	0.01%	0.00001	0.0%	-	-
75	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Other Fuels	N2O	2.28	5.24	0.01%	0.00006	0.0%	-	-
76	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Gaseous Fuels	CH4	2.66	4.74	0.01%	0.00004	0.0%	-	-
77	2F5	2. Industrial P	F. Consumption of Halocarbons and SF6; Solvents			HFC	0.00	4.59	0.01%	0.00009	0.0%	-	-
78	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Biomass	CH4	9.74	4.13	0.01%	0.00011	0.0%	-	-
79	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Gaseous Fuels	CH4	2.41	3.83	0.01%	0.00003	0.0%	-	-
80	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	N2O	0.00	3.47	0.01%	0.00007	0.0%	-	-

Table A - 2 continued. Key category analysis Tier 1 2012 (without LULUCF) regarding level and trend.

Tier 1 Key category analysis 2012 without LULUCF categories													
A						B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (without LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Year 2012 Estimate [Gg CO2 eq]	Level Assessm	Trend Assessm	% Contrib. in Trend	Result level assessm	Result trend assessm
81	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Biomass	N2O	1.45	3.23	0.01%	0.00004	0.0%	-	-
82	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.86	0.01%	0.00002	0.0%	-	-
83	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Solid Fuels	N2O	6.44	2.41	0.00%	0.00008	0.0%	-	-
84	2B	1. Industrial F	B. Chemical Industry			CH4	1.54	2.39	0.00%	0.00002	0.0%	-	-
85	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.71	2.28	0.00%	0.00003	0.0%	-	-
86	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	6.00	2.26	0.00%	0.00007	0.0%	-	-
87	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Biomass	CH4	2.46	1.56	0.00%	0.00002	0.0%	-	-
88	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.46	0.00%	0.00001	0.0%	-	-
89	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.62	1.43	0.00%	0.00000	0.0%	-	-
90	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Liquid Fuels	CH4	3.06	1.40	0.00%	0.00003	0.0%	-	-
91	2C5	2. Industrial F	C. Metal Production; Non-ferrous metals-CO2			CO2	1.65	1.36	0.00%	0.00000	0.0%	-	-
92	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.49	1.35	0.00%	0.00002	0.0%	-	-
93	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Gaseous Fuels	N2O	0.59	1.15	0.00%	0.00001	0.0%	-	-
94	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	2.01	1.13	0.00%	0.00002	0.0%	-	-
95	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.65	1.12	0.00%	0.00001	0.0%	-	-
96	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Liquid Fuels	CH4	2.32	1.04	0.00%	0.00002	0.0%	-	-
97	2G	2. Industrial F	G. Other			CO2	1.04	0.91	0.00%	0.00000	0.0%	-	-
98	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	N2O	0.66	0.82	0.00%	0.00000	0.0%	-	-
99	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Gaseous Fuels	N2O	0.55	0.82	0.00%	0.00001	0.0%	-	-
100	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.70	0.00%	0.00001	0.0%	-	-
101	1B2	1. Energy	B. Fugitive Emissions fr	2. Oil and Natural Gas		N2O	0.62	0.68	0.00%	0.00000	0.0%	-	-
102	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.67	0.00%	0.00000	0.0%	-	-
103	7	7. Other				N2O	0.62	0.62	0.00%	0.00000	0.0%	-	-
104	7	7. Other				CH4	0.55	0.57	0.00%	0.00000	0.0%	-	-
105	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.38	0.55	0.00%	0.00002	0.0%	-	-
106	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	N2O	0.60	0.55	0.00%	0.00000	0.0%	-	-
107	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	CH4	0.58	0.54	0.00%	0.00000	0.0%	-	-
108	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	N2O	0.38	0.52	0.00%	0.00000	0.0%	-	-
109	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.33	0.43	0.00%	0.00000	0.0%	-	-
110	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Other Fuels	CH4	0.54	0.37	0.00%	0.00000	0.0%	-	-
111	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Biomass	N2O	0.21	0.35	0.00%	0.00000	0.0%	-	-
112	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.16	0.28	0.00%	0.00000	0.0%	-	-
113	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.25	0.00%	0.00000	0.0%	-	-
114	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.29	0.18	0.00%	0.00000	0.0%	-	-
115	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Biomass	CH4	0.80	0.15	0.00%	0.00001	0.0%	-	-
116	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Solid Fuels	CH4	0.40	0.14	0.00%	0.00000	0.0%	-	-
117	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.16	0.12	0.00%	0.00000	0.0%	-	-
118	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	CH4	0.00	0.10	0.00%	0.00000	0.0%	-	-
119	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.04	0.00%	0.00000	0.0%	-	-
120	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CH4	0.06	0.03	0.00%	0.00000	0.0%	-	-
121	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		N2O	0.02	0.03	0.00%	0.00000	0.0%	-	-
122	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.02	0.00%	0.00000	0.0%	-	-
123	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	CH4	0.01	0.02	0.00%	0.00000	0.0%	-	-
124	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.02	0.01	0.00%	0.00000	0.0%	-	-
125	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	CH4	0.01	0.01	0.00%	0.00000	0.0%	-	-
126	6D	6. Waste	D. Other			CO2	0.00	0.00	0.00%	0.00000	0.0%	-	-
127	6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.24	0.00	0.00%	0.00000	0.0%	-	-
128	2C3	2. Industrial F	C. Metal Production; Aluminium Production-CO2			CO2	139.26	0.00	0.00%	0.00000	0.0%	-	-
129	2C3	2. Industrial F	C. Metal Production; Aluminium Production-PFC			PFC	100.17	0.00	0.00%	0.00000	0.0%	-	-
130	2C	2. Industrial F	C. Metal Production; Aluminium Foundries			SF6	0.00	0.00	0.00%	0.00000	0.0%	-	-
131	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	44.84	0.00	0.00%	0.00000	0.0%	-	-
132	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.00	0.00%	0.00000	0.0%	-	-
133	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.24	0.00	0.00%	0.00000	0.0%	-	-
134	6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.24	0.00	0.00%	0.00000	0.0%	-	-
135	6D	6. Waste	D. Other			CO2	0.00	0.00	0.00%	0.00000	0.0%	-	-

A1.3 KCA Tier 1 2012 including LULUCF categories

Results of Key Category Analysis Tier 1 – Level and Trend

Table A - 3 Key category analysis Tier 1 2012 (with LULUCF) regarding level and trend.

Tier 1 Key category analysis 2012 with LULUCF categories													
	A					B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (with LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Year 2012 Estimate [Gg CO2 eq]	Level Assessm	Trend Assessm	% Contrib. in Trend	Result level assessm	Result trend assessm
1	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11335.27	9016.58	16.21%	0.03753	9.2%	KC level	KC trend
2	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.79	7374.50	13.26%	0.04828	11.8%	KC level	KC trend
3	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2587.68	6767.05	12.16%	0.07824	19.1%	KC level	KC trend
4	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Liquid Fuels	CO2	4606.43	3038.51	5.46%	0.02679	6.5%	KC level	KC trend
5	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1519.73	2714.50	4.88%	0.02273	5.5%	KC level	KC trend
6	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1424.38	2649.60	4.76%	0.02324	5.7%	KC level	KC trend
7	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Liquid Fuels	CO2	3692.22	2640.18	4.75%	0.01770	4.3%	KC level	KC trend
8	4A	4. Agricultu	A. Enteric Fermentation			CH4	2635.45	2496.98	4.49%	0.00134	0.3%	KC level	KC trend
9	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	-2416.89	-2134.56	3.84%	0.00409	1.0%	KC level	KC trend
10	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Gaseous Fuels	CO2	1074.09	2096.41	3.77%	0.01934	4.7%	KC level	KC trend
11	2A1	2. Industria	A. Mineral Products; Cement Production-CO2			CO2	2524.68	1787.11	3.21%	0.01244	3.0%	KC level	KC trend
12	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Gaseous Fuels	CO2	987.24	1482.76	2.67%	0.00959	2.3%	KC level	KC trend
13	4D1	4. Agricultu	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.48	1143.10	2.05%	0.00322	0.8%	KC level	KC trend
14	2F1	2. Industria	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	1137.81	2.05%	0.02098	5.1%	KC level	KC trend
15	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	693.69	805.16	1.45%	0.00237	0.6%	KC level	KC trend
16	5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	345.17	707.27	1.27%	0.00683	1.7%	KC level	KC trend
17	4D3	4. Agricultu	D. Agricultural Soils; Indirect Emissions			N2O	822.48	674.93	1.21%	0.00234	0.6%	KC level	KC trend
18	4B	4. Agricultu	B. Manure Management			CH4	671.61	646.11	1.16%	0.00016	0.0%	KC level	-
19	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	547.34	540.01	0.97%	0.00012	0.0%	KC level	-
20	5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO2	-621.57	-518.61	0.93%	0.00161	0.4%	KC level	KC trend
21	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	289.73	498.74	0.90%	0.00399	1.0%	KC level	KC trend
22	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Solid Fuels	CO2	1204.47	454.87	0.82%	0.01327	3.2%	KC level	KC trend
23	4B	4. Agricultu	B. Manure Management			N2O	454.68	335.81	0.60%	0.00198	0.5%	KC level	KC trend
24	5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	382.71	302.93	0.54%	0.00129	0.3%	KC level	-
25	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Other Fuels	CO2	134.15	288.60	0.52%	0.00291	0.7%	KC level	KC trend
26	6B	6. Waste	B. Wastewater Handling			N2O	184.72	240.28	0.43%	0.00111	0.3%	KC level	-
27	4D2	4. Agricultu	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	220.79	0.40%	0.00177	0.4%	KC level	KC trend
28	1B2	1. Energy	B. Fugitive Emissions fror	2. Oil and Natural Gas		CH4	263.72	169.45	0.30%	0.00162	0.4%	KC level	KC trend
29	5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO2	59.85	169.07	0.30%	0.00204	0.5%	-	KC trend
30	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	158.26	0.28%	0.00945	2.3%	-	KC trend
31	3	3. Solvent and Other Product Use				CO2	360.04	155.28	0.28%	0.00361	0.9%	-	KC trend
32	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	136.65	0.25%	0.00202	0.5%	-	KC trend
33	2F9	2. Industria	F. Consumption of Halocarbons and SF6; Other			SF6	79.58	135.91	0.24%	0.00108	0.3%	-	-
34	5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	107.09	134.74	0.24%	0.00056	0.1%	-	-
35	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	111.93	121.14	0.22%	0.00022	0.1%	-	-
36	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	203.58	114.80	0.21%	0.00154	0.4%	-	KC trend
37	6D	6. Waste	D. Other			CH4	29.94	113.76	0.20%	0.00156	0.4%	-	KC trend
38	5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land		CO2	91.98	112.28	0.20%	0.00042	0.1%	-	-
39	2B	2. Industria	B. Chemical Industry			CO2	111.22	110.47	0.20%	0.00004	0.0%	-	-
40	2A3	2. Industria	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2			CO2	150.39	98.48	0.18%	0.00089	0.2%	-	-
41	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	CO2	0.00	83.59	0.15%	0.00154	0.4%	-	KC trend
42	2F9	2. Industria	F. Consumption of Halocarbons and SF6; Other			HFC	0.00	76.14	0.14%	0.00140	0.3%	-	KC trend
43	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	5.74	66.06	0.12%	0.00111	0.3%	-	-
44	2A2	2. Industria	A. Mineral Products; Lime Production-CO2			CO2	53.35	54.26	0.10%	0.00004	0.0%	-	-
45	2B	2. Industria	B. Chemical Industry			N2O	68.13	53.57	0.10%	0.00024	0.1%	-	-
46	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CO2	31.42	45.44	0.08%	0.00027	0.1%	-	-
47	3	3. Solvent and Other Product Use				N2O	110.14	44.62	0.08%	0.00116	0.3%	-	-
48	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	28.69	39.69	0.07%	0.00022	0.1%	-	-
49	1B2	1. Energy	B. Fugitive Emissions fror	2. Oil and Natural Gas		CO2	84.62	39.29	0.07%	0.00080	0.2%	-	-
50	2F8	2. Industria	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	36.81	0.07%	0.00047	0.1%	-	-
51	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	97.87	33.78	0.06%	0.00114	0.3%	-	-
52	5E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements		CO2	3.60	33.69	0.06%	0.00056	0.1%	-	-
53	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	54.59	33.60	0.06%	0.00036	0.1%	-	-
54	2C	2. Industria	C. Metal Production; Magnesium Foundries			SF6	0.00	31.72	0.06%	0.00058	0.1%	-	-
55	5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands		CO2	20.06	28.95	0.05%	0.00017	0.0%	-	-
56	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	142.38	27.52	0.05%	0.00205	0.5%	-	KC trend
57	6C	6. Waste	C. Waste Incineration			N2O	19.06	25.86	0.05%	0.00013	0.0%	-	-
58	6D	6. Waste	D. Other			N2O	5.82	25.55	0.05%	0.00037	0.1%	-	-
59	5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO2	43.33	22.26	0.04%	0.00037	0.1%	-	-
60	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	20.85	20.96	0.04%	0.00001	0.0%	-	-
61	4D4	4. Agricultu	D. Agricultural Soils; Use of sewage sludge as fertilizers			N2O	28.30	20.85	0.04%	0.00012	0.0%	-	-
62	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	27.72	19.75	0.04%	0.00013	0.0%	-	-
63	2F7	2. Industria	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture			SF6	0.00	19.55	0.04%	0.00036	0.1%	-	-
64	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	97.47	18.82	0.03%	0.00141	0.3%	-	KC trend
65	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.94	18.69	0.03%	0.00012	0.0%	-	-
66	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	41.45	18.48	0.03%	0.00040	0.1%	-	-
67	2F2	2. Industria	F. Consumption of Halocarbons and SF6; Hard Foam			HFC	0.00	13.27	0.02%	0.00024	0.1%	-	-
68	2F4	2. Industria	F. Consumption of Halocarbons and SF6; Metered Dose Inhalers and Other			HFC	0.00	13.22	0.02%	0.00024	0.1%	-	-
69	2F9	2. Industria	F. Consumption of Halocarbons and SF6; Other			PFC	0.00	13.10	0.02%	0.00024	0.1%	-	-
70	7	7. Other				CO2	10.96	12.92	0.02%	0.00004	0.0%	-	-
71	6C	6. Waste	C. Waste Incineration			CO2	54.10	12.34	0.02%	0.00074	0.2%	-	-
72	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Liquid Fuels	N2O	13.92	11.76	0.02%	0.00003	0.0%	-	-
73	2C1	2. Industria	C. Metal Production; Steel Production			CO2	9.20	9.89	0.02%	0.00002	0.0%	-	-
74	6B	6. Waste	B. Wastewater Handling			CH4	4.65	9.28	0.02%	0.00009	0.0%	-	-
75	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.79	9.07	0.02%	0.00003	0.0%	-	-
76	5D2	5. LULUCF	D. Land converted to Wet	5(II) Non-CO2 emissions from drainage of soils and we		CH4	9.03	9.03	0.02%	0.00000	0.0%	-	-
77	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Liquid Fuels	N2O	11.70	7.80	0.01%	0.00007	0.0%	-	-
78	2A7	2. Industria	A. Mineral Products; Other non-specified-CO2			CO2	15.30	7.68	0.01%	0.00013	0.0%	-	-
79	2F5	2. Industria	F. Consumption of Halocarbons and SF6; Solvents			PFC	0.00	7.29	0.01%	0.00013	0.0%	-	-
80	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Biomass	N2O	1.68	6.85	0.01%	0.00010	0.0%	-	-

Table A – 3 continued. Key category analysis Tier 1 2012 (with LULUCF) regarding level and trend.

Tier 1 Key category analysis 2012 with LULUCF categories													
	A					B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (with LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Year 2012 Estimate [Gg CO2 eq]	Level Assessm	Trend Assessm	% Contrib. in Trend	Result level assessm	Result trend assessm
81	2F7	2. Industria	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture			PFC	0.00	6.54	0.01%	0.00012	0.0%	-	-
82	6C	6. Waste	C. Waste Incineration			CH4	11.58	6.14	0.01%	0.00009	0.0%	-	-
83	2F1	2. Industria	F. Consumption of Halocarbons and SF6; Refrigeration			PFC	0.04	6.14	0.01%	0.00011	0.0%	-	-
84	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.24	6.10	0.01%	0.00005	0.0%	-	-
85	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	4.96	5.54	0.01%	0.00001	0.0%	-	-
86	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Other Fuels	N2O	2.28	5.24	0.01%	0.00006	0.0%	-	-
87	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Gaseous Fuels	CH4	2.66	4.74	0.01%	0.00004	0.0%	-	-
88	2F5	2. Industria	F. Consumption of Halocarbons and SF6; Solvents			HFC	0.00	4.59	0.01%	0.00008	0.0%	-	-
89	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Biomass	CH4	9.74	4.13	0.01%	0.00010	0.0%	-	-
90	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Gaseous Fuels	CH4	2.41	3.83	0.01%	0.00003	0.0%	-	-
91	5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		N2O	5.58	3.58	0.01%	0.00003	0.0%	-	-
92	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	N2O	0.00	3.47	0.01%	0.00006	0.0%	-	-
93	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Biomass	N2O	1.45	3.23	0.01%	0.00003	0.0%	-	-
94	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.86	0.01%	0.00001	0.0%	-	-
95	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Solid Fuels	N2O	6.44	2.41	0.00%	0.00007	0.0%	-	-
96	2B	1. Industria	B. Chemical Industry			CH4	1.54	2.39	0.00%	0.00002	0.0%	-	-
97	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.71	2.28	0.00%	0.00002	0.0%	-	-
98	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	6.00	2.26	0.00%	0.00007	0.0%	-	-
99	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Biomass	CH4	2.46	1.56	0.00%	0.00002	0.0%	-	-
100	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.46	0.00%	0.00001	0.0%	-	-
101	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.62	1.43	0.00%	0.00000	0.0%	-	-
102	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Liquid Fuels	CH4	3.06	1.40	0.00%	0.00003	0.0%	-	-
103	2C5	2. Industria	C. Metal Production; Non-ferrous metals-CO2			CO2	1.65	1.36	0.00%	0.00000	0.0%	-	-
104	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.49	1.35	0.00%	0.00002	0.0%	-	-
105	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Gaseous Fuels	N2O	0.59	1.15	0.00%	0.00001	0.0%	-	-
106	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	2.01	1.13	0.00%	0.00002	0.0%	-	-
107	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.65	1.12	0.00%	0.00001	0.0%	-	-
108	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Liquid Fuels	CH4	2.32	1.04	0.00%	0.00002	0.0%	-	-
109	2G	2. Industria	G. Other			CO2	1.04	0.91	0.00%	0.00000	0.0%	-	-
110	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	N2O	0.66	0.82	0.00%	0.00000	0.0%	-	-
111	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutio	Gaseous Fuels	N2O	0.55	0.82	0.00%	0.00001	0.0%	-	-
112	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.70	0.00%	0.00001	0.0%	-	-
113	1B2	1. Energy	B. Fugitive Emissions fror	2. Oil and Natural Gas		N2O	0.62	0.68	0.00%	0.00000	0.0%	-	-
114	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.67	0.00%	0.00000	0.0%	-	-
115	7	7. Other				N2O	0.62	0.62	0.00%	0.00000	0.0%	-	-
116	7	7. Other				CH4	0.55	0.57	0.00%	0.00000	0.0%	-	-
117	5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands		CO2	2.87	0.56	0.00%	0.00004	0.0%	-	-
118	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.38	0.55	0.00%	0.00001	0.0%	-	-
119	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	N2O	0.60	0.55	0.00%	0.00000	0.0%	-	-
120	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	CH4	0.58	0.54	0.00%	0.00000	0.0%	-	-
121	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	N2O	0.38	0.52	0.00%	0.00000	0.0%	-	-
122	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	Biomass Burnir	CO2	25.36	0.51	0.00%	0.00045	0.1%	-	-
123	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.33	0.43	0.00%	0.00000	0.0%	-	-
124	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CH4	20.90	0.42	0.00%	0.00037	0.1%	-	-
125	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Other Fuels	CH4	0.54	0.37	0.00%	0.00000	0.0%	-	-
126	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Biomass	N2O	0.21	0.35	0.00%	0.00000	0.0%	-	-
127	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.16	0.28	0.00%	0.00000	0.0%	-	-
128	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.25	0.00%	0.00000	0.0%	-	-
129	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.29	0.18	0.00%	0.00000	0.0%	-	-
130	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Biomass	CH4	0.80	0.15	0.00%	0.00001	0.0%	-	-
131	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constr	Solid Fuels	CH4	0.40	0.14	0.00%	0.00000	0.0%	-	-
132	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.16	0.12	0.00%	0.00000	0.0%	-	-
133	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	CH4	0.00	0.10	0.00%	0.00000	0.0%	-	-
134	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		N2O	4.77	0.09	0.00%	0.00008	0.0%	-	-
135	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.04	0.00%	0.00000	0.0%	-	-
136	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CH4	0.06	0.03	0.00%	0.00000	0.0%	-	-
137	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		N2O	0.02	0.03	0.00%	0.00000	0.0%	-	-
138	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.02	0.00%	0.00000	0.0%	-	-
139	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	CH4	0.01	0.02	0.00%	0.00000	0.0%	-	-
140	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.02	0.01	0.00%	0.00000	0.0%	-	-
141	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	CH4	0.01	0.01	0.00%	0.00000	0.0%	-	-
142	5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CH4	0.41	0.00	0.00%	0.00001	0.0%	-	-
143	5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		N2O	0.19	0.00	0.00%	0.00000	0.0%	-	-
144	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	44.84	0.00	0.00%	0.00000	0.0%	-	-
145	2C3	2. Industria	C. Metal Production; Aluminium Production-CO2			CO2	139.26	0.00	0.00%	0.00000	0.0%	-	-
146	6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.24	0.00	0.00%	0.00000	0.0%	-	-
147	6D	6. Waste	D. Other			CO2	0.00	0.00	0.00%	0.00000	0.0%	-	-
148	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.00	0.00%	0.00000	0.0%	-	-
149	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.24	0.00	0.00%	0.00000	0.0%	-	-
150	2C3	2. Industria	C. Metal Production; Aluminium Production-PFC			PFC	100.17	0.00	0.00%	0.00000	0.0%	-	-
151	2C	2. Industria	C. Metal Production; Aluminium Foundries			SF6	0.00	0.00	0.00%	0.00000	0.0%	-	-

A1.4 KCA Tier 2 2012 *without LULUCF categories.*

Results of Key Category Analysis Tier 2 – Level and Trend

Table A - 4 Key category analysis Tier 2 2012 (without LULUCF) regarding level and trend.

Tier 2 Key category analysis 2012 without LULUCF categories													
	A					B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (without LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Year 2012 Estimate [Gg CO2 eq]	Level Assessm. with Uncertainty	Trend Assessm. with Uncertainty	% Contrib. in Trend	Result level assessm	Result trend assessm
1	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	822.48	674.93	2.18%	0.00415	8.1%	KC level	KC trend
2	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.48	1143.10	1.85%	0.00285	5.6%	KC level	KC trend
3	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1519.73	2714.50	1.67%	0.00781	15.3%	KC level	KC trend
4	4A	4. Agriculture	A. Enteric Fermentation			CH4	2635.45	2496.98	0.89%	0.00024	0.5%	KC level	-
5	4B	4. Agriculture	B. Manure Management			CH4	671.61	646.11	0.68%	0.00008	0.2%	KC level	-
6	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Trans	Gasoline	CO2	11335.27	9016.58	0.45%	0.00103	2.0%	KC level	KC trend
7	4B	4. Agriculture	B. Manure Management			N2O	454.68	335.81	0.41%	0.00135	2.6%	KC level	KC trend
8	4D2	4. Agriculture	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	220.79	0.36%	0.00163	3.2%	KC level	KC trend
9	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Trans	Diesel	CO2	2587.68	6767.05	0.29%	0.00190	3.7%	KC level	KC trend
10	2F1	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	1137.81	0.27%	0.00273	5.3%	KC level	KC trend
11	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Reside	Gaseous Fuels	CO2	1424.38	2649.60	0.26%	0.00127	2.5%	KC level	KC trend
12	6B	6. Waste	B. Wastewater Handling			N2O	184.72	240.28	0.23%	0.00061	1.2%	KC level	KC trend
13	6D	6. Waste	D. Other			CH4	29.94	113.76	0.22%	0.00170	3.3%	KC level	KC trend
14	2F9	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Other			SF6	79.58	135.91	0.21%	0.00094	1.8%	KC level	KC trend
15	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Gaseous Fuels	CO2	1074.09	2096.41	0.20%	0.00105	2.1%	KC level	KC trend
16	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Reside	Liquid Fuels	CO2	10248.79	7374.50	0.20%	0.00072	1.4%	KC level	KC trend
17	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	158.26	0.18%	0.00596	11.7%	KC level	KC trend
18	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Other Fuels	CO2	134.15	288.60	0.18%	0.00100	2.0%	KC level	KC trend
19	3	3. Solvent and Other Product Use				CO2	360.04	155.28	0.15%	0.00195	3.8%	KC level	KC trend
20	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Comm	Gaseous Fuels	CO2	987.24	1482.76	0.14%	0.00052	1.0%	KC level	KC trend
21	2F9	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Other			HFC	0.00	76.14	0.12%	0.00122	2.4%	KC level	KC trend
22	1B2	1. Energy	B. Fugitive Emissions from F	2. Oil and Natural Gas		CH4	263.72	169.45	0.10%	0.00052	1.0%	KC level	KC trend
23	2A1	2. Industrial Pro	A. Mineral Products; Cement Production-CO2			CO2	2524.68	1787.11	0.10%	0.00038	0.7%	KC level	-
24	2A3	2. Industrial Pro	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2			CO2	150.39	98.48	0.10%	0.00049	1.0%	-	KC trend
25	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Comm	Liquid Fuels	CO2	4606.43	3038.51	0.08%	0.00040	0.8%	-	KC trend
26	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Liquid Fuels	CO2	3692.22	2640.18	0.07%	0.00026	0.5%	-	-
27	3	3. Solvent and Other Product Use				N2O	110.14	44.62	0.07%	0.00100	2.0%	-	KC trend
28	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Solid Fuels	CO2	1204.47	454.87	0.07%	0.00111	2.2%	-	KC trend
29	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	289.73	498.74	0.05%	0.00022	0.4%	-	-
30	2B	2. Industrial Pro	B. Chemical Industry			N2O	68.13	53.57	0.04%	0.00010	0.2%	-	-
31	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Reside	Biomass	CH4	97.87	33.78	0.04%	0.00078	1.5%	-	KC trend
32	6D	6. Waste	D. Other			N2O	5.82	25.55	0.04%	0.00032	0.6%	-	-
33	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	20.85	20.96	0.03%	0.00001	0.0%	-	-
34	4D4	4. Agriculture	D. Agricultural Soils; Use of sewage sludge as fertilizers			N2O	28.30	20.85	0.03%	0.00011	0.2%	-	-
35	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	27.72	19.75	0.03%	0.00012	0.2%	-	-
36	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Reside	Liquid Fuels	N2O	25.94	18.69	0.03%	0.00010	0.2%	-	-
37	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Trans	Diesel	N2O	5.74	66.06	0.03%	0.00027	0.5%	-	-
38	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Trans	Gasoline	N2O	142.38	27.52	0.03%	0.00111	2.2%	-	KC trend
39	1B2	1. Energy	B. Fugitive Emissions from F	2. Oil and Natural Gas		CO2	84.62	39.29	0.02%	0.00026	0.5%	-	-
40	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	693.69	805.16	0.02%	0.00004	0.1%	-	-
41	2B	2. Industrial Pro	B. Chemical Industry			CO2	111.22	110.47	0.02%	0.00000	0.0%	-	-
42	2F9	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Other			PFC	0.00	13.10	0.02%	0.00021	0.4%	-	-
43	6C	6. Waste	C. Waste Incineration			N2O	19.06	25.86	0.02%	0.00006	0.1%	-	-
44	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Liquid Fuels	N2O	13.92	11.76	0.02%	0.00003	0.1%	-	-
45	2F7	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Semiconductor Manufactu			SF6	0.00	19.55	0.02%	0.00016	0.3%	-	-
46	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agricul	Liquid Fuels	CO2	547.34	540.01	0.01%	0.00000	0.0%	-	-
47	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Reside	Biomass	N2O	10.79	9.07	0.01%	0.00002	0.0%	-	-
48	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Trans	Gasoline	CH4	97.47	18.82	0.01%	0.00056	1.1%	-	KC trend
49	2F2	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Hard Foam			HFC	0.00	13.27	0.01%	0.00013	0.3%	-	-
50	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Comm	Liquid Fuels	N2O	11.70	7.80	0.01%	0.00006	0.1%	-	-
51	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Biomass	N2O	1.68	6.85	0.01%	0.00008	0.2%	-	-
52	2F4	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Metered Dose Inhalers and			HFC	0.00	13.22	0.01%	0.00011	0.2%	-	-
53	7	7. Other				CO2	10.96	12.92	0.01%	0.00002	0.0%	-	-
54	6C	6. Waste	C. Waste Incineration			CO2	54.10	12.34	0.01%	0.00032	0.6%	-	-
55	2C	2. Industrial Pro	C. Metal Production; Magnesium Foundries			SF6	0.00	31.72	0.01%	0.00010	0.2%	-	-
56	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agricul	Liquid Fuels	N2O	4.96	5.54	0.01%	0.00001	0.0%	-	-
57	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Trans	Natural Gas	CO2	0.00	83.59	0.01%	0.00008	0.2%	-	-
58	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Other Fuels	N2O	2.28	5.24	0.01%	0.00005	0.1%	-	-
59	2C1	2. Industrial Pro	C. Metal Production; Steel Production			CO2	9.20	9.89	0.01%	0.00001	0.0%	-	-
60	6C	6. Waste	C. Waste Incineration			CH4	11.58	6.14	0.01%	0.00006	0.1%	-	-
61	2F8	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	36.81	0.01%	0.00005	0.1%	-	-
62	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	136.65	0.01%	0.00005	0.1%	-	-
63	6B	6. Waste	B. Wastewater Handling			CH4	4.65	9.28	0.01%	0.00003	0.1%	-	-
64	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Trans	Natural Gas	N2O	0.00	3.47	0.01%	0.00006	0.1%	-	-
65	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	111.93	121.14	0.01%	0.00001	0.0%	-	-
66	2F7	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Semiconductor Manufactu			PFC	0.00	6.54	0.01%	0.00005	0.1%	-	-
67	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Reside	Solid Fuels	CO2	54.59	33.60	0.01%	0.00003	0.1%	-	-
68	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Comm	Biomass	N2O	1.45	3.23	0.01%	0.00003	0.1%	-	-
69	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.86	0.00%	0.00001	0.0%	-	-
70	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CO2	31.42	45.44	0.00%	0.00001	0.0%	-	-
71	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.49	1.35	0.00%	0.00003	0.1%	-	-
72	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Solid Fuels	N2O	6.44	2.41	0.00%	0.00006	0.1%	-	-
73	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Reside	Gaseous Fuels	CH4	3.24	6.10	0.00%	0.00002	0.0%	-	-
74	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	2.01	1.13	0.00%	0.00002	0.0%	-	-
75	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	203.58	114.80	0.00%	0.00002	0.0%	-	-
76	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Gaseous Fuels	CH4	2.66	4.74	0.00%	0.00001	0.0%	-	-
77	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Comm	Biomass	CH4	9.74	4.13	0.00%	0.00003	0.1%	-	-
78	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	N2O	0.66	0.82	0.00%	0.00001	0.0%	-	-
79	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Reside	Gaseous Fuels	N2O	0.79	1.46	0.00%	0.00001	0.0%	-	-
80	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Comm	Gaseous Fuels	CH4	2.41	3.83	0.00%	0.00001	0.0%	-	-

Table A – 4 continued. Key category analysis Tier 2 2012 (without LULUCF) regarding level and trend.

Tier 2 Key category analysis 2012 without LULUCF categories													
	A					B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (without LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Year 2012 Estimate [Gg CO2 eq]	Level Assessm. with Uncertainty	Trend Assessm. with Uncertainty	% Contrib. in Trend	Result level assessm	Result trend assessm
81	2A2	2. Industrial Pro	A. Mineral Products; Lime Production-CO2			CO2	53.35	54.26	0.00%	0.00000	0.0%	-	-
82	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Trans	Biomass	N2O	0.00	0.70	0.00%	0.00002	0.0%	-	-
83	7	7. Other				N2O	0.62	0.62	0.00%	0.00000	0.0%	-	-
84	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agricul	Gaseous Fuels	CO2	41.45	18.48	0.00%	0.00002	0.0%	-	-
85	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Gaseous Fuels	N2O	0.59	1.15	0.00%	0.00001	0.0%	-	-
86	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	28.69	39.69	0.00%	0.00001	0.0%	-	-
87	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	N2O	0.60	0.55	0.00%	0.00000	0.0%	-	-
88	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	N2O	0.38	0.52	0.00%	0.00000	0.0%	-	-
89	2F1	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Refrigeration			PFC	0.04	6.14	0.00%	0.00001	0.0%	-	-
90	2B	1. Industrial Pro	B. Chemical Industry			CH4	1.54	2.39	0.00%	0.00001	0.0%	-	-
91	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Reside	Solid Fuels	CH4	3.71	2.28	0.00%	0.00001	0.0%	-	-
92	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Reside	Liquid Fuels	CH4	6.00	2.26	0.00%	0.00002	0.0%	-	-
93	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Comm	Gaseous Fuels	N2O	0.55	0.82	0.00%	0.00000	0.0%	-	-
94	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Biomass	CH4	2.46	1.56	0.00%	0.00000	0.0%	-	-
95	7	7. Other				CH4	0.55	0.57	0.00%	0.00000	0.0%	-	-
96	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agricul	Liquid Fuels	CH4	1.62	1.43	0.00%	0.00000	0.0%	-	-
97	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Comm	Liquid Fuels	CH4	3.06	1.40	0.00%	0.00001	0.0%	-	-
98	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.65	1.12	0.00%	0.00000	0.0%	-	-
99	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Liquid Fuels	CH4	2.32	1.04	0.00%	0.00001	0.0%	-	-
100	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agricul	Biomass	N2O	0.21	0.35	0.00%	0.00000	0.0%	-	-
101	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.16	0.28	0.00%	0.00000	0.0%	-	-
102	1B2	1. Energy	B. Fugitive Emissions from F	2. Oil and Natural Gas		N2O	0.62	0.68	0.00%	0.00000	0.0%	-	-
103	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.67	0.00%	0.00000	0.0%	-	-
104	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	CH4	0.58	0.54	0.00%	0.00000	0.0%	-	-
105	2A7	2. Industrial Pro	A. Mineral Products; Other non-specified-CO2			CO2	15.30	7.68	0.00%	0.00000	0.0%	-	-
106	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.25	0.00%	0.00000	0.0%	-	-
107	2F5	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Solvents			PFC	0.00	7.29	0.00%	0.00000	0.0%	-	-
108	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Reside	Solid Fuels	N2O	0.29	0.18	0.00%	0.00000	0.0%	-	-
109	2C5	2. Industrial Pro	C. Metal Production; Non-ferrous metals-CO2			CO2	1.65	1.36	0.00%	0.00000	0.0%	-	-
110	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.33	0.43	0.00%	0.00000	0.0%	-	-
111	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Trans	Diesel	CH4	1.38	0.55	0.00%	0.00000	0.0%	-	-
112	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Other Fuels	CH4	0.54	0.37	0.00%	0.00000	0.0%	-	-
113	2F5	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Solvents			HFC	0.00	4.59	0.00%	0.00000	0.0%	-	-
114	2G	2. Industrial Pro	G. Other			CO2	1.04	0.91	0.00%	0.00000	0.0%	-	-
115	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agricul	Biomass	CH4	0.80	0.15	0.00%	0.00000	0.0%	-	-
116	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industr	Solid Fuels	CH4	0.40	0.14	0.00%	0.00000	0.0%	-	-
117	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.16	0.12	0.00%	0.00000	0.0%	-	-
118	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Trans	Natural Gas	CH4	0.00	0.10	0.00%	0.00000	0.0%	-	-
119	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		N2O	0.02	0.03	0.00%	0.00000	0.0%	-	-
120	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CH4	0.06	0.03	0.00%	0.00000	0.0%	-	-
121	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agricul	Gaseous Fuels	CH4	0.09	0.04	0.00%	0.00000	0.0%	-	-
122	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Trans	Biomass	CH4	0.00	0.02	0.00%	0.00000	0.0%	-	-
123	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agricul	Gaseous Fuels	N2O	0.02	0.01	0.00%	0.00000	0.0%	-	-
124	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	CH4	0.01	0.02	0.00%	0.00000	0.0%	-	-
125	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	CH4	0.01	0.01	0.00%	0.00000	0.0%	-	-
126	6D	6. Waste	D. Other			CO2	0.00	0.00	0.00%	-	0.0%	-	-
127	6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.24	0.00	0.00%	-	0.0%	-	-
128	2C3	2. Industrial Pro	C. Metal Production; Aluminium Production-CO2			CO2	139.26	0.00	0.00%	-	0.0%	-	-
129	2C3	2. Industrial Pro	C. Metal Production; Aluminium Production-PFC			PFC	100.17	0.00	0.00%	-	0.0%	-	-
130	2C	2. Industrial Pro	C. Metal Production; Aluminium Foundries			SF6	0.00	0.00	0.00%	-	0.0%	-	-
131	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	44.84	0.00	0.00%	-	0.0%	-	-
132	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.00	0.00%	-	0.0%	-	-
133	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.24	0.00	0.00%	-	0.0%	-	-
134	6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.24	0.00	0.00%	-	0.0%	-	-
135	6D	6. Waste	D. Other			CO2	0.00	0.00	0.00%	-	0.0%	-	-

A1.5 KCA Tier 2 2012 *including LULUCF categories*

Results of Key Category Analysis Tier 2 – Level and Trend

Table A - 5 Key category analysis Tier 2 2012 (with LULUCF) regarding level and trend.

Tier 2 Key category analysis 2012 with LULUCF categories

	A					B	C	D	E-L	E-T	F-T	M	N
No.	**IPCC Source Categories and fuels if applicable (with LULUCF categories)**					**Direct GHG**	**Base Year 1990 Estimate** [Gg CO2 eq]	**Year 2012 Estimate** [Gg CO2 eq]	**Level Assessm. with Uncertainty**	**Trend Assessm. with Uncertainty**	**% Contrib. in Trend**	**Result level assessm**	**Result trend assessm**
1	5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	107.09	134.74	5.05%	0.01165	15.8%	KC level	KC trend
2	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	-2416.89	-2134.56	2.41%	0.00257	3.5%	KC level	KC trend
3	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	822.48	674.93	2.01%	0.00389	5.3%	KC level	KC trend
4	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.48	1143.10	1.71%	0.00268	3.6%	KC level	KC trend
5	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1519.73	2714.50	1.54%	0.00719	9.7%	KC level	KC trend
6	5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	345.17	707.27	1.40%	0.00751	10.2%	KC level	KC trend
7	4A	4. Agriculture	A. Enteric Fermentation			CH4	2635.45	2496.98	0.82%	0.00025	0.3%	KC level	-
8	4B	4. Agriculture	B. Manure Management			CH4	671.61	646.11	0.63%	0.00009	0.1%	KC level	-
9	5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO2	-621.57	-518.61	0.59%	0.00101	1.4%	KC level	KC trend
10	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11335.27	9016.58	0.42%	0.00097	1.3%	KC level	KC trend
11	4B	4. Agriculture	B. Manure Management			N2O	454.68	335.81	0.38%	0.00126	1.7%	KC level	KC trend
12	4D2	4. Agriculture	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	220.79	0.34%	0.00150	2.0%	KC level	KC trend
13	5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	382.71	302.93	0.27%	0.00065	0.9%	KC level	KC trend
14	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2587.68	6767.05	0.27%	0.00175	2.4%	KC level	KC trend
15	2F1	2. Industrial Pr	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	1137.81	0.25%	0.00252	3.4%	KC level	KC trend
16	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuel	CO2	1424.38	2649.60	0.24%	0.00117	1.6%	KC level	KC trend
17	6B	6. Waste	B. Wastewater Handling			N2O	184.72	240.28	0.22%	0.00055	0.8%	KC level	KC trend
18	6D	6. Waste	D. Other			CH4	29.94	113.76	0.21%	0.00157	2.1%	KC level	KC trend
19	5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO2	59.85	169.07	0.21%	0.00138	1.9%	KC level	KC trend
20	2F9	2. Industrial Pr	F. Consumption of Halocarbons and SF6; Other			SF6	79.58	135.91	0.20%	0.00086	1.2%	KC level	KC trend
21	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Gaseous Fuel	CO2	1074.09	2096.41	0.19%	0.00097	1.3%	KC level	KC trend
22	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.79	7374.50	0.18%	0.00067	0.9%	KC level	KC trend
23	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	158.26	0.17%	0.00551	7.5%	KC level	KC trend
24	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Other Fuels	CO2	134.15	288.60	0.16%	0.00092	1.2%	-	KC trend
25	3	3. Solvent and Other Product Use				CO2	360.04	155.28	0.14%	0.00180	2.4%	-	KC trend
26	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutiona	Gaseous Fuel	CO2	987.24	1482.76	0.13%	0.00048	0.7%	-	-
27	2F9	2. Industrial Pr	F. Consumption of Halocarbons and SF6; Other			HFC	0.00	76.14	0.11%	0.00112	1.5%	-	KC trend
28	5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land		CO2	91.98	112.28	0.10%	0.00021	0.3%	-	-
29	1B2	1. Energy	B. Fugitive Emissions fr	2. Oil and Natural Gas		CH4	263.72	169.45	0.09%	0.00049	0.7%	-	KC trend
30	2A1	2. Industrial Pr	A. Mineral Products; Cement Production-CO2			CO2	2524.68	1787.11	0.09%	0.00035	0.5%	-	-
31	2A3	2. Industrial Pr	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2			CO2	150.39	98.48	0.09%	0.00045	0.6%	-	-
32	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutiona	Liquid Fuels	CO2	4606.43	3038.51	0.08%	0.00037	0.5%	-	-
33	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Liquid Fuels	CO2	3692.22	2640.18	0.07%	0.00025	0.3%	-	-
34	3	3. Solvent and Other Product Use				N2O	110.14	44.62	0.06%	0.00093	1.3%	-	KC trend
35	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Solid Fuels	CO2	1204.47	454.87	0.06%	0.00103	1.4%	-	KC trend
36	5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO2	43.33	22.26	0.06%	0.00053	0.7%	-	KC trend
37	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuel	CO2	289.73	498.74	0.04%	0.00020	0.3%	-	-
38	2B	2. Industrial Pr	B. Chemical Industry			N2O	68.13	53.57	0.04%	0.00010	0.1%	-	-
39	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	97.87	33.78	0.04%	0.00072	1.0%	-	KC trend
40	6D	6. Waste	D. Other			N2O	5.82	25.55	0.04%	0.00029	0.4%	-	-
41	5E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements		CO2	3.60	33.69	0.03%	0.00028	0.4%	-	-
42	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	20.85	20.96	0.03%	0.00001	0.0%	-	-
43	4D4	4. Agriculture	D. Agricultural Soils; Use of sewage sludge as fertilizers			N2O	28.30	20.85	0.03%	0.00010	0.1%	-	-
44	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	27.72	19.75	0.03%	0.00011	0.1%	-	-
45	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.94	18.69	0.03%	0.00010	0.1%	-	-
46	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	5.74	66.06	0.03%	0.00025	0.3%	-	-
47	5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands		CO2	20.06	28.95	0.03%	0.00009	0.1%	-	-
48	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	142.38	27.52	0.02%	0.00103	1.4%	-	KC trend
49	1B2	1. Energy	B. Fugitive Emissions fr	2. Oil and Natural Gas		CO2	84.62	39.29	0.02%	0.00024	0.3%	-	-
50	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	693.69	805.16	0.02%	0.00003	0.0%	-	-
51	2B	2. Industrial Pr	B. Chemical Industry			CO2	111.22	110.47	0.02%	0.00000	0.0%	-	-
52	2F9	2. Industrial Pr	F. Consumption of Halocarbons and SF6; Other			PFC	0.00	13.10	0.02%	0.00019	0.3%	-	-
53	6C	6. Waste	C. Waste Incineration			N2O	19.06	25.86	0.02%	0.00005	0.1%	-	-
54	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Liquid Fuels	N2O	13.92	11.76	0.02%	0.00003	0.0%	-	-
55	2F7	2. Industrial Pr	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture			SF6	0.00	19.55	0.01%	0.00014	0.2%	-	-
56	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	547.34	540.01	0.01%	0.00000	0.0%	-	-
57	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.79	9.07	0.01%	0.00002	0.0%	-	-
58	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	97.47	18.82	0.01%	0.00052	0.7%	-	KC trend
59	2F2	2. Industrial Pr	F. Consumption of Halocarbons and SF6; Hard Foam			HFC	0.00	13.27	0.01%	0.00012	0.2%	-	-
60	5D2	5. LULUCF	D. Land converted to We	5(II) Non-CO2 emissions from drainage of soils and wet		CH4	9.03	9.03	0.01%	0.00000	0.0%	-	-
61	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutiona	Liquid Fuels	N2O	11.70	7.80	0.01%	0.00005	0.1%	-	-
62	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Biomass	N2O	1.68	6.85	0.01%	0.00008	0.1%	-	-
63	2F4	2. Industrial Pr	F. Consumption of Halocarbons and SF6; Metered Dose Inhalers and Other			HFC	0.00	13.22	0.01%	0.00010	0.1%	-	-
64	7	7. Other				CO2	10.96	12.92	0.01%	0.00002	0.0%	-	-
65	6C	6. Waste	C. Waste Incineration			CO2	54.10	12.34	0.01%	0.00030	0.4%	-	-
66	2C	2. Industrial Pr	C. Metal Production; Magnesium Foundries			SF6	0.00	31.72	0.01%	0.00009	0.1%	-	-
67	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	4.96	5.54	0.01%	0.00001	0.0%	-	-
68	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	CO2	0.00	83.59	0.01%	0.00008	0.1%	-	-
69	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Other Fuels	N2O	2.28	5.24	0.01%	0.00004	0.1%	-	-
70	2C1	2. Industrial Pr	C. Metal Production; Steel Production			CO2	9.20	9.89	0.01%	0.00001	0.0%	-	-
71	6C	6. Waste	C. Waste Incineration			CH4	11.58	6.14	0.01%	0.00006	0.1%	-	-
72	2F8	2. Industrial Pr	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	36.81	0.01%	0.00005	0.1%	-	-
73	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	136.65	0.01%	0.00005	0.1%	-	-
74	5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		N2O	5.58	3.58	0.01%	0.00003	0.0%	-	-
75	6B	6. Waste	B. Wastewater Handling			CH4	4.65	9.28	0.01%	0.00003	0.0%	-	-
76	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	N2O	0.00	3.47	0.00%	0.00005	0.1%	-	-
77	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	111.93	121.14	0.00%	0.00000	0.0%	-	-
78	2F7	2. Industrial Pr	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture			PFC	0.00	6.54	0.00%	0.00005	0.1%	-	-
79	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	54.59	33.60	0.00%	0.00003	0.0%	-	-
80	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutiona	Biomass	N2O	1.45	3.23	0.00%	0.00003	0.0%	-	-

Table A – 5 continued. Key category analysis Tier 2 2012 (with LULUCF) regarding level and trend.

Tier 2 Key category analysis 2012 with LULUCF categories													
	A					B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (with LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2 eq]	Year 2012 Estimate [Gg CO2 eq]	Level Assessm. with Uncertainty	Trend Assessm. with Uncertainty	% Contrib. in Trend	Result level assessm	Result trend assessm
81	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.86	0.00%	0.00001	0.0%	-	-
82	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CO2	31.42	45.44	0.00%	0.00001	0.0%	-	-
83	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.49	1.35	0.00%	0.00003	0.0%	-	-
84	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construc	Solid Fuels	N2O	6.44	2.41	0.00%	0.00006	0.1%	-	-
85	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.24	6.10	0.00%	0.00002	0.0%	-	-
86	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	2.01	1.13	0.00%	0.00002	0.0%	-	-
87	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	203.58	114.80	0.00%	0.00002	0.0%	-	-
88	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construc	Gaseous Fuels	CH4	2.66	4.74	0.00%	0.00001	0.0%	-	-
89	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutiona	Biomass	CH4	9.74	4.13	0.00%	0.00003	0.0%	-	-
90	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	N2O	0.66	0.82	0.00%	0.00000	0.0%	-	-
91	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.46	0.00%	0.00001	0.0%	-	-
92	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutiona	Gaseous Fuels	CH4	2.41	3.83	0.00%	0.00001	0.0%	-	-
93	2A2	2. Industrial Pr	A. Mineral Products; Lime Production-CO2			CO2	53.35	54.26	0.00%	0.00000	0.0%	-	-
94	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.70	0.00%	0.00002	0.0%	-	-
95	7	7. Other				N2O	0.62	0.62	0.00%	0.00000	0.0%	-	-
96	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	41.45	18.48	0.00%	0.00002	0.0%	-	-
97	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construc	Gaseous Fuels	N2O	0.59	1.15	0.00%	0.00001	0.0%	-	-
98	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	28.69	39.69	0.00%	0.00000	0.0%	-	-
99	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	N2O	0.60	0.55	0.00%	0.00000	0.0%	-	-
100	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	N2O	0.38	0.52	0.00%	0.00000	0.0%	-	-
101	2F1	2. Industrial Pr	F. Consumption of Halocarbons and SF6; Refrigeration			PFC	0.04	6.14	0.00%	0.00001	0.0%	-	-
102	2B	1. Industrial Pr	B. Chemical Industry			CH4	1.54	2.39	0.00%	0.00000	0.0%	-	-
103	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.71	2.28	0.00%	0.00001	0.0%	-	-
104	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	6.00	2.26	0.00%	0.00002	0.0%	-	-
105	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutiona	Gaseous Fuels	N2O	0.55	0.82	0.00%	0.00000	0.0%	-	-
106	5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands		CO2	2.87	0.56	0.00%	0.00004	0.1%	-	-
107	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construc	Biomass	CH4	2.46	1.56	0.00%	0.00000	0.0%	-	-
108	7	7. Other				CH4	0.55	0.57	0.00%	0.00000	0.0%	-	-
109	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.62	1.43	0.00%	0.00000	0.0%	-	-
110	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutiona	Liquid Fuels	CH4	3.06	1.40	0.00%	0.00001	0.0%	-	-
111	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	Biomass Burni	CO2	25.36	0.51	0.00%	0.00032	0.4%	-	-
112	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.65	1.12	0.00%	0.00000	0.0%	-	-
113	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construc	Liquid Fuels	CH4	2.32	1.04	0.00%	0.00001	0.0%	-	-
114	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CH4	20.90	0.42	0.00%	0.00026	0.4%	-	-
115	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Biomass	N2O	0.21	0.35	0.00%	0.00000	0.0%	-	-
116	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.16	0.28	0.00%	0.00000	0.0%	-	-
117	1B2	1. Energy	B. Fugitive Emissions fro	2. Oil and Natural Gas		N2O	0.62	0.68	0.00%	0.00000	0.0%	-	-
118	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.67	0.00%	0.00000	0.0%	-	-
119	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	CH4	0.58	0.54	0.00%	0.00000	0.0%	-	-
120	2A7	2. Industrial Pr	A. Mineral Products; Other non-specified-CO2			CO2	15.30	7.68	0.00%	0.00000	0.0%	-	-
121	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.25	0.00%	0.00000	0.0%	-	-
122	2F5	2. Industrial Pr	F. Consumption of Halocarbons and SF6; Solvents			PFC	0.00	7.29	0.00%	0.00000	0.0%	-	-
123	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.29	0.18	0.00%	0.00000	0.0%	-	-
124	2C5	2. Industrial Pr	C. Metal Production; Non-ferrous metals-CO2			CO2	1.65	1.36	0.00%	0.00000	0.0%	-	-
125	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.33	0.43	0.00%	0.00000	0.0%	-	-
126	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.38	0.55	0.00%	0.00000	0.0%	-	-
127	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construc	Other Fuels	CH4	0.54	0.37	0.00%	0.00000	0.0%	-	-
128	2F5	2. Industrial Pr	F. Consumption of Halocarbons and SF6; Solvents			HFC	0.00	4.59	0.00%	0.00000	0.0%	-	-
129	2G	2. Industrial Pr	G. Other			CO2	1.04	0.91	0.00%	0.00000	0.0%	-	-
130	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		N2O	4.77	0.09	0.00%	0.00006	0.1%	-	-
131	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Biomass	CH4	0.80	0.15	0.00%	0.00000	0.0%	-	-
132	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construc	Solid Fuels	CH4	0.40	0.14	0.00%	0.00000	0.0%	-	-
133	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.16	0.12	0.00%	0.00000	0.0%	-	-
134	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	CH4	0.00	0.10	0.00%	0.00000	0.0%	-	-
135	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		N2O	0.02	0.03	0.00%	0.00000	0.0%	-	-
136	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CH4	0.06	0.03	0.00%	0.00000	0.0%	-	-
137	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.04	0.00%	0.00000	0.0%	-	-
138	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.02	0.00%	0.00000	0.0%	-	-
139	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.02	0.01	0.00%	0.00000	0.0%	-	-
140	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	CH4	0.01	0.02	0.00%	0.00000	0.0%	-	-
141	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	CH4	0.01	0.01	0.00%	0.00000	0.0%	-	-
142	5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CH4	0.41	0.00	0.00%	0.00001	0.0%	-	-
143	5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		N2O	0.19	0.00	0.00%	0.00000	0.0%	-	-
144	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	44.84	0.00	0.00%	-	0.0%	-	-
145	2C3	2. Industrial Pr	C. Metal Production; Aluminium Production-CO2			CO2	139.26	0.00	0.00%	-	0.0%	-	-
146	6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.24	0.00	0.00%	-	0.0%	-	-
147	6D	6. Waste	D. Other			CO2	0.00	0.00	0.00%	-	0.0%	-	-
148	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.00	0.00%	-	0.0%	-	-
149	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.24	0.00	0.00%	-	0.0%	-	-
150	2C3	2. Industrial Pr	C. Metal Production; Aluminium Production-PFC			PFC	100.17	0.00	0.00%	-	0.0%	-	-
151	2C	2. Industrial Pr	C. Metal Production; Aluminium Foundries			SF6	0.00	0.00	0.00%	-	0.0%	-	-

Annex 2: Sulphur Dioxide (SO_2)

Table A - 6 Sulphur content and SO_2 emission factors. For explanations see next page.

year	maximum legal limit of sulphur content					
	Diesel oil	Gasoline	Gas oil	Natural gas	Res. fuel oil	Coal
	ppm	ppm	ppm	ppm	%	%
1990	1400	200	2000	190	1.0	1.0
1991	1300	200	2000	190	1.0	1.0
1992	1200	200	2000	190	1.0	1.0
1993	1000	200	2000	190	1.0	1.0
1994	500	200	2000	190	1.0	1.0
2000	350	150	2000	190	1.0	1.0
2005	50	50	2000	190	1.0	1.0
2008	50	50	1000	190	1.0	1.0
2009	10	50	1000	190	1.0	1.0
2010	10	10	1000	190	1.0	1.0
2011	10	10	1000	190	1.0	1.0
2012	10	10	1000	190	1.0	1.0

year	Effective sulphur content					
	Diesel oil	Gasoline	Gas oil	Natural gas	Res. fuel oil	Coal
	ppm	ppm	ppm	ppm	%	%
1990	1400	200	1600	11.6	0.97	0.9
1991	1300	200	1300	11.6	0.89	0.9
1992	1200	200	1200	11.6	0.86	0.9
1993	1000	200	1000	11.6	0.87	0.9
1994	434	200	1350	11.6	0.77	0.9
1995	341	200	1170	11.6	0.78	0.9
1996	372	200	1160	11.6	0.78	0.9
1997	353	200	1250	11.6	0.70	0.9
1998	402	200	926	11.6	0.83	0.9
1999	443	200	650	11.6	0.62	0.9
2000	272	142	680	11.6	0.66	0.9
2001	250	121	830	11.6	0.82	0.9
2002	235	101	798	11.6	0.78	0.9
2003	200	81	700	11.6	0.79	0.9
2004	10	8.0	700	11.6	0.76	0.9
2005	10	8.0	799	11.6	0.78	0.9
2006	10	8.0	699	11.6	0.74	0.9
2007	10	8.0	630	11.6	0.71	0.9
2008	10	8.0	641	11.6	0.67	0.9
2009	10	8.0	539	11.6	0.64	0.9
2010	10	8.0	509	11.6	0.60	0.9
2011	10	8.0	477	11.6	0.60	0.9
2012	10	8.0	445	11.6	0.60	0.9

year	Effective SO_2 emission factor					
	Diesel oil	Gasoline	Gas oil	Natural gas	Res. fuel oil	Coal
	kg/TJ					
1990	65.4	9.4	75.1	0.50	473	350
1991	60.7	9.4	61.0	0.50	432	350
1992	56.1	9.4	56.3	0.50	417	350
1993	46.7	9.4	46.9	0.50	422	350
1994	20.3	9.4	63.4	0.50	374	350
1995	15.9	9.4	54.9	0.50	377	350
1996	17.4	9.4	54.5	0.50	379	350
1997	16.5	9.4	58.7	0.50	340	350
1998	18.8	9.4	43.5	0.50	403	350
1999	20.7	9.4	30.5	0.50	301	350
2000	12.7	6.7	31.9	0.50	320	350
2001	11.7	5.7	39.0	0.50	398	350
2002	11.0	4.8	37.5	0.50	398	350
2003	9.3	3.8	32.9	0.50	383	350
2004	0.5	0.4	32.9	0.50	369	350
2005	0.5	0.4	37.5	0.50	379	350
2006	0.5	0.4	32.8	0.50	361	350
2007	0.5	0.4	29.6	0.50	344	350
2008	0.5	0.4	30.1	0.50	326	350
2009	0.5	0.4	25.3	0.50	309	350
2010	0.5	0.4	23.9	0.50	291	350
2011	0.5	0.4	22.4	0.50	291	350
2012	0.5	0.4	20.9	0.50	291	350

Explanation to Table A - 6

- For liquid and solid fuels the SO_2 emission factors are determined by the sulphur content. The upmost lines in Table A - 6 “maximum legal limit on sulphur content” show the maximum values as defined in the Federal Ordinance on Air Pollution Control OAPC (Swiss Confederation 1985).
- The lines in the middle part of Table A - 6 contain the effective sulphur contents. They are based on measurements: Summary and annual reports of the Swiss Petroleum Association (EV), reports by the Federal Administration of Customs (OZD) since 2000.
- The lines at the bottom part of Table A - 6 give the emission factors in kg/TJ. They are calculated from the sulphur content S, the net calorific value NCV and the quotient of the molar masses of S and SO_2

$$EF_{SO2} = \frac{M_{SO2}}{M_S} \cdot \frac{S}{NCV} = 2 \cdot \frac{S}{NCV}$$

- Coal: Note that the legal limit of sulphur content depends on the size of the heat capacity of the combustion system. The value shown in the table above (1%, 350 kg/TJ SO_2) holds for heat capacity below 1 MW; see OAPC Annex 4, §513 (Swiss Confederation 1985). For larger capacities the value is 3% (OAPC Annex 5, §2, Swiss Confederation 1985). For industrial combustion plants, the limit for the exhaust emissions actually sets the corresponding maximum sulphur content to 1.4% (500 kg/TJ).
- Residual fuel oil: OAPC Annex 5, §11, lit.2 sets 2.8% for the legal limit. Simultaneously, OAPC dispenses from emission control measurements if residual fuel oil is used with sulphur content of maximum 1% (see OAPC Annex 3, §421, lit. 2, Swiss Confederation 1985), which holds for most combustion plants.

Annex 3: Other detailed methodological descriptions for individual source or sink categories

A3.1 Sector Energy

A3.1.1 Swiss Energy Flow

The diagrams show a summary of the Swiss energy flow 2012 and 1990 as published by the Swiss Federal Office of Energy (SFOE 2013). Diagram languages are German and French.

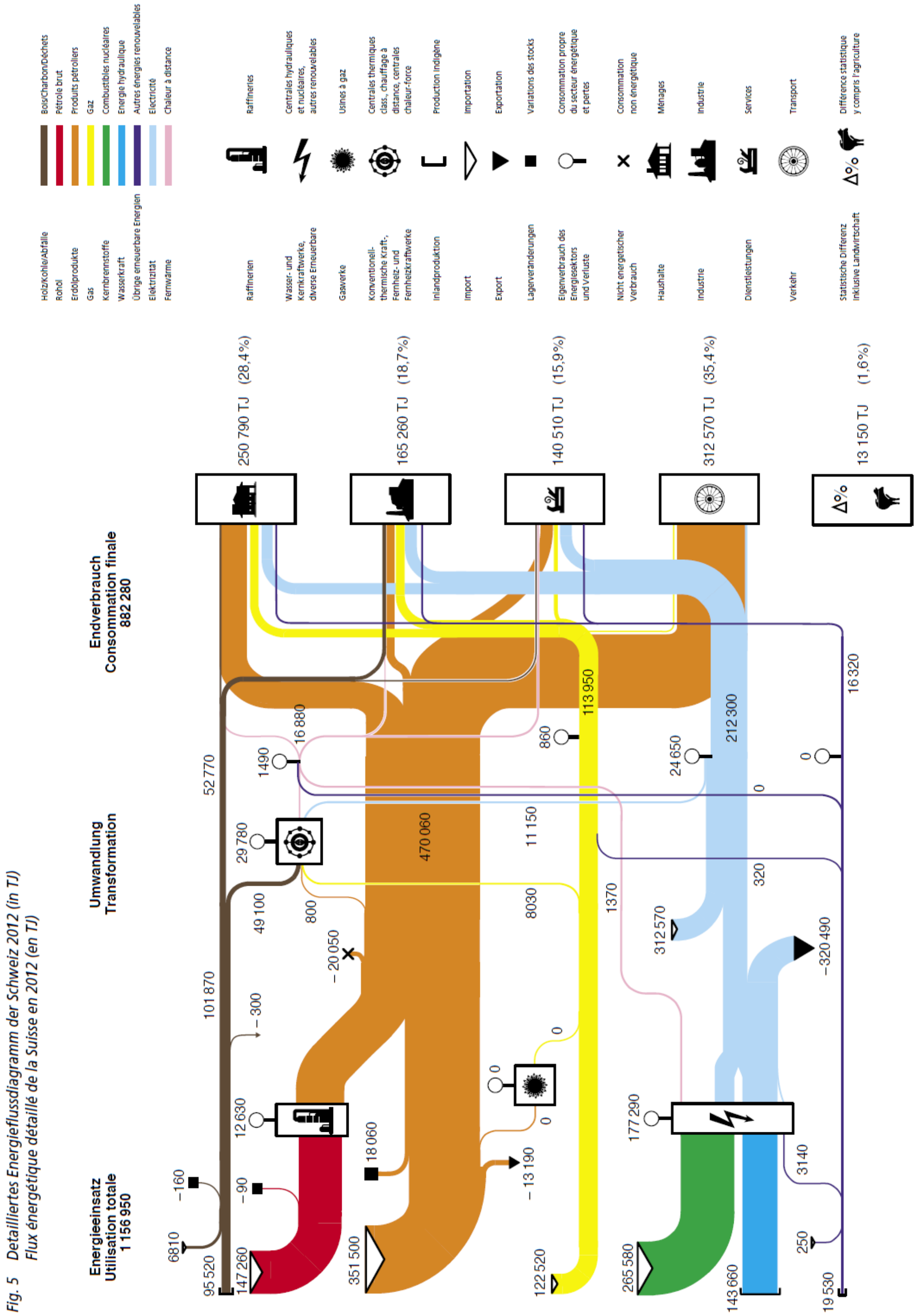


Figure A - 1 Energy flow in Switzerland 2012 in TJ (SFOE 2013)

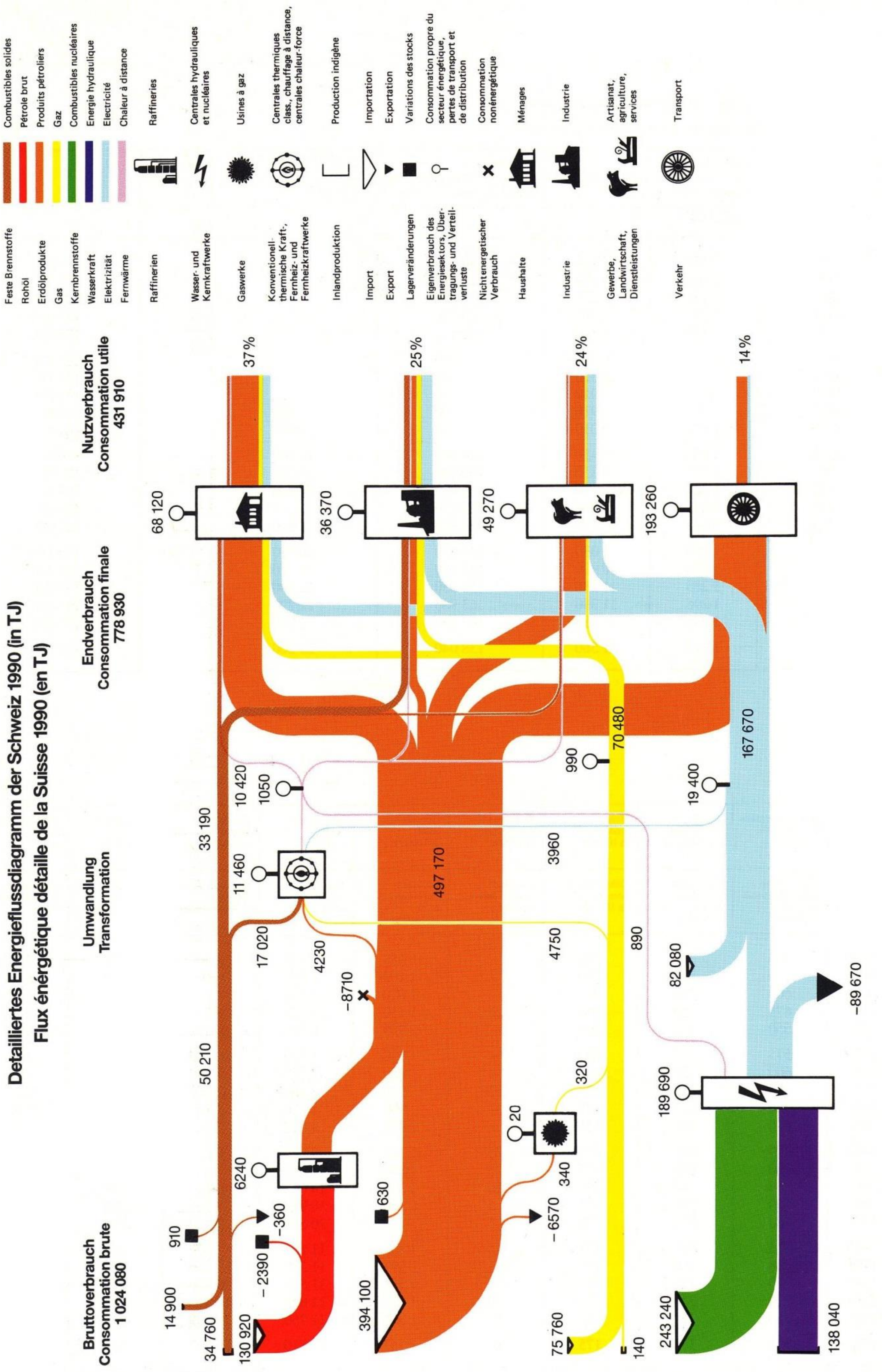


Figure A - 2 Energy flow in Switzerland 1990 in TJ (SFOE 1991)

A3.1.2 Emissions from Fuel Consumption: Disaggregation of Fuel Consumption

See Chapter 3.2.5.

A3.1.3 Emission from Manufacturing Industries and Construction

The emission factors of precursors in the manufacturing industries and construction sector are given below. Emission factors for greenhouse gases are given in 3.2.7.

Table A - 7 Emission factors of precursors from Manufacturing Industries and Construction

1A2 Emission factors (mix of bottom-up and top-down approach (modelling))	**NO_x**	**CO**	**NMVOC**	**SO_2**
	kg/TJ	kg/TJ	kg/TJ	kg/TJ
1A2a Iron and Steel				
Gas oil	33	8	2	22
Liquefied petroleum gas	33	8	2	22
Residual fuel oil	125	13	4	291
Petroleum coke	NO	NO	NO	NO
Bituminous coal	14	2'282	8	311
Lignite	NO	NO	NO	NO
Natural gas	36	5	2	0.5
1A2b Non-Ferrous Metals				
Gas oil	33	182	37	22
Liquefied petroleum gas	33	8	2	22
Residual fuel oil	NO	NO	NO	NO
Petroleum coke	NO	NO	NO	NO
Bituminous coal	NO	NO	NO	NO
Lignite	NO	NO	NO	NO
Natural gas	19	9	2	0.5
1A2c Chemicals				
Gas oil	33	8	2	22
Liquefied petroleum gas	33	8	2	22
Residual fuel oil	125	13	4	291
Petroleum coke	NO	NO	NO	NO
Bituminous coal	NO	NO	NO	NO
Lignite	NO	NO	NO	NO
Natural gas	19	9	2	0.5
1A2d Pulp, Paper and Print				
Gas oil	33	8	2	22
Liquefied petroleum gas	33	8	2	22
Residual fuel oil	125	13	4	291
Petroleum coke	NO	NO	NO	NO
Bituminous coal	NO	NO	NO	NO
Lignite	NO	NO	NO	NO
Natural gas	19	9	2	0.5
1A2e Food Processing, Beverages and Tobacco				
Gas oil	33	8	2	22
Liquefied petroleum gas	33	8	2	22
Residual fuel oil	NO	NO	NO	NO
Petroleum coke	NO	NO	NO	NO
Bituminous coal	NO	NO	NO	NO
Lignite	NO	NO	NO	NO
Natural gas	19	9	2	0.5
1A2fi Other				
Gas oil	33	8	7	22
Liquefied petroleum gas	33	8	2	22
Residual fuel oil	125	13	4	291
Petroleum coke	200	100	0	500
Bituminous coal	200	100	10	500
Lignite	213	100	10	500
Natural gas	19	9	3	0.5
Biomass	137	282	7	15
Other fuels (fossil waste incineration in cement industry)	IE	IE	IE	IE
Fuels, not itemized (fiber construction board, fine ceramics, glass, glass wool, bottle glas, lime, asphalt, rock wool, brick, cement)	253	455	20	127
1A2fii Construction and industrial machinery	**NO_x**	**CO**	**NMVOC**	**SO_2**
	kg/h	kg/h	kg/h	kg/h
Diesel and gasoline	440	807	75	0.5

A3.1.4 Civil Aviation

This paragraph contains further information to the emission modelling. More complete information is provided in FOCA (2006-2012) and on request for reviewers by FOCA.

Emission factors

Table A - 8 Aircraft cruise factors, used for cruise emission calculation (extract of list of 881 aircraft) GKL_ICAO = ICAO seat categories. Mass emissions are given in kilograms or grams per nautical mile (NM).

Aircraft Cruise _Factors						
Aircraft_ICAO	GKL_ICAO	Cruise_D_Source	kg_fuel_NM	kg_NOx_NM	g_VOC_NM	g_CO_NM
AA1	0	P002FOCA	0.21	0.0098	1.79	61.7
AA5	0	P002FOCA	0.21	0.0098	1.79	61.7
AC11	0	P002FOCA	0.21	0.0098	1.79	61.7
AC14	0	P002FOCA	0.21	0.0098	1.79	61.7
AC50	0	P001FOCA	0.77	0.021	4.14	364.17
AC68	0	P001FOCA	0.77	0.0075	4.14	364.17
AC6T	1	FOCAINV95-03.2T	1.58	0.021	0.87	2.9
AC90	1	FOCAINV95-03.2T	1.58	0.021	0.87	2.9
AC95	1	FOCAINV95-03.2T	1.58	0.021	0.87	2.9
AEST	0	P001FOCA	0.77	0.021	4.14	364.17
AJET	0	FOCAEDBJ014	2.92	0.0146	8.53	63
ALO2	0	FOCAHeli	1.91	0.024	0.42	2.1
ALO3	0	FOCAHeli	1.91	0.024	0.42	2.1
AN12	0	AN26*2	5.36	0.0062	143	348
AN2	0	FOCA/91/DC3	0.82	0.0002	13.7	1000
AN22	6	FOCAINV95-03.2T*2	3.16	0.042	1.74	5.8
AN24	2	AN26	2.68	0.0031	71.7	174
AN26	1	500	2.68	0.0031	71.7	174
AN72	2	FOCAINV95-03.2J	6.4	0.1	0.83	10
AR7	0	P002FOCA	0.21	0.0098	1.79	61.7
AR7A	0	P002FOCA	0.21	0.0098	1.79	61.7
AS02	0	P002FOCA	0.21	0.0098	1.79	61.7
AS16	0	P002FOCA	0.21	0.0098	1.79	61.7
AS20	0	P002FOCA	0.21	0.0098	1.79	61.7
AS24	0	P002FOCA	0.21	0.0098	1.79	61.7
AS25	0	P002FOCA	0.21	0.0098	1.79	61.7
AS26	0	P002FOCA	0.21	0.0098	1.79	61.7
AS2T	0	FOCAEDBT758	0.95	0.005	1.8	12
AS30	0	FOCAHeli*2	3.82	0.048	0.82	4.2
AS32	1	FOCAHeli*2	3.82	0.048	0.82	4.2
AS33	0	FOCAHeli*2	3.82	0.048	0.82	4.2
AS35	0	FOCAHeli	1.91	0.024	0.42	2.1
AS50	0	FOCAHeli*2	3.82	0.048	0.82	4.2
AS55	0	FOCAHeli*2	3.82	0.048	0.82	4.2
AS65	0	FOCAHeli*2	3.82	0.048	0.82	4.2
ASK1	0	P002FOCA	0.21	0.0098	1.79	61.7
ASTA	0	FOCAINV95-03.B	3.016	0.046	0.3	2.8
ASTR	0	FOCAINV95-03.B	3.016	0.046	0.3	2.8
ASTRA	0	FOCAINV95-03.B	3.016	0.046	0.3	2.8
AT42	1	FOCAINV95-03.2T	1.58	0.021	0.87	2.9
AT43	1	500	1.6	0.013	0	15

Activity data

LTO-cycle times (minutes). ICAO standard cycle times were originally designed for emissions certification, not for emissions modelling. Today, they do generally not match real world aircraft LTO operations. Swiss FOCA has therefore adjusted some of the ICAO standard cycle times for different aircraft categories. For jets, the mean time for taxi-in and taxi-out at Swiss airports has been determined 20 minutes instead of the standard 26 minutes.

Table A - 9 For jets, business jets, turboprops, piston engines and helicopters, the times in mode are shown and are based on ICAO, US EPA and Swiss FOCA data. "Type" is a classification variable. J = Jet, T = Turboprop, P = Piston, H = Helicopter, B = Business jet, SJ = Supersonic Jet. The number in "Type" stands for the number of engines. For Jet Aircraft, the cycle times and associated thrust settings still lead to an overestimation of LTO emissions (FOCA 2007b).

LTO Cycle				
Type	Time_Take_Off	Time_Climbout	Time_Approach	Zeit_Taxi
1J	0.7	2.2	4	20
1T	0.5	2.5	4.5	13
1P	0.3	2.5	3	12
1H	0	6.5	6.5	7
2B	0.4	0.5	1.6	13
3B	0.4	0.5	1.6	13
2T	0.5	2.5	4.5	13
4T	0.5	2.5	4.5	13
2J	0.7	2.2	4	20
3J	0.7	2.2	4	20
4J	0.7	2.2	4	20
2P	0.3	2.5	3	12
3P	0.3	2.5	3	12
4P	0.3	2.5	3	12
2H	0	6.5	6.5	7
4SJ	1.2	2	2.3	20
3H	0	6.5	6.5	7
4H	0	6.5	6.5	7
4B	0.4	0.5	1.6	13

Table A - 10 Aircraft-Engine Combinations and associated codes for SWISS FOCA emissions database. (Extract from list of more than 26'000 individual aircraft)

Aircraft Engine Combinations							
Engine Name	Aircraft Name	Aircraft Registr.	No. Eng.	Code	Type	Aircr. ICAO	Source
V2527-A5	AIRBUS A320-232	ECHXA	2	J220	2J	A320	1IA003
CF34-3B1	BOMBARDIER CRJ200ER (CL-600-2B19)	ECHXM	2	J090	2J	CRJ2	1GE034
CFM56-3C1	BOEING 737-4K5	ECHXT	2	J022	2J	B734	1CM007
TPE331-11U-611G	FAIRCHILD (SWEARIN-GEN) SA227AC METR	ECHXY	2	T310	2T	SW4	FOI
CFM56-5B4/P	AIRBUS A320-214	ECHYC	2	J067	2J	A320	3CM026
CFM56-5B4/P	AIRBUS A320-214	ECHYD	2	J067	2J	A320	3CM026
CF34-3B1	BOMBARDIER CRJ200ER (CL-600-2B19)	ECHYG	2	J090	2J	CRJ2	1GE034
CFEC-FE738-1-1B	DASSAULT FALCON 2000	ECHYI	2	B130	2B	F2TH	FOI-Ho-neywell
GA TPE331-11U-612G		ECHZH	2	T310	2T	FA3	FOI
CF34-3B1	BOMBARDIER CRJ200ER (CL-600-2B19)	ECHZR	2	J090	2J	CRJ2	1GE034
CFM56-7B27B1	BOEING 737-86Q (WINGLETS)	ECHZS	2	J075	2J	B738	3CM034
CFM56-5B4/P	AIRBUS A320-214	ECHZU	2	J067	2J	A320	3CM026
CF34-3B1	BOMBARDIER CRJ200ER (CL-600-2B19)	ECIAA	2	J090	2J	CRJ2	1GE034
FJ44-1A	CESSNA 525 CITATIONJET	ECIAB	2	B001	2B	C525	FOCA
CFM56-5B4/P	AIRBUS A320-214	ECIAG	2	J067	2J	A320	3CM026
V2527-A5	AIRBUS A320-232	ECIAZ	2	J220	2J	A320	1IA003
BRBR700-710A2-20	BOMBARDIER BD-700-1A10 GLOBAL EX-PRE	ECIBD	2	J854	2J	GLEX	4BR009
PT6A-60A	BEECH-CRAFT KING AIR 350 (RAYTHEON B	ECIBK	2	T738	2T	B350	FOI
CF34-3B1	BOMBARDIER CRJ200ER (CL-600-2B19)	ECIBM	2	J090	2J	CRJ2	1GE034
CFM56-7B27B1	BOEING 737-81Q (WINGLETS)	ECICD	2	J075	2J	B738	3CM034
CFM56-5B4/P	AIRBUS A320-214	ECICK	2	J067	2J	A320	3CM026

Emissions

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

Table A - 11 Extract of the output file of FOCA emission and fuel consumption modelling. Upper part: LTO, lower part: cruise (example for 2004). Emissions and fuel consumption in tons.

Airport	Distance	Type Traffic	Move-ments	Type	Aircraft ICAO	Engine Name	Fuel (LTO) tons	Emissions (LTO) in tons					
	Km		No.					CO_2	H_2O	SO_2	NO_x	VOC	CO
LSGG	181501.69	Taxi	165	2B	C550	JT15D-4	5673.492	17871.5	6978.395	5.673	26.04	139	359.2
LSGG	164165.197	Taxi	77	2J	B752	RB211-535E4	47470.5	149532.1	58388.72	47.47	554.91	0	361.47
LSGG	133166.837	Taxi	118	2B	F2TH	CFE738-1-1B	6164.2728	19417.46	7582.056	6.164	87.539	40.59	185.53
LSGG	117228.943	Taxi	99	3B	F900	TFE731-60-1C	5668.542	17855.91	6972.307	5.669	46.937	28.13	163.44
LSGG	114258.902	Taxi	134	2B	LJ45	TFE731-20R	4725.108	14884.09	5811.883	4.725	31.31	53.62	169.01
LSGG	112510.267	Taxi	100	2B	F2TH	CFE738-1-1B	5223.96	16455.47	6425.471	5.224	74.186	34.4	157.23
LSGG	107945.477	Taxi	96	2B	C560	JT15D-5D	3795.3216	11955.26	4668.246	3.795	16.959	271.6	287.98
LSGG	181501.69	Taxi	165	2B	C550	JT15D-4	307732.68	969357.9	378511.2	307.7	4513	29.43	274.71
LSGG	164165.197	Taxi	77	2J	B752	RB211-535E4	673698.47	2122150	828649.1	673.7	7986.4	647.8	1038.2
LSGG	133166.837	Taxi	118	2B	F2TH	CFE738-1-1B	225781.85	711212.8	277711.7	225.8	3311.2	21.59	201.55
LSGG	117228.943	Taxi	99	3B	F900	TFE731-60-1C	298139.18	939138.4	366711.2	298.1	4372.3	28.52	266.14
LSGG	114258.902	Taxi	134	2B	LJ45	TFE731-20R	193723.81	610230	238280.3	193.7	2841	18.53	172.93
LSGG	106761.289	Taxi	100	2B	F2TH	CFE738-1-1B	181011.75	570187	222644.4	181	2654.6	17.31	161.58
LSGG	103217.159	Taxi	96	2B	C560	JT15D-5D	175002.74	551258.6	215253.4	175	2566.5	16.74	156.22

A3.1.5 Road Transportation

Emission factors

The derivation of the emission factors for road vehicles is described in detail in INFRAS 2010 (this report is available in English). Some important features of the emission factor methodologies are summarised in this paragraph.

The emission factors have to be differentiated according to the vehicle categories. Each category contains a number of vehicle classes, which differ by emission concepts. The next table illustrates the classes of the passenger cars. Similar “segmentations” hold for the other vehicle categories too. Emission factors for vehicle classes are combined to average emission factors for vehicles categories weighted according to the fleet composition, which varies from year to year (see below).

Table A - 12 Vehicle segmentation of the passenger cars. Each segment is subdivided into three cubic capacities: <1.4 litre, 1.4-2.0 litres, > 2.0 litres (INFRAS 2010).

Fuel type	Vehicle segment
Gasoline	<ECE
	AGV82 (CH)
	PreEuro 3WayCat <1987
	PreEuro 3WayCat 1987-90
	ECE-15'00
	ECE-15'01/02
	ECE-15'03
	Euro-1
	Euro-2
	Euro-3
	Euro-4
	Euro-5
	Euro-6
Diesel	<1986
	1986-1988
	Euro-1
	Euro-2
	Euro-3
	Euro-4
	Euro-5 Diesel Particle Filter
	Euro-6 Diesel Particle Filter

The emission factors published in the handbook (CD ROM, INFRAS 2010) are classified by “traffic situations”. The scheme (see Table below) distinguishes the traffic situations along 4 dimensions: urban/rural areas, 5 functional road types, speed limit and 4 levels of service. This leads to the definition of 276 different traffic situations in total. A traffic situation is primarily characterised by the type of road which induces a typical driving behaviour. (Because driving behaviour is not independent of the amount of traffic on that particular road, on the same segment different driving patterns may exist.) For the handbook several typical traffic situations have been defined, based on driving behaviour studies in Germany and in Switzerland (see e.g. SAEFL 1995, Chp. 4).

Table A - 13 Traffic situation-scheme in HBEFA 3.1 (INFRAS 2010). Every traffic situation is characterised by a typical driving pattern (i.e. a speed-time curve)

			Speed Limit [km/h]											
Area	**Road type**	**Levels of service**	30	40	50	60	70	80	90	100	110	120	130	>130
Rural	**Motorway-Nat.**	**4 levels of service**						■	■	■	■	■	■	■
	Semi-Motorway	**4 levels of service**							■		■			
	TrunkRoad/Primary-Nat.	**4 levels of service**				■	■	■	■	■	■			
	Distributor/Secondary	**4 levels of service**			■	■	■	■	■	■				
	Distributor/Secondary(sinuous)	**4 levels of service**			■	■	■	■	■	■				
	Local/Collector	**4 levels of service**			■	■	■	■						
	Local/Collector(sinuous)	**4 levels of service**			■	■	■	■						
	Access-residential	**4 levels of service**	■	■	■									
Urban	**Motorway-Nat.**	**4 levels of service**						■	■	■	■	■	■	
	Motorway-City	**4 levels of service**				■	■	■	■	■	■			
	TrunkRoad/Primary-Nat.	**4 levels of service**					■	■	■	■	■			
	TrunkRoad/Primary-City	**4 levels of service**			■	■	■	■	■					
	Distributor/Secondary	**4 levels of service**			■	■	■	■						
	Local/Collector	**4 levels of service**			■	■								
	Access-residential	**4 levels of service**	■	■	■									

Traffic situations are defined independently of vehicle categories (LDV, HDV, 2-wheelers). But behind the same traffic situation each vehicle category may know its own “driving pattern” which may be expressed as a speed curve (i.e. speed time series). Emission factors originally are derived for these underlying driving patterns based on measurements performed on laboratory test benches. Emission factors per traffic situation are then calculated by attributing the driving patterns to different traffic situations (based on statistical analysis).

Emission factors for Switzerland are shown in the next table (FOEN 2010i, updated based on Prognos 2012a). They represent weighted averages over all traffic situations. The year indicates the date when the corresponding vehicle class appears in the market. E.g. “Euro-3” standard came into force on 1 Jan, 2001, but the first vehicles with Euro-3 standard already appeared in 1999.

Table A - 14 Mean emission factors of passenger cars (PC), light duty vehicles (LDV), heavy duty vehicles (HDV), coaches, urban buses (Bus) and Motorcycles (MC) in grams per kilometre, incl. cold starts and evaporation. (FOEN 2010i, updated based on Prognos 2012a). CO_2 (rep.) refers to the fossil part, CO_2 (total) includes fossil and biomass.

Pollutant	Year	PC	LDV	HDV	Coach	Bus	MC
grams per vehicle kilometre, incl. cold starts and evaporation							
CH_4	1990	0.080	0.090	0.020	0.017	0.053	0.236
CH_4	1995	0.050	0.065	0.018	0.016	0.046	0.159
CH_4	2000	0.033	0.039	0.013	0.014	0.034	0.120
CH_4	2005	0.021	0.020	0.009	0.011	0.018	0.103
CH_4	2010	0.013	0.012	0.004	0.007	0.005	0.092
CH_4	2015	0.009	0.006	0.002	0.004	0.003	0.082
CO	1990	9.58	20.16	2.39	2.09	5.99	14.70
CO	1995	5.46	14.60	2.18	2.01	5.68	14.14
CO	2000	3.59	8.86	1.77	1.84	4.64	13.62
CO	2005	2.53	4.39	1.61	1.73	2.92	11.68
CO	2010	1.64	2.09	1.44	1.70	1.26	8.09
CO	2015	1.19	1.28	1.27	1.63	1.03	5.63
CO_2(rep.)	1990	234	249	803	871	1'194	82
CO_2(rep.)	1995	237	252	799	860	1'199	90
CO_2(rep.)	2000	230	254	759	833	1'162	92
CO_2(rep.)	2005	217	246	790	823	1'127	94
CO_2(rep.)	2010	195	237	768	812	1'078	96
CO_2(rep.)	2015	169	224	739	794	1'045	91
CO_2(total)	1990	234	249	803	871	1'194	82
CO_2(total)	1995	237	252	799	860	1'199	90
CO_2(total)	2000	230	255	760	834	1'163	92
CO_2(total)	2005	217	246	793	826	1'131	94
CO_2(total)	2010	199	240	777	821	1'094	99
CO_2(total)	2015	180	232	760	817	1'079	98
HC	1990	1.58	2.02	0.85	0.70	2.20	3.69
HC	1995	0.92	1.38	0.74	0.66	1.93	2.65
HC	2000	0.57	0.77	0.56	0.60	1.42	2.08
HC	2005	0.36	0.38	0.38	0.47	0.73	1.64
HC	2010	0.23	0.19	0.16	0.27	0.22	1.19
HC	2015	0.17	0.12	0.07	0.16	0.12	0.85
N_2O	1990	0.009	0.005	0.008	0.008	0.003	0.002
N_2O	1995	0.012	0.007	0.009	0.008	0.003	0.002
N_2O	2000	0.011	0.009	0.009	0.008	0.003	0.002
N_2O	2005	0.005	0.007	0.008	0.007	0.002	0.002
N_2O	2010	0.003	0.006	0.030	0.014	0.001	0.002
N_2O	2015	0.002	0.005	0.041	0.023	0.002	0.002
NMHC	1990	1.504	1.930	0.827	0.681	2.151	3.451
NMHC	1995	0.871	1.320	0.721	0.640	1.880	2.489
NMHC	2000	0.538	0.735	0.543	0.582	1.383	1.964
NMHC	2005	0.343	0.362	0.373	0.459	0.714	1.538
NMHC	2010	0.217	0.180	0.155	0.265	0.209	1.096
NMHC	2015	0.163	0.116	0.069	0.156	0.110	0.773
NO_x	1990	2.147	4.167	22.457	22.929	33.896	0.294
NO_x	1995	1.608	3.485	20.751	21.648	32.841	0.392
NO_x	2000	1.301	3.067	18.148	19.938	29.997	0.423
NO_x	2005	0.968	2.595	15.051	17.360	24.703	0.444
NO_x	2010	0.679	2.117	9.512	13.381	18.000	0.400
NO_x	2015	0.535	1.857	6.213	10.142	13.576	0.352
SO_2	1990	0.040	0.093	0.714	0.774	1.061	0.010
SO_2	1995	0.031	0.041	0.173	0.186	0.260	0.011
SO_2	2000	0.022	0.034	0.131	0.144	0.201	0.008
SO_2	2005	0.001	0.001	0.005	0.005	0.007	0.000
SO_2	2010	0.001	0.001	0.005	0.005	0.007	0.001
SO_2	2015	0.001	0.001	0.005	0.005	0.006	0.001

Activity Data

Activity data for the emission model are the mileages of the vehicle categories per traffic situation. To that aim, three steps must be carried out.

1. Vehicle turnover: The vehicle fleet is built up for each year accounting for the stock changes. This vehicle turnover is modelled on the basis of new registrations and by applying survival probabilities. Trends in traffic volume per vehicle category, including structural changes (size distributions, shares of diesel vehicles) are then combined to draw the continual substitution of older technologies by new ones constantly altering the fleet composition or mileage by emission concepts in all vehicle categories (see following Figure).

2. The total mileage is calculated by vehicle stock multiplied with the specific mileage per vehicle and annum. The latter data are derived from household surveys and from specific odometer readings during vehicle inspections (ARE 2002).

3. Assignment of the mileage to the traffic situations for all vehicle categories. This step requires the adoption of the traffic model: Each road segment carries its mileage and its traffic, which allows the assignment sought.

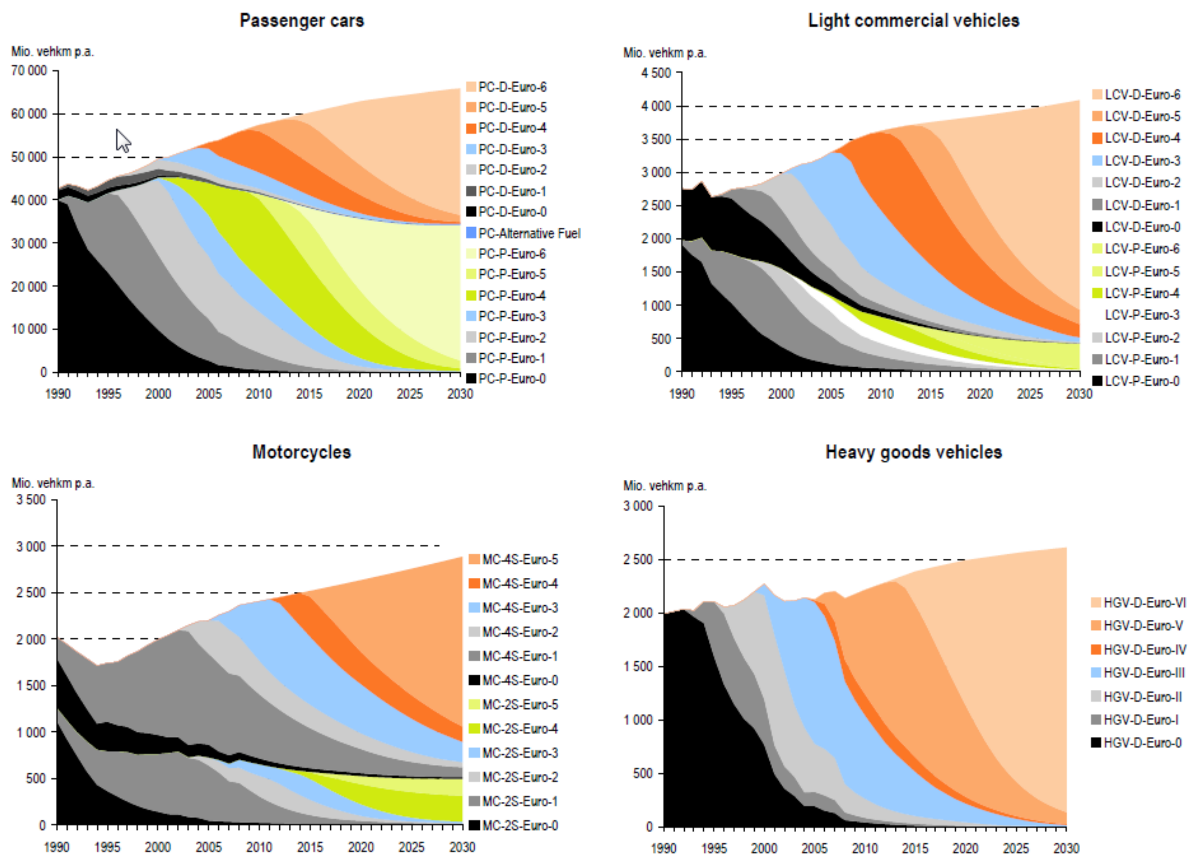


Figure A - 3 Mileage composition by emission concept (in million vehicle kilometres per year), FOEN 2010i.

Modelling hot exhaust emissions

As a next step in the modelling process, the mileage classified by vehicle segments and traffic situations is multiplied with the emission factors resulting in hot exhaust emissions.

The results do not yet contain the emissions from tank tourism. For this purpose a special procedure is carried out (described in section 3.2.8.2 b), providing the fuel consumption of tank tourism. From that, the emissions are calculated by multiplication with mean emission factors.

Cold start and evaporative emissions

The handbook also contains emission factors for modelling cold start excess emissions and evaporative emissions (diurnal and hot/warm soak and running losses). For a technical description the reader may be referred to INFRAS (2010).

Results show that for CO_2 the hot exhaust emissions contribute to 97% of the total. Only 3% stem from cold start excess emissions. For CH_4 however, the picture is much different. Only about 40% of the emission total is hot exhaust. More than 59% are cold start excess emissions, the rest results evaporative emissions. For N_2O, no cold start emissions or evaporative emissions are taken into account due to lack of data.

A3.1.6 Off-road Vehicles

Methodology

The emissions of the whole off-road sector underwent a complete revision for Submission 2010. The emissions are calculated with a Tier 2 method. Activity data and emission factors were updated for Submission 2010; for the present Submission, activity data have again been recalculated following the update of the latest figures on population and economy (Prognos 2012a). The modelling is carried out in a database (INFRAS 2008) that is structured in analogy to the on-road database (INFRAS 2010). The off-road sector has been allocated to 1A2, 1A3 and 1A4, with only military offroad remaining in 1A5.

The modelling of the emission and of the fuel consumption are carried out by using the formula

$$E^{g}_{i,j,t,\tau} = N_{i,j,t} \cdot T_{i,j,t} \cdot \omega_{t-\tau} \cdot P_{i,j} \cdot L_{i,j} \cdot \nu_{t-\tau} \cdot \varepsilon^{g}_{i,j,\tau}$$

E: Emission and fuel consumption
N: number of vehicles
T: average operating hours per year
ω: age dependency
P: motor power in kW
L: load factor
ν: degradation factor (due to aging)
ε: emission factor in g/kWh
indices: g: gas (CH_4, N_2O, CO, NO_X, SO_2) and fuel consumption,
i off-road family (railway, navigation etc.),
j size class,
t: year (1980, 1985, 1990, 1995, 2000, … , 2020)
τ: year of construction (note: t - τ = age of vehicle)

Note that the emissions are only calculated in steps of 5 years. Emissions for years in-between like 1991, 1992 etc. are interpolated linearly.

Emission and fuel consumption factors for off-road vehicles

The CO_2 emission factors are derived from fuel type and fuel consumption (see tables below). The emission factors for CH_4 and N_2O are only specified by the fuel type.

Table A - 15 CH_4 (TTM 2006a) and N_2O (TTM 2006b) emission factors used in the off-road model (INFRAS 2008).

Gas	Diesel	Gasoline	
		4-stroke	2-stroke
	mg/kWh		
CH_4	6	500	4000
N_2O	30	50	--

The values differ from default values (IPCC 1996, vol III, tbl 1-7, 1-8, conversion factor used: 1 g/kWh = 278 kg/TJ): For CH_4 IPCC recommends 18 mg/kWh for diesel oil, 72 mg/kWh for gasoline four-stroke, 210 mg/kWh gasoline two-stroke. For N_2O IPCC gives 2 mg/kWh (diesel oil and gasoline four-stroke) and 6 mg/kWh (gasoline two-stroke).

Table A - 16 Emission and consumption factors for diesel engines (without ships and rail vehicles). PreEU-A etc. indicate emission standards.

Basic emission factors of diesel engines (g/kWh)						
power class	PreEU-A <1996	PreEU-B 1996	EU-I 2002/2003	EU-II 2003/2004	EU-IIIA 2007/2008	EU-IIIB 2011/2012
Carbon monoxide (CO)						
<18 kW	6.71	6.71	2.90	2.90	2.90	2.90
18-37 kW	6.71	6.71	2.76	2.42	2.06	1.76
37-75 kW	4.68	4.68	1.87	1.63	1.39	1.19
75-130 kW	3.62	3.62	1.28	1.01	0.86	0.73
>130 kW	3.62	3.62	1.04	0.91	0.77	0.66
VOC						
<18 kW	2.28	2.28	1.60	1.00	0.59	0.59
18-37 kW	2.41	2.41	0.92	0.56	0.37	0.37
37-75 kW	1.33	1.33	0.65	0.46	0.33	0.24
75-130 kW	0.91	0.91	0.45	0.35	0.28	0.17
>130 kW	0.91	0.91	0.43	0.3	0.22	0.17
Nitrogen oxides (NO_x)						
<18 kW	10.31	8.2	5.95	5.95	5.95	5.95
18-37 kW	10.31	8.2	6.34	6.34	6.34	6.34
37-75 kW	12.4	9.87	8.95	6.56	3.90	3.39
75-130 kW	12.52	9.96	8.44	5.67	3.32	2.97
>130 kW	12.52	9.96	8.19	5.66	3.38	1.80
Fuel consumption (FC)						
<18 kW	248	248	248	248	248	248
18-37 kW	248	248	248	248	248	248
37-75 kW	248	248	248	248	248	248
75-130 kW	223	223	223	223	223	223
>130 kW	223	223	223	223	223	223

Table A - 17 Emission and consumption factors for gasoline four-stroke engines. PreEU-A etc. indicate emission standards.

Basic emission factors of equipment with 4-stroke gasoline engines (g/kWh).					
power class	PreEU-A <1995	PreEU-B 1995	PreEU-C 2000	EU-I 2004	EU-II 2005-2009
Carbon monoxide (CO)					
<66 ccm	470	470	470	467	467
66-100 ccm	470	470	470	467	467
100-225 ccm	470	470	470	467	467
>225 ccm	470	470	470	467	467
VOC					
<66 ccm	60	60	60	41	41
66-100 ccm	40	40	40	32	32
100-225 ccm	20	20	20	12	12
>225 ccm	20	20	20	10	9
Nitrogen oxides (NO_x)					
<66 ccm	1.5	2	3	4.5	4.5
66-100 ccm	1.5	2	3	3.6	3.6
100-225 ccm	3.5	3.5	3.5	2.8	2.8
>225 ccm	3.5	3.5	3.5	2.2	1.9
Fuel consumption (FC)					
<66 ccm	500	500	500	480	480
66-100 ccm	480	480	480	470	470
100-225 ccm	460	460	460	450	450
>225 ccm	460	460	460	450	450

Table A - 18 Emission and consumption factors for gasoline two-stroke engines. PreEU-A etc. indicate emission standards.

Basic emission factors of equipment with 2-stroke gasoline engines (g/kWh)					
gas/fuel consumption	PreEU-A <1995	PreEU-B 1995	PreEU-C 2000	EU-I 2004	EU-II 2009/2011
Carbon monoxide (CO)	650	640	620	600	600
VOC	260	250	150	100	41
Nitrogen oxides (NO_x)	1.5	2.0	3.0	4.8	4.5
Fuel consumption (FC)	660	650	550	500	440

Table A - 19 Emission and consumption factors for rail vehicles with diesel engines. PreEU etc. indicate emission standards.

Basic emission factors of rail vehicles (g/kWh)					
power class	PreEU <2000	UIC I 2000	UIC II 2003	EU IIIa 2006/2009	EU IIIb 2012
Carbon monoxide (CO)					
<560 kW	4	3	2.5	2.5	2.5
>560 kW	4	3	3	3	3
VOC					
<560 kW	1.6	0.8	0.6	0.4	0.17
>560 kW	1.6	0.8	0.8	0.5	0.4
Nitrogen oxides (NO_x)					
<560 kW	13	12	6	3.2	1.8
>560 kW	16	12	9.5	5.4	3.2
Fuel consumption (FC)					
<560 kW	223	223	223	223	223
>560 kW	223	223	223	223	223

Table A - 20 Emission and consumption factors for ships with diesel engines. PreSAV etc. indicate emission standards.

Basic emission factors of diesel engine ships (g/kWh)						
power class	PreSAV <1995	SAV 1995	EU I 2003	EU II 2008	EU III-a 2009	EU III-b 2012
Carbon monoxide (CO)						
<18 kW	6.7	6.7	6.7	6.7	6.7	5.5
18-37 kW	6.7	6.7	6.7	6.7	6.7	5
37-75 kW	5.9	5.9	5.9	4.5	4.5	4.5
75-130 kW	5	5	4.5	4.5	4.5	4.5
>130 kW	5	5	4.5	4.5	4.5	3.5
VOC						
<18 kW	10	7.2	5	3	2	1
18-37 kW	10	7.2	5	3	2	1
37-75 kW	10	5.4	1.2	1.2	1.1	0.6
75-130 kW	10	4.1	1.2	0.9	0.8	0.4
130-399 kW	5	3.6	1.2	0.9	0.8	0.4
300–560 kW	5	3.2	1.2	0.9	0.8	0.4
>560 kW	5	2.8	1.2	0.9	0.8	0.4
Nitrogen oxides (NO_x)						
<18 kW	10.3	10.3	10.3	10.3	10.3	8
18-37 kW	10.3	10.3	10.3	10.3	10.3	8
37-75 kW	12.4	12.4	8.3	6.3	5.7	3.3
75-130 kW	12.5	12.5	8.3	6.3	5.7	3.3
>130 kW	12.5	12.5	8.3	6.3	5.7	2
Fuel consumption (FC)						
<18 kW	248	248	248	248	248	248
18-37 kW	248	248	248	248	248	248
37-75 kW	248	248	248	248	248	248
75-130 kW	223	223	223	223	223	223
>130 kW	223	223	223	223	223	223

Table A - 21 Emission and consumption factors for boats with diesel engines. PreSAV etc. indicate emission standards.

Basic emission factors of diesel engine boats (g/kWh)				
power class	**PreSAV <1995**	**SAV 1995**	**EU-I 2007**	**EU II 2012**
Carbon monoxide (CO)				
<4.4 kW	6.7	6.7	4.5	4
4.4-7.4 kW	6.7	6.7	4.5	4
7.4-37 kW	6.7	6.7	4.5	4
37-74 kW	5.9	5.9	4.5	4
74-100 kW	5	5	4.5	4
>100 kW	5	3.6	3.6	3.5
VOC				
<4.4 kW	10	10	2.4	1.5
4.4-7.4 kW	10	10	2.1	1.5
7.4-37 kW	10	2	1.7	1.5
37-74 kW	10	1.4	1.4	1.3
74-100 kW	10	1.2	1.2	1
>100 kW	5	1.2	1.2	1
Nitrogen oxides (NO_x)				
<4.4 kW	13	11	8.8	6
4.4-7.4 kW	13	11	8.8	6
7.4-37 kW	13	11	8.8	6
37-74 kW	13	11	8.8	6
74-100 kW	13	11	8.8	6
>100 kW	13	11	8.8	6
Fuel consumption (FC)				
<4.4 kW	400	400	400	400
4.4-7.4 kW	400	400	400	400
7.4-37 kW	400	380	380	380
37-74 kW	380	350	350	350
74-100 kW	400	330	330	330
>100 kW	300	300	300	300

Table A - 22 Emission and consumption factors for boats with gasoline engines. PreSAV etc. indicate emission standards.

Basic emission factors of gasoline engine boats (g/kWh)						
power class	2-stroke gasoline engine			4-stroke gasoline engine		
	PreSAV <1995	SAV 1995	SAV/EU 2007	PreSAV <1995	SAV 2007	EU 2007
Carbon monoxide (CO)						
<4.4 kW	645	315	315	350	315	315
4.4-7.4 kW	645	200	225	350	200	225
7.4-37 kW	645	100	162	350	100	162
37-74 kW	645	65	144	350	65	144
74-100 kW	645	55	141	350	55	141
>100 kW	645	45	139	350	45	139
VOC						
<4.4 kW	260	22	25	25	22	25
4.4-7.4 kW	260	12	13	20	12	13
7.4-37 kW	260	6	8	20	6	8
37-74 kW	260	4	6	20	4	6
74-100 kW	260	3.3	5	20	3.3	5
>100 kW	260	2.1	5	20	2.1	5
Nitrogen oxides (NO_x)						
<4.4 kW	15	13	13	3.5	13	13
4.4-7.4 kW	15	9.3	9.3	3.5	9.3	9.3
7.4-37 kW	15	9.3	9.3	3.5	9.3	9.3
37-74 kW	15	9.3	9.3	3.5	9.3	9.3
74-100 kW	15	9.3	9.3	3.5	9.3	9.3
>100 kW	15	9.6	9.6	3.5	9.6	9.6
Fuel consumption (FC)						
<4.4 kW	700	400	400	400	400	400
4.4-7.4 kW	700	400	400	400	400	400
7.4-37 kW	650	380	380	380	380	380
37-74 kW	650	380	380	380	380	380
74-100 kW	650	380	380	380	380	380
>100 kW	650	380	380	380	380	380

Table A - 23 Emission and consumption factors (FC) for ships with steam engines (gas oil). steam 1 etc. indicate emission standards.

Basic emission factors of steam (gas oil) engine ships (g/kWh)							
pollutant	steam 1 <1950	steam 2 1950	steam 3 1980	steam 4 1990	steam 5 1995	steam 6 2005	steam 7 2005
CO	0.3	0.3	0.3	0.09	0.09	0.09	0.09
HC	0.45	0.45	0.45	0.33	0.33	0.33	0.33
NO_x	2.34	2.34	2.34	1.77	1.56	1.26	1.03
PM	0.033	0.024	0.015	0.009	0.006	0.006	0.006
FC	1406	1012	787	703	703	703	703

Activity data off-road vehicles

The activity data are described in detail in INFRAS (2008). Aggregated numbers are shown in the following tables.

Table A - 24 Number of vehicles per off-road family (INFRAS 2008)

Family	1990	1995	2000	2005	2010	2015
	no. of vehicles					
Construction	56'070	52'443	47'995	47'354	48'162	48'770
Industry	13'947	18'372	22'748	22'748	23'739	24'499
Agriculture	324'567	324'047	337'869	339'948	359'496	372'900
Forestry	13'844	13'357	13'055	12'749	12'548	12'144
Garden/Hobby	659'828	719'118	779'052	763'881	786'481	800'506
Navigation	93'395	89'042	82'674	82'647	86'790	90'134
Railway	1'300	1'305	1'255	1'255	1'318	1'370
Military	1'340	1'340	1'340	1'340	1'408	1'462
Sum	**1'164'291**	**1'219'024**	**1'285'988**	**1'271'922**	**1'319'942**	**1'351'784**

Table A - 25 Operating hours per vehicle per year and (Table A- 1million) operating hours per off-road family (INFRAS 2008).

Family	1990	1995	2000	2005	2010	2015
	operating hours per veh. per year					
Construction	299	353	383	386	387	388
Industry	628	648	660	660	660	659
Agriculture	119	118	112	108	104	100
Forestry	199	201	203	202	202	201
Garden/Hobby	22	25	27	27	27	28
Navigation	40	39	40	40	40	40
Railway	612	627	616	616	616	616
Military	51	53	54	52	49	47

Family	1990	1995	2000	2005	2010	2015
	mio. of operating hours					
Construction	16.75	18.52	18.38	18.26	18.65	18.95
Industry	8.76	11.90	15.01	15.01	15.66	16.16
Agriculture	38.77	38.21	37.68	36.57	37.26	37.45
Forestry	2.76	2.68	2.64	2.57	2.53	2.44
Garden/Hobby	14.42	17.71	21.09	20.78	21.52	22.04
Navigation	3.72	3.46	3.34	3.33	3.49	3.61
Railway	0.80	0.82	0.77	0.77	0.81	0.84
Military	0.07	0.07	0.07	0.07	0.07	0.07
Sum	**86.04**	**93.37**	**98.99**	**97.36**	**100.00**	**101.56**

A3.2 Industrial Processes

Illustrative Example of modelling Mobile Air-Conditioning / Cars

Table A - 26 Model structure and assumptions for calculating emissions from mobile air conditioning in cars. The example represents data for the year 2012. The basic parameters have not changed for the present inventory.

Parameters for Car Air-Conditioning		
Initial Charge in kg	1994	0.81
	2002	0.7
	Other years inter-/extrapolated	
All units are imported with refrigerants charged		
Emission factor 1995	Annual loss	8.5%
	Share recharged regularly	6.0%
	Share not recharged	2.5%
Charge at end of life		58.0%
Disposal emissions	Up to 1999	100.0%
	From 2000 onwards	50.0%
Export of second hand cars		50.0%
Reuse of recovered refrigerant (estimate value)		80.0%
Servicing emission factor		10.0%
Product lifetime		15
Market growth rate		0.5%

Year	New registered vehicles	Vehicles in use	Disposed vehicles	AC units in new registered cars			Stock - AC units in use		Disposal	Initial charge
	(VSAI, EFKO)	(B. f. Statistik/Astra)		Portion of vehicles with AC [%]	R134a as refrigerant [%]	AC units with R134	Portion of vehicles with R134a [%]	Units with R134	Units AC with R134	kg /vehicle
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	0.81
1995	272'897	3'229'169	208'771	24	100	65'495	5	146'147	0	0.78
1996	269'529	3'268'073	230'625	38	100	102'421	8	248'568	0	0.77
1997	272'441	3'323'421	217'093	52	100	141'669	12	390'237	0	0.76
1998	297'336	3'383'275	237'482	68	100	202'188	18	592'426	0	0.75
1999	317'985	3'467'275	233'985	75	100	238'489	24	830'914	0	0.73
2000	315'398	3'545'247	237'426	77	100	242'856	30	1'073'771	0	0.72
2001	317'126	3'629'713	232'660	85	100	269'557	37	1'343'328	0	0.71
2002	295'109	3'704'822	220'000	87	100	256'745	43	1'600'073	0	0.70
2003	271'541	3'754'000	222'363	89	100	241'671	49	1'841'744	0	0.70
2004	269'211	3'811'351	211'860	91	100	244'982	55	2'086'726	0	0.70
2005	259'426	3'863'807	206'970	92	100	238'672	60	2'325'398	0	0.70
2006	269'421	3'899'917	233'311	96	100	258'644	66	2'582'409	1'633	0.70
2007	284'674	3'955'787	228'804	96	100	273'287	72	2'849'519	6'178	0.70
2008	288'525	4'030'965	213'347	96	100	276'984	77	3'106'789	19'713	0.70
2009	266'018	4'051'569	245'414	96	100	255'377	82	3'320'201	41'966	0.70
2010	294'239	4'119'370	226'438	96	100	282'469	86	3'548'325	54'345	0.70
2011	327'896	4'209'300	237'966	96	100	314'780	90	3'772'678	90'427	0.70
2012	328'139	4'254'725	282'714	96	100	315'013	93	3'940'680	147'011	0.70

R 134a	Activity			Emissions				Recharge	
	Input with vehicles	Stock	Disposed	Stock incl. Recharge	Disposal	Recharge	Total	import in bulk	recovered/reused
	[t]	[t]	[t]	[t]	[t]	[t]	[t]	[t]	[t]
1990	0	0	0	0	0	0	0	0	0
1991	2	2	0	0	0	0	0	0.1	0.0
1992	7	8	0	0	0	0	0	0.3	0.0
1993	20	28	0	2	0	0	2	1.1	0.0
1994	37	65	0	4	0	0	4	2.8	0.0
1995	51	115	0	8	0	0	8	5.4	0.0
1996	79	191	0	14	0	1	14	9.2	0.0
1997	107	294	0	23	0	2	23	14.6	0.0
1998	151	437	0	35	0	4	35	21.9	0.0
1999	175	599	0	49	0	5	49	31.1	0.0
2000	176	757	0	65	0	8	65	40.7	0.0
2001	192	924	0	82	0	11	82	50.4	0.0
2002	180	1'072	0	100	0	15	100	59.9	0.0
2003	169	1'201	0	114	0	18	114	68.2	0.0
2004	171	1'326	0	125	0	18	125	75.8	0.0
2005	167	1'444	0	137	0	19	137	83.1	0.0
2006	181	1'571	1	146	0	18	146	90.5	0.2
2007	191	1'706	3	156	1	17	157	98.3	0.6
2008	194	1'839	9	168	2	17	170	106.4	1.9
2009	179	1'947	20	178	5	17	183	113.6	4.0
2010	198	2'061	25	188	6	18	195	120.2	5.0
2011	220	2'188	41	200	10	19	210	127.5	8.1
2012	221	2'296	65	210	16	19	226	134.5	13.0

A3.3 Agriculture

Additional data for estimating enteric fermentation emission factors for cattle

Table A - 27 Data for estimating enteric fermentation emission factors for cattle. Reference: IPCC 1997c, p 4.31 – 4.33

Data for estimating enteric fermentation emission factors for cattle in Switzerland										
Type	Age[a]	Weight[a] kg	Weight Gain[a] kg/day	Feeding Situation / Further Specification[a]	Milk[b] kg/day	Work hrs/day	Pregnant[a] %	Digesti-bility of Feed[d] %	CH_4 Conver-sion[d] %	Em. Factor kg/head/ year[e]
Mature Dairy Cattle	NA	650	0		16.1 - 22.6 [c]	0	305 days of lactation	60	6.00	101.52 - 122.83
Mature Non-Dairy Cattle	NA	550	0		8.2	0		60	6.00	80.71
Fattening Calves	0-98 days	60-200	1.43	Rations of unskimmed milk and supplement feed when life weight exceeds 100 kg. Rations are apportioned on two servings per day.	0	0	0	65	0.00	0.00
Pre-Weaned Calves	0-10 month	60-325	1	"Natura beef" production, milk from mother cow and additional feed.	0	0	0	65	6.00	18.03
Breeding Calves	0-4 month	50-120	0.8	Feeding plan for a dismission with 14 to 15 weeks. Milk, feed concentrate (100kg in total), hay (80 kg in total).	0	0	0	65	6.00	26.58
Breeding Cattle (4-12 months)	4-12	120-300	0.8	Premature race (Milk-race)	0	0	0	60	6.00	
Breeding Cattle (> 1 year)	12-28/30	300-600	0.8	Premature race (Milk-race)	0	0	0	60	6.00	50.79
Fattening Calves (0-4 months)	0-4 month	70-175	0.86	Diet based on milk or milk-powder and feed concentrate, hay and/or silage	0	0	0	65	6.00	40.78
Fattening Cattle (4-12 months)	4-12 month	175-550	1.3	Feeding recommendations for fattening steers, concentrate based	0	0	0	60	6.00	

[a] data source: RAP 1999 and calculations according to Soliva 2006
[b] Milk production in kg/day is calculated by dividing the average annual milk production per head by 305 days (lactation period).
[c] data source: Swiss farmers union (SBV 2011).
[d] data source: IPCC 1997c and IPCC 2000
[e] For better comparability emission factors of young cattle have been converted to kg/head/year although the time span of most of the individual categories is less than 365 days.

Additional data for estimating manure management CH_4 emission factors

Table A - 28 Data for estimating manure management CH_4 emission factors. Reference: IPCC 1997c, Tables B-1 to B-7.

Data for estimating Manure Management CH_4 emission factors in Switzerland							
Type	Weight kg [a]	Digestibility of Feed % [b]	Energy Intake MJ/day	Feed Intake kg/day	% Ash Dry Basis [b]	VS kg/head/ day	B_0 m^3 CH_4/kg VS [b]
Mature Dairy Cattle	650	60	258 - 312	15.89 [c]	8	5.15-6.24	0.24
Mature Non-Dairy Cattle	550	60	205.1	10.96 [c]	8	4.09	0.24
Fattening Calves	60 – 200	65	47.6	2.02 [a]	8	0.83	0.17
Pre-Weaned Calves	60 – 325	65	55.7	2.98 [a]	8	0.97	0.17
Breeding Calves	50 – 120	65	26.9	1.5 [a]	8	0.47	0.17
Breeding Cattle (4-12 months)	120 – 300	60	89.2	4.88 [a]	8	1.78	0.17
Breeding Cattle (> 1 year)	300 – 600	60	129.1	7.78 [a]	8	2.57	0.17
Fattening Calves (0-4 months)	70 – 175	65	55.6	3.27 [a]	8	0.97	0.17
Fattening Cattle (4-12 months)	175 – 550	60	124.6	6.82 [a]	8	2.48	0.17
Sheep	Not determined	60	21 - 24	1.09-1.24 [c]	8	0.40 [b]	0.19
Goats	Not determined	60	25 - 28	1.21-1.26 [c]	8	0.28 [b]	0.17
Horses	Not determined	70	107 - 108	7.73-7.83 [c]	4	1.72 [b]	0.33
Mules and Asses	Not determined	70	39 - 40	Not estimated	4	0.94 [b]	0.33
Swine	Not determined	75	26 - 32	Not estimated	2	0.50 [b]	0.45
Poultry	Not determined	Not estimated	1.2 - 1.6 [d]	Not estimated	Not estimated	0.10 [b]	0.32

[a] RAP 1999
[b] IPCC 1997c and IPCC 2000
[c] Flisch et al. 2009
[d] based on metabolizable energy (ME)

Additional data for N_2O emission calculation of agricultural soils

Table A - 29 Additional data for N_2O emission calculation of agricultural soils.

2012	Total crop production Crop(O) and Crop(BF) (kg DM)	Nitrogen incorporated with crop residues F(CR) (t N)	N_2O emissions from crop residues (t N_2O)	N fixed per kg crop DM (kg N/kg crop)	N fixed (kg N)	N_2O emissions from N fixation (t N_2O)
1. Cereals						
Wheat	426'771'400	1'788	35.12			
Barley	156'827'550	800	15.70			
Maize	124'897'300	1'191	23.39			
Oats	7'450'250	46	0.91			
Rye	8'896'100	38	0.74			
Other:						
Triticale	47'007'550	230	4.53			
Spelt	12'203'450	112	2.19			
Mix of Fodder Cereals	844'050	4	0.08			
Mix of Bread Cereals	209'100	1	0.02			
2. Pulse						
Dry Beans	804'100	32	0.63	0.0521	41'861	0.82
Peas (Eiweisserbsen)	11'139'250	328	6.44	0.0424	471'780	9.27
Soybeans	2'635'000	109	2.13	0.0671	176'700	3.47
Other:						
Leguminous Vegetables	2'771'489	402	7.90	0.1170	324'149	6.37
3. Tuber and Root						
Potatoes	96'694'400	353	6.94			
Other:						
Fodder Beet	10'864'000	87	1.71			
Sugar Beet	368'007'420	3'312	65.06			
5. Other						
Fruit	51'304'640	205	4.03			
Grass	6'261'698'258	22'299	438.02	0.0051	32'117'271	630.87
Green Corn	109'609'171	50	0.98			
Non-Leguminous Vegetables	55'165'829	514	10.09			
Rape	59'760'000	873	17.14			
Renewable Energy Crops	4'176'000	61	1.20			
Silage Corn	644'759'829	370	7.27			
Sunflowers	7'820'000	166	3.25			
Tobacco	1'071'000	28	0.55			
Vine	25'430'600	153	3.00			
Total Non-leguminous	2'219'769'639	10'381	203.91			
Total Leguminous	17'349'839	870	17.10		1'014'490	19.9
Total excluding grass	2'237'119'478	11'251	221.01		1'014'490	19.9
Total including grass	8'498'817'736	33'551	659.03		33'131'761	650.8

Table A - 30 Additional data for N_2O emission calculation of agricultural soils.

2012	Residue/ Crop ratio (kg/kg)	Dry matter (dm) fraction of residue (kg/kg)	Nitrogen content of residues (kg/kg)
1. Cereals			
Wheat	1.15	0.85	0.0037
Barley	1.00	0.85	0.0051
Maize	1.11	0.85	0.0086
Oats	1.27	0.85	0.0049
Rye	1.17	0.85	0.0036
Other :			
Triticale	1.25	0.85	0.0039
Spelt	1.56	0.85	0.0059
Mix of Fodder Cereals	1.00	0.85	0.0051
Mix of Bread Cereals	1.17	0.85	0.0037
2. Pulse			
Dry Beans	1.13	0.85	0.0353
Peas (Eiweisserbsen)	1.25	0.85	0.0235
Soybeans	1.00	0.85	0.0412
Other:			
Leguminous Vegetables	3.87	0.16	0.0328
3. Tuber and Root			
Potatoes	0.47	0.13	0.0127
Other :			
Fodder Beet	0.41	0.15	0.0233
Sugar Beet	0.67	0.15	0.0220
5. Other			
Fruit	NA	0.17	0.0040
Grass	0.26	NA	0.0215
Green Corn	0.05	0.32	0.0091
Non-Leguminous Vegetables	0.46	0.13	0.0230
Rape	1.86	0.85	0.0083
Renewable Energy Crops	1.86	0.85	0.0083
Silage Corn	0.05	0.32	0.0115
Sunflowers	2.00	0.60	0.0150
Tobacco	1.18	NA	0.0221
Vine	NA	0.20	0.0060

Annex 4: CO_2 Reference Approach and comparison with Sectoral Approach, and relevant information on the national energy balance

Reviewers have repeatedly asked for explanations of the apparent differences between the energy data held by the International Energy Agency (IEA) and the data reported in the reference approach. In order to clarify the pertaining issues, the reasons for the major differences are given below. Data for the year 2010 are used to illustrate the description.

General remarks

The **net calorific values** used by IEA differ from those used in the GHG inventory. In order to avoid differences caused by the conversion with different NCV, the comparison between IEA and the reference approach is made in Gg.

Stock changes as reported by IEA are only including primary stocks (IEA 2005), while the reporting in the reference approach includes secondary and tertiary stocks. This results in a particularly large difference for gas oil, as retailers and end-consumers hold considerable amounts of heating fuel on stock. The IEA subsumes secondary and tertiary stock changes under statistical difference.

All data regarding liquid fuel consumption reported by the IEA includes fuel consumption in **Liechtenstein** (Geographical coverage in IEA 2012). For reporting purposes under the UNFCCC, consumption of Liechtenstein is subtracted.

Data sources used for the comparison shown in table A-33 below are:

- Switzerland’s greenhouse gas inventory 1990-2011, submission of 15. April 2013, CRF-table 1.A(b), (FOEN 2013).
- Energy statistics of OECD countries (2012 Edition), (IEA 2012).

Liquid fuels

The total amount of liquid fuel consumption as reported in the greenhouse gas inventory is 11'052 Gg. There is a difference of 13 Gg (0.1%) between CRF and IEA. This difference is primarily caused by the different methodology used for aviation bunkers (see below).

Crude oil

Crude oil in the reference approach contains additives, while IEA lists them separately (data in italics in table A-33). The difference between CRF and IEA is smaller than 0.1% if the sum of additives, refindery feedstocks and crude oil is considered.

Gasoline

The comparison is made for motor gasoline only. Aviation gasoline is included under aviation fuels. Gasoline reported by IEA includes gasoline used in Liechtenstein (LIE), which is subtracted for reporting under the UNFCCC. The difference between CRF and IEA is approximately 0.1%, if the consumption of LIE is taken into account.

Aviation fuels

The different aviation fuels are aggregated in the greenhouse gas inventory. For comparison of IEA and reference approach, all aviation fuels are summed up. The difference between IEA and reference approach if considering the apparent final consumption is 12 Gg (approximately 1% of imports). This difference is largely due to a different methodology used to estimate international bunker. Aviation bunkers have to be reported monthly to the IEA. As the tier 3 approach used for the greenhouse gas inventory is not available on a monthly basis, the international bunker fuel estimate of IEA consists of the total consumption at the two international airports in Zurich and Geneva, while all remaining fuel use is considered domestic. The reporting in the national greenhouse gas inventory is based on a much more detailed approach, where information on single flights is taken into account. Due to the different approach, the numbers are somewhat different. However, the order of magnitude is the same, and the information in the inventory is based on a higher-tier method and presumably more accurate.

Diesel and gas oil

The IEA numbers include diesel and gas oil used in Liechtenstein. Furthermore, stock changes are reported differently in the CRF and by the IEA. Secondary and tertiary stock changes are subsumed under statistical difference by the IEA, while they are included in the stock change reported in the reference approach. If the statistical difference is taken into account, the difference in the apparent consumption is less than 0.1%.

Residual fuel oil

Data agree between IEA and UNFCCC. It seems as if there is a rounding error in the imported amounts, leading to an apparent difference of 1 Gg. According to the foreign trade statistics, 33'693 t of residual fuel oil had been imported in 2010.

Bitumen

Bitumen is a main feedstock in the greenhouse gas inventory. Data between IEA and the reference approach compare well. Again, small differences are likely due to the use of rounded values, leading to apparent differences of the order of 1-2 Gg.

Petroleum coke

There are considerable differences (26 Gg) in the reported numbers for petroleum coke import. The reason for this apparent difference is that for IEA, all petroleum coke is reported together. In the greenhouse gas inventory, however, only the petroleum coke used as a fuel is reported under petroleum coke, while calcined petroleum coke is reported together with “other oil” as feedstocks. This is largely a consequence of the treatment of fuels and feedstocks in the Swiss energy statistic (SFOE 2012).

Lubricants

There are small differences between IEA and the reference approach, as the data reported to the IEA comprises a slightly different set of customs tariff headings for lubricants to the one used for the Swiss energy statistic. The substances not reported under lubricants in the reference approach are reported under other oil.

Liquefied petroleum gas (LPG)

The reporting of liquefied petroleum gas in the greenhouse gas inventory includes white spirit and lamp oil. As for petroleum coke, IEA numbers include fuels that are used as feedstocks, while in the reference approach, only liquefied petroleum gas, white spirit and lamp oil used as fuels are reported under liquefied petroleum gas. The difference in apparent consumption between IEA and the reference approach is 3 Gg (0.03% of total liquid fuel consumption).

Other oil products

In the greenhouse gas inventory, all other oil products are reported together, while IEA has a finer degree of disaggregation. As already mentioned above, the share of petroleum coke that is used as a feedstock is reported under other oil in the greenhouse gas inventory. Therefore, the difference between IEA and the reference approach corresponds largely to the difference in apparent consumption of petroleum coke.

Solid fuels

Solid fuels play only a minor role in Switzerland (246 Gg) and are reported in good agreement.

Gaseous fuels

In the greenhouse gas inventory, the amount of gas reported under 1B2b Fugitive emissions is subtracted from the total gas import as reported by IEA, as this gas is not used for energy purposes. Taking this into account the difference is of the order of 2 TJ.

Table A - 31 Comparison of the IEA energy statistic with the Reference Approach for the year 2010. Numbers in italics are fuels that are reported in a finer disaggregation in the IEA energy statistic than in the Reference Approach. Numbers in bold aggregate the data to the level of disaggregation used in the Reference Approach.

CRF vs. IEA (2010)	**Import**		**Export**		**Bunker**		**Stock change**		**Stat.diff.**	**LIE**	**Consumption**	
Gg	**IEA**	**CRF**	**IEA**	**CRF**	**IEA**	**CRF**	**IEA**	**CRF**	**IEA**	**CRF**	**IEA**	**CRF**
Crude oil	*4'488*	*4'546*					*0*	*1*	*0*		*4'488*	*4'547*
Refinery feedstocks	*3*						*1*		*2*		*6*	
Additives/blending components	*51*						*-1*		*2*		*52*	
											4'546	**4'547**
Motor gasoline	1'850	1'838					-9	-6	4	15	**1'830**	**1'832**
Aviation gasoline	*7*						*-2*		*-1*		*4*	
Kerosene type jet fuel	*1'354*	*1'362*			*-1'367*	*-1'352*		*2*	*6*		*-7*	*12*
Other Kerosene	*3*										*3*	
											0	**12**
Gas/diesel oil	3'510	3'485	-21	-39	-10	-11	38	1'072	1'020	27	**4'510**	**4'507**
Fuel oil	33	34	-323	-316			-17	-17	7		**-300**	**-299**
Liquefied petroleum gases (LPG)	*50*	*54*	*-24*	*-25*						*0.1*	*26*	*29*
White spirit & SBP	*7*								*-1*		*6*	
											32	**29**
Bitumen	317	318	-2	-2							**315**	**317**
Lubricants	86	72	-38	-16					7		**55**	**56**
Petroleum coke	73	47									**73**	**47**
Naphtha	*1*						*5*		*-1*		*5*	
Paraffin waxes	*1*										*1*	
Non-specified oil products / other oil	*4*	*63*	-	*-23*			-	*-6*			*4*	*33*
											10	**33**
Liquid fuels											**11'039**	**11'052**
Anthracite	*7*										*7*	
Other bituminous coal	*123*	*152*					*36*	*32*			*159*	*184*
Lignite	*66*	*62*					*-4*				*62*	*62*
Coke oven coke	*18*										*18*	
Solid fuels											**246**	**246**
Natural gas (TJ, NCV)	126'014	125'627									126'014	125'627
Fugitive emissions (TJ, NCV)		389										389
Gaseous fuels											**126'014**	**126'016**

Annex 5: Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded

No supplementary information to the statements given in Chapter 1.8 Completeness Assessment.

Annex 6: Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information

A6.1 Independent verification of the National Swiss Inventory for F-gases

Introduction:

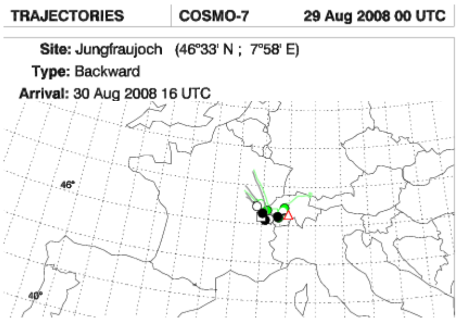
Since 2000 the Swiss Federal Laboratories for Materials Science and Technology (Empa) performs continuous measurements of halogenated greenhouse gases at the high-Alpine site of Jungfraujoch (3580 m asl). These measurements are used for the independent estimation of hydrofluorocarbon (HFC) emissions from Switzerland and neighbouring countries and can serve as a verification tool for their Swiss emissions. For this verification the so-called tracer-ratio method is applied, where Swiss HFC pollution events are scaled to concurrent pollution events of carbon monoxide (CO) and then multiplied by the Swiss CO emission inventory. Other methods that rely on atmospheric observations are also being developed at Empa for future usage. Similar approaches are also used for independent verification of greenhouse gas emissions in the United Kingdom (UK MetOffice – using measurements from Mace Head, Ireland) and in Australia (CSIRO – using measurements from Cape Grim, Tasmania).

Method description:

For yearly estimates of Swiss emissions of HFCs based on data from Jungfraujoch, only periods are used when the air masses at the high-Alpine station of Jungfraujoch are predominantly influenced by emissions from Switzerland. The number of events which can be used each year depends on the meteorological conditions and is between 7-15 days per year. The process to select these periods is shown in Figure A-4 and is shortly described here. First, the trajectories from the COSMO-model from MeteoSwiss are screened for periods when the Jungfraujoch site has been under the influence of air masses which were within the Swiss boundary layer for the last 48 hours. Second, for these periods mixing ratios of HFCs are compared with those of CO. Periods which show a concurrent increase for both groups of compounds are selected for the independent verification of Swiss emissions, as this is taken as an indication of thorough mixing of Swiss emissions during the transport to the measurement site. Third, the emissions are calculated for each case/day using the formula in Figure A-4. The resulting emissions are only used for the annual emission estimate if they are within three standard deviations of the average (Grubbs test). This criterion is met by approximately 90% of the selected data. Finally, annual emissions are estimated as the median from these individual cases. These annual estimates are merged to a 3-year annual average centred over a 3-year period (e.g. the estimate for 2009 emissions is calculated by using data from 2008–2010). The error of the estimates based on data from Jungfraujoch has been assessed by using the range of 25%-75% percentiles of the estimates from single pollution events, since 2009. For estimates between 2001-2008 the average of the 2009-2011 errors has been taken. An additional absolute error could occur if the Swiss emissions of CO are over/underestimated by the inventory. This would linearly be transmitted to the emissions of the fluorinated greenhouse gases.

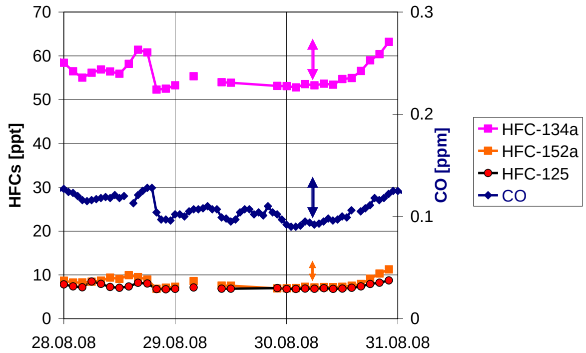
1st step:

Selection of periods with Swiss influence 2 days prior to the measurements by using COSMO trajectories from MeteoSwiss



2nd step:

Confine selected periods by using only periods with concurrent enhancement of CO and HFCs



$$E_H = E_{CO} \times \frac{\Delta H}{\Delta CO}$$

E_H = Swiss emission HFC

E_{CO} = Swiss Emission of CO (e.g. in 2010: 250 kt)

ΔH = HFC concentration increase

ΔCO = CO concentration increase

Swiss-emission estimation:

Median of all cases per year

3-year average

Figure A - 4 Description of the procedure to estimate annual emissions of HFCs from Switzerland by using continuous measurements of HFCs at Jungfraujoch (Switzerland).

Results and Discussion:

In the following, Swiss emissions of five HFCs (HFC-134a, HFC-125, HFC-152a, HFC-143a, HFC-32) are estimated based on data from Jungfraujoch and are compared to the emission estimate of the Swiss greenhouse gas inventory. Further emission estimates of other HFC's and other fluorinated greenhouse gases (e.g. SF_6) will be added in future National Inventory Reports (NIR) upon availability.

HFC-134a

HFC-134a is the most important anthropogenic HFC. Its main source is the diffuse emission from its usage as cooling agent in mobile air conditioners (MACs). Further relevant applications are the usage as propellant and the usage as cooling agent in the industrial and commercial refrigeration. The stock of HFC-134a in MACs and the related emissions have been steadily increasing over the past years. The stabilization of the total emissions between 2005 and 2010 is related to the decreasing HFC use as propellant and optimizations in the industrial and commercial refrigeration. Increasing tendencies are found again in the inventory 2012 due to the still growing stock of HFC-134a in refrigeration and air-conditioning equipment and due to new applications using HFC-134a for research (i.e. as tracer gas). Estimated emissions based on measurements at Jungfraujoch agree fairly well with the emission estimates of the Swiss greenhouse gas inventory. The emissions according to the inventory are slightly higher than the ones based on measurements. But in recent years, the data agree within the estimated uncertainty of 25%, except for the last 3 years. Differences in the last 3 years might occur from the conservative model assumption regarding research use (100% loss assumed, increasing consumption in research of HFC-134a 2010-2012).

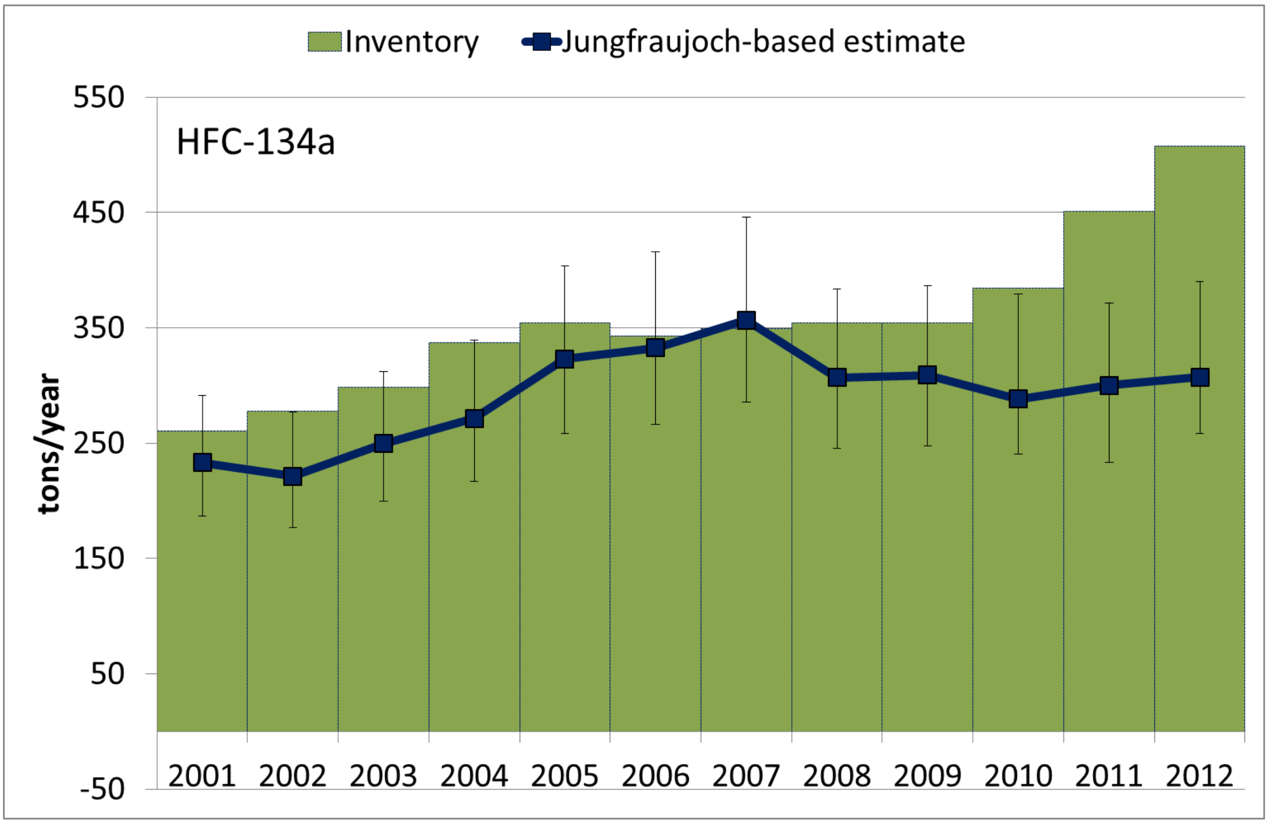


Figure A - 5 Comparison of HFC-134a emissions from Switzerland: Inventory and estimates from measurements at Jungfraujoch.

HFC-125

HFC-125 is mainly used as cooling agent in air conditioners and commercial refrigeration equipment. Estimated emissions from Jungfraujoch measurement data are in fairly good agreement with emissions provided by the inventory. Although, in recent years, the inventory emissions seem to slightly exceed the estimates based on data from Jungfraujoch.

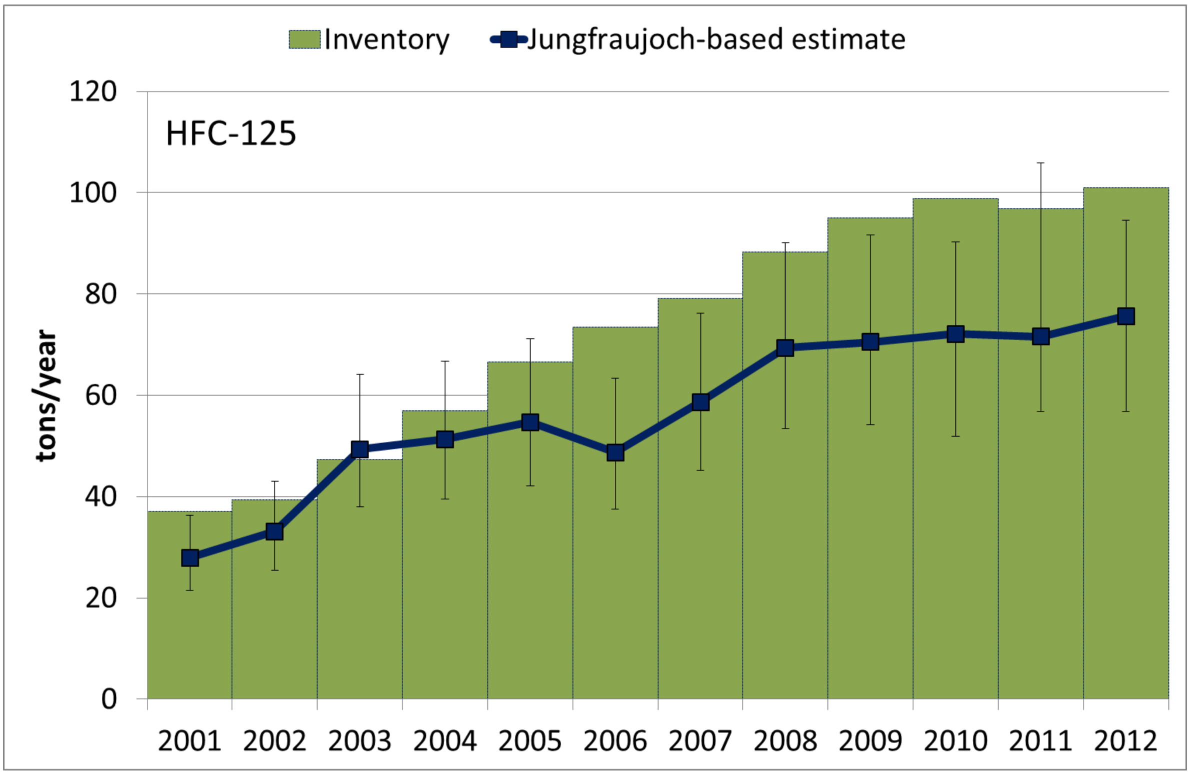


Figure A - 6 Comparison of HFC-125 emissions from Switzerland: Inventory and estimates from measurements at Jungfraujoch.

HFC-152a

HFC-152a is mainly used as a blowing agent. It has been used in open-cell polyurethane (PU) foams, in closed cell PU-Sprays and closed-cell extruded polystyrene (XPS) foams. In open cell foams, 100% of emissions are related to the blowing process. In closed cell foams a portion of the blowing agent remains in the product, emissions occur continuously over the lifetime, depending on the cell- and molecular-structure of the blowing agent. Unlike for other blowing agents, experts assume that within the first year of the foam lifetime 95-100% of HFC-152a is emitted. The emissions of the first year are commonly allocated to the country of production (according to UNFCCC good practice guidance). These assumptions and allocation are also applied for the model used in the Swiss inventory for estimating HFC-152a emissions under source category 2F2 Foam Blowing.

HFC-152a emissions from foams in the inventory are mainly related to the production and consumption of PU-Spray (Swiss production HFC free since 2008). Most of other foam products are imported and consequently these emissions are allocated to the country of origin. The reported decrease in the inventory since 2003 reflects the replacement of HFC-152a in PU-Spray.

Up to the year 2002 estimated emissions from Jungfraujoch measurement data are lower than reported in the inventory and from then onwards they are higher. This can be explained by the UNFCCC practice to allocate HFC-152a emissions of the first year to the country of production of foams (which is except for PU-Spray mainly outside Switzerland). However, in reality a fraction of these first year emissions actually occur during usage of the products (e.g. for insulation) in Switzerland and therefore are reflected in the measurements but are not reflected by definition in the inventory[19]. Emissions estimated from Jungfraujoch show a consistent negative trend related to the partial phase-out of HFC-152a from the foam-blowing applications.

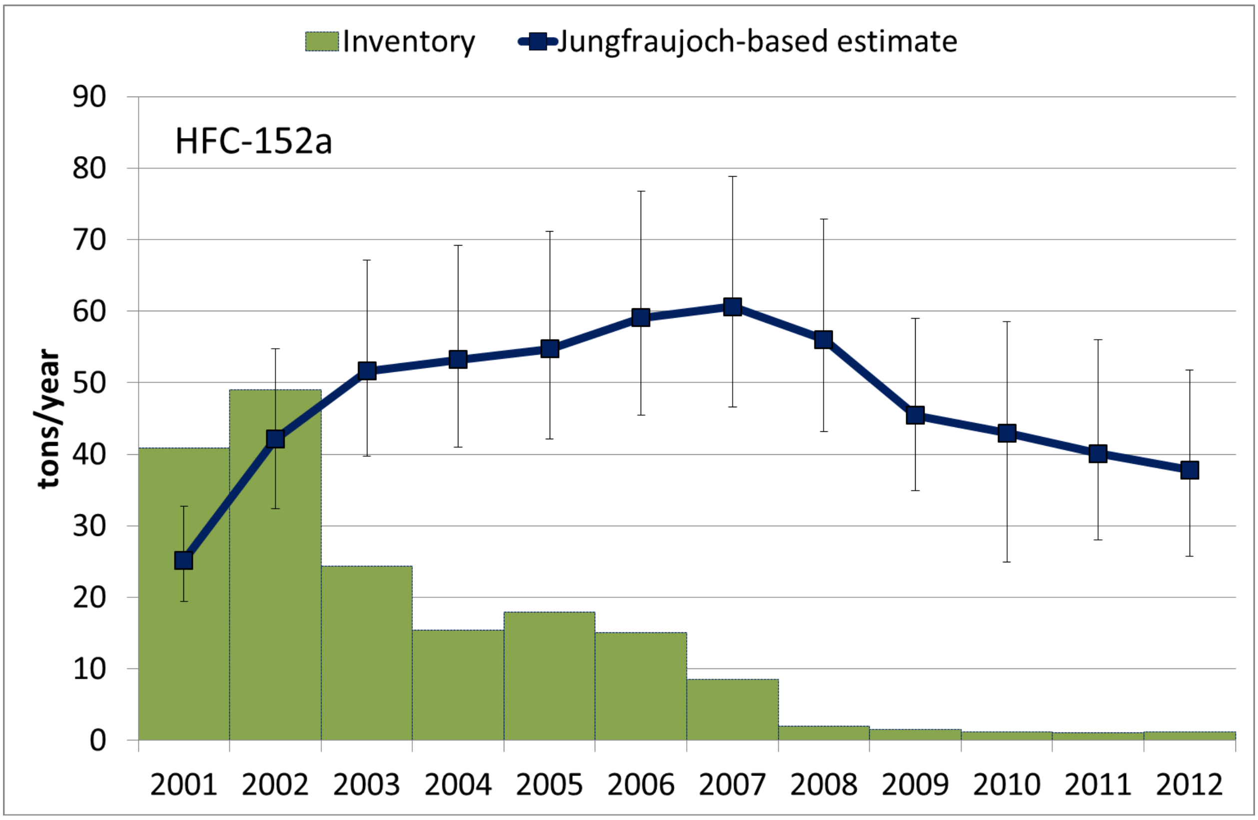


Figure A - 7 Comparison of HFC-152a emissions from Switzerland: Inventory and estimates from measurements at Jungfraujoch.

HFC-143a and HFC-32

HFC-143a and HFC-32 are mainly used as cooling agent mixtures in commercial refrigeration and stationary air conditioners (together with HFC-134a and/or HFC-125). Estimated emissions from Jungfraujoch measurement data are consistently slightly lower than emissions provided by the inventory. However, they normally agree within the uncertainty of 40% reached for these two compounds by the Jungfraujoch-based estimates.

[19] Nonetheless it is important to apply the UNFCCC approach in the inventory as otherwise double counting may occur when allocating the total emissions to the country of origin and the country of product use.

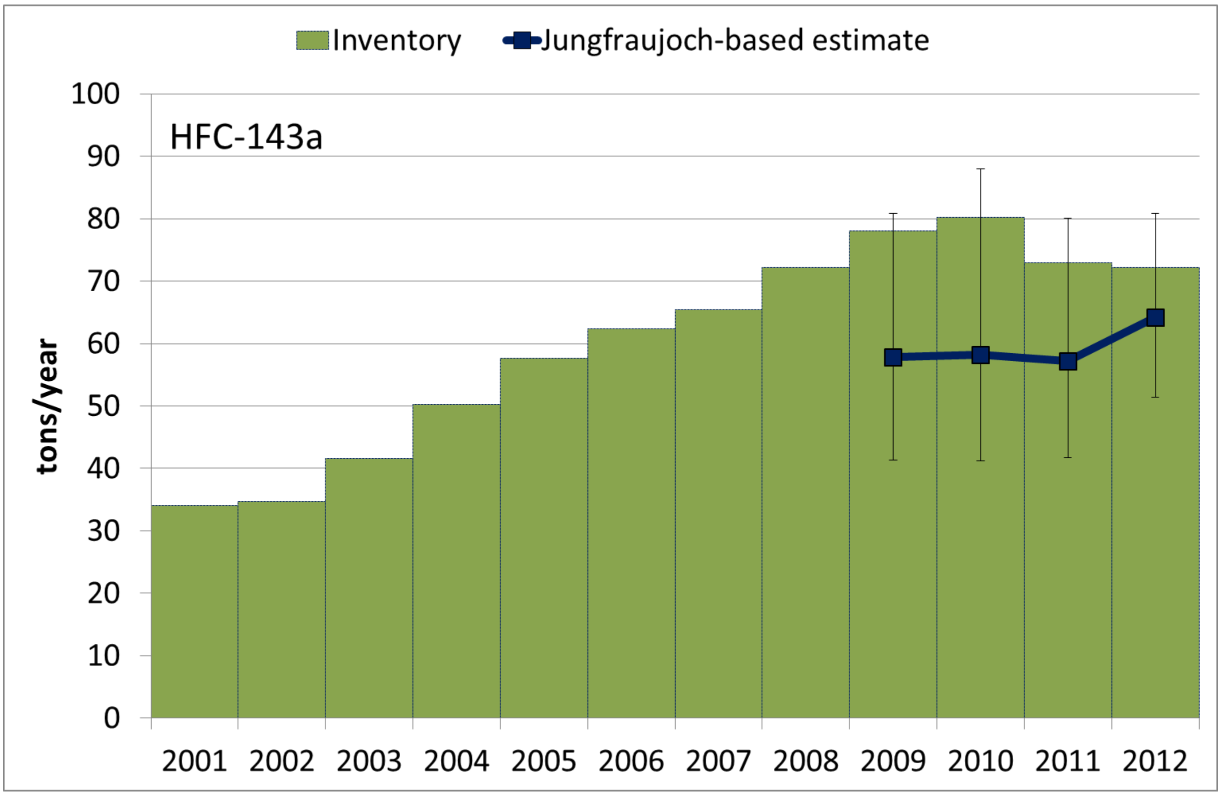


Figure A - 8 Comparison of HFC-143a emissions from Switzerland: Inventory and estimates from measurements at Jungfraujoch.

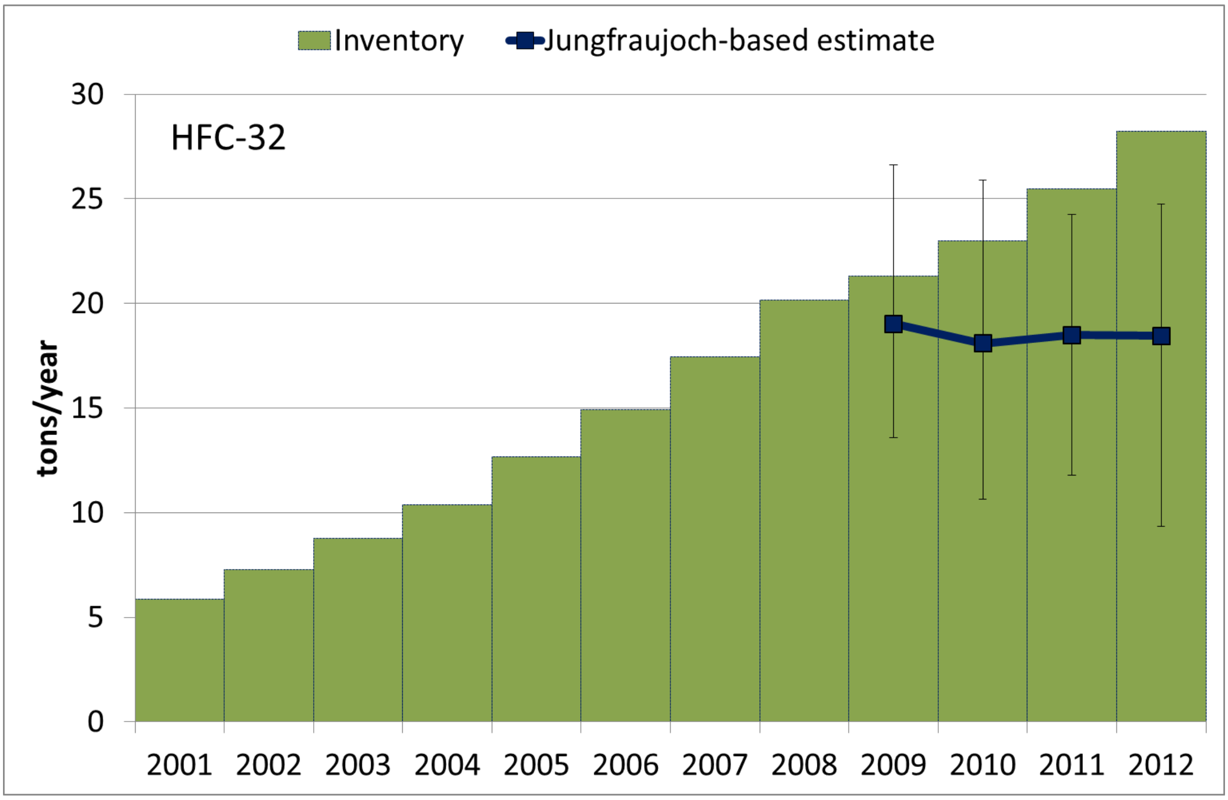


Figure A - 9 Comparison of HFC-32 emissions from Switzerland: Inventory and estimates from measurements at Jungfraujoch.

Annex 7: Supplementary Information on the Uncertainty Analysis

A7.1 Approach for the Monte Carlo Simulations

As a first step, the shape and extent of the probability distributions were derived for the activity data and emission factors, based on measured data, literature or expert judgement. The mean value of the probability distributions was set equal to the value of the GHG inventory. In most cases, normal distributions were assumed, for three agricultural categories, triangular distributions are applied.

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

In a third step, the correlations were chosen. Correlations may have a significant effect on the overall inventory uncertainty. The more the source categories are differentiated the more correlations can be considered. The choice was restricted to categories with relevant amounts of uncertainty. For consistency reasons, Crystal Ball software adjusted a few of the correlation coefficients by an average of 0.10.

The Monte Carlo simulation then provided information on the simulated distribution, on the 2.5 and 97.5 percentiles of emissions, on the uncertainty of the national total emission in 2012 and in the base year 1990 as well as on the trend uncertainty 1990–2012.

A7.2 Assumptions for the Monte Carlo Simulations

A7.2.1 Assumptions for the Probability Distributions

For almost all source and sink categories, normal distributions have been chosen. The important exceptions are the agricultural source categories 4B and 4D shown in the table below.

Table A - 32 Probability distribution assigned to activity data and emission factors (1990 and 2012) of categories that are not normally distributed. For the remaining categories, normal probability distributions have been assigned to the emission uncertainties.

IPCC Source Category				Gas	Probability distribution	
					AD	EF
4B	Agriculture	B. Manure Management	liquid	N2O	normal	triangular
4B	Agriculture	B. Manure Management	solid	N2O	normal	triangular
4D2	Agriculture	D. Agricultural Soils; Pasture, Range and Paddock Manure		N2O	normal	triangular
4D3	Agriculture	D. Agricultural Soils; Indirect Emissions	deposition	N2O	normal	triangular
4D3	Agriculture	D. Agricultural Soils; Indirect Emissions	leaching and runoff	N2O	normal	triangular

A7.2.2 Assumptions for the Correlation Coefficients

Since there are no quantitative correlations available, only three values 1 and ±0.5 have been used if any are assumed:

- “strong” positive correlations are set to r = 1.0 (like perfect correlations),
- “weak” correlations correlations are set to r = ±0.5.

For modelling of the level uncertainty, the following assumption has been made:

- CO_2 emission factors of liquid fuels are strongly and positively correlated (r = 1.0) for large sources (more than 1000 Gg CO_2 eq. The restriction is not relevant since correlations have hardly any influence for small sources).The same holds for gaseous fuels.
- Activity data of liquid and gaseous fuels from the categories 1A2, 1A4a and 1A4b are negatively correlated (r = -0.5), since the total amount is well known but the partitioning into the different categories is not. Therefore, if the amount is overestimated in one category it is underestimated in one of the other categories.
- Activity data of 4A (Enteric Fermentation) and 4B (Manure Management) are positively correlated (r=0.5) since they are both based on livestock numbers.

For modelling of the trend uncertainty, the following assumptions have been made:

- CO_2 emission factors of each source of gasoline and gas oil are strongly and positively correlated (r = 1.0) between 1990 and 2012.
- Activity data/emissions of the major sources (1A2: CO2, 1A3: CO2, 1A4: CO2,4A: CH4, 4B: CH4, 2F: HFC) are medium and positively correlated between 1990 and 2012 (r = 0.5).

Table A - 33 Correlation coefficients of activity data . “b_”: base year 1990.” t_”: 2012.

	b_AD_1A2Gaseous FuelsCO2 (MC)	t_AD_1A2Gaseous FuelsCO2 (MC)	b_AD_1A2Liquid FuelsCO2 (MC)	t_AD_1A2Liquid FuelsCO2 (MC)	b_AD_1A3bDieselCO2 (MC)	t_AD_1A3bDieselCO2 (MC)	b_AD_1A3bGasolineCO2 (MC)	t_AD_1A3bGasolineCO2 (MC)	b_AD_1A4aGaseous FuelsCO2 (MC	t_AD_1A4aGaseous FuelsCO2 (MC)	b_AD_1A4aLiquid FuelsCO2 (MC)	t_AD_1A4aLiquid FuelsCO2 (MC)	b_AD_1A4bGaseous FuelsCO2 (MC	t_AD_1A4bGaseous FuelsCO2 (MC)	b_AD_1A4bLiquid FuelsCO2 (MC)	t_AD_1A4bLiquid FuelsCO2 (MC)	b_EM_2F1HFC (MC)	t_EM_2F1HFC (MC)	b_AD_4ACH4 (MC)	t_AD_4ACH4 (MC)	b_AD_4BCH4 (MC)	t_AD_4BCH4 (MC)
b_AD_1A2Gaseous FuelsCO2 (MC	1.0	0.5							-0.5				-0.5									
t_AD_1A2Gaseous FuelsCO2 (MC)		1.0								-0.5				-0.5								
b_AD_1A2Liquid FuelsCO2 (MC)			1.0	0.5							-0.5				-0.5							
t_AD_1A2Liquid FuelsCO2 (MC)				1.0								-0.5				-0.5						
b_AD_1A3bDieselCO2 (MC)					1.0	0.5																
t_AD_1A3bDieselCO2 (MC)						1.0																
b_AD_1A3bGasolineCO2 (MC)							1.0	0.5														
t_AD_1A3bGasolineCO2 (MC)								1.0														
b_AD_1A4aGaseous FuelsCO2 (MC)									1.0	0.5			-0.5									
t_AD_1A4aGaseous FuelsCO2 (MC)										1.0				-0.5								
b_AD_1A4aLiquid FuelsCO2 (MC)											1.0	0.5			-0.5							
t_AD_1A4aLiquid FuelsCO2 (MC)												1.0				-0.5						
b_AD_1A4bGaseous FuelsCO2 (MC)													1.0	0.5								
t_AD_1A4bGaseous FuelsCO2 (MC)														1.0								
b_AD_1A4bLiquid FuelsCO2 (MC)															1.0	0.5						
t_AD_1A4bLiquid FuelsCO2 (MC)																1.0						
b_EM_2F1HFC (MC)																	1.0	0.5				
t_EM_2F1HFC (MC)																		1.0				
b_AD_4ACH4 (MC)																			1.0	0.5	0.5	
t_AD_4ACH4 (MC)																				1.0		0.5
b_AD_4BCH4 (MC)																					1.0	0.5
t_AD_4BCH4 (MC)																						1.0

Table A - 34 Correlation coefficients for CO_2 emission factors of category 1A1.

	b_EF_1A1Other FuelsCO2 (MC)	t_EF_1A1Other FuelsCO2 (MC)
b_EF_1A1Other FuelsCO2 (MC)	1.0	0.5
t_EF_1A1Other FuelsCO2 (MC)		1.0

Table A - 35 Correlation coefficients for emission factors of agricultural categories 4A, 4B and 4D.

	b_EF_4ACH4 (MC)	t_EF_4ACH4 (MC)	b_EF_4BCH4 (MC)	t_EF_4BCH4 (MC)	b_EF_4BliquidN2O (MC)	t_EF_4BliquidN2O (MC)	b_EF_4BsolidN2O (MC)	t_EF_4BsolidN2O (MC)	b_EF_4D1fertilizerN2O (MC)	t_EF_4D1fertilizerN2O (MC)	b_EF_4D1organic soilsN2O (MC)	t_EF_4D1organic soilsN2O (MC)	b_EF_4D20N2O (MC)	t_EF_4D20N2O (MC)	b_EF_4D3depositionN2O (MC)	t_EF_4D3depositionN2O (MC)	b_EF_4D3leaching and runoffN2O (M	t_EF_4D3leaching and runoffN2O (M	b_EF_4D40N2O (MC)	t_EF_4D40N2O (MC)
b_EF_4ACH4 (MC)	1.0	1.0																		
t_EF_4ACH4 (MC)		1.0																		
b_EF_4BCH4 (MC)			1.0	1.0																
t_EF_4BCH4 (MC)				1.0																
b_EF_4BliquidN2O (MC)					1.0	1.0														
t_EF_4BliquidN2O (MC)						1.0														
b_EF_4BsolidN2O (MC)							1.0	1.0												
t_EF_4BsolidN2O (MC)								1.0												
b_EF_4D1fertilizerN2O (MC)									1.0	1.0										
t_EF_4D1fertilizerN2O (MC)										1.0										
b_EF_4D1organic soilsN2O (MC)											1.0	1.0								
t_EF_4D1organic soilsN2O (MC)												1.0								
b_EF_4D20N2O (MC)													1.0	1.0						
t_EF_4D20N2O (MC)														1.0						
b_EF_4D3depositionN2O (MC)															1.0	1.0				
t_EF_4D3depositionN2O (MC)																1.0				
b_EF_4D3leaching and runoffN2O (MC)																	1.0	1.0		
t_EF_4D3leaching and runoffN2O (MC)																		1.0		
b_EF_4D40N2O (MC)																			1.0	1.0
t_EF_4D40N2O (MC)																				1.0

Table A - 36 Correlation coefficients for activity data of the agricultural categories 4A and 4B.

	b_AD_4ACH4 (MC)	t_AD_4ACH4 (MC)	b_AD_4BCH4 (MC)	t_AD_4BCH4 (MC)	b_AD_4BsolidN2O (MC)	t_AD_4BsolidN2O (MC)
b_AD_4ACH4 (MC)	1.0	0.5	0.5			
t_AD_4ACH4 (MC)		1.0		0.5		
b_AD_4BCH4 (MC)			1.0	0.5	0.5	
t_AD_4BCH4 (MC)				1.0		0.5
b_AD_4BsolidN2O (MC)					1.0	0.5
t_AD_4BsolidN2O (MC)						1.0

A7.3 Comments to the Results of Monte Carlo Simulations

A7.3.1 Relation between simulated and inventory values

The Monte Carlo method simulates a probability distribution of the Swiss greenhouse gas emissions from which all relevant statistical parameters can be derived (mean, standard deviation and percentiles). The simulated mean value may slightly differ from the reported CRF value.

The discrepancy between simulated and reported values becomes apparent when mean numbers in Figure 1-4 are compared to reported numbers in the CRF-tables. Note that it is not a relevant issue for the uncertainty analysis but is rather confusing for readers and reviewers who carefully study the numbers. For transparency reasons, the numbers are explained in Table A - 37.

The absolute percentiles generated by the simulation are firstly expressed as relative numbers (the simulated mean is set to 100%). Then the relative numbers are transferred to the numbers reported in the CRF-tables, and they are applied to derive the absolute uncertainties.

Table A - 37 Mean values, 2.5 and 97.5 percentiles of the Monte Carlo simulation and corresponding values of the reported emissions (as of CRF-tables).

Year	Parmeters	Unit	Emission (without LULUCF)	Lower bound 2.5 percentile	Upper bound 97.5 percentile	Lower uncertainty	Upper uncertainty
1990	**simulated values**						
	absolute	Gg CO_2 eq	53'357	51'314	55'748	-2'043	2'392
	relative	%	100.0%	96.2%	104.5%	-3.8%	4.5%
	values of CRF						
	absolute	Gg CO_2 eq	52'890	50'865	55'261	-2'025	2'371
	relative	%	100.0%	96.2%	104.5%	-3.8%	4.5%
2012	**simulated values**						
	absolute	Gg CO_2 eq	51'825	49'945	53'944	-1'880	2'119
	relative	%	100.0%	96.4%	104.1%	-3.6%	4.1%
	values of CRF						
	absolute	Gg CO_2 eq	51'449	49'582	53'552	-1'867	2'103
	relative	%	100.0%	96.4%	104.1%	-3.6%	4.1%

A7.3.2 Tornado Diagram

The following chart shows the results of a sensitivity analysis, depicting the most important sources of uncertainty including LULUCF. These can either be emission factors, activity data or emissions. The bars depict the amount of uncertainty introduced compared to total emissions (on x-axis), and the the numbers attached to the bars indicate the value of the corresponding emission factor or activity data.

The figure shows that the very high uncertainty of the emissions of category 5C1 Grasland remaining Grasland (CO_2) cause the most important contribution to the total uncertainty (see bar on top of the Tornado plot). Further important contributions stem from 5A1 Forestland remaining Forestland (CO_2), 4D1 Direct Soil Emission, Synthetic Fertilizers (N_2O), 4D3 Indirect Emissions, Leaching and Runoff (N_2O).

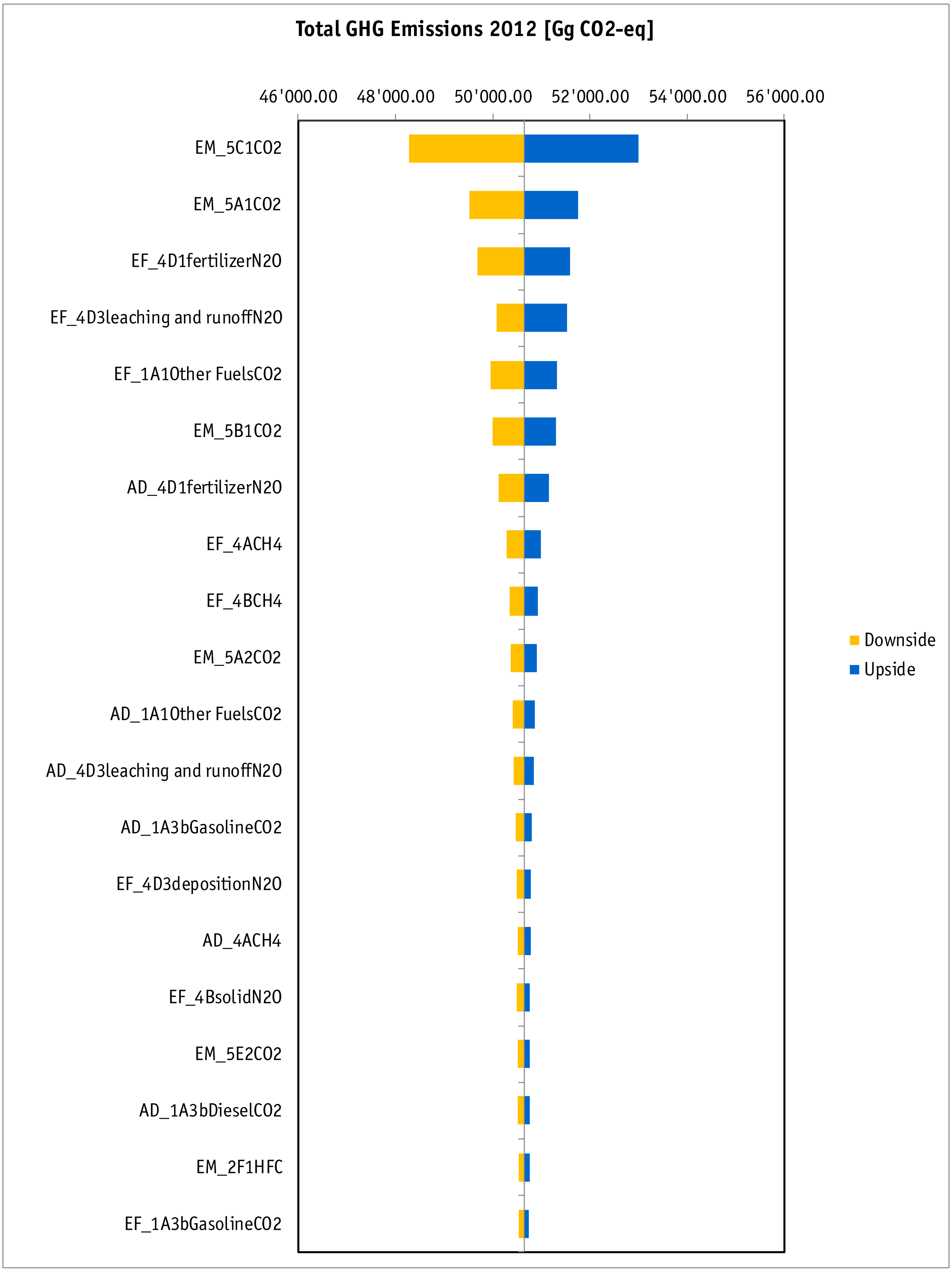


Figure A - 10 Most important sources of uncertainty in 2012 (incl. LULUCF). Explanations see text above figure. Abbrev.: The letter "t" refers to 2012, "EF" emission factor, "AD" activity data, "EM" emission. x-axis: National total of CO_2 eq emissions in 2012. Numbers attached to the bars indicate the values of emissions factor, activity or emission data in original units (Gg CO_2eq, kg/TJ, ha etc.).

Annex 8: Supplementary Information under Article 7, paragraph 1 of the Kyoto Protocol

No supplementary information under this item.