Switzerland's Greenhouse Gas Inventory 1990–2011

National Inventory Report 2013

including reporting elements under the Kyoto Protocol

Submission of 15 April 2013
under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol

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Bern, 15 April 2013

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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)
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
CSS	Mix of special waste with saw dust; used as fuel in cement kilns
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
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
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
LFO	Light fuel oil (Gas oil)
LPG	Liquefied Petroleum Gas (Propane/Butane)
LTO	Landing-Takeoff-Cycle (Aviation)
LULUCF	Land Use, Land-Use Change and Forestry
MSW	Municipal solid waste
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
SGCI/SSCI	Schweizerische Gesellschaft für Chemische Industrie / Swiss Society of Chemical Industries
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
VSAI/AISA	Vereinigung Schweizer Automobil-Importeure / Association Importateurs Suisses d'Automobiles
VTG	Luftwaffe (Swiss Air Force Administration)
WSL	Swiss Federal Institute for Forest, Snow and Landscape Research

Executive Summary

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 findings confirm a warming trend with an observed increase in mean annual temperature of approximately 1.6 °C between 1864 and 2008 for Switzerland. Over the last 100 years, mean annual temperatures increased by 0.12-0.19 °C per decade, with a substantially accelerated warming in recent decades. The most visible change in the Alps resulting from global warming is the retreat of glaciers, which is predicted to continue (FOEN 2009d).

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 rose 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).

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 2013 inventory submission under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol (FOEN 2013) includes the NIR on hand, the greenhouse gas inventory 1990–2011 and the Kyoto Protocol LULUCF tables 2008–2011 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 2013a) 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 Reckenholz-Tänikon Research Station (ART) 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 Inventory Report, Switzerland took into account the findings of the in-country review of the inventory submitted in 2004 (UNFCCC 2004), the centralized review of the inventory submitted in 2005 (UNFCCC 2006), the in-country review of the inventory submitted in 2006 (UNFCCC 2007), the centralized reviews of the submissions 2007/2008, and 2009 (UNFCCC 2009, UNFCCC 2010), the in-country review of submission 2010 (UNFCC 2011) and the centralized review of the submission 2011 (UNFCC 2012). The Annual Review Report for the submission 2012 is currently still in preparation. The recommendations of the "Saturday Paper" (UNFCCC 2012a) are included in the present submission as well (see Chapter 16). Since the draft review report for submission 2012 was not made available until 12 March 2013, the recommendations from the most recent review could only partially be included in present submission.

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 Association for Quality and Management Systems (SQS 2010).
- 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 (0.16%) in the base year emissions (1990) and a small change in the latest year of recalculations (2010: 0.30%). 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 2012a) that resulted from the 2012 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 and 2011. 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 2011, Switzerland emitted 50’010 Gg (kilotonnes) CO_2 equivalent, corresponding to 6.32 tonnes CO_2 equivalent per capita (CO_2: 5.29 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 2011 and for the base year 1990.

- Tier 1 analysis (without LULUCF): For 2011, among a total of 135 categories, 31 have been identified as key categories (level and/or trend) with an aggregated contribution of 97.1% to total national emissions. Of the 31 key categories, 18 are in sector 1 Energy, accounting for 78.4% of total CO_2 equivalent emissions in 2011.
- Tier 2 analysis (without LULUCF): For 2011, among a total of 135 categories, 29 have been identified as key categories (level and/or trend) with an aggregated contribution of 92.8% of the sum of all level assessments weighted with their uncertainty in 2011. Of the 29 key categories, 14 are in sector 1 Energy, accounting for 27.8% of the sum of all level assessments weighted with their uncertainty in 2011. Sector 4 Agriculture accounts for 44.8% 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 A1.5).

Table E-1 shows Switzerland's annual GHG emissions by individual GHGs from 1990 (base year) to 2011. Despite clear trends in some GHG emissions (see below), there is no significant trend in the total emissions of the period 1990–2011. 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 2011, total gross GHG emissions (excluding LULUCF) show a decrease of 5.6% compared to the level recorded for 1990 (see also Table E-2).

[1] Inhabitants in Switzerland in 2011: 7.91 million

Table E-1 Summary of Switzerland's GHG emissions in CO_2 equivalent (Gg), 1990–2011 (from CRF Tables 10s5, 10s5.2 and 10s5.3). HFCs increased by 5'076'959% 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	41'423	43'026	43'185	39'427	39'810	39'682	39'403	37'945	39'528	41'288
CO_2 emissions excluding net CO_2 from LULUCF	44'597	46'320	46'214	43'673	42'935	43'584	44'236	43'421	44'723	44'841
CH_4 emissions including CH_4 from LULUCF	4'682	4'646	4'510	4'375	4'284	4'271	4'195	4'098	4'044	3'983
CH_4 emissions excluding CH_4 from LULUCF	4'674	4'645	4'510	4'375	4'281	4'267	4'193	4'086	4'043	3'983
N_2O emissions including N_2O from LULUCF	3'468	3'466	3'443	3'364	3'324	3'330	3'333	3'227	3'217	3'188
N_2O emissions excluding N_2O from LULUCF	3'458	3'460	3'438	3'359	3'317	3'323	3'327	3'215	3'210	3'183
HFCs	0	0	6	14	33	179	224	296	351	412
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)	**49'817**	**51'369**	**51'363**	**47'336**	**47'581**	**47'574**	**47'267**	**45'716**	**47'323**	**49'054**
Total (excluding LULUCF)	**52'973**	**54'656**	**54'386**	**51'577**	**50'696**	**51'466**	**52'092**	**51'169**	**52'510**	**52'602**

Greenhouse Gas Emissions	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	CO2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	42'689	45'109	43'511	42'013	41'058	42'057	42'997	41'137	43'827	42'141
CO_2 emissions excluding net CO_2 from LULUCF	43'921	44'873	43'829	45'009	45'634	46'259	45'894	43'927	45'448	44'239
CH_4 emissions including CH_4 from LULUCF	3'915	3'929	3'878	3'785	3'764	3'770	3'781	3'780	3'843	3'787
CH_4 emissions excluding CH_4 from LULUCF	3'914	3'929	3'875	3'781	3'764	3'770	3'780	3'778	3'843	3'786
N_2O emissions including N_2O from LULUCF	3'188	3'216	3'198	3'143	3'092	3'075	3'074	3'095	3'114	3'068
N_2O emissions excluding N_2O from LULUCF	3'183	3'211	3'192	3'137	3'088	3'070	3'069	3'090	3'110	3'064
HFCs	491	584	624	695	802	882	905	938	999	1'039
PFCs	69	45	40	57	53	33	32	29	39	35
SF_6	158	157	168	174	190	213	201	186	245	187
Total (including LULUCF)	**50'510**	**53'040**	**51'420**	**49'868**	**48'959**	**50'030**	**50'989**	**49'164**	**52'067**	**50'257**
Total (excluding LULUCF)	**51'737**	**52'799**	**51'728**	**52'852**	**53'530**	**54'227**	**53'881**	**51'948**	**53'683**	**52'350**

Greenhouse Gas Emissions	**2010**	**2011**	Change baseyear to 2011 (%)
	CO2 eq. (Gg)		
CO_2 emissions including net CO_2 from LULUCF	43'494	38'439	*-7.2%*
CO_2 emissions excluding net CO_2 from LULUCF	45'903	41'856	*-6.1%*
CH_4 emissions including CH_4 from LULUCF	3'766	3'734	*-20.3%*
CH_4 emissions excluding CH_4 from LULUCF	3'766	3'732	*-20.2%*
N_2O emissions including N_2O from LULUCF	3'137	3'078	*-11.2%*
N_2O emissions excluding N_2O from LULUCF	3'133	3'074	*-11.1%*
HFCs	1'094	1'144	*see caption*
PFCs	37	39	*-60.7%*
SF_6	155	164	*14.4%*
Total (including LULUCF)	**51'683**	**46'599**	***-6.5%***
Total (excluding LULUCF)	**54'088**	**50'010**	***-5.6%***

With regard to the distribution of emissions by individual greenhouse gases, CO_2 is the largest single contributor to emissions, accounting for 83.7% of total gross GHG emissions (excluding LULUCF) in 2011 (1990: 84.2%). The share of CH_4 decreased from 8.8% (1990) to 7.5% (2011). Over the same period, the share of N_2O decreased from 6.5% to 6.1%, while the share of F-gases increased from 0.5% to 2.7%.

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	44'597	84.2%	43'584	84.7%	43'921	84.9%	46'259	85.3%
CH_4	4'674	8.8%	4'267	8.3%	3'914	7.6%	3'770	7.0%
N_2O	3'458	6.5%	3'323	6.5%	3'183	6.2%	3'070	5.7%
HFCs	0	0.0%	179	0.3%	491	0.9%	882	1.6%
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)	**52'973**	**100%**	**51'466**	**100%**	**51'737**	**100%**	**54'227**	**100%**

Greenhouse Gas Emissions	**2008**		**2009**		**2010**		**2011**	
(excluding LULUCF)	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
CO2	45'448	84.7%	44'239	84.5%	45'903	84.9%	41'856	83.7%
CH4	3'843	7.2%	3'786	7.2%	3'766	7.0%	3'732	7.5%
N2O	3'110	5.8%	3'064	5.9%	3'133	5.8%	3'074	6.1%
HFCs	999	1.9%	1'039	2.0%	1'094	2.0%	1'144	2.3%
PFCs	39	0.1%	35	0.1%	37	0.1%	39	0.1%
SF6	245	0.5%	187	0.4%	155	0.3%	164	0.3%
Total (excluding LULUCF)	**53'683**	**100%**	**52'350**	**100%**	**54'088**	**100%**	**50'010**	**100%**

Figure E-1 shows the shares of 2011 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 1990–2011.

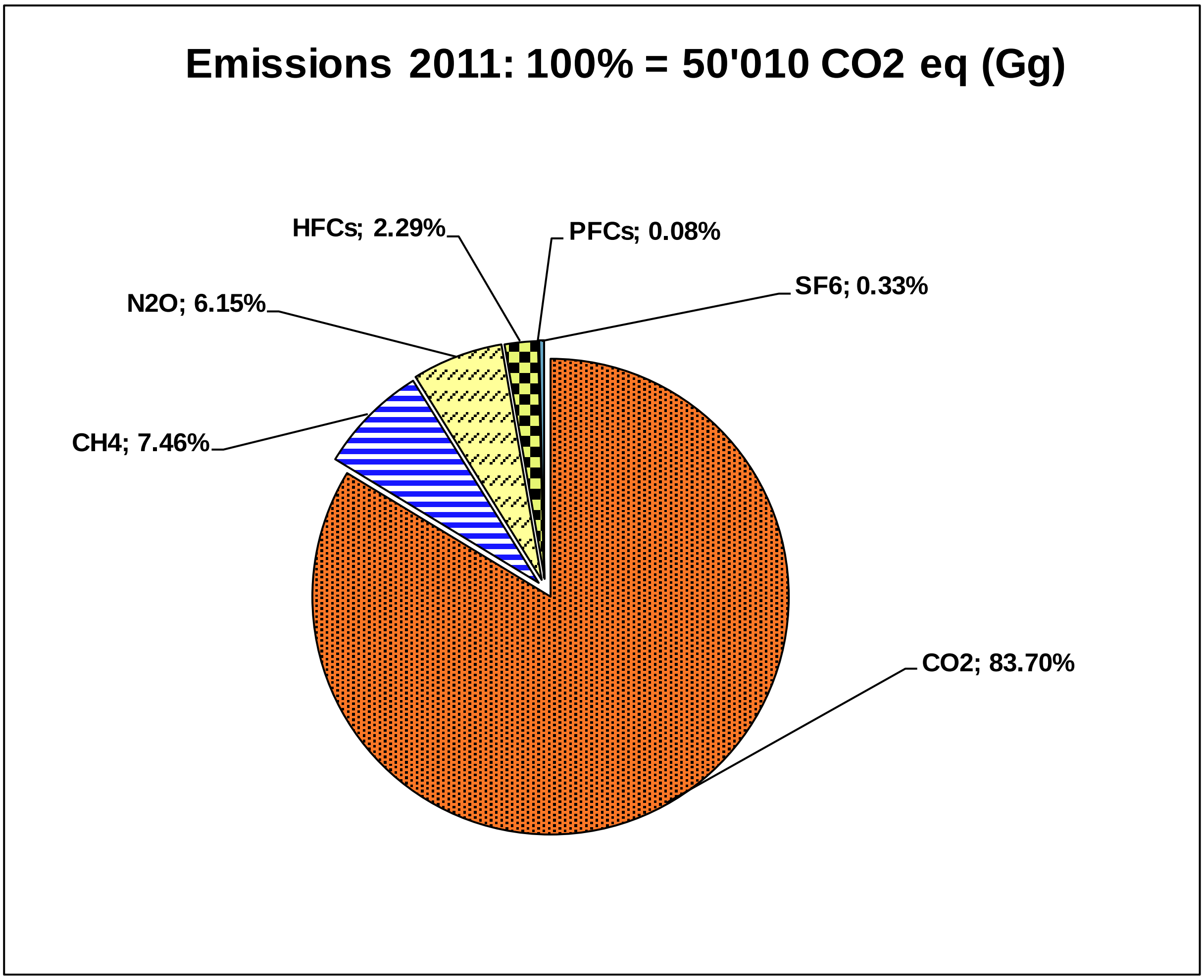

Figure E-1 Contribution of individual gases to Switzerland's GHG emissions (excluding LULUCF) in 2011. 100% = 50'010 Gg CO_2 eq. (Numbers may not add to total due to rounding.)

For the emission data of 2011 excluding LULUCF, an uncertainty analysis on Tier 1 level was carried out resulting in a **level uncertainty of 3.55% and a trend uncertainty of 1.89% (1990-2011).** The analysis was also carried out including the LULUCF sector resulting in increases of the uncertainties to 4.79% (level uncertainty) and 1.99% (trend uncertainty).

Chapter 10 explains and justifies recalculations that have been performed since the previous inventory submission to the UNFCCC secretariat in November 2012 after the centralized review 2012. The recalculations result in a decrease of the total base year (1990) emissions of 0.16% in CO_2 equivalents compared to the previous inventory (without LULUCF). For the year 2010 emissions, the decrease is 0.30% without emissions and removals from LULUCF. If the LULUCF sector is included there is a increase of 1.23% in 1990 and a decrease of 3.16% in 2010.

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., 1999-2011

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	228.20	228.19	227.28	225.85	224.10	222.61	177.08
Article 3.4 activities	-3941.42	-801.22	-96.70	-297.06	-3256.69	-3938.76	-4142.46

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	145.24	119.76	77.43	207.07	202.07	200.66	
Article 3.4 activities	-3339.56	-2200.43	-1374.82	-2178.56	-2884.02	-2936.20	

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 79.7% 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 and an increasing trend in source category 2 Industrial Processes. However, there is no significant trend in total emissions over the period 1990–2011 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), 1990–2011 (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	42'007	44'099	44'126	41'814	40'920	41'774	42'612	41'959	43'274	43'370
1A1 Energy Industries	2'551	2'818	2'908	2'563	2'600	2'637	2'853	2'818	3'144	3'182
1A2 Manufacturing Industries and Construction	6'119	6'300	5'955	5'870	5'870	6'063	5'839	5'735	5'917	5'902
1A3 Transport	14'598	15'092	15'417	14'351	14'539	14'228	14'293	14'850	15'061	15'669
1A4 Other Sectors	18'061	19'233	19'234	18'459	17'368	18'349	19'157	18'095	18'699	18'181
1A5 Other (Military)	206	188	180	171	166	148	137	147	146	132
1B Fugitive emissions from oil and natural gas	472	468	432	400	377	349	333	315	305	304
2. Industrial Processes	3'381	3'023	2'868	2'563	2'724	2'653	2'527	2'464	2'558	2'661
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	5'808	5'819	5'780	5'606	5'578	5'511
6. Waste	1'011	1'008	980	918	857	852	828	819	800	773
7. Other	12	12	13	13	13	13	13	13	14	14
Total (excluding LULUCF)	52'973	54'656	54'386	51'577	50'696	51'466	52'092	51'169	52'510	52'602
5. Land Use, Land-Use Change and Forestry	-3'156	-3'287	-3'023	-4'241	-3'115	-3'891	-4'825	-5'453	-5'187	-3'548
Total (including LULUCF)	49'817	51'369	51'363	47'336	47'581	47'574	47'267	45'716	47'323	49'054

Source and Sink Categories	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (Gg)									
1. Energy	42'290	43'221	42'197	43'397	43'828	44'345	44'010	42'008	43'552	42'430
1A1 Energy Industries	3'093	3'223	3'314	3'347	3'667	3'852	4'128	3'879	4'061	3'976
1A2 Manufacturing Industries and Construction	5'788	6'074	5'813	5'948	6'066	6'118	6'256	6'090	6'096	5'719
1A3 Transport	15'901	15'601	15'526	15'693	15'769	15'829	15'952	16'284	16'662	16'473
1A4 Other Sectors	17'089	17'899	17'141	18'044	17'971	18'187	17'307	15'407	16'385	15'914
1A5 Other (Military)	136	134	140	125	114	124	127	120	115	116
1B Fugitive emissions from oil and natural gas	284	291	263	240	242	236	239	229	235	231
2. Industrial Processes	2'930	3'034	3'032	3'079	3'347	3'520	3'496	3'519	3'640	3'505
3. Solvent and Other Product Use	259	245	233	224	211	211	205	204	201	200
4. Agriculture	5'496	5'561	5'536	5'461	5'447	5'474	5'494	5'556	5'648	5'593
6. Waste	748	723	716	677	682	663	662	646	626	608
7. Other	14	14	14	14	14	14	14	14	14	14
Total (excluding LULUCF)	51'737	52'799	51'728	52'852	53'530	54'227	53'881	51'948	53'683	52'350
5. Land Use, Land-Use Change and Forestry	-1'227	241	-308	-2'985	-4'572	-4'197	-2'892	-2'784	-1'616	-2'093
Total (including LULUCF)	50'510	53'040	51'420	49'868	48'959	50'030	50'989	49'164	52'067	50'257

Source and Sink Categories	2010	2011	2011/1990
	CO_2 eq	CO_2 eq	%
1. Energy	43'908	39'864	-5.1%
1A1 Energy Industries	4'197	3'994	56.5%
1A2 Manufacturing Industries and Construction	5'873	5'371	-12.2%
1A3 Transport	16'380	16'206	11.0%
1A4 Other Sectors	17'110	13'958	-22.7%
1A5 Other (Military)	121	108	-47.5%
1B Fugitive emissions from oil and natural gas	227	226	-52.1%
2. Industrial Processes	3'723	3'742	10.7%
3. Solvent and Other Product Use	198	199	-57.6%
4. Agriculture	5'647	5'604	-8.0%
6. Waste	597	587	-41.9%
7. Other	14	14	17.2%
Total (excluding LULUCF)	54'088	50'010	-5.6%
5. Land Use, Land-Use Change and Forestry	-2'405	-3'411	8.1%
Total (including LULUCF)	51'683	46'599	-6.5%

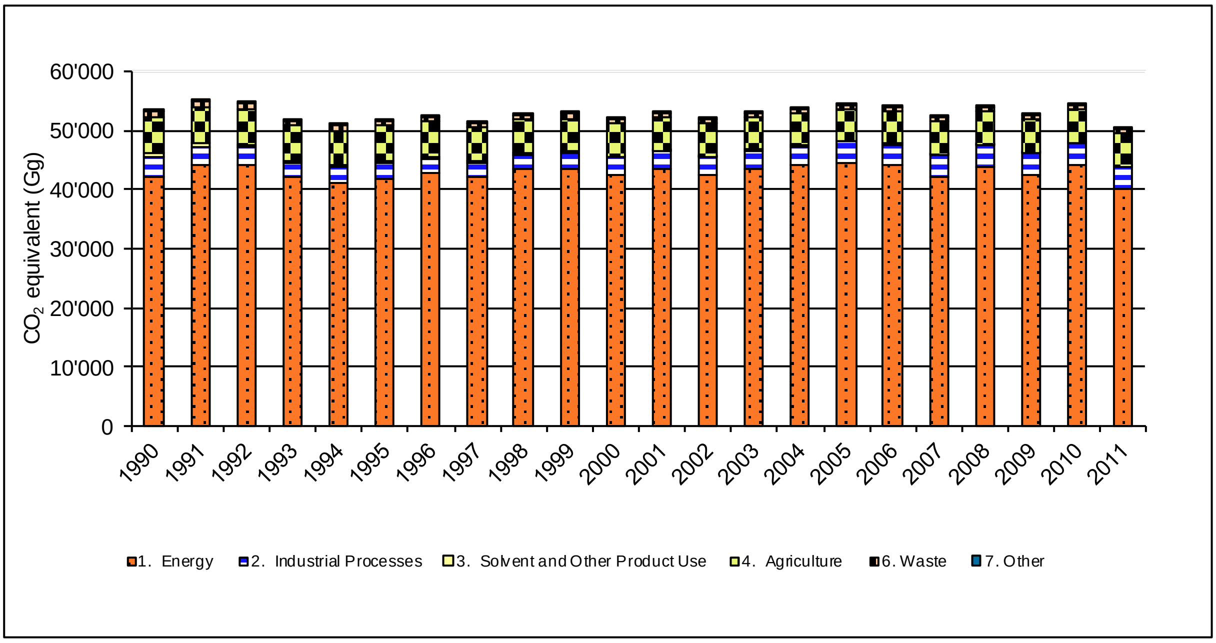

Figure E-2 Switzerland's greenhouse gas emissions in CO_2 equivalent (Gg) by main source categories, 1990–2011 (excluding LULUCF).

Table E-5 shows the contributions of individual sectors to total emissions excl. LULUCF for selected years in more detail. Between 1990 and 2011, the relative contribution of sector 1 Energy increased marginally from 79.3% to 79.7%, whereas emissions from sector 4 Agriculture decreased from 11.5% to 11.2% and those from sector 6 Waste changed from 1.1% to 1.2%. Sector 2 Industrial Processes contributed 6.4% to total emissions in 1990 and 7.5 % in 2011, 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	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1. Energy	42'007	79.3%	41'774	81.2%	42'290	81.7%	44'345	81.8%
1A1 Energy Industries	*2'551*	*4.8%*	2'637	*5.1%*	3'093	*6.0%*	3'852	*7.1%*
1A2 Manufacturing Industries and Construction	*6'119*	*11.6%*	6'063	*11.8%*	5'788	*11.2%*	6'118	*11.3%*
1A3 Transport	*14'598*	*27.6%*	14'228	*27.6%*	15'901	*30.7%*	15'829	*29.2%*
1A4 Other Sectors	*18'061*	*34.1%*	18'349	*35.7%*	17'089	*33.0%*	18'187	*33.5%*
1A5 Other (Military)	*206*	*0.4%*	148	*0.3%*	136	*0.3%*	124	*0.2%*
1B Fugitive emissions from oil and natural gas	*472*	*0.9%*	349	*0.7%*	284	*0.5%*	236	*0.4%*
2. Industrial Processes	3'381	6.4%	2'653	5.2%	2'930	5.7%	3'520	6.5%
3. Solvent and Other Product Use	470	0.9%	354	0.7%	259	0.5%	211	0.4%
4. Agriculture	6'092	11.5%	5'819	11.3%	5'496	10.6%	5'474	10.1%
6. Waste	1'011	1.9%	852	1.7%	748	1.4%	663	1.2%
7. Other	12	0.0%	13	0.0%	14	0.0%	14	0.0%
Total (excluding LULUCF)	52'973	100.0%	51'466	100.0%	51'737	100.0%	54'227	100.0%

Source and Sink Categories	2008		2009		2010		2011	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1. Energy	43'552	81.1%	42'430	81.0%	43'908	81.2%	39864	79.7%
1A1 Energy Industries	4'061	*7.6%*	3'976	*7.6%*	4'197	*7.8%*	3994	8.0%
1A2 Manufacturing Industries and Construction	6'096	*11.4%*	5'719	*10.9%*	5'873	*10.9%*	5371	10.7%
1A3 Transport	16'662	*31.0%*	16'473	*31.5%*	16'380	*30.3%*	16206	32.4%
1A4 Other Sectors	16'385	*30.5%*	15'914	*30.4%*	17'110	*31.6%*	13958	27.9%
1A5 Other (Military)	115	*0.2%*	116	*0.2%*	121	*0.2%*	108	0.2%
1B Fugitive emissions from oil and natural gas	235	*0.4%*	231	*0.4%*	227	*0.4%*	226	0.5%
2. Industrial Processes	3'640	6.8%	3'505	6.7%	3'723	6.9%	3742	7.5%
3. Solvent and Other Product Use	201	0.4%	200	0.4%	198	0.4%	199	0.4%
4. Agriculture	5'648	10.5%	5'593	10.7%	5'647	10.4%	5604	11.2%
6. Waste	626	1.2%	608	1.2%	597	1.1%	587	1.2%
7. Other	14	0.0%	14	0.0%	14	0.0%	14	0.0%
Total (excluding LULUCF)	53'683	100.0%	52'350	100.0%	54'088	100.0%	50'010	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 2011, Deforestations were responsible for an emission of 233.22 Gg CO_2 equivalent, whereas Afforestations stored -32.55 Gg CO_2 equivalent and Forest Management -2936.26 Gg CO_2 equivalent.

Detailed quantitative information of the inventory years 2008, 2009, 2010 and 2011 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., 1999-2011.

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	**228.20**	**228.19**	**227.28**	**225.85**	**224.10**	**222.61**	**177.08**
A.1. Afforestation and Reforestation	-6.40	-7.19	-8.23	-9.67	-11.41	-13.26	-15.60
A.2. Deforestation	234.60	235.38	235.51	235.52	235.51	235.87	192.67
B. Article 3.4 activities	**-3941.42**	**-801.22**	**-96.70**	**-297.06**	**-3256.69**	**-3938.76**	**-4142.46**
B.1. Forest Management incl. biomass burning	-3941.42	-801.22	-96.70	-297.06	-3256.69	-3938.76	-4142.46
gains living biomass	-12538.67	-12548.99	-12558.14	-12567.19	-12576.31	-12586.43	-12602.52
losses living biomass	9955.69	12833.46	13232.16	13075.27	10612.85	10272.12	10719.66
litter	-183.95	55.92	310.98	236.12	-202.74	-442.97	-941.39
dead wood pool	-1114.46	-1079.98	-1025.80	-1009.55	-1062.07	-1115.30	-1226.30
soil C min. soils	-69.07	-71.80	-66.09	-57.11	-60.11	-75.71	-102.55
soil C org. soils	8.68	8.69	8.70	8.70	8.71	8.71	8.73
sum forest management excl. biomass burning	-3941.78	-802.69	-98.20	-313.76	-3279.67	-3939.58	-4144.37

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	**145.24**	**119.76**	**77.43**	**207.07**	**202.07**	**200.66**	
A.1. Afforestation and Reforestation	-17.99	-20.99	-23.02	-25.15	-30.35	-32.55	
A.2. Deforestation	163.22	140.75	100.45	232.23	232.43	233.22	
B. Article 3.4 activities	**-3339.56**	**-2200.43**	**-1374.82**	**-2178.56**	**-2884.02**	**-2936.20**	
B.1. Forest Management incl. biomass burning	-3339.56	-2200.43	-1374.82	-2178.56	-2884.02	-2936.20	
gains living biomass	-12707.70	-12805.29	-12904.16	-12915.75	-12920.06	-12924.49	
losses living biomass	10298.16	10749.27	10856.07	10447.87	10211.58	10188.90	
litter	-194.38	224.17	650.77	275.94	-125.54	-146.81	
dead wood pool	-628.87	-278.80	93.99	58.94	-11.42	-21.71	
soil C min. soils	-119.62	-108.06	-82.08	-55.77	-48.23	-46.67	
soil C org. soils	8.74	8.75	8.76	8.76	8.77	8.77	
sum forest management excl. biomass burning	-3343.68	-2209.96	-1376.66	-2180.02	-2884.89	-2942.01	

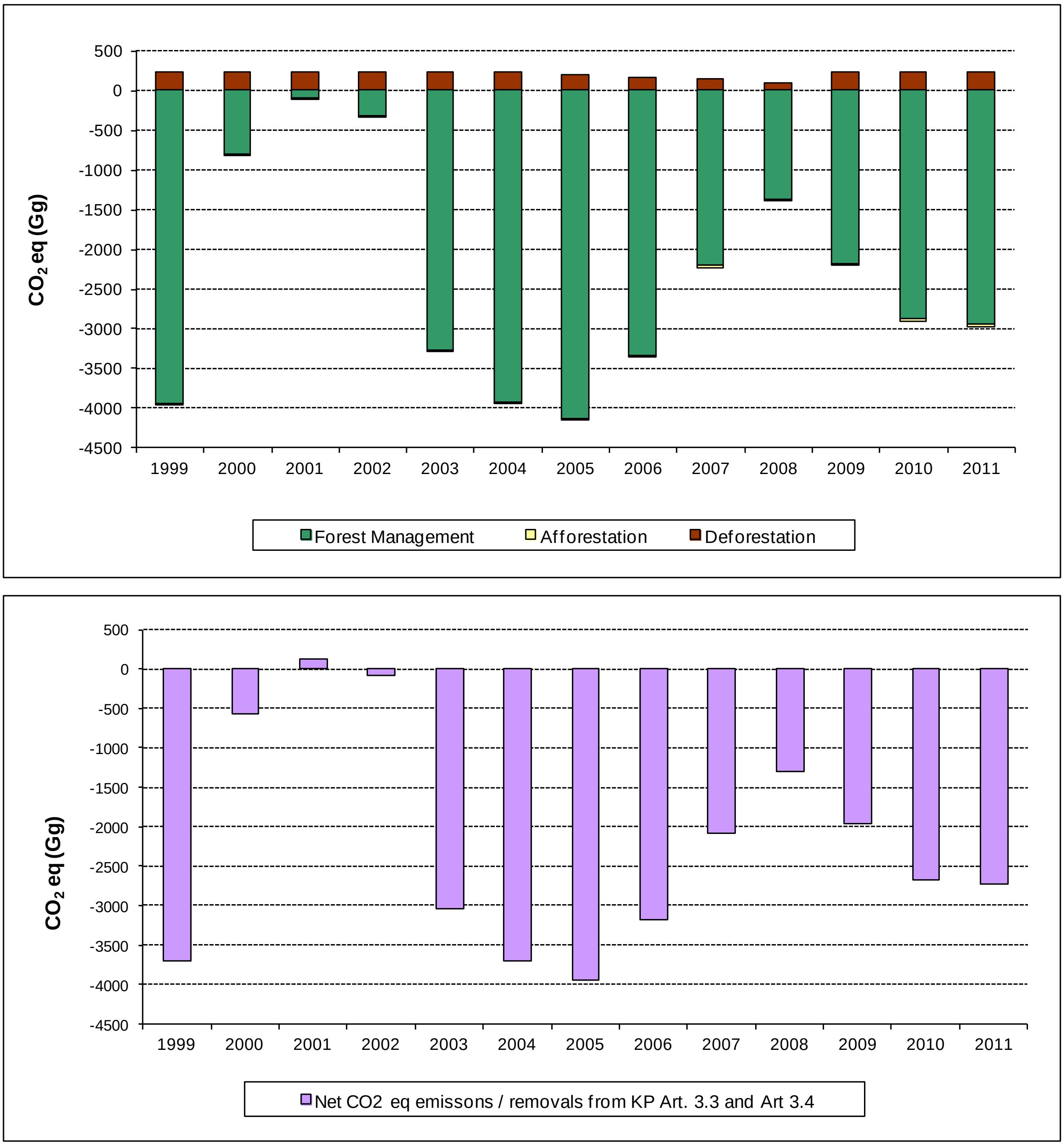

Figure E-3: Emissions (positive sign) and removals (negative sign) of CO_2 eq from Afforestation and Deforestation under Article 3, paragraph 3 and Forest Management under Article 3, paragraph 4 (upper panel) and the total contribution of these activities in CO_2 equivalents (lower panel), 1999-2011.

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), 1990–2011 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	42'007	44'099	44'126	41'814	40'920	41'774	42'612	41'959	43'274
		2 Industrial Processes	3'258	3'381	3'023	2'868	2'563	2'724	2'653	2'527	2'464	2'558
		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	5'808	5'819	5'780	5'606	5'578
		6 Waste	1'030	1'011	1'008	980	918	857	852	828	819	800
		Total (Annex A sources)	**52'791**	**52'961**	**54'644**	**54'373**	**51'564**	**50'683**	**51'453**	**52'079**	**51'156**	**52'496**

		Sector	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
			CO_2 equivalent (Gg)									
Annex A sources		1 Energy	43'370	42'290	43'221	42'197	43'397	43'828	44'345	44'010	42'008	43'552
		2 Industrial Processes	2'661	2'930	3'034	3'032	3'079	3'347	3'520	3'496	3'519	3'640
		3 Solvent and Other Product Use	273	259	245	233	224	211	211	205	204	201
		4 Agriculture	5'511	5'496	5'561	5'536	5'461	5'447	5'474	5'494	5'556	5'648
		6 Waste	773	748	723	716	677	682	663	662	646	626
		Total (Annex A sources)	**52'588**	**51'723**	**52'785**	**51'714**	**52'838**	**53'516**	**54'213**	**53'867**	**51'933**	**53'668**
KP-LULUCF	Art.3.3	Afforestation & reforestation										-23
		Deforestation										100
	Art.3.4	Forest management										-1'375
		Cropland management										NA
		Grazing land management										NA
		Revegetation										NA

		Sector	2009	2010	2011	2011 – base year
			CO_2 equivalent (Gg)			%
Annex A sources		1 Energy	42'430	43'908	39'864	-5%
		2 Industrial Processes	3'505	3'723	3'742	15%
		3 Solvent and Other Product Use	200	198	199	-57%
		4 Agriculture	5'593	5'647	5'604	-5%
		6 Waste	608	597	587	-43%
		Total (Annex A sources)	**52'336**	**54'073**	**49'995**	**-5%**
KP-LULUCF	Art.3.3	Afforestation & reforestation	-25	-30	-33	
		Deforestation	232	232	233	
	Art.3.4	Forest management	-2'179	-2'884	-2'936	
		Cropland management	NA	NA	NA	
		Grazing land management	NA	NA	NA	
		Revegetation	NA	NA	NA	

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), 1990-2011.

		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	44'586	46'309	46'203	43'662	42'923	43'572	44'224	43'409	44'711
		CH_4	4'370	4'674	4'644	4'510	4'374	4'281	4'267	4'193	4'086	4'042
		N_2O	3'623	3'457	3'460	3'437	3'358	3'317	3'322	3'326	3'214	3'210
		HFCs	0.0	0.0	0.2	6	14	33	179	224	296	351
		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**	**52'961**	**54'644**	**54'373**	**51'564**	**50'683**	**51'453**	**52'079**	**51'156**	**52'496**

		GHG	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
			CO_2 equivalent (Gg)									
Annex A sources		CO_2	44'829	43'908	44'860	43'816	44'996	45'621	46'246	45'881	43'914	45'435
		CH_4	3'982	3'914	3'928	3'875	3'780	3'763	3'769	3'779	3'778	3'842
		N_2O	3'182	3'183	3'210	3'191	3'136	3'087	3'070	3'068	3'089	3'109
		HFCs	412	491	584	624	695	802	882	905	938	999
		PFCs	36	69	45	40	57	53	33	32	29	39
		SF_6	147	158	157	168	174	190	213	201	186	245
		Total (Annex A sources)	**52'588**	**51'723**	**52'785**	**51'714**	**52'838**	**53'516**	**54'213**	**53'867**	**51'933**	**53'668**
KP-LULUCF	Art.3.3	CO_2										77.4
		CH_4										NO
		N_2O										0.1
		Total (Art. 3.3)										**77.5**
	Art.3.4	CO_2										-1'375.5
		CH_4										0.4
		N_2O										0.2
		Total (Art. 3.4)										**-1'374.9**

		GHG	2009	2010	2011	2011 – base year
			CO_2 equivalent (Gg)			%
Annex A sources		CO_2	44'226	45'890	41'843	-6%
		CH_4	3'786	3'765	3'732	-15%
		N_2O	3'064	3'133	3'073	-15%
		HFCs	1'039	1'094	1'144	NA
		PFCs	35	37	39	-61%
		SF_6	187	155	164	14%
		Total (Annex A sources)	**52'336**	**54'073**	**49'995**	**-5%**
KP-LULUCF	Art.3.3	CO_2	207.1	202.0	200.6	
		CH_4	NO	NO	NO	
		N_2O	0.0	0.0	0.0	
		Total (Art. 3.3)	**207.1**	**202.0**	**200.6**	
	Art.3.4	CO_2	-2'179.1	-2'884.4	-2'938.2	
		CH_4	0.3	0.2	1.2	
		N_2O	0.2	0.1	0.7	
		Total (Art. 3.4)	**-2'178.6**	**-2'884.1**	**-2'936.3**	

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 48% to 75% in the period 1990-2011 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 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). Another report by FOEN (2009d) confirms a warming trend with an observed increase in mean annual temperature of 1.6 °C between 1864 and 2008. Over the last 100 years, mean annual temperatures increased by 0.12-0.19 °C per decade, with a substantially accelerated warming in recent decades. In the course of the 21st century, Swiss climate is projected to depart significantly from present and past conditions (CH2011 2011). Mean temperature will very likely increase in all regions and seasons. According to the OcCC (2008) report, the average temperatures will rise by another 2 °C in winter and 2.5 °C in summer until 2050. The best estimate of the CH2011 (2011) report projects increases of the seasonal mean temperature of 1.2 – 4.8 °C by the end of the century, depending on the social-economic scenario. 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 2009d). According to the OcCC (2008) report, the area covered by alpine glaciers will diminish by about three quarters in case of a medium warming by 2050.

The observed trends in precipitation are less distinct than in temperature. For a number of stations a significant increase in precipitation is found in winter and spring (+2.7 to +3.1% per decade). For summer and autumn no significant trends are detectable. Based on regional climate scenarios (OcCC 2008), an increase in mean winter precipitation of 8% compared to 1990 is expected north of the Alps by 2050 (11% south of the Alps), and a decrease of 17% in summer (19% south of the Alps). The current mean precipitation scenarios for the year 2100 project a decreasing summer mean precipitation for Switzerland by 8 – 28 % depending on the scenario considered. This 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, for instance, typical alpine vascular plants have shifted uphill over the past few years. 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 a yearly 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 now includes the accounting and reporting of the national registry as well (ISO 9001:2008, SQS 2010). 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 an extended reporting under the Kyoto Protocol.

The 2013 inventory submission under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol (FOEN 2013) includes the NIR on hand, the greenhouse gas inventory 1990–2011 and the Kyoto Protocol LULUCF tables 2008–2011 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 2013a) 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 2008-2011 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.

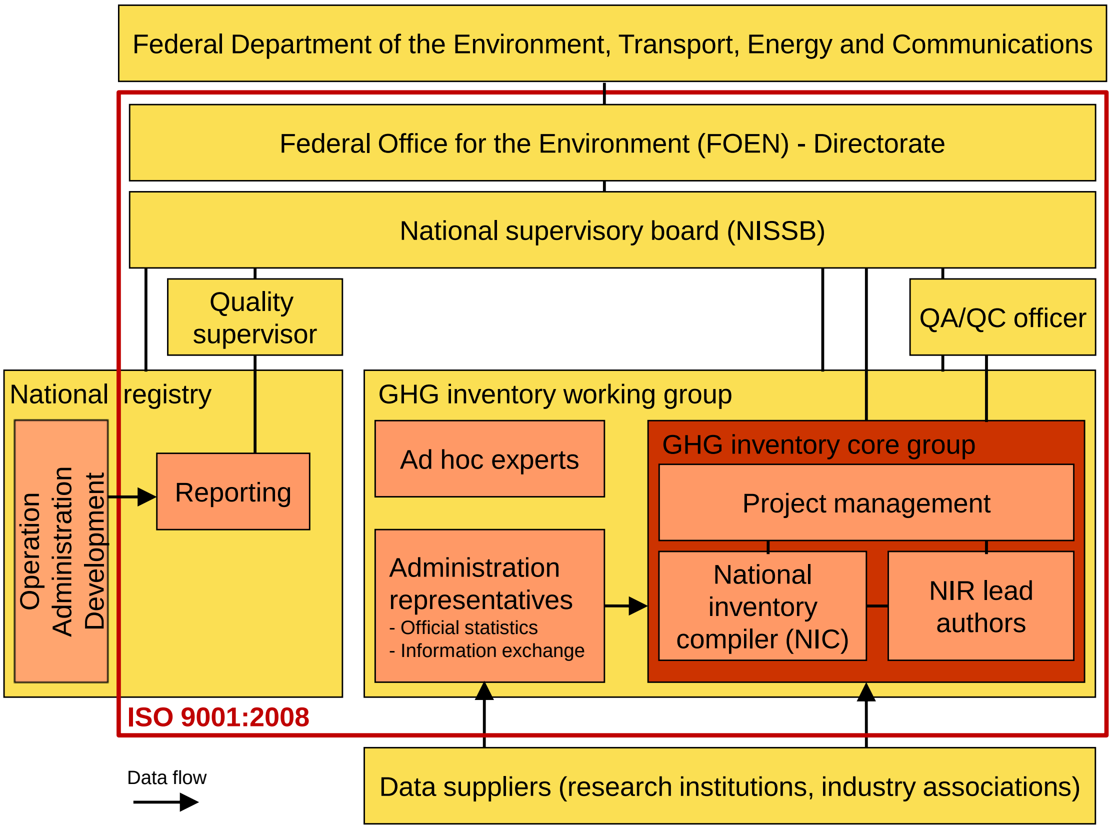

Figure 1-1 Institutional setting of the National Inventory System. The red frame marks the institutions that are included in the ISO 9001:2008 certification.

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 2013a), 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 2013a).

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	ART	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, SGIA	Gas Distribution Losses						■							
18	EMPA	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, 2013a). 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 2013a).

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 2013a) 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 3.5.2) 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 (2013a).

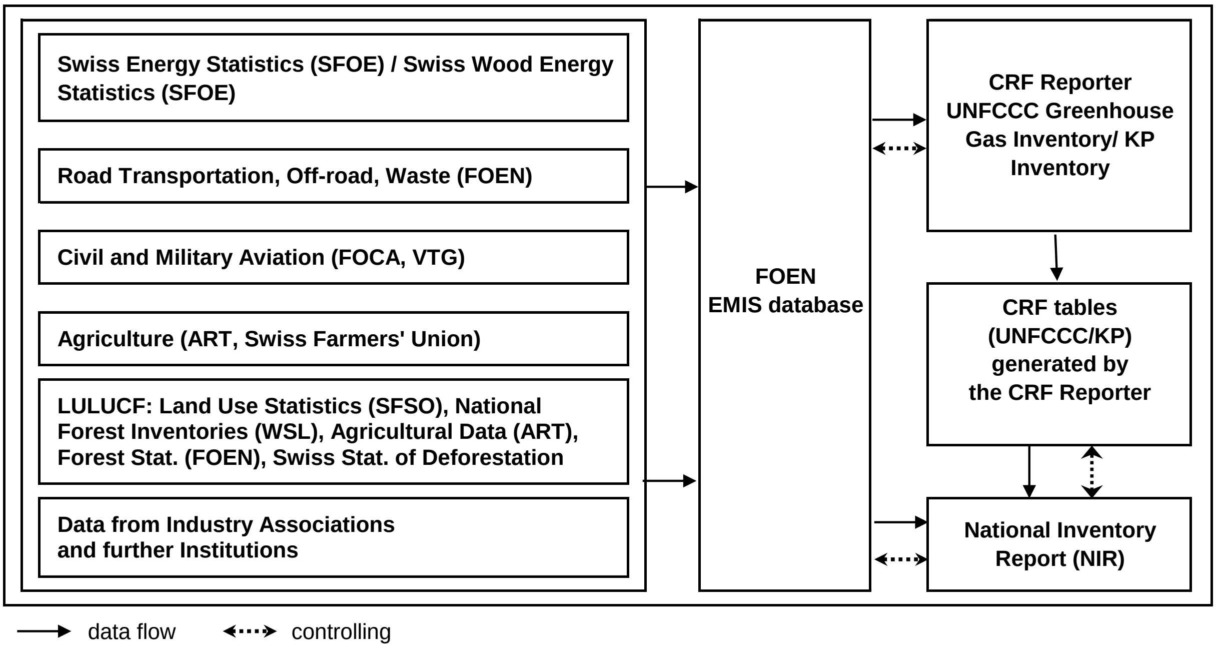

Figure 1-2 Schematic overview: Data collection for EMIS database, CRF Reporter and National Inventory Report (NIR).

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 2013a) 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).

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,T2,T3**	**CS**	**CS,T2,T3**	**CR,CS**	**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	CS	CS,T3	CS	D	D
1. Solid Fuels	NA	NA	NA	NA	NA	NA
2. Oil and Natural Gas	CS	CS	CS,T3	CS	D	D
2. Industrial Processes	**CS,T2**	**CS,D,PS**	**CS,T2**	**CS,D**	**T2**	**PS**
A. Mineral Products	CS,T2	CS,D,PS	NA	NA	NA	NA
B. Chemical Industry	CS,T2	CS,D,PS	CS,T2	CS,D	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,D**	**CS,D**			**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	NA	NA	NA	NA
D. Wetlands	T2	CS	NA	NA	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			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 2012). 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 present inventory, the two approaches show a good correspondence; with CO_2 emissions differing by 0.78% and energy consumption by 0.67% in 2011 (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), hydrochloric acid (HCl), particulate matter, heavy metals (lead, zinc, cadmium, mercury), polychlorinated dibenzodioxins and -furanes (PCDD/PCDF), 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 uncertainty.

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 2011, among a total of 135 categories, 31 have been identified as key categories with an aggregated contribution of 97.1% to total national emissions. 24 categories are key due to the level assessment, 27 due to the trend assessment.

Of the 31 key categories, 18 are in sector 1 Energy, accounting for 78.4% of total CO_2 equivalent emissions in 2011. The other key categories are from sectors 2 Industrial Processes (6.3%), 3 Solvent and Other Product Use (0.3%), 4 Agriculture (11.1%) 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 18.7%
- 1A4b Energy, Fuel Combustion, Other Sectors, Residential, Liquid Fuels, CO_2, level contribution 13.6%
- 1A3b Energy, Fuel Combustion, Road Transportation, Diesel, CO_2, level contribution 12.7%

Compared to the key category analysis in the previous inventory report of April 2012 (FOEN 2012), the following categories are new key categories:

- N_2O emissions from 1A3b Road Transportation, Gasoline
- CO_2 emissions from 2C1 Metal Production, Steel Production

The following category are no longer key categories in Tier 1 compared to the previous submission of April 2012:

- CH_4 emissions from 1A3b Road Transportation, Gasoline

The following table shows the contributions of the individual key categories. The complete results of the key category analysis for 2011 are given in Annex A1.2.

Table 1-3 List of Switzerland's Tier 1 key categories 2011 without LULUCF categories, sorted by category code.

Tier 1 Key category analysis 2011 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 2011 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 IndustriesGaseous Fuels	CO2	242.32	442.34	0.88%	0.00452	1.1%	KC level	KC trend
2	1A1	1. Energy A. Fuel Comb.1. Energy IndustriesLiquid Fuels	CO2	691.39	868.79	1.74%	0.00458	1.1%	KC level	KC trend
3	1A1	1. Energy A. Fuel Comb.1. Energy IndustriesOther Fuels	CO2	1519.73	2591.93	5.18%	0.02451	6.0%	KC level	KC trend
4	1A2	1. Energy A. Fuel Comb.2. Manufac. Ind. and Constr.Gaseous Fuels	CO2	1046.30	2015.43	4.03%	0.02177	5.3%	KC level	KC trend
5	1A2	1. Energy A. Fuel Comb.2. Manufac. Ind. and Constr.Liquid Fuels	CO2	3684.05	2484.54	4.97%	0.02104	5.1%	KC level	KC trend
6	1A2	1. Energy A. Fuel Comb.2. Manufac. Ind. and Constr.Other Fuels	CO2	134.15	321.33	0.64%	0.00412	1.0%	KC level	KC trend
7	1A2	1. Energy A. Fuel Comb.2. Manufac. Ind. and Constr.Solid Fuels	CO2	1220.95	514.65	1.03%	0.01351	3.3%	KC level	KC trend
8	1A3a	1. EnergyA. Fuel Comb.3. Transport; Civil Aviation	CO2	252.55	132.35	0.26%	0.00225	0.5%	-	KC trend
9	1A3b	1. EnergyA. Fuel Comb.3. Transport; Road Transp.Diesel	CO2	2587.68	6348.51	12.69%	0.08272	20.1%	KC level	KC trend
10	1A3b	1. EnergyA. Fuel Comb.3. Transport; Road Transp.Gasoline	CO2	11335.25	9358.64	18.71%	0.02844	6.9%	KC level	KC trend
11	1A3b	1. EnergyA. Fuel Comb.3. Transport; Road Transp.Gasoline	N2O	137.27	43.85	0.09%	0.00182	0.4%	-	KC trend
12	1A4a	1. Energy A. Fuel Comb.4. Other Sectors; Com./Instit.Gaseous Fuels	CO2	961.96	1312.66	2.62%	0.00857	2.1%	KC level	KC trend
13	1A4a	1. Energy A. Fuel Comb.4. Other Sectors; Com./Instit.Liquid Fuels	CO2	4614.55	2915.76	5.83%	0.03051	7.4%	KC level	KC trend
14	1A4b	1. Energy A. Fuel Comb.4. Other Sectors; ResidentialGaseous Fuels	CO2	1409.10	2254.45	4.51%	0.01958	4.8%	KC level	KC trend
15	1A4b	1. Energy A. Fuel Comb.4. Other Sectors; ResidentialLiquid Fuels	CO2	10248.78	6802.19	13.60%	0.06086	14.8%	KC level	KC trend
16	1A4c	1. Energy A. Fuel Comb.4. Other Sect.; Agric./ForestryLiquid Fuels	CO2	547.19	526.38	1.05%	0.00021	0.1%	KC level	-
17	1A5	1. Energy A. Fuel Comb.5. OtherLiquid Fuels	CO2	203.58	106.92	0.21%	0.00181	0.4%	-	KC trend
18	1B2	1. Energy B. Fugitive Emissions from Fuels2. Oil and Natural Gas	CH4	380.43	173.32	0.35%	0.00394	1.0%	-	KC trend
19	2A1	2. Industrial Proc.A. Mineral Products; Cement Production-CO2	CO2	2524.77	1903.58	3.81%	0.01017	2.5%	KC level	KC trend
20	2C1	2. Industrial Proc.C. Metal Production; Steel Production	CO2	110.80	185.08	0.37%	0.00170	0.4%	KC level	KC trend
21	2F1	2. Industrial Proc.F. Cons. of Halocarbons and SF6; Refrig. & AC Eq.	HFC	0.02	1046.30	2.09%	0.02216	5.4%	KC level	KC trend
22	3	3. Solvent and Other Product Use	CO2	359.98	155.28	0.31%	0.00391	0.9%	-	KC trend
23	4A	4. AgricultureA. Enteric Fermentation	CH4	2635.45	2509.11	5.02%	0.00045	0.1%	KC level	-
24	4B	4. AgricultureB. Manure Management	CH4	671.61	649.83	1.30%	0.00033	0.1%	KC level	-
25	4B	4. AgricultureB. Manure Management	N2O	454.68	336.43	0.67%	0.00197	0.5%	KC level	KC trend
26	4D1	4. AgricultureD. Agricultural Soils; Direct Soil Emissions	N2O	1351.47	1163.25	2.33%	0.00239	0.6%	KC level	KC trend
27	4D2	4. AgricultureD. Agr. Soils; Pasture, Range and Paddock Manure	N2O	128.10	223.57	0.45%	0.00217	0.5%	KC level	KC trend
28	4D3	4. AgricultureD. Agr. Soils; Indirect Emissions	N2O	822.48	691.74	1.38%	0.00179	0.4%	KC level	KC trend
29	6A	6. Waste A. Solid Waste Disposal on Land	CH4	688.16	180.72	0.36%	0.00993	2.4%	-	KC trend
30	6B	6. Waste B. Wastewater Handling	N2O	184.72	211.23	0.42%	0.00078	0.2%	KC level	-
31	6D	6. Waste D. Other	CH4	29.94	105.75	0.21%	0.00164	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.

Combined 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 IndustriesGaseous Fuels	CO2	242.32	0.46%	KC level
2	1A1	1. Energy A. Fuel Combustion 1. Energy IndustriesLiquid Fuels	CO2	691.39	1.31%	KC level
3	1A1	1. Energy A. Fuel Combustion 1. Energy IndustriesOther Fuels	CO2	1519.73	2.87%	KC level
4	1A2	1. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionGaseous Fuels	CO2	1046.30	1.98%	KC level
5	1A2	1. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionLiquid Fuels	CO2	3684.05	6.95%	KC level
6	1A2	1. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionSolid Fuels	CO2	1220.95	2.30%	KC level
7	1A3a	1. EnergyA. Fuel Combustion 3. Transport; Civil Aviation	CO2	252.55	0.48%	KC level
8	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road TransportationDiesel	CO2	2587.68	4.88%	KC level
9	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	CO2	11335.25	21.40%	KC level
10	1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalGaseous Fuels	CO2	961.96	1.82%	KC level
11	1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalLiquid Fuels	CO2	4614.55	8.71%	KC level
12	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialGaseous Fuels	CO2	1409.10	2.66%	KC level
13	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialLiquid Fuels	CO2	10248.78	19.35%	KC level
14	1A4c	1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/ForestryLiquid Fuels	CO2	547.19	1.03%	KC level
15	1A5	1. Energy A. Fuel Combustion 5. OtherLiquid Fuels	CO2	203.58	0.38%	KC level
16	1B2	1. Energy B. Fugitive Emissions from Fuels2. Oil and Natural Gas	CH4	380.43	0.72%	KC level
17	2A1	2. Industrial Proc.A. Mineral Products; Cement Production-CO2	CO2	2524.77	4.77%	KC level
18	3	3. Solvent and Other Product Use	CO2	359.98	0.68%	KC level
19	4A	4. AgricultureA. Enteric Fermentation	CH4	2635.45	4.98%	KC level
20	4B	4. AgricultureB. Manure Management	CH4	671.61	1.27%	KC level
21	4B	4. AgricultureB. Manure Management	N2O	454.68	0.86%	KC level
22	4D1	4. AgricultureD. Agricultural Soils; Direct Soil Emissions	N2O	1351.47	2.55%	KC level
23	4D3	4. AgricultureD. Agricultural Soils; Indirect Emissions	N2O	822.48	1.55%	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 2011.

Compared to the key category analysis in the previous inventory report of April 2012, the key categories in the base year 1990 are the same.

Tier 2

For 2011, among a total of 135 categories, 29 have been identified as key categories with an aggregated contribution of 92.8% of the sum of all level assessments weighted with their uncertainty in 2011. 23 categories are key due to the level assessment, 26 due to the trend assessment.

Of the 29 key categories, 14 are in sector 1 Energy, accounting for 27.8% of the sum of all level assessments weighted with their uncertainty in 2011 (14.3%, see Table A - 4). Sector 4 Agriculture accounts for 44.8% of that sum. Tier 2 key category analysis shows that these two sectors have the highest impact on inventory uncertainty. The other key categories are from sectors 2 Industrial Processes (14.2%), 3 Solvent and Other Product Use (1.6%) and 6 Waste (4.4%). There are four major key categories contributing more than 10% to the level assessment weighted with their uncertainty:

- 1A1 Energy, Fuel Combustion, Energy Industries, Other Fuels, CO_2, contribution of 11.5% to the sum of all level assessments weighted with their uncertainty.
- 2A1 Industrial Processes, Mineral Products, Cement Production, CO_2, contribution of 10.7% to the sum of all level assessment weighted with their uncertainty.
- 4D1, Agricultural Soils; Direct Soil Emissions, N_2O, contribution of 12.4% to the sum of all level assessments weighted with their uncertainty.
- 4D3, Agricultural Soils; Indirect Emissions, N_2O, contribution of 15.3% 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 2011 are given in Annex A1.4.

Compared to the submission of April 2012, there is one new key category in Tier 2: N_2O emissions from Gasoline in 1A3b Transport.

No longer key in Tier 2 are the following categories:

- CO_2 emissions from Liquid Fuels in 1A2 Fuel Combustion in Manufacturing Industries and Construction;
- SF_6 emissions from 2F9 Others.

Table 1-5 List of Switzerland’s Tier 2 key categories 2011 without LULUCF categories, sorted by category code.

Tier 2 Key category analysis 2011 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 2011 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 Combustion 1. Energy IndustriesOther Fuels	CO2	1519.73	2591.93	1.64%	0.00775	14.1%	KC level	KC trend
2	1A2	1. Energy A. Fuel Combustion 2. Manufac. Ind. and Constr.Solid Fuels	CO2	1220.95	514.65	0.21%	0.00282	5.1%	KC level	KC trend
3	1A2	1. Energy A. Fuel Combustion 2. Manufac. Ind. and Constr.Other Fuels	CO2	134.15	321.33	0.20%	0.00130	2.4%	KC level	KC trend
4	1A2	1. Energy A. Fuel Combustion 2. Manufac. Ind. and Constr.Gaseous Fuels	CO2	1046.30	2015.43	0.20%	0.00109	2.0%	KC level	KC trend
5	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road Transp.Gasoline	CO2	11335.25	9358.64	0.48%	0.00073	1.3%	KC level	KC trend
6	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road Transp.Diesel	CO2	2587.68	6348.51	0.28%	0.00185	3.4%	KC level	KC trend
7	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road Transp.Gasoline	N2O	137.27	43.85	0.04%	0.00091	1.7%	-	KC trend
8	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road Transp.Gasoline	CH4	101.15	20.95	0.02%	0.00059	1.1%	-	KC trend
9	1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Com./Instit.Gaseous Fuels	CO2	961.96	1312.66	0.13%	0.00043	0.8%	KC level	KC trend
10	1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Com./Instit.Liquid Fuels	CO2	4614.55	2915.76	0.10%	0.00050	0.9%	-	KC trend
11	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialGaseous Fuels	CO2	1409.10	2254.45	0.23%	0.00098	1.8%	KC level	KC trend
12	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialLiquid Fuels	CO2	10248.78	6802.19	0.22%	0.00100	1.8%	KC level	KC trend
13	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialBiomass	CH4	95.89	29.98	0.04%	0.00082	1.5%	-	KC trend
14	1B2	1. Energy B. Fugitive Emissions from Fuels2. Oil and Natural Gas	CH4	380.43	173.32	0.17%	0.00197	3.6%	KC level	KC trend
15	2A1	2. Industrial Proc.A. Mineral Products; Cement Production-CO2	CO2	2524.77	1903.58	1.52%	0.00407	7.4%	KC level	KC trend
16	2C1	2. Industrial Proc.C. Metal Production; Steel Production	CO2	110.80	185.08	0.15%	0.00069	1.3%	KC level	KC trend
17	2F1	2. Industrial Proc.F. Cons. of Halocarbons and SF6; Refrig. & AC Eq.	HFC	0.02	1046.30	0.25%	0.00266	4.8%	KC level	KC trend
18	2F9	2. Industrial Proc.F. Cons. of Halocarbons and SF6; Other	HFC	0.00	64.38	0.10%	0.00109	2.0%	-	KC trend
19	3	3. Solvent and Other Product Use	CO2	359.98	155.28	0.16%	0.00195	3.6%	KC level	KC trend
20	3	3. Solvent and Other Product Use	N2O	110.14	44.15	0.07%	0.00101	1.8%	-	KC trend
21	4A	4. AgricultureA. Enteric Fermentation	CH4	2635.45	2509.11	0.91%	0.00008	0.1%	KC level	-
22	4B	4. AgricultureB. Manure Management	CH4	671.61	649.83	0.71%	0.00018	0.3%	KC level	-
23	4B	4. AgricultureB. Manure Management	N2O	454.68	336.43	0.42%	0.00123	2.2%	KC level	KC trend
24	4D1	4. AgricultureD. Agr. Soils; Direct Soil Emissions	N2O	1351.47	1163.25	1.77%	0.00182	3.3%	KC level	KC trend
25	4D2	4. AgricultureD. Agr. Soils; Pasture, Range and Paddock Manure	N2O	128.10	223.57	0.41%	0.00201	3.7%	KC level	KC trend
26	4D3	4. AgricultureD. Agr. Soils; Indirect Emissions	N2O	822.48	691.74	2.19%	0.00284	5.2%	KC level	KC trend
27	6A	6. Waste A. Solid Waste Disposal on Land	CH4	688.16	180.72	0.21%	0.00579	10.5%	KC level	KC trend
28	6B	6. Waste B. Wastewater Handling	N2O	184.72	211.23	0.21%	0.00039	0.7%	KC level	-
29	6D	6. Waste D. Other	CH4	29.94	105.75	0.21%	0.00165	3.0%	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.

Combined 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 (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 IndustriesOther Fuels	CO2	1519.73	0.91%	KC level
2	1A2	1. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionSolid Fuels	CO2	1220.95	0.48%	KC level
3	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	CO2	11335.25	0.55%	KC level
4	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	N2O	137.27	0.13%	KC level
5	1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalLiquid Fuels	CO2	4614.55	0.14%	KC level
6	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialBiomass	CH4	95.89	0.12%	KC level
7	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialGaseous Fuels	CO2	1409.10	0.13%	KC level
8	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialLiquid Fuels	CO2	10248.78	0.32%	KC level
9	1B2	1. Energy B. Fugitive Emissions from Fuels2. Oil and Natural Gas	CH4	380.43	0.36%	KC level
10	2A1	2. Industrial Proc.A. Mineral Products; Cement Production-CO2	CO2	2524.77	1.91%	KC level
11	2F9	2. Industrial Proc.F. Consumption of Halocarbons and SF6; Other	SF6	79.58	0.12%	KC level
12	3	3. Solvent and Other Product Use	CO2	359.98	0.34%	KC level
13	3	3. Solvent and Other Product Use	N2O	110.14	0.17%	KC level
14	4A	4. AgricultureA. Enteric Fermentation	CH4	2635.45	0.91%	KC level
15	4B	4. AgricultureB. Manure Management	CH4	671.61	0.69%	KC level
16	4B	4. AgricultureB. Manure Management	N2O	454.68	0.54%	KC level
17	4D1	4. AgricultureD. Agricultural Soils; Direct Soil Emissions	N2O	1351.47	1.94%	KC level
18	4D2	4. AgricultureD. Agricultural Soils; Pasture, Range and Paddock Manure	N2O	128.10	0.22%	KC level
19	4D3	4. AgricultureD. Agricultural Soils; Indirect Emissions	N2O	822.48	2.45%	KC level
20	6A	6. Waste A. Solid Waste Disposal on Land	CH4	688.16	0.76%	KC level
21	6B	6. Waste B. Wastewater Handling	N2O	184.72	0.17%	KC level

There are 21 level Tier 2 key categories in the base year 1990 (see Table 1-6). Except SF_6 emissions from category 2F9, all of them are also key categories in 2011.

Compared to the key category analysis in the previous inventory report of April 2012, CH_4 emissions from Biomass consumption in 1A4b Fuel Combustion of the Residential Sector is new key category in 1990. CO_2 emissions from Liquid Fuels combustion in 1A2 in Manufacturing Industries and Construction is not a key category anymore.

1.5.1.3 Combined KCA without and with LULUCF categories

The key category analysis including LULUCF categories has also been carried out for 2011 and 1990. The complete results of the key category analysis for 2011 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 2011 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 (level and trend key category)
- CO_2 emissions from 5E2 Land converted to Settlements (level and trend key category)

The categories 5A2 Land converted to Forest Land and 5A1 Forest Land remaining Forest Land are large categories, contributing for 5.4% and 1.9% to the level assessment. Categories 5B1, 5C2, and 5E2 contribute less to the level assessment with 0.4%, 0.4% and 0.6%, respectively.

The five LULUCF key categories 5A1, 5A2, 5B1, 5C2 and 5E2 were also key in the analysis for 2010 as contained in the previous inventory report of April 2012 (FOEN 2012).

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 2011) and Table 1-8 (1990).

Tier 2

In the Tier 2 KCA for 2011 including LULUCF categories, there are six additional categories out of the LULUCF sector: CO_2 emissions from 5A1, 5A2, 5B1, 5C1, 5C2 and 5E2. Five of these categories are also key categories out of the LULUCF sector as in Tier 1. Additionally, CO2 emissions from 5C1 is key in Tier 2.

The categories 5A1 Land converted to Forest Land and 5A2 Forest Land remaining Forest Land are large categories, contributing for 10.5% and 4.4% to the level assessment weighted with their uncertainty. Source categories 5B1, 5C1, 5C2 and 5E2 contribute less, with 1.0%, 0.8%, 1.0%, 1.1% and 1.7%, respectively.

The six LULUCF key categories 5A1, 5A2, 5B1, 5C1, 5C2 and 5E2 were also key in the analysis for 2010 as contained in the previous inventory report of April 2012 (FOEN 2012).

For the combined KCA without and with LULUCF categories, these categories are added to the other 29 key categories from the KCA without LULUCF.

In the KCA for the year 1990, four of these six LULUCF categories are also key categories. Source categories 5C1 and 5C2 are not key categories for the year 1990.

Compared to the previous submission of April 2012 (FOEN 2012), 5C1 is not key category anymore.

For the combined KCA without and with LULUCF categories, these categories are added to the other 21 key categories from the KCA without LULUCF. The results of the combined Tier 2 KCA are summarised in Table 1-9 (year 2011) 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 2011, sorted by category code.

Tier 1 Key category analysis 2011, combined with and without 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 2011 Estimate** [Gg CO2 eq]	**Level Assessm**	**Trend Assessm**	**% Contrib in Trend**	**Result level Assessm**	**Result trend Assessm**
1	1A1	1. Energy A. Fuel Combustion 1. Energy IndustriesGaseous Fuels	CO2	242.32	442.34	0.80%	0.00411	1.1%	KC level	KC trend
2	1A1	1. Energy A. Fuel Combustion 1. Energy IndustriesLiquid Fuels	CO2	691.39	868.79	1.58%	0.00416	1.1%	KC level	KC trend
3	1A1	1. Energy A. Fuel Combustion 1. Energy IndustriesOther Fuels	CO2	1519.73	2591.93	4.71%	0.02228	5.7%	KC level	KC trend
4	1A2	1. Energy A. Fuel Combustion 2. Manufac. Ind. and Constr.Gaseous Fuels	CO2	1046.30	2015.43	3.66%	0.01978	5.1%	KC level	KC trend
5	1A2	1. Energy A. Fuel Combustion 2. Manufac. Ind. and Constr.Liquid Fuels	CO2	3684.05	2484.54	4.51%	0.01910	4.9%	KC level	KC trend
6	1A2	1. Energy A. Fuel Combustion 2. Manufac. Ind. and Constr.Other Fuels	CO2	134.15	321.33	0.58%	0.00375	1.0%	KC level	KC trend
7	1A2	1. Energy A. Fuel Combustion 2. Manufac. Ind. and Constr.Solid Fuels	CO2	1220.95	514.65	0.93%	0.01227	3.2%	KC level	KC trend
8	1A3a	1. EnergyA. Fuel Combustion 3. Transport; Civil Aviation	CO2	252.55	132.35	0.24%	0.00204	0.5%	-	KC trend
9	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road Transp.Diesel	CO2	2587.68	6348.51	11.53%	0.07518	19.4%	KC level	KC trend
10	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road Transp.Gasoline	CO2	11335.25	9358.64	17.00%	0.02578	6.6%	KC level	KC trend
11	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road Transp.Gasoline	N2O	137.27	43.85	0.08%	0.00165	0.4%	-	KC trend
12	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road Transp.Gasoline	CH4	101.15	20.95	0.04%	0.00143	0.4%	-	KC trend
13	1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Com./Instit.Gaseous Fuels	CO2	961.96	1312.66	2.38%	0.00779	2.0%	KC level	KC trend
14	1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Com./Instit.Liquid Fuels	CO2	4614.55	2915.76	5.30%	0.02770	7.1%	KC level	KC trend
15	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialGaseous Fuels	CO2	1409.10	2254.45	4.10%	0.01779	4.6%	KC level	KC trend
16	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialLiquid Fuels	CO2	10248.78	6802.19	12.36%	0.05525	14.2%	KC level	KC trend
17	1A4c	1. Energy A. Fuel Combustion 4. Other Sectors; Agr.e/ForestryLiquid Fuels	CO2	547.19	526.38	0.96%	0.00019	0.0%	KC level	-
18	1A5	1. Energy A. Fuel Combustion 5. OtherLiquid Fuels	CO2	203.58	106.92	0.19%	0.00164	0.4%	-	KC trend
19	1B2	1. Energy B. Fugitive Emissions from Fuels2. Oil and Natural Gas	CH4	380.43	173.32	0.31%	0.00357	0.9%	-	KC trend
20	2A1	2. Industrial Proc.A. Mineral Products; Cement Production-CO2	CO2	2524.77	1903.58	3.46%	0.00922	2.4%	KC level	KC trend
21	2C1	2. Industrial Proc.C. Metal Production; Steel Production	CO2	110.80	185.08	0.34%	0.00155	0.4%	KC level	KC trend
22	2F1	2. Industrial Proc.F. Cons. of Halocarbons and SF6; Refrig. & AC Eq.	HFC	0.02	1046.30	1.90%	0.02014	5.2%	KC level	KC trend
23	2F9	2. Industrial Proc.F. Cons. of Halocarbons and SF6; Other	HFC	0.00	64.38	0.12%	0.00124	0.3%	-	KC trend
24	3	3. Solvent and Other Product Use	CO2	359.98	155.28	0.28%	0.00355	0.9%	-	KC trend
25	4A	4. AgricultureA. Enteric Fermentation	CH4	2635.45	2509.11	4.56%	0.00042	0.1%	KC level	-
26	4B	4. AgricultureB. Manure Management	CH4	671.61	649.83	1.18%	0.00031	0.1%	KC level	-
27	4B	4. AgricultureB. Manure Management	N2O	454.68	336.43	0.61%	0.00178	0.5%	KC level	KC trend
28	4D1	4. AgricultureD. Agr. Soils; Direct Soil Emissions	N2O	1351.47	1163.25	2.11%	0.00216	0.6%	KC level	KC trend
29	4D2	4. AgricultureD. Agr. Soils; Pasture, Range and Paddock Manure	N2O	128.10	223.57	0.41%	0.00198	0.5%	KC level	KC trend
30	4D3	4. AgricultureD. Agr. Soils; Indirect Emissions	N2O	822.48	691.74	1.26%	0.00163	0.4%	KC level	KC trend
31	*5A1*	*5. LULUCFA. Forest Land1. Forest Land remaining Forest Land*	*CO2*	*3018.12*	*2961.48*	*5.38%*	*0.00218*	*0.6%*	*KC level*	*KC trend*
32	*5A2*	*5. LULUCFA. Forest Land2. Land converted to Forest Land*	*CO2*	*1236.12*	*1025.34*	*1.86%*	*0.00272*	*0.7%*	*KC level*	*KC trend*
33	*5B1*	*5. LULUCFB. Cropland1. Cropland remaining Cropland*	*CO2*	*346.67*	*232.92*	*0.42%*	*0.00181*	*0.5%*	*KC level*	*KC trend*
34	*5C2*	*5. LULUCFC. Grassland2. Land converted to Grassland*	*CO2*	*66.41*	*190.66*	*0.35%*	*0.00246*	*0.6%*	*KC level*	*KC trend*
35	*5E2*	*5. LULUCFE. Settlements2. Land converted to Settlements*	*CO2*	*390.23*	*305.59*	*0.56%*	*0.00121*	*0.3%*	*KC level*	*KC trend*
36	6A	6. Waste A. Solid Waste Disposal on Land	CH4	688.16	180.72	0.33%	0.00902	2.3%	-	KC trend
37	6B	6. Waste B. Wastewater Handling	N2O	184.72	211.23	0.38%	0.00071	0.2%	KC level	-
38	6D	6. Waste D. Other	CH4	29.94	105.75	0.19%	0.00149	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.

Tier 1 Key category analysis for the base year 1990, combined with and without LULUCF categories						
		A	B	C	E-L	M
No.	**IPCC Source Categories and fuels if applicable (with 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 IndustriesGaseous Fuels	CO2	242.32	0.42%	KC level
2	1A1	1. Energy A. Fuel Combustion 1. Energy IndustriesLiquid Fuels	CO2	691.39	1.19%	KC level
3	1A1	1. Energy A. Fuel Combustion 1. Energy IndustriesOther Fuels	CO2	1519.73	2.61%	KC level
4	1A2	1. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionGaseous Fuels	CO2	1046.30	1.79%	KC level
5	1A2	1. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionLiquid Fuels	CO2	3684.05	6.32%	KC level
6	1A2	1. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionSolid Fuels	CO2	1220.95	2.09%	KC level
7	1A3a	1. EnergyA. Fuel Combustion 3. Transport; Civil Aviation	CO2	252.55	0.43%	KC level
8	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road TransportationDiesel	CO2	2587.68	4.44%	KC level
9	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	CO2	11335.25	19.43%	KC level
10	1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalGaseous Fuels	CO2	961.96	1.65%	KC level
11	1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalLiquid Fuels	CO2	4614.55	7.91%	KC level
12	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialGaseous Fuels	CO2	1409.10	2.42%	KC level
13	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialLiquid Fuels	CO2	10248.78	17.57%	KC level
14	1A4c	1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/ForestryLiquid Fuels	CO2	547.19	0.94%	KC level
15	1A5	1. Energy A. Fuel Combustion 5. OtherLiquid Fuels	CO2	203.58	0.35%	KC level
16	1B2	1. Energy B. Fugitive Emissions from Fuels2. Oil and Natural Gas	CH4	380.43	0.65%	KC level
17	2A1	2. Industrial Proc.A. Mineral Products; Cement Production-CO2	CO2	2524.77	4.33%	KC level
18	3	3. Solvent and Other Product Use	CO2	359.98	0.62%	KC level
19	4A	4. AgricultureA. Enteric Fermentation	CH4	2635.45	4.52%	KC level
20	4B	4. AgricultureB. Manure Management	CH4	671.61	1.15%	KC level
21	4B	4. AgricultureB. Manure Management	N2O	454.68	0.78%	KC level
22	4D1	4. AgricultureD. Agricultural Soils; Direct Soil Emissions	N2O	1351.47	2.32%	KC level
23	4D3	4. AgricultureD. Agricultural Soils; Indirect Emissions	N2O	822.48	1.41%	KC level
24	*5A1*	*5. LULUCFA. Forest Land1. Forest Land remaining Forest Land*	*CO2*	*3018.12*	*5.17%*	*KC level*
25	*5A2*	*5. LULUCFA. Forest Land2. Land converted to Forest Land*	*CO2*	*1236.12*	*2.12%*	*KC level*
26	*5B1*	*5. LULUCFB. Cropland1. Cropland remaining Cropland*	*CO2*	*346.67*	*0.59%*	*KC level*
27	*5E2*	*5. LULUCFE. Settlements2. Land converted to Settlements*	*CO2*	*390.23*	*0.67%*	*KC level*
28	6A	6. Waste A. Solid Waste Disposal on Land	CH4	688.16	1.18%	KC level

Table 1-9 List of Switzerland’s Tier 2 key categories, combined KCA without and with LULUCF (*in italic*) categories 2011, sorted by category code.

Tier 2 Key category analysis 2011, combined with and without 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 2011 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 Combustion 1. Energy IndustriesOther Fuels	CO2	1519.73	2591.93	1.49%	0.00705	12.6%	KC level	KC trend
2	1A1	1. Energy A. Fuel Combustion 1. Energy IndustriesOther Fuels	N2O	20.85	43.57	0.06%	0.00037	0.7%	-	KC trend
3	1A2	1. Energy A. Fuel Combustion 2. Manufac. Ind. and Constr.Gaseous Fuels	CO2	1046.30	2015.43	0.18%	0.00099	1.8%	KC level	KC trend
4	1A2	1. Energy A. Fuel Combustion 2. Manufac. Ind. and Constr.Other Fuels	CO2	134.15	321.33	0.18%	0.00119	2.1%	KC level	KC trend
5	1A2	1. Energy A. Fuel Combustion 2. Manufac. Ind. and Constr.Solid Fuels	CO2	1220.95	514.65	0.20%	0.00256	4.6%	KC level	KC trend
6	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road Transp.Diesel	CO2	2587.68	6348.51	0.26%	0.00168	3.0%	KC level	KC trend
7	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road Transp.Gasoline	CO2	11335.25	9358.64	0.44%	0.00066	1.2%	KC level	KC trend
8	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road Transp.Gasoline	N2O	137.27	43.85	0.04%	0.00083	1.5%	-	KC trend
9	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road Transp.Gasoline	CH4	101.15	20.95	0.01%	0.00053	0.9%	-	KC trend
10	1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Com./Instit.Gaseous Fuels	CO2	961.96	1312.66	0.12%	0.00039	0.7%	-	KC trend
11	1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Com./Instit.Liquid Fuels	CO2	4614.55	2915.76	0.09%	0.00045	0.8%	-	KC trend
12	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialBiomass	CH4	95.89	29.98	0.03%	0.00074	1.3%	-	KC trend
13	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialGaseous Fuels	CO2	1409.10	2254.45	0.21%	0.00089	1.6%	KC level	KC trend
14	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialLiquid Fuels	CO2	10248.78	6802.19	0.20%	0.00091	1.6%	KC level	KC trend
15	1B2	1. Energy B. Fugitive Emissions from Fuels2. Oil and Natural Gas	CH4	380.43	173.32	0.16%	0.00179	3.2%	KC level	KC trend
16	2A1	2. Industrial Proc.A. Mineral Products; Cement Production-CO2	CO2	2524.77	1903.58	1.38%	0.00369	6.6%	KC level	KC trend
17	2C1	2. Industrial Proc.C. Metal Production; Steel Production	CO2	110.80	185.08	0.14%	0.00062	1.1%	KC level	KC trend
18	2F1	2. Industrial Proc.F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	HFC	0.02	1046.30	0.23%	0.00242	4.3%	KC level	KC trend
19	2F9	2. Industrial Proc.F. Consumption of Halocarbons and SF6; Other	HFC	0.00	64.38	0.09%	0.00099	1.8%	-	KC trend
20	3	3. Solvent and Other Product Use	CO2	359.98	155.28	0.14%	0.00178	3.2%	KC level	KC trend
21	3	3. Solvent and Other Product Use	N2O	110.14	44.15	0.06%	0.00092	1.6%	-	KC trend
22	4A	4. AgricultureA. Enteric Fermentation	CH4	2635.45	2509.11	0.83%	0.00008	0.1%	KC level	-
23	4B	4. AgricultureB. Manure Management	CH4	671.61	649.83	0.64%	0.00017	0.3%	KC level	-
24	4B	4. AgricultureB. Manure Management	N2O	454.68	336.43	0.38%	0.00112	2.0%	KC level	KC trend
25	4D1	4. AgricultureD. Agricultural Soils; Direct Soil Emissions	N2O	1351.47	1163.25	1.61%	0.00164	2.9%	KC level	KC trend
26	4D2	4. AgricultureD. Agricultural Soils; Pasture, Range and Paddock Manure	N2O	128.10	223.57	0.38%	0.00183	3.3%	KC level	KC trend
27	4D3	4. AgricultureD. Agricultural Soils; Indirect Emissions	N2O	822.48	691.74	1.99%	0.00257	4.6%	KC level	KC trend
28	*5A1*	*5. LULUCFA. Forest Land1. Forest Land remaining Forest Land*	*CO2*	*3018.12*	*2961.48*	*1.72%*	*0.00070*	*1.2%*	*KC level*	*KC trend*
29	*5A2*	*5. LULUCFA. Forest Land2. Land converted to Forest Land*	*CO2*	*1236.12*	*1025.34*	*0.71%*	*0.00104*	*1.9%*	*KC level*	*KC trend*
30	*5B1*	*5. LULUCFB. Cropland1. Cropland remaining Cropland*	*CO2*	*346.67*	*232.92*	*0.17%*	*0.00071*	*1.3%*	*KC level*	*KC trend*
31	*5C1*	*5. LULUCFC. Grassland1. Grassland remaining Grassland*	*CO2*	*97.65*	*135.19*	*0.12%*	*0.00042*	*0.7%*	*KC level*	*KC trend*
32	*5C2*	*5. LULUCFC. Grassland2. Land converted to Grassland*	*CO2*	*66.41*	*190.66*	*0.18%*	*0.00125*	*2.2%*	*KC level*	*KC trend*
33	*5E2*	*5. LULUCFE. Settlements2. Land converted to Settlements*	*CO2*	*390.23*	*305.59*	*0.28%*	*0.00062*	*1.1%*	*KC level*	*KC trend*
34	6A	6. Waste A. Solid Waste Disposal on Land	CH4	688.16	180.72	0.19%	0.00526	9.4%	KC level	KC trend
35	6B	6. Waste B. Wastewater Handling	N2O	184.72	211.23	0.19%	0.00036	0.6%	KC level	KC trend
36	6D	6. Waste D. Other	CH4	29.94	105.75	0.19%	0.00150	2.7%	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

Tier 2 Key category analysis 1990, combined with and without LULUCF categories						
	A		B	C	E-L	M
No.	IPCC Source Categories and fuels if applicable (combined with 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 IndustriesOther Fuels	CO2	1519.73	0.82%	KC level
2	1A2	1. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionSolid Fuels	CO2	1220.95	0.44%	KC level
3	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	CO2	11335.25	0.50%	KC level
4	1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	N2O	137.27	0.12%	KC level
5	1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalLiquid Fuels	CO2	4614.55	0.13%	KC level
6	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialBiomass	CH4	95.89	0.10%	KC level
7	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialGaseous Fuels	CO2	1409.10	0.12%	KC level
8	1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialLiquid Fuels	CO2	10248.78	0.29%	KC level
9	1B2	1. Energy B. Fugitive Emissions from Fuels2. Oil and Natural Gas	CH4	380.43	0.33%	KC level
10	2A1	2. Industrial Proc.A. Mineral Products; Cement Production-CO2	CO2	2524.77	1.73%	KC level
11	2F9	2. Industrial Proc.F. Consumption of Halocarbons and SF6; Other	SF6	79.58	0.11%	KC level
12	3	3. Solvent and Other Product Use	CO2	359.98	0.31%	KC level
13	3	3. Solvent and Other Product Use	N2O	110.14	0.15%	KC level
14	4A	4. AgricultureA. Enteric Fermentation	CH4	2635.45	0.82%	KC level
15	4B	4. AgricultureB. Manure Management	CH4	671.61	0.63%	KC level
16	4B	4. AgricultureB. Manure Management	N2O	454.68	0.49%	KC level
17	4D1	4. AgricultureD. Agricultural Soils; Direct Soil Emissions	N2O	1351.47	1.76%	KC level
18	4D2	4. AgricultureD. Agricultural Soils; Pasture, Range and Paddock Manure	N2O	128.10	0.20%	KC level
19	4D3	4. AgricultureD. Agricultural Soils; Indirect Emissions	N2O	822.48	2.23%	KC level
20	*5A1*	*5. LULUCFA. Forest Land1. Forest Land remaining Forest Land*	*CO2*	*3018.12*	*1.66%*	*KC level*
21	*5A2*	*5. LULUCFA. Forest Land2. Land converted to Forest Land*	*CO2*	*1236.12*	*0.81%*	*KC level*
22	*5B1*	*5. LULUCFB. Cropland1. Cropland remaining Cropland*	*CO2*	*346.67*	*0.23%*	*KC level*
23	*5E2*	*5. LULUCFE. Settlements2. Land converted to Settlements*	*CO2*	*390.23*	*0.34%*	*KC level*
24	6A	6. Waste A. Solid Waste Disposal on Land	CH4	688.16	0.69%	KC level
25	6B	6. Waste B. Wastewater Handling	N2O	184.72	0.16%	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 2011.

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 2011 and 1990, sorted by category code.

Overview on key categories without and with LULUCF categories for both Tier 1 and 2, and for both the submission and the base year								
IPCC Source Categories and fuels if applicable (with LULUCF categories)		Direct GHG	2011		1990	2011		1990
			Tier 1	Tier 1	Tier 1	Tier 2	Tier 2	Tier 2
1A1	1. Energy A. Fuel Combustion 1. Energy IndustriesGaseous Fuels	CO2	KC level	KC trend	KC level	-	-	-
1A1	1. Energy A. Fuel Combustion 1. Energy IndustriesLiquid Fuels	CO2	KC level	KC trend	KC level	-	-	-
1A1	1. Energy A. Fuel Combustion 1. Energy IndustriesOther Fuels	CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
1A2	1. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionGaseous Fuels	CO2	KC level	KC trend	KC level	KC level	KC trend	-
1A2	1. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionLiquid Fuels	CO2	KC level	KC trend	KC level	-	-	-
1A2	1. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionOther Fuels	CO2	KC level	KC trend	-	KC level	KC trend	-
1A2	1. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionSolid Fuels	CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
1A3a	1. EnergyA. Fuel Combustion 3. Transport; Civil Aviation	CO2	-	KC trend	KC level	-	-	-
1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road TransportationDiesel	CO2	KC level	KC trend	KC level	KC level	KC trend	-
1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	CH4	-	-	-	-	KC trend	-
1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
1A3b	1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	N2O	-	KC trend	-	-	KC trend	KC level
1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalGaseous Fuels	CO2	KC level	KC trend	KC level	KC level	KC trend	-
1A4a	1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalLiquid Fuels	CO2	KC level	KC trend	KC level	-	KC trend	KC level
1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialBiomass	CH4	-	-	-	-	KC trend	KC level
1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialGaseous Fuels	CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
1A4b	1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialLiquid Fuels	CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
1A4c	1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/ForestryLiquid Fuels	CO2	KC level	-	KC level	-	-	-
1A5	1. Energy A. Fuel Combustion 5. OtherLiquid Fuels	CO2	-	KC trend	KC level	-	-	-
1B2	1. Energy B. Fugitive Emissions from Fuels2. Oil and Natural Gas	CH4	-	KC trend	KC level	KC level	KC trend	KC level
2A1	2. Industrial Proc.A. Mineral Products; Cement Production-CO2	CO2	KC level	KC trend	KC level	KC level	KC trend	KC level
2C1	2. Industrial Proc.C. Metal Production; Steel Production	CO2	KC level	KC trend	-	KC level	KC trend	-
2F1	2. Industrial Proc.F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	HFC	KC level	KC trend	-	KC level	KC trend	-
2F9	2. Industrial Proc.F. Consumption of Halocarbons and SF6; Other	HFC	-	-	-	-	KC trend	-
2F9	2. Industrial Proc.F. Consumption of Halocarbons and SF6; Other	SF6	-	-	-	-	-	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. AgricultureA. Enteric Fermentation	CH4	KC level	-	KC level	KC level	-	KC level
4B	4. AgricultureB. Manure Management	CH4	KC level	-	KC level	KC level	-	KC level
4B	4. AgricultureB. Manure Management	N2O	KC level	KC trend	KC level	KC level	KC trend	KC level
4D1	4. AgricultureD. Agricultural Soils; Direct Soil Emissions	N2O	KC level	KC trend	KC level	KC level	KC trend	KC level
4D2	4. AgricultureD. Agricultural Soils; Pasture, Range and Paddock Manure	N2O	KC level	KC trend	-	KC level	KC trend	KC level
4D3	4. AgricultureD. Agricultural Soils; Indirect Emissions	N2O	KC level	KC trend	KC level	KC level	KC trend	KC level
5A1	5. LULUCFA. Forest Land1. Forest Land remaining Forest Land	*CO2*	*KC level*	*KC trend*	*KC level*	*KC level*	*KC trend*	*KC level*
5A2	5. LULUCFA. Forest Land2. Land converted to Forest Land	*CO2*	*KC level*	*KC trend*	*KC level*	*KC level*	*KC trend*	*KC level*
5B1	5. LULUCFB. Cropland1. Cropland remaining Cropland	*CO2*	*KC level*	*KC trend*	*KC level*	*KC level*	*KC trend*	*KC level*
5C1	5. LULUCFC. Grassland1. Grassland remaining Grassland	*CO2*	-	-	-	*KC level*	*KC trend*	-
5C2	5. LULUCFC. Grassland2. Land converted to Grassland	*CO2*	*KC level*	*KC trend*	-	*KC level*	*KC trend*	-
5E2	5. LULUCFE. Settlements2. Land converted to Settlements	*CO2*	*KC level*	*KC trend*	*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 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, Sfforestation 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) and re-certified in 2010 (SQS, 2010). Certification is upheld since through annual audits by SQS. Annual audits by SQS are part of the recertification procedure.

The major QMS elements are summarized below. The detailed state of its implementation is documented in the Description of the Quality Management System (FOEN 2013a), submitted alongside this report. All activities are embedded in an annual cycle of inventory planning, preparation, and management (see Table 1 in FOEN 2013a).

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 (2013a). 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.

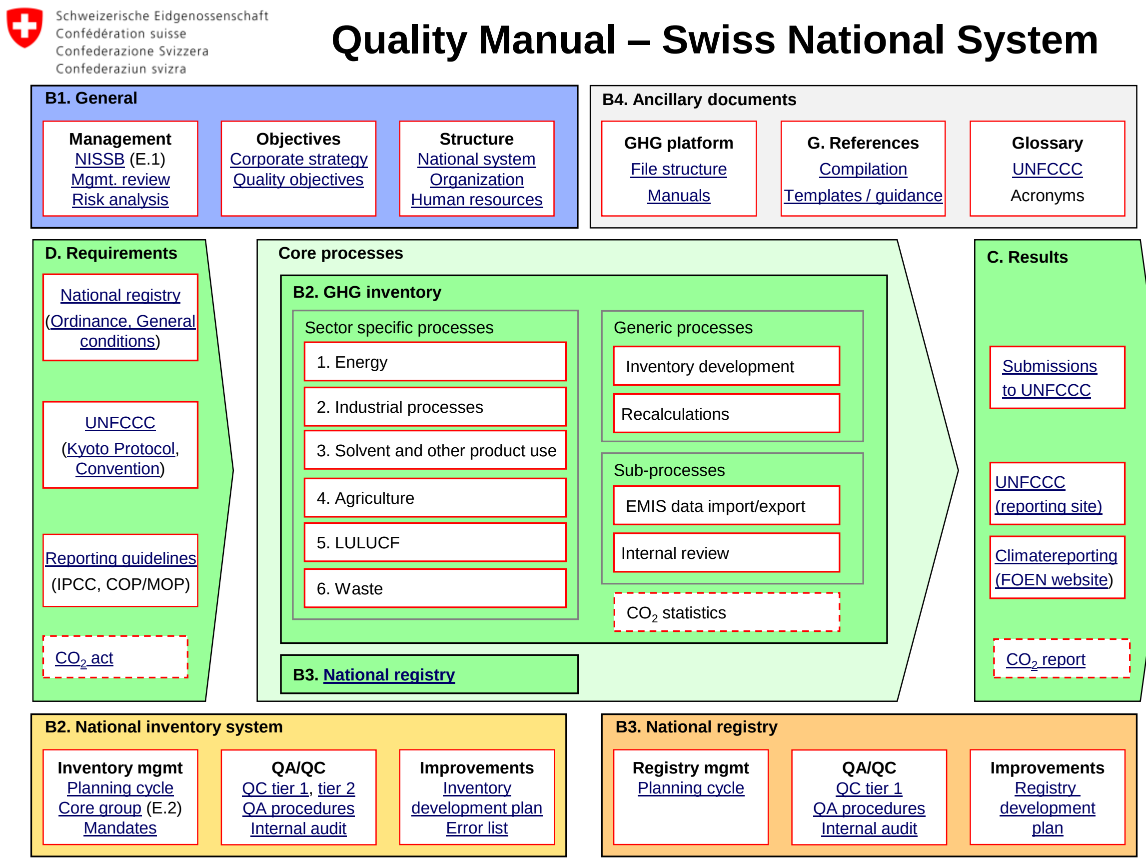

Figure 1-3: Overview of the quality manual of the national inventory system

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 2013a, Annex D for a list of past and current activities). Significant outcomes are fed into the inventory development plan (IDP; FOEN 2013a, 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. The review of the industrial processes sector started in May 2012 and the final review report is due in the first quarter of 2013.

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 Inventory improvements based on recommendations of the ERT

Based on a suggestion made by the review team during the in-country review in 2010, a list of the changes already made in response to questions or recommendations of the ERT is inserted below. However, the draft of the latest review was not available until 8 April 2013 and could thus not be considered. Several issues raised by the ERT 2012 have been addressed and are labelled with ERT2012.The first column refers to the year the review took place and the paragraph in the corresponding review report, if available. 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 FOEN 2013a).

Table 1-12 Improvements due to questions or recommendations of the Expert Review Team.

ARR: Year (para.)	**Recommendation**	**Improvement – NIR chapter**	**IDP**
	General		
2010 (31) 2011 (20) 2011 (23)	Documentation of recalculations	Recalculations have been described in more detail (see e.g. 3.2.7.5 Source-specific recalculations for recalculations in sector 1A2). The inventory compiler provides a list to all authors, where relevant information is available.	2
2011 (18)	Updated uncertainties where AD or EF changed	Uncertainties have been reassessed whenever AD or EF changed (e.g. LULUCF, section 7.2.5).	3
	Energy	l	
2008 (11)	Reassess uncertainty estimate of energy statistics	The uncertainty estimates of the energy statistics have been discussed with the Swiss Federal Office of Energy and all uncertainties were reassessed.	1
2011 (35)	Provide more information regarding country-specific methods.	For a couple of key categories, background data sheets have been translated into English and were made available to reviewers (e.g. waste incineration plants, solid waste disposal sites, waste water, cement (energy), ethene production).	2
2011 (36), ERT2012	Provide information on EF that change over time or that deviate from IPCC default	For example: The N_2O EF for gasoline continuously decreases over time as listed in Table 3-31 and Annex 3.1.5 of the NIR. There is a discontinuity of the EF SF_6 in sector 2F8 as described in NIR section 4.7.2.8.	4, 15

2011 (42)	Discrepancy for jet kerosene in CRF 1.C and 1.A(b)	The difference was caused by intermediate rounding for one of the two tables.This has been eliminated.	8
2011 (52, 53), ERT2012	Provide information regarding EF for refining/ storage of oil and flaring of oil.	This issue has been addressed in the Saturday Paper of last year's submission and has been included in the Section 3.3.2.2. on Fugitive emissions (1.B.2)	6, 16, 17, 18
2011 (47) ERT2012	Improve description of waste flows	The waste flows are described in the Waste Section in Figure 8-4 in chapter 8.1.2.	9
ERT2012	Include N2O emissions from road transportation, gaseous fuels	N_2O emissions from road transportation, gaseous fuels are now included in the reporting. For further detail please see chapter 3.2.8.	14
	Industrial processes		
2011 (59) ERT2012	Information regarding EF for blasting operation in cement production	More detailed information on blasting operation in cement production has been given in section 4.2.2.1.	1
2010 (67) 2011 (60/61)	Justification of assumptions made for bricks and tiles	We are in contact with the Swiss association of brick and tile industry. In the course of the implementation of the revised CO_2-act in 2013, further information on the carbon content of the raw materials used will become available for the years 2011 and 2012 and will be reported in submission 2014.	3
2011 (64)	Reassess data for N_2O use in anaesthesia	Emissions of N_2O have been updated for this year's submission (see section 5.5.5).	4
2006 (58) ERT2012	Country specific carbon content of NMVOC	The indirect CO_2 emissions due to decomposition of NMVOC in the atmosphere are declining substantially since 1990. Due to the wide range of applications of NMVOCs (more than 50 processes), efforts to collect country-specific carbon content of NMVOC emissions would be very large and the potential benefit in terms of reduced uncertainty might actually be marginal. Therefore, the GHG inventory core group decided not to give priority to this area of the inventory but to invest the available resources elsewhere.	7
ERT2012	Emissions of cement kiln dust	Detailed information on the CDK situation in Switzerland has been given in section 4.2.2.1 to justify the use of a correction factor of 1.	12
ERT2012	Lime production: Include information regarding autoproducer	Information on the situation of autoproduction of lime in Switzerland has been given in section 4.2.2.2.	13
ERT2012	Inter-annual variability in emissions from glass production	See detailed information in section 4.2.2.7.	14
	Agriculture		
2010 (81) 2011 (77)	Reassessment of GEI for mules and asses	A new assessment has been carried out based on Meyer and Coenen (2002) elaborated at the Research Station ALP-Haras (Stricker 2012).See section 6.2.5.	5
2011 (79)	Histosol area used for calculation of direct N_2O emissions	The area of cultivated organic soils has been revised. The new estimate is based on the area of cultivated organic soils under Cropland and Grassland in the LULUCF sector as reported in CRF table 5.B and 5.C (see also chapter 6.5.5).	6
2011 (80)	Provide relevant	$Frac_{GASF}$ and $Frac_{GASM}$ are calculated retrospectively in the	7

	information regarding $Frac_{GASF}$ and $Frac_{GASM}$	model. A detailed explanation is given in Chapter 6.5.2, in section "Direct emissions from soil (4D1)". The recalculation of $Frac_{GASM}$ is described in Chapter 6.5.5. Additionally a comment has been made in the documentation box of CRF table 4.Ds1.	
ERT2011	Manure use for biogas production: Coordination with sector 6D	This issue will be addressed in Submission 2014. Consultations with the involved stakeholders have started (compare Chapter 6.3.6).	8
	LULUCF		
2006 (92) 2010 (121)	Improve method or use the appropriate BEF values.	Switzerland changed the calculation of gains and losses to a single tree basis (see Chapter 7.3.4.4 and Thürig and Herold 2013).	1, 2
2008 (78) 2010 (93,99,122,123) 2011 (89, 122)	Improve estimate of carbon stocks and their changes in soils.	Both Nussbaum et al. (2012) and Didion et al. (2012) have been implemented. Improvements with regard to estimates of cabon stocks and their changes in mineral soils as well as the methodological approach are decribed in Chapters 7.3.4.8 and 7.3.4.9.	4
2011 (92)	Temporal variation of emissions in 5.D wetlands	Those small fluctuations arise from the evolution of land-use changes (including land-use changes between CC41 and CC42) and are the result of the algorithms presented in Chapter 7.1.3.2.	10
	Waste		
2010 (110) 2011 (98/105) ERT2012	Provide AD for wastewater in CRF 6.B. Improve description of waste water treatment.	Activity data used for emission calculations in 6B correspond to the number of connected inhabitants (see chapter 8.3.2). The degradable organic content provided in CRF is only given as additional information. Description of waste water treatment has been improved in last year's submission (see 8.3.1. 2nd section) giving an overview of current infrastructure and the different steps involved. The error in the calculation of the CH_4 emission factor for biogas upgrade has been corrected in the current submission.	2
2011 (102)	Methane recovery from SWDS	Recovered methan reported in CRF is either flared or used as a fuel in motors and is thus reported under 1A1a. Table 8-7 now gives an overview of all emissions.	3
	KP		
2011 (90) 2011 (89, 90, 111, 118, 121)	Harmonize reporting methods Emissions from organic soils	The reporting methodology has been harmonized (see Chapter 11.3.1.1). A detailed description and an overview table shows the methodology used for activities reported under Art. 3.3 and Art. 3.4. Carbon stock changes under FM on mineral soils were estimated by Yasso07. For land-use changes like Afforestation and Deforestation, the differences in carbon stocks were considered (see chapter 7.1.3.2). Changes in litter on Afforestations are not considered a source. An explantion is given in Chapter 11.3.1.2. Emissions from organic soils due to drainage are reported using the IPCC default emission factor (see chapter 7.3.4.9 and 11.3.1.1).	13

2011 (113)	Changes in litter under FM and biomass burning	Temporal changes in C stocks of litter are estimated by the model Yasso07 as described in Chapter 7.3.4.8. Emissions from litter due to wildfires are accounted for by encompassing litter stocks in the “available fuel” for combustion (see Chapter 7.3.4.12).	3
2011 (115)	Document the relationship between areas reported under LULUCF 5.A and those under KP-activities	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). A table (Table 11-5) transparently showing the relationship has been added in Chapter 11.2.3.	13
2011 (116)	Description of uncertainty estimate of “naturally regenerating forest”	The description of the uncertainties under the KP was extended with regard to lands under FM due to natural regeneration (see Chapter 11.3.1.5.	11
2011 (120)	Provide transparent information about “permanence” with respect to Deforestation	The description of land classification under the KP was extended (see Chapters 11.1.3, 11.2.3 and 11.4.2). The permance issue was investigated in a study by Sigmaplan (2012a) and is briefly described in Chapter 11.4.2.	12

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 (EMIS 2013/ (NFR-Code); FOEN 2006c).

Information on the QMS, all QA/QC activities performed, decisions reached by the experts (minutes), results of key category analyses and uncertainty analyses as well as inventory development (IDP) is documented and archived in the FOEN IDM system and accessible to authorised collaborators via the GHG 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 2011 are compared with the results 2010 within the current CRF
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012.
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

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 subcategories 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 refer to a single enterprise are 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

The uncertainty analysis Tier 1 of the April 2012 submission (FOEN 2012) has been updated for the present submission. A Tier 2 analysis (Monte Carlo simulation) has not been updated, since Tier 2 analysis are only carried out every two years. The last update was carried out for the submission 2012. In this chapter, the main results of the quantitative uncertainty evaluation Tier 1 are presented. Further information, especially about the Tier 2 analysis of the last submission in 2012, is found in Annex 7.

Uncertainties are assessed in accordance with the IPCC Good Practice Guidance

- Tier 1 methodology (IPCC 2000: p. 6.13ff.)

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

For a number of non-key categories, no precise quantitative uncertainties are available. For those categories, a semi-quantitative assessment has been carried out. Based on results of the 2nd International Workshop on Uncertainty in Greenhouse Gas Inventories (Vienna 27-28 September 2007) a list of overall uncertainties has been defined (see Table 1-13).

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

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).

1.7.1.2 Data Used

For many 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.

Distributions are assumed to be symmetric for the Tier 1 method. For the Monte Carlo simulation of the previous submission in April 2012 (Annex 7.2), asymmetric distributions like e.g. lognormal or triangle were also adopted.

Uncertainties in the GWP values were not taken into account.

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 Uncertainty Estimates

For categories with no quantitative uncertainty data available, the NIR provides qualitative estimates of uncertainties. The terms high, medium and low data quality is used. In order to extend the quantitative uncertainty analysis to every category, the default values as presented in Table 1-13 are used. They 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 1-13 Semi-quantitative uncertainties (2 σ) for non-key categories.

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

1.7.1.4 Results of Tier 1 Uncertainty Evaluation

With this submission, results of a new 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 results of the Tier 1 uncertainty analysis for GHG emissions 2011 are summarised in Table 1-15. Details of the uncertainty estimates for specific sources are provided in the sub-sections on "Uncertainties and Time-Series Consistency" in each of the chapters on source categories below.

The resulting **Tier 1 level uncertainty in the national total annual CO_2 equivalent emissions without LULUCF is estimated to be 3.55%. Tier 1 trend uncertainty is 1.89%** meaning that the change of the base year (1990) to 2011, reported as -5.6%, lies with a probability of 95% between -7.5% and -3.7%.

Compared to the results of the previous inventory 2010 (level 3.84%, trend 2.00%; FOEN 2012), the level and the trend uncertainties for 2011 for the emissions without the LULUCF sector are slightly lower. This is based on lower emission factor uncertainties.

The resulting Tier 1 **total inventory uncertainty** in the national total annual CO_2 equivalent emissions **including LULUCF** sector is estimated to be 4.79% (level uncertainty). Trend uncertainty is 1.99%.

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 (cf. Column H, Table 1-14), indirect and direct emissions of N_2O from Agricultural Soils, CO_2 from 1A Fuel Combustion Activities (Other fuels) and CO_2 from 2A1 Industrial Processes are the top four contributors. This permits the identification of future areas of improvement in the context of the Inventory Development Plan (IDP).

Table 1-14 Ranked combined level uncertainties for sources in Switzerland.

IPCC GPG Table 6.1
Tier 1 Uncertainty Calculation and Reporting

A	B	C	D	E	F	G	H
IPCC Source category	Gas	Base year emissions 1990	Year 2011 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	%	%	%	%
4D34. AgricultureD. Agricultural Soils; Indirect Emissions	N2O	822.48	691.74	20.6	156.72	158.1	2.346
4D14. AgricultureD. Agricultural Soils; Direct Soil Emissions	N2O	1'351.47	1'163.25	10.5	75.38	76.1	1.900
1A11. Energy A. Fuel Combustion 1. Energy IndustriesOther Fuels	CO2	1'519.73	2'591.93	10.0	30.00	31.6	1.759
2A12. Industrial Proc.A. Mineral Products; Cement Production-CO2	CO2	2'524.77	1'903.58	2.0	40.00	40.0	1.636
4A4. AgricultureA. Enteric Fermentation	CH4	2'635.45	2'509.11	6.4	17.05	18.2	0.981
4B4. AgricultureB. Manure Management	CH4	671.61	649.83	6.4	53.95	54.3	0.758
1A3b1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	CO2	11'335.25	9'358.64	2.2	1.36	2.6	0.518
4B4. AgricultureB. Manure Management	N2O	454.68	336.43	28.6	55.83	62.7	0.453
4D24. AgricultureD. Agricultural Soils; Pasture, Range and Paddock Manure	N2O	128.10	223.57	68.1	62.50	92.4	0.443
5E25. LULUCFE. Settlements2. Land converted to Settlements	CO2	390.23	305.59	11.0	50.00	51.2	0.336
1A3b1. EnergyA. Fuel Combustion 3. Transport; Road TransportationDiesel	CO2	2'587.68	6'348.51	2.2	0.47	2.2	0.305
2F12. Industrial Proc.F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	HFC	0.02	1'046.30	8.5	8.49	12.0	0.269
1A4b1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialGaseous Fuels	CO2	1'409.10	2'254.45	2.0	4.60	5.0	0.243
1A4b1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialLiquid Fuels	CO2	10'248.78	6'802.19	1.6	0.53	1.6	0.240
1A21. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionSolid Fuels	CO2	1'220.95	514.65	20.3	5.00	20.9	0.231
6D6. Waste D. Other	CH4	29.94	105.75	10.0	100.00	100.5	0.228
6B6. Waste B. Wastewater Handling	N2O	184.72	211.23	1.3	50.00	50.0	0.227
6A6. Waste A. Solid Waste Disposal on Land	CH4	688.16	180.72	30.0	50.00	58.3	0.226
1A21. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionOther Fuels	CO2	134.15	321.33	10.0	30.00	31.6	0.218
1A21. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionGaseous Fuels	CO2	1'046.30	2'015.43	2.0	4.60	5.0	0.217
5C25. LULUCFC. Grassland2. Land converted to Grassland	CO2	66.41	190.66	8.0	50.00	50.6	0.207
1B21. Energy B. Fugitive Emissions from Fuels2. Oil and Natural Gas	CH4	380.43	173.32	35.4	35.36	50.0	0.186
3 3. Solvent and Other Product Use	CO2	359.98	155.28	35.4	35.36	50.0	0.167
2C12. Industrial Proc.C. Metal Production; Steel Production	CO2	110.80	185.08	5.0	40.00	40.3	0.160
5C15. LULUCFC. Grassland1. Grassland remaining Grassland	CO2	97.65	135.19	6.0	50.00	50.4	0.146
1A4a1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalGaseous Fuels	CO2	961.96	1'312.66	2.0	4.60	5.0	0.141
2F92. Industrial Proc.F. Consumption of Halocarbons and SF6; Other	SF6	79.58	81.31	56.6	56.57	80.0	0.140
5F25. LULUCFF. Other Land2. Land converted to Other Land	CO2	95.63	113.35	6.0	50.00	50.4	0.122
2F92. Industrial Proc.F. Consumption of Halocarbons and SF6; Other	HFC	0.00	64.38	56.6	56.57	80.0	0.111
1A4a1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/InstitutionalLiquid Fuels	CO2	4'614.55	2'915.76	1.6	0.53	1.6	0.103
1A21. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionLiquid Fuels	CO2	3'684.05	2'484.54	1.6	0.53	1.6	0.088
3 3. Solvent and Other Product Use	N2O	110.14	44.15	56.6	56.57	80.0	0.076
1A11. Energy A. Fuel Combustion 1. Energy IndustriesOther Fuels	N2O	20.85	43.57	10.0	79.37	80.0	0.075
2A32. Industrial Proc.A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2	CO2	103.37	66.87	10.0	50.00	51.0	0.073
1A11. Energy A. Fuel Combustion 1. Energy IndustriesBiomass	N2O	27.72	42.43	21.2	77.14	80.0	0.073
4D44. AgricultureD. Agricultural Soils; Use of sewage sludge as fertilizers	N2O	28.30	29.61	8.1	80.00	80.4	0.051
2B2. Industrial Proc.B. Chemical Industry	N2O	68.13	54.13	29.0	28.99	41.0	0.048
1A11. Energy A. Fuel Combustion 1. Energy IndustriesGaseous Fuels	CO2	242.32	442.34	2.0	4.60	5.0	0.048
1A3b1. EnergyA. Fuel Combustion 3. Transport; Road TransportationGasoline	N2O	137.27	43.85	2.2	50.00	50.0	0.047
6D6. Waste D. Other	N2O	5.82	23.96	56.6	56.57	80.0	0.041
1A4b1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialBiomass	CH4	95.89	29.98	21.2	60.00	63.6	0.041
5E15. LULUCFE. Settlements1. Settlements remaining Settlements	CO2	0.91	32.22	11.0	50.00	51.2	0.035
5D25. LULUCFD. Wetlands2. Land converted to Wetlands	CO2	21.54	29.74	8.0	50.00	50.6	0.032
1A11. Energy A. Fuel Combustion 1. Energy IndustriesLiquid Fuels	CO2	691.39	868.79	1.6	0.53	1.6	0.031
1A4b1. Energy A. Fuel Combustion 4. Other Sectors; ResidentialLiquid Fuels	N2O	25.94	17.25	1.6	79.98	80.0	0.030
6C6. Waste C. Waste Incineration	N2O	20.10	30.26	28.3	28.28	40.0	0.026
1A3b1. EnergyA. Fuel Combustion 3. Transport; Road TransportationDiesel	N2O	5.84	53.24	2.2	22.00	22.1	0.025
2B2. Industrial Proc.B. Chemical Industry	CO2	109.80	110.55	7.1	7.07	10.0	0.024
1A21. Energy A. Fuel Combustion 2. Manufacturing Industries and ConstructionLiquid Fuels	N2O	14.61	11.75	1.6	79.98	80.0	0.020

Table 1-15 Tier 1 uncertainty results for sources in Switzerland 2011 (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 2011 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		**49'817.38**	**46'598.74**				**4.79**					**1.99**
Emissions without LULUCF												
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Biomass	CH4	0.31	0.28	21.2	21.21	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	CH4	0.56	1.01	2.0	29.93	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	0.65	1.6	29.96	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	20.3	22.12	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	1.49	21.2	21.21	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 Gaseous Fuels	CH4	2.65	4.64	2.0	29.93	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	0.98	1.6	29.96	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	0.00	0.00	10.0	28.28	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 Solid Fuels	CH4	0.40	0.16	20.3	22.12	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3a 1. Energy A. Fuel Combustion 3. Transport; Civil Aviation	CH4	0.24	0.26	42.4	42.43	60.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Biomass	CH4	0.00	0.02	21.2	56.12	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	CH4	1.36	0.62	2.2	20.00	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	101.15	20.95	2.2	37.00	37.1	0.017	-0.0015	0.0004	-0.05	0.00	0.05
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Natural Gas	CH4	0.00	0.05	3.5	29.79	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	CH4	0.01	0.01	1.6	29.96	30.0	0.000	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	29.92	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	0.51	2.2	29.92	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3e 1. Energy A. Fuel Combustion 3. Transport; Other non-specified	CH4	0.06	0.04	35.4	35.36	50.0	0.000	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	3.72	21.2	21.21	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	CH4	2.40	3.53	2.0	29.93	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	1.35	1.6	29.96	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	95.89	29.98	21.2	60.00	63.6	0.041	-0.0012	0.0006	-0.07	0.02	0.07
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Gaseous Fuels	CH4	3.26	5.32	2.0	29.93	30.0	0.003	0.0000	0.0001	0.00	0.00	0.00
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Liquid Fuels	CH4	6.00	2.09	1.6	29.96	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	20.3	22.12	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	0.14	21.2	21.21	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	CH4	0.09	0.04	2.0	29.93	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	1.36	1.6	29.96	30.0	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	0.11	1.6	29.96	30.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1B2 1. Energy B. Fugitive Emissions 2. Oil and Natural Gas	CH4	380.43	173.32	35.4	35.36	50.0	0.186	-0.0037	0.0035	-0.13	0.17	0.22
2B 1. Industria B. Chemical Industry	CH4	9.63	8.61	21.2	21.21	30.0	0.006	0.0000	0.0002	0.00	0.01	0.01
4A 4. Agricultu A. Enteric Fermentation	CH4	2'635.45	2'509.11	6.4	17.05	18.2	0.981	0.0009	0.0504	0.02	0.46	0.46
4B 4. Agricultu B. Manure Management	CH4	671.61	649.83	6.4	53.95	54.3	0.758	0.0004	0.0130	0.02	0.12	0.12
4F 4. Agricultu F. Field Burning of Agricultural Residues	CH4	0.00	0.00	30.0	51.96	60.0	0.000	0.0000	0.0000	0.00	0.00	0.00
6A 6. Waste A. Solid Waste Disposal on Land	CH4	688.16	180.72	30.0	50.00	58.3	0.226	-0.0093	0.0036	-0.46	0.15	0.49
6B 6. Waste B. Wastewater Handling	CH4	4.65	10.02	21.2	21.21	30.0	0.006	0.0001	0.0002	0.00	0.01	0.01
6C 6. Waste C. Waste Incineration	CH4	14.25	12.71	42.4	42.43	60.0	0.016	0.0000	0.0003	0.00	0.02	0.02
6D 6. Waste D. Other	CH4	29.94	105.75	10.0	100.00	100.5	0.228	0.0016	0.0021	0.16	0.03	0.16
7 7. Other	CH4	0.55	0.58	21.2	21.21	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	242.32	442.34	2.0	4.60	5.0	0.048	0.0043	0.0089	0.02	0.03	0.03
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Liquid Fuels	CO2	691.39	868.79	1.6	0.53	1.6	0.031	0.0045	0.0174	0.00	0.04	0.04
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Other Fuels	CO2	1'519.73	2'591.93	10.0	30.00	31.6	1.759	0.0235	0.0520	0.70	0.74	1.02
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Solid Fuels	CO2	45.47	0.00	20.3	5.00	20.9	0.000	-0.0009	0.0000	0.00	0.00	0.00
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Gaseous Fuels	CO2	1'046.30	2'015.43	2.0	4.60	5.0	0.217	0.0208	0.0405	0.10	0.11	0.15
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Liquid Fuels	CO2	3'684.05	2'484.54	1.6	0.53	1.6	0.088	-0.0193	0.0499	-0.01	0.11	0.11
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Other Fuels	CO2	134.15	321.33	10.0	30.00	31.6	0.218	0.0039	0.0065	0.12	0.09	0.15
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Solid Fuels	CO2	1'220.95	514.65	20.3	5.00	20.9	0.231	-0.0126	0.0103	-0.06	0.30	0.30
1A3a 1. Energy A. Fuel Combustion 3. Transport; Civil Aviation	CO2	252.55	132.35	2.2	1.16	2.5	0.007	-0.0021	0.0027	0.00	0.01	0.01
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Diesel	CO2	2'587.68	6'348.51	2.2	0.47	2.2	0.305	0.0788	0.1274	0.04	0.39	0.40
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Gasoline	CO2	11'335.25	9'358.64	2.2	1.36	2.6	0.518	-0.0249	0.1879	-0.03	0.58	0.58
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Natural Gas	CO2	0.00	39.60	3.5	3.55	5.0	0.004	0.0008	0.0008	0.00	0.00	0.00
1A3c 1. Energy A. Fuel Combustion 3. Transport; Railways	CO2	28.69	38.12	2.2	0.53	2.3	0.002	0.0002	0.0008	0.00	0.00	0.00
1A3d 1. Energy A. Fuel Combustion 3. Transport; Navigation	CO2	111.88	117.52	2.2	0.53	2.3	0.006	0.0003	0.0024	0.00	0.01	0.01
1A3e 1. Energy A. Fuel Combustion 3. Transport; Other non-specified	CO2	30.80	46.20	2.2	4.49	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	961.96	1'312.66	2.0	4.60	5.0	0.141	0.0083	0.0263	0.04	0.07	0.08
1A4a 1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institut Liquid Fuels	CO2	4'614.55	2'915.76	1.6	0.53	1.6	0.103	-0.0281	0.0585	-0.01	0.13	0.13
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Gaseous Fuels	CO2	1'409.10	2'254.45	2.0	4.60	5.0	0.243	0.0188	0.0453	0.09	0.13	0.15
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Liquid Fuels	CO2	10'248.78	6'802.19	1.6	0.53	1.6	0.240	-0.0558	0.1365	-0.03	0.30	0.30
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Solid Fuels	CO2	55.36	34.07	20.3	5.00	20.9	0.015	-0.0004	0.0007	0.00	0.02	0.02
1A4c 1. Energy A. Fuel Combustion 4. Other Sectors; Agriculture/Forestry Gaseous Fuels	CO2	40.64	19.10	2.0	4.60	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	547.19	526.38	1.6	0.53	1.6	0.019	0.0003	0.0106	0.00	0.02	0.02
1A5 1. Energy A. Fuel Combustion 5. Other Liquid Fuels	CO2	203.58	106.92	1.6	0.53	1.6	0.004	-0.0017	0.0021	0.00	0.00	0.00
1B2 1. Energy B. Fugitive Emissions 2. Oil and Natural Gas	CO2	91.36	52.22	7.1	7.07	10.0	0.011	-0.0007	0.0010	0.00	0.01	0.01
2A1 2. Industria A. Mineral Products; Cement Production-CO2	CO2	2'524.77	1'903.58	2.0	40.00	40.0	1.636	-0.0092	0.0382	-0.37	0.11	0.38
2A2 2. Industria A. Mineral Products; Lime Production-CO2	CO2	53.35	56.31	1.4	1.41	2.0	0.002	0.0001	0.0011	0.00	0.00	0.00
2A3 2. Industria A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2	CO2	103.37	66.87	10.0	50.00	51.0	0.073	-0.0006	0.0013	-0.03	0.02	0.04
2A7 2. Industria A. Mineral Products; Other non-specified-CO2	CO2	15.30	6.59	1.4	1.41	2.0	0.000	-0.0002	0.0001	0.00	0.00	0.00
2B 2. Industria B. Chemical Industry	CO2	109.80	110.55	7.1	7.07	10.0	0.024	0.0002	0.0022	0.00	0.02	0.02
2C1 2. Industria C. Metal Production; Steel Production	CO2	110.80	185.08	5.0	40.00	40.3	0.160	0.0016	0.0037	0.07	0.03	0.07
2C3 2. Industria C. Metal Production; Aluminium Production-CO2	CO2	139.26	0.00	7.1	7.07	10.0	0.000	-0.0026	0.0000	-0.02	0.00	0.02
2C5 2. Industria C. Metal Production; Non-ferrous metals-CO2	CO2	1.65	1.55	7.1	7.07	10.0	0.000	0.0000	0.0000	0.00	0.00	0.00
2G 2. Industria G. Other	CO2	1.04	1.15	7.1	7.07	10.0	0.000	0.0000	0.0000	0.00	0.00	0.00
3 3. Solvent a	CO2	359.98	155.28	35.4	35.36	50.0	0.167	-0.0036	0.0031	-0.13	0.16	0.20
6A 6. Waste A. Solid Waste Disposal on Land	CO2	9.24	0.00	7.1	7.07	10.0	0.000	-0.0002	0.0000	0.00	0.00	0.00
6C 6. Waste C. Waste Incineration	CO2	54.10	12.34	28.3	28.28	40.0	0.011	-0.0008	0.0002	-0.02	0.01	0.02
6D 6. Waste D. Other	CO2	0.00	0.00	7.1	7.07	10.0	0.000	0.0000	0.0000	0.00	0.00	0.00
7 7. Other	CO2	10.96	13.03	28.3	28.28	40.0	0.011	0.0001	0.0003	0.00	0.01	0.01
2F1 2. Industria F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	HFC	0.02	1'046.30	8.5	8.49	12.0	0.269	0.0210	0.0210	0.18	0.25	0.31
2F2 2. Industria F. Consumption of Halocarbons and SF6; Hard Foam	HFC	0.00	13.43	34.6	34.65	49.0	0.014	0.0003	0.0003	0.01	0.01	0.02

Table 1-15 continued. Tier 1 uncertainty results for sources in Switzerland 2011 (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 2011 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		**49'817.38**	**46'598.74**				**4.79**					**1.99**
Emissions without LULUCF												
2F4 2. Industria F. Consumption of Halocarbons and SF6; Metered Dose Inhalers and Other	HFC	0.00	16.94	7.8	7.78	11.0	0.004	0.0003	0.0003	0.00	0.00	0.00
2F5 2. Industria F. Consumption of Halocarbons and SF6; Solvents	HFC	0.00	2.73	1.4	1.41	2.0	0.000	0.0001	0.0001	0.00	0.00	0.00
2F9 2. Industria F. Consumption of Halocarbons and SF6; Other	HFC	0.00	64.38	56.6	56.57	80.0	0.111	0.0013	0.0013	0.07	0.10	0.13
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Biomass	N2O	27.72	42.43	21.2	77.14	80.0	0.073	0.0003	0.0009	0.03	0.03	0.04
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Gaseous Fuels	N2O	0.14	0.25	2.0	79.97	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	3.06	1.6	79.98	80.0	0.005	0.0000	0.0001	0.00	0.00	0.00
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Other Fuels	N2O	20.85	43.57	10.0	79.37	80.0	0.075	0.0005	0.0009	0.04	0.01	0.04
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Solid Fuels	N2O	0.24	0.00	20.3	77.39	80.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Biomass	N2O	1.68	6.39	21.2	77.14	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 Gaseous Fuels	N2O	0.58	1.13	2.0	79.97	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	14.61	11.75	1.6	79.98	80.0	0.020	0.0000	0.0002	0.00	0.00	0.00
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Other Fuels	N2O	2.28	5.81	10.0	79.37	80.0	0.010	0.0001	0.0001	0.01	0.00	0.01
1A2 1. Energy A. Fuel Combustion 2. Manufacturing Industries and Cons Solid Fuels	N2O	6.44	2.70	20.3	77.39	80.0	0.005	-0.0001	0.0001	-0.01	0.00	0.01
1A3a 1. Energy A. Fuel Combustion 3. Transport; Civil Aviation	N2O	2.49	1.30	106.1	106.07	150.0	0.004	0.0000	0.0000	0.00	0.00	0.00
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Biomass	N2O	0.00	0.35	21.2	148.49	150.0	0.001	0.0000	0.0000	0.00	0.00	0.00
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Diesel	N2O	5.84	53.24	2.2	22.00	22.1	0.025	0.0010	0.0011	0.02	0.00	0.02
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Gasoline	N2O	137.27	43.85	2.2	50.00	50.0	0.047	-0.0017	0.0009	-0.08	0.00	0.08
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Transportation Natural Gas	N2O	0.00	1.87	3.5	79.92	80.0	0.003	0.0000	0.0000	0.00	0.00	0.00
1A3c 1. Energy A. Fuel Combustion 3. Transport; Railways Liquid Fuels	N2O	0.38	0.49	1.6	149.99	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	N2O	0.66	0.79	2.2	149.98	150.0	0.003	0.0000	0.0000	0.00	0.00	0.00
1A3d 1. Energy A. Fuel Combustion 3. Transport; Navigation Gasoline	N2O	0.60	0.53	2.2	149.98	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	N2O	0.02	0.03	56.6	56.57	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 Biomass	N2O	1.45	2.83	21.2	77.14	80.0	0.005	0.0000	0.0001	0.00	0.00	0.00
1A4a 1. Energy A. Fuel Combustion 4. Other Sectors; Commercial/Institut Gaseous Fuels	N2O	0.54	0.74	2.0	79.97	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	11.72	7.48	1.6	79.98	80.0	0.013	-0.0001	0.0002	-0.01	0.00	0.01
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Biomass	N2O	10.64	8.14	21.2	77.14	80.0	0.014	0.0000	0.0002	0.00	0.00	0.01
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Gaseous Fuels	N2O	0.79	1.27	2.0	79.97	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	17.25	1.6	79.98	80.0	0.030	-0.0001	0.0003	-0.01	0.00	0.01
1A4b 1. Energy A. Fuel Combustion 4. Other Sectors; Residential Solid Fuels	N2O	0.29	0.18	20.3	77.39	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 Biomass	N2O	0.21	0.29	21.2	77.14	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 Gaseous Fuels	N2O	0.02	0.01	2.0	79.97	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	4.97	5.30	1.6	79.98	80.0	0.009	0.0000	0.0001	0.00	0.00	0.00
1A5 1. Energy A. Fuel Combustion 5. Other Liquid Fuels	N2O	2.01	1.06	1.6	149.99	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	N2O	0.62	0.87	56.6	56.57	80.0	0.001	0.0000	0.0000	0.00	0.00	0.00
2B 2. Industria B. Chemical Industry	N2O	68.13	54.13	29.0	28.99	41.0	0.048	-0.0002	0.0011	-0.01	0.04	0.04
3 3. Solvent a	N2O	110.14	44.15	56.6	56.57	80.0	0.076	-0.0012	0.0009	-0.07	0.07	0.10
4B 4. Agricultu B. Manure Management	N2O	454.68	336.43	28.6	55.83	62.7	0.453	-0.0018	0.0068	-0.10	0.27	0.29
4D1 4. Agricultu D. Agricultural Soils; Direct Soil Emissions	N2O	1'351.47	1'163.25	10.5	75.38	76.1	1.900	-0.0020	0.0234	-0.15	0.35	0.38
4D2 4. Agricultu D. Agricultural Soils; Pasture, Range and Paddock Manure	N2O	128.10	223.57	68.1	62.50	92.4	0.443	0.0021	0.0045	0.13	0.43	0.45
4D3 4. Agricultu D. Agricultural Soils; Indirect Emissions	N2O	822.48	691.74	20.6	156.72	158.1	2.346	-0.0016	0.0139	-0.24	0.40	0.47
4D4 4. Agricultu D. Agricultural Soils; Use of sewage sludge as fertilizers	N2O	28.30	29.61	8.1	80.00	80.4	0.051	0.0001	0.0006	0.01	0.01	0.01
6B 6. Waste B. Wastewater Handling	N2O	184.72	211.23	1.3	50.00	50.0	0.227	0.0008	0.0042	0.04	0.01	0.04
6C 6. Waste C. Waste Incineration	N2O	20.10	30.26	28.3	28.28	40.0	0.026	0.0002	0.0006	0.01	0.02	0.03
6D 6. Waste D. Other	N2O	5.82	23.96	56.6	56.57	80.0	0.041	0.0004	0.0005	0.02	0.04	0.04
7 7. Other	N2O	0.62	0.62	56.6	56.57	80.0	0.001	0.0000	0.0000	0.00	0.00	0.00
2C3 2. Industria C. Metal Production; Aluminium Production-PFC	PFC	100.17	0.00	13.0	13.01	18.4	0.000	-0.0019	0.0000	-0.02	0.00	0.02
2F1 2. Industria F. Consumption of Halocarbons and SF6; Refrigeration	PFC	0.04	6.58	8.5	8.49	12.0	0.002	0.0001	0.0001	0.00	0.00	0.00
2F5 2. Industria F. Consumption of Halocarbons and SF6; Solvents	PFC	0.00	6.26	1.4	1.41	2.0	0.000	0.0001	0.0001	0.00	0.00	0.00
2F7 2. Industria F. Consumption of Halocarbons and SF6; Semiconductor Manufacture	PFC	0.00	8.23	28.3	28.28	40.0	0.007	0.0002	0.0002	0.00	0.01	0.01
2F9 2. Industria F. Consumption of Halocarbons and SF6; Other	PFC	0.00	18.30	28.3	28.28	40.0	0.016	0.0004	0.0004	0.01	0.01	0.02
2C 2. Industria C. Metal Production; Aluminium Foundries	SF6	0.00	0.00	14.1	14.14	20.0	0.000	0.0000	0.0000	0.00	0.00	0.00
2C 2. Industria C. Metal Production; Magnesium Foundries	SF6	0.00	30.28	14.1	14.14	20.0	0.013	0.0006	0.0006	0.01	0.01	0.01
2F7 2. Industria F. Consumption of Halocarbons and SF6; Semiconductor Manufacture	SF6	0.00	9.23	28.3	28.28	40.0	0.008	0.0002	0.0002	0.01	0.01	0.01
2F8 2. Industria F. Consumption of Halocarbons and SF6; Electrical Eq.	SF6	64.04	43.55	7.1	7.07	10.0	0.009	-0.0003	0.0009	0.00	0.01	0.01
2F9 2. Industria F. Consumption of Halocarbons and SF6; Other	SF6	79.58	81.31	56.6	56.57	80.0	0.140	0.0001	0.0016	0.01	0.13	0.13
LULUCF												
5A1 5. LULUCF A. Forest Land 1. Forest Land remaining Forest Lanc	CH4	8.19	1.24	10.0	70.00	70.7	0.002	-0.0001	0.0000	-0.01	0.00	0.01
5A1 5. LULUCF A. Forest Land 1. Forest Land remaining Forest Lanc Biomass Burning, V	CO2	25.36	3.84	10.0	70.00	70.7	0.006	-0.0004	0.0001	-0.03	0.00	0.03
5A1 5. LULUCF A. Forest Land 1. Forest Land remaining Forest Lanc	CO2	-3'018.12	-2'961.48	2.0	32.00	32.1	-2.038	-0.0028	-0.0594	-0.09	-0.17	0.19
5A2 5. LULUCF A. Forest Land 2. Land converted to Forest Land	CO2	-1'236.12	-1'025.34	21.0	32.00	38.3	-0.842	0.0026	-0.0206	0.08	-0.61	0.62
5B1 5. LULUCF B. Cropland 1. Cropland remaining Cropland	CO2	346.67	-232.92	30.0	25.00	39.1	-0.195	-0.0112	-0.0047	-0.28	-0.20	0.34
5B2 5. LULUCF B. Cropland 2. Land converted to Cropland	CO2	38.65	-6.76	13.0	50.00	51.7	-0.007	-0.0009	-0.0001	-0.04	0.00	0.04
5C1 5. LULUCF C. Grassland 1. Grassland remaining Grassland	CO2	97.65	135.19	6.0	50.00	50.4	0.146	0.0009	0.0027	0.04	0.02	0.05
5C2 5. LULUCF C. Grassland 2. Land converted to Grassland	CO2	66.41	190.66	8.0	50.00	50.6	0.207	0.0026	0.0038	0.13	0.04	0.14
5D1 5. LULUCF D. Wetlands 1. Wetlands remaining Wetlands	CO2	-3.00	-0.65	30.0	100.00	104.4	-0.001	0.0000	0.0000	0.00	0.00	0.00
5E1 5. LULUCF E. Settlements 1. Settlements remaining Settlements	CO2	0.91	32.22	11.0	50.00	51.2	0.035	0.0006	0.0006	0.03	0.01	0.03
5E2 5. LULUCF E. Settlements 2. Land converted to Settlements	CO2	390.23	305.59	11.0	50.00	51.2	0.336	-0.0012	0.0061	-0.06	0.10	0.11
5D2 5. LULUCF D. Wetlands 2. Land converted to Wetlands	CO2	21.54	29.74	8.0	50.00	50.6	0.032	0.0002	0.0006	0.01	0.01	0.01
5F2 5. LULUCF F. Other Land 2. Land converted to Other Land	CO2	95.63	113.35	6.0	50.00	50.4	0.122	0.0005	0.0023	0.02	0.02	0.03
5A1 5. LULUCF A. Forest Land 1. Forest Land remaining Forest Lanc	N2O	4.77	0.71	10.0	70.00	70.7	0.001	-0.0001	0.0000	-0.01	0.00	0.01
5B2 5. LULUCF B. Cropland 2. Land converted to Cropland	N2O	5.58	3.66	13.0	90.00	90.9	0.007	0.0000	0.0001	0.00	0.00	0.00

Table 1-15 continued. Tier 1 uncertainty results for sources in Switzerland 2011 (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 Indı Gaseous Fuels	CO2	M	D		Section 3.2.6
1A1	1. Energy A. Fuel Comb 1. Energy Indı Liquid Fuels	CO2	M	R		Section 3.2.6
1A1	1. Energy A. Fuel Comb 1. Energy Indı 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 Sect Gaseous Fuels	CO2	M	D		Section 3.2.9
1A4a	1. Energy A. Fuel Comb 4. Other Sect Liquid Fuels	CO2	M	R		Section 3.2.9
1A4b	1. Energy A. Fuel Comb 4. Other Sect Gaseous Fuels	CO2	M	D		Section 3.2.9
1A4b	1. Energy A. Fuel Comb 4. Other Sect Liquid Fuels	CO2	M	R		Section 3.2.9
1A4b	1. Energy A. Fuel Comb 4. Other Sect Biomass	CO2	M	R		Section 3.2.9
1A4c	1. Energy A. Fuel Comb 4. Other Sect Liquid Fuels	CO2	M	R		Section 3.2.9
1A5	1. Energy A. Fuel Comb 5. Other Liquid and Gased	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 Pad	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.

1.7.1.5 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 2011 (i.e. the current submission) the Monte Carlo simulation has not been updated. This will be done for the next submission in 2014.

The main results of the Monte Carlo simulation for the **previously submitted in 2012 (inventory 2010)** were

- The total level uncertainty of the 2010 Swiss emissions is 3.97% of the total GHG emissions excluding LULUCF. The 95% confidence interval is almost symmetric and lies between 96.2% and 104.2% of the total GHG emissions.
- The trend uncertainty of the 2.24% increase of total emissions excluding LULUCF between 1990 and 2010 is 3.2%. With a probability of 95%, the change lies within the range of -1.19% to +5.27%

Assumptions and further results are shown in Annex 7.2-7.5

1.7.1.6 Comparison of Tier 1 and Tier 2 Results

Since no Tier 2 analysis was carried out for the GHG inventory 2011, there is no comparison for the numbers 2011 available. Note that a comparison was carried out for the GHG inventory 2010. The results of the comparison are described in Annex A7.3.

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 gives an overview of Switzerland's GHG emissions/removals and trends for the period 1990–2011. 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 2011 (UNFCCC)

In 2011, Switzerland emitted 50'010 Gg CO_2 equivalent (excluding LULUCFand international bunkers) to the atmosphere or 6.32 tonnes CO_2 equivalent per capita (inhabitants 2011: 7.91 million, SFSO 2012a). The largest contributor gas was CO_2, 41'856 Gg (5.29 tonnes per capita), and the most important source was sector 1 Energy, 39'864 Gg CO_2 equivalent. 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 2011.

Emissions 2011	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**Total**	**Share**
	CO_2 equivalent (Gg)							
1 Energy	39'344	255	265				39'864	79.7%
2 Industrial Processes	2'332	9	54	1'144	39	164	3'742	7.5%
3 Solvent an Other Product Use	155	0	44				199	0.4%
4 Agriculture	0	3'159	2'445				5'604	11.2%
6 Waste	12	309	265				587	1.2%
7 Other	13	1	1				14	0.0%
Total (excluding LULUCF)	41'856	3'732	3'074	1'144	39	164	50'010	100.0%
5 LULUCF	-3'417	1	4				-3'411	-6.8%
Total (including LULUCF)	38'439	3'734	3'078	1'144	39	164	46'599	93.2%
International Aviation Bunkers	4'689	1	46				*4'737*	
International Marine Bunkers	30.74	0.01	0.30				*31.05*	

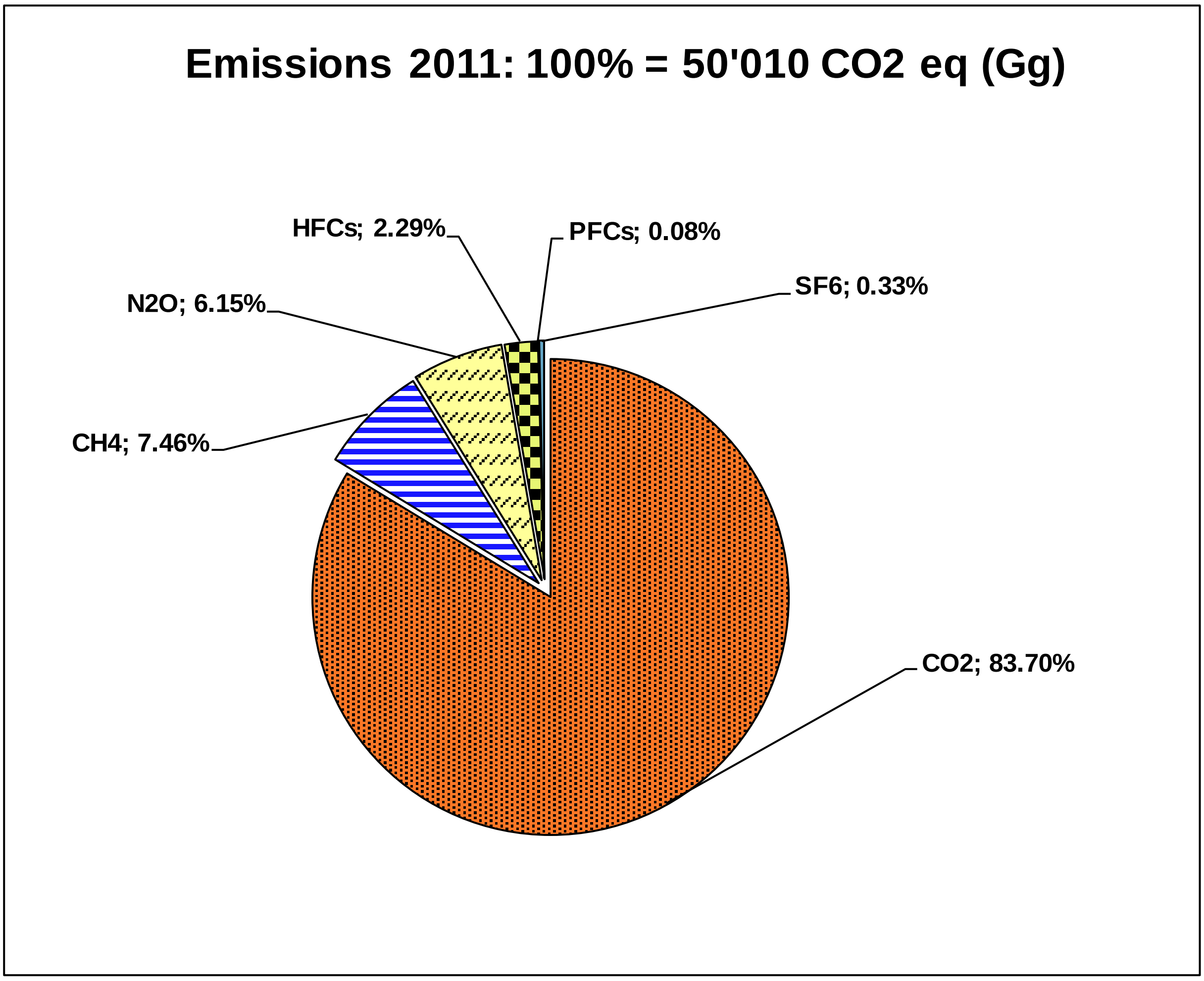

Figure 2-1 Contribution of individual gases to Switzerland's GHG emissions (excluding LULUCF) in 2011. 100% correspond to 50'010 CO_2 eq (Gg). (Numbers may not add to total due to rounding.)

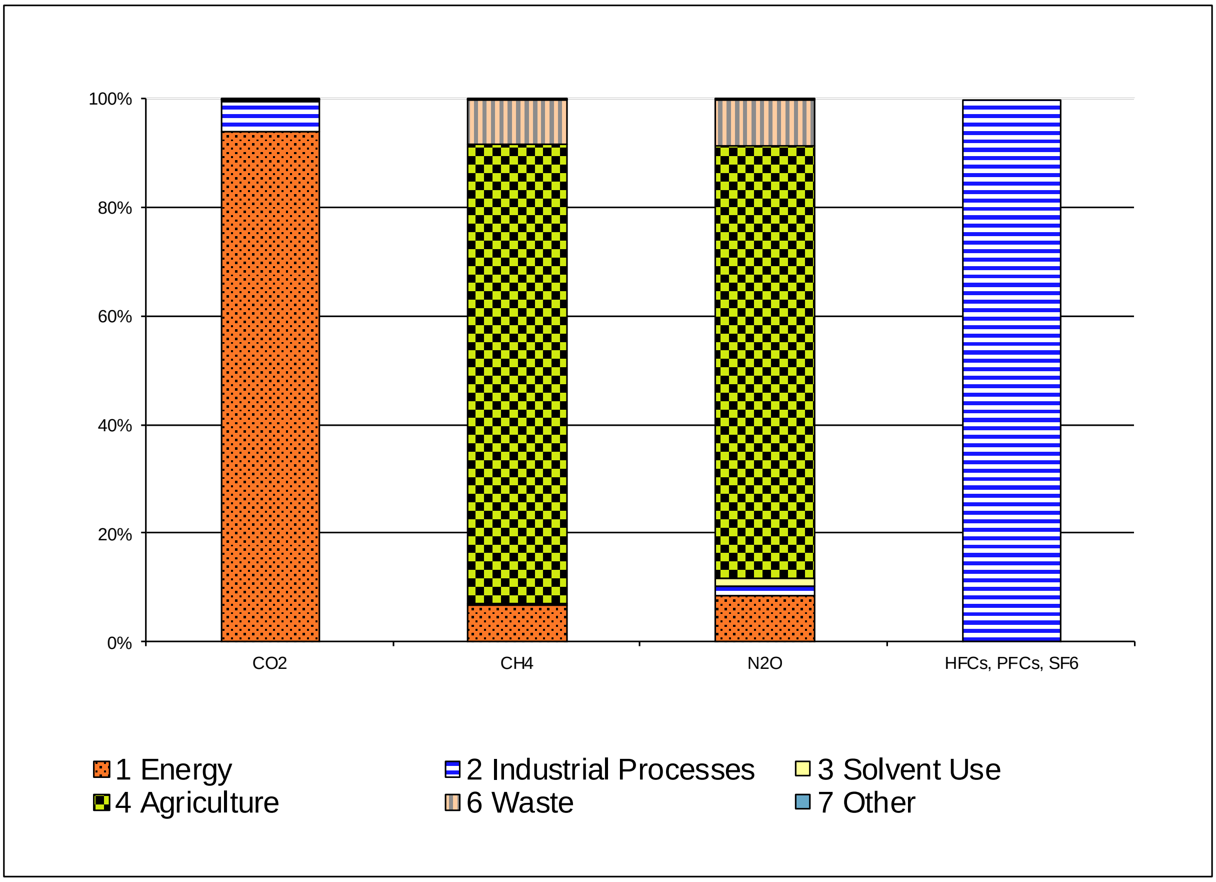

Figure 2-2 Relative contributions of the individual sectors (excluding LULUCF) to GHG emissions in 2011.

Fuel combustion within the energy sector was by far the largest source of emissions of CO_2 in 2011. 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 1990–2011 are summarized in Table 2-2.

Table 2-2 Switzerland's GHG emissions in CO_2 equivalent (Gg) by gas; 1990–2011 (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 2011 as compared to the base year 1990. HFCs increased by 5'076'959% 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	41'423	43'026	43'185	39'427	39'810	39'682	39'403	37'945	39'528	41'288
CO_2 emissions excluding net CO_2 from LULUCF	44'597	46'320	46'214	43'673	42'935	43'584	44'236	43'421	44'723	44'841
CH_4 emissions including CH_4 from LULUCF	4'682	4'646	4'510	4'375	4'284	4'271	4'195	4'098	4'044	3'983
CH_4 emissions excluding CH_4 from LULUCF	4'674	4'645	4'510	4'375	4'281	4'267	4'193	4'086	4'043	3'983
N_2O emissions including N_2O from LULUCF	3'468	3'466	3'443	3'364	3'324	3'330	3'333	3'227	3'217	3'188
N_2O emissions excluding N_2O from LULUCF	3'458	3'460	3'438	3'359	3'317	3'323	3'327	3'215	3'210	3'183
HFCs	0	0	6	14	33	179	224	296	351	412
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)	**49'817**	**51'369**	**51'363**	**47'336**	**47'581**	**47'574**	**47'267**	**45'716**	**47'323**	**49'054**
Total (excluding LULUCF)	**52'973**	**54'656**	**54'386**	**51'577**	**50'696**	**51'466**	**52'092**	**51'169**	**52'510**	**52'602**

Greenhouse Gas Emissions	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	CO2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	42'689	45'109	43'511	42'013	41'058	42'057	42'997	41'137	43'827	42'141
CO_2 emissions excluding net CO_2 from LULUCF	43'921	44'873	43'829	45'009	45'634	46'259	45'894	43'927	45'448	44'239
CH_4 emissions including CH_4 from LULUCF	3'915	3'929	3'878	3'785	3'764	3'770	3'781	3'780	3'843	3'787
CH_4 emissions excluding CH_4 from LULUCF	3'914	3'929	3'875	3'781	3'764	3'770	3'780	3'778	3'843	3'786
N_2O emissions including N_2O from LULUCF	3'188	3'216	3'198	3'143	3'092	3'075	3'074	3'095	3'114	3'068
N_2O emissions excluding N_2O from LULUCF	3'183	3'211	3'192	3'137	3'088	3'070	3'069	3'090	3'110	3'064
HFCs	491	584	624	695	802	882	905	938	999	1'039
PFCs	69	45	40	57	53	33	32	29	39	35
SF_6	158	157	168	174	190	213	201	186	245	187
Total (including LULUCF)	**50'510**	**53'040**	**51'420**	**49'868**	**48'959**	**50'030**	**50'989**	**49'164**	**52'067**	**50'257**
Total (excluding LULUCF)	**51'737**	**52'799**	**51'728**	**52'852**	**53'530**	**54'227**	**53'881**	**51'948**	**53'683**	**52'350**

Greenhouse Gas Emissions	**2010**	**2011**	Change baseyear to 2011 (%)
	CO2 eq. (Gg)		
CO_2 emissions including net CO_2 from LULUCF	43'494	38'439	*-7.2%*
CO_2 emissions excluding net CO_2 from LULUCF	45'903	41'856	*-6.1%*
CH_4 emissions including CH_4 from LULUCF	3'766	3'734	*-20.3%*
CH_4 emissions excluding CH_4 from LULUCF	3'766	3'732	*-20.2%*
N_2O emissions including N_2O from LULUCF	3'137	3'078	*-11.2%*
N_2O emissions excluding N_2O from LULUCF	3'133	3'074	*-11.1%*
HFCs	1'094	1'144	*see caption*
PFCs	37	39	*-60.7%*
SF_6	155	164	*14.4%*
Total (including LULUCF)	**51'683**	**46'599**	***-6.5%***
Total (excluding LULUCF)	**54'088**	**50'010**	***-5.6%***

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 94.4% in 2011 and a maximum of 103.2% in 1991 (100%: value of base year 1990). In 2011, the total emissions were therefore 5.6% lower than the emissions recorded in the base year 1990. CO_2 contributed the largest share of emissions, accounting for 83.7% of the total in 2011.
- Total emissions (including LULUCF) in 2011 show a decrease of 6.5% 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 1990-2011, 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 2011 but simultaneously an increase of the net CO_2 sink in comparison to 2010.
- A comparison of CO_2 emissions with the number of heating degree days (definition is shown in footnote 2 on page 74) in the period 1990–2011 (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.
- Between 1990 and 2011, CH_4 decreased by 20.2%, 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 8.8% in 1990 to 7.5% in 2011.
- 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 dropped by 11.1% between 1990 and 2011 and accounts now for a share of 6.1%.
- HFC emissions increased significantly due to their application as substitutes for CFCs, while PFC emissions declined by -60.8%. SF_6 emissions have shown relatively large fluctuations between 94 and 245 Gg CO_2 eq since 1990. In 2011, SF_6 emissions increased by 14.6% compared to 1990. The share of all F-gases combined rose from 0.5% in 1990 to 2.7% in 2011.

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	44'597	84.2%	43'584	84.7%	43'921	84.9%	46'259	85.3%
CH_4	4'674	8.8%	4'267	8.3%	3'914	7.6%	3'770	7.0%
N_2O	3'458	6.5%	3'323	6.5%	3'183	6.2%	3'070	5.7%
HFCs	0	0.0%	179	0.3%	491	0.9%	882	1.6%
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)	**52'973**	**100%**	**51'466**	**100%**	**51'737**	**100%**	**54'227**	**100%**

Greenhouse Gas Emissions	2008		2009		2010		2011	
(excluding LULUCF)	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
CO2	45'448	84.7%	44'239	84.5%	45'903	84.9%	41'856	83.7%
CH4	3'843	7.2%	3'786	7.2%	3'766	7.0%	3'732	7.5%
N2O	3'110	5.8%	3'064	5.9%	3'133	5.8%	3'074	6.1%
HFCs	999	1.9%	1'039	2.0%	1'094	2.0%	1'144	2.3%
PFCs	39	0.1%	35	0.1%	37	0.1%	39	0.1%
SF6	245	0.5%	187	0.4%	155	0.3%	164	0.3%
Total (excluding LULUCF)	**53'683**	**100%**	**52'350**	**100%**	**54'088**	**100%**	**50'010**	**100%**

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

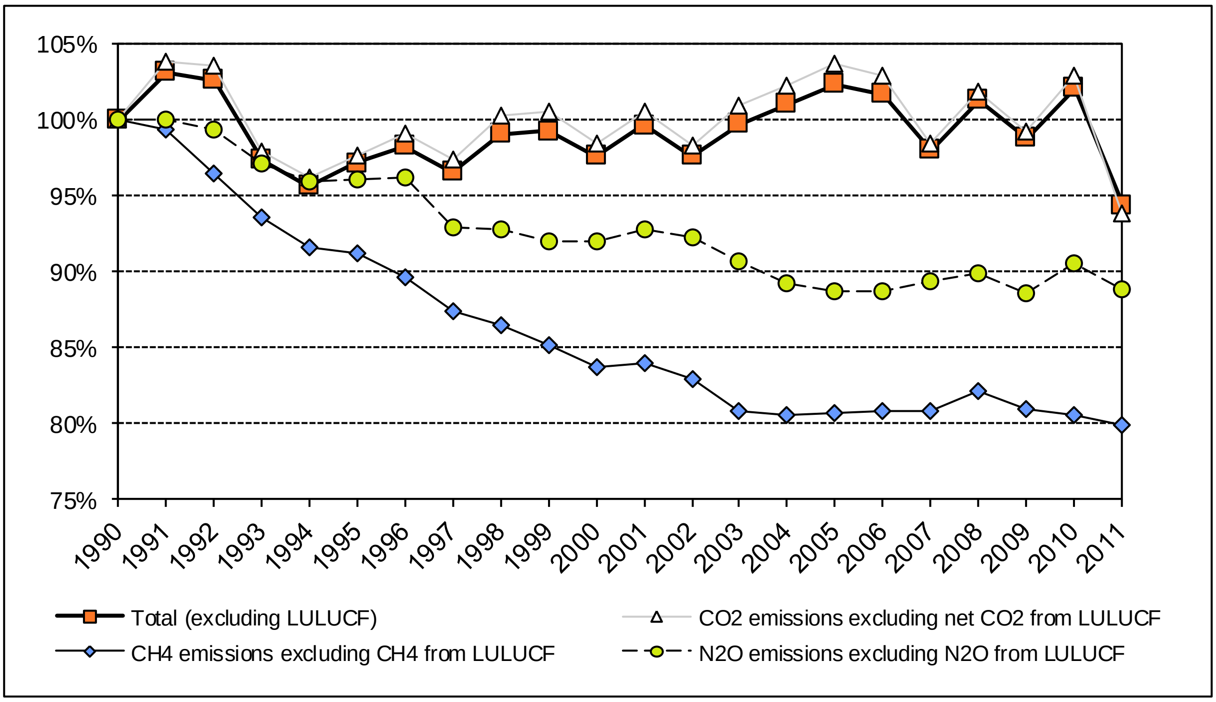

Figure 2-3 Relative trend of Switzerland's GHG emissions excluding LULUCF by gas, 1990–2011 (base year 1990: 100%). The increase of the F-gases is not shown (553% in 2011, compared to 1990).

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, 1990–2011. The column below on the far right (digits in italics) indicates the percentage change in emissions in 2011 as compared to the base year 1990.

Source and Sink Categories	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
1. Energy	42'007	44'099	44'126	41'814	40'920	41'774	42'612	41'959	43'274	43'370
1A1 Energy Industries	2'551	2'818	2'908	2'563	2'600	2'637	2'853	2'818	3'144	3'182
1A2 Manufacturing Industries and Construction	6'119	6'300	5'955	5'870	5'870	6'063	5'839	5'735	5'917	5'902
1A3 Transport	14'598	15'092	15'417	14'351	14'539	14'228	14'293	14'850	15'061	15'669
1A4 Other Sectors	18'061	19'233	19'234	18'459	17'368	18'349	19'157	18'095	18'699	18'181
1A5 Other (Military)	206	188	180	171	166	148	137	147	146	132
1B Fugitive emissions from oil and natural gas	472	468	432	400	377	349	333	315	305	304
2. Industrial Processes	3'381	3'023	2'868	2'563	2'724	2'653	2'527	2'464	2'558	2'661
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	5'808	5'819	5'780	5'606	5'578	5'511
6. Waste	1'011	1'008	980	918	857	852	828	819	800	773
7. Other	12	12	13	13	13	13	13	13	14	14
Total (excluding LULUCF)	52'973	54'656	54'386	51'577	50'696	51'466	52'092	51'169	52'510	52'602
5. Land Use, Land-Use Change and Forestry	-3'156	-3'287	-3'023	-4'241	-3'115	-3'891	-4'825	-5'453	-5'187	-3'548
Total (including LULUCF)	49'817	51'369	51'363	47'336	47'581	47'574	47'267	45'716	47'323	49'054

Source and Sink Categories	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	CO_2 equivalent (Gg)									
1. Energy	42'290	43'221	42'197	43'397	43'828	44'345	44'010	42'008	43'552	42'430
1A1 Energy Industries	3'093	3'223	3'314	3'347	3'667	3'852	4'128	3'879	4'061	3'976
1A2 Manufacturing Industries and Construction	5'788	6'074	5'813	5'948	6'066	6'118	6'256	6'090	6'096	5'719
1A3 Transport	15'901	15'601	15'526	15'693	15'769	15'829	15'952	16'284	16'662	16'473
1A4 Other Sectors	17'089	17'899	17'141	18'044	17'971	18'187	17'307	15'407	16'385	15'914
1A5 Other (Military)	136	134	140	125	114	124	127	120	115	116
1B Fugitive emissions from oil and natural gas	284	291	263	240	242	236	239	229	235	231
2. Industrial Processes	2'930	3'034	3'032	3'079	3'347	3'520	3'496	3'519	3'640	3'505
3. Solvent and Other Product Use	259	245	233	224	211	211	205	204	201	200
4. Agriculture	5'496	5'561	5'536	5'461	5'447	5'474	5'494	5'556	5'648	5'593
6. Waste	748	723	716	677	682	663	662	646	626	608
7. Other	14	14	14	14	14	14	14	14	14	14
Total (excluding LULUCF)	51'737	52'799	51'728	52'852	53'530	54'227	53'881	51'948	53'683	52'350
5. Land Use, Land-Use Change and Forestry	-1'227	241	-308	-2'985	-4'572	-4'197	-2'892	-2'784	-1'616	-2'093
Total (including LULUCF)	50'510	53'040	51'420	49'868	48'959	50'030	50'989	49'164	52'067	50'257

Source and Sink Categories	**2010**	**2011**	2011/1990
	CO_2 eq	CO_2 eq	%
1. Energy	43'908	39'864	-5.1%
1A1 Energy Industries	4'197	3'994	56.5%
1A2 Manufacturing Industries and Construction	5'873	5'371	-12.2%
1A3 Transport	16'380	16'206	11.0%
1A4 Other Sectors	17'110	13'958	-22.7%
1A5 Other (Military)	121	108	-47.5%
1B Fugitive emissions from oil and natural gas	227	226	-52.1%
2. Industrial Processes	3'723	3'742	10.7%
3. Solvent and Other Product Use	198	199	-57.6%
4. Agriculture	5'647	5'604	-8.0%
6. Waste	597	587	-41.9%
7. Other	14	14	17.2%
Total (excluding LULUCF)	54'088	50'010	-5.6%
5. Land Use, Land-Use Change and Forestry	-2'405	-3'411	8.1%
Total (including LULUCF)	51'683	46'599	-6.5%

The percentage shares of source categories are shown for selected years in Table 2-5. Figure 2-4 through 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	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1. Energy	42'007	79.3%	41'774	81.2%	42'290	81.7%	44'345	81.8%
1A1 Energy Industries	*2'551*	*4.8%*	2'637	*5.1%*	3'093	*6.0%*	3'852	*7.1%*
1A2 Manufacturing Industries and Construction	*6'119*	*11.6%*	6'063	*11.8%*	5'788	*11.2%*	6'118	*11.3%*
1A3 Transport	*14'598*	*27.6%*	14'228	*27.6%*	15'901	*30.7%*	15'829	*29.2%*
1A4 Other Sectors	*18'061*	*34.1%*	18'349	*35.7%*	17'089	*33.0%*	18'187	*33.5%*
1A5 Other (Military)	*206*	*0.4%*	148	*0.3%*	136	*0.3%*	124	*0.2%*
1B Fugitive emissions from oil and natural gas	*472*	*0.9%*	349	*0.7%*	284	*0.5%*	236	*0.4%*
2. Industrial Processes	3'381	6.4%	2'653	5.2%	2'930	5.7%	3'520	6.5%
3. Solvent and Other Product Use	470	0.9%	354	0.7%	259	0.5%	211	0.4%
4. Agriculture	6'092	11.5%	5'819	11.3%	5'496	10.6%	5'474	10.1%
6. Waste	1'011	1.9%	852	1.7%	748	1.4%	663	1.2%
7. Other	12	0.0%	13	0.0%	14	0.0%	14	0.0%
Total (excluding LULUCF)	52'973	100.0%	51'466	100.0%	51'737	100.0%	54'227	100.0%

Source and Sink Categories	2008		2009		2010		2011	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1. Energy	43'552	81.1%	42'430	81.0%	43'908	81.2%	39864	79.7%
1A1 Energy Industries	4'061	*7.6%*	3'976	*7.6%*	4'197	*7.8%*	3994	8.0%
1A2 Manufacturing Industries and Construction	6'096	*11.4%*	5'719	*10.9%*	5'873	*10.9%*	5371	10.7%
1A3 Transport	16'662	*31.0%*	16'473	*31.5%*	16'380	*30.3%*	16206	32.4%
1A4 Other Sectors	16'385	*30.5%*	15'914	*30.4%*	17'110	*31.6%*	13958	27.9%
1A5 Other (Military)	115	*0.2%*	116	*0.2%*	121	*0.2%*	108	0.2%
1B Fugitive emissions from oil and natural gas	235	*0.4%*	231	*0.4%*	227	*0.4%*	226	0.5%
2. Industrial Processes	3'640	6.8%	3'505	6.7%	3'723	6.9%	3742	7.5%
3. Solvent and Other Product Use	201	0.4%	200	0.4%	198	0.4%	199	0.4%
4. Agriculture	5'648	10.5%	5'593	10.7%	5'647	10.4%	5604	11.2%
6. Waste	626	1.2%	608	1.2%	597	1.1%	587	1.2%
7. Other	14	0.0%	14	0.0%	14	0.0%	14	0.0%
Total (excluding LULUCF)	53'683	100.0%	52'350	100.0%	54'088	100.0%	50'010	100.0%

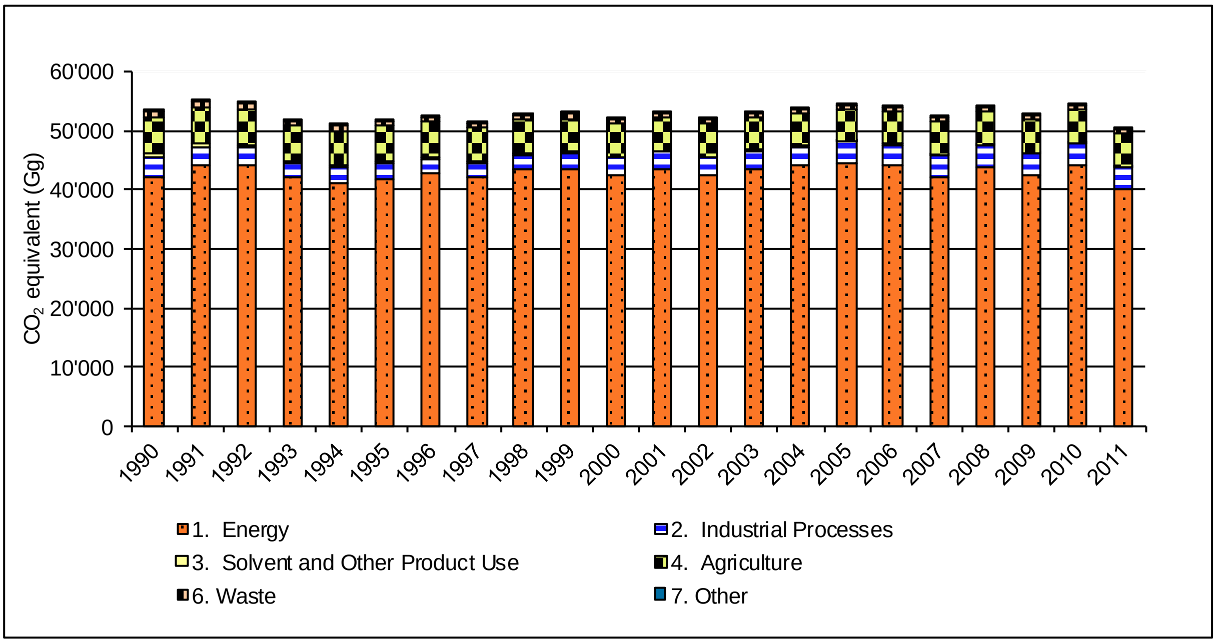

Figure 2-4 Switzerland's GHG emissions in CO_2 equivalent (Gg) by sectors, 1990–2011 (excluding LULUCF).

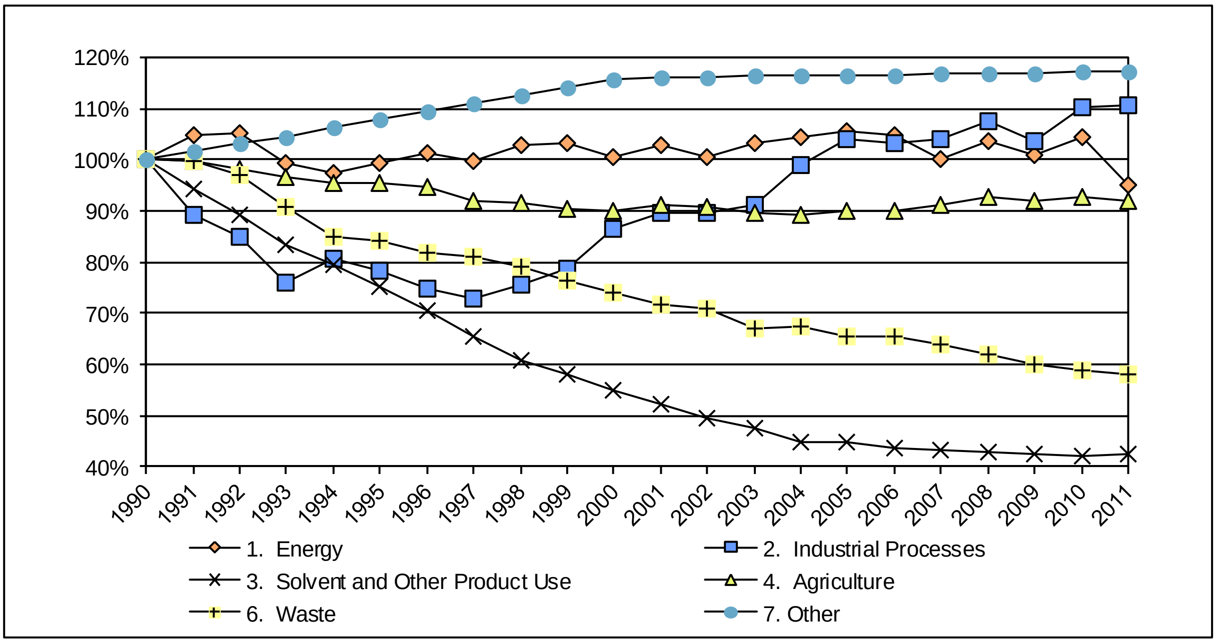

Figure 2-5 Relative emission (CO_2 eq.) trends by main source categories (base year 1990 = 100%).

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 constant rebound between 1998 and 2011, 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 71.8% 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 remained relatively stable.
- 6 Waste: Total emissions from the source category Waste decreased steadily throughout the period 1990-2003. Since 2000, emissions have been further reduced further by a change in legislation: disposal of combustible municipal solid 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, 4D and 6 have *increased* since 1990 by 31.6 % (see Figure 8-3 in Chapter 8).
- 7 Other: The total emissions from sector 7 Other increased troughout the period 1990-2000. Since 2000 the emission 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.

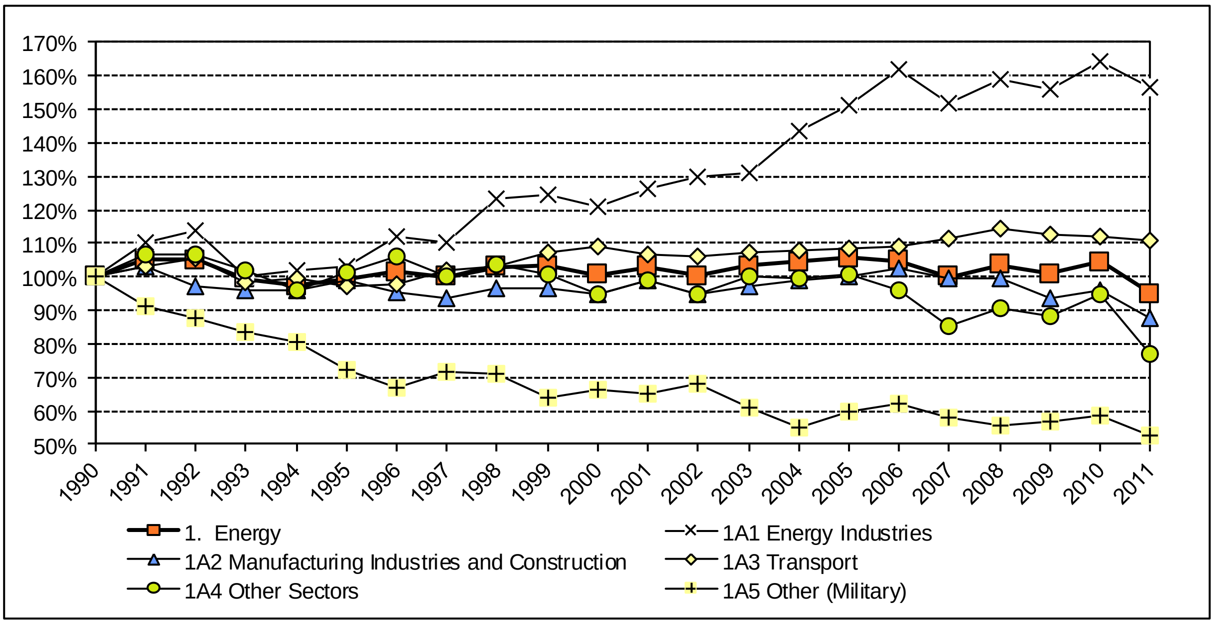

Figure 2-6 Emission trends (CO_2 eq.) for the source categories in sector 1 Energy/1A Fuel Combustion. The trend for the entire sector "1 Energy" is shown with a bold line. Not included in the figure is the trend for 1B Fugitive Emissions, which continuously decreased from 100% in 1990 to 51% in 2003 and since then remain stable.

It is noteworthy that, due to Switzerland's electricity production structure (about 95% generated by hydroelectric and nuclear power plants in 2011; see SFOE 2012: 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 crystallises 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.
- Overall emissions from source category 1A1 Energy Industry 2011 have increased by 56.5% since 1990 but decreased by 4.8% compared to the last year. Fluctuations are caused by varying combustion activities in the petroleum refinery industry, waste incineration and new installations of district heating. From 2010 to 2011, emissions from Gaseous Fuel consumption within source category 1A also decreased by 11.3% due to the fact that 2011 was the warmest year measured since measurements started: spring season 2011 was the warmest ever, autumn was the second warmest in 150 years and in November further record warm temperatures were measured (see Figure 2-7). 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 1990–2011 by 11.0%, but with fluctuations indicating a fairly strong correlation between this sector and overall economic development in Switzerland, with periods of stagnation (1993–1996, 2001–2003 and 2008–2011) and growth (gross value-added) in 1997–2000 and 2004–2008 (SFSO 2009a).

- 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 2011 heating degree days decreased by 18.1% compared to 2010 and CO_2 emissions from fuel combustions in source category 1A4 Stationary Sources decreased simultaneously by 19.0%. In the period 1990–2011, 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.

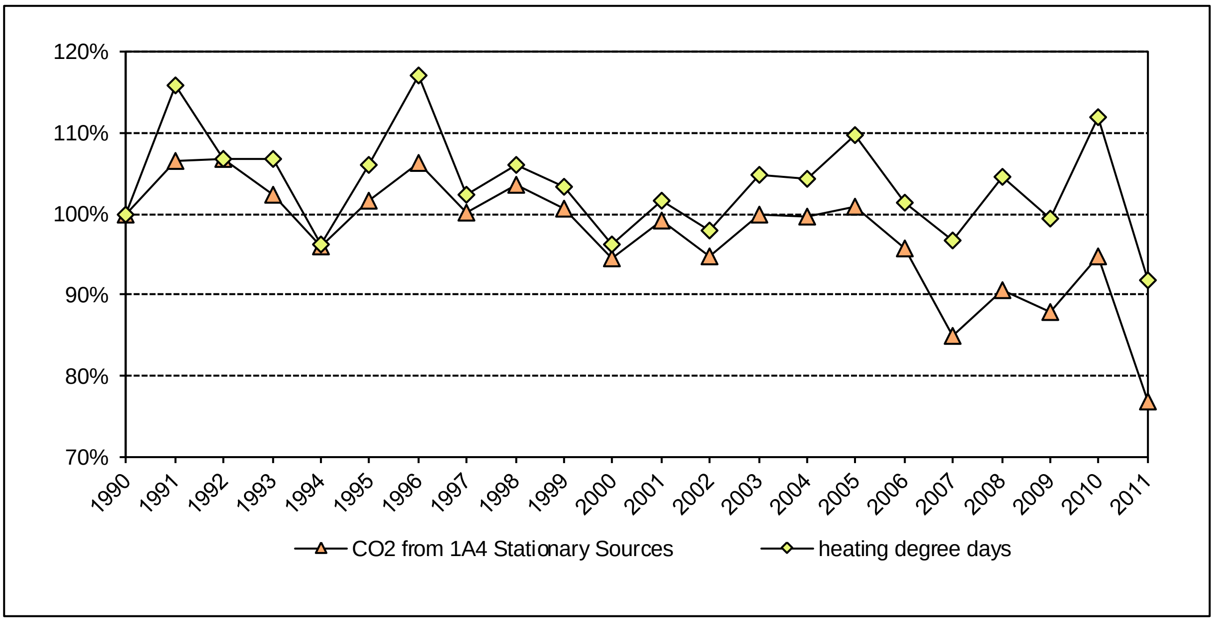

Figure 2-7 Relative trend for CO_2 emissions from 1A4 Fuel Combustion - Other Sectors (stationary sources only) compared with the number of heating degree days.

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 the removals in the LULUCF sector were higher than the emissions throughout the period 1990-2011. However, a strong year to year variation is evident over the whole period. The removals increased by 8.1% since 1990 and by 41.8% since 2010.The reason for the positive value in 2001 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.

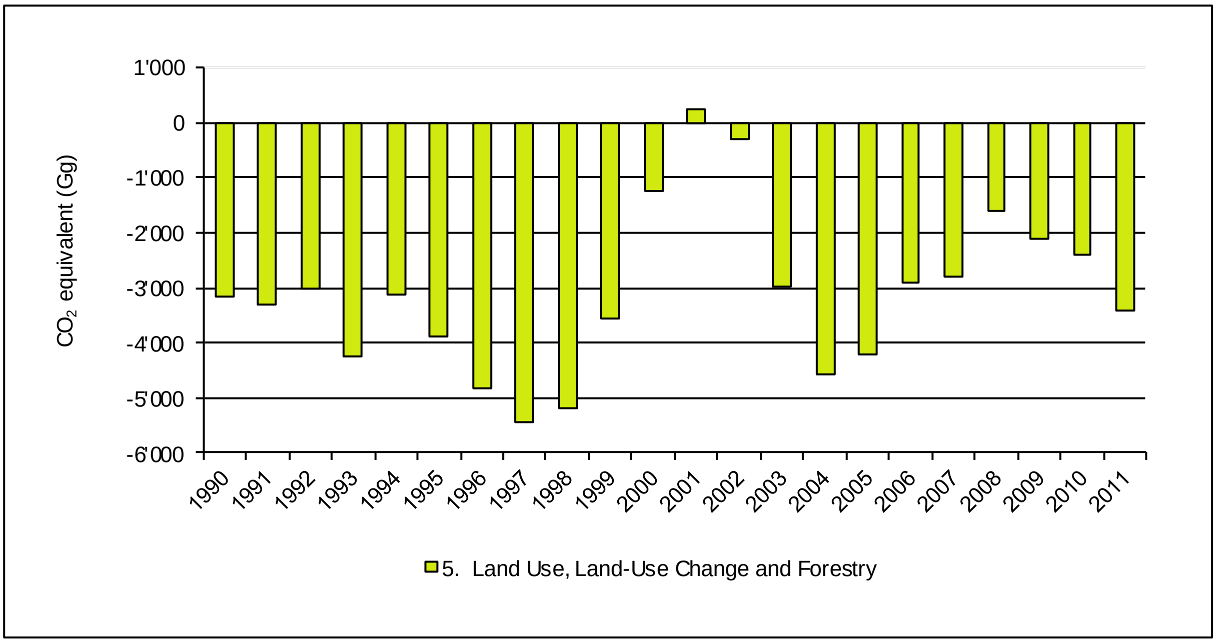

Figure 2-8 Switzerland's net CO_2 equivalent balance of sector Land Use, Land-Use Change and Forestry (LULUCF) 1990–2011 in Gg. Positive values refer to emissions, negative values refer to removals. Note that the annual contributions of CH_4 and N_2O emissions from LULUCF in this period are very small 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 of 48% to 75% in emissions of air pollutants over the period 1990-2011. 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), 1990–2011 (without NMVOC from LULUCF).

Indirect Greenhouse Gases and SO2	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	Gg									
NOx	149	148	141	129	127	123	118	114	113	113
CO	836	807	756	663	606	564	545	512	489	473
NMVOC	311	294	273	244	222	205	193	180	166	156
SO_2	40	37	33	27	28	26	26	24	23	17

Indirect Greenhouse Gases and SO2	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	Gg									
NOx	110	106	100	98	96	95	92	89	88	83
CO	443	419	390	377	357	340	316	297	287	271
NMVOC	147	139	128	119	109	105	101	97	95	93
SO_2	16	18	16	15	16	16	15	13	14	12

Indirect Greenhouse Gases and SO2	**2010**	**2011**
	Gg	
NOx	82	77
CO	262	286
NMVOC	91	88
SO_2	12	10

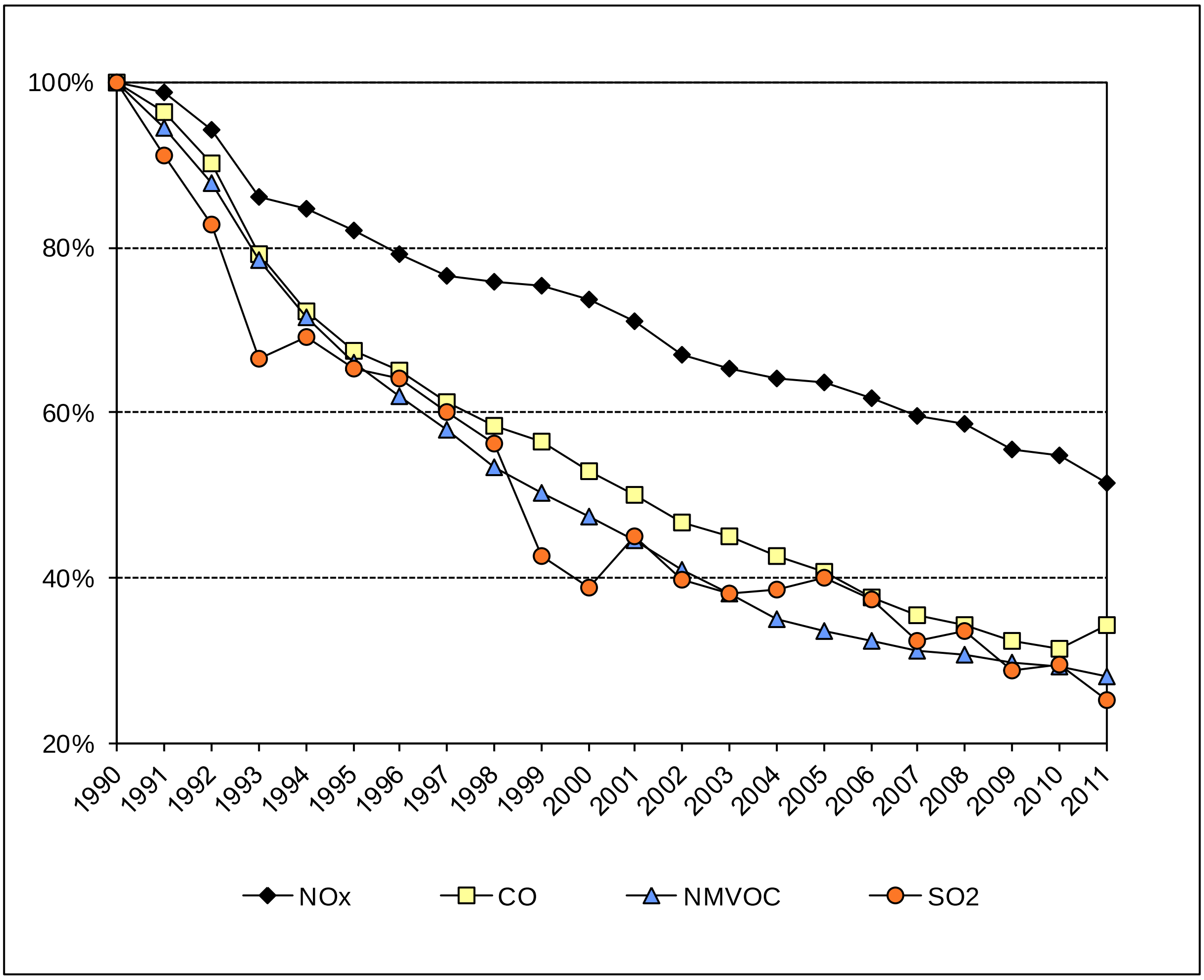

Figure 2-9 Relative trends for indirect GHG and SO_2 emissions (without NMVOC from LULUCF), 1990–2011 (base year 1990 = 100%).

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 23.2% 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 52.2% of the total in 2011.

Table 2-7 Indirect GHG and SO_2 emissions (Gg) by source, 2011. The total NMVOC emissions including NMVOC from LULUCF.

Sources	**NO_x**	**CO**	**NMVOC**	**SO_2**
	Emissions 2011 (Gg)			
1 Energy	71.71	270.46	31.07	9.26
2 Industrial Processes	0.43	6.22	7.35	0.79
3 Solvent and Other Product Use	0.00	0.01	42.44	0.01
4 Agriculture	4.19	NA, NO	3.97	NO
5 LULUCF	IE, NE	IE, NE	95.52	NE
6 Waste	0.60	8.70	2.59	0.12
7 Other	0.07	0.80	0.13	0.01
Total	**77.00**	**286.19**	**183.07**	**10.18**

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.

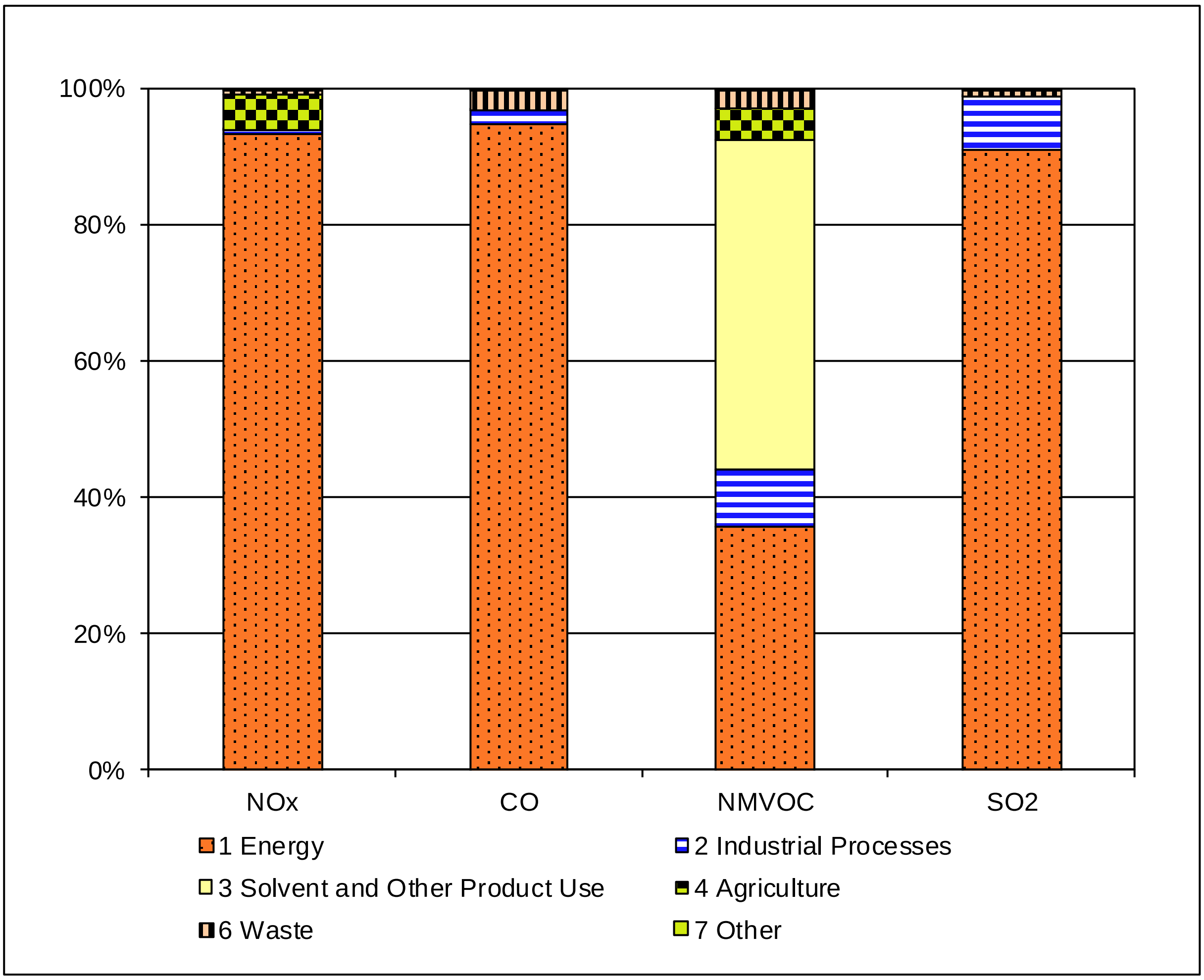

Figure 2-10 Relative contributions of individual sectors to indirect GHG and SO_2 emissions in 2011 (without NMVOC from LULUCF).

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), 1990–2011 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	42'007	44'099	44'126	41'814	40'920	41'774	42'612	41'959	43'274
Annex A sources		2 Industrial Processes	3'258	3'381	3'023	2'868	2'563	2'724	2'653	2'527	2'464	2'558
Annex A sources		3 Solvent and Other Product Use	466	470	444	420	392	374	354	331	308	286
Annex A sources		4 Agriculture	5'903	6'092	6'069	5'979	5'877	5'808	5'819	5'780	5'606	5'578
Annex A sources		6 Waste	1'030	1'011	1'008	980	918	857	852	828	819	800
Annex A sources		**Total (Annex A sources)**	**52'791**	**52'961**	**54'644**	**54'373**	**51'564**	**50'683**	**51'453**	**52'079**	**51'156**	**52'496**

		Sector	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
			CO_2 equivalent (Gg)									
Annex A sources		1 Energy	43'370	42'290	43'221	42'197	43'397	43'828	44'345	44'010	42'008	43'552
Annex A sources		2 Industrial Processes	2'661	2'930	3'034	3'032	3'079	3'347	3'520	3'496	3'519	3'640
Annex A sources		3 Solvent and Other Product Use	273	259	245	233	224	211	211	205	204	201
Annex A sources		4 Agriculture	5'511	5'496	5'561	5'536	5'461	5'447	5'474	5'494	5'556	5'648
Annex A sources		6 Waste	773	748	723	716	677	682	663	662	646	626
Annex A sources		**Total (Annex A sources)**	**52'588**	**51'723**	**52'785**	**51'714**	**52'838**	**53'516**	**54'213**	**53'867**	**51'933**	**53'668**
KP-LULUCF	Art.3.3	Afforestation & reforestation										-23
KP-LULUCF	Art.3.3	Deforestation										100
KP-LULUCF	Art.3.4	Forest management										-1'375
KP-LULUCF	Art.3.4	Cropland management										NA
KP-LULUCF	Art.3.4	Grazing land management										NA
KP-LULUCF	Art.3.4	Revegetation										NA

		Sector	2009	2010	2011	2011 – base year
			CO_2 equivalent (Gg)			%
Annex A sources		1 Energy	42'430	43'908	39'864	-5%
Annex A sources		2 Industrial Processes	3'505	3'723	3'742	15%
Annex A sources		3 Solvent and Other Product Use	200	198	199	-57%
Annex A sources		4 Agriculture	5'593	5'647	5'604	-5%
Annex A sources		6 Waste	608	597	587	-43%
Annex A sources		**Total (Annex A sources)**	**52'336**	**54'073**	**49'995**	**-5%**
KP-LULUCF	Art.3.3	Afforestation & reforestation	-25	-30	-33	
KP-LULUCF	Art.3.3	Deforestation	232	232	233	
KP-LULUCF	Art.3.4	Forest management	-2'179	-2'884	-2'936	
KP-LULUCF	Art.3.4	Cropland management	NA	NA	NA	
KP-LULUCF	Art.3.4	Grazing land management	NA	NA	NA	
KP-LULUCF	Art.3.4	Revegetation	NA	NA	NA	

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), 1990-2011.

		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	44'586	46'309	46'203	43'662	42'923	43'572	44'224	43'409	44'711
		CH_4	4'370	4'674	4'644	4'510	4'374	4'281	4'267	4'193	4'086	4'042
		N_2O	3'623	3'457	3'460	3'437	3'358	3'317	3'322	3'326	3'214	3'210
		HFCs	0.0	0.0	0.2	6	14	33	179	224	296	351
		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**	**52'961**	**54'644**	**54'373**	**51'564**	**50'683**	**51'453**	**52'079**	**51'156**	**52'496**

		GHG	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
			CO_2 equivalent (Gg)									
Annex A sources		CO_2	44'829	43'908	44'860	43'816	44'996	45'621	46'246	45'881	43'914	45'435
		CH_4	3'982	3'914	3'928	3'875	3'780	3'763	3'769	3'779	3'778	3'842
		N_2O	3'182	3'183	3'210	3'191	3'136	3'087	3'070	3'068	3'089	3'109
		HFCs	412	491	584	624	695	802	882	905	938	999
		PFCs	36	69	45	40	57	53	33	32	29	39
		SF_6	147	158	157	168	174	190	213	201	186	245
		Total (Annex A sources)	**52'588**	**51'723**	**52'785**	**51'714**	**52'838**	**53'516**	**54'213**	**53'867**	**51'933**	**53'668**
KP-LULUCF	Art.3.3	CO_2										77.4
		CH_4										NO
		N_2O										0.1
		Total (Art. 3.3)										**77.5**
	Art.3.4	CO_2										-1'375.5
		CH_4										0.4
		N_2O										0.2
		Total (Art. 3.4)										**-1'374.9**

		GHG	2009	2010	2011	2011 – base year
			CO_2 equivalent (Gg)			%
Annex A sources		CO_2	44'226	45'890	41'843	-6%
		CH_4	3'786	3'765	3'732	-15%
		N_2O	3'064	3'133	3'073	-15%
		HFCs	1'039	1'094	1'144	NA
		PFCs	35	37	39	-61%
		SF_6	187	155	164	14%
		Total (Annex A sources)	**52'336**	**54'073**	**49'995**	**-5%**
KP-LULUCF	Art.3.3	CO_2	207.1	202.0	200.6	
		CH_4	NO	NO	NO	
		N_2O	0.0	0.0	0.0	
		Total (Art. 3.3)	**207.1**	**202.0**	**200.6**	
	Art.3.4	CO_2	-2'179.1	-2'884.4	-2'938.2	
		CH_4	0.3	0.2	1.2	
		N_2O	0.2	0.1	0.7	
		Total (Art. 3.4)	**-2'178.6**	**-2'884.1**	**-2'936.3**	

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

3.1.1 Greenhouse Gas Emissions

This chapter provides information on the estimation of the greenhouse gas emissions from sector energy. 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 2011, it emitted 39’864 Gg CO_2 equivalent which corresponds to 79.7% of total emissions (50’010 Gg CO_2 equivalent, national total without LULUCF). The emissions of the period 1990–2011 are depicted in Figure 3-1.

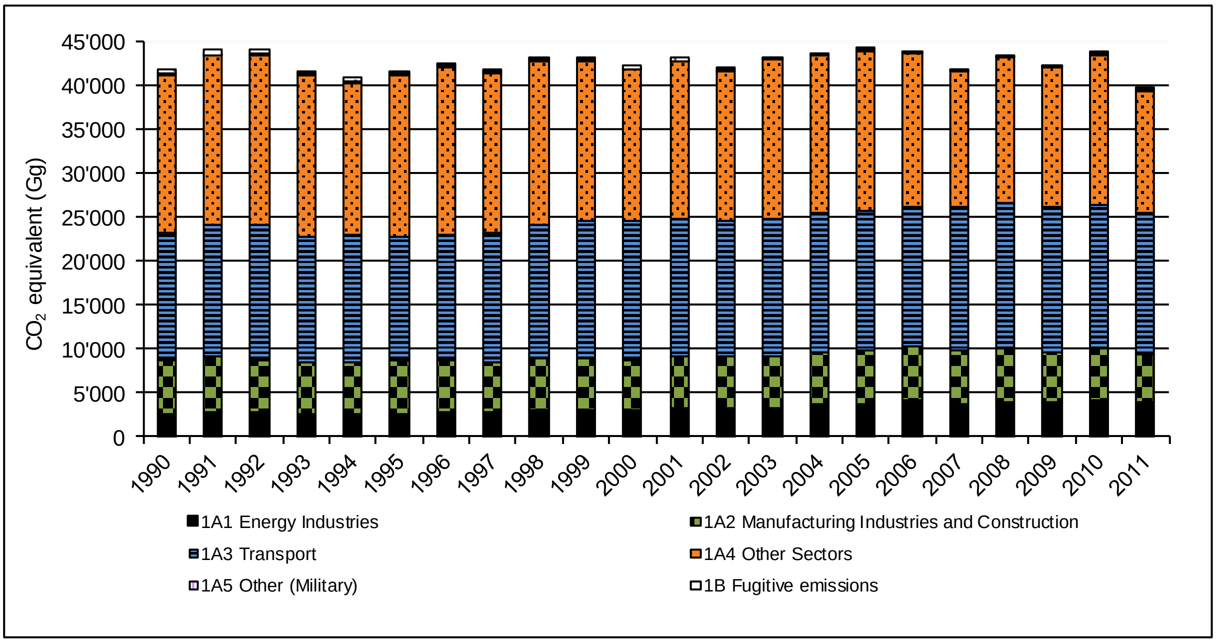

Figure 3-1 Switzerland’s GHG emissions of sector 1 Energy 1990–2011 in CO_2 equivalent (Gg).

For the total emissions of the energy sector, there are fluctuations up to 11% (100% = emissions 2011) in the period 1990–2011 but no trends. The value 2011 is 5.1% lower than the value of the base year. Three sub-categories dominate the emissions:

- 1A3 Transport and 1A4 Other Sectors are the main sources of the sector energy that cover 40.7% and 35.0% of total energy emissions in 2011 respectively,
- 1A2 Manufacturing Industries and Construction are of minor importance. They contribute in 2011 13.5% to the total emissions of the sector energy.
- 1A1 Energy Industries, 1A5 Other (Military) and 1B Fugitive Emissions only play a minor role. In 2011, they cover 10.0%, 0.3% and 0.6%, respectively, of the total emissions of the sector energy.

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

- By far the most important gas emitted from the sector energy is CO_2. It accounts for 98.7% of the category. Its fluctuations reflect *inter alia* the climatic variability in Switzerland (see Figure 2-7 and related comments).
- In 2011, CH_4 emissions contributed 0.64% 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 (17.96 Gg in 1990, 8.04 Gg in 2011) and reduced emissions from gasoline passenger cars due to catalytic converters.
- N_2O contributed 0.66% 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), 1990–2011.

Gas	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
CO_2	41'104	43'190	43'247	40'985	40'107	40'976	41'817	41'190	42'506	42'594
CH_4	620	603	555	509	481	454	432	398	388	388
N_2O	283	306	324	321	332	344	363	371	380	387
Sum	42'007	44'099	44'126	41'814	40'920	41'774	42'612	41'959	43'274	43'370

Gas	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	CO_2 equivalent (Gg)									
CO_2	41'546	42'477	41'496	42'725	43'217	43'745	43'422	41'445	42'985	41'880
CH_4	357	359	323	302	296	290	280	269	273	268
N_2O	388	386	378	370	316	310	308	294	295	282
Sum	42'290	43'221	42'197	43'397	43'828	44'345	44'010	42'008	43'552	42'430

Gas	**2010**	**2011**
	CO_2 eq	
CO_2	43'356	39'344
CH_4	269	255
N_2O	283	265
Sum	43'908	39'864

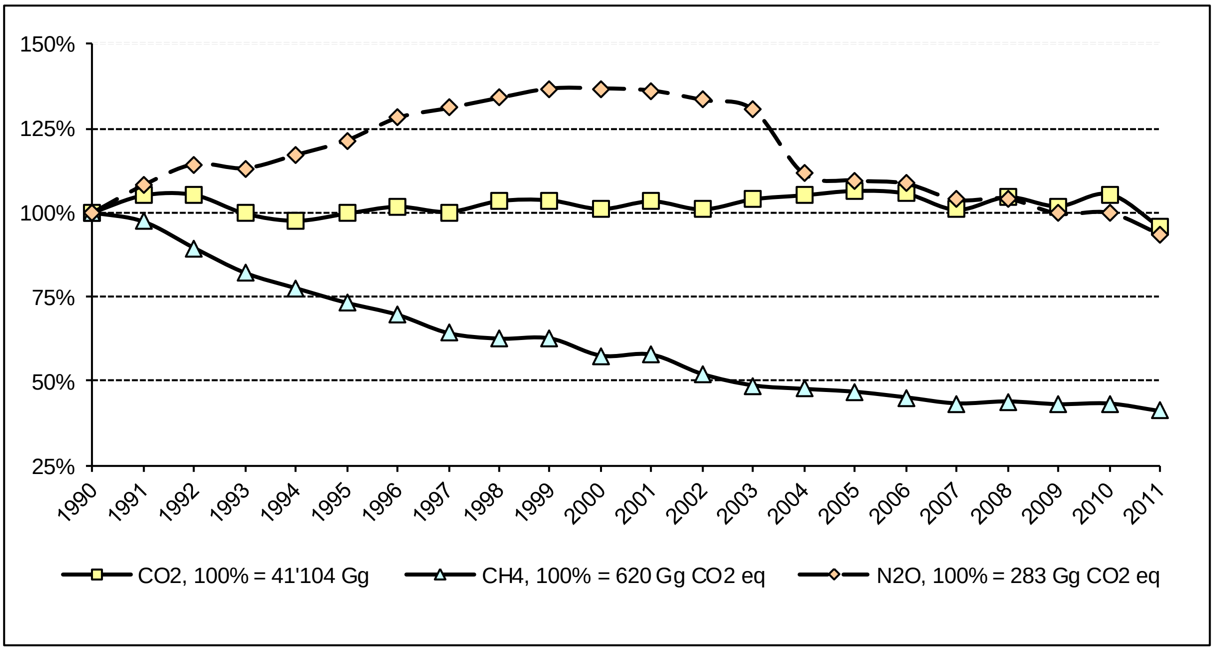

Figure 3-2 Relative trends of the greenhouse gases of source category 1 “Energy” in the period 1990–2011. The base year 1990 represents 100%.

The following table summarises the emissions of the sector energy in 2011. The table includes emissions from international bunkers (aviation and marine) as well as 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 2011 in Gg CO_2 equivalent (Total: rounded values).

Emissions 2011	**CO_2**	**CH_4**	**N_2O**	***Total***
	CO_2 equivalent (Gg)			
1 Energy	39'343.7	254.9	264.9	*39'864*
1A Fuel Combustion	39'291.5	81.6	264.1	*39'637*
1A1 Energy Industries	3'903.1	1.9	89.3	*3'994*
1A2 Manufacturing Industries and Construction	5'335.9	7.3	27.8	*5'371*
1A3 Transport	16'080.9	22.5	102.4	*16'206*
1A4 Other Sectors	13'864.6	49.8	43.5	*13'958*
1A5 Other (Military)	106.9	0.1	1.1	*108*
1B Fugitive Emissions from Fuels	52.2	173.3	0.9	*226*
International Bunkers	4'719.9	1.4	46.5	*4'768*
CO_2 Emissions from Biomass	6'184.3	0.0	0.0	*6'184*

In 2011, the Swiss greenhouse gas inventory identifies in Tier 1 analysis 31 key sources (without LULUCF), 18 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] Biomass CO_2 emissions from 1 Energy in the Table above and in the CRF inventory are for technical reasons incomplete. For full biomass CO_2 emissions see Section 3.2.5.

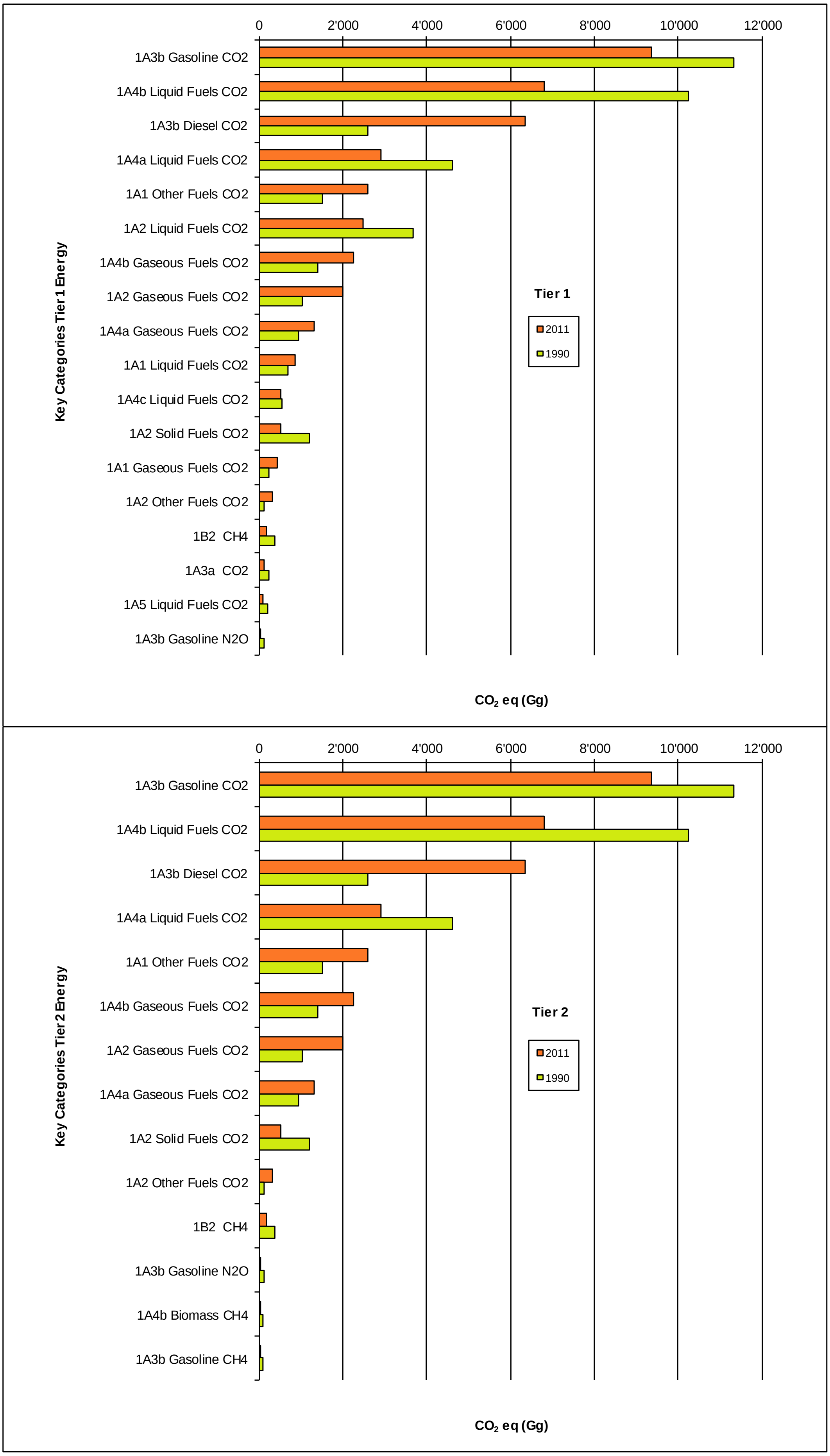

Figure 3-3 Key sources in the Swiss GHG inventory from the energy sector. Top: Tier 1, bottom Tier 2 analysis.

3.1.2 CO_2 Emission Factors

The CO_2 emission factors used for the calculation of the emissions of 1 Energy are shown in Table 3-3. Further details are given in Annex A2.1, Methodology for Estimating CO_2 Emissions. Note that the CO_2 emission factors are constant over the whole time period 1990-2011, which is supported by measurement campaigns of NCV and carbon content of fuels in 1999, 2008 and 2011 (EMPA 1999, Intertek 2008, Intertek 2012). Measurements will be repeated periodically. For further details see Annex 2.1.

Table 3-3 CO_2 emission factors for fossil and biofuels. The values are assumed to be constant over the period 1990-2011. The value for natural gas also holds for CNG (compressed natural gas).

CO_2 Emission Factors 1990-2011			
Fuel	**t CO_2 / TJ**	**t CO_2 / t**	**Data sources**
Diesel Oil	73.6	3.15	SFOE (2001), Intertek (2008)
Gas Oil	73.7	3.14	SFOE (2001), Intertek (2008)
Gasoline	73.9	3.14	SFOE (2001), Intertek (2008)
Lignite	96.0	2.26	FOEN (2011k)
Bituminous Coal	94.0	2.36	FOEN (2011k)
Jet Kerosene	73.2	3.15	SFOE (2001), Intertek (2008)
Natural Gas	55.0	2.56	SFOE (2001)
Propane/Butane (LPG)	65.5	---	SFOE (2001)
Residual Fuel Oil	77.0	3.17	SFOE (2001), Intertek (2008)
Fuel	t CO_2 / TJ	t CO_2 / t	
Biodiesel	73.6		EMIS (2013/1A3b)
Bioethanol	73.9		EMIS (2013/1A3b)
Biogas	55.0		EMIS (2013/1A3b)
Wood	92.0		EMIS (2013/1A solid fuels/wood) SFOE (2001)

3.1.3 Feedstocks

Energy data are taken from the Swiss overall energy statistics (SFOE 2012). These statistics account for production, imports, exports, transformation and stock changes. Hence all figures for energy consumption, on which the Swiss GHG inventory is based, correspond to apparent consumption figures.

In the Reference Approach of the GHG inventory, carbon stored in feedstocks has to be subtracted from fuel import to report the effective CO_2 emissions correctly. The data for feedstocks is taken from the Swiss overall energy statistics (SFOE 2012). The most important feedstock in Switzerland is bitumen.

3.1.4 Energy flow and energy consumption

As mentioned above, the Swiss overall energy statistics (SFOE 2012) serves as basic input for the emission calculation. It is updated annually and contains all the information on primary and final energy consumption. Table 3-4 shows the energy balance in Switzerland in 2011. An energy flow chart for 2011 and for the base year 1990 are given in Annex 3.1.1.

Table 3-4 Energy balance for Switzerland 2011 (SFOE 2012) in TJ.

			Holzenergie	Kohle	Müll und Industrieabfälle	Rohöl	Erdölprodukte	Gas	Wasserkraft	Kernbrennstoffe	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 renouvelables	Electricité	Chaleur à distance	Total
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Inlandproduktion	Production indigène	(a)	34 970	–	55 490	–	–	–	121 660	–	16 950	–	–	229 070
+ Import	Importation	(b)	1 250	4 800	–	190 180	298 950	111 770	–	278 840	190	299 870	–	1 185 850
+ Export	Exportation	(c)	– 300	0	–	–	– 18 780	–	–	–	–	–290 560	–	– 309 640
+ Lagerveränderung[1]	Variation de stock[1]	(d)	–	1 190	–	– 480	25 630	–	–	–	–	–	–	26 340
= Bruttoverbrauch	Consommation brute	(e)	35 920	5 990	55 490	189 700	305 800	111 770	121 660	278 840	17 140	9 310	0	1 131 620
+ Energieumwandlung:	Transformation d'énergie:													
• Wasserkraftwerke	• Centrales hydrauliques	(f)	–	–	–	–	–	–	– 121 660	–	–	121 660	–	0
• Kernkraftwerke	• Centrales nucléaires	(g)	–	–	–	–	–	–	–	–278 840	–	92 020	1 290	– 185 530
• konventionell-thermische Kraft-, Fernheiz- und Fernheizkraftwerke	• Centrales thermiques class., chauffage à distance, centrales chaleur-force	(h)	– 1 240	–	– 45 410	–	– 440	– 7 580	–	–	–	10 390	16 070	– 28 210
• Gaswerke	• Usines à gaz	(i)	–	–	–	–	–	–	–	–	–	–	–	–
• Raffinerien	• Raffineries	(j)	–	–	–	– 189 700	188 230	–	–	–	–	–	–	– 1 470
• Diverse Erneuerbare	• Renouvelables div.	(k)	– 1 010	–	–	–	–	290	–	–	– 2 530	2 310	0	– 940
+ Eigenverbrauch des Energiesektors, Netzverluste, Verbrauch der Speicherungen	Consommation propre du secteur énergétique, pertes de réseau, pompage d'accumulation	(l)	–	–	–	–	– 13 180	– 780	–	–	–	– 24 730	– 1 500	– 40 190
+ Nichtenergetischer Verbrauch	Consommation non énergétique	(m)	–	–	–	–	– 22 950	–	–	–	–	–	–	– 22 950
= Endverbrauch	Consommation finale	(n)	33 670	5 990	10 080	0	457 460	103 700	0	0	14 610	210 960	15 860	852 330
Haushalte	Ménages	(o)	17 670	400	–	–	92 290	40 990	–	–	9 720	64 590	5 870	231 530
Industrie	Industrie	(p)	9 410	5 590	10 080	–	27 310	34 590	–	–	1 180	69 140	6 350	163 650
Dienstleistungen	Services	(q)	5 970	–	–	–	37 790	20 050	–	–	2 710	62 650	3 640	132 810
Verkehr	Transport	(r)	0	–	–	–	298 060	1 560	–	–	450	11 020	–	311 090
Statistische Differenz inkl. Landwirtschaft	Différence statistique, y compris l'agriculture	(s)	620	0	–	–	2 010	6 510	–	–	550	3 560	0	13 250

A time series of the final energy consumption is depicted in Figure 3-4. The total consumption has increased by 6.7% in the period 1990-2011. Simultaneously significant substitutions occurred: heating fuel consumption decreased by -35.8%, natural gas and transport fuel consumption increased by 63.5% and 17.7%, respectively, and electricity by 25.8%.

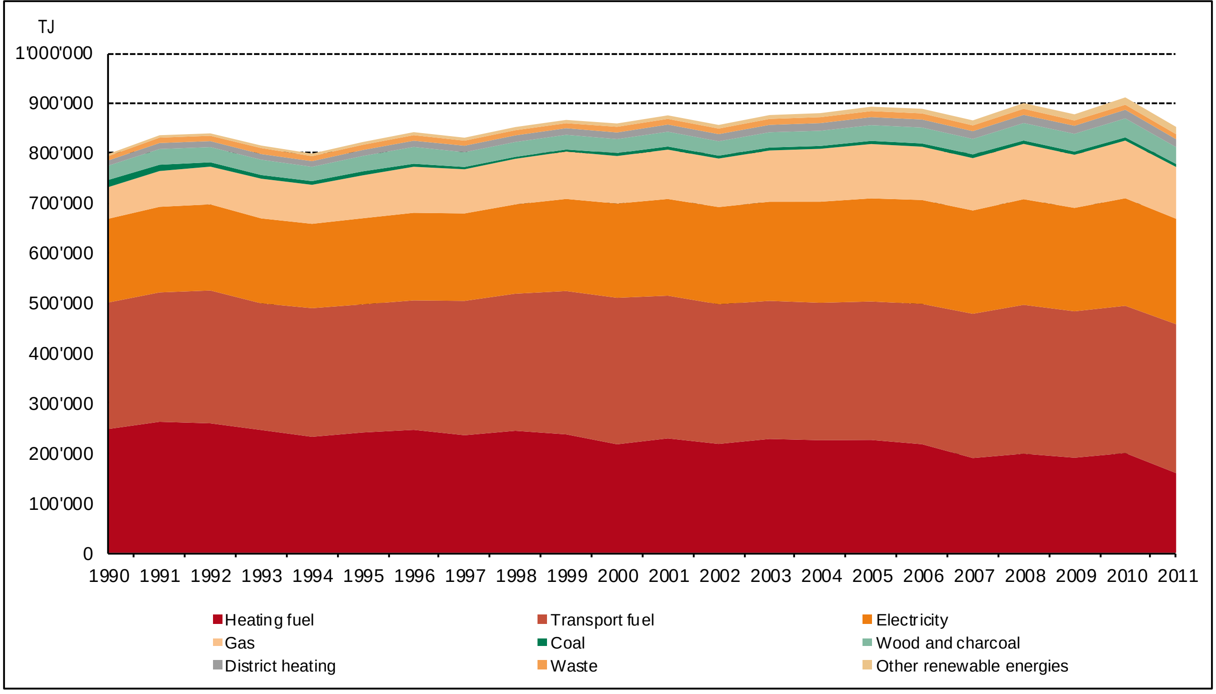

Figure 3-4 Final energy consumption in Switzerland between 1990 and 2011 by fuel type (SFOE 2012). Note that Liechtenstein's consumption of heating and transport fuel is included in the numbers. It corresponds to 0.61% of the Swiss fuel consumption. See Section 3.1.5

3.1.5 Correction of Fuel Consumption Related to Liechtenstein

The Swiss overall energy statistics (SFOE 2012) contains the fossil fuel consumption of the Principality of Liechtenstein (about 36'636 inhabitants, 35'253 employees in industrial and service sector) except for natural gas, since the two countries form a customs and monetary union governed by a customs treaty. Thus, all imports of liquid fossil fuel into Switzerland also contain the fuel consumed in Lichtenstein, which needs to be subtracted from the imports. The following method is being applied to get the correct Swiss fuel consumption:

Liechtenstein's energy consumption is taken from its energy statistics [see Table 3-4 in Liechtenstein's NIR (OEP 2013)]. In 2011 the sum of fossil fuels used in Liechtenstein was 2'788 TJ that corresponds to 0.61% of the Swiss consumption. The total consumption of every fuel (gasoline, diesel oil, gas oil etc.) is subtracted from the corresponding figures of the Swiss overall energy statistics. This procedure is carried out for every year 1990–2011. The Swiss emissions are then modelled using the correctly reduced activity data.

3.1.6 Disaggregation of the energy consumption

Figure 3-5 shows the disaggregation procedure of the fuel consumption. The total due to the sales principle is given in the Swiss overall energy statistics (SFOE 2012). The statistics also contains the split into energy consumption and energy transformation, further splits into residential, commercial and transportation as well as into public electricity, district heatings and refineries. The fuel consumption of wood is based on the Swiss wood energy statistics

(SFOE 2012b). Further disaggregations are carried out with the help of models run by FOEN, FOCA and the companies INFRAS and Prognos as well as the oil industry association (EV). The model run by Prognos is described in detail in Annex A3.1.2.

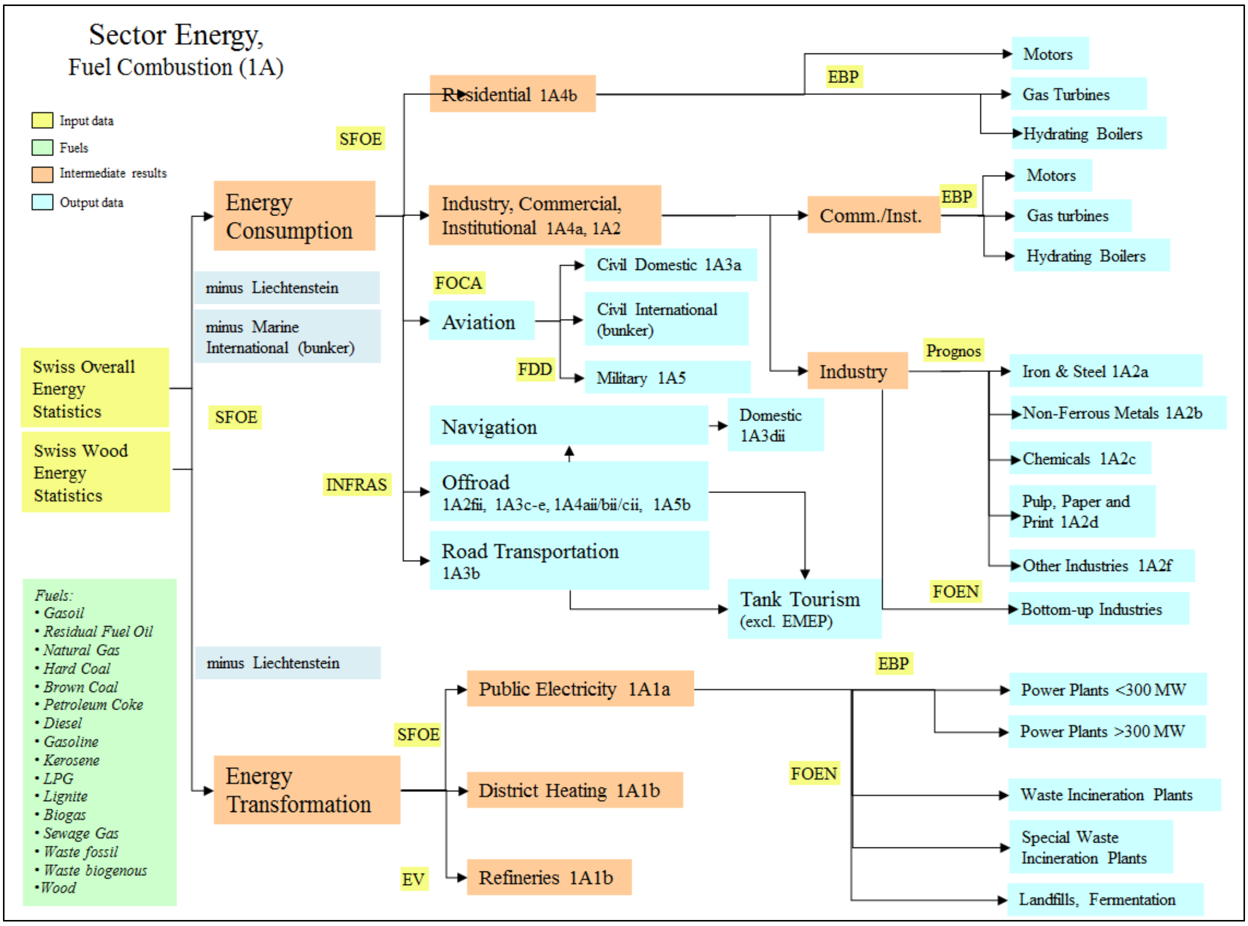

Figure 3-5 Schematic disaggregation of 1A Fuel Consumption.

3.2 *Source Category 1A – Fuel Combustion Activities*

3.2.1 Comparison Sectoral Approach- 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).

The Sectoral Approach uses specific methods for the different source categories: Fossil fuel consumption statistics (top-down approach, Tier 1) and bottom-up modelling of fuel consumption (bottom-up, Tier 2 and Tier 3).

The Reference Approach however, corresponds to a top-down approach (Tier 1) based on net quantities of fuel imported into Switzerland. Therefore the fossil fuel supply statistics is used: 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

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

(SFOE 2012). Subsequently the apparent consumption, the net carbon emissions, and the effective CO_2 emissions are calculated for the Reference Approach as prescribed in the CRF tables 1A(b)–1A(d). Thus the Reference Approach covers the CO_2 emissions of all net imported primary fuels, emissions from crude oil treatment (secondary fuel production) in the two Swiss refineries and emissions of imported secondary fuels. In 2011 38% of all fossil fuels sold in Switzerland were produced in Swiss refineries (EV 2012) from primary fuels.

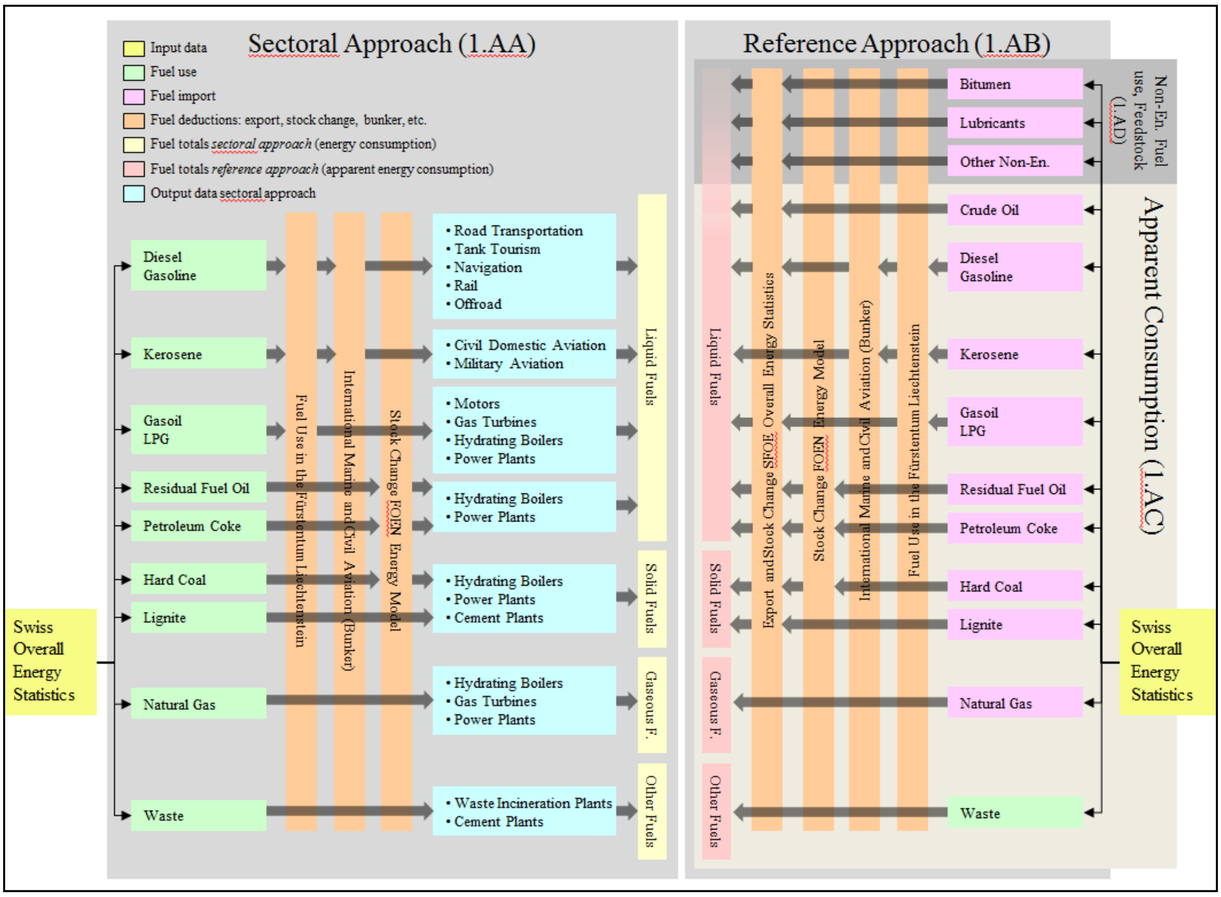

Figure 3-6 Calculation of the Reference and Sectoral Approach. The input data for both approaches stems from the Swiss overall energy statistics (SFOE 2012) but while the Reference Approach considers the net import/export balance, the Sectoral Approach considers the fuel use of the SFOE.

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 (cf. Chapter 3.2.5.1.)[5]

[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)."

- For the Reference Approach, Liechtenstein's fossil fuel consumption is subtracted from the input figures of fossil fuel consumption, which originally include Liechtenstein's consumption except for natural gas (see also Chapter 3.1.5).

Also, the differences between Reference and Sectoral Approach are calculated within EMIS. The results 1990-2011 are shown in Table 3-5 and in Figure 3-7. The CO_2 emissions from both approaches (excluding non-energy use and feedstocks) concur very well. For all years the differences lie between 0.28% and 0.95% and the difference in 2011 is 0.78%. For the corresponding energy consumption (excluding non-energy use and feedstocks) the differences lie between 0.43% and 0.97% while the difference in 2011 is 0.67%.

The 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.

Table 3-5 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	0.64	0.85	0.97	0.67	0.86	0.71	0.43	0.65	0.71	0.54
CO_2 Emissions	0.46	0.65	0.81	0.50	0.72	0.58	0.28	0.60	0.72	0.50

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	%									
Energy Consumption	0.53	0.69	0.57	0.60	0.61	0.52	0.88	0.70	0.68	0.79
CO_2 Emissions	0.44	0.60	0.53	0.51	0.56	0.48	0.95	0.74	0.72	0.91

	2010	**2011**
	%	
Energy Consumption	0.70	0.67
CO_2 Emissions	0.77	0.78

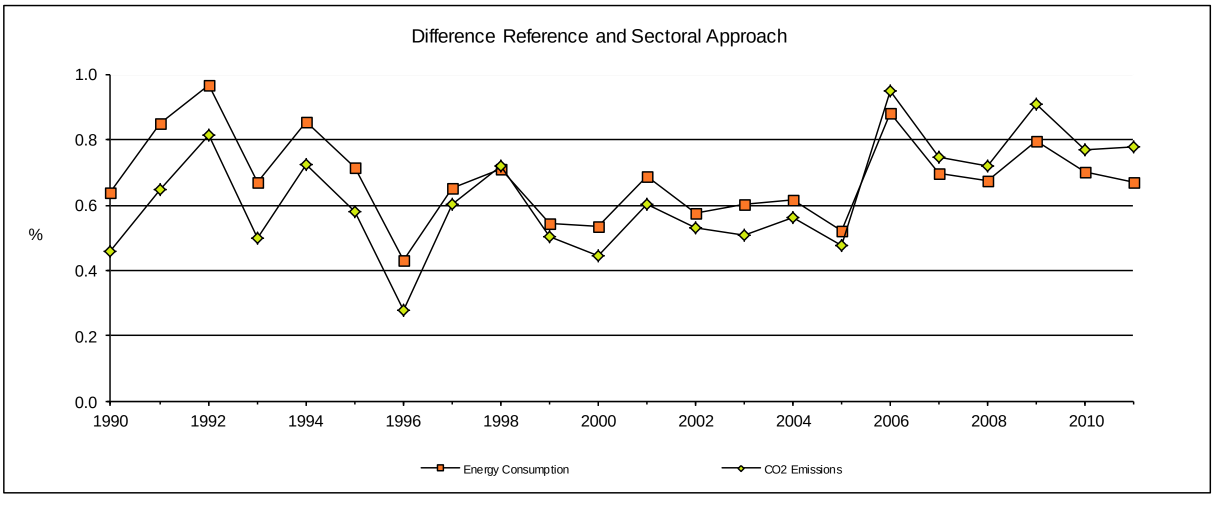

Figure 3-7 Time series for the differences between Reference and Sectoral Approach. Numbers are taken from Table 3-5.

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 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 and Rotterdam (NL) and on the two international Swiss lakes (Lake of Geneva, Lake of Constance).

Table 3-6 Specification of Swiss source category International Bunkers.

International Bunker Fuels	Specification	Data Source
Civil Aviation	Country specific model (Tier 3a)	FOCA 2006, 2007, 2008, 2009, 2010, 2011, 2012
Marine Bunkers	Navigation on the Rhine river north of Basel (Tier 1)	CARBURA 2010
	Navigation on foreign territory on the Lake of Geneva and Lake Constance (Bodensee)	Schweiz. Bodenseeschifffahrt (SBS), Schifffahrt Untersee und Rhein (Urh), Compagnie Générale de Navigation sur le lac Léman (CGN): INFRAS 2011a

3.2.2.2 Methodological Issues

The methodologies used for international aviation are described in chapter 3.2.8.2 a). The emissions from civil aviation (domestic and international) are calculated with a Tier 3a method. The emission factors are country specific with one exception N_2O (IPCC default). The activity data of the bunker is summarised in Table 3-7 (see also Table 3-30).

Due to the detailed information about activity data, the resulting fuel consumption is considered complete. In spite of this, there remain small differences between the fuel consumption modelled bottom-up and the total fuel sold (SFOE 2012). 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 of 10% can easily result from fuelling strategies of airlines (FOCA investigation showed that airlines are calculating whether it is economically beneficial to refuel at a place with lower fuel prize.) In order to match the bottom up calculation with the fuel quantity sold, any occurring difference is attributed to international bunker emissions. The factor between calculated international fuel consumption and adjusted international fuel consumption is used to scale the bunker emissions linearly. For instance in 1990, the bunker fuel consumption and the emissions had to be expanded by the factor 1.045. For 2006, they had to be reduced by the factor 0.974 (FOCA 2007). For 2011, the correction factor was 0.986 (FOCA 2012). For the more recent years, the modelled and actual total fuel sales are listed in Table 3-6a.

Table 3-6a 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
	t						
Modelled domestic fuel sales	38'754	38'550	43'968	37'627	39'626	39'252	42'047
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
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
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
Difference between FOCA and GEST	3.8%	2.6%	3.2%	3.4%	4.6%	3.2%	1.4%
Correction factor	0.962	0.974	0.968	0.966	0.954	0.969	0.986

Emissions from marine bunkers are calculated with a Tier 1 method. The emission factors are country specific and in accordance with Table 3-3. Activity data of these bunkers is summarised in Table 3-7.

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 as well as by CARBURA, the Swiss organisation for the compulsory stockpiling of oil products. From the latter, coherent data series are used. 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.

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. 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 3-7 International bunker fuels. Consumption of kerosene and diesel oil in TJ. (Note that Liechtenstein's kerosene consumption is subtracted, see Chapter 3.1.5.)

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	425	498	460	474	439	432
Total	64'211	60'523	55'818	50'185	47'321	48'169	50'569	54'017	58'283	55'670
1990 = 100%	150%	142%	131%	118%	111%	113%	118%	127%	137%	130%

International Bunker Fuels	2010	2011
	F. c. in TJ	
Total international aviation (1A3ai)	58'118	64'060
Total marine bunkers	468	418
Total	58'586	64'477
1990 = 100%	137%	151%

3.2.2.3 Uncertainties and Time-Series Consistency

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

3.2.2.4 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 2011 are compared with the results 2010 within the current CRF
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012.
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

3.2.2.5 Source-Specific Recalculations

No source specific recalculations.

3.2.2.6 Source-Specific Planned Improvements

No further planned improvements.

3.2.3 Feedstocks and Non-Energy Use of Fuels

The following feedstocks and fuels used for non-energy purposes are listed in the Swiss energy statistics (SFOE 2012) and reported in CRF Table 1A (d) as feedstocks and non-energy use:

- bitumen,
- lubricants,
- other fuels containing: other petrols, other diesels, paraffin & waxes, petroleum coke and white spirit.

3.2.4 CO_2 Capture from Flue Gases and Subsequent CO_2 Storage if Applicable

(Not applicable for Switzerland.)

3.2.5 Country-Specific Issues

3.2.5.1 Oxidation Factors

For the calculation of CO_2 emissions, an oxidation factor of 100% is assumed for all fossil fuel combustion processes (including coal). A first reason 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 2011: +64.3% to 111'451 TJ), overestimating of oxidation factors for gaseous fuels would tend to overestimate emission increase and would therefore be conservative. As the consumption of liquid fuels decreased (1990 to 2011: -13.1% to 404'491 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 oxidation 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 and decreased significantly over the considered period (1990 to 2011 by -58.7% to 5'801 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 2011 (EMIS 2013/1A2fi Zementwerke Feuerung). According to EU guidelines, the oxidation factor in cement production is assumed to be 100% (EC 2004). With this 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.

3.2.5.2 CO_2 from Biomass

A description of the methodology for calculating CO_2 emissions from the combustion of biomass is included in the relevant Chapters 3 (Energy) and 8 (Waste). Energy related emissions from municipal solid waste (MSW) incineration plants are reported under 1A1 Energy Industries (see Section 3.2.6.1).

The following CO_2 emissions are not foreseen for reporting in the CRF: 2D2 (Industrial Processes, Food and Drink), 3D5 (Other – consumption of tobacco), 6A (Solid Waste Disposal on Land) and 6D (Composting and Fermentation of Waste). Therefore, the CO_2 emissions from biomass in the CRF are incomplete.

The following table provides an overview of effective biomass CO_2 emissions in Switzerland in 2011 and their reporting in the CRF (without land-use, land-use change and forestry). Data is provided from the CRF and the FOEN internal GHG files.

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

Table 3-8 Effective biomass CO_2 emissions in Switzerland in 2011 and their representation in the CRF.

Biomass CO_2 emissions	Unit	2011	Note
1A1 Energy Industries (without MSW incineration)	Gg	459	Included in CRF
1A1 Energy generation from MSW Incineration	Gg	2'439	Included in CRF
1A2d Use of waste derived fuels in cellulose production	Gg	0	Included in CRF
1A2f Manufacturing Industry and Construction	Gg	1'138	Included in CRF
thereof use of waste derived fuels in cement production	Gg	52	
1A3 Transport	Gg	32	Included in CRF
1A4 Other Sectors (Commercial/Institutional, Residential)	Gg	2'115	Included in CRF
2D Industrial Processes, Other (food and drink, charcoal)	Gg	15	Not included in CRF
3D Other (consumption of tabacco)	Gg	13	Not included in CRF
6A Solid Waste Disposal on Land	Gg	29	Not included in CRF
6B Wastewater Handling	Gg	135	Not included in CRF
6C Waste Incineration (without MSW incineration)	Gg	219	Included in CRF
6D Other Waste (compost and fermentation of waste)	Gg	380	Not included in CRF
Total biomass combustion CO_2 emissions included in CRF	Gg	6'403	
Total energy related biomass combustion CO_2 emissions included in CRF 1A	Gg	6'184	See table "Summary 2" in CRF
Total biomass CO_2 emissions in Switzerland in 2011	Gg	6'976	

3.2.5.3 Wood firing

Wood combustion processes take place in several source categories, i.e. 1A1, 1A2fi, 1A4ai, 1A4bi, and 1A4ci. In submission 2010 the categories of wood combustion installations have been revised completely according to the Swiss wood energy statistics (SFOE 2012b, EMIS2013/1A solid fuels/wood). Thereby also all emission factors for CH_4, NO_x, CO and NMVOC have been reevaluated on the basis of these new categories, see Tables 3–9 and 3–10.

Regarding the N_2O emission factor of Biomass, the reported value of 1.6 kg/TJ is lower than the average of the emission factors of the reporting countries and lower than the IPCC default value of 4.

Table 3-9 Range of values of emission factors for wood firing

1A	Unit	CH_4	N_2O	NO_x	CO	NMVOC
Wood combustion	g/GJ	2.8 – 233	1.6	61 – 220	144 – 4750	6.5 – 543

Table 3-10 Categories of wood combustion installations based on SFOE 2012b

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

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 not occurring and 1A1 includes only emissions from the production of heat and/or electricity for sale to the public. Energy Industries (source category 1A1) therefore 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).
- Manufacture of Solid Fuels and Other Energy Industries (1A1c) does not occur.

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 1A1.

In Switzerland, electricity production is dominated by hydroelectric power plants (54%) and nuclear power stations (40%). Other sources such as (fossil fuelled) combined heat and power generation (CHP), and power generation from solar, wind and biomass account only for about 6% of the electricity generated in Switzerland (SFOE 2012; table 24; data for the year 2011).

Table 3-11 Specification of source category 1A1 “Energy Industries”

1A1	Source	Specification	Data Source
1A1a	Public Electricity and Heat Production	Main source are waste incineration plants with heat and power generation (Other fuels) and public district heating systems, including a small fraction of CHP. The only fossil fuelled public electricity generation unit “Vouvry” (300 MW_e; no public heat production) ceased operation in 1999.	Waste incineration: AD: FOEN 2012f; EMIS 2013/1A1a EF: SAEFL 2005g; EMIS 2013/1A1a Other sources: AD: SFOE 2012: SFOE 2012a; SFOE 2012b; EV 2012; EMIS 2013/1A1a EF: SAEFL 2000; SFOE 2001; EMIS 2013/1A1a, EMIS 2013/1A solid fuels/wood
1A1b	Petroleum Refining	Combustion activities supporting the refining of petroleum products, excluding evaporative emissions.	AD: EV 2012, SFOE 2012; EMIS 2013/1 Energy model EF: Industry data; EMIS 2013/Energy model
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Not occurring in Switzerland	-

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 light fuel oil (LFO), heavy fuel oil (HFO), 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 (excluding biomass in municipal solid waste) and biogas generation from co-generation of landfills and fermentation engines

Methodology

Except for waste incineration, the method used for fuel combustion in Public Electricity and Heat Production (1A1a) is a country specific Tier 2 method. A top-down approach based on aggregated fuel consumption data from the Swiss overall energy statistics is used to calculate emissions. The different sources are characterised by rather similar industrial combustion processes and the same emission factors are applied throughout these sources. Emissions of GHGs are calculated by multiplying fuel consumption (in TJ) by emission factors.

For waste incineration, the method used is a country specific method. 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 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.

For fermentation engines and co-generation on landfills the GHG emissions are calculated by multiplying quantities of combusted CH_4 by emission factors.

An oxidation factor of 100% is assumed for all combustion processes and fuels (see sub-section on oxidation factors in 3.2.5.1).

Emission Factors

(a) Waste incineration with heat and/or power generation (reported under "Other fuels") emission factors for CO_2, N_2O, NO_X, CO, NMVOC and SO_2 emissions per ton of waste incinerated are country specific based on measurements and expert estimates, documented in the EMIS database (EMIS 2013/1A1a 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 hazardous waste incineration plants is very high.

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

A study conducted by the Swiss Federal Laboratories for Materials Testing EMPA evaluated the waste incinerated in Switzerland (national and imported waste). Based on this information, the share of organic matter in the waste incinerated in MSW incineration plants is estimated to be 52.2% in 2011 (EMIS 2013/1A1a Kehrichtverbrennungsanlagen). In addition, as mentioned in the Section Waste, the results of a detailed analysis to provide more information on emission factors and activity data of digesting organic waste has been included.

(b) Other Public Electricity and Heat Production
The emission factors for CO_2 are country specific and based on measurements and analysis of fuel samples carried out by EMPA and Intertek (EMPA 1999; Intertek 2008; carbon emission factor documented in SFOE 2001, Table 45: p. 51; net calorific values on p. 61. See also Annex 2.1.1).

Emission factors for CH_4, NO_x, CO, NMVOC and SO_2 are country specific based on comprehensive life cycle analysis of industrial boilers, documented in SAEFL 2000 (pp. 14-27). For NO_x emission factors, expert judgement has been used to estimate the fraction of low-NO_x burners. The emission factors for NO_x and CO for natural gas and LFO have been recalculated for the time series based on a new study as documented in EMIS (EMIS 2013/1 Energy Model).

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

Emission factors for co-generation from landfills and fermentation engines are considered to be the same as for natural gas engines in commercial and institutional buildings (EMIS 2013/1 Energy Model). Emission factors for the use of wood in district combined heat and power units as well as for plants for renewable waste from wood products are based on SAEFL 2000 (pp. 26) and a new study for wood use in the sector 1A (EMIS 2013/1A solid fuels/wood). Categories for the use of wood in the 1A sector have been restructured on the basis of the Swiss wood energy statistics (SFOE 2012b), and recalculated for the entire time series with this submission.

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

Table 3-12 Emission Factors for 1A1a Public Electricity and Heat Production in Energy Industries in 2011.

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
Light fuel oil	73.7		1.0	0.6	36	7	2.0	22
Heavy fuel oil	77.0		4.0	0.8	125	15	4.0	291.0
Natural gas	55.0		6.0	0.1	19	11	2.0	0.5
Other (waste-to-energy), fossil	102.0		NA	5.5	33	7	1.2	4
Other (waste-to-energy), biogenic		108.7	NA	5.8				
Biomass (wood, renewable waste)		61.4	1.9	1.1	163	288	6.6	20
Biogas (co-generation from landfills, fermentation engines)		99.3	2	0.004	50	68	2.9	14

The emission factor for N_2O from Other Fuels is exceptionally high with 5.5 kg/TJ. An analysis in 2012 showed, that the value is considerably higher than in other countries and as the IPCC default value. This is because Swiss waste incineration plants include catalytic after-treatment and dispose of DeNOx-installations which produce N_2O as a by-product. Because of that, the emission factor for N_2O doubled between 1990 and 2003. Since then, it is decreasing based on improved DeNOx-equipments. It is expected that the N_2O emission factor will further decrease until 2020 (EMIS 2013/1A1a Kehrichtverbrennungsanlagen).

Activity Data

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

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 2012f and provided in the table below.

Special waste is composed by hazardous 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 3-13 Activity data for 1A1a Other fuels: municipal solid waste and special waste incinerated with heat and/or power generation 1990 to 2011.

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
1A1a Other fuels			
Total Other fuels in 1A1a	Gg	3'968	3'924
Municipal solid waste	Gg	3'717	3'676
Special waste	Gg	252	247

The table above documents the increase by 49% of municipal solid waste and 86 % of special waste incinerated from 1990 to 2011. This is due to the fact that since 1st of January 2000, disposal on landfill sites of waste which can be incinerated is prohibited by law. See also Chapter 8.4 on Waste Incineration. This increase results in CO_2 emissions from Other fuels in category 1A1 being a key category regarding trend. The increase is also partly due to municipal solid waste imported from neighbouring countries to optimize the load factor of MSW incineration plants.

Other Public Electricity and Heat Production

Activity data on fuel consumption (TJ) for Public Electricity and Heat Production (1A1a) is extracted from the Swiss overall energy statistics. The activity data for 2011 correspond to the consumption of LFO, HFO and natural gas (SFOE 2012; tables 21, 26, and 28; EV 2012). "Other fuel" is calculated from the annual amount of waste incinerated producing heat and/or electricity (seeTable 3-13).

Activity data for co-generation from landfills and fermentation engines is taken from the Swiss renewable energies statistics (SFOE 2012a).

Activity data for wood for district combined heat and power units and for plants for renewable waste from wood products are taken from the Swiss wood energy statistics (SFOE 2012b).

Table 3-14 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	40'417	41'416	43'395	38'631	38'301	39'383	42'412	43'252	48'556	49'692
Light fuel oil	TJ	980	1'790	1'917	1'662	810	554	810	1'065	852	1'065
Heavy fuel oil	TJ	3'195	5'006	6'336	1'748	1'541	1'791	2'420	1'063	4'093	1'227
Natural gas	TJ	4'406	4'533	4'582	4'629	4'899	5'617	6'985	7'368	7'262	9'547
Coal	TJ	484	102	102	51	76	51	0	0	0	0
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	657

1A1a Public Electricity /Heat	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total fuel consumption	TJ	50'397	52'304	53'242	54'272	55'375	57'674	60'982	59'210	61'054	58'918
Light fuel oil	TJ	810	852	810	1'065	810	1'321	1'278	810	469	554
Heavy fuel oil	TJ	314	371	377	455	350	289	297	242	158	124
Natural gas	TJ	8'679	9'051	9'298	10'111	10'120	10'213	9'038	8'232	8'820	8'399
Coal	TJ	0	0	0	0	0	0	0	0	0	0
Other (waste-to-energy), fossil	TJ	18'564	18'995	19'321	19'559	20'492	21'551	24'023	23'770	24'687	23'675
Other (waste-to-energy), biogenic	TJ	20'807	21'814	22'164	21'740	22'294	22'956	24'857	24'031	23'858	22'427
Biomass (wood, renewable waste)	TJ	547	583	689	774	813	844	943	1'462	2'314	2'878
Biogas (co-generation from landfills, fermentation engines)	TJ	677	637	584	567	496	500	546	663	749	861

1A1a Public Electricity /Heat	Unit	2010	2011
Total fuel consumption	TJ	62'998	61'234
Light fuel oil	TJ	512	426
Heavy fuel oil	TJ	52	0
Natural gas	TJ	10'326	8'043
Coal	TJ	0	0
Other (waste-to-energy), fossil	TJ	25'280	25'403
Other (waste-to-energy), biogenic	TJ	22'997	22'444
Biomass (wood, renewable waste)	TJ	2'958	3'978
Biogas (co-generation from landfills, fermentation engines)	TJ	872	940

The table above shows that in 2011 Other fuels are the major component with 78% of the total fuel consumptions. The fossil fuels contribute with a total of 14% while natural gas has the major contribution. Biomass and Biogas contribute with 8% to the total fuel consumption.

The table above documents the increase of Other Fuel consumption (fossil) by 83% from 1990 to 2011. Overall, Other Fuels increased by 56%. This increase is the reason for category 1A1 Other Fuels – CO_2 being a key category regarding trend.

The consumption of Natural Gas increased by 83% and the consumption of liquid fuels decreased by 57% for light fuel oil and 100% for heavy fuel oil. These developments show why the CO_2 emissions from liquid and gaseous are key categories regarding trend in this submission.

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 generally based on measurements and data from individual sources from the refining industry. The greenhouse gas emissions are calculated by multiplying the fuel consumption by the respective emission factor.

Emission Factors

Emission factors for CO_2, CH_4, N_2O, NO_x, CO, NMVOC and SO_2 are country specific based on measurements and data from industry and expert estimates, documented in the EMIS database (EMIS 2013/1 Energy model) and in SAEFL 2000.

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

Table 3-15 Emission Factors for 1A1b Petroleum Refining in 2011.

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							
Heavy fuel oil	77	4	0.8	110	15	2.5	490
Gas (refinery LPG)	59.3	1	0.6	55	15	2.3	25
P-Coke	91.4	10	1.6	200	100	10.0	500

Activity Data

Activity data on fuel combustion (TJ) for Petroleum Refining (1A1b) is extracted from the Annual Reports of the Swiss Petroleum Association (EV 2012).

Table 3-16 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
Heavy fuel oil	TJ	1'296	1'216	998	1'054	1'426	1'834	1'618	1'780	1'428	1'698
Gas (refinery LPG)	TJ	4'610	7'454	7'139	8'237	9'253	8'483	9'474	8'913	9'594	9'655
Petroleum coke	TJ	0	0	0	0	0	0	0	0	0	0

Source/fuel	Unit	2000	2001	2002	2003	2004	2005	2006	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
Heavy 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
1A1b Petroleum Refining Fuel Consumption			
Total	TJ	13'912	12'975
Heavy fuel oil	TJ	895	783
Gas (refinery LPG)	TJ	11'015	10'508
Petroleum coke	TJ	2'002	1'684

The table above documents the increase of gas (refinery LPG) consumption for petroleum refining by 128% from 1990 to 2011 and is therefore key category 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.

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 3-17 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 2012	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	381'390	1.0	25'630	20	407'020	1.6	1
Gaseous fuels	Gas	111'770	2	0	0	111'770	2.0	2
Solid fuels	Kohle	4'800	5	1'190	100	5'990	20.3	3
Other fuels	Müll- und Industrieabfälle	55'490	10	0	0	55'490	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 2012; Table 4). Accordingly, also net import/net production data were taken from the Swiss overall energy statistics for the present uncertainty analysis.

Uncertainty in CO_2 emission factors in fuel combustion (1A1)

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 0.53% (defined as two standard deviations, STD) results for the emission factor. In 2008, an extended measurement programme was conducted for the country-specific NCVs and EFs for liquid fuels (Intertek 2008). The results of this programme have confirmed the values from 1998 and the assumption of constant NCVs for fuels sold within Switzerland.

Table 3-18 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 2011 (approx.)
Heavy fuel oil	41.2	0.85	2.06	4.13	0.000010	6	0.4%
Light fuel oil	42.6	0.13	0.31	0.61	0.002688	10	40%
Diesel	42.8	0.10	0.23	0.47	0.000671	10	26%
Gasoline	42.5	0.29	0.68	1.36	0.009132	30	33%
Jet kerosene	43.0	0.25	0.58	1.16	0.000004	10	1%
Sum	42.6				0.012505	66	100%
Combined STD/Unc		0.112	0.26	0.53			

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 (1A1)

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 3-19 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 Input data	Year 2011 emissions Input data	Activity data uncertainty Input data	Emission factor uncertainty Input data	Combined uncertainty Calc/Input	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
				Gg CO2 eq	Gg CO2 eq	%	%	%	%	%	%	%	%	%
1A1	1. Energy Industries	Gaseous Fuels	CO2	242.32	442.34	2.0	4.60	5.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A1	1. Energy Industries	Liquid Fuels	CO2	691.39	868.79	1.6	0.53	1.6	0.000	0.0000	0.0000	0.00	0.00	0.00
1A1	1. Energy Industries	Other Fuels	CO2	1'519.73	2'591.93	10.0	30.00	31.6	0.002	0.0002	0.0007	0.00	0.00	0.00
1A1	1. Energy Industries	Solid Fuels	CO2	45.47	0.00	20.3	5.00	20.9	0.001	0.0000	0.0000	0.00	0.00	0.00
1A2	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1'046.30	2'015.43	2.0	4.60	5.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A2	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3'684.05	2'484.54	1.6	0.53	1.6	0.000	0.0000	0.0000	0.00	0.00	0.00
1A2	2. Manufacturing Industries and Construction	Other Fuels	CO2	134.15	321.33	10.0	30.00	31.6	0.005	0.0000	0.0022	0.00	0.01	0.01
1A2	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1'220.95	514.65	20.3	5.00	20.9	0.002	0.0000	0.0000	0.00	0.00	0.00
1A3a	3. Transport; Civil Aviation		CO2	252.55	132.35	2.2	1.16	2.5	0.001	0.0000	0.0000	0.00	0.00	0.00
1A3b	3. Transport; Road Transportation	Diesel	CO2	2'587.68	6'348.51	2.2	0.47	2.2	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3b	3. Transport; Road Transportation	Gasoline	CO2	11'335.25	9'358.64	2.2	1.36	2.6	0.005	0.0000	0.0009	0.00	0.00	0.00
1A3b	3. Transport; Road Transportation	Natural Gas	CO2	0.00	39.60	3.5	3.55	5.0	0.000	0.0000	0.0000	0.00	0.00	0.00
1A3c	3. Transport; Railways		CO2	28.69	38.12	2.2	0.53	2.3	0.003	-0.0001	0.0001	0.00	0.00	0.00
1A3d	3. Transport; Navigation		CO2	111.88	117.52	2.2	0.53	2.3	0.002	0.0000	0.0001	0.00	0.00	0.00
1A3ei	3. Transport; Other non-specified		CO2	30.80	46.20	2.2	4.49	5.0	0.001	0.0000	0.0000	0.00	0.00	0.00
1A4a	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	961.96	1'312.66	2.0	4.60	5.0	0.130	0.0091	0.0266	0.04	0.08	0.09
1A4a	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'614.55	2'915.76	1.6	0.53	1.6	0.150	-0.0173	0.0680	-0.01	0.21	0.21
1A4b	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'409.10	2'254.45	2.0	4.60	5.0	0.005	0.0000	0.0001	0.00	0.01	0.01
1A4b	4. Other Sectors; Residential	Liquid Fuels	CO2	10'248.78	6'802.19	1.6	0.53	1.6	0.001	0.0000	0.0000	0.00	0.00	0.00
1A4b	4. Other Sectors; Residential	Solid Fuels	CO2	55.36	34.07	20.3	5.00	20.9	0.014	0.0000	0.0002	0.00	0.01	0.01
1A4c	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	40.64	19.10	2.0	4.60	5.0	0.044	-0.0011	0.0007	-0.07	0.02	0.07
1A4c	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	547.19	526.38	1.6	0.53	1.6	0.003	0.0001	0.0001	0.00	0.00	0.00
1A5	5. Other	Liquid Fuels	CO2	203.58	106.92	1.6	0.53	1.6	0.001	-0.0001	0.0000	0.00	0.00	0.00

Qualitative estimate of further uncertainties of non-CO_2 non-key category emissions in 1A Fuel Combustion

Uncertainty in emissions of other non-CO_2 gases are estimated to be medium resulting in 30% for CH_4 and 80% for N_2O (see Table 1-13).

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, see Section 3.2.5.

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 1990–2011 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 (1A1a)

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 2011 are compared with the results 2010 within the current CRF
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of last submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of last submission 2012

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 and the emission factor for N_2O 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: The activity data of all fuels of the overall time series have been recalculated based on the new data from SFOE 2012.
- 1A: The activity data of wood consumption have been recalculated for the overall time series based on the new data from SFOE 2012b.
- 1A: Activity data of sewage gas out of purification plants has changed between 2000 and 2007.
- 1A: The emissions factor of bituminous coal has changed because it was weighted with P-Coke before.
- Activity data for municipal waste incineration for 2009 and 2010 have been recalculated based on new measurements of the net calorifc values.
- Emission factor of CH_4 in category Biogas has been corrected for the entire time series to 6g/GJ. In the previous submission, is was 6'000g/GJ due to an error in the unit conversion.
- Activity data of 1A1a Boiler has been recalculated for the overall time series in order to correctly account for losses in gas distribution as reported under 1B2b. So far, the gas reported as fugitive emissions was also reported under 1A1a Boiler, i.e. there was a double-counting.

3.2.6.6 Source-Specific Planned Improvements

No planned improvements are foreseen in this category.

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, gas turbines and engines within manufacturing industries and construction. This includes emissions from conventional and waste fuel use in cement production.

Off-road construction and industrial vehicles and machinery are also reported in 1A2.

Not included are combustion installations in the commercial/institutional and the residential sector as well as in agriculture/forestry. These are included in category 1A4 ("Other Sectors").

In line with the IPCC guidelines, non-energy emissions of CO_2 from calcination are reported in category 2, Industrial Processes.

Table 3-20 Specification of source category 1A2 Manufacturing Industries and Construction

1A2	Source	Specification	Data Source
1A2a	Iron and Steel	Iron and Steel industry	AD: SFOE 2012; Prognos, 2012 and industry data; EMIS 2013/1A2a EF: EMIS 2013/1A2a; SAEFL 2000
1A2b	Non-ferrous Metals	Non-ferrous Metals industry	AD: Same as in 1A2a, EMIS 2013/1A2b EF: EMIS 2013/1A2b, SAEFL 2000
1A2c	Chemicals	Chemical industry	1 Energy model
1A2d	Pulp, Paper and Print	Pulp, Paper and Print industry	Same as in 1A2b, EMIS 2013/1A2d
1A2e	Food Processing, Beverages and Tobacco	Food Processing, Beverages and Tobacco industry	1 Energy model
1A2f 1A2f i	Other (Combustion Installations in Industries)	Category 1A2f i contains Cement, Lime, Brick and tile, Fine ceramics, Asphalt concrete plants, Container glass, Glass, Glass wool, Mineral wool, Fibreboard Production, industrial fossil fuel and biomass boilers and engines that do not provide heat or electricity to the public.	SFOE 2012b, EMIS 2013/1A solid fuels/wood, EMIS 2013/1A2fi

1A2	Source	Specification	Data Source
1A2f ii		Category 1A2f ii contains off-road construction and industrial vehicles and machinery.	INFRAS 2008

Today the fuel used in iron and steel manufacturing is mainly natural gas as well as liquefied petroleum gas and light fuel oil with shares of 78%, 10% and 9%, respectively, in 2011. In addition anthracite is used in cupola furnaces of iron foundries.

The non-ferrous metals industry uses mainly natural gas and a small portion of light fuel oil for the drying of chips.

The chemical industry uses natural gas and light fuel oil for its processes. The use of heavy fuel oil has drastically decreased and is only a marginal part of the fuel used in the chemical industry.

The pulp and paper industry uses mainly natural gas as fuel and a small amount of light fuel oil for its production. Also in the pulp an paper industry, the use of heavy fuel oil strongly decreased and is only a marginal part of the fuel uesd in the production of pulp an paper.

The food processing, beverage and tobacco industry uses a mix of natural gas and light fuel oil as fuel.

The other manufacturing industries use different fuels depending on the sector and industry:

- The production of fine ceramics is based on the use of natural gas and light fuel oil. The use of natural gas was around 83% in 1990 and increased in the last years constantly up to 98%. For further information on the fine ceramics sector, please see 4.2.2.3.
- In Switzerland, rock wool is produced by only one producer. The production of rock wool is based on the founding of rocks at a temperature of around 1'500 degrees in a cupola furnace fuelled by coke. Additionally, some gas and a small amount of fuel oil are used in the production. For further information on the rock wool production, please see 4.2.2.3.
- The brick and tile production is realised in Switzerland by around 20 producing plants. The fuels used in the production process are light fuel oil, natural gas as well as small amounts of paper-making residues and wood. For further information on the brick and tile production, please see 4.2.2.3.
- The glass production includes three types of glass: container glass, tableware glass and glass wool. The production of these includes heavy fuel oil, natural gas and LPG. The container glass production mainly uses heavy fuel oil (2011: 78%) and natural gas (12%). For further information on the glass production, please see 4.2.2.7.
- Fibre board is produced by two companies in Switzerland. The fuels used are light and heavy fuel oil, natural gas and biomass. In 2000 the share of these fuels was about 50% natural gas, 40% biomass and 10% fuel oil. In 2010 the use of light fuel oil was stopped and in 2011 the share of used fuels is about 85% biomass, 10% natural gas and 5% heavy fuel oil.
- The production of mixed goods includes mainly bituminous goods for the production of street coverage. A total of 110 production sites are producing the mixed goods. The used fuels for the production include mainly light fuel oil and natural gas.
- The cement production is based on the use of alternative fuels and ordinary fuels. Alternative fuels include for example industrial wastes, animal residues or used tires.

Ordinary fuels are coal, petroleum coke and to a lesser extent light and heavy fuel oil as well as natural gas.

3.2.7.2 Methodological Issues

For fuel combustion in Manufacturing Industries and Construction (1A2) a country specific Tier 2/3 method is used. The method combines both bottom-up and top-down elements (see table below). Emissions of GHGs are calculated by multiplying levels of activity by emission factors.

- A top-down method based on aggregated fuel consumption data from the Swiss overall energy statistics and energy-economic modelling is used to calculate overall emissions of each of the categories 1A2a to 1A2f. Identical emission factors for each fuel type are applied throughout these sources with the exception of 1A2f. The unit of emission factors refers to fuel consumption (in TJ).
- A bottom-up (Tier2/Tier3) method is used to calculate the emissions for a part of the activities in the categories in 1A2a, 1A2b, 1A2d and 1A2f (see Table 3-21). This bottom-up approach does not change overall emissions of the gases CO_2, CH_4 and N_2O in these categories, as in each of the categories, the difference between the bottom-up part and the top-down allocation for the entire category is allocated to other sources in this category (with the exception of the fossil part of waste combustion in cement industry and the mobile off-road sources, both in 1A2f). Estimates for HFO and coal consumption for the bottom-up part of 1A2f exceeded the amounts allocated top-down for 1A2f in some years. It was interpreted that this was due to stock changes, and corresponding corrections were made. Activities which were determined bottom-up are: Cupola furnaces in iron foundries and reheating furnaces in steel plants (1A2a); Aluminium second smelter and non-ferrous metal foundries (1A2b); biomass use in Pulp, Paper and Print (1A2d); Cement, Lime, Brick and tile, Fine ceramics, Asphalt concrete plants, Container glass, Glass, Glass wool, Mineral wool, Fibreboard production and industrial biogas boilers and engines that do not provide heat or electricity to the public (all in 1A2f i) and mobile off-road sources including construction and industrial vehicles and machinery (1A2f ii). The calculations are based on measurements and data from individual point sources from industry. Emission factors refer both to fuel consumption (in TJ) or production data (e.g. in tons of steel or cement produced). A bottom-up approach is also used to estimate CO_2 emissions from waste derived fuels used in cement industry ("Other fuels").

Table 3-21 Overview on methods applied to calculate GHG emissions in 1A2.

1A2	Source	Specification	Data Source
1A2a	Iron and Steel Cupola furnaces in iron foundries and reheating furnaces in steel plants Other sources in 1A2a	Bottom-up Top-down	EMIS 2013/1A2a
1A2b	Non-Ferrous Metals Aluminium second smelter and non-ferrous metal foundries Other sources in 1A2b	Bottom-up Top-down	EMIS 2013/1A2b
1A2c	Chemicals	Top-down	1 Energy model
1A2d	Pulp, Paper and Print Biomass (waste derived fuels from paper and pulp) All other fuels	Bottom-up Top-down	Industry data, EMIS 2013/1A2d
1A2e	Food Processing, Beverages, and Tobacco	Top-down	1 Energy model

1A2	Source	Specification	Data Source
1A2f	Other		
1A2f i	Cement/Lime/Glass/… industry	Bottom-up	Industry data, EMIS 2013/1A2fi
	Other sources (fossil fuel boilers and engines, wood boilers)	Top-down	
1A2f	Mobile off-road sources (construction and industrial vehicles and machinery)	Bottom up	INFRAS 2008

An oxidation factor of 100% is assumed for all combustion processes and fuels (see sub-section on oxidation factors in the beginning of Section 3.2.5.1).

Emission factors

Top-down approach

For all sources and gases where a top-down approach is applied, emission factors are the same as for source category 1A1a (see also Chapter 3.2.6.2).

The emission factors for CO_2 are country specific and based on measurements and analyses of fuel samples carried out by the Swiss Federal Laboratories for Materials Testing, Research EMPA and Intertek (EMPA 1999; Intertek 2008; carbon emission factor documented in SFOE 2001, Table 45: p. 51; net calorific values on p. 61. See also Annex A2.1.1).

The coal emission factor for CO_2 is the emission factor of hard coal. For net calorific values see Annex A2.1.1.

Emission factors for CH_4, NO_x, CO and NMVOC are country specific based on comprehensive life cycle analysis of industrial boilers, documented in SAEFL 2000 (pp. 14-27). For NO_x emission factors, expert judgement has been used to estimate the fraction of low-NO_x burners. The emission factors for NO_x and CO for natural gas and light fuel oil have been recalculated for the entire time series based on a study as documented in EMIS (EMIS 2013/1 Energy Model).

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

All emission factors for biomass are based on SAEFL 2000 (pp. 26ff) and a new study for wood combustion (EMIS 2013/1A solid fuels/wood).

The following table presents the emission factors used for the sources in categories 1A2a-f. Categories 1A2a-e and part of 1A2f are calculated with the top-down approach:

Table 3-22 Emission factors for sources in 1A2a-f for 2011. For sources that include activities calculated bottom-up, the table shows implied emission factors.

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
1A2a Iron and Steel				
Light fuel oil	73.7		1	0.6
Liquefied petroleum gas	65.5		1	0.6
Heavy fuel oil	77.0		4	0.8
Coal	94.0		10	1.6
Natural gas	55.0		6	0.1
1A2b Non-Ferrous Metals				
Light fuel oil	73.7		1	0.6
Liquefied petroleum gas	65.5		1	0.6
Heavy fuel oil (including petrolkoks)	NO		NO	NO
Natural gas	55.0		6	0.1
1A2c Chemicals				
Light fuel oil	73.7		1	0.6
Liquefied petroleum gas	65.5		1	0.6
Heavy fuel oil	77.0		4	0.8
Coal	NO		NO	NO
Natural gas	55.0		6	0.1
1A2d Pulp, Paper and Print				
Light fuel oil	73.7		1	0.6
Liquefied petroleum gas	65.5		1	0.6
Heavy fuel oil	77.0		4	0.8
Natural gas	55.0		6	0.1
1A2e Food Processing, Beverages and Tobacco				
Light fuel oil	73.7		1	0.6
Liquefied petroleum gas	65.5		1	0.6
Heavy fuel oil (including petrolkoks)	NO		NO	NO
Coal	NO		NO	NO
Natural gas	55.0		6	0.1
1A2fi Other				
Light fuel oil	73.7		1	0.6
Liquefied petroleum gas	65.5		1	0.6
Heavy fuel oil (including petrolkoks)	83.6		2.7	1.2
Coal	94.6		1.3	1.6
Natural gas	55.0		6	0.1
Biomass		88.7	5.5	1.6
Other fuels (fossil waste derived fuel in cement industry)	68.6		NA	4
1A2fii Diesel and gasoline for construction and industrial machinery	73.6		2.1	2.8

In 1A2f Other, the CO_2 emission factor for coal (94.6 t/TJ in 2011) is an implied emission factor. The CO_2 emission factor for HFO is a weighted average emission factor for heavy fuel oil and petrolkoks.

The emission factors of the precursors NO_x, CO and NMVOC and SO_2 of 1A2 are provided in Annex A3.1.3.

Bottom-up approach

By default, the same emission factors for CO_2, CH_4 and N_2O are used for the bottom-up as for the top-down approach, unless more specific information is available on emission factors. Following IPCC Tier 3, bottom-up emission factors for emissions other than CO_2, CH_4 or N_2O are based on production data (e.g. tons of cement or steel produced) or on fuel consumption. Implied emission factors for NO_x, CO, NMVOC and SO_2 for each of the categories (see Annex A3.1.3) were revised in order to gain a more coherent allocation of emissions to fuel consumption within the different processes.

The emission factors for CO_2 are country specific and based on measurements and analysis of fuel samples carried out by EMPA and Intertek (EMPA 1999; Intertek 2008; carbon emission factor documented in SFOE 2001, Table 45: p. 51; net calorific values on p. 61). For net calorific values see Annex A2.1.1.

The coal emission factor for CO_2 in source category 1A2f is an implied emission factor.

Emission factors for CH_4, CO and NMVOC are country specific based on measurements and data from industry and expert estimates, documented in the EMIS database (EMIS 2013/1A2a,1A2b,1A2d,1A2fi). They have been updated for the recent years by expert judgement. Emission factors for N_2O are determined by default values except for the waste incineration categories where country specific emission factors were applied (EMIS 2013/1A2a,1A2b,1A2d,1A2fi).

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

Table 3-23 Emission factors for sources in Iron and Steel 1A2a in 2011.

1A2a Iron and Steel (Coke, coal and gas)	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	t/TJ	kg/TJ		g/t iron			
Coke cupolas	91.4	10	1.6	67	11'000	40	1'500
	t/TJ	kg/TJ		g/t iron			
Coal cupolas	94	10	1.6	67	11'000	40	1'500
	t/TJ	kg/TJ		g/t steel			
Gas (steel plants)	55	6	0.1	75	0.5	2.8	0.7

Table 3-24 Emission factors for cement industry in 2011 (NO: not occurring). Source: EMIS data base (EMIS 2013/1A2f). Emission factors for CO_2 are fuel specific; they are the same as in the top-down approach (see Table 3-22).

Cement industry (part of 1A2f)	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	t/TJ	g/t cement					
Cement	fuel specific	NA	fuel specific	836	1'400	45	360

These cement fuel consumption emission factors describe emissions from average fuel mix (of liquid, solid, gaseous and waste derived fuels).

The consumption of Other fuels in 1A2 refers to the use of waste derived fuels in the cement industry. The following table provides an overview of the emission factors used. The NCVs and other characteristics of waste derived fuels are taken from FOEN internal data sources, EMIS 2013/1A2fi Zementwerke Feuerung as well as Hackl, A., Mauschitz, G. 2003.

Table 3-25 Emission factors and other characteristics of waste derived fuels (Other fuels) used in the cement industry. Sources: FOEN internal data sources, EMIS 2013/1A2fi Zementwerke Feuerung and calculations as documented in EMIS 2013/1A2fi

	NCV	**EF CO_2 Tot.**	**Fraction biomass-C**
Waste derived fuel	MJ/kg	kg CO_2/GJ	%
Waste oil	32.48	74.35	0
Sewage sludge (dried)	9.39	94.52	100
Wood	16.26	99.90	100
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
Animal meal	16.81	86.66	100
Mix of special waste with saw dust (CSS)	9.22	102.40	78
Waste coke from coke filters	23.70	97.00	0
Sawdust	16.26	99.90	100
Mixed industrial waste	18.34	74.00	0
Other fossil waste fuels	20.85	97.00	0
Agricultural waste / other biomass	12.72	110.00	100

The emissions of the mobile off-road sources (1A2f ii) are calculated by the same approach as for all other off-road categories. The emissions are calculated with a Tier 2 method. Some details of the emission modelling that hold for all off-road families are described in Annex A3.1.6 Off-road vehicles. Activity data and emission factors were updated and the emission calculation was carried out in a new database structured in analogy to the on-road database (INFRAS 2008).

The emission modelling is carried out for 1990, 1995, 2000, 2005, 2010, etc. For the GHG inventory the missing years are interpolated linearly by vehicle category. For the mobile sources diesel oil and gasoline are used as fuels and for industry there is consumption of some CNG reported for forklifts.

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 1990-2011 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 3-3.
- For SO_2 the emission factors are country specific and are given in Table Table A - 7 in Annex A2.2.
- The emission factors for all other gases are country specific and shown in Table A - 16 to Table A - 19 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 14 on page 104.

Activity data

Top-down approach

Activity data on fuel consumption (TJ) for "top-down" sources in category 1A2 (see Table 3-21 above) are based on aggregated fuel consumption data from the Swiss overall energy statistics (SFOE 2012) and energy-economic modelling. A detailed description of the modelling work for the disaggregation of fuel consumption to the level of 1A2a-f is provided in Annex A3.1.2. The resulting disaggregated fuel consumption data for 1990 to 2011 is provided in the table below.

Table 3-26 Activity data fuel consumption in 1A2 Manufacturing Industries and Construction 1990 to 2011; "Other Fuels" occur only in the category 1A2fi, where they refer to waste fuels in cement production as well as diesel and gasoline for construction and industrial machinery. The consumption of the waste fuels in cement production has been calculated (in TJ) bottom-up from the amount (in tons) of waste derived fuels used. Fuel consumption of mobile sources 1A2f has also been calculated bottom-up

Source	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
1A2 Manufacturing Industries and Constr. (Total)	TJ	89'186	93'478	90'213	90'111	90'378	94'102	92'778	92'228	95'031	95'360
Light fuel oil	TJ	19'197	23'417	23'457	23'240	21'863	23'282	24'358	25'382	26'447	28'346
Liquefied petroleum gas	TJ	4'495	5'236	4'723	4'542	4'683	4'684	4'866	5'789	6'157	6'664
Heavy fuel oil	TJ	20'141	18'276	17'137	15'396	16'249	14'822	12'036	10'019	10'796	8'634
Coal	TJ	12'982	10'902	7'550	6'246	6'342	6'875	5'219	4'014	3'359	3'282
Natural gas	TJ	19'024	21'731	23'239	25'906	26'507	28'474	29'066	29'761	30'473	30'297
Biomass	TJ	5'801	6'111	6'042	6'029	5'986	6'345	6'905	6'814	7'054	7'348
Other Fuels	TJ	7'547	7'807	8'066	8'752	8'748	9'620	10'327	10'448	10'746	10'787
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
Light fuel 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
Heavy fuel oil	TJ	346	350	364	370	367	131	128	139	151	7
Coal	TJ	433	347	328	259	263	289	247	253	273	271
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
Light fuel 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
Heavy fuel oil	TJ	0	0	0	0	0	0	0	0	0	0
Coal	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
Light fuel 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
Heavy fuel oil	TJ	1'434	1'193	851	796	654	693	561	383	256	315
Coal	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
Light fuel 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
Heavy fuel oil	TJ	5'250	4'904	4'136	3'667	3'228	3'061	2'867	2'885	2'739	2'023
Coal	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
Light fuel 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
Heavy fuel oil	TJ	1'160	1'009	810	705	553	466	405	284	221	184
Coal	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	46'786	48'772	45'093	45'297	46'549	50'913	48'852	49'466	52'371	53'528
Light fuel oil	TJ	5'565	7'947	8'987	8'527	9'403	10'477	9'488	11'644	13'241	12'493
Liquefied petroleum gas	TJ	3'099	3'701	3'196	3'092	3'135	3'387	3'538	4'244	4'492	4'808
Heavy fuel oil	TJ	11'951	10'821	10'977	9'858	11'447	10'471	8'075	6'327	7'429	6'106
Coal	TJ	12'549	10'555	7'221	5'987	6'079	6'586	4'972	3'761	3'086	3'011
Natural gas	TJ	2'359	3'729	2'314	4'575	3'192	5'385	6'990	7'754	7'934	10'670
Biomass	TJ	3'716	4'212	4'331	4'505	4'545	4'987	5'463	5'288	5'444	5'654
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	6'079	6'268	6'458	6'581	6'704	6'827	6'951

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	93'462	98'448	95'215	98'083	99'957	100'445	102'602	101'167	101'836	95'351
Light fuel oil	TJ	26'069	27'636	27'346	28'778	27'982	28'550	27'178	25'708	25'578	24'100
Liquefied petroleum gas	TJ	5'928	5'562	6'160	5'331	5'194	4'596	5'054	4'548	4'319	4'595
Heavy fuel oil	TJ	6'194	8'045	5'209	5'052	6'654	5'663	6'900	4'989	4'798	3'927
Coal	TJ	5'401	5'503	5'094	5'272	4'798	5'482	5'916	6'834	6'140	5'699
Natural gas	TJ	31'250	32'004	31'007	32'474	33'569	34'506	35'825	36'674	38'082	34'644
Biomass	TJ	7'194	7'381	7'518	7'962	8'067	8'244	8'316	8'710	8'621	7'831
Other Fuels	TJ	11'426	12'318	12'882	13'213	13'692	13'405	13'412	13'705	14'298	14'555
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
Light fuel 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
Heavy fuel oil	TJ	21	40	9	3	191	179	310	230	232	171
Coal	TJ	266	234	179	163	148	154	150	160	177	70
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
Light fuel 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
Heavy fuel oil	TJ	0	0	0	0	0	0	0	0	0	0
Coal	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
Light fuel 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
Heavy fuel oil	TJ	253	282	289	311	345	168	431	37	365	415
Coal	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
Light fuel 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
Heavy fuel oil	TJ	1'421	2'256	1'235	1'941	2'074	1'811	2'239	1'644	1'175	643
Coal	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
Light fuel 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
Heavy fuel oil	TJ	137	141	113	96	114	0	0	0	0	0
Coal	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
1A2f Other	TJ	52'621	55'454	54'669	54'795	56'971	57'253	58'486	59'358	62'073	59'250
Light fuel oil	TJ	12'491	13'708	14'420	15'650	15'333	16'441	15'557	15'948	16'216	13'973
Liquefied petroleum gas	TJ	4'141	3'844	4'141	3'536	3'475	3'002	3'132	2'787	2'687	2'761
Heavy fuel oil	TJ	4'362	5'326	3'562	2'701	3'930	3'505	3'919	3'078	3'025	2'698
Coal	TJ	5'135	5'269	4'915	5'109	4'650	5'327	5'765	6'674	5'963	5'629
Natural gas	TJ	9'566	9'056	8'972	8'510	9'853	9'382	10'460	10'554	12'586	11'804
Biomass	TJ	5'500	5'933	5'776	6'077	6'038	6'191	6'240	6'611	7'297	7'831
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	7'074	7'113	7'153	7'193	7'232	7'272	7'276	7'279	7'283	7'286

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

Source	Unit	2010	2011
1A2 Manufacturing Industries and Constr. (Total)	TJ	98'852	91'813
Light fuel oil	TJ	24'186	19'625
Liquefied petroleum gas	TJ	4'181	4'136
Heavy fuel oil	TJ	3'683	2'789
Coal	TJ	5'783	5'439
Natural gas	TJ	37'754	36'644
Biomass	TJ	7'909	7'573
Other Fuels	TJ	15'356	15'607
1A2a Iron and Steel	TJ	3'449	3'400
Light fuel oil	TJ	327	322
Liquefied petroleum gas	TJ	327	338
Heavy fuel oil	TJ	149	1
Coal	TJ	76	88
Natural gas	TJ	2'569	2'652
Biomass	TJ	0	0
Other Fuels	TJ	0	0
1A2b Non-Ferrous Metals	TJ	1'175	1'215
Light fuel oil	TJ	157	136
Liquefied petroleum gas	TJ	12	12
Heavy fuel oil	TJ	0	0
Coal	TJ	0	0
Natural gas	TJ	1'007	1'067
Biomass	TJ	0	0
Other Fuels	TJ	0	0
1A2c Chemicals	TJ	13'755	12'729
Light fuel oil	TJ	3'276	3'030
Liquefied petroleum gas	TJ	311	311
Heavy fuel oil	TJ	217	3
Coal	TJ	0	0
Natural gas	TJ	9'952	9'385
Biomass	TJ	0	0
Other Fuels	TJ	0	0
1A2d Pulp, Paper and Print	TJ	4'599	4'339
Light fuel oil	TJ	478	349
Liquefied petroleum gas	TJ	91	92
Heavy fuel oil	TJ	83	1
Coal	TJ	0	0
Natural gas	TJ	3'947	3'897
Biomass	TJ	0	0
Other Fuels	TJ	0	0
1A2e Food Processing, Beverages and Tobacco	TJ	14'430	14'437
Light fuel oil	TJ	5'723	5'520
Liquefied petroleum gas	TJ	984	1'008
Heavy fuel oil	TJ	0	0
Coal	TJ	0	0
Natural gas	TJ	7'723	7'909
Biomass	TJ	0	0
Other Fuels	TJ	0	0
1A2f Other	TJ	61'443	55'692
Light fuel oil	TJ	14'224	10'267
Liquefied petroleum gas	TJ	2'455	2'375
Heavy fuel oil	TJ	3'234	2'784
Coal	TJ	5'707	5'351
Natural gas	TJ	12'558	11'735
Biomass	TJ	7'909	7'573
Other Fuels	TJ	8'066	8'350
1A2fii Diesel and gasoline for construction and industrial machinery	TJ	7'290	7'258

The table above documents the increase of natural gas consumption for manufacturing industries by 93%, the increase of other fuels by 107%, the decrease of coal consumption by 58% and the decrease of heavy fuel oil of 86% respectively from 1990 to 2012. This is mainly due to the shift of fuel consumption in the cement production in Switzerland.

Since 1990, the consumption of coal and petroleum coke in the cement production reduced by 58% from 10'980 TJ to 4'564 TJ in 2011. On the other hand, the use of alternative fuels increased from 13% to 59% of fuel in the total process heat production. This shift in fuel mix is the reason for CO_2 emissions from the use of Liquid, Solid Gaseous and Other Fuels in category 1A2 being key categories regarding trend.

Bottom-up approach

Activity data on iron and steel production that is used to calculate bottom-up emissions from cupola furnaces in iron foundries and reheating furnaces in steel plants is based on data from EMIS 2013/1A2a.

Table 3-27 Activity data: Production in Iron and Steel that is used to calculate bottom-up emissions from sources in 1A2a (EMIS 2013/1A2a).

Source/production	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A2a Iron and Steel											
Iron foundries: cupol ovens	Gg	90	72	68	54	55	60	51	53	57	56
Steel plants: reheating furnaces	Gg	1'108	1'155	1'245	1'276	1'230	716	738	789	880	918

Source/production	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1A2a Iron and Steel											
Iron foundries: cupol ovens	Gg	55	49	37	34	31	32	31	33	37	15
Steel plants: reheating furnaces	Gg	1'022	1'048	1'125	1'142	1'226	1'158	1'252	1'264	1'312	933

Source/production	Unit	2010	2011
1A2a Iron and Steel			
Iron foundries: cupol ovens	Gg	16	18
Steel plants: reheating furnaces	Gg	1'217	1'320

The table above documents the activity data of the iron and steel production. It shows the decrease of the emissions in iron foundries by 80% and the increase of emissions in steel plants by 19% between 1990 and 2011.

Activity data on cement production have been received from the industry association cemsuisse (EMIS 2013/1A2fi Zementwerke Feuerung) (See Table 4-4 in Chapter 4.2.2 a).

The amount of waste derived fuels used in cement industry (in tons) is provided by the following table. Data has been collected from estimates by FOEN experts and cemsuisse (Cemsuisse 2012). The activity data is used to calculate CO_2 emissions from "Other fuels" in 1A2f. The following table provides an overview of fuel use in cement industry in energy units (TJ):

Table 3-28 Activity data: Overview on fuel use in cement industry.

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cement industry											
Cement, total incl. waste	TJ	15'833	13'842	12'571	11'191	12'738	12'102	10'411	9'915	9'721	9'716
Cement fossil without waste	TJ	13'959	11'941	10'644	8'812	10'596	9'323	7'090	6'657	6'350	6'487
HFO	TJ	2'807	3'627	4'427	3'763	5'569	3'655	4'057	3'446	3'578	3'726
Coal	TJ	10'790	8'300	6'150	5'000	5'000	5'500	3'000	3'200	2'710	2'640
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 distillation	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 saw dust (CSS)	TJ	23	14	5	51	147	136	111	100	118	132
Waste coke from coke filters	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 biomass	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	10'446	10'983	10'662	10'396	11'132	10'814	9'829	10'232	10'358	10'437
Cement fossil without waste	TJ	6'760	6'482	5'659	5'137	5'365	5'399	4'510	5'124	4'793	4'748
HFO	TJ	1'989	1'521	1'668	807	1'269	1'275	1'123	1'087	1'171	1'094
Coal	TJ	4'750	4'950	3'980	4'330	4'080	4'120	3'383	4'033	3'618	3'650
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 distillation	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 saw dust (CSS)	TJ	158	130	116	114	163	133	146	164	157	131
Waste coke from coke filters	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 biomass	TJ	0	0	0	0	0	0	0	5	2	7

Source	Unit	2010	2011
Cement industry			
Cement, total incl. waste	TJ	12'123	12'476
Cement fossil without waste	TJ	6'013	6'148
HFO	TJ	1'242	1'182
Coal	TJ	4'750	4'950
Gas	TJ	21	16
Cement, waste derived fuel	TJ	6'109	6'329
Waste oil	TJ	1'253	1'170
Sewage sludge (dried)	TJ	477	483
Wood	TJ	292	409
Solvents and residues from distillation	TJ	1'189	1'264
Waste tyres and rubber	TJ	842	1'033
Plastics	TJ	1'252	1'163
Animal meal	TJ	624	614
Mix of special waste with saw dust (CSS)	TJ	123	96
Waste coke from coke filters	TJ	0	0
Sawdust	TJ	6	24
Mixed industrial waste	TJ	0	0
Other fossil waste fuels	TJ	45	55
Agricultural waste / other biomass	TJ	7	18

The table above documents the activity data of the cement industry. It shows the decrease of the consumption of fossil fuels by 56% and the increase of waste derived fuel by 237% between 1990 and 2011.

Underlying data for the activity data on mobile off-road sources (1A2f) like vehicle stock and operating hours are shown in Table A - 25 to Table A - 27 in Annex A3.1.6.

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 1-13).

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 2011 are compared with the results 2010 within the current CRF.
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of last year submission 2012.
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of last year submission 2012.

In 2012, the emission factors of category 1A2 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 values if available (INFRAS 2012). The emission factor for N_2O from Biomass is lower than the mean value of the other countries and the default emission factor from IPCC (see also section 3.2.5.3). The emission factors of CO_2 and N_2O of Other Fuels are also slightly different from the mean values of other countries emission factors.

3.2.7.5 Source-Specific Recalculations

- 1A: The activity data of all fuels of the overall time series have been recalculated based on the new data from SFOE 2012.
- 1A: The activity data of wood consumption have been recalculated for the overall time series based on the new data from SFOE 2012b.
- 1A: Activity data of sewage gas out of purification plants has changed between 2000 and 2007.
- 1A: The emission factor of bituminous coal has changed because it was weighted with P-Coke before.
- The activity data of LFO and LPG have been recalculated for the periods 1995 - 2010, respectively 2007 and 2010 based on changes in the energy consumption of Liechtenstein.
- A new study of Prognos (2012) led to recalculations of the whole time series of the activity data of the industry energy consumption. While the total energy consumption in

Switzerland remains unchanged, the allocation to the different subcategories has changed due to the new study. This concerns particularly sector 1A2 and 1A4a.

- A new study of Prognos (2012) led to recalculations of the actvitiy data for LFO and LPG and permitted to eliminate the weighted emission factor of LFO and LPG. Now, the two fuels are listed separately.
- The emission factor of the cellulose burning has been adapted.
- Activity data has been corrected for wood waste consumtion over the whole time series in order to eliminate double counting in chipboard-fibreboard and cement production.
- Activity data in brick and tile production has been corrected for wood consumption for 2000 - 2010.
- Activity data and emission factor of coal consumption of the iron and steel industry has been recalculated for the whole time series based on the elimination of the former split into anthracite and petroleum coke. Now the entire coal consumption is attributed to anthracite.
- Activity data and emission factors of the chipboard-fibreboard production has been recalculated for the whole time series based on the inclusion of the activity data of the second fibre board production plant. The emission factors have been adjusted.
- Emission factors for all air polluants of industrial engines have been introduced for the whole time series.
- Activity data and emission factors of the cement industry have been recalculated for the whole time series.. Emission factor for CO_2 of alternative fuels have been slightly adapted due to non-rounded values. Activity data has been adapted for 1990 - 2003 and 2007 - 2010 based on changes in the net calorific value of alternative fuels, respectively corrected data.

3.2.7.6 Source-Specific Planned Improvements

No planned improvements are foreseen in this category.

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)
CH_4 from the combustion of Gasoline (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)

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 3-29 Specification of Swiss source category 1A3 "Transport".

1A3	Transport	Specification	Data Source
1A3a	Civil Aviation (National)	Large (jet, turboprop, business jet) and small (piston) aircrafts, helicopters	AD: SFOE 2012, FOCA 2006, 2006a, 2007, 2008, 2009, 2010, 2011, 2012.
1A3b	Road Transportation	Light and heavy motor vehicles, coaches, two-wheelers	AD: SFOE 2012, Method, EF: FOEN 2010i, Hausberger et al. 2009, EEA 2010, INFRAS 2010
1A3c	Railways	Diesel locomotives	Method, AD, EF: INFRAS 2008
1A3d	Navigation (National)	Passenger ships, motor and sailing boats on the Swiss lakes	Method, AD, EF: INFRAS 2008
1A3e	Pipeline Transportation	Compressor station in Ruswil, Lucerne.	AD: SFOE 2012, SGWA 2005, SGIA 2012, Swissgas 2008 EF: Battelle 1994, Xinmin 2004, SGWA 2007

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 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 3-8.

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.

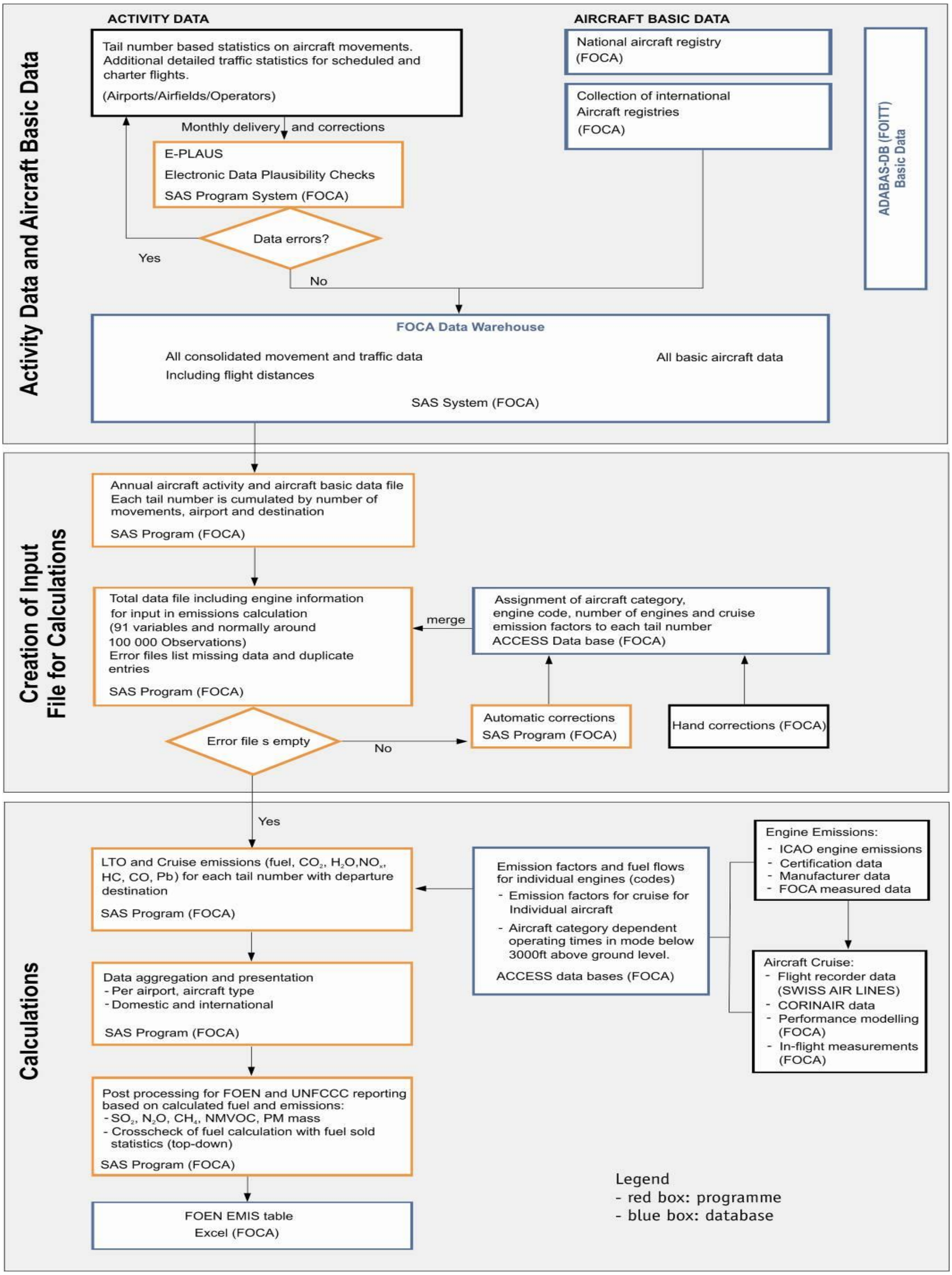

Figure 3-8 Modelling scheme (activity data, emission factors, emissions) for civil aviation.

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, 2004–2011. 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 3-3). 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)[6]. For CH_4, the average emission factor for domestic flights is 2.0 kg/TJ in 2011 average LTO is 3.8 kg/TJ, cruise 0.70 kg/TJ (FOCA 2010).
- N_2O: The IPCC default value 2.3 kg/TJ is used for the whole period 1990-2011 (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 1990–2011 (IPCC 1997c, chp 1.4.2.6)

Precursors (country specific; CORINAIR):

- Assignment of emission factors for the 1990 and 1995: The fleet that operated in and from Switzerland during those years has been analysed. The corresponding most frequent engines within an aircraft category (ICAO Code) have been assigned to every aircraft type.
- Assignment of emission factors for the year 2000, 2002, 2004 to 2011: 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 “Aircraft Engine Combinations”).

FOCA determines the emission factors of NO_x, VOC, CO and further pollutants as follows:

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).

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6 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.

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 450’690 aircraft movements in the total of scheduled and charter traffic in 2011 as given by FOCA 2012).

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).
- Helicopters: The movements are taken from "Unternehmensstatistik der Schweizer Helikopterunternehmen” (FOCA 2004), which is updated annually. From fleet composition data, a split of 87% single engine helicopters and 13% twin engine helicopter can be derived. Note that all emissions from helicopter are considered domestic. There is a helicopter base in the Principality of Liechtenstein consuming a certain very small amount of fuel contained in the Swiss statistics. Thus, its consumption leads to domestic instead of international bunker emissions (about 0.4 Gg CO_2). FOCA and FOEN decided to report these emissions as Swiss-domestic since it is a very small amount and the effort for a separation would be considerable.
  In 2007, the determination of the activity data has been changed to electronical transmission and plausibility checks (software E-Plaus). Due to a higher resolution, the number of helicopter movements increased statistically (not in real-world) leading to an overestimation of the helicopter emissions since then and improvements are about to be implemented. However, the development of detailed helicopter emissions modelling has to be considered as fine tuning, given the fact that helicopter emissions usually represent an order of 0.1% of the civil aviation total emissions.

Fuel consumption: Table 3-30 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 2012) while the consumptions of military aircraft and of Liechtenstein's helicopter consumption is subtracted (see Section 3.1.5). 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 3-30 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 2007a, 2007, 2008, 2009, 2010, 2011).

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%

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%

Civil Aviation	2010	2011
	F. c. in TJ	
Total domestic (1A3aii)	1'688	1'808
Total international (1A3ai)	58'118	64'060
Sum	59'805	65'868
1990 = 100%	132%	145%

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)
CH_4 from the combustion of gasoline (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)

CO_2

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 3-3). 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 2012).

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 2012) the Swiss renewable energy statistics (SFOE 2012a) and the Swiss Federal Customs Administrations (SFCA 2008, 2012).

Other gases

The other gases are modelled with a well-documented country specific method (SAEFL 1995, 2004, 2004a, FOEN 2010i, INFRAS 2010, 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),

Data collection: Activity data

The activity data is derived from different data sources:

- Vehicle stock: The Federal vehicle registration database (SFSO 2012b) supplies the number of vehicles (including age distributions) per vehicle category[7]. 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).
- 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).
- Numbers of starts/stops: Derived from vehicles stock, with data on trip length distributions and parking time distributions (ARE/SFSO 2005).

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7 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.

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[8]). 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 (see Table 3-3). 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 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). The latest version (3.1) is presented and documented on the website http://www.hbefa.net/. Several reports may be downloaded from there:

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

- 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 table gives a selection of mean emission factors. The CO_2 factors are constant over the whole period 1990–2011. 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 the current submission, 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 chapter 16.

For the first time, in this submission N_2O emission factors for gaseous fuels are used. 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 and vegetable/waste oil: The implied emission factors 1A3b for fossil diesel are used. Values for 2011:

  CO_2 73.6 t/TJ; CH_4 0.31 kg/TJ; N_2O 2.17 kg/TJ
- Bio ethanol: The implied emission factors 1A3b for gasoline are used. Values for 2011:

  CO_2 73.9 t/TJ; CH_4 5.96 kg/TJ; N_2O 0.92 kg/TJ
- Biogas: The implied emission factors 1A3b for CNG are used. Values for 2011:

  CO_2 55.0 t/TJ; CH_4 5.35 kg/TJ; N_2O 8.37 kg/TJ

Table 3-31 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									
CO2	Gasoline	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9
	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
	CNG										
CH4	Gasoline	0.0279	0.0253	0.0229	0.0210	0.0190	0.0175	0.0162	0.0149	0.0138	0.0128
	Diesel	0.0015	0.0015	0.0013	0.0012	0.0013	0.0012	0.0011	0.0010	0.0009	0.0009
	CNG										
N2O	Gasoline	0.0029	0.0032	0.0034	0.0036	0.0038	0.0040	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
NOx	Gasoline	0.3758	0.3485	0.3174	0.2951	0.2809	0.2723	0.2631	0.2509	0.2390	0.2264
	Diesel	0.2524	0.2555	0.2459	0.2390	0.2451	0.2405	0.2395	0.2392	0.2409	0.2448
	CNG										
CO	Gasoline	3.4384	3.0624	2.6997	2.4135	2.1550	1.9628	1.7921	1.6424	1.5136	1.3998
	Diesel	0.3029	0.3051	0.2795	0.2617	0.2666	0.2493	0.2367	0.2189	0.2024	0.1865
	CNG										
NMVOC	Gasoline	0.5291	0.4740	0.4211	0.3791	0.3384	0.3071	0.2788	0.2540	0.2319	0.2122
	Diesel	0.0609	0.0618	0.0548	0.0505	0.0516	0.0470	0.0443	0.0408	0.0378	0.0351
	CNG										
SO2	Gasoline	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
	Diesel	0.0654	0.0607	0.0561	0.0467	0.0203	0.0159	0.0174	0.0165	0.0188	0.0207
	CNG										

Gas	Fuel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Passenger Cars		t/TJ									
CO2	Gasoline	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9
	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
	CNG								55.0	55.0	55.0
CH4	Gasoline	0.0118	0.0110	0.0101	0.0094	0.0087	0.0083	0.0076	0.0073	0.0068	0.0065
	Diesel	0.0008	0.0007	0.0006	0.0006	0.0005	0.0005	0.0004	0.0004	0.0004	0.0003
	CNG								0.0061	0.0057	0.0056
N2O	Gasoline	0.0037	0.0035	0.0032	0.0029	0.0017	0.0016	0.0014	0.0013	0.0012	0.0011
	Diesel	0.0016	0.0017	0.0018	0.0019	0.0020	0.0020	0.0021	0.0021	0.0021	0.0021
NOx	Gasoline	0.2141	0.2006	0.1843	0.1705	0.1580	0.1484	0.1307	0.1230	0.1110	0.1024
	Diesel	0.2525	0.2627	0.2731	0.2843	0.2895	0.2879	0.2751	0.2658	0.2588	0.2540
	CNG								0.0223	0.0222	0.0223
CO	Gasoline	1.3025	1.2337	1.1587	1.0977	1.0426	1.0073	0.9371	0.9049	0.8587	0.8234
	Diesel	0.1698	0.1523	0.1334	0.1219	0.1116	0.1016	0.0888	0.0826	0.0761	0.0717
	CNG								0.1578	0.1586	0.1592
NMVOC	Gasoline	0.1938	0.1803	0.1652	0.1523	0.1416	0.1350	0.1238	0.1194	0.1120	0.1072
	Diesel	0.0323	0.0293	0.0261	0.0242	0.0223	0.0204	0.0177	0.0163	0.0149	0.0140
	CNG								0.0005	0.0005	0.0005
SO2	Gasoline	0.0067	0.0057	0.0048	0.0038	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
	Diesel	0.0127	0.0117	0.0110	0.0093	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
	CNG								0.0000	0.0000	0.0000

Gas	Fuel	2010	2011
Passenger Cars		t/TJ	
CO2	Gasoline	73.9	73.9
	Diesel	73.6	73.6
	CNG	55.0	55.0
CH4	Gasoline	0.0062	0.0060
	Diesel	0.0003	0.0003
	CNG	0.0055	0.0054
N2O	Gasoline	0.0010	0.0009
	Diesel	0.0021	0.0022
NOx	Gasoline	0.0946	0.0872
	Diesel	0.2503	0.2474
	CNG	0.0224	0.0225
CO	Gasoline	0.7925	0.7654
	Diesel	0.0679	0.0647
	CNG	0.1578	0.1545
NMVOC	Gasoline	0.1031	0.0997
	Diesel	0.0133	0.0128
	CNG	0.0005	0.0005
SO2	Gasoline	0.0004	0.0004
	Diesel	0.0005	0.0005
	CNG	0.0000	0.0000

Table 3-32 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									
CO2	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH4	Diesel	0.0018	0.0018	0.0018	0.0017	0.0016	0.0016	0.0016	0.0015	0.0014	0.0013
N2O	Diesel	0.0007	0.0007	0.0008	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009
NOx	Diesel	1.026	1.024	1.021	1.011	0.982	0.950	0.929	0.916	0.906	0.898
CO	Diesel	0.215	0.215	0.214	0.210	0.203	0.198	0.193	0.187	0.181	0.175
NMVOC	Diesel	0.074	0.073	0.073	0.071	0.067	0.065	0.064	0.060	0.058	0.055
SO2	Diesel	0.065	0.061	0.056	0.047	0.020	0.016	0.017	0.016	0.019	0.021

Gas	Fuel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Heavy duty vehicles		t/TJ									
CO2	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH4	Diesel	0.0013	0.0011	0.0010	0.0010	0.0009	0.0008	0.0008	0.0007	0.0005	0.0005
N2O	Diesel	0.0009	0.0009	0.0008	0.0008	0.0007	0.0007	0.0009	0.0013	0.0019	0.0022
NOx	Diesel	0.878	0.835	0.796	0.758	0.717	0.698	0.665	0.623	0.550	0.513
CO	Diesel	0.168	0.160	0.156	0.155	0.149	0.149	0.146	0.144	0.140	0.139
NMVOC	Diesel	0.051	0.045	0.042	0.039	0.035	0.034	0.031	0.027	0.022	0.019
SO2	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
Heavy duty vehicles		t/TJ	
CO2	Diesel	73.6	73.6
CH4	Diesel	0.0004	0.0004
N2O	Diesel	0.0025	0.0027
NOx	Diesel	0.483	0.457
CO	Diesel	0.137	0.137
NMVOC	Diesel	0.017	0.015
SO2	Diesel	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 2012). 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 3-33 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
						PJ					
Gasoline											
on-road consumption (model)	1A3b	137.2	140.7	139.0	135.7	138.7	141.8	143.2	143.6	144.5	145.8
"tank tourism"	1A3b	16.2	19.2	26.7	17.8	15.0	7.2	9.7	15.3	15.7	19.9
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	36.6	37.6	38.5	38.3	39.2	40.0	39.8	40.2	41.3	42.9
"tank tourism"	1A3b	-1.5	-2.0	-4.7	-6.4	-4.8	-5.0	-7.9	-6.6	-6.0	-4.9
off-road consumption (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	10.9	11.1	11.4	11.6	11.9	12.1	12.3	12.5	12.6	12.8
Diesel sold in Switzerland		46.0	46.7	45.2	43.5	46.2	47.2	44.2	46.0	47.9	50.9
Total											
on-road consumption (model)	1A3b	173.8	178.2	177.5	174.0	177.9	181.8	183.0	183.7	185.8	188.7
"tank tourism"	1A3b	14.7	17.2	22.1	11.5	10.2	2.2	1.8	8.6	9.7	15.1
off-road consumption (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	13.3	13.5	13.8	14.0	14.2	14.5	14.6	14.8	15.0	15.1
Gasoline and Diesel sold in Switzerland		201.8	208.9	213.3	199.4	202.3	198.4	199.4	207.2	210.4	218.8

Activity data	Source category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
						PJ					
Gasoline											
on-road consumption (model)	1A3b	147.3	145.8	144.7	142.0	138.9	135.7	131.5	128.2	125.3	122.6
"tank tourism"	1A3b	18.5	15.3	13.3	15.3	15.5	14.0	13.6	15.5	15.2	14.0
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	2.1	2.1	2.1	2.1
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		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
on-road consumption (model)	1A3b	45.0	46.0	47.6	50.7	54.2	57.6	61.1	65.3	68.1	71.3
"tank tourism"	1A3b	-3.6	-3.6	-3.2	-3.0	-1.9	0.7	3.1	4.7	10.3	8.6
off-road consump. (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	13.0	13.1	13.1	13.2	13.3	13.3	13.3	13.4	13.4	13.4
Diesel sold in Switzerland		54.4	55.5	57.5	61.0	65.6	71.6	77.6	83.4	91.8	93.3
Total		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
on-road consumption (model)	1A3b	192.3	191.8	192.3	192.7	193.1	193.3	192.6	193.5	193.4	194.0
"tank tourism"	1A3b	14.9	11.8	10.1	12.3	13.6	14.7	16.7	20.2	25.5	22.6
off-road consump. (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	15.3	15.3	15.4	15.4	15.4	15.5	15.5	15.5	15.5	15.5
Gasoline and Diesel sold in Switzerland		222.4	218.9	217.7	220.4	222.2	223.5	224.8	229.1	234.4	232.1

Activity data	Source category	2010	2011
		PJ	
Gasoline			
on-road consumption (model)	1A3b	119.7	116.4
"tank tourism"	1A3b	12.0	10.2
off-road consump. (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	2.1	2.0
Gasoline sold in Switzerland		133.8	128.7
Diesel		0.0	0.0
on-road consumption (model)	1A3b	74.4	77.2
"tank tourism"	1A3b	9.2	9.0
off-road consump. (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	13.4	13.4
Diesel sold in Switzerland		97.0	99.7
Total		0.0	0.0
on-road consumption (model)	1A3b	194.2	193.6
"tank tourism"	1A3b	21.2	19.3
off-road consump. (models)	1A2fii;1A3aii,c,d,e;1A4aii,bii,cii;1A5	15.5	15.4
Gasoline and Diesel sold in Switzerland		230.9	228.3

Biofuels	1990-96	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
								TJ								
Biodiesel	0	57.2	51.4	48.3	56.4	60.4	55.0	72.3	100.7	196.4	272.7	304.7	368.2	232.0	287.9	316.8
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
Biogas	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	32.4	36.4	40.6	44.7
Sum	0	57.2	51.4	48.3	56.4	60.4	55.0	72.3	100.7	215.4	295.0	381.9	469.8	299.7	383.1	446.8
Share of total fuel consump. 1A3b	0%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.4%	0.5%	1.1%	1.5%	2.0%	2.4%	1.5%	2.0%	2.3%

Further activity data needed for modelling the non-CO_2 emissions are the mileages (vehicle kilometres) per vehicle category in Table 3-34.

Table 3-34 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	43'280	44'639	45'567	46'138	47'056	48'166
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	50'074	51'538	52'443	53'115	54'178	55'503
(1990=100%)	100%	102%	101%	99%	101%	104%	106%	107%	109%	112%

Veh. category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	million vehicle-km									
PC	49'552	49'986	50'860	51'655	52'532	53'354	53'979	54'876	55'850	56'643
LDV	2'978	3'059	3'119	3'149	3'215	3'300	3'375	3'473	3'529	3'570
HDV	2'273	2'165	2'109	2'115	2'144	2'127	2'189	2'203	2'223	2'264
Coaches	99	95	93	95	98	106	118	120	114	120
Urban Bus	200	205	211	215	220	229	233	240	245	247
2-Wheelers	1'999	2'048	2'098	2'152	2'190	2'204	2'262	2'300	2'366	2'387
Sum	57'101	57'558	58'490	59'382	60'399	61'321	62'156	63'211	64'326	65'231
(1990=100%)	115%	116%	118%	119%	122%	123%	125%	127%	129%	131%

Veh. category	2010	2011
	million vehicle-km	
PC	57'419	57'950
LDV	3'607	3'641
HDV	2'304	2'340
Coaches	119	119
Urban Bus	250	252
2-Wheelers	2'409	2'431
Sum	66'108	66'733
(1990=100%)	133%	134%

In 2011, 86.8% of total vehicle kilometres are driven by passenger cars, 5.5% and 3.5% by light and heavy duty vehicles, respectively. The mileages increased for all vehicle categories (except coaches), totalling 34% in the period 1990–2011. In the same period, fuel consumption increased less strongly, by 13.1%, indicating improved fuel efficiency. This effect is also reflected in Table 3-35 that depicts the specific fuel consumption per vehicle-km. For most vehicle categories, the specific consumption has decreased in the period 1990-2011 (between 3% and 23%). Consumption of light duty vehicles remained indifferent while two-wheelers (21%) have increased their average specific consumption. Concerning the whole car fleet, a decrease of 17% in specific consumption has been reached between 1990 and 2011.

Table 3-35 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	3.21	3.23	3.23	3.24	3.23	3.22	3.20	3.18	3.15	3.12
	Diesel	2.91	2.91	2.91	2.97	2.89	2.89	2.88	2.89	2.87	2.83
	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	10.99	11.04	11.07	11.02	11.07	10.93	10.79	10.65	10.53	10.46
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	3.09	3.06	3.04	3.01	2.97	2.94	2.89	2.86	2.82	2.78
	Diesel	2.77	2.69	2.62	2.54	2.47	2.40	2.36	2.34	2.30	2.28
	CNG								2.60	2.56	2.53
LDV	gasoline	3.18	3.17	3.18	3.19	3.19	3.19	3.21	3.21	3.20	3.20
	Diesel	3.75	3.71	3.63	3.56	3.48	3.42	3.37	3.34	3.32	3.31
HDV	Diesel	10.38	10.66	10.71	10.74	10.73	10.91	10.85	10.86	10.78	10.72
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	14.98
	CNG								20.95	21.02	20.95
2-Wheeler	gasoline	1.25	1.25	1.24	1.25	1.27	1.28	1.29	1.31	1.33	1.34
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
		MJ/veh-km	
PC	gasoline	2.75	2.72
	Diesel	2.26	2.24
	CNG	2.51	2.48
LDV	gasoline	3.19	3.18
	Diesel	3.31	3.31
HDV	Diesel	10.67	10.63
Coach	Diesel	11.16	11.15
Urban Bus	Diesel	14.93	14.88
	CNG	20.88	20.82
2-Wheeler	gasoline	1.34	1.34
Average		**2.89**	**2.86**
		84%	**83%**

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 3-36 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	4'047
LDV	260	268	274	278	284	291	298	307	312	317
2-Wheelers	732	740	753	763	771	770	784	789	806	809
	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
PC	4'102	4'140
LDV	321	324
2-Wheelers	812	816
PC	2.34	2.34
LDV	1.96	1.96
2-Wheelers	1.57	1.57

c) Railways (1A3c)

The entire Swiss railway system is electrified. Electric locomotives are used in passenger as well as freight railway traffic. Diesel locomotives are used for shunting purposes in marshalling yards and for construction activities only.

The complete revision of the emissions of the whole off-road sector that began in 2005 was completed in 2008. The emissions of all off-road categories like railways, navigation etc. are modelled by the same approach. The emissions are calculated with a Tier 2 method. Some details of the emission modelling that hold for all off-road families are described in Annex A3.1.6 Off-road vehicles. Activity data and emission factors were updated and the emission calculation was carried out in a new database structured in analogy to the on-road database (INFRAS 2008). Emissions are calculated for the years 1990, 1995, 2000, 2005, 2010 etc. up to 2020. For the years in-between, the emissions are interpolated linearly.

Emission Factors

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

- The emission factor for CO_2 is country specific and assumed to be constant in the period 1990-2011 with value 73.6 t/TJ (diesel oil, see Table 3-3, SFOE 2001).
- For SO_2 the emission factors are country specific. They are depicted in Table A - 7 in Annex A2.2, 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 - 20 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)[9].

Activity data

The fuel consumption is calculated by using the formula given above for the emission modelling. Instead of the emission factor, consumption factors are used (see Table A - 17). 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). The resulting fuel consumption is shown in Table 3-37.

Table 3-37 Activity data (diesel oil consumption) for railways.

Railways	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Diesel	TJ	390	400	410	420	430	441	444	447	449	452
1990=100%		100.0%	102.6%	105.2%	107.8%	110.4%	113.0%	113.8%	114.6%	115.3%	116.1%

Railways	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Diesel	TJ	455	461	467	473	478	484	490	496	502	507
1990=100%		116.8%	118.3%	119.8%	121.3%	122.7%	124.2%	125.7%	127.2%	128.7%	130.2%

Railways	Unit	2010	2011
Diesel	TJ	513	518
1990=100%		131.6%	132.9%

d) Navigation (1A3d)

The complete revision of the emissions of the whole off-road sector that began in 2005 was completed in 2008. The emissions of all off-road categories like railways, navigation etc. are modelled by the same approach. The emissions are calculated with a Tier 2 method. Some details of the emission modelling that hold for all off-road families are described in Annex A3.1.6 Off-road vehicles. Activity data and emission factors were updated and the emission calculation was carried out in a new database structured in analogy to the on-road database (INFRAS 2008).

There are passenger ships, dredgers, fishing boats, motor and sailing boats on the lakes of Switzerland and on the river Rhine. Every boat is registered at the cantonal authorities. The emissions are calculated for the years 1990, 1995, 2000, 2005, 2010 etc. up to 2020. For the years in-between, the emissions are interpolated linearly.

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 1990-2011 with value 73.6 t/TJ for diesel oil, 73.9 t/TJ for gasoline and 73.7 t/TJ for gas oil (Table 3-3, SFOE 2001).
- For SO_2 the emission factors are country specific and are given in Table A - 7 in Annex A2.2 (diesel oil, gasoline, gas oil).

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

- The emission factors for all other gases are country specific and are shown in Table A - 21 to Table A - 24 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 9 on previous page.

Activity data

The numbers of vehicles and of operating hours are given in Annex A3.1.6 (INFRAS 2008). Table 3-38 shows the domestic fuel consumption. In 2011, the fuel-split was 52%, 38% and 10% for diesel oil, gasoline and gas oil.

Table 3-38 Fuel consumption of (domestic) navigation.

Navigation	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Diesel	TJ	705	703	701	698	696	694	708	723	738	753
Gasoline	TJ	701	692	682	673	664	654	647	639	631	623
Gas oil	TJ	110	116	122	127	133	139	141	142	144	145
Sum	TJ	1'517	1'511	1'505	1'499	1'493	1'487	1'496	1'504	1'513	1'521
1990 = 100%		100%	100%	99%	99%	98%	98%	99%	99%	100%	100%

Navigation	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Diesel	TJ	767	771	776	780	784	788	795	801	808	814
Gasoline	TJ	616	614	613	612	611	609	609	608	608	607
Gas oil	TJ	147	150	152	155	157	160	160	160	160	160
Sum	TJ	1'530	1'535	1'541	1'547	1'552	1'558	1'563	1'569	1'575	1'581
1990 = 100%		101%	101%	102%	102%	102%	103%	103%	103%	104%	104%

Navigation	Unit	2010	2011
Diesel	TJ	821	828
Gasoline	TJ	606	606
Gas oil	TJ	160	160
Sum	TJ	1'587	1'594
1990 = 100%		105%	105%

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.

Emission Factors

The emission factors for 1A3e are calculated for each year separately based on expert judgement.

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 2011; Table 13).

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: Uncertainty in CH_4 and N_2O emission factors for gasoline and diesel vehicles 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 are 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 (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 burn, total distance, number of passenger (without freight) per aircraft type, the fuel consumption per 100 passenger km has been calculated (backward calculation). The result of 2 to 10 kg fuel/100 passenger km is in line with expectations for 1990 passenger fleets.
- The implied emission factors were calculated for 2011 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.

- 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 98.4% (2011) 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 86.6% (2011) compared to the amount sold.

3.2.8.5 Source-Specific Recalculations

- 1A3a: an error in the number of occurrences of fuel dumping in the activity data for 2010 has been corrected.
- 1A3b: the share of biogenic fuel use has been subtracted from the on-road activity data modelled with the handbook of emission factors (INFRAS 2010) in order to avoid double-counting, as the use of biogenic fuels is also separately accounted for. The entire time-series 1990-2010 has been recalculated.
- 1A3b: activity data on the use of biogenic fuels for the time-series 1997-2010 have been updated.
- 1A3b: For diesel and gasoline, 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 this submission, in contrast to previous submissions that applied a constant value in g/TJ fuel consumption. This results in a more pronounced change pattern over time of N_2O emissions from road transportation than in earlier submissions.
- 1A3b: A new EF of N_2O for gaseous fuels is used 1990-2010 in accordance with the default value provided in the IPCC Guidelines 2006 (IPCC 2006).
- 1A3e: Activity data from SFOE (2012) on fuel consumption of the gas pipeline compressor station in Ruswil for 1990-2010 have been updated.

3.2.8.6 Source-Specific Planned Improvements

Civil Aviation (1A3a): For the years to come, efficiency improvements in the fuel consumption of large aircrafts will be considered in the modelling approach in order to avoid overestimation of consumption.

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 3-39 Specification of source category 1A4 “Other sectors”.

1A4	Source	Specification	Data Source
1A4a	Commercial/ Institutional	Emission from fuel combustion in commercial and institutional buildings and from professional gardening off-road machinery and motorised equipment	AD: SFOE 2012, SFOE 2012b, Prognos, 2012, INFRAS 2008 EF: EMIS 2013/1A4 div., SAEFL 2000; SFOE 2001, IPCC 1997c, EMIS 2013/1 solid fuels/wood, INFRAS 2008
1A4b	Residential	Emissions from fuel combustion in households and from hobby gardening machinery and motorised equipment	AD: SFOE 2012, SFOE 2012b, INFRAS 2008 EF: EMIS 2013/1A4div., SAEFL 2000; SFOE 2001, IPCC 1997c, EMIS 2013/1A solid fuels/wood, INFRAS 2008
1A4c	Agriculture/ Forestry/ Fishing	Comprises fuel for wood combustion in Agriculture and Forestry and grass drying and off-road machinery in agriculture/forestry	wood combustion: AD: SFOE 2012b EF EMIS 2013/1A solid fuels/wood AD, EF: EMIS 2013/1A4ci off-road machinery: AD, EF INFRAS 2008

3.2.9.2 Methodological Issues

a) Commercial/Institutional (1A4a) and Residential (1A4b)

For Fuel Combustion in Commercial and Institutional Buildings (1A4ai) and in Households (1A4bi), a country specific Tier 2 method is used. A top-down method based on aggregated fuel consumption data from the Swiss overall energy statistics is used to calculate emissions (SFOE 2012).

The wood fuel consumption is based on the Swiss wood energy statistics (SFOE 2012b). For the calculation of non-CO_2 emissions from the use of LFO and natural gas the following sources are differentiated: (α) heat only boilers, (β) combined heat and power production in turbines and (γ) combined heat and power production in engines.

Emissions of GHGs are calculated by multiplying levels of activity by emission factors. An oxidation factor of 100% is assumed for all combustion processes and fuels (see sub-section on oxidation factors in the beginning of Section 3.2.5.1).

For mobile off-road sources (1A4aii and 1A4bii) the emissions are calculated by the same approach as all other off-road categories. The emissions are calculated with a Tier 2 method. Some details of the emission modelling that hold for all off-road families are described in Annex A3.1.6 Off-road vehicles. Activity data and emission factors were updated and the emission calculation was carried out in a new database structured in analogy to the on-road database (INFRAS 2008). The emission modelling is carried out for 1990, 1995, 2000, 2005, 2010. For the GHG inventory, the missing years in-between the modelling years are interpolated linearly by vehicle category. Diesel oil and gasoline are used as fuels only.

Emission Factors

The emission factors for CO_2 are country specific and based on measurements and analysis of fuel samples carried out by EMPA and Intertek (EMPA 1999; Intertek 2008; carbon emission factor documented in SFOE 2001, Table 45: p. 51; net calorific values on p. 61. See also Annex A2.1.1).

Emission factors for CH_4, NO_x, CO, NMVOC and SO_2 for heat only boilers are country specific based on comprehensive life cycle analysis of combustion boilers, turbines and engines in the residential, commercial institutional and agricultural sectors, documented in SAEFL 2000 (pp. 42-56) and EMIS. For NO_x emission factors, expert judgement has been used to estimate the fraction of low-NO_x burners. The emission factors for NO_x and CO for natural gas and LFO have been recalculated for the entire time series based on a new study as documented in EMIS (EMIS 2013/1 Energy Model).

Emission factors for CH_4, NO_x, CO, NMVOC and SO_2 for combined heat and power generation in turbines and engines are country specific based on comprehensive measurements (EMIS 2013/1A4). CH_4 emission factors have been recalculated for the time series.

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

The coal emission factor for CO_2 (see table below) is the emission factor for hard coal.

Emission factors for biomass are based on SAEFL 2000 (pp. 26ff) and a study on wood use (EMIS 2013/1A solid fuels/wood). See also Chapter 3.2.5.3 about Wood firing.

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

Table 3-40 Emission Factors for 1A4a and 1A4b: Commercial/Institutional and Residential in “Other Sectors” for 2010.

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								
LFO (weighted average)	73.7		0	0.6	36	7	6	22
LFO (heat only boilers)	73.7		1	0.6	36	7	6	22
LFO (turbines)	NO		NO	NO	NO	NO	NO	NO
LFO (engines)	73.7		0	0.6	40	30	8	22
Natural gas (weighted average)	55		1.5	0.1	26	15	2	0.6
NG (heat only boilers)	55		0	0.1	19	11	2	0.5
NG (turbines)	55		2	0.1	60	15	0	0.5
NG (engines)	55		20	0.1	120	60	1	1.5
Coal	NO		NO	NO	NO	NO	NO	NO
Biomass (weighted average)		87.4	28.5	1.4	116	718	65	18
Biomass (wood)		91	31	1.6	125	787	72	20
Biomass (biogas)		55	6	0.1	19	11	2	0.5
Gasoline (gardening professional)	73.9		93	2.1	154	23'129	2'336	0.4
1A4 b Other Sectors: Residential								
LFO (weighted average)	73.7		1	0.6	38	13	6	22
LFO (heat only boilers)	73.7		1	0.6	38	13	6	22
LFO (turbines)	NO		NO	NO	NO	NO	NO	NO
LFO (engines)	73.7		2	0.6	40	31	8	22
Natural gas (weighted average)	55		6.2	0.1	18	14	2	0.5
NG (heat only boilers)	55		6	0.1	18	14	2	0.5
NG (turbines)	55		2	0.1	60	15	0	0.5
NG (engines)	55		20	0.1	38	59	1	1.5
Coal	94.0		300	1.6	65	2'000	100	350
Biomass		92	87	1.6	93	1'864	203	20
Gasoline (gardening)	73.9		51	2.4	152	23'804	1'653	0.4

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 1990-2011 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 3-3.
- For SO_2 the emission factors are country specific and are given in Table A - 7 in Annex A2.2.
- The emission factors for all other gases are country specific and shown in Table A - 16 to Table A - 19 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 9 above.

Activity Data

Activity data on fuel consumption for Commercial/Institutional and Residential (1A4a and b) correspond to the consumption of light fuel oil (including LPG), natural gas, coal and biogas in the categories “Services” (for 1A4a) and “Households” (for 1A4b) of the Swiss overall energy statistics (SFOE 2012; Table 17).

Activity data for Biomass use (wood) in 1A4a and 1A4b correspond to a study based on the data of the Swiss wood energy statistics (SFOE 2012b), as documented in the EMIS database (EMIS 2013/1A solid fuels/wood).

The amount of LFO and natural gas that is used for co-generation in turbines and engines is taken from Kaufmann (2008).

Table 3-41 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	83'055	90'367	90'329	88'855	82'691	84'960	91'569	87'604	90'681	86'967
Light fuel oil	TJ	62'404	67'247	66'258	63'774	58'018	58'113	62'635	59'966	61'971	58'661
LFO heat only boilers	TJ	62'380	67'196	66'200	63'718	57'896	57'937	62'404	59'678	61'673	58'334
LFO turbines	TJ	0	0	0	0	0	0	0	0	0	0
LFO engines	TJ	24	51	58	56	122	175	231	288	298	327
Natural gas	TJ	17'490	19'516	20'462	21'360	21'051	22'721	24'259	23'242	24'007	23'449
NG heat only boilers	TJ	17'214	19'080	19'902	20'734	20'228	21'550	22'848	21'777	22'404	21'739
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
Coal	TJ	0	0	0	0	0	0	0	0	0	0
Biomass	TJ	2'953	3'385	3'376	3'477	3'367	3'861	4'399	4'108	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	25	26	27	30	33	36	40	43	44	44
Gasoline (gardening professional)	TJ	208	220	232	243	255	266	277	288	299	309
1A4b Residential	TJ	186'575	198'896	198'533	189'729	178'783	192'834	200'469	186'011	192'191	189'004
Light fuel oil	TJ	138'916	145'507	145'175	136'252	128'901	137'597	139'992	131'915	136'508	131'838
LFO heat only boilers	TJ	138'915	145'506	145'173	136'251	128'900	137'593	139'961	131'877	136'459	131'785
LFO turbines	TJ	0	0	0	0	0	0	0	0	0	0
LFO engines	TJ	1	1	1	1	1	4	32	38	49	53
Natural gas	TJ	25'620	29'240	30'680	31'090	29'530	33'880	38'000	34'550	36'090	38'040
NG heat only boilers	TJ	25'560	29'138	30'536	30'922	29'326	33'622	37'693	34'237	35'740	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
Coal	TJ	589	680	471	480	435	417	236	199	127	127
Biomass	TJ	21'451	23'470	22'207	21'907	19'917	20'940	22'241	19'346	19'466	18'999
Gasoline (gardening)	TJ	145	147	150	153	155	158	160	162	164	167

Source/Fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1A4a Commercial/Institutional	TJ	84'792	88'535	83'055	87'279	86'505	87'626	82'441	74'206	79'636	76'706
Light fuel oil	TJ	55'633	57'653	54'099	56'570	54'789	54'789	51'228	44'408	47'420	44'793
LFO heat only boilers	TJ	55'282	57'285	53'747	56'237	54'464	54'472	50'934	44'226	47'251	44'640
LFO turbines	TJ	0	0	0	0	0	0	0	0	0	0
LFO engines	TJ	351	367	352	333	326	318	293	181	169	154
Natural gas	TJ	24'504	25'856	24'059	25'374	26'274	27'234	24'970	23'722	25'540	24'929
NG heat only boilers	TJ	22'767	24'050	22'149	23'378	24'307	25'202	23'018	21'796	23'682	23'116
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
Coal	TJ	0	0	0	0	0	0	0	0	0	0
Biomass	TJ	4'335	4'714	4'591	5'034	5'148	5'315	5'960	5'795	6'399	6'710
Biomass (wood)	TJ	4'289	4'660	4'530	4'966	5'065	5'202	5'779	5'508	6'042	6'310
Biomass (biogas)	TJ	46	54	60	68	83	113	181	288	357	400
Gasoline (gardening professional)	TJ	320	313	307	300	294	287	284	280	277	274
1A4b Residential	TJ	174'364	183'730	177'252	187'555	187'667	190'902	183'800	163'748	175'463	172'041
Light fuel oil	TJ	120'784	127'553	122'470	129'328	128'194	129'613	124'415	107'798	114'325	110'985
LFO heat only boilers	TJ	120'731	127'498	122'414	129'269	128'120	129'550	124'352	107'733	114'273	110'944
LFO turbines	TJ	0	0	0	0	0	0	0	0	0	0
LFO 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
Coal	TJ	118	118	118	118	362	362	362	362	362	362
Biomass	TJ	17'172	18'060	16'875	17'780	17'451	18'137	17'943	16'267	18'226	18'063
Gasoline (gardening)	TJ	169	167	164	162	160	158	155	153	151	149

Source/Fuel	Unit	2010	2011
1A4a Commercial/Institutional	TJ	82'720	69'642
Light fuel oil	TJ	47'933	39'294
LFO heat only boilers	TJ	47'779	39'140
LFO turbines	TJ	0	0
LFO engines	TJ	154	154
Natural gas	TJ	27'329	23'867
NG heat only boilers	TJ	25'515	22'053
NG turbines	TJ	26	26
NG engines	TJ	1'787	1'787
Coal	TJ	0	0
Biomass	TJ	7'189	6'214
Biomass (wood)	TJ	6'699	5'664
Biomass (biogas)	TJ	489	549
Gasoline (gardening professional)	TJ	270	268
1A4b Residential	TJ	186'546	149'919
Light fuel oil	TJ	118'021	92'151
LFO heat only boilers	TJ	117'979	92'109
LFO turbines	TJ	0	0
LFO engines	TJ	42	42
Natural gas	TJ	48'390	40'990
NG heat only boilers	TJ	47'852	40'452
NG turbines	TJ	0	0
NG engines	TJ	538	538
Coal	TJ	362	362
Biomass	TJ	19'772	16'415
Gasoline (gardening)	TJ	146	144

The table above documents the net increase from 1990 and 2011 of Natural Gas consumption by 36% (1A4a) and 60% (1A4b), and the net decrease of liquid fuel consumption by 37% (1A4a) and 34% (1A4b), for the same period. 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 Table A - 25 to Table A - 27 in Annex A3.1.6

b) Agriculture/Forestry (1A4c)

Emissions from all three sources are calculated bottom up. For grass drying, emission factors refer both to fuel consumption (in TJ) and production data (i.e. in tons of dried grass).

The emissions of all off-road categories like railways, navigation etc. are modelled by the same approach. The emissions are calculated with a Tier 2 method. Some details of the emission modelling that hold for all off-road families are described in Annex A3.1.6 Off-road Vehicles. Activity data and emission factors were updated and the emission calculation was carried out in a new database structured in analogy to the on-road database (INFRAS 2008). Emissions are calculated for the years 1990, 1995, 2000, 2005, 2010 etc. up to 2020. For the years in-between, the emissions are interpolated linearly.

An oxidation factor of 100% is assumed for all combustion processes and fuels (see sub-section on oxidation factors in Section 3.2.5.1).

For wood heating the emissions are calculated by multiplying the activity data by the emission factors.

Emission Factors drying of grass

The emission factors for CO_2 are country specific and based on measurements and analysis of fuel samples carried out by the Swiss Federal Laboratories for Materials Testing, Research EMPA and Intertek (EMPA 1999; Intertek 2008; carbon emission factor documented in SFOE 2001, Table 45: p. 51; net calorific values on p. 61). Emission factors for CH_4, N_2O, CO and NMVOC are country specific based on comprehensive life cycle analysis of a drying unit, documented in the EMIS database (EMIS 2013/1A4ci, see Section 4). Some of the emission factors have been updated based on expert judgement.

Emission Factors off-road machinery

- The emission factor for CO_2 is country specific and is assumed to be constant in the period 1990-2011 with value 73.6 t/TJ for diesel oil and 73.9 t/TJ for gasoline (Table 3-3, SFOE 2001).
- For SO_2 the emission factors are country specific and are given in Table A - 7 in Annex A2.2 (diesel oil, gasoline).
- The emission factors for all other gases are country specific and are shown in Table A - 16 to Table A - 19 in the Annex A3.1.6 (INFRAS 2008). 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 9 above.

Emission Factors wood heating

The emission factors are country specific and based on SAEFL 2000 (pp. 26ff) and a new study for wood combustion (EMIS 2013/1A solid fuels/wood).

Activity data

Drying of grass: Activity data on grass drying (in tons of dried grass) is extracted from the EMIS database (EMIS 2013/1A4ci).

Off-road machinery: Activity data is shown in Annex A3.1.6 (INFRAS 2008).

Table 3-42 Activity data in 1A4c Agriculture/Forestry.

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A4c Agriculture/Forestry	TJ	8'447	8'472	8'416	8'392	8'334	8'337	8'361	8'268	8'260	8'237
Drying of Grass	TJ	1'895	1'828	1'748	1'683	1'620	1'544	1'482	1'409	1'349	1'291
light fuel 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	6'125	6'157	6'189	6'221	6'253	6'285	6'315	6'345	6'374	6'404
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	8'163	8'063	8'031	8'073	8'080	8'112	7'908	7'979	7'921	7'965
Drying of Grass	TJ	1'223	1'077	1'061	1'055	1'039	994	845	948	822	856
light fuel 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	6'434	6'440	6'446	6'452	6'458	6'464	6'467	6'471	6'474	6'477
Biomass	TJ	506	546	524	566	582	654	596	560	625	632

Source/Fuel	Unit	2010	2011
1A4c Agriculture/Forestry	TJ	7'918	8'096
Drying of Grass	TJ	739	1'077
light fuel oil	TJ	451	657
natural gas	TJ	288	420
Machinery (diesel, gasoline)	TJ	6'480	6'440
Biomass	TJ	699	579

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 1-13).

A general description of the time series consistency of the Energy Sector is provided in Chapter 3.2.6.3a).

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 2011 are compared with the results 2010 within the current CRF.
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of the last submission 2012.
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of the last submission 2012.

For A4ci grass drying: The fuel consumption was verified in 2003 by a statistical analysis of 20 typical grass drying plants (VSTB 2003).

In 2012, the emission factor of category 1A4 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 values correspond to the emission factors of other countries or are in between the IPCC default values.

The emission factors for CH_4 emission of biomass combustion is significantly lower than the default emission factor and the emission factors of other Parties because the firing installation are of the best available technology.

3.2.9.5 Source-Specific Recalculations

- 1A: The activity data of all fuels of the overall time series have been recalculated based on the new data from SFOE 2011.
- 1A: The activity data of wood consumption have been recalculated for the overall time series based on the new data from SFOE 2012b.
- 1A: Activity data of sewage gas out of purification plants has changed between 2000 and 2007.
- 1A: The emissions factor of bituminous coal has changed because it was weighted with P-Coke before.
-

3.2.9.6 Source-Specific Planned Improvements

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 3-43 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 -Military Aviation	Tanks and similar off-road vehicles. (emissions from military road vehicles are included in 1A3b Road Transportation)	Method, AD, EF: INFRAS 2008 VTG 2012

3.2.10.2 Methodological Issues

a) Military off-road vehicles

The complete revision of the emissions of the whole off-road sector that began in 2005 was completed in 2008. The emissions of the military off-road categories (excluded aviation) are modelled by the same approach as railways, navigation etc. The emissions are calculated with a Tier 2 method. Some details of the emission modelling that hold for all off-road families are described in Annex A3.1.6 Off-road vehicles. Activity data and emission factors were updated and the emission calculation was carried out in a new database structured in analogy to the on-road database (INFRAS 2008).

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

b) Military aviation

To calculate the emissions from military aviation, a Tier 1 method is used. The fuel consumption 1990–2011 is known on an annual basis (VTG 2012). 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 1990-2011 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 3-3.
- For SO_2 the emission factors are country specific and are given in Table A - 7 in Annex A2.2.
- The emission factors for all other gases are country specific and shown in Table A - 16 to Table A - 19 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 9 above.

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 3-3, SFOE 2001).
- NO_x, VOC, CO: Engine producer information is used (CORINAIR, for details see SAEFL 1996: p. 202) for calculation of the emission factors in 1990 and 1995. For 1991-1994 the values are linearly interpolated between 1990 and 1995. For 1996-2011, 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 1996-2011, the values 1995 are used. The division of VOC into CH_4 and NMVOC is carried out by a constant split of 53%: 47% (country specific).
- N_2O: The IPCC default value 23 kg/TJ is used (IPCC 1997b) for the whole period 1990–2011.
- 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 1990–2011 (IPCC 1997c, Table 1-50)

Activity data for military off-road vehicles and military aviation

Fuel consumption data is shown in Table 3-44. The underlying data for military off-road such as vehicle stock and operating hours are shown in Table A - 25 to Table A - 27 in Annex A3.1.6.

Fuel consumption of military aviation is copied from the logbooks of the military aircrafts and summed up yearly (VTG 2012).

Table 3-44 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	49	48	48	47	47	47
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**
		f.c. in TJ	
Military off-road	Diesel	46	46
Military off-road	Gasoline	0.6	0.6
Military aviation	Jet kerosene	1'586	1'414

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 3.2.6.4.

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 2011 are compared with the results 2010 within the current CRF.
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012.

- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012.

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

No recalculations have been carried out.

3.2.10.6 Source-Specific Planned Improvements

There are no source-specific planned improvements.

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 flaring at oil and gas production facilities are included while emissions from vehicles are not included in 1B.

Source Category 1B “Fugitive Emissions from Fuels” comprises the following sub-categories:

- Solid fuels (1B1)
- Oil and Natural Gas (1B2)

3.3.1 Source Category 1B1 - Solid Fuels

Coal mining is not occurring in Switzerland.

3.3.2 Source Category 1B2 - Oil and Natural Gas

3.3.2.1 Source Category Description

Tier 1 Key categories 1B2
CH_4 from fugitive emissions of Oil and Natural Gas (trend)

Tier 2 Key categories 1B2

CH_4 from fugitive emissions of Oil and Natural Gas (level and trend)

In Switzerland, the fugitive emissions in the oil industry result from two refining companies and several fuel handling stations. In the natural gas industry, the fugitive emissions are from different distribution sites of natural gas.

Table 3-45 Specification of source category 1B2 Fugitive Emissions from Oil and Natural Gas.

1B2	Source	Specification	Data Source
1B2a	Oil	Emissions from refining/storage of oil and the distribution of oil products	AD: SFOE 2012 EF: EMIS 2013/1B2aiv, 1B2av
1B2b	Natural Gas	Emissions from gas pipelines	AD: SFOE 2012, SGWA 2005, SGIA 2012, Swissgas 2008 EF: Battelle 1994, Xinmin 2004, SGWA 2007
1B2c	Venting / Flaring	The release/combustion of excess gas at the oil refinery	AD: SFOE 2012 EF: EMIS 2013/1B2c

3.3.2.2 Methodological Issues

For source 1B2a Oil, the emissions of CO_2, CH_4 and NMVOC are reported. Fugitive emissions from oil transport are not occuring. Oil pipelines are very short in Switzerland (approximately 40km and 70km) and are mainly all underground. These pipelines are regularly tested on the tightness and any leakage has ever been detected. Undetected emissions would be very small and are likely to be oxidised in the top soil covering the pipelines. Therefore, Switzerland is confident that the minimum detectable limit of the testing would be low enough to identify emissions on the scale of the GPG default.

For source 1B2b Natural Gas, the emissions of CH_4 and NMVOC leakages from gas pipelines are calculated with a new country specific Tier 3 method. The method considers the length, type and pressure of the gas pipelines as well as the annual gas consumption. The distribution network components (regulators, shut off fittings and gas meters), the losses from maintenance and extension as well as the end user losses are separately taken into account.

For source category 1B2c Venting/Flaring (Oil), CO_2 as well as CH_4, N_2O, NO_x, CO and NMVOC are considered.

The indirect CO_2 emissions from the decomposition of NMVOC in the atmosphere have been calculated from the average carbon contents of NMVOC emissions for the subcategory 1B2a and 1B2b.

The emissions from oil and venting/flaring (1B2a and 1B2c) are calculated based on annual production/consumption data which is consistent with the IPCC Tier 1 approach. Emissions of greenhouse gases are calculated by multiplying level of activity by emission factor.

Emission factors

1B2a and 1B2c: The emission factors for direct CO_2, CH_4 and NMVOC are based on data from the refining and gas industry and expert estimates.

The emission factors for gas distribution losses (source 1B2b) depend on the type and pressure of the natural gas pipeline (see Table 3-46; sources: Battelle 1994, Xinmin 2004, SGWA 2007). The CH_4 emissions due to gas meters are considered with the emission factor of 5.1 m^3 CH_4 per gas meter and year. The emission factors for 1B2b are calculated for each year separately.

Table 3-46 CH_4 emission factors for 1B2 Fugitive Emissions from Oil and Natural Gas (Battelle 1994, Xinmin 2004, SGWA 2007)

1B2 Fugitive Emissions from Oil and Natural Gas	< 100 mbar	100-1000 mbar	1- 5 bar	> 5 bar
	Emission factors in [m3/h/km]			
Cast iron	0.80000	1.20000	0.19200	-
Cast steel	0.08800	0.13200	0.00230	-

Steel normal	0.08800	0.01320	0.00062	-
Steel cath.	0.00800	0.01200	0.00002	0.028
HDPE (Polyethylene)	0.00800	0.01600	0.00062	-
other	0.00800	0.01600	0.00002	-

Resulting emission factors are 3.15 Gg CO_2/Gg NMVOC for 1B2a (Oil) and 2.93 Gg CO_2/Gg NMVOC for 1B2b (Natural gas) (EMIS 2013/1B2a Raffinerie, Leckverluste iv, SGWA 2007).

The emission factors for CH_4 is significantly lower compared to other countries and the default values provided by IPCC. This is based on the fact that the oil transport in Switzerland is realised mainly through underground pipelines. From the provided documentation of the Swiss refineries, it is not clear if leakages from the transport are included in their data or not. This issue will be further analysed and results will be presented in the next NIR submissions.

Activity data

The activity data for fugitive emissions such as the total annual gasoline consumption and gas imports are extracted from the Swiss overall energy statistics (SFOE 2012).

The activity data for CH_4 of Natural Gas (source 1B2b) are provided by the Swiss gas and water industry association (SFOE 2012), but an extrapolation of data from 2005 is made based on aggregate increases in grid length in order to include the length of junction tubes (SFOE 2012, SGIA 2012, SGWA 2005, Swissgas 2008). Fugitive emissions from a high pressure natural gas transfer pipeline, crossing Switzerland from France to Italy, are included in the inventory.

3.3.2.3 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 1-13).

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 2011 are compared with the results 2010 within the current CRF
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of the last submission 2012.
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of the last submission 2012.

In 2012, the emission factor of category 1B2 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 values are significantly lower than the other countries and the IPCC default values. For further information, please see section 3.3.2.2.

3.3.2.5 Source-Specific Recalculations

- The activity data of the oil distribution was recalculated for the whole time series based on a check of the energy file and the data from the fuel imports.
- The emission factor of the oil distribution was recalculated for 2009 and 2010 due an error the CO_2 emission factor of NMVOC (oxidation). There were also small recalcutaions in the time serie of activity data.

3.3.2.6 Source-Specific Planned Improvements

In the course of 2013, the fugitive emissions from the Swiss gas industry will be reassessed. As part of the Swiss QC tier 2 activities, a study is being commissioned jointly by the FOEN and the gas industry. The study will be carried out by a leading Swiss research institute specialized in life cycle analysis.

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 under sector 1 Energy. Figure 4-1 shows the development of greenhouse gas emissions in source category 2 between 1990 and 2011.

Please note that for several industrial processes within source categories 2A Mineral Products and 2B Chemical Products data and information of emission factors and acticity data are classified as confidential (C). For reviewers there is an additional version – including all confidential data and information – of chapter 4 Industrial Processes available.

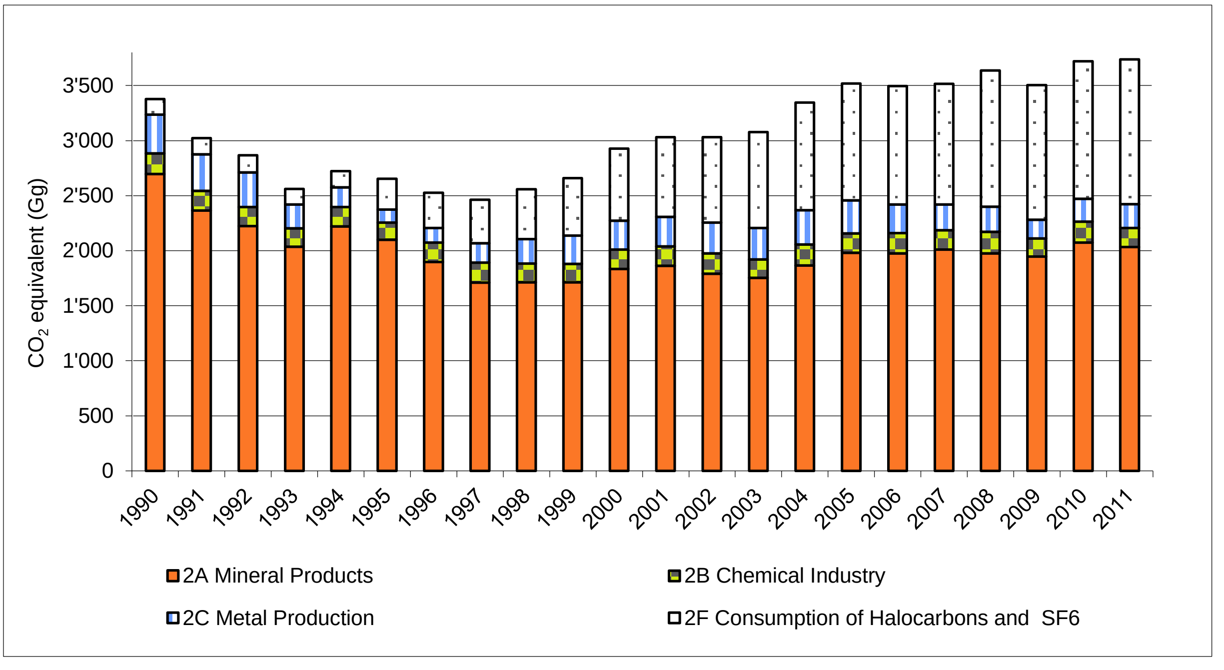

Figure 4-1 Switzerland's greenhouse gas emissions of sector 2 Industrial Processes 1990-2011. Source category 2D Other Production emits no direct greenhouse gas. The emissions of source category 2G Other are small (2011: 1.2 Gg CO_2 eq) and are therefore not visible in this figure.

2A Mineral Products remain the dominant source of sector 2 with a share of 54.3% of the greenhouse gas emissions in 2011 although they have decreased by 24.6% since 1990. 2B

Chemical Industry accounts for 4.6% and has decreased by 7.6% since 1990. 2C Metal Production has decreased by 38.4% and accounts for 5.8% in 2011. 2F Consumption of Halocarbons and SF_6 is of increasing importance: The emissions have increased by a factor of 9.2 since 1990 and are currently responsible for 35.2% 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 are given by gases. 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 1990-2011.

Gas	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
CO_2	3'059	2'721	2'581	2'332	2'493	2'294	2'126	1'958	1'962	2'004
CH_4	9.6	9.3	9.0	8.6	8.3	8.0	8.0	8.2	7.9	7.7
N_2O	68	62	54	52	61	60	58	51	54	55
Synth. gases	244	231	224	170	162	291	336	447	534	595
Sum	3'381	3'023	2'868	2'563	2'724	2'653	2'527	2'464	2'558	2'661

Gas	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	CO_2 equivalent (Gg)									
CO_2	2'144	2'176	2'126	2'086	2'232	2'331	2'290	2'299	2'282	2'178
CH_4	7.9	8.1	8.0	8.0	8.6	8.6	8.3	8.5	8.7	7.9
N_2O	60	63	66	59	62	52	60	58	67	58
Synth. gases	717	787	833	926	1'045	1'128	1'138	1'152	1'282	1'261
Sum	2'930	3'034	3'032	3'079	3'347	3'520	3'496	3'519	3'640	3'505

Gas	**2010**	**2011**
	CO_2 eq (Gg)	
CO_2	2'369	2'332
CH_4	8.4	8.6
N_2O	60	54
Synth. gases	1'286	1'348
Sum	3'723	3'742

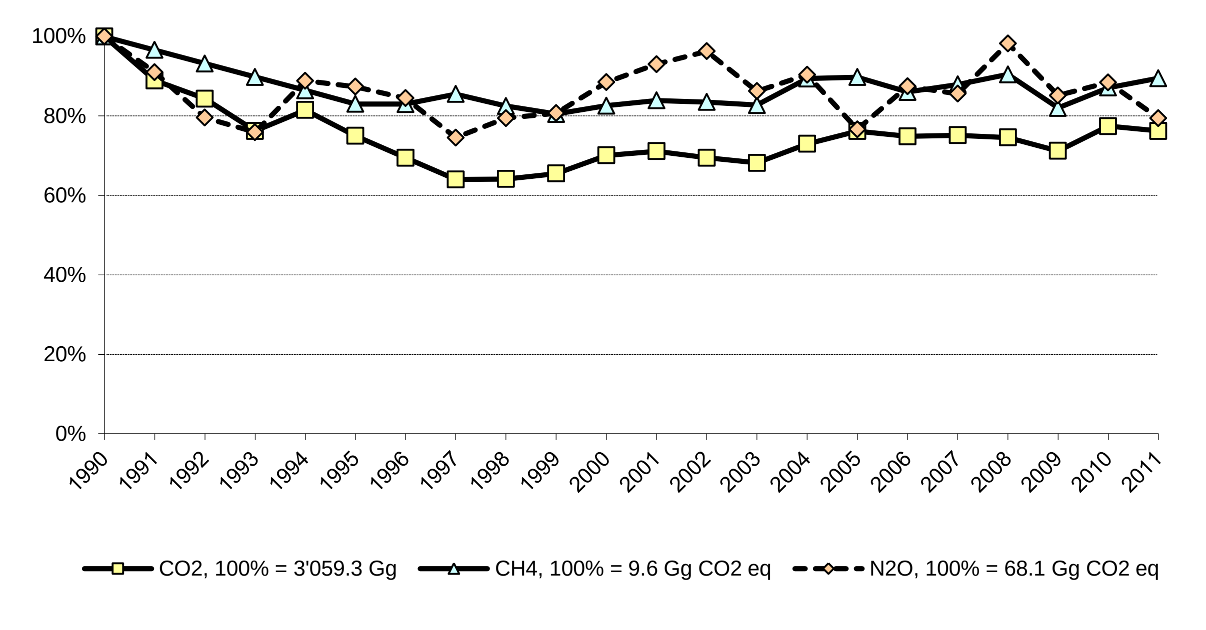

Figure 4-2 Relative trends of the greenhouse gases of sector 2 Industrial Processes in the period 1990-2011. The base year 1990 represents 100%.

Figure 4-2 shows that in the period 1990-2011 the emissions of CO_2, CH_4 and N_2O from sector 2 Industrial Processes have decreased to 76%, 89% and 79%, respectively compared to the base year 1990.

Figure 4-3 shows that the emissions of F-gases have increased to 553% compared to the year 1990.

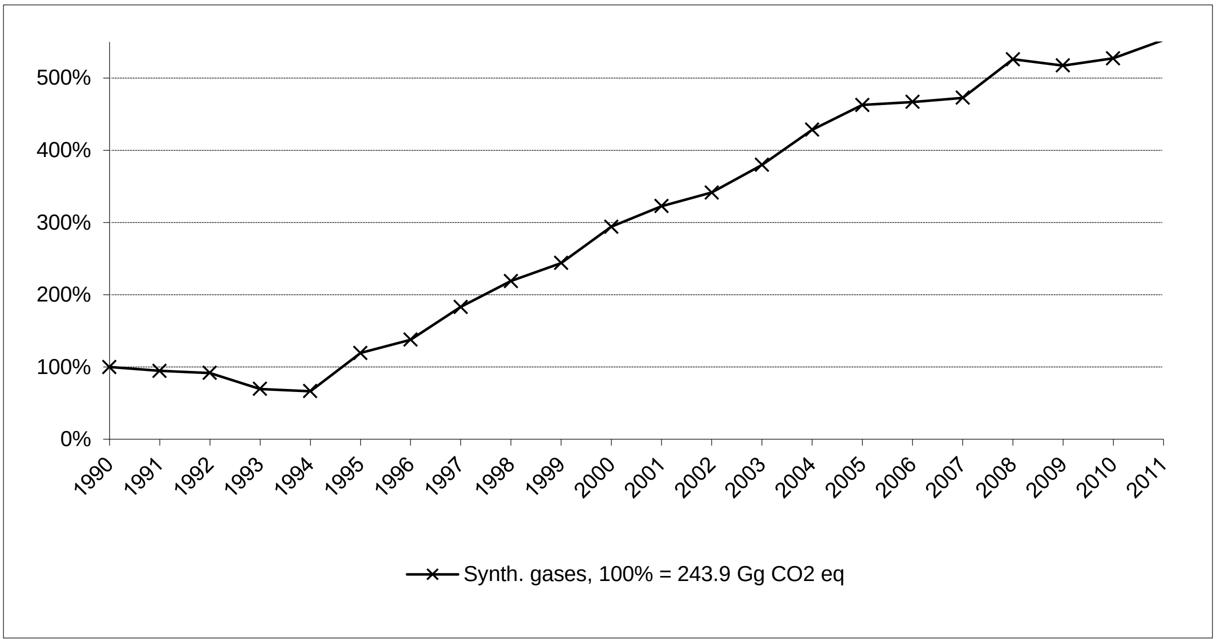

Figure 4-3 Relative trends of the F-gases of sector 2 Industrial Processes in the period 1990-2011. The base year 1990 represents 100%.

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 and 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”.

2A	Source	Specification	Data Source
2A1	Cement Production	Geogenic CO_2 emissions from calcination process in cement production Emissions of CO_2, NO_x, CO, NMVOC and SO_2 from blasting operations	AD, EF: EMIS 2013/2A1 Zementwerke Rohmaterial AD, EF: EMIS 2013/2A1 Zementwerke übriger Betrieb
2A2	Lime Production	Geogenic CO_2 emissions from calcination process in lime production Emissions of CO_2, NO_x, CO, NMVOC and SO_2 from blasting operations	AD, EF: EMIS 2013/2A2 Kalkproduktion, Rohmaterial AD, EF: EMIS 2013/2A2 Kalkproduktion, übriger Betrieb
2A3	Limestone and Dolomite Use	Geogenic CO_2 emissions from fine ceramics, rock wool, and brick and tile production	EF: IPCC 2006, EMIS 2013/2A3 Ziegeleien AD: EMIS 2013/2A3 Feinkeramik Produktion, EMIS 2013/2A3 Steinwolle Produktion, EMIS 2013/2A3 Ziegeleien
2A4	Soda Ash Production and Use	Production is not occurring in Switzerland. Geogenic CO_2 emissions from the use of soda ash in fine ceramics and glass production is reported in 2A3 Limestone and Dolomite Use and 2A7 Other	
2A5	Asphalt Roofing	Emissions of CO and NMVOC from asphalt roofing	AD, EF: EMIS 2013/2A5 Dachpappenproduktion und Verlegung
2A6	Road Paving with Asphalt	Emissions of NMVOC from road paving	AD, EF: EMIS 2013/2A6 Strassenbelagsarbeiten
2A7	Other	Emissions of CO_2, NO_x, CO, NMVOC and SO_2 from the production of plaster Geogenic CO_2 emissions from production of container and tableware glass, and glass wool	AD, EF: EMIS 2013/2A7 Gips-Produktion übriger Betrieb EF: IPCC 2006 AD, EF: EMIS 2013/2A7 Hohlglas Produktion, EMIS 2013/2A7 Glas übrige Produktion, EMIS 2013/2A7 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. But 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 Emissions = $M_{Clinker} \bullet EF_{Clinker} \bullet CDK_{Correction\ Faktor}$

In Switzerland no long wet or long dry kilns but only modern preheater or precalciner kilns are used as well as no so-called low-alkali cement is produced. Switzerland has Therefore there is no landfilling of calcined cement dust (CKD). 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 CDK 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[10] (EMIS 2013/2A1 Zementwerke übriger Betrieb).

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[10] For release of CO_2 from blasting operations in lime production the same emission factor is taken as for blasting operations in cement production. This approach is justifyable as the raw materials (lime stone) are basically the same. 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 avaible 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 CO2 per ton of cement and lime therefore amounts to 96 g/t cement or lime.

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.

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. It amounts to 531 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.

Blasting operations:

The emission factors are country specific based on measurements and data from industry and expert estimates as documented in EMIS 2013/2A1 Zementwerke übriger Betrieb. They are given per ton of *cement*.

Table 4-3 CO_2 emission factors for calcination process and blasting operations in kg/t clinker and g/t cement, respectively, and emission factors for NO_x, CO, NMVOC and SO_2 from blasting operations in g/t cement from source category 2A1 Cement Production in 2011 (EMIS 2013/2A1 Zementwerke Rohmaterial and EMIS 2013/2A1 Zementwerke übriger Betrieb).

2A1 Cement production	Unit	CO_2	NO_X	CO	NMVOC	SO_2
Calcination	kg/t clinker	531	NA	NA	NA	NA
Blasting operations	g/t cement	96	3.7	22	9.6	0.16

Activity Data

Activity data on annual clinker and cement production is provided by industry and documented in EMIS 2013/2A1 Zementwerke Rohmaterial and EMIS 2013/2A1 Zementwerke übriger Betrieb.

Table 4-4 Activity data of clinker and cement production in Switzerland for the period 1990-2011 in Gg (EMIS 2013/2A1 Zementwerke Rohmaterial and EMIS 2013/2A1 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
Cement production	Gg	4'553	4'577
Clinker production	Gg	3'642	3'587

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 lime stone 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 2013/2A2 Kalkproduktion, Rohmaterial). The value is considered confidential, however, available to reviewers.

Blasting operations:

The emission factors are country specific based as documented in EMIS 2013/2A1 Kalkproduktion, übriger Betrieb. The value is considered confidential, however, available to reviewers.

Table 4-5 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 2011 (EMIS 2013/2A2 Kalkproduktion, Rohmaterial and EMIS 2013/2A1 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 2013/2A2 Kalkproduktion, Rohmaterial and EMIS 2013/2A1 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 2013/2A3 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 4-6 Geogenic CO_2 emission factors for 2011 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 2013/2A3 Ziegeleien).

2A3 Lime stone 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	80'000

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 of the carbonate containing raw materials are considered confidential; however, they are 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 2013/2A3 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 4-6).

Activity Data

Activity data are based on industry data from the single rock wool production plant in Switzerland.

Table 4-7 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 1990-2011 in Gg (EMIS 2013/2A3 Feinkeramik Produktion, EMIS 2013/2A3 Steinwolle Produktion, EMIS 2013/2A3 Ziegeleien).

2A3 Lime stone 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 Lime stone 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	941	866	848	1'023	1'091	1'068	975	865	701

2A3 Lime stone and dolomite use	Unit	2010	2011
fine ceramics production			
limestone use	Gg	C	C
dolomite use	Gg	C	C
soda use	Gg	C	C
rock wool production			
dolomite use	Gg	5.9	5.9
brick and tile production	Gg	879	800

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 is no specific information on the employed raw materials available from Swiss industry. Several requests to the Swiss association of brick and tile industry (Verband Schweizerische Ziegelindustrie VSZ) resulted in the following answer only:

“Due to the large range of variation of the carbonate content in the used raw materials we can only provide a rough estimate on the CO_2 emission resulting from the calcination process. We assume an amount of 4-12 mass-% of the produced amount of brick and tile to be released as CO_2”.

In order to estimate the geogenic CO_2 emission from brick and tile production in Switzerland the following formula was used:

CO_2 Emissions = $M_{brick\ and\ tile} \bullet EF_{brick\ and\ tile}$

Emission Factors

For estimating the geogenic CO_2 emissions from Swiss brick and tile production, a constant emission factor of 0.08 t CO_2/t brick and tile was assumed. This represents the mean value provided by the industry association as discussed above.

Activity Data

Activity Data are based on production data from the Swiss association of brick and tile industry (see Table 4-7).

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 2013/2A5 Dachpappenproduktion und Verlegung.

Table 4-8 Emission factors for 2011 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 2013/2A5 Dachpappenproduktion und Verlegung and EMIS 2013/2A6 Strassenbelagsarbeiten).

	Unit	CO	NMVOC
2A5 Asphalt roofing	kg/t asphalt sealing sheeting	120	24
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 2013/2A5 Dachpappen Produktion und Verlegung.

Table 4-9 Activity data for asphalt roofing and road paving with asphalt for the period 1990-2011 in Gg (EMIS 2013/2A5 Dachpappenproduktion und Verlegung and EMIS 2013/2A6 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	26	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
2A5 Asphalt roofing			
asphalt sealing sheeting	Gg	25	25
2A6 Road paving with asphalt			
asphalt concrete	Gg	5'250	5'300

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 2013/2A5 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 2013/2A6 Strassenbelagsarbeiten (see Table 4-8).

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 2013/2A6 Strassenbelagsarbeiten (see Table 4-9).

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 2013/2A7 Gips-Produktion übriger Betrieb.

Table 4-10 Emission factors for plaster production in g/t mined rocks for 2011 (EMIS 2013/2A7 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 2013/2A7 Gips-Produktion übriger Betrieb.

Table 4-11 Activity data for the mining of gypsum in Switzerland for the period 1990-2011 in Gg (EMIS 2013/2A7 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
rocks	Gg	335	293

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:

$$CO_2 \text{ Emissions} = M_{\text{Glass type}} \bullet EF_{\text{Glass type}} \bullet (1 - \text{cullet ratio})$$

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 4-12 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 are 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 are based on industry data from the two glass wool production plants in Switzerland.

Table 4-13 Glass production in Switzerland for the period 1990-2011 in Gg and cullet ratio in % (EMIS 2013/2A7 Hohlglas Produktion, EMIS 2013/2A7 Glas übrige Produktion and EMIS 2013/2A7 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	22.5	22.9	20.9	24.0	23.0	18.9	24.3	26.0	30.9
cullet ratio	%	21	26	50	55	67	47	64	69	68	70

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	30.1	24.4	19.4	25.7	32.8	37.5	38.1	44.5	44.4	33.5
cullet ratio	%	71	67	61	62	65	65	73	71	69	69

2A7 Glass production	Unit	2010	2011
container glass			
production	Gg	C	C
cullet ratio	%	C	C
glass (speciality tableware)			
production	Gg	C	C
cullet ratio	%	C	C
glass wool			
production	Gg	35.7	41.4
cullet ratio	%	71	72

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 6.3%. The uncertainty of CO_2 emissions from clinker calcination 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 clinker production data (Tier 2), an activity data uncertainty of 2% is assumed. The uncertainty of the emission factor is based on the fact that an average CaO content of the clinker of 64.2% is assumed. According to the estimated default uncertainty values in the range of 4-8% in table 3.2 of the IPCC Good Practice Guidance a value of 6% is chosen for Switzerland.

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 1-13 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 2011 are compared with the results 2010 within the current CRF tables
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

In the last year's 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 the last year's 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 the last year's 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: The cement industry association has provided updated EF values for geogenic CO_2 for 2009 and following years resulting in a slight increase in CO_2 emissions

2A3 Fine ceramics production: The assumed EF values of geogenic CO_2 for the years 1990-2000 have been revised. So far they have been based on mean relative glaze fractions of the years 2001-2009. Since there is a clear decrease in relative glaze fractions between 2001 and 2011 the mean values of the glaze fractions of the years 2001 and 2002 are now assumed for the missing glaze amounts in 1990-2000. Glaze amounts for 2010 have been revised based on biennial update from industry.

2A6 Road paving: The EF for NMVOC has been updated for the years 1991-2010.

2A7 Glasswool production: Cullet ratio has been revised for the entire time series since also the second production plant provided data of the cullet ratio resulting in an increase of the geogenic CO_2 emissions.

4.2.6 Source-Specific Planned Improvements

It will be checked whether the revised Swiss CO2-act and ordinance (FOEN 2013f) could provide an improved data base for the largest industrial emitters.

Furthermore, in 2012 a national review on sector 2 Industrial Processes took place (CSD 2013). The final report will be evaluated in order to see which suggestions for improvement could be implemeted in future submissions.

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 4-14 Specification of source category 2B “Chemical Industry”.

2B	Source	Specification	Data Source
2B1	Ammonia Production	Emissions of CO_2 and NMVOC are reported in 2B5 Ethylene production	AD, EF: EMIS 2013/2B1 Ammoniak-Produktion
2B2	Nitric Acid Production	Emissions of N_2O and NO_x from the production of nitric acid	AD, EF: EMIS 2013/2B2 Salpetersäure Produktion
2B3	Adipic Acid Production	Not occurring in Switzerland	
2B4	Carbide Production	Emissions of CO_2, CH_4 and SO_2 from the production of silicon carbide	EF: IPCC 2006, EMIS 2013/2B4 Graphit und Siliziumkarbid Produktion AD: EMIS 2013/2B4 Graphit und Siliziumkarbid Produktion
2B5	Other	Emissions of CO_2 and NMVOC from ethylene production Emissions of CH_4, CO and NMVOC from acetic acid production SO_2 emissions from sulphuric acid production	AD, EF: EMIS 2013/2B5 Ethen-Produktion AD, EF: EMIS 2013/2B5 Essigsäure-Produktion AD, EF: EMIS 2013/2B5 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 petroleum 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 (ethene, 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 2013/2B1 Ammoniak-Produktion and EMIS 2013/2B5 Ethen-Produktion, respectively.

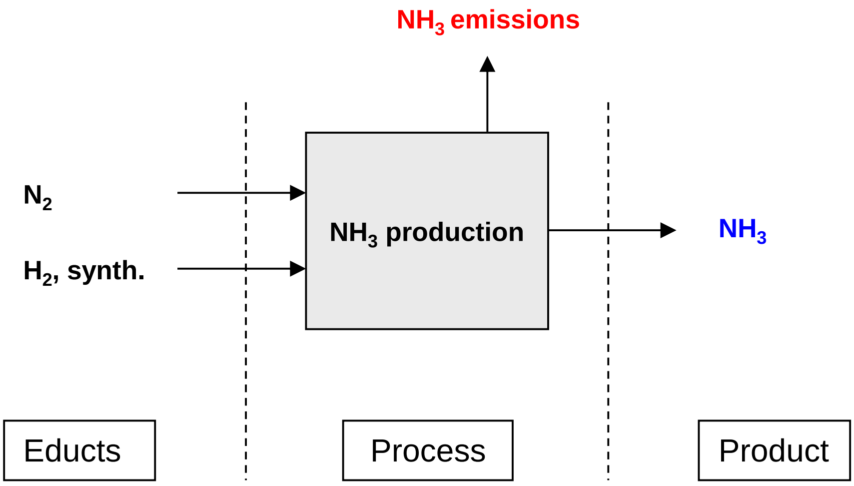

Figure 4-4 Process flow chart for the production of ammonia (NH_3) from nitrogen (N_2) and hydrogen (H_2, synth.). Hydrogen is derived from the thermal cracking process in the same plant (see Figure 4-5).

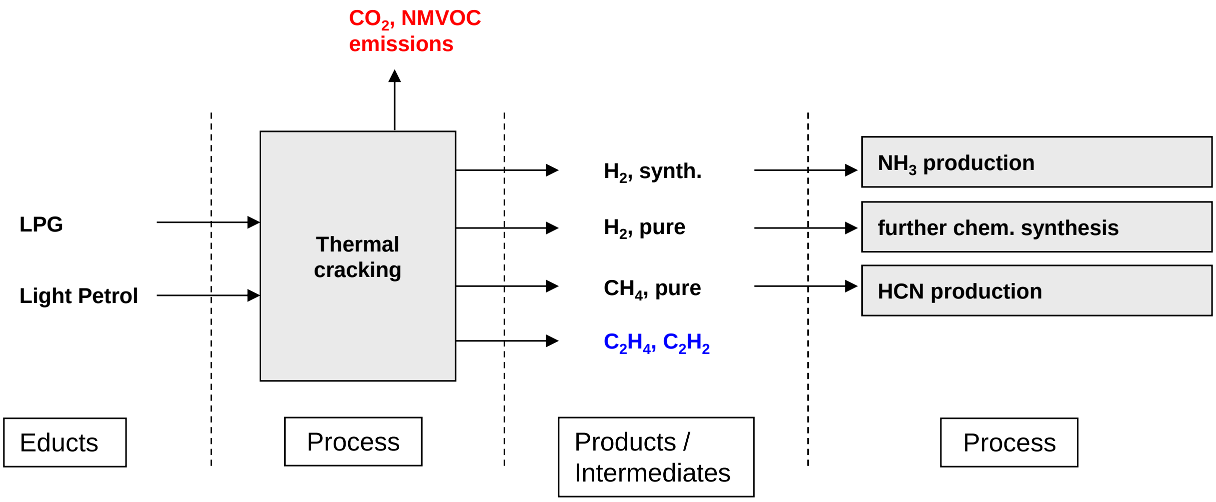

Figure 4-5 Process flow chart for the production of ethylene (C_2H_4) and acetylene (C_2H_2) by thermal cracking of liquefied petroleum gas (LPG) and light petrol. The intermediate product H_2, synth. is used as educt in the ammonia production in the same plant (see Figure 4-4)

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 oxide (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 values are documented in EMIS 2013/2B2 Salpetersäure Produktion. They are considered confidential, however, available to reviewers on request.

Table 4-15 Emission factors for N_2O and NO_x for nitric acid production in Switzerland in kg/t nitric acid for 2011. Data refers to 100% nitric acid (EMIS 2013/2B2 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 1990-2011. The data is confidential but available for reviewers (see EMIS 2013/2B2 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 2013/2B2 Graphit und Siliziumkarbid Produktion.

Table 4-16 Emission factors for CO_2, CH_4 and SO_2 for carbide production in Switzerland for 2011 in kg/t silicon carbide respectively (EMIS 2013/2B4 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 base on industry data for 1990 and 1995 and interpolated values in between. The data is confidential but available for reviewers (see EMIS 2013/2B4 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 light petrol. 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 educt in the downstream production of cyanic acid (HCN) in the same facility (again, see Figure 4-5 and for further information see EMIS 2013/2B5 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 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 were 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 4-17 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 2011 in kg/t product (EMIS 2013/2B5 Ethen-Produktion, EMIS 2013/2B5 Essigsäure-Produktion and EMIS 2013/2B5 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	NA	10	30	0.2	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 1990-2011. The data is considered confidential but available for reviewers on request.

Table 4-18 Activity data for the production of ethylene, acetic acid and sulphuric acid in Switzerland for the period 1990-2011 in Gg (EMIS 2013/2B5 Ethen-Produktion, EMIS 2013/2B5 Essigsäure-Produktion and EMIS 2013/2B5 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	31	31	31	31	31	31	31	31	31	31
sulphuric acidproduction	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	31	31	31	31	31	31	30	30	30	30
sulphuric acidproduction	Gg	C	C	C	C	C	C	C	C	C	C

2B5 Chemical industry, other	Unit	2010	2011
ethylene production	Gg	C	C
acetic acid production	Gg	30	30
sulphuric acidproduction	Gg	C	C

4.3.2.6 Acetic and sulphuric acid production (2B5)

In Switzerland there are three plants producing acetic acid (CH_3COOH). From acetic acid production emissions of CH_4, CO and NMVOC occur. 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 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 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 2013/2B5 Essigsäure-Produktion and EMIS 2013/2B5 Schwefelsäure-Produktion (see Table 4-17). 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 2013/2B5 Essigsäure-Produktion and EMIS 2013/2B5 Schwefelsäure-Produktion (see Table 4-18). 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 1-13 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 2011 are compared with the results 2010 within the current CRF tables
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

In the last year's 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

2B4 Silicon carbide production: EF values have been revised due to corrected data from industry for the years 2008-2010 resulting in recalculated interpolated values for 2006 and 2007 as well.

2B5 Ethylene production: The last year forgotten update of the EF for 2010 values has been caught up.

4.3.6 Source-Specific Planned Improvements

It will be checked whether the revised Swiss CO2-act and ordinance (FOEN 2013f) could provide an improved data base for the largest industrial emitters.

Furthermore, in 2012 a national review on sector 2 Industrial Processes took place (CSD 2013). The final report will be evaluated in order to see which suggestions for improvement could be implemeted in future submissions.

4.4 Source Category 2C – Metal Production

4.4.1 Source Category Description

Tier 1 Key category 2C1
CO_2 emissions from Iron and Steel Production (level and trend).

Tier 2 Key category 2C1
CO2 emissions from Iron and Steel Production (level and trend).

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 4-19 Specification of source category 2C “Metal Production”.

2C	Source	Specification	Data Source
2C1	Iron and Steel Production	Emissions of CO_2, NO_x, CO, NMVOC and SO_2 from the production of iron and steel	AD, EF: EMIS 2013/2C1 Eisengiessereien Elektroschmelzofen/übriger Betrieb, EMIS 2013/2C1 Stahl-Produktion Elektroschmelzöfen/übriger Betrieb
2C2	Ferroalloys Production	Production is not occuring in Switzerland	
2C3	Aluminium Production	Emissions of PFC, CO_2, NO_x, CO, NMVOC and SO_2 from the production of aluminium (ceased in 2006)	AD: EMIS 2013/2C3 Aluminium Produktion EF for PFC: Industry Data EF other gases: EMIS 2013/2C3 Aluminium Produktion
2C4	Use of SF6 in Aluminium and Magnesium Foundries	Emissions from use of SF_6 in aluminium and magnesium foundries	AD: Industry Data EF: IPCC 2006
2C5	Other	Emissions of CO_2, NO_x, CO and SO_2 from battery recycling Emissions of CO and NMVOC from non-ferrous metal foundries	AD, EF: EMIS 2013/2C5e Batterie-Recycling, AD, EF: EMIS 2013/2C5e 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 the 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 this process CO_2 emissions occur due to consumption of the electrodes. 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 70% of the iron is processed in induction furnaces and 30% 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.

Since most of the steel qualities produced in the above mentioned steel plants in Switzerland are alloyed steels it was so far reported that the emissions from source category 2C2 Ferroalloys Production are included in 2C1. This statement was a misunderstanding on our side as there is no ferroalloy production from raw ores but from recycled scrap steel only.

Methodology

For determination of CO_2 emission from steel production a Tier 1 approach according to IPCC 2006 (chapter 4.2 *Iron & steel and metallurgical coke production)* is used. 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 2013/2C1 Eisengiessereien Elektroschmelzofen/übriger Betrieb, EMIS 2013/2C1 Stahl-Produktion Elektroschmelzöfen and EMIS 2013/2C1 Stahlwerke Walzwerke.

Table 4-20 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 2011 (EMIS 2013/2C1 Eisengiessereien Elektroschmelzofen/übriger Betrieb, EMIS 2013/2C1 Stahl-Produktion Elektroschmelzöfen and EMIS 2013/2C1 Stahlwerke Walzwerke, EMIS 2013/2C5e Batterie-Recycling and 2013/2C5e Buntmetallgiessereien Elektroöfen).

2C Metal production	Unit	CO_2	NO_x	CO	NMVOC	SO_2
2C1 Iron	kg/t	NA	0.01	4.1	5.4	NA
2C1 Steel	kg/t	140	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 are given in the following table:

Table 4-21 Production of iron, steel, aluminium and non-ferrous metals as well as amount of batteries recycled in Switzerland for the period 1990-2011 in Gg (EMIS 2013/2C1 Eisengiessereien Elektroschmelzofen/übriger Betrieb, EMIS 2013/2C1 Stahl-Produktion Elektroschmelzöfen, EMIS 2013/2C3 Aluminium Produktion, EMIS 2013/2C5e Batterie-Recycling and 2013/2C5e 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
2C1 Iron	Gg	53	61
2C1 Steel	Gg	1'218	1'322
2C3 Aluminium	Gg	0	0
2C5 Battery recycling	Gg	3.3	2.8
2C5 Non-ferrous metals	Gg	20	12

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 2013/2C3 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 2013/2C3 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 processes 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 4-22 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 4-22 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

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 4-21.

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 2011 inventory the mean value of 2010 and 2011 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 2011 the mean value of 2010 and 2011 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 2011 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 2011. 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 2013/2C5e Batterie-Recycling and 2013/2C5e Buntmetallgiessereien Elektroöfen (see Table 4-20).

Activity Data

The annual amount of recycled batteries and produced non-ferrous metals in Switzerland is reported from industry and foundry association as documented in EMIS 2013/2C5e Batterie-Recycling and 2013/2C5e 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 2013/2C1 Stahl-Produktion Elektroschmelzöfen). The uncertainty for the CO_2 emission factor is estimated to be 40% (EMIS 2013/2C1 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 2013).

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 1-13, 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 2011 are compared with the results 2010 within the current CRF tables
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

In the last year's 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 have been checked for double counting.

4.4.5 Source-Specific Recalculations

No recalculations have been made in category 2C in this year's submission

4.4.6 Source-Specific Planned Improvements

It will be checked whether the revised Swiss CO2-act and ordinance (FOEN 2013f) could provide an improved data base for the largest industrial emitters.

Furthermore, in 2012 a national review on sector 2 Industrial Processes took place (CSD 2013). The final report will be evaluated in order to see which suggestions for improvement could be implemeted in future submissions.

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 only 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.

Table 4-23 Specification of source category 2D “Other Production”.

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 2013/2D111
2D2	Food and Drink	Emissions of CO and NMVOC from production of food and drink	AD, EF: EMIS 2013/2D2
2D3	Wood Processing	Emissions of CO and NMVOC from production of charcoal	AD, EF: EMIS 2013/2D3

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.

Emission Factors

The emission factors for NMVOC emissions from pulp and paper production in Switzerland are country specific and bases on measurements and data from industry and expert estimates documented in EMIS 2013/2D1.

[11] As far as no further specification is given, all EMIS documents under this source category are ment. If the text refers to a specific EMIS document the whole name is written out e.g. EMIS 2013/2D1 Spanplatten-Produktion.

Table 4-24 Emission factors for CO and NMVOC in pulp and paper production, food and drink production and charcoal production for 2011 (EMIS 2013/2D1, EMIS 2013/2D2 and EMIS 2013/2D3).

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	350
2D3 Charcoal production	kg/t	280	720

Activity Data

The annual amount of pulp and paper produced in Switzerland bases on data from industry and expert estimates documented in EMIS 2013/2D1. The activity data of fibreboard production has been revised for the years 1991-2010 since data of a second production plant has been taken into account from 1996 onwards yielding an increase in the production volume between about a factor of 1.5 and 5.

Table 4-25 Production of pulp and paper, food and drink and charcoal in Switzerland for the period 1990-2011 in Gg (EMIS 2013/2D1, EMIS 2013/2D2 and EMIS 2013/2D3).

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
2D3 Charcoal production	Gg	0.04	0.06	0.04	0.05	0.06	0.05	0.06	0.08	0.06	0.06

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	2'372	2'469
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
2D3 Charcoal production	Gg	0.07	0.06	0.06	0.07	0.09	0.11	0.11	0.11	0.11	0.11

2D Other production	Unit	2010	2011
2D1 Pulp and paper	Gg	570	534
2D2 Food and drink (exc. beer, wine, spirits)	Gg	2'436	2'411
2D2 Food and drink (beer, wine, spirits)	m3	467'699	462'446
2D3 Charcoal production	Gg	0.10	0.11

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 2013/2D2 (see Table 4-24).

Activity Data

The annual amount of food and drink produced in Switzerland base on data from industry and expert estimates documented in EMIS 2013/2D2 (see Table 4-25).

4.5.2.3 Charcoal production (2D3)

Methodology

To determine CO and NMVOC emissions from charcoal production a country specific approach is used. The emissions are calculated by multiplying the annual amount of produced charcoal by the corresponding emission factors.

Emission Factors

The emission factor for CO and NMVOC emissions from charcoal production in Switzerland are country specific and base on measurements and data from industry and expert estimates documented in EMIS 2013/2D3 (see Table 4-24).

Activity Data

The annual amount of charcoal produced in Switzerland base on data from the industry and single charcoal burners association documented in EMIS 2013/2D3 (see Table 4-25).

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 2011 are compared with the results 2010 within the current CRF tables
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

4.5.5 Source-Specific Recalculations

2D1 Pulp and Paper: Activity data of the fibreboard production have been revised since data of a second plant have been taken into account as well from 1996 onwards (revised interpolated data 1991-1995). For the chipboard production the interpolated AD of 2010 has been replaced by effective data from industry.

4.5.6 Source-Specific Planned Improvements

It will be checked whether the revised Swiss CO2-act and ordinance (FOEN 2013f) could provide an improved data base for the largest industrial emitters.

Furthermore, in 2012 a national review on sector 2 Industrial Processes took place (CSD 2013). The final report will be evaluated in order to see which suggestions for improvement could be implemeted in future submissions.

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 (trend).

HFC from the consumption of halocarbons and SF_6; Other (level).

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

Table 4-26 Specification of source category 2F "Consumption of Halocarbons and SF_6". Data source: Carbotech (2013).

2F	Source	Specification	Data Source
2F1	Refrigeration and Air Conditioning Equipment	Emissions from Refrigeration and Air Conditioning Equipment	AD: Various national statistics[12] and industry data EF: Industry data and expert estimates
2F2	Foam Blowing	Emissions from Foam Blowing, incl. Polyurethane Spray	AD: Industry data EF: Expert estimates
2F3	Fire Extinguishers	Not occurring in Switzerland	
2F4	Aerosol / Metered Dose Inhalers	Emissions from use as aerosols, incl. metered dose inhalers	AD: Import statistics EF: IPCC default values
2F5	Solvents	Emissions from use as solvents	AD: Import statistics EF: IPCC default values
2F6	Other applications using ODS substitutes	Not occurring in Switzerland	

[12] e.g. statistics on registration of cars and trucks, import statistics on F-gases (Carbotech 2013).

2F7	Semiconductor Manufacturing	Emissions from use in semiconductor manufacturing	AD: Import statistics and industry data[13] EF: IPCC default values and industry data
2F8	Electrical Equipment	Emissions from use in electrical equipment	AD: Industry data EF: Industry data
2F9	Other	Emissions of SF_6 which are not yet accounted for under 2F8. Emissions of different halocarbons not accounted in other source categories (i.e. for example research and laboratory use).	AD: Import statistics and Industry data EF: Industry data and estimates

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.

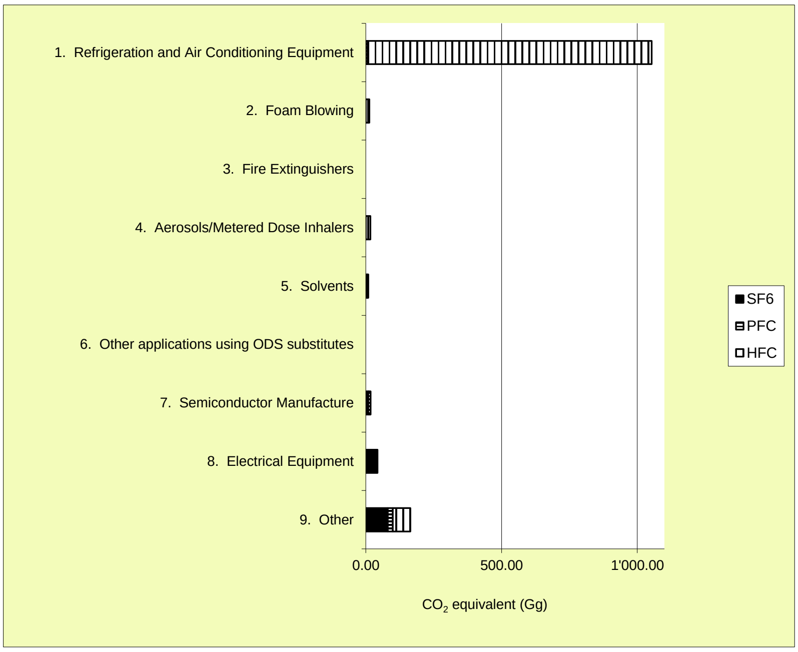

Figure 4-6 Distribution of emissions under source category 2F “Consumption of Halocarbons and SF_6“ (2011 data).

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 4-27). Detailed documentation of the individual data models is available from Carbotech (2013) as well as related background documents. This information is FOEN internal due to confidentiality of data, but is open for consultation by reviewers.

[13] e.g. import amount of some substance for specific company with known application type.

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.

For the present submission for the first time 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.

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. 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 4-27 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 2011 (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).

Table 4-27 Typical values on life time, charge and emission factors used in model calculations for Refrigeration and Air Conditioning Equipment. Where values in brackets are provided, the first value shows the assumption for 1995 while the second value (in brackets) shows the assumption for 2011 respectively 2020. Data between 1995 and 2011 respectively 2020 is linearly interpolated.

Equipment type	Product life time [a]	Initial charge of new product [kg]	Manufacturing emission factor [% of initial charge]	Product life emission factor [% per annum]	Charge at end of life [% of initial charge of new product] *)	Disposal loss emission factor [% of remaining charge
Domestic Refrigeration	16	0.1	NO	0.5	92	19 **)
Commercial and Industrial Refrigeration	10	NR	0.5	12 (2020: 5)	100	20
Transport Refrigeration / Trucks	10	1.8 … 7.8	NO	15	100	20
Transport Refrigeration / Railway	12	NR	NO	10	100	10
Stationary Air Conditioning (direct / indirect cooling system)	15	NR	direct: 3 indirect: 1	direct: 10 (2011: 4) indirect: 6 (2011: 4)	100	direct: 28 indirect: 19
Heat Pumps	15	4.7 …7.5 till 1999 Going down to 2.8 …4.5 in 2010 onwards	3	2	100	20
Mobile Air Conditioning / Cars	15	0.7 (0.84) ***)	NO	8.5	58	50 ****)
Mobile Air Conditioning / Trucks	12	1.1	NO	10 until year 2000 Going down to 8.35 in 2011	35	50 ****)
Mobile Air Conditioning / Buses	12	7.5	NO	10 until year 2009 8.5 for 2010 onwards	35	50 ****)
Mobile Air Conditioning / Railway	13	20	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. 29% of the total emissions (CO2 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 (share of import for Liechtenstein << 0.5%).

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 4-28 Typical values on life time, charge and emission factors used in model calculations for foam blowing.

		Product life time years	Charge of new product % of product weight	Manufacturing emission factor % of initial charge	Product life emission factor % per annum	Charge at end of life % charge of new product
PU foam		50	4.5	NR	NR	NR
XPS foam	HFC 134a HFC 152a	50	6.5	NR	10 / 0.66** 100 / 0**	65 0
PU spray		50	13.6 / 0 *	0.8	95 / 2.5 **	0
Sandwich Elements HFC 134a, HFC 227ea, HFC 365 mfc HFC 152a		50	3	10 100	0.7 0	64 0

* Data for 1990 / since 2009

** Data for 1st year / following years

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

Activity Data

The export rate of PU spray from Swiss production is 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.

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.

For the present submission as a first time 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 previous year (FOEN 2012) 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)” are related to the semiconductor manufacturing and thus the model for allocation of imported PFC volumes was adjusted accordingly.

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 most PFC import declared as “Solvents (2F7)” 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.

Emission Factors

Default emission factors as per IPCC GPG are used. Since the inventory report 2012 (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. For the further industries it is assumed that 66% of applications do have emission control technologies.

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 2011 the calculated product life emission factor is 0.10%. The calculated product life emission factor is varying between 0.77%/a (2005) and 0.10%/a (2011). 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 the present inventory report 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 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 CF_4 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. 80% of the production of cables and electrical control systems is exported. Also for the present inventory report 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 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 2013). 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 4-30 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 (2013).

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 1997–2011 led to the estimations given in Table 4-29.

Table 4-29 Estimated uncertainty for the data of the imported substances

Year	Minimal	Maximal	remarks
Up to 1999	-10%	+30%	assumed that the data are not complete
2000 – 2003	-10%	+15%	data can be incomplete or possible double declaration
2004 – 2011	-10%	+10%	data can be incomplete or possible double declaration

The following table summarises the results for the application-specific emission models. The “value 2011” represents the actual emissions in Gg CO_2 equivalent for the specific application as used for calculating the 2011 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 11%. Higher values result for the contributions of single applications.

Uncertainties of more than 20% have been calculated for the following applications:

- Stationary Air Conditioning
- Transport refrigeration
- Domestic Refrigeration
- Foam blowing
- Aerosols
- Semiconductors
- Others

Uncertainties of 15% to 20% have been calculated for the following applications:

- Commercial/ Industrial Refrigeration
- Mobile Air-Conditioning
- Electrical Equipment

Low uncertainties of less than 15% have been calculated for the following applications:.

- Solvents

For the model calculations of stocks, uncertainties result with a maximum of 42% for R134a in Commercial/ Industrial Refrigeration. 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 4-30 Summary of results for model parameter “emissions” from Monte Carlo Analysis for 2011 data on selected emission sources.

Application	Model para-meter	value 2011 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.	1053	1074	1073	846	1354	12.0
- Commercial / Industrial Refrigeration		570	583	583	410	813	19.4
- Mobile Air-Conditioning		309	304	304	215	406	20.0
- Stationary Air-Conditioning		131	146	146	86.9	212	24.2
- Transport Refrigeration		28.0	31.8	31.7	21.8	48.3	22.6
- Domestic Refrigeration		15.4	8.8	5.9	0.2	35.8	*)
2F2 Foam Blowing		14.1 **)	16.4	16.0	7.1	34.5	45.2
2F4 Aerosol		16.9	17.0	16.9	6.65	29.59	40.8
2F5 Solvents		8.98	8.95	8.97	7.27	10.27	13.4
2F7 Semiconductors		17.4	18.9	18.8	6.50	33.2	39.2
2F8 Electrical equipment		43.6	43.6	43.6	30.8	58.6	15.8
2F9 Other		146	155	145	94.4	263.4	53.6
Total HFC, PFC and SF_6 from 2F		1316	1351	1350	1101	1619	11.2

*) 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 2011 are compared with the results 2010 within the current CRF tables.
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012.
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012.

Recalculations were identified and explained. Detailed controls of all modelling results produced by Carbotech (2013) 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.

For the inventory of this year, again a 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

Source-specific recalculations for the time series 1990 to 2011 are summarized in Table 4-31. 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 2010 delivers about 1.9% higher total emissions under source category 2F than reported in the previous submission.

Table 4-31 Summary of recalculations in source category 2F.

NFR code, precise	name of sector/ process	AD/EF	year	pollutant / gas	explanation
2 IIA F 1 2 a / 2 IIA F 1 5 a	Refrigeration - Commercial/Industrial refrigeration - Air-conditioning equipment	AD	1995-2011	HFC 134a	Shift of used in bulk refrigerant from Commercial&Industrial refrigeration to air-conditioning equipment. The present SMKW statistics indicate HFC 134a stock in air-conditioning to be higher than model calculation. HFC 134a w as used to replace HCFC in air-conditioning equipment (Germany reports high amounts of HFC 134a for the replacement w ithin the time period 1995-2000). The use of HFC 134a for the replacement of HCFC in air-conditioning w as included in model calculations and lead to a low er left amount for Commerical&Industrial refrigeration.
2 IIA F 1 5 a	Refrigeration- Transport refrigeration		1991-2011	HFC 134a	Correction of model calculations, link of data on stock and emissions of railw ay systems
2 IIA F 1 5 a	Refrigeration- Heat pumps	AD	2008-2011	HFC 134a	The portion of HFC w as elevated (less alternatives in use than assumed so far)
2 IIA F 1 2 c / 2 IIA F 1 5 c	Refrigeration - Commercial/Industrial refrigeration - Air-conditioning equipment	EF	2000-2011	All HFC and C3F8	Disposal emission factor elevated, due to the gap betw een FOEN statistics on the disposal/recovery of refrigerant and the model value.
2 IIA F 1 2	Refrigeration - Commercial/Industrial refrigeration	AD	2008-2011	All HFC and C3F8	Adaptation of import in bulk, considering portion of import for Liechtenstein (<1%)
2 IIA F 1 2	Refrigeration - Commercial/Industrial refrigeration	AD	2000-2011	HFC 134a, HFC 125, HFC 134a	Improvement of the model calculations of stock, amount of recovered and reused refrigerant for maintenance and filling of equipment (R134a and R404a).
2 IIA F 1 6	Refrigeration - Mobile Air-conditioning	AD/EF	1991-2011	HFC 134a	Improvement of model calculation of railw ay and bus air-conditioning, emissions from stock.
2 F 5 a	Solvents	AD	2008-2011	HFC 43-10mee	Improvement of model calculation, considering portion of import for Liechtenstein (<1%).
2 F 9	Other	AD	2010	SF6	Improvement in the modelling of the not specified left amount SF_6 used in ‘other applications’

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.

In the data files used for calculating the emissions from Mobile Air-Conditioning / Buses in source category 2F1 an error has been discovered during the final stage of the reporting process. This has the effect that all emissions related to the equipment type Mobile Air-Conditioning / Buses are not taken into account in the total figure for emissions under source category 2F1. Threfore the emissions for source category 2F1 are underestimated by approx. 2%. Due to the late discovery, the data files could not be corrected for the present submission. For next years submission the calculation model will be adjusted.

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 4-32 Specification of source category 2G “Other”.

2G	Source	Specification	Data Source
2G	Other	Emissions of CO_2, NO_x, CO, NMVOC and SO_2 from blasting and shooting	AD, EF: EMIS 2013/2G Sprengen und Schiessen
		Emissions of SO_2 from Claus units in refineries	AD, EF: SFOE 2012, 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 2013/2G 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 2013/2G Sprengen und Schiessen.

Table 4-33 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 2011 (EMIS 2013/2G 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 2013/2G Sprengen und Schiessen and the Swiss overall energy statistics (SFOE 2012), respectively.

Table 4-34 Amount of used explosives and processed crude oil in Switzerland for the period 1990-2011 in Gg (EMIS 2013/2G 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	5'323	4'984	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
Blasting and shooting			
blasting agent and powder	Gg	2.4	2.9
Claus units in refineries			
crude oil	Gg	4'491	4'402

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 1-13, 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 2011 are compared with the results 2010 within the current CRF tables
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

4.8.5 Source-Specific Recalculations

No recalculations have been made in category 2G in this year’s submission

4.8.6 Source-Specific Planned Improvements

It will be checked whether the revised Swiss CO2-act and ordinance (FOEN 2013f) could provide an improved data base for the largest industrial emitters.

Furthermore, in 2012 a national review on sector 2 Industrial Processes took place (CSD 2013). The final report will be evaluated in order to see which suggestions for improvement could be implemeted in future submissions.

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 (level and trend).
N_2O emissions from Solvent and Other Product Use (trend).

5.1.1 Emissions of CO_2 and N_2O

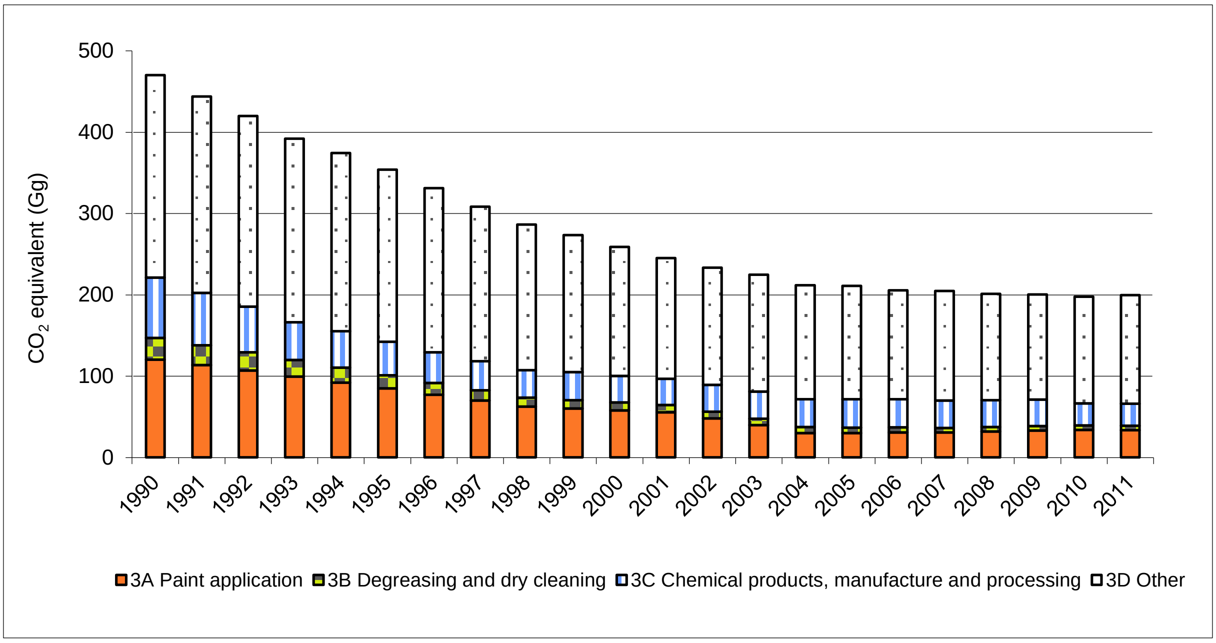

Figure 5-1 Switzerland's GHG emissions of sector 3 Solvent and Other Product Use 1990-2011 in Gg CO_2 eq.

In 2011 199 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 57.6% between 1990 and 2011. Source category 3D Other remains the dominant source within the category 3 Solvent and Other Product Use although its emissions have decreased by 46.3% since 1990. Source category 3A Paint Application has decreased by 72.4% since 1990, source category 3C

Chemical Products has decreased by 63.5% and source category 3B Degreasing and Dry Cleaning has decreased by 79.6%.

Table 5-1 Emissions of sector 3 Solvent and Other Product Use 1990-2011 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	199	191	181	172	160	158	157	157	155	155
N_2O	59	54	52	53	51	52	49	47	46	45
Sum	259	245	233	224	211	211	205	204	201	200

Gas	2010	2011
	CO_2 eq. (Gg)	
CO_2	152	155
N_2O	46	44
Sum	198	199

The relative trends of the emissions of CO_2 and N_2O are shown in Figure 5-2. The base year 1990 represents 100%.

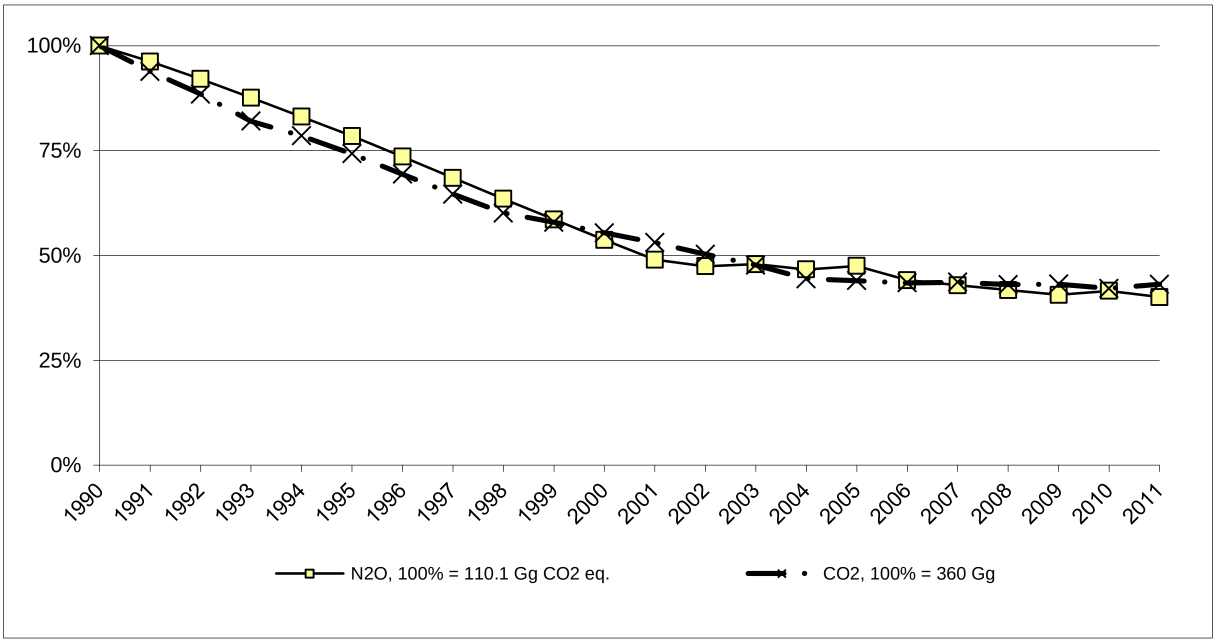

Figure 5-2 Relative trends of the greenhouse gases of sector 3 Solvent and Other Product Use in the period 1990-2011.

5.1.2 Emissions of NMVOC

Due to the importance of NMVOC emissions in sector 3 Solvent and Other Product Use they are shown separately in Table 5-2.

Table 5-2 Emissions of NMVOC in sector 3 Solvent and Other Product Use 1990-2011 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	40	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	25	24	24
Sum	67	62	57	51	45	44	43	43	43	43

NMVOC	2010	2011
	Gg	
3A Paint application	13	13
3B Degreasing and dry cleaning	2	2
3C Chemical products, manufacture and processing	4	4
3D Other	24	23
Sum	43	42

NMVOC emissions have decreased by 72.6 % between 1990 and 2011. 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".

	Source	Specification	Data Source
3A	Paint Application	Emissions of CO_2 and NMVOC from paint application in households, industry and construction	AD, EF: EMIS 2013/3A1, 3A2 and 3A3[14]

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 2013 contains a description of the country-specific methods used for

[14] As far as no further specification is given, all EMIS documents which are published under this source category are ment. If the text refers to a specific EMIS document the whole name is written out e.g. EMIS 2013/3A1 Farben-Anwendung Bau.

estimating the NMVOC emissions from the most important sources within source category 3A (FOEN 2013e, 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 leads to additional direct CO_2 emissions resulting from post-combustion of NMVOC. 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 2013/3A).

For paint application in construction, which is the most important NMVOC source in 3A Paint Application, the emission factor amounts to 58 kg NMVOC per ton of paint in 2011 (EMIS 2013/3A1 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 correspond 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 2013/3A).

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 2011 (EMIS 2013/3A1 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 2011 are compared with the results 2010 within the current CRF tables
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

5.2.5 Source-Specific Recalculations

3A: The carbon content fraction for calculating the indirect CO_2 emissions from decomposition of NMVOC in the atmosphere has been changed to 0.6 using the default value from the 2006 IPCC Guidelines (former carbon content fraction: 0.64).

3A1 Paint Application in Construction: EF values for 1990 and 2010 have been updated resulting in revised interpolated values for the years 1991-1997 and 2008-2009, respectively. Activity data for 2010 has been updated resulting in revised interpolated values for the years 2008 and 2009 as well.

3A1: Paint Applications in Households: The values for 2010 have been updated resulting in revised interpolated values for the years 2008 and 2009 as well.

3A2: Paint Application, others, industrial: The values for 2010 have been updated resulting in revised interpolated values for the years 2008 and 2009 as well.

3A2: Paint Application car repair: EF values and activity data for 1995, 1998, 2001, 2004, 2007 and 2010 have been updated resulting in revised interpolated values for the years 1991-1994, 1996, 1997, 1999, 2000, 2002, 2003, 2005, 2006, 2009 and 2010 as well.

3A2: Paint Application, others, non-industrial: The values for 2010 have been updated resulting in revised interpolated values for the years 2008 and 2009 as well.

5.2.6 Source-Specific Planned Improvements

Gradual improvement of the data quality in co-operation with industry and industry associations is on-going.

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".

	Source	**Specification**	**Data Source**
3B	Degreasing and Dry Cleaning	Emissions of CO_2 and NMVOC from degreasing; dry cleaning; cleaning of electronic components; cleaning of parts in metal processing; other industrial cleaning	AD, EF: EMIS 2013/3B1 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 2013 contains a description of the country-specific methods used for estimating the

NMVOC emissions from the most important sources within source category 3B (FOEN 2013e, 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 2013/3B).

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 2011 (EMIS 2013/3B1 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 correspond 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 2013/3B).

For degreasing of metal, which is the most important NMVOC source in source category 3B Degreasing and Dry Cleaning, the activity data equals to 2'299 t solvent in 2011 (EMIS 2013/3B1 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 2011 are compared with the results 2010 within the current CRF tables
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

5.3.5 Source-Specific Recalculations

3B: The carbon content fraction for calculating the indirect CO_2 emissions from decomposition of NMVOC in the atmosphere has been changed to 0.6 using the default value from the 2006 IPCC Guidelines (former carbon content fraction: 0.61).

5.3.6 Source-Specific Planned Improvements

Gradual improvement of the data quality in co-operation with industry and industry associations is on-going.

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".

	Source	**Specification**	**Data Source**
3C	Chemical Products, Manufacture and Processing	Emissions of CO_2 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 2013/3C

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 2013 contains a description of the country-specific methods used for estimating the NMVOC emissions from the most important sources within source category 3C (FOEN 2013e, 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 base on data from Swiss industry and expert estimates, documented in the EMIS database (EMIS 2013/3C). Emission factors for handling and storage of solvents are estimated according to the solvent vapour pressure.

The emission factor for indirect CO_2 emissions from decomposition of NMVOC in the atmosphere is 2.2 Gg CO2/Gg NMVOC (carbon content fraction * molecular weight of carbon dioxide / molecular weight of carbon).

Activity Data

Activity data correspond to the annual consumption of solvents. They are based on data from industry and expert estimates, documented in the EMIS database (EMIS 2013/3C).

For fine chemical production, which is the most important NMVOC source in source category 3C Chemical Products, Manufacture and Processing, the NMVOC emissions equal to 1'110 t NMVOC in 2011 (EMIS 2013/3C Feinchemikalien-Produktion). Up to now, data for fine chemical production directly referred to the emissions without distinction between activity data and emission factor. For this year's submission the direct emissions have been converted into AD and EF time series. For activity data the index of production according to the Swiss Federal Office of Statistics is used. The emission factor for 2011 equals to $3.68*10^6$ g NMVOC/index point (EMIS 2013/3C Feinchemikalien-Produktion)

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 2011 are compared with the results 2010 within the current CRF tables
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

5.4.5 Source-Specific Recalculations

3C: The carbon content fraction for calculating the indirect CO_2 emissions from decomposition of NMVOC in the atmosphere has been changed to 0.6 using the default value from the 2066 IPCC Guidelines (former carbon content fraction: 0.63).

3C Paint and ink manufacturing: AD and NMVOC EF values for 2010 have been updated resulting in revised interpolated values for the years 2008 and 2009 as well.

3C Fine chemical production: Former so-called direct emissions of this source category have been converted into AD and EF time series resulting in small rounding differences of the NMVOC emissions.

3C Handling and storage of solvents: Former so-called direct emissions of this source category have been converted into AD and EF time series resulting in small rounding differences of the NMVOC emissions.

3C Pharmaceutical production: AD and NMVOC EF for 2011 have been updated resulting in revised interpolated values for the years 2008-2010.

3C Tanning: AD values for 2005, 2007, 2008 and 2011 have been updated resulting in revised interpolated values for 2006, 2007, 2009 and 2010.

5.4.6 Source-Specific Planned Improvements

Gradual improvement of the data quality in co-operation with industry and industry associations is on-going.

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".

	Source	Specification	Data Source
3D1	Use of N_2O for Anaesthesia	Emissions of N_2O from the use of N_2O in hospitals	AD, EF: EMIS 2013/3D1
3D3	N_2O from Aerosol Cans	Emissions of N_2O from the use of aerosol cans	AD, EF: EMIS 2013/3D3
3D5	Other	Emissions of CO_2 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 CO_2, NO_x, CO and SO_2 from use of fireworks	AD, EF: EMIS 2013/3D5

5.5.2 Methodological Issues

Methodology

Emissions of N2O 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 N2O 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 2013 contains a description of the country-specific methods used for estimating the NMVOC emissions from the most important sources within source category 3D (FOEN 2013e, 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 and source category 3D3 N_2O from aerosol cans the emission factor is calculated based on the amount on N_2O sold in Switzerland divided by the number of inhabitants (EMIS 2013/3D1 Lachgasanwendung Spitäler and EMIS 2013/3D3 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 2011(EMIS 2013/3D1 Lachgasanwendung Spitäler; EMIS 2013/3D3 Lachgasanwendung Haushalt).

3D Other	Unit	N_2O
3D1 Use of N_2O for anaesthesia	g/inhabitant	6
3D3 N_2O from aerosol cans	g/inhabitant	12

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 2013/3D). For house cleaning, which is the most important emission source in source category 3D5 Other, the emission factor for NMVOC amounts to 896 g per inhabitant in 2011 (EMIS 2013/3D5 Reinigung Gebäude IGD).

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 7'912'000 in 2011 (EMIS 2013/3D1 Lachgasanwendung Spitäler and EMIS 2013/3D3 Lachgasanwendung Haushalt).

For source category 3D5 Other the activity data correspond to the annual production/ consumption of solvents. Data bases on industry data and expert estimates, documented in the EMIS database (EMIS 2013/3D5). 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 7'912'000 in 2011 (EMIS 2013/3D5 Reinigung Gebäude IGD).

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).

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 2011 are compared with the results 2010 within the current CRF table
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

5.5.5 Source-Specific Recalculations

3D1 and 3D3: EF values have been updated for N_2O emissions for the years 2004-2010.

3D5: The carbon content fraction for calculating the indirect CO_2 emissions from decomposition of NMVOC in the atmosphere has been changed to 0.6 using the default value from the 2066 IPCC Guidelines (former carbon content fraction: 0.69).

3D5: EF and AD values have been updated for several source categories (hairdressers, removal of paint and lacquer, other health care institutions, impregnating of glass and mineral wool, wood preservation, cosmetic institutions, medical practitioners, extraction of oil and fats, paper and paper board production, production of perfume /aroma and cosmetics, use of pesticides, production and use of tobacco products, scientific laboratories, house cleaning industry/craft/services, textile production) resulting in adjusted values for NMVOC emissions for the whole time series.

5.5.6 Source-Specific Planned Improvements

Gradual improvement of the data quality in co-operation with industry and industry associations is on-going.

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 2011 were 5'604 Gg CO_2 equivalents in total which is a contribution of 12.0% to the total of Swiss greenhouse gas emissions. Main agricultural sources of greenhouse gases in 2011 were enteric fermentation emitting 2'509 Gg CO_2 equivalents (45% of all agricultural greenhouse gases), followed by agricultural soils with 2'108 Gg CO_2 equivalents (38%) and Manure Management with 986 Gg CO_2 equivalents (18%).

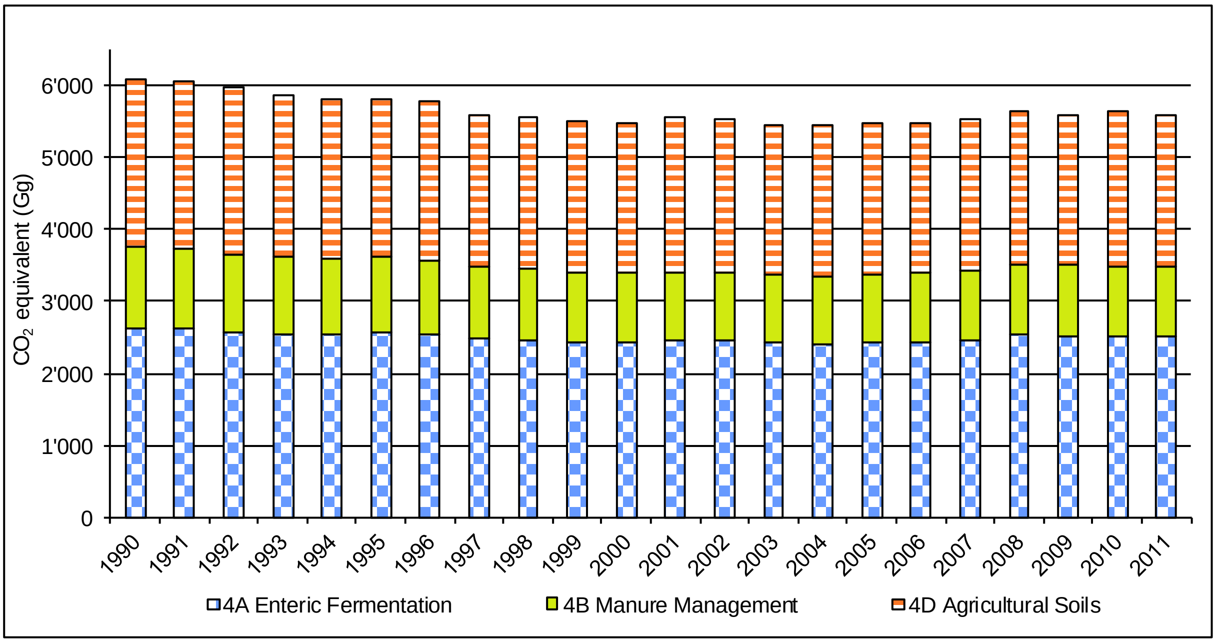

Figure 6-1 Greenhouse gas emissions of agriculture in Gg CO_2 equivalents 1990-2011.

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 1990-2011.

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	3'188	3'201	3'171	3'107	3'092	3'055
N_2O	2'785	2'772	2'743	2'678	2'620	2'618	2'609	2'499	2'486	2'456
Sum	6'092	6'069	5'979	5'877	5'808	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	2'406	2'437	2'445	2'419
Sum	5'496	5'561	5'536	5'461	5'447	5'474	5'494	5'556	5'648	5'593

Gas	2010	2011
	CO2 eq. (Gg)	
CO_2	0	0
CH_4	3'167	3'159
N_2O	2'480	2'445
Sum	5'647	5'604

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 2007 total emissions seem to be fluctuating on a rather stable level. Most emission factors did not change significantly.

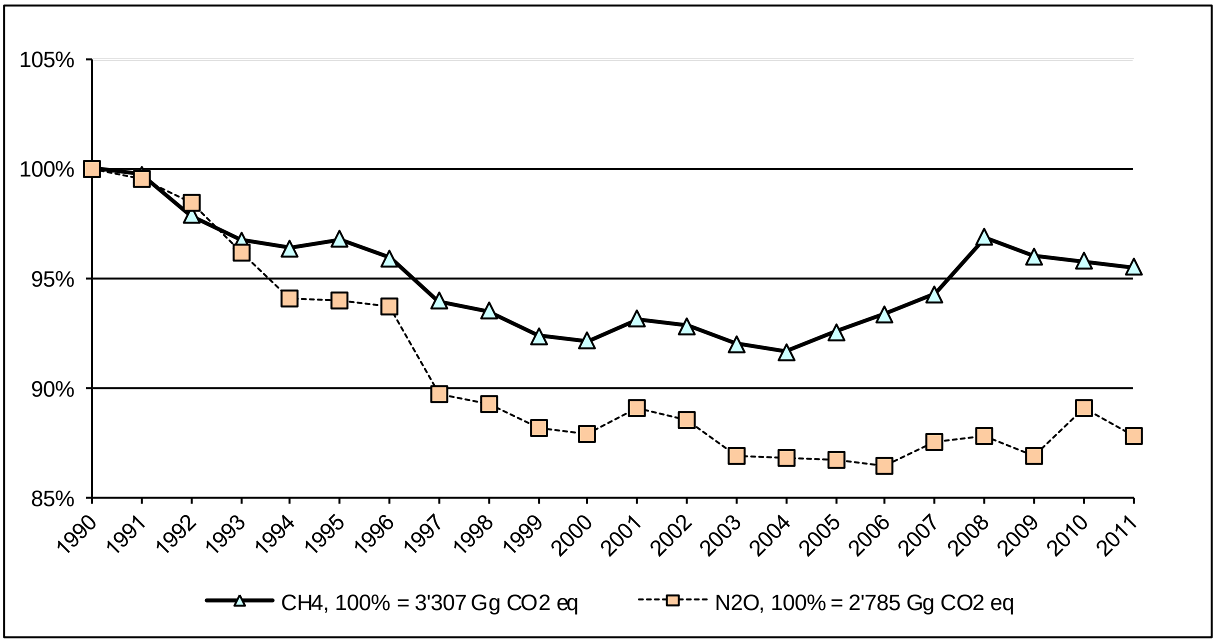

Figure 6-2 Trend of the greenhouse gases of the agricultural sector 1990-2011. The base year 1990 represents 100%.

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

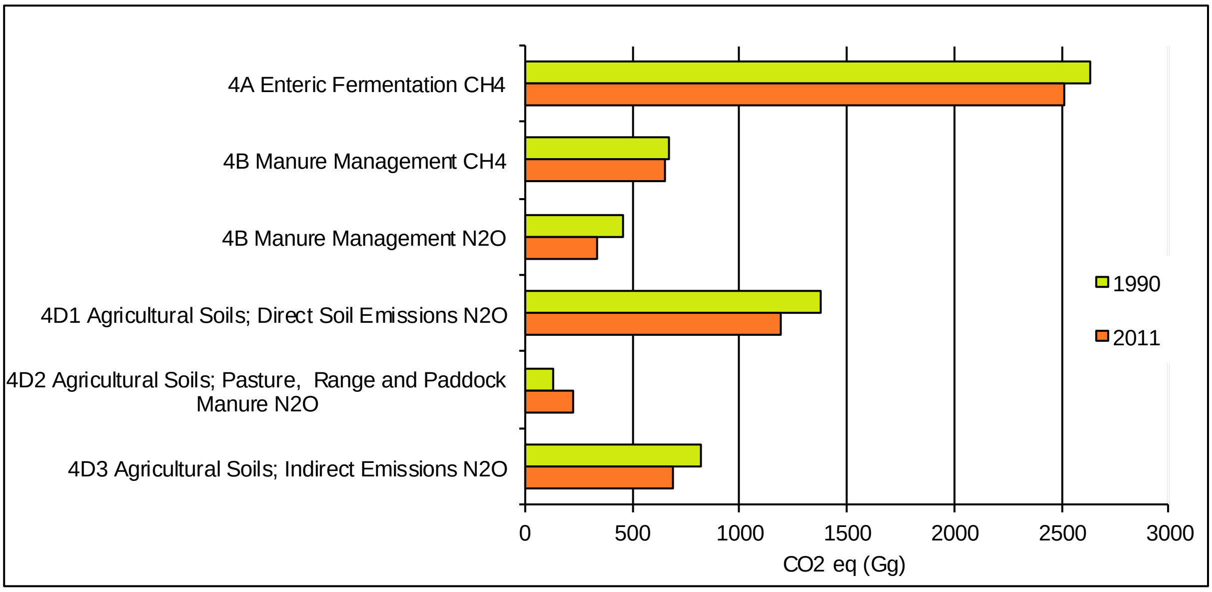

Figure 6-3 Key sources (Tier 1 and Tier 2) in Agriculture, emissions 1990 and 2011 in CO_2 equivalents (Gg).

6.2 Source Category 4A – Enteric Fermentation

6.2.1 Source Category Description

Tier 1 and 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 2012; ART/SHL 2012 Net energy and metabolisable energy (calves) from RAP 1999 EF: Soliva 2006
4A3 4A4	Sheep Goats		AD: Livestock data from SBV 2012 and ART/SHL 2012, and net energy data from Giuliani 2012 EF: Soliva 2006

4A6 4A7 4A8	Horses Mules and asses Swine		AD: Livestock data from SBV 2012 and ART/SHL 2012, and digestible energy data from Giuliani 2012 and Stricker 2012 EF: Soliva 2006
4A9	Poultry		AD: Livestock data from SBV 2012 and ART/SHL 2012, and metabolisable energy data from Giuliani 2012 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 (2012) as well as on Stricker 2012. The method is described in detail in Soliva (2006) and is realised in ART (2013).

Different energy levels (Figure 6-4) are used to express the energy conversion from energy required for maintenance and performance to gross energy intake.

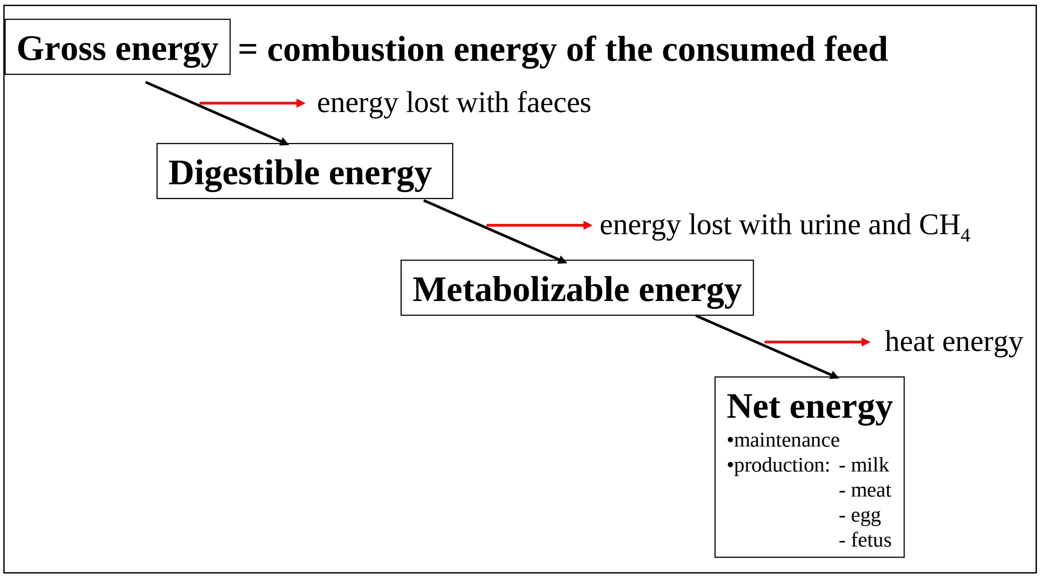

Figure 6-4 Levels of feed energy conversion. Reference: Soliva 2006.

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 subcategory 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 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
Sheep	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 2012 and RAP (1999). All sub-categories displayed in italic.

Gross Energy Intake		**1990-1999**									
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
		MJ/head/day									
Cattle											
Mature Dairy Cattle		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	93.8	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									
Cattle											
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	91.0	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	22.4	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	**2011**
		MJ/h./d.	
Cattle			
Mature Dairy Cattle		310.8	312.6
Mature Non-Dairy Cattle		205.1	205.1
Young Cattle Average (weighted)		90.4	90.1
	Fattening Calves	*47.6*	*47.6*
	Pre-Weaned Calves	*55.7*	*55.7*
	Breeding Calves	*26.9*	*26.9*
	Breeding Cattle (4-12 months)	*89.2*	*89.2*
	Breeding Cattle (> 1 year)	*129.1*	*129.1*
	Fattening Calves (0-4 months)	*55.6*	*55.6*
	Fattening Cattle (4-12 months)	*124.6*	*124.6*
Sheep		22.8	22.8
Goats		24.9	24.9
Horses		107.9	107.9
Mules and Asses		40.2	39.9
Swine		27.5	27.5
Poultry [1)]		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 6’920 kg per head and year in 2011. Statistics of annual milk production are provided by the Swiss Farmers Union (SBV 2012). Milk production includes marketed milk, milk consumed by calves on farms and milk sold outside the commercial industry (MISTA 2012).

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	742'046	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	618'100	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
Population Size Mature Dairy Cattle	head	589'024	589'239
Lactation Period	day	305	305
Milk Yield Mature Dairy Cattle	kg/head/day	22.46	22.69
Milk Yield Mature Non-Dairy Cattle	kg/head/day	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 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 2012) and the Swiss Federal Statistical Office (SFSO 2012d). 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 2012).

Population Size		1990-1999									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		1'000 head									
Cattle		1'855	1'829	1'783	1'745	1'746	1'748	1'747	1'673	1'641	1'609
Mature Dairy Cattle		783	781	764	744	742	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	984	986	983	929	904	884
	Fattening Calves	*112*	*111*	*110*	*111*	*106*	*102*	*112*	*106*	*108*	*116*
	Pre-Weaned Calves	*10*	*11*	*14*	*14*	*16*	*18*	*22*	*26*	*29*	*33*
	Breeding Calves	*214*	*204*	*197*	*184*	*175*	*166*	*155*	*139*	*136*	*72*
	Breeding Cattle (4-12 months)	*132*	*133*	*127*	*125*	*127*	*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*	*79*	*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									
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	861	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	451	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	2011
		1'000 head	
Cattle		1'591	1'577
Mature Dairy Cattle		589	589
Mature Non-Dairy Cattle		111	111
Young Cattle		891	877
	Fattening Calves	*99*	*101*
	Pre-Weaned Calves	*88*	*88*
	Breeding Calves	*77*	*75*
	Breeding Cattle (4-12 months)	*149*	*145*
	Breeding Cattle (> 1 year)	*332*	*324*
	Fattening Calves (0-4 months)	*34*	*34*
	Fattening Cattle (4-12 months)	*111*	*111*
Sheep		434	424
Goats		83	83
Horses		71	66
Mules and Asses		23	22
Swine		1'589	1'579
Poultry		9'025	9'478

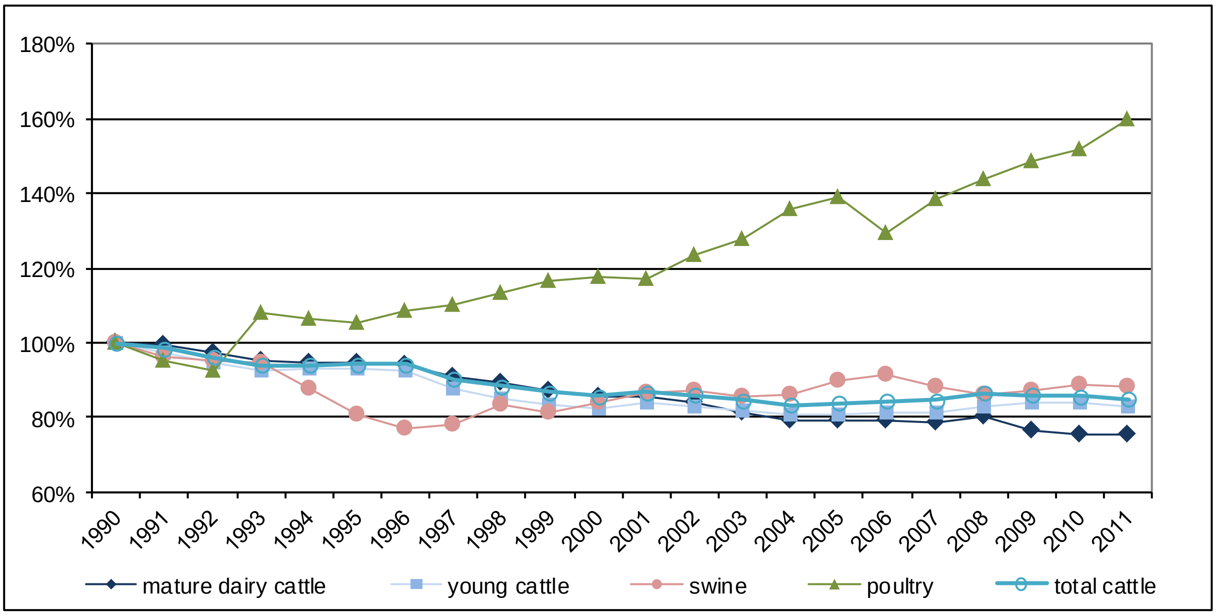

Figure 6-5 Relative development of main animal categories 1990-2011.

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, and have since remained stable.

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 2011 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 (17.0%), resulting in a combined uncertainty of 18.2%. For further results see Section 1.7.

The time series 1990–2011 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 three inventory years cattle population statistics were not available in the usual format. Data for 2009 to 2011 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 - 29 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 2012 (INFRAS 2012). Implied emission factors for enteric fermentation in Switzerland are generally higher than IPCC 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). In the case of young cattle, energy intake values are lower than when calculated with the IPCC default methodology. High feed quality together with high genetic standard i.e. high energy use efficiency of Swiss cattle might be a reason for the differences (ART 2013a). However, a straightforward comparison is difficult due to 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.

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 2011 are compared with the results for 2010 within the current CRF
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of the submission 2012.
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission the 2012

Additionally an independent quality control was conducted by INFRAS by a countercheck of the data and calculation sheets elaborated by ART (ART 2013).

6.2.5 Source-Specific Recalculations

Preliminary estimates for energy requirements for non cattle populations have been revised. A new dataset for the time period 1990 – 2010 has been received from the Swiss Farmers Union (Giuliani 2012). 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 estimated to be approximatively -10 Gg CO_2 equivalents.

For gross energy intake of horses, mules and asses a new assessment has been made due to recommendations in the annual review reports (UNFCCC 2011, UNFCCC 2012). The new estimates are based on Meyer and Coenen 2002 and have been elaborated at the Research Station ALP-Haras (Stricker 2012). The effect of the recalculation on overall greenhouse gas emissions is estimated to account -10 Gg CO_2 equivalents.

6.2.6 Source-Specific Planned Improvements

There are no source-specific improvements planned.

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 follow closely the development of the cattle population. Emissions were declining from 1990 until 2004, and have been slightly increasing again 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	AD: SBV 2012; ART/SHL 2012 EF: IPCC 2000; IPCC 1997c; Flisch et al. 2009; Kupper et al. 2013; Soliva 2006
		Mature non-dairy cattle	
		Young cattle	
4B3 4B4 4B6 4B8	Sheep Goats Horses Swine		AD: SBV 2012; ART/SHL 2012 EF: IPCC 2000; IPCC 1997c; Flisch et al. 2009; Kupper et al. 2013; Soliva 2006
4B7	Mules and Asses		AD: SBV 2012; ART/SHL 2012 EF: IPCC 2000; IPCC 1997c; Flisch et al. 2009; Kupper et al. 2013; Soliva 2006
4B9	Poultry		AD: SBV 2012; ART/SHL 2012 EF: IPCC 2000; IPCC 1997c; Flisch et al. 2009; Kupper et al. 2013; Soliva 2006

Table 6-8 Specification of source category 4B “Manure Management” (N_2O).

4B	Source	Specification	Data Source
4B11 4B12	Liquid systems Solid storage and dry lot		AD: SBV 2012; ART/SHL 2012; 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 ART (2013).

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**) 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%
Liquid/slurry	Combined storage of dung and urine under animal confinements for longer than 1 month.	10%
Pasture	Manure is allowed to lie as it is, and is not managed (distributed, etc.).	1%
Deep litter	Dung and urine is excreted in a barn with lots of litter and is not removed for a long time (months). This is applied for the cattle sub-categories of fattening calves, fattening calves 0-4 months, and for sheep and goats.	10%
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 a number of studies representative for the country specific management conditions. 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.

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		
	%			%			%			%			%		
Cattle	Solid manure/ Deep litter	Liquid/ Slurry	Pasture range and pad-dock	Solid manure/ Deep litter	Liquid/ Slurry	Pasture range and pad-dock	Solid manure/ Deep litter	Liquid/ Slurry	Pasture range and pad-dock	Solid manure/ Deep litter	Liquid/ Slurry	Pasture range and pad-dock	Solid manure/ Deep litter	Liquid/ Slurry	Pasture range and pad-dock
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 (2012) and the Swiss Federal Statistical Office (SFSO 2012d). 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, subcategory 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 2012) and the Swiss Federal Statistical Office (SFSO 2012d). 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 2012).

Population Size		**1990-1999**									
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
		1000 head									
Cattle											
Mature Dairy Cattle		783.1	780.5	763.5	744.5	742.0	739.6	736.0	711.6	701.3	683.5
Mature Non-Dairy Cattle		12.0	14.0	17.0	18.0	20.0	23.0	28.0	32.0	36.0	41.2
Young Cattle Average (weighted)		1060.1	1034.4	1002.1	982.6	983.7	985.6	983.0	929.3	903.5	884.0
	Fattening Calves	112.3	111.4	109.5	111.1	106.4	101.7	112.0	106.0	108.1	116.4
	Pre-Weaned Calves	9.6	11.2	13.6	14.4	16.0	18.4	22.4	25.6	28.8	33.2
	Breeding Cattle 1st Year	346.4	336.7	324.0	308.2	301.5	294.7	286.1	260.1	253.5	218.7
	Breeding Cattle 2nd Year	253.3	251.9	250.5	238.7	238.6	238.6	243.0	232.9	217.4	187.5
	Breeding Cattle 3rd Year	150.7	148.4	146.7	142.3	140.8	139.4	139.9	139.3	132.7	117.9
	Fattening Cattle	187.8	174.8	157.8	168.0	180.4	192.9	179.6	165.4	163.1	210.2
Sheep		395.2	409.4	414.7	424.0	405.4	386.7	418.6	420.4	422.3	423.5
	Fattening Sheep	190.6	200.8	201.0	211.1	201.2	191.4	207.6	208.0	208.7	221.7
	Milksheep	4.3	4.0	3.8	3.5	3.3	3.0	2.8	3.1	4.4	5.8
Goats		68.3	65.2	58.2	56.7	54.9	53.2	56.8	58.0	60.1	61.6
	Goat Places	44.8	43.1	38.4	37.3	35.9	34.6	37.1	37.7	39.8	40.8
Horses		51.2	52.2	53.2	54.3	58.0	61.6	62.4	64.7	63.8	65.3
	Horses <3 years	11.0	11.3	11.5	11.7	14.1	16.4	15.5	14.1	13.8	14.8
	Horses >3 years	40.2	41.0	41.8	42.6	43.9	45.2	46.9	50.7	50.1	50.5
Mules and Asses		10.7	10.9	11.1	11.3	11.3	11.2	12.3	13.3	13.7	15.2
	Mules	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.6
	Asses	10.4	10.6	10.8	11.0	10.9	10.8	11.8	12.8	13.2	14.6
Swine		1787.0	1722.6	1705.7	1691.8	1568.7	1445.6	1379.4	1394.9	1487.0	1453.3
	Piglets	299.4	282.5	290.8	299.6	287.2	274.8	240.9	252.2	261.8	281.0
	Fattening Pig over 25 kg	1024.6	989.6	972.8	943.0	855.5	767.9	778.7	779.6	837.4	734.4
	Dry Sows	129.3	126.0	124.9	125.3	117.1	108.9	98.8	104.3	110.9	101.2
	Nursing Sows	37.4	36.8	36.8	37.3	35.1	33.0	30.2	29.9	31.4	35.0
	Boars	8.4	8.1	8.0	8.2	7.7	7.1	6.3	6.4	6.4	6.2
Poultry		5938.2	5646.8	5501.6	6409.8	6330.3	6250.7	6440.5	6552.5	6739.6	6907.5
	Growers	718.9	664.2	709.6	719.2	716.8	714.4	732.1	732.9	793.5	760.9
	Layers	3083.0	2645.4	2535.8	2517.6	2317.9	2118.2	2226.0	2277.5	2270.1	2222.8
	Broilers	2019.9	2198.6	2095.5	2990.2	3110.6	3231.0	3293.2	3342.0	3502.3	3747.4
	Turkey	94.7	117.4	140.1	162.8	166.5	170.2	173.8	184.4	157.8	154.6
	Other Poultry (Geese, Ducks, Ostriches, Quails)	21.8	21.2	20.6	20.0	18.4	16.9	15.3	15.8	15.9	21.9

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Population Size		2000-2009									
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		1000 head									
Cattle											
Mature Dairy Cattle		669.4	669.4	657.9	638.3	621.0	620.7	618.1	614.8	628.5	599.4
Mature Non-Dairy Cattle		44.9	50.6	58.1	65.1	70.0	78.5	87.3	93.5	98.4	108.4
Young Cattle		873.7	891.3	877.7	866.7	853.6	855.5	861.4	863.4	877.4	889.7
	Fattening Calves	103.3	114.7	114.4	113.9	111.3	105.6	101.2	100.5	95.0	100.5
	Pre-Weaned Calves	35.7	40.4	46.9	52.3	56.6	62.5	67.3	72.2	76.1	85.8
	Breeding Cattle 1st Year	236.0	238.1	229.5	219.8	214.7	222.0	223.2	223.3	232.4	225.7
	Breeding Cattle 2nd Year	221.9	219.3	219.1	212.7	205.4	204.7	210.2	210.5	212.7	212.2
	Breeding Cattle 3rd Year	129.8	130.4	126.0	124.0	120.9	113.3	110.1	109.1	109.6	118.8
	Fattening Cattle	147.1	148.5	141.7	144.1	144.7	147.5	149.4	148.0	151.6	146.6
Sheep		420.7	420.0	429.5	444.8	440.5	446.4	450.9	443.6	446.2	431.9
	Fattening Sheep	216.6	216.6	219.9	228.6	227.5	229.4	230.6	230.0	229.4	227.3
	Milksheep	6.7	7.0	7.2	8.0	8.1	8.9	13.0	10.2	10.7	11.7
Goats		62.5	63.0	66.0	67.4	70.6	74.0	76.3	79.1	81.4	81.2
	Goat Places	41.4	42.1	43.0	44.9	46.2	48.5	50.6	51.9	53.4	54.3
Horses		66.2	64.4	64.3	64.7	64.5	64.9	65.8	66.9	67.8	69.1
	Horses <3 years	13.3	12.5	12.0	11.5	11.3	11.0	11.1	11.2	11.0	10.4
	Horses >3 years	52.9	51.9	52.4	53.2	53.3	53.8	54.7	55.7	56.7	58.8
Mules and Asses		15.5	16.0	16.6	17.3	17.8	18.8	19.2	19.9	20.5	22.1
	Mules	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.9
	Asses	15.0	15.4	16.0	16.7	17.3	18.2	18.6	19.3	19.9	21.1
Swine		1498.2	1547.7	1556.7	1528.9	1537.5	1609.5	1634.8	1573.1	1540.1	1557.2
	Piglets	296.6	318.8	326.6	322.8	327.8	337.6	366.5	344.8	336.1	338.4
	Fattening Pig over 25 kg	750.9	762.5	767.9	751.7	753.2	796.7	786.1	766.9	763.2	779.5
	Dry Sows	104.8	108.0	108.6	105.3	107.9	112.7	115.2	105.7	105.4	104.7
	Nursing Sows	36.7	37.5	36.5	35.8	35.3	36.0	36.5	34.9	32.6	33.1
	Boars	6.2	6.1	5.8	5.3	5.2	5.1	4.9	4.2	4.0	3.8
Poultry		6983.0	6939.5	7338.6	7587.3	8060.7	8260.4	7670.3	8228.5	8542.8	8809.4
	Growers	831.7	745.3	753.9	809.0	853.1	867.7	888.4	901.8	919.0	966.7
	Layers	2150.3	2069.5	2154.1	2117.2	2088.8	2188.5	2147.3	2197.7	2254.9	2318.3
	Broilers	3807.8	3993.2	4298.2	4518.4	4970.8	5060.4	4481.3	5002.4	5300.4	5456.2
	Turkey	172.6	123.0	123.9	133.8	138.8	132.3	137.1	112.5	53.8	52.4
	Other Poultry (Geese, Ducks, Ostriches, Quails)	20.7	8.6	8.5	8.8	9.3	11.5	16.1	14.2	14.7	15.9

Population Size			
		2010	2011
		1000 head	
Cattle			
Mature Dairy Cattle		589.0	589.2
Mature Non-Dairy Cattle		111.3	110.7
Young Cattle		890.9	877.5
	Fattening Calves	99.4	100.5
	Pre-Weaned Calves	88.1	87.6
	Breeding Cattle 1st Year	226.4	220.7
	Breeding Cattle 2nd Year	212.8	207.5
	Breeding Cattle 3rd Year	119.2	116.2
	Fattening Cattle	145.1	145.0
Sheep		434.1	424.0
	Fattening Sheep	228.2	221.8
	Milksheep	12.4	12.4
Goats		82.8	83.0
	Goat Places	54.7	55.9
Horses		71.4	65.8
	Horses <3 years	10.0	9.5
	Horses >3 years	61.4	56.3
Mules and Asses		23.5	21.8
	Mules	1.1	0.9
	Asses	22.3	20.9
Swine		1589.0	1578.7
	Piglets	350.9	352.7
	Fattening Pig over 25 kg	788.1	787.2
	Dry Sows	106.1	103.4
	Nursing Sows	33.5	32.3
	Boars	3.7	3.3
Poultry		9024.9	9477.7
	Growers	925.5	969.7
	Layers	2438.1	2437.0
	Broilers	5580.1	5984.1
	Turkey	58.1	57.8
	Other Poultry (Geese, Ducks, Ostriches, Quails)	23.2	29.0

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 dairy cattle is dependent on milk production and is therefore increasing from 1990 to 2011. 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 (kg N/head/year) 1990-2011 (Kupper et al. 2013).

Nitrogen Excretion		**1990-1999**									
		1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
		kg N / head / year									
Cattle											
Mature Dairy Cattle		96.06	96.57	97.09	97.61	98.13	98.65	99.35	100.05	100.75	101.45
Mature Non-Dairy Cattle		80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
Young Cattle Average (weighted)		33.08	33.11	33.21	33.13	33.25	33.37	33.28	33.56	33.31	32.85
	Fattening Calves	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	Pre-Weaned Calves	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00
	Breeding Cattle 1st Year	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
	Breeding Cattle 2nd Year	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
	Breeding Cattle 3rd Year	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00
	Fattening Cattle	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00
Sheep		7.46	7.56	7.46	7.64	7.62	7.59	7.58	7.58	7.63	8.14
	Fattening Sheep	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
	Milksheep	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00
Goats		10.49	10.58	10.56	10.53	10.47	10.41	10.43	10.42	10.58	10.59
	Goat Places	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Horses		43.57	43.57	43.57	43.57	43.51	43.47	43.50	43.56	43.57	43.55
	Horses <3 years	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
	Horses >3 years	44.00	44.00	44.00	44.00	44.00	44.00	44.00	44.00	44.00	44.00
Mules and Asses		15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70
	Mules	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70
	Asses	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70
Swine		13.37	13.38	13.31	13.13	12.95	12.75	12.72	12.35	11.99	10.88
	Piglets	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	17.01	16.95	16.88	16.81	16.75	16.68	16.15	15.63	15.10	14.58
	Dry Sows	24.28	24.28	24.28	24.28	24.28	24.28	23.53	22.77	22.02	21.26
	Nursing Sows	47.57	47.57	47.57	47.57	47.57	47.57	46.77	45.98	45.18	44.39
	Boars	20.50	20.50	20.50	20.50	20.50	20.50	20.02	19.53	19.04	18.56
Poultry		0.57	0.56	0.56	0.54	0.53	0.53	0.54	0.54	0.54	0.55
	Growers	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.32
	Layers	0.71	0.71	0.71	0.71	0.71	0.71	0.72	0.74	0.75	0.76
	Broilers	0.40	0.40	0.40	0.40	0.40	0.40	0.41	0.41	0.42	0.43
	Turkey	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)	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56

Nitrogen Excretion		**2000-2009**									
		2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
		kg N / head / year									
Cattle											
Mature Dairy Cattle		102.15	102.85	103.55	104.49	105.42	106.35	107.28	108.21	108.20	108.18
Mature Non-Dairy Cattle		80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
Young Cattle		33.56	33.27	33.26	33.27	33.25	33.12	33.18	33.17	33.25	33.42
	Fattening Calves	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	Pre-Weaned Calves	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00	34.00
	Breeding Cattle 1st Year	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
	Breeding Cattle 2nd Year	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
	Breeding Cattle 3rd Year	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00
	Fattening Cattle	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00
Sheep		8.06	8.08	8.03	8.09	8.13	8.13	8.28	8.26	8.22	8.47
	Fattening Sheep	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
	Milksheep	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00
Goats		10.60	10.69	10.43	10.66	10.47	10.49	10.61	10.50	10.49	10.70
	Goat Places	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Horses		43.60	43.61	43.63	43.64	43.65	43.66	43.66	43.67	43.67	43.70
	Horses <3 years	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
	Horses >3 years	44.00	44.00	44.00	44.00	44.00	44.00	44.00	44.00	44.00	44.00
Mules and Asses		15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70
	Mules	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70
	Asses	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70	15.70
Swine		10.53	10.10	9.75	9.61	9.50	9.42	9.21	9.09	9.18	9.23
	Piglets	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	14.05	13.53	13.00	12.78	12.55	12.33	12.11	11.89	11.95	12.02
	Dry Sows	20.51	19.75	19.00	19.08	19.16	19.24	19.33	19.41	19.51	19.62
	Nursing Sows	43.59	42.80	42.00	42.43	42.86	43.30	43.73	44.16	43.17	42.18
	Boars	18.07	17.58	17.10	17.18	17.27	17.35	17.43	17.52	17.73	17.94
Poultry		0.55	0.55	0.55	0.55	0.54	0.54	0.55	0.54	0.53	0.53
	Growers	0.32	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
	Layers	0.77	0.79	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
	Broilers	0.44	0.44	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
	Turkey	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)	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56

continued on next page

Nitrogen Excretion			
		2010	**2011**
		kg N / head / year	
Cattle			
Mature Dairy Cattle		108.17	110.39
Mature Non-Dairy Cattle		80.00	80.00
Young Cattle		33.45	33.36
	Fattening Calves	13.00	13.00
	Pre-Weaned Calves	34.00	34.00
	Breeding Cattle 1st Year	25.00	25.00
	Breeding Cattle 2nd Year	40.00	40.00
	Breeding Cattle 3rd Year	55.00	55.00
	Fattening Cattle	33.00	33.00
Sheep		8.48	8.46
	Fattening Sheep	15.00	15.00
	Milksheep	21.00	21.00
Goats		10.57	10.76
	Goat Places	16.00	16.00
Horses		43.72	43.71
	Horses <3 years	42.00	42.00
	Horses >3 years	44.00	44.00
Mules and Asses		15.70	15.70
	Mules	15.70	15.70
	Asses	15.70	15.70
Swine		9.18	9.17
	Piglets	4.36	4.36
	Fattening Pig over 25 kg	12.09	12.09
	Dry Sows	19.73	19.73
	Nursing Sows	41.19	41.19
	Boars	18.16	18.16
Poultry		0.54	0.53
	Growers	0.31	0.31
	Layers	0.80	0.80
	Broilers	0.45	0.45
	Turkey	1.40	1.40
	Other Poultry (Geese, Ducks, Ostriches, Quails)	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 54.3% for CH_4 of 4B and 62.7% for N_2O from 4B. To aggregate liquid systems and solid storage (as required for input into Tier 1 analysis 4B CH_4/N_2O), the combined uncertainty of the emissions is determined by using Tier 1 error propagation for the sub-systems. For further results see Section 1.7.

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 mainly kept constant until new survey results are available. N_{ex} values for mature dairy cattle for the years after 2010 were extrapolated using average yearly milk production per dairy cow as driver.

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 2011 are compared with the results for 2010 within the current CRF
- the results for 2010 are compared between the current CRF tables and the CRF tables of the submission 2012
- the results for the base year 1990 are compared between the current CRF tables and the CRF tables of the submission 2012.

Additionally an independent quality control was conducted by INFRAS by a countercheck of the data and calculation sheets elaborated by ART (ART 2013).

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 - 30 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 2012 (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.

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

The share of manure excreted on pasture, range and paddock and the distribution of animal manure management systems has been recalculated due to new projections of the AGRAMMON model (Kupper et al. 2013). The new projections include new survey results for the year 2010. The effect of the recalculation on overall greenhouse gas emissions is negligible as changes are small and partially compensate each other.

6.3.6 Source-Specific Planned Improvements

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.

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 2012). 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 dropped on pasture, range and paddock. NO_x emissions declined by almost 16% 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, crop residues, N-fixing crops, organic soils, residues form meadows and pasture, N-fixation on meadows and pasture	AD: SBV 2012; ART/SHL 2012 ; Agricura 2012; FAL/RAC 2001; Flisch et al. 2009; Kupper et al. 2013; Leifeld et al. 2003; Schmid et al. 2000; Walther et al. 1994 EF: IPCC 1997c (N2O); IPCC 2000
4D2	Pasture, Range and Paddock Manure	Emissions from pasture, range and paddock	AD: SBV 2012; ART/SHL 2012 ; Flisch et al. 2009; Kupper et al. 2013 EF: IPCC 1997c
4D3	Indirect emissions	Leaching and run-off, N deposition air to soil	AD: SBV 2012; 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 2012; 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) have 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 ART (2013). The model structure is displayed in the following figure.

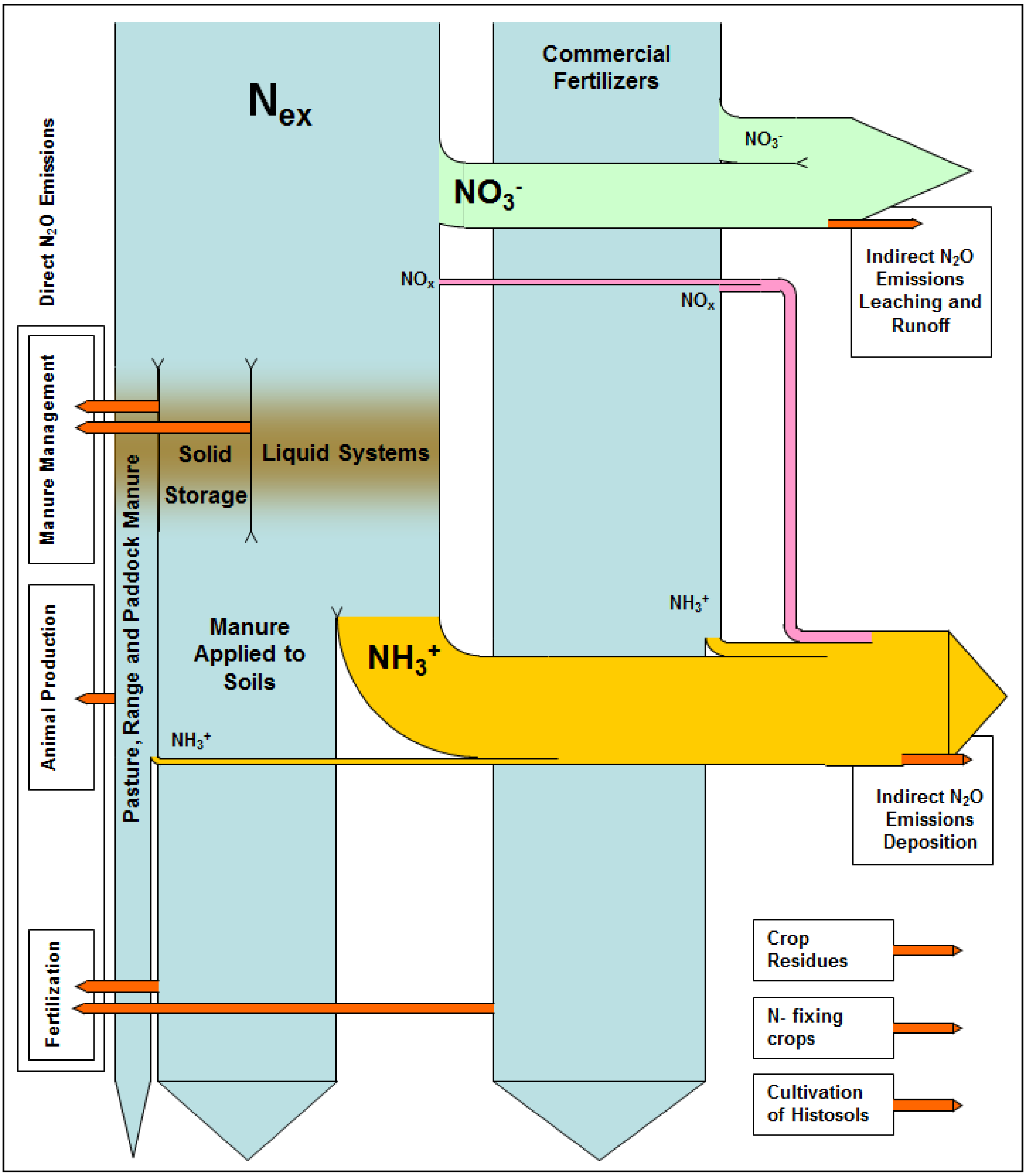

Figure 6-6 Diagram depicting the methodology of the approach to calculate the N_2O emissions in Agriculture. Note that the figure shows explicitly the methodology of the approach and not the physical nitrogen flow.

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 nitrogen excreted 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.

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 (2012), 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 data received by the Directorate General of Customs (Oberzolldirektion). Fertilizer production in Switzerland is negligible. 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 (Vanderweerden 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

2012), 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 (2012) and the Swiss Federal Statistical Office (SFSO 2012d). 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 on meadows and pastures)	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 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 fertilizers and animal manure has to be estimated. The relevant input data is based on FAL/RAC 2001, 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 assumed. 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 Vanderweerden 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 5 and 18% depending on the relative share of the individual fertilizer types (Kupper et al. 2013). Total $Frac_{GASF}$ 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.

Table 6-16 Overview of Ammonia emission factors 1990–2010. Data source: Kupper et al. (2013)

Ammonia Emission Factor		**1990**	**1995**	**2002**	**2007**	**2010**
		%				
Cattle						
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	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	10.52
	Agricultural Soils (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. Since 2003 the use of sewage sludge as fertilizer is prohibited in Switzerland. However, a transition period applies for some areas. Accordingly the individual 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.

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 (2012).

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 SBV (2012) and ART/SHL (2012; animal livestock population), SBV (2012; 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 - 31 and Table A - 32 in Annex A3.3.

Table 6-18 Activity data for calculating N_2O emissions from agricultural soils.

Related Activity Data		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		1990-1999									
		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	76'185	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)	18'491	18'456	18'422	18'391	18'354	18'316	18'278	18'244	18'209	18'173
Animal production											
Pasture, range and paddock	N excretion on pasture range and paddock (t N/yr)	13'148	13'399	13'498	13'421	13'613	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	137'186	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 leachin and run off (t N/yr)	43'986	43'772	43'276	41'914	40'874	40'615	40'118	37'843	37'713	37'430
Deposition	Sum volatized N (NH_3 and NO_x) from fertilizers, animal manure and agricultural soils (t N/yr)	58'871	57'806	56'970	56'190	55'566	55'076	54'517	52'370	51'746	50'218
	Emissions NH_3 from fertilizers, animal manure and agricultural soils (tN/yr)	57'331	56'274	55'455	54'723	54'135	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	1'431	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	2001	2002	2003	2004	2005	2006	2007	2008	2009
		2000-2009									
		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	52'470	50'222
	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	3'160	3'790
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	65'209	64'609	63'125	62'268	61'606	62'443	62'707	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)	18'138	18'103	18'068	18'032	17'997	17'977	17'945	17'913	17'892	17'863
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	23'737	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	128'859	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	54'853	52'397
Leaching and run-off	N from fertilizers and animal manure that is lost through leachin and run off (t N/yr)	37'203	38'176	37'705	36'871	36'664	36'764	36'775	37'329	37'279	36'518
Deposition	Sum volatized N (NH_3 and NO_x) from fertilizers, animal manure and agricultural soils (t N/yr)	49'567	49'595	48'819	48'209	48'152	48'868	49'370	50'031	50'339	49'443
	Emissions NH_3 from fertilizers, animal manure and agricultural soils (tN/yr)	48'265	48'259	47'499	46'918	46'869	47'582	48'083	48'724	49'034	48'165
	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	1'305	1'278
	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	2011
		Value	
Direct Emissions			
Fertilizers (t N/yr)	Total commercial fertilizers	57'845	51'902
	Mineral fertilizer (t N/yr)	53'425	47'040
	Sewage sludge (t N/yr)	0	0
	Compost (t N/yr)	4'421	4'863
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	64'504	64'848
N-fixation	N fixation peas, dry beans, soybeans and leguminous vegetables (t N/yr)	1'037	1'095
	N fixation meadows and pasture (t N/yr)	31'983	32'164
Crop residue	N from crop residues (t N/yr)	10'442	12'160
	N from residues meadows and pasture (t N/yr)	22'266	22'332
	Area of meadows and pasture (ha)	807'226	809'513
Organic soils	Area of cultivated organic soils (ha)	17'832	17'802
Animal production			
Pasture, range and paddock	N excretion on pasture range and paddock (t N/yr)	22'992	22'947
Indirect emissions			
	N excretion of all animals (t N/yr)	129'900	130'397
	Fertilizer (t N/yr)	60'440	54'354
Leaching and run-off	N from fertilizers and animal manure that is lost through leachin and run off (t N/yr)	38'068	36'950
Deposition	Sum volatized N (NH_3 and NO_x) from fertilizers, animal manure and agricultural soils (t N/yr)	49'611	49'623
	Emissions NH_3 from fertilizers, animal manure and agricultural soils (tN/yr)	48'279	48'330
	Emissions NO_x from fertilizers and animal manure (t N/yr)	1'332	1'293
	Area of agricultural soils (ha)	1'051'748	1'051'866

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: 76.1%, 4D2: 92.4%, 4D3: 158.1% and 4D4 80.4%. 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 further results see Section 1.7.

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.

For quality of livestock population data consult Chapter 6.2.4.

An internal documentation of the Agroscope Reckenholz-Tänikon Research Station (ART) about the calculation of the greenhouse gas emissions in agriculture assures transparency and traceability of the calculation methods (Berthoud 2004). 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.

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 2011 are compared with the results for 2010 within the current CRF
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of the submission 2012.
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of the submission 2012

Additionally an independent quality control was conducted by INFRAS by a countercheck of the data and calculation sheets elaborated by ART (ART 2013).

6.5.5 Source-Specific Recalculations

In the year 2009 the Swiss fertilization guidance "Principles of Fertilization in Arable and Forage Crop Production" (GruDAF; Flisch et al. 2009) has been revised. New values for standard crop yields as well as for crop nitrogen- and dry matter contents provided in Flisch et al. (2009) were adopted in order to calculate nitrogen inputs from crop residues and biological nitrogen fixation. The effect of the recalculation on overall emissions is a decrease of less than 25 Gg CO_2 equivalent.

The area of cultivated organic soils has been revised due to a recommendation during the 2011 review process (UNFCCC 2011). Until the last submission an estimated area of 17'000 ha based on Leifeld et al. (2003) has been used for the whole time series. The new estimate is based on the area of cultivated organic soils under Cropland and Grassland in the LULUCF sector as reported in CRF table 5.B and 5.C (see also chapter 7.2.3). As a result overall N_2O emissions increased on average by 6.2 Gg CO_2 equivalent.

Activity data for recycling fertilizers (compost, digestate liquid, digestate solid and sewage sludge) has been revised. New estimates have been consolidated at the School of Agricultural, Forest and Food Science (HAFL) in the context of the AGRAMMON inventory (Kupper et al. 2013). Repercussions are different for the individual years, however, effects on overall emissions are always very small and not exceeding ±0.5 Gg CO_2 equivalent.

Input data from the Swiss ammonia model AGRAMMON has been updated to the most recent projections from October 2012. Recalculations concern mainly the years 2007-2010 but generally affect the whole time series. Revisions have been made for various components of the nitrogen flux model (see Figure 6-6). Repercussions on overall emissions are hard to assess but considered to be very small as various effects compensate each other.

$Frac_{GASM}$ as reported in CRF table 4.Ds2 has been recalculated. It 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. The recalcualtion has no effects on overall emissions as $Frac_{GASM}$ is calculated retrospectively from the nitrogen flow model (Figure 6-6). 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.

The agricultural area used to estimate NH_3 volatilization from the plant canopy on agricultural lands has been revised. New estimates are based on consolidated data from the Swiss Federal Statistical Office (SFSO 2012d). Missing years between 1990 and 1996 have been estimated by linear interpolation. Effects on N_2O emissions are neglectable, being +0.2 Gg CO_2 equivalent at the most (in the year 1995).

Finally, the interpolation of data for fertilization with urea has been revised for the years 1992-1995. Changes of the amount of urea and related emissions are minimal.

A general recalculation for the year 2010 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

No source-specific improvements are planned at this stage.

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 waste incineration as burning of residues in agriculture and forerstry.

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 1990-2011 are represented by geographically explicit land-use data with a resolution of one hectare (following approach 3 for representing land areas; IPCC 2003). Direct and repeated assessment of land use with full spatial coverage also enables to calculate spatially explicit land-use change matrices. In 2004 the new Swiss land-use statistics has been launched (referred to as AREA). Simultaneously, aerial photos from two earlier Swiss land-use statistics (1979/85 and 1992/97) are being re-evaluated, applying the same approach. At the editorial deadline the interpretation of 83% of the Swiss territory was completed for all three time slices. A full coverage is expected in 2013. To estimate the land use and land-use change for each year in the period 1990-2011, a spatial extrapolation based on the presently available AREA data in combination with both earlier land-use statistics had to be performed.

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 stock values for forests were derived from four Swiss National Forest Inventories (NFI 1 – NFI 4a), which had been finalised in 1985, 1995, 2006 and 2011, respectively. The inventories comprehended ca. 2'000 (2011), 6'000 (1995, 2006) and 12'000 (1985) terrestrial sampling plots (see table Table 7-13), where biomass stock, growth, harvesting and mortality had been measured.

For other land-use categories, carbon stock values and GHG emissions/removals were derived from particular research activities, surveys and measurements in the fields of agriculture (cropland, grassland) and nature conservation (wetlands). Partially, also IPCC default values and expert estimates have been 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 1990-2011. The total net emissions and removals of CO_2 from 1990 to 2011 vary between -5'476 Gg (1997) and 236 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.

- 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. The dead organic matter increases in most years. 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. As a result, the LULUCF sector was a sink of -3'098 Gg CO_2 on the average between 1990 and 2011 (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 1990-2011. 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	-13'207	-13'147	-13'306	-13'259	-13'200	-13'468	-13'520	-13'462	-13'090	-13'100
Losses of living biomass	9'536	9'683	9'638	8'577	9'114	8'738	9'528	9'415	9'709	10'482
Net change in dead organic matter	-209	-506	-36	-246	246	90	-1'575	-2'162	-2'489	-1'580
Net change in soil, liming, wildfires	706	676	675	682	716	739	735	733	674	645
Total Sector 5: LULUCF	-3'174	-3'294	-3'029	-4'247	-3'124	-3'902	-4'833	-5'476	-5'195	-3'553

LULUCF	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	Gg CO_2									
Gains of living biomass	-13'539	-13'114	-13'170	-13'127	-13'864	-13'252	-13'224	-13'861	-13'479	-13'513
Losses of living biomass	12'962	13'684	13'223	10'994	10'469	10'876	10'819	10'795	10'802	10'667
Net change in dead organic matter	-1'298	-982	-1'036	-1'528	-1'820	-2'461	-1'113	-344	446	118
Net change in soil, liming, wildfires	643	648	665	665	639	635	621	620	610	631
Total Sector 5: LULUCF	-1'232	236	-317	-2'996	-4'576	-4'202	-2'897	-2'790	-1'621	-2'098

LULUCF	**2010**	**2011**	**Mean**
	Gg CO_2		
Gains of living biomass	-13'434	-14'112	-13'384
Losses of living biomass	10'738	10'428	10'494
Net change in dead organic matter	-351	-375	-873
Net change in soil, liming, wildfires	638	642	665
Total Sector 5: LULUCF	-2'409	-3'417	-3'098

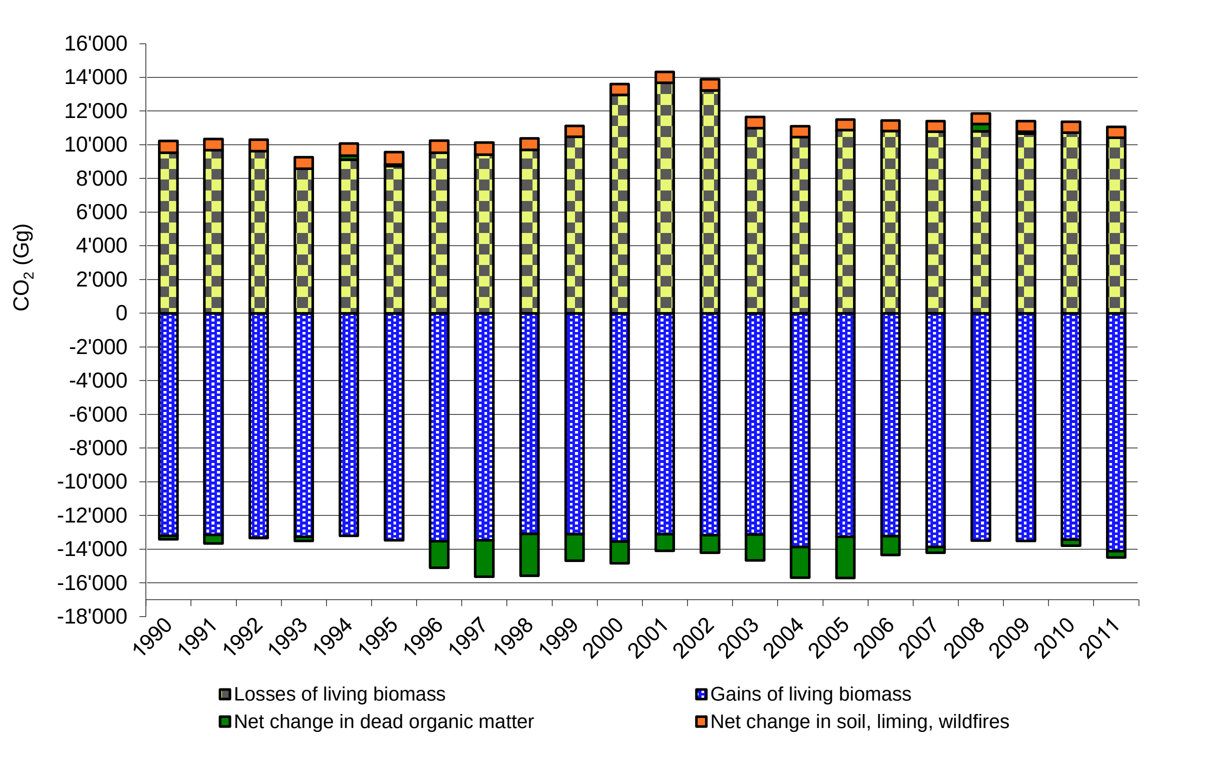

Figure 7-1 (i) CO_2 removals due to the gain (growth) of living biomass, (ii) CO_2 emissions due to the loss (harvest and mortality) of living biomass, (iii) net CO_2 emissions and removals due to changes in dead organic matter, and (iv) net CO_2 emissions from soils, due to liming and wildfires, 1990–2011.

The non-CO_2 emissions associated with land use, land-use change and forestry are very small. Between 1990 and 2011 annual CH_4 emissions add up to less than 0.53 Gg, and N_2O emissions equal at maximum 0.04 Gg. Those emissions arise from 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 7.3.4.12 and 7.4.4.4, respectively.

Figure 7-2 shows the resulting net GHG balances of LULUCF 1990–2011 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”.

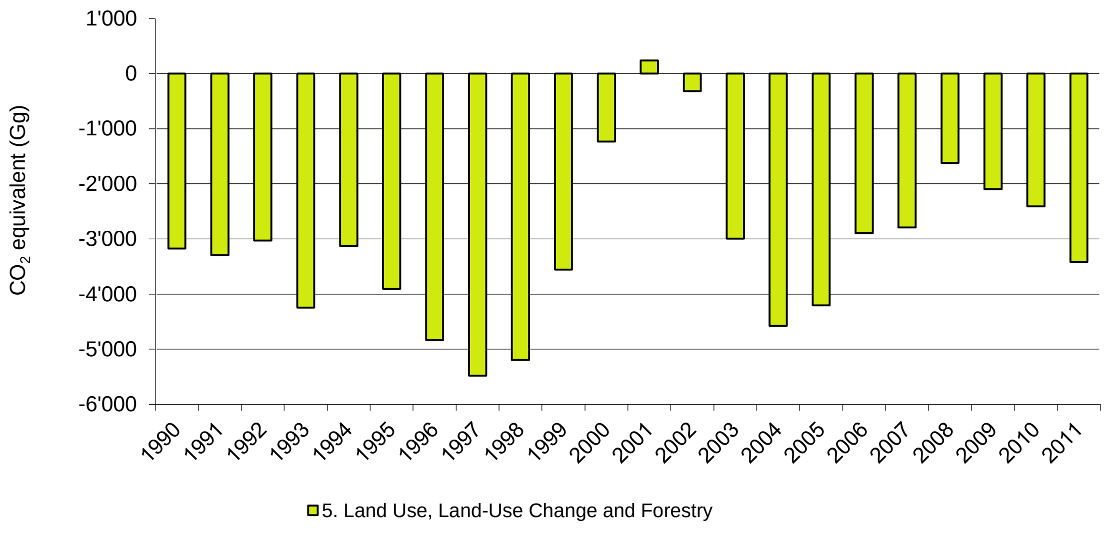

Figure 7-2 Switzerland's net GHG balance of category 5 Land Use, Land-Use Change and Forestry 1990–2011 (in Gg CO_2 eq). Positive values refer to emissions, negative values refer to removals.

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 (FOEN 2007f; SFSO 2006a).
- Define criteria and collect data for the spatial stratification of the land-use categories.
- Measure or estimate the carbon stocks and carbon stock changes for each spatial stratum of the land-use categories.
- Calculate the land use and the land-use change matrix in each spatial stratum.
- Calculate the carbon stock changes in living biomass ($deltaC_l$), in dead organic matter ($deltaC_d$) and in soil ($deltaC_s$) for all cells of the land-use change matrix.
- Finally, aggregate the results by summarising the carbon stock changes over land-use categories and strata according to the level of disaggregation displayed in the CRF tables.

Table 7-2 Land-use categories used in this report (so-called combination categories CC): 6 main 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 CC see FOEN (2007f) and SFSO (2006a).

CC Main category	**CC Sub-division**	**Remarks**	**Terminology in CRF tables**	**CC code**
A. Forest Land	Afforestations	areas converted to forest by active measures, e.g. planting	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

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})

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 conversion (b), a land-use category after the conversion (a), and the area of converted land within the spatial stratum (i). Equations 7.1.-7.3 show the general approach of calculating C emissions and removals taking into account the net carbon stock changes in living biomass, dead organic matter and soils as well as the stock changes due to conversion of land use (difference of the stocks before and after the conversion):

$$deltaC_{l,i,ba} = [\, V_{l,ba} * (gainC_{l,i,a} - lossC_{l,i,a}) + W_{l,ba} * (stockC_{l,i,a} - stockC_{l,i,b})\,] * A_{i,ba} \quad (7.1)$$

$$deltaC_{d,i,ba} = [\, V_{d,ba} * changeC_{d,i,a} + (stockC_{d,i,a} - stockC_{d,i,b})\,] * A_{i,ba} \quad (7.2)$$

$$deltaC_{s,i,ba} = [\, V_{s,ba} * changeC_{s,i,a} + W_{s,ba} * (stockC_{s,i,a} - stockC_{s,i,b})\,] * A_{i,ba} \quad (7.3)$$

where:

$_a$:	land-use category after conversion (CC = a)
$_b$:	land-use category before conversion (CC = b)
$_{ba}$:	land use conversion from b to a
$_i$:	spatial stratum
$A_{i,ba}$:	area of land converted from b to a in the spatial stratum i (activity data from the land-use change matrix)
$V_{l,ba}$:	weighting factor for gain and loss of living biomass between b and a.
$V_{d,ba}$:	weighting factor for change of carbon stock in dead organic matter between b and a.
$V_{s,ba}$:	weighting factor for change in soil carbon stock between b and a.
$W_{l,ba}$:	weighting factor for the stock difference in living biomass beween b and a.
$W_{s,ba}$:	weighting factor for the stock difference in soil between b and a.

$V_{d,ba}$ and $V_{s,ba}$ are 1 for all land-use changes. A more differentiated approach was used for KP-LULUCF reporting (see Chapter 11.3.1.1).

For $V_{l,ba}$ the following values have been chosen:

- If land use after conversion is forest (a = CC12, CC13) the factor is set to: $V_{l,ba} = 0$. This means that on areas converted to forests or in the case of conversions within forests only the difference in carbon stock is reported during the conversion period of 20 years (see below). The gains and losses of living biomass in forests are omitted in order to avoid potential double counting of carbon sinks.
- In all other cases the factor is 1, i.e. the gains and losses of carbon in living biomass after the conversion are taken fully into account: $V_{l,ba} = 1$.

The following values for $W_{l,ba}$ have been chosen:

- If the land-use conversion leads to afforestation (a = CC11) the factor is set to: $W_{l,ba} = 0$. This means, the carbon stock difference between b and a is not reported on afforestations, because the act of afforestation does not instantly change the biomass pool. Thus, only the CC11-specific gain in living biomass is reported (loss of living biomass in CC11 is zero, cf. Table 7-4).

- In all other cases the factor is 1, i.e. the differences of the C stocks before and after the conversion are taken fully into account: $W_{l,ba}$ = 1.

The following values for $W_{s,ba}$ have been chosen:

- If ”Buildings and Constructions” are involved in the conversion (a = CC51 or b = CC51) the factor for soils is set to: $W_{s,ba}$ = 0.5. It is assumed that only 50% of the soil carbon is emitted because the humus layer is re-used on green spaces of construction sites (see Chapter 7.7.4.2).
- In all other cases the factor is 1, i.e. the differences of the C stocks before and after the conversion are taken fully into account: $W_{s,ba}$ = 1.

7.1.3.3 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 $deltaC_{l,i,ba}$ are inserted in the column “Gains” and negative values in the column “Losses”, respectively. The values of $deltaC_{d,i,ba}$ and $deltaC_{s,i,ba}$ 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 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 soil and biomass, a carbon stock change is calculated according to the equations presented in Chapter 7.1.3.2.

7.1.3.4 Considering the Conversion Delay Time

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 (T). Following the IPCC default value (T = 20 years), the carbon emission or removal due to a soil carbon stock difference ($stockC_{s,i,a}$ – $stockC_{s,i,b}$) does not occur in one year but is distributed evenly over the 20 years following the land-use conversion.

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 to forest land including changes between productive and unproductive forest land.

The land-use category “afforestations" (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 subcategory “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.

Table 7-3 Conversion time periods applied for different land-use transitions and carbon pools.

	Conversion time T [years]		
Land-Use Categories	**living biomass**	**dead organic matter**	**soil**
5A2. Land converted to Forest Land (including afforestations)	20	20	20
5B2. Land converted to Cropland	1	1	20
5C2. Land converted to Grassland	1	1	20
5D2. Land converted to Surface Water	1	1	1
5D2. Land converted to Wetlands	1	1	20
5E2. Land converted to Settlements	1	1	20
5F2. Land converted to Other Land	1	1	20

There is no consistent data on land-use changes before 1990, but it is well known (ARE/SAEFL 2001, FOEN 2012g) 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.

7.1.4 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 1990-2011 with the following exceptions:

- The carbon stock, gain and loss of living biomass, the carbon stock and net change in dead organic matter as well as the net change in mineral soils of productive forest (CC12): The deduction of the annually changing data of CC12 is described in Chapter 7.3.4. The resulting annual data are given in Table 7-5.
- The carbon stock, gain and loss of living biomass of cropland (CC21): The annual data of CC21 are listed in Table 7-6 and Table 7-28 (see Chapter 7.4.4.1 for further explanations).

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 1990-2011 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	13.12	82.65	240	3.60	-2.41	0.03	0.00	-0.68
	1	2	124.88	12.07	102.03	240	3.21	-2.27	-0.06	-0.01	-0.68
	1	3	84.73	9.06	121.34	240	1.95	-1.34	-0.06	-0.02	-0.68
	2	1	134.18	10.03	55.40	240	4.63	-4.13	-0.05	-0.02	-0.68
	2	2	146.77	13.83	62.12	240	4.63	-3.93	0.02	0.01	-0.68
	2	3	101.21	13.83	122.00	240	1.60	-0.86	0.02	0.01	-0.68
	3	1	135.06	8.23	66.10	240	4.56	-3.04	0.11	0.03	-0.68
	3	2	147.43	19.14	75.91	240	4.15	-3.06	-0.07	-0.01	-0.68
	3	3	119.32	31.91	95.78	240	2.48	-2.11	-0.23	-0.01	-0.68
	4	1	94.81	5.24	66.47	240	3.24	-2.71	0.05	0.00	-0.68
	4	2	104.42	26.72	74.39	240	2.49	-1.81	-0.12	-0.01	-0.68
	4	3	96.41	38.56	69.48	240	1.81	-1.62	0.11	0.01	-0.68
	5	1	70.67	13.36	102.37	240	2.74	-1.01	0.04	-0.02	-0.68
	5	2	76.70	14.03	108.99	240	2.20	-0.71	-0.06	-0.02	-0.68
	5	3	76.70	36.47	107.08	240	1.61	-0.48	-0.04	0.05	-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)

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]**				
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	

Table 7-5 Annual carbon data for productive forest (CC12) disaggregated for NFI region (NFI) and altitude zone (Alt.), 1990-2011, 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	129.18	129.13	128.95	128.80
1	2	133.61	133.79	134.17	134.74	135.72	136.57	137.00	137.34	137.67	138.02
1	3	92.00	92.46	93.01	93.66	94.52	95.30	96.63	98.00	99.42	100.88
2	1	140.40	138.51	136.24	134.09	133.77	133.68	133.23	132.58	131.99	131.77
2	2	155.10	153.34	151.11	148.95	148.70	148.67	146.97	145.24	143.83	142.95
2	3	107.54	107.16	106.64	106.12	106.12	106.19	106.69	107.24	107.86	108.59
3	1	153.16	154.11	154.78	155.44	156.77	158.25	158.51	158.19	157.40	156.69
3	2	160.20	159.64	158.47	157.10	156.87	156.97	158.22	159.27	160.14	161.18
3	3	126.18	125.85	125.07	124.10	123.89	123.92	124.47	125.07	125.77	126.60
4	1	104.50	106.09	107.99	109.95	111.82	113.65	114.10	114.11	113.82	113.43
4	2	111.87	112.71	113.77	114.88	115.89	116.88	119.32	120.52	121.68	122.77
4	3	99.89	100.53	101.29	102.09	102.78	103.49	104.63	105.74	106.82	107.85
5	1	83.20	83.82	84.51	85.24	85.97	86.70	87.74	89.14	90.87	92.68
5	2	91.06	92.59	94.16	95.76	97.35	98.93	99.76	100.42	100.94	101.47
5	3	88.01	89.33	90.75	92.22	93.63	95.02	96.30	97.51	98.73	99.89

NFI	Alt.	2010	2011								
		CC12: carbon stock in living biomass (stockCl,i) [t C ha^{-1}]									
1	1	128.64	128.47								
1	2	138.40	138.77								
1	3	102.36	103.86								
2	1	131.81	131.97								
2	2	142.46	142.15								
2	3	109.38	110.21								
3	1	155.94	155.05								
3	2	162.31	163.43								
3	3	127.52	128.46								
4	1	112.81	111.99								
4	2	123.77	124.71								
4	3	108.82	109.78								
5	1	94.39	95.98								
5	2	101.93	102.29								
5	3	101.06	102.18								

(Table 7-5 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	3.44	3.50	3.57	3.57
1	2	3.04	3.04	3.04	3.04	3.04	3.04	3.19	3.34	3.48	3.48
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	4.40	4.27	4.13	4.13
2	2	4.56	4.56	4.56	4.56	4.56	4.56	4.54	4.52	4.50	4.50
2	3	1.28	1.28	1.28	1.28	1.28	1.28	1.29	1.30	1.31	1.31
3	1	4.23	4.23	4.23	4.23	4.23	4.23	3.99	3.74	3.50	3.50
3	2	4.15	4.15	4.15	4.15	4.15	4.15	4.03	3.91	3.78	3.78
3	3	2.50	2.50	2.50	2.50	2.50	2.50	2.59	2.69	2.78	2.78
4	1	3.44	3.44	3.44	3.44	3.44	3.44	3.35	3.26	3.16	3.16
4	2	2.50	2.50	2.50	2.50	2.50	2.50	2.58	2.64	2.70	2.70
4	3	1.90	1.90	1.90	1.90	1.90	1.90	1.94	1.98	2.03	2.03
5	1	2.04	2.04	2.04	2.04	2.04	2.04	2.50	2.97	3.43	3.43
5	2	2.18	2.18	2.18	2.18	2.18	2.18	2.19	2.20	2.22	2.22
5	3	1.79	1.79	1.79	1.79	1.79	1.79	1.88	1.98	2.07	2.07

NFI	Alt.	2010	2011								
		CC12: gain of living biomass (gainCl,i) [t C ha^{-1} yr^{-1}]									
1	1	3.57	3.57								
1	2	3.48	3.48								
1	3	2.03	2.03								
2	1	4.13	4.13								
2	2	4.50	4.50								
2	3	1.31	1.31								
3	1	3.50	3.50								
3	2	3.78	3.78								
3	3	2.78	2.78								
4	1	3.16	3.16								
4	2	2.70	2.70								
4	3	2.03	2.03								
5	1	3.43	3.43								
5	2	2.22	2.22								
5	3	2.07	2.07								

(Table 7-5 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	-3.25	-3.55	-3.75	-3.73
1	2	-2.86	-2.65	-2.46	-2.06	-2.19	-2.38	-2.75	-3.00	-3.16	-3.13
1	3	-1.35	-1.25	-1.16	-0.93	-1.02	-1.13	-0.55	-0.59	-0.61	-0.58
2	1	-6.42	-6.81	-6.69	-4.86	-4.63	-5.01	-4.86	-4.92	-4.72	-4.36
2	2	-6.33	-6.79	-6.72	-4.82	-4.59	-4.96	-6.25	-6.26	-5.91	-5.39
2	3	-1.66	-1.80	-1.80	-1.27	-1.21	-1.31	-0.79	-0.76	-0.68	-0.59
3	1	-3.28	-3.56	-3.58	-2.90	-2.76	-2.84	-3.72	-4.06	-4.29	-4.20
3	2	-4.72	-5.33	-5.52	-4.39	-4.05	-4.05	-2.78	-2.86	-2.91	-2.74
3	3	-2.83	-3.28	-3.46	-2.72	-2.46	-2.41	-2.05	-2.08	-2.09	-1.95
4	1	-1.84	-1.53	-1.48	-1.56	-1.61	-1.64	-3.06	-3.25	-3.45	-3.56
4	2	-1.66	-1.44	-1.39	-1.50	-1.51	-1.52	-1.34	-1.44	-1.54	-1.60
4	3	-1.26	-1.14	-1.09	-1.20	-1.19	-1.18	-0.80	-0.87	-0.95	-1.00
5	1	-1.43	-1.35	-1.31	-1.32	-1.32	-1.29	-1.46	-1.56	-1.69	-1.62
5	2	-0.65	-0.60	-0.58	-0.59	-0.59	-0.59	-1.36	-1.55	-1.70	-1.69
5	3	-0.47	-0.37	-0.32	-0.38	-0.40	-0.41	-0.61	-0.76	-0.86	-0.91

NFI	Alt.	2010	2011								
		CC12: loss of living biomass (lossCl,i) [t C ha^{-1} yr^{-1}]									
1	1	-3.73	-3.74								
1	2	-3.11	-3.11								
1	3	-0.55	-0.53								
2	1	-4.09	-3.98								
2	2	-4.99	-4.81								
2	3	-0.52	-0.49								
3	1	-4.25	-4.39								
3	2	-2.66	-2.66								
3	3	-1.86	-1.85								
4	1	-3.78	-3.98								
4	2	-1.70	-1.76								
4	3	-1.05	-1.07								
5	1	-1.72	-1.83								
5	2	-1.75	-1.86								
5	3	-0.91	-0.95								

(Table 7-5 continued)

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	13.12	13.13	13.12	13.12	13.11	13.09	13.16	13.32	13.56	13.75
1	2	12.07	12.06	12.03	12.02	11.99	11.95	12.10	12.26	12.43	12.58
1	3	9.06	9.11	9.15	9.19	9.22	9.25	9.65	10.01	10.33	10.62
2	1	10.03	10.03	10.03	10.03	10.02	10.02	10.24	10.50	10.78	11.06
2	2	13.83	13.83	13.83	13.83	13.82	13.80	14.01	14.29	14.65	15.00
2	3	13.83	13.83	13.83	13.83	13.82	13.80	14.01	14.29	14.65	15.00
3	1	8.23	8.25	8.26	8.27	8.28	8.29	8.74	9.19	9.65	10.10
3	2	19.14	19.15	19.15	19.15	19.14	19.13	19.40	19.76	20.23	20.68
3	3	31.91	31.79	31.68	31.57	31.47	31.36	32.10	32.82	33.53	34.21
4	1	5.24	5.27	5.30	5.32	5.33	5.34	5.62	5.91	6.22	6.52
4	2	26.72	26.65	26.56	26.48	26.39	26.32	26.35	26.44	26.58	26.71
4	3	38.56	38.62	38.67	38.71	38.74	38.78	39.01	39.24	39.45	39.64
5	1	13.36	13.45	13.52	13.57	13.60	13.63	14.30	14.82	15.16	15.45
5	2	14.03	14.02	14.00	13.99	13.97	13.96	14.28	14.56	14.78	14.97
5	3	36.47	36.24	36.02	35.80	35.60	35.42	35.47	35.56	35.70	35.82

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	13.91	14.05	14.18	14.31	14.45	14.61	14.90	15.10	15.18	15.29
1	2	12.73	12.86	12.99	13.14	13.30	13.49	13.86	14.14	14.35	14.58
1	3	10.90	11.16	11.42	11.67	11.92	12.19	12.97	13.63	14.14	14.61
2	1	11.34	11.61	11.88	12.17	12.48	12.80	12.80	12.73	12.60	12.50
2	2	15.34	15.67	16.00	16.34	16.70	17.08	17.18	17.17	17.05	16.97
2	3	15.34	15.67	16.00	16.34	16.70	17.08	17.18	17.17	17.05	16.97
3	1	10.55	10.99	11.43	11.87	12.33	12.80	13.04	13.23	13.36	13.51
3	2	21.14	21.58	22.03	22.47	22.93	23.42	23.55	23.49	23.24	23.03
3	3	34.87	35.51	36.13	36.74	37.37	38.01	38.45	38.75	38.93	39.12
4	1	6.81	7.09	7.37	7.67	7.98	8.31	8.11	7.83	7.51	7.21
4	2	26.81	26.91	26.99	27.09	27.20	27.34	27.54	27.60	27.51	27.42
4	3	39.83	40.00	40.17	40.36	40.57	40.80	40.86	40.83	40.72	40.61
5	1	15.71	15.95	16.18	16.44	16.70	17.03	17.19	17.24	17.11	16.97
5	2	15.14	15.30	15.45	15.61	15.77	15.97	16.05	16.24	16.49	16.73
5	3	35.93	36.04	36.14	36.26	36.39	36.56	36.42	36.43	36.50	36.47

NFI	Alt.	2010	2011								
		CC12: carbon stock in dead organic matter (stockCd,i) [t C ha^{-1}]									
1	1	15.42	15.56								
1	2	14.83	15.09								
1	3	15.07	15.49								
2	1	12.41	12.34								
2	2	16.91	16.88								
2	3	16.91	16.88								
3	1	13.67	13.83								
3	2	22.86	22.70								
3	3	39.34	39.54								
4	1	6.94	6.69								
4	2	27.36	27.31								
4	3	40.52	40.45								
5	1	16.81	16.70								
5	2	16.96	17.20								
5	3	36.36	36.17								

(Table 7-5 continued)

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	0.03	0.14	-0.04	0.05	-0.13	-0.13	0.10	0.31	0.44	0.15
1	2	-0.06	0.05	-0.08	0.00	-0.13	-0.11	0.20	0.31	0.38	0.15
1	3	-0.06	0.01	-0.07	-0.01	-0.07	-0.04	0.31	0.25	0.20	0.16
2	1	-0.05	0.08	-0.05	0.02	-0.13	-0.13	0.26	0.44	0.54	0.29
2	2	0.02	0.12	-0.03	0.05	-0.12	-0.12	0.25	0.46	0.61	0.36
2	3	0.02	0.12	-0.03	0.05	-0.12	-0.12	0.25	0.46	0.61	0.36
3	1	0.11	0.16	0.04	0.07	-0.08	-0.08	0.45	0.53	0.58	0.39
3	2	-0.07	0.02	-0.04	0.01	-0.11	-0.09	0.37	0.58	0.77	0.55
3	3	-0.23	-0.14	-0.18	-0.10	-0.20	-0.16	0.80	0.87	0.93	0.74
4	1	0.05	0.09	-0.06	-0.01	-0.10	-0.07	0.32	0.42	0.51	0.30
4	2	-0.12	-0.07	-0.18	-0.12	-0.18	-0.14	0.08	0.22	0.34	0.14
4	3	0.11	0.14	-0.02	0.03	-0.09	-0.02	0.32	0.44	0.49	0.26
5	1	0.04	0.07	0.03	0.00	-0.05	0.00	0.77	0.70	0.53	0.38
5	2	-0.06	-0.02	-0.07	-0.08	-0.13	-0.04	0.46	0.53	0.46	0.30
5	3	-0.04	-0.06	-0.16	-0.21	-0.28	-0.16	0.30	0.50	0.52	0.30

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	0.11	0.02	0.06	0.18	0.25	0.36	0.19	0.01	-0.16	0.05
1	2	0.14	0.07	0.10	0.18	0.24	0.35	0.37	0.25	0.16	0.28
1	3	0.19	0.17	0.19	0.23	0.26	0.32	0.87	0.77	0.65	0.61
2	1	0.23	0.14	0.20	0.33	0.43	0.52	-0.04	-0.20	-0.30	-0.15
2	2	0.31	0.20	0.26	0.38	0.48	0.59	0.01	-0.23	-0.40	-0.20
2	3	0.31	0.20	0.26	0.38	0.48	0.59	0.01	-0.23	-0.40	-0.20
3	1	0.37	0.30	0.33	0.44	0.53	0.64	0.24	0.10	0.04	0.12
3	2	0.51	0.42	0.42	0.46	0.53	0.61	0.10	-0.22	-0.44	-0.29
3	3	0.73	0.62	0.60	0.60	0.67	0.77	0.42	0.18	0.03	0.14
4	1	0.25	0.17	0.21	0.33	0.43	0.58	-0.14	-0.35	-0.50	-0.40
4	2	0.07	0.00	0.02	0.14	0.22	0.37	0.31	0.04	-0.20	-0.14
4	3	0.14	0.06	0.08	0.25	0.37	0.57	0.21	-0.05	-0.32	-0.23
5	1	0.28	0.28	0.21	0.36	0.31	0.54	0.29	0.19	-0.18	-0.22
5	2	0.18	0.17	0.12	0.28	0.25	0.49	0.28	0.37	0.19	0.16
5	3	0.15	0.14	0.08	0.29	0.26	0.61	0.11	0.22	-0.08	-0.17

NFI	Alt.	2010	2011								
		CC12: net change in dead organic matter (changeCd,i) [t C ha^{-1} yr^{-1}]									
1	1	0.17	0.20								
1	2	0.40	0.36								
1	3	0.63	0.54								
2	1	-0.03	0.00								
2	2	-0.03	0.00								
2	3	-0.03	0.00								
3	1	0.21	0.18								
3	2	-0.16	-0.18								
3	3	0.26	0.17								
4	1	-0.26	-0.24								
4	2	-0.02	-0.03								
4	3	-0.07	-0.02								
5	1	-0.23	-0.11								
5	2	0.17	0.24								
5	3	-0.22	-0.20								

(Table 7-5 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	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.02
1	2	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.01	-0.01	0.00
1	3	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.03	-0.03	-0.04	-0.05
2	1	-0.02	-0.01	-0.01	-0.01	-0.02	-0.03	-0.03	-0.02	0.00	0.00
2	2	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.03	0.04
2	3	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.03	0.04
3	1	0.03	0.03	0.04	0.04	0.04	0.03	0.03	0.03	0.04	0.04
3	2	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	0.01	0.02
3	3	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.01	0.00	0.00
4	1	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00	0.00	0.01
4	2	-0.01	-0.01	-0.02	-0.02	-0.02	-0.03	-0.02	-0.02	-0.01	-0.01
4	3	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.03	0.03
5	1	-0.02	-0.02	-0.02	-0.02	-0.03	-0.03	-0.03	-0.02	-0.01	-0.01
5	2	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	0.00	0.00
5	3	0.05	0.05	0.06	0.06	0.05	0.05	0.06	0.07	0.09	0.10

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	0.02	0.02	0.01	0.01	0.02	0.03	0.03	0.02	0.01	0.00
1	2	0.00	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00
1	3	-0.05	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.05
2	1	0.00	0.00	-0.01	-0.01	0.00	0.01	0.01	0.00	-0.01	-0.01
2	2	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.03	0.02
2	3	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.03	0.02
3	1	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02
3	2	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.04	0.03	0.02
3	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.02
4	1	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00
4	2	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	-0.01
4	3	0.03	0.03	0.02	0.02	0.03	0.03	0.04	0.04	0.03	0.03
5	1	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.01	0.01	0.01
5	2	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.03	0.03
5	3	0.10	0.10	0.10	0.10	0.10	0.10	0.12	0.12	0.13	0.13

NFI	Alt.	2010	2011								
		CC12: net change in mineral soil (changeCs,i) [t C $ha^{-1} yr^{-1}$]									
1	1	0.00	0.00								
1	2	0.00	0.01								
1	3	-0.05	-0.04								
2	1	-0.01	-0.01								
2	2	0.02	0.01								
2	3	0.02	0.01								
3	1	0.02	0.02								
3	2	0.01	0.00								
3	3	-0.02	-0.02								
4	1	-0.01	-0.01								
4	2	-0.01	-0.01								
4	3	0.02	0.02								
5	1	0.00	0.00								
5	2	0.03	0.02								
5	3	0.12	0.12								

Table 7-6 Annual carbon data for cropland (CC21), 1990-2011. Annual carbon stocks are broken down for arable crops in Table 7-28. 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**	**mean 1990-2011**
	CC21: carbon stocks and changes in living biomass [t C ha^{-1}]		
stock	4.99	5.44	4.67
change	-0.198	0.455	0.053

7.1.5 Uncertainty Estimates

Table 7-7 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 (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 subcategories.

Table 7-7 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	32	
5A2	2. Land converted to Forest Land	CO_2	21	32	
5B1	1. Cropland remaining Cropland	CO_2	30	25	organic soil
5B2	2. Land converted to Cropland	CO_2	13	50	
5B2	2. Land converted to Cropland	N_2O	13	90	
5C1	1. Grassland remaining Grassland	CO_2	6	50	
5C2	2. Land converted to Grassland	CO_2	8	50	
5D1	1. Wetlands remaining Wetlands	CO_2	30	100	organic soil
5D2	2. Land converted to Wetlands	CO_2	8	50	
5E1	1. Settlements remaining Settlements	CO_2	11	50	
5E2	2. Land converted to Settlements	CO_2	11	50	
5F2	2. Land converted to Other Land	CO_2	6	50	
5(IV)	Agricultural lime application	CO_2	40	25	
5(V)	Forest Land	CO_2	10	70	wildfire
5(V)	Forest Land	CH_4	10	70	wildfire
5(V)	Forest Land	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 2012) are the basis of activity data. In the course of the AREA surveys, every hectare of Switzerland's territory (4'128 kha) will be assigned to one of 46 land-use categories and to one of 27 land-cover categories by means of stereographic interpretation of aerial photos (SFSO 2006a). The AREA surveys were launched in 2004 and are on-going. They are expected to be completed in 2013.

For the reconstruction of the land use conditions in Switzerland during the period 1990-2011 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 and AREA2 were taken 1977-1986 and 1990-1998, respectively, and used for two earlier Swiss land-use statistics (ASCH1 and ASCH2; SFSO 2005). They are now simultaneously being re-evaluated according to the newly designed AREA set of land-use and land-cover categories (SFSO 2006a) as shown in Figure 7-3.

The new nomenclature of AREA (NOAS04) is not compatible with the former nomenclature NOAS92 used in ASCH. Nevertheless, ASCH2 is used as auxiliary data in making projections of AREA for the whole territory as long as the AREA surveys are not yet completed (see Chapter 7.2.4). Presently, coherently interpreted data of 83% of the Swiss territory are available for all three time slices: AREA1, AREA2 and AREA3 (SFSO 2012). In the previous submission (FOEN 2012), coverage has been restricted to 72%.

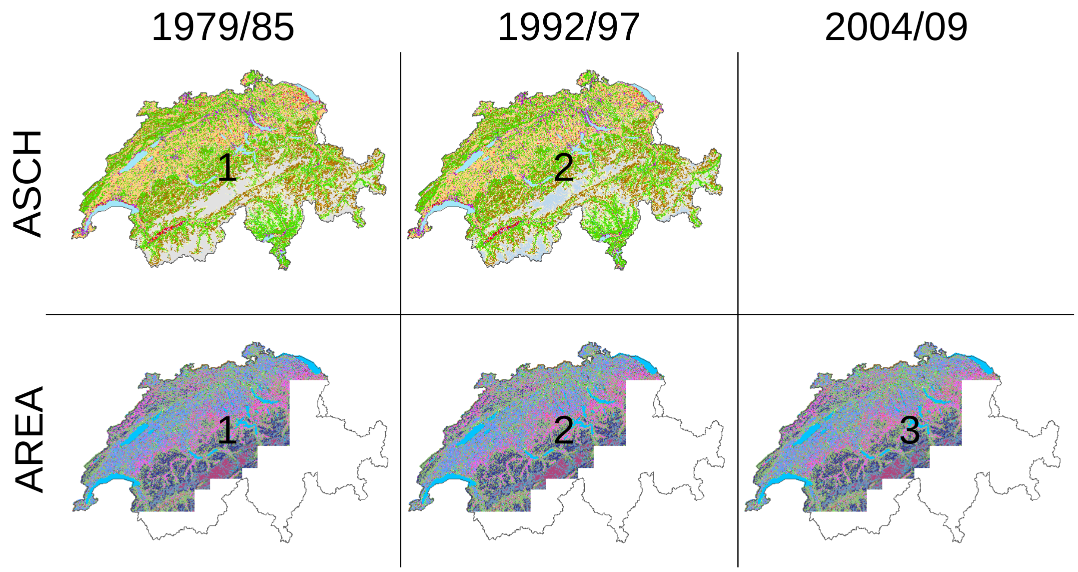

Figure 7-3 The land-use surveys ASCH and AREA. At present, only the ASCH surveys cover the whole territory. In the course of the on-going AREA survey the earlier ASCH aerial photos are gradually re-evaluated according to the AREA nomenclature.

The inter-survey period is not the same throughout the Swiss territory, but varies regionally. It averages approximately 12 years. This methodical characteristic needs to be considered when reconstructing the annual country-wide status 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; 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.

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 7-4: 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.

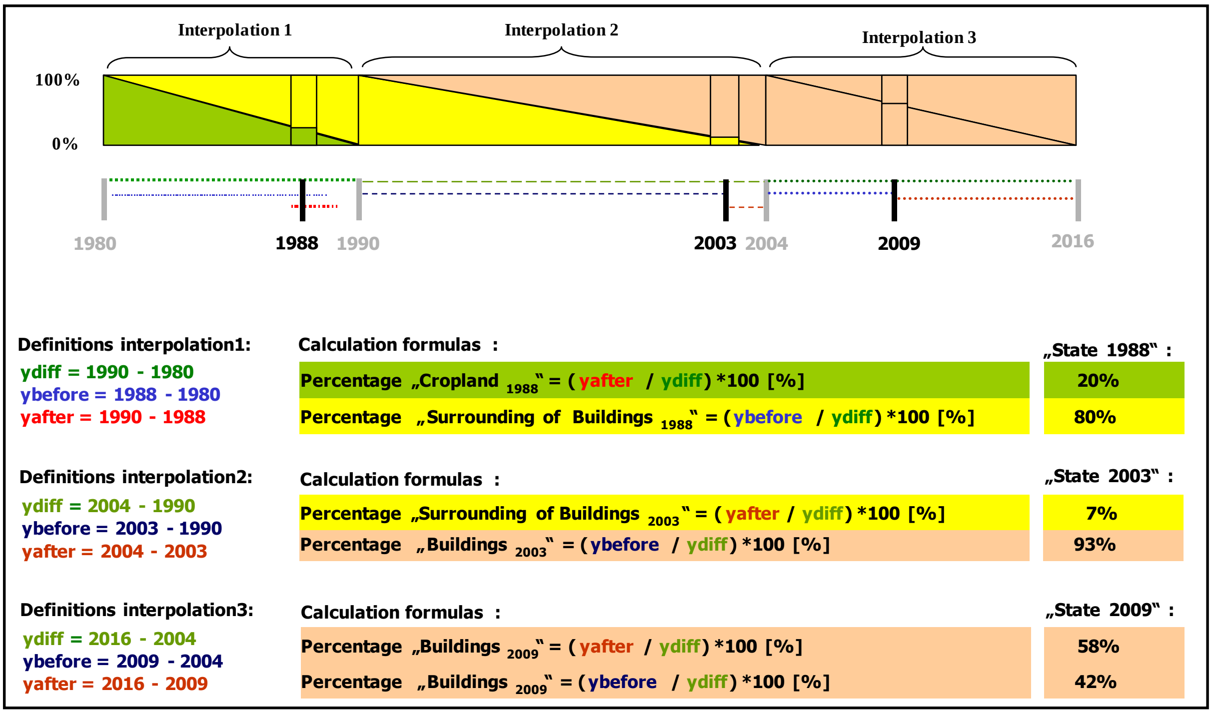

Figure 7-4 Hypothetical linear development of land-use changes between AREA1, AREA2 and AREA3 considering as example a hectare changing from “Cropland” to “Surrounding of Buildings” and then from "Surrounding of Buildings" to "Buildings". For 2009, a linear interpolation has been carried out between AREA3 and a virtual fourth survey modelled for the year 2016 (here resulting in no change of land use).

The “status 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 “status 2003”).

At present, AREA3 comprehends aerial photos from six years (2004-2009). More recent photos have not been interpreted yet. 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 7-4: example “status 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 2013). 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 1990-2011 for the whole Swiss territory results from the summation of the fractions of all hectares per 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 7-5): 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 7-5).

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 7-5). 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 (EAFV/BFL 1988; Brassel and Brändli 1999; Brändli 2010). These regions were adopted from EAFV/BFL (1988) as shown in Figure 7-5:

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.

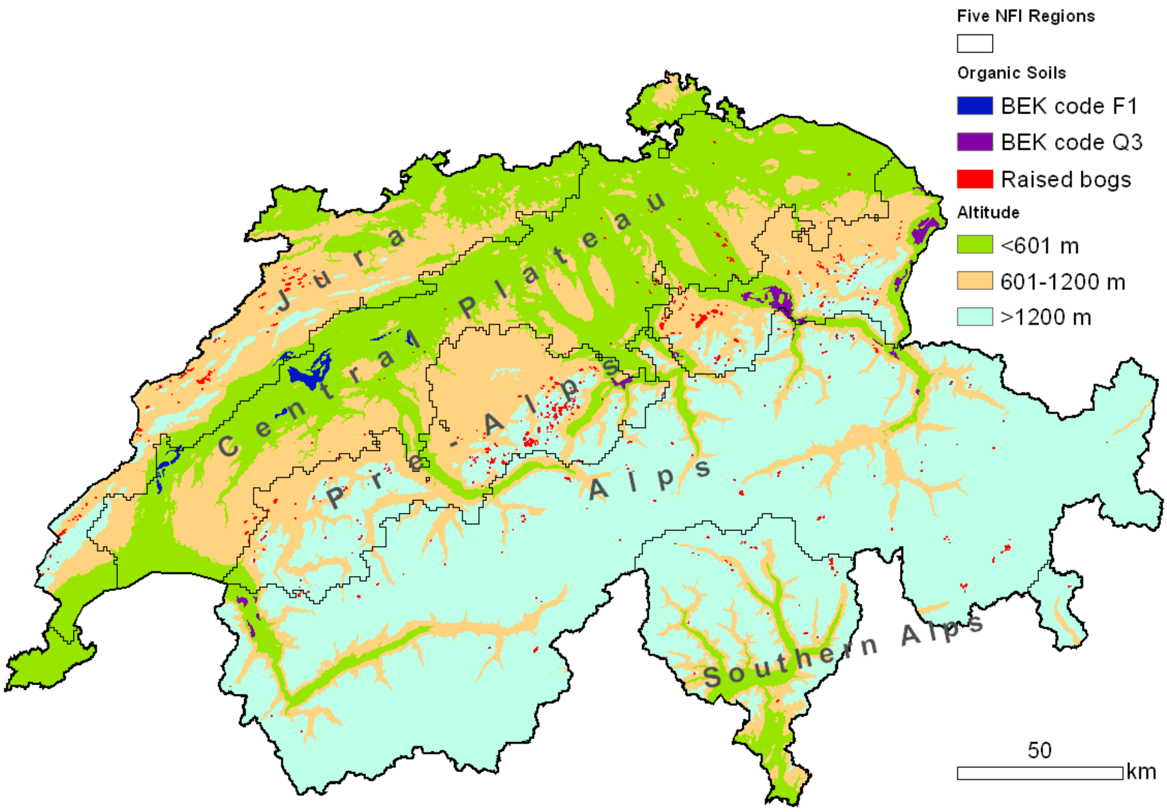

Figure 7-5 Map showing the spatial stratification according to NFI region, altitude, and soil type.

7.2.3.2 The Land-use Tables and Change Matrices

In Table 7-8 the land-use statistics resulting from spatial stratification (Chapter 7.2.3.1), interpolation in time (Chapter 7.2.2.3) and spatial extrapolation (Chapter 7.2.4) are exemplarily shown for the year 1990. This table gives also an overview of the size of the individual spatial strata. The combination codes (CC) have been introduced in Table 7-2.

Table 7-8 Land use (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	299.3	152.0	2.9	23.0	37.5	1.2	0.5	2.9	137.1	5.1	116.2	47.7	2.8	18.3	1.8	1072.6
601-1200	1.6	502.2	7.8	131.9	360.0	8.3	4.2	39.9	0.4	2.6	1.6	10.0	5.5	47.3	17.1	0.9	5.3	7.8	1154.4
>1200	2.1	383.2	80.8	0.3	424.5	138.4	0.0	31.2	0.0	146.7	58.3	13.9	14.9	11.6	3.4	0.2	1.1	590.8	1901.4
	4.7	1108.0	89.1	431.5	936.5	149.6	27.3	108.6	1.6	149.9	62.7	161.1	25.5	175.1	68.2	3.9	24.6	600.4	4128.4
Soil																			
mineral	4.7	1104.7	89.0	419.7	931.0	149.4	27.2	108.1	1.6	149.8	62.4	160.5	22.3	173.4	67.5	3.9	24.5	600.4	4100.1
organic	0.0	3.3	0.1	11.8	5.5	0.1	0.1	0.5	0.0	0.1	0.3	0.5	3.2	1.8	0.7	0.1	0.1	0.026	28.3
	4.7	1108.0	89.1	431.5	936.5	149.6	27.3	108.6	1.6	149.9	62.7	161.1	25.5	175.1	68.2	3.9	24.6	600.4	4128.4
NFI-region																			
1	0.7	197.8	5.3	76.7	122.3	0.9	4.4	14.8	0.3	0.2	0.6	23.7	1.2	27.4	11.1	0.5	4.8	0.6	493.3
2	0.8	227.1	0.4	307.1	155.5	0.9	10.2	31.3	1.0	0.2	1.6	69.5	4.2	84.7	34.6	1.6	12.5	0.7	943.8
3	1.0	215.3	9.0	31.7	259.5	10.1	0.8	21.8	0.1	8.4	7.0	30.8	12.3	26.8	9.1	0.5	2.8	14.6	661.7
4	1.4	330.0	53.3	13.4	362.6	104.4	10.1	31.6	0.2	117.6	47.0	26.9	7.1	27.1	9.4	0.7	2.9	526.2	1672.0
5	0.8	137.9	21.0	2.6	36.6	33.3	1.7	9.1	0.0	23.4	6.5	10.2	0.7	9.2	4.0	0.6	1.6	58.4	357.6
	4.7	1108.0	89.1	431.5	936.5	149.6	27.3	108.6	1.6	149.9	62.7	161.1	25.5	175.1	68.2	3.9	24.6	600.4	4128.4

Table 7-9 shows the overall trends of land-use changes between 1990 and 2011. For example, the area of afforestations (CC11) decreased by 80% 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 7-9 Statistics of land use (CC) (in kha) and relative change (%) between 1990 and 2011.

CC:	11	12	13	21	31	32	33	34	35	36	37	41	42	51	52	53	54	61	Sum
Year:																			
1990	4.7	1108.0	89.1	431.5	936.5	149.6	27.3	108.6	1.6	149.9	62.7	161.1	25.5	175.1	68.2	3.9	24.6	600.4	4128.4
1991	4.5	1110.3	89.5	430.7	934.7	149.0	27.3	107.4	1.5	149.6	62.6	161.1	25.5	176.8	68.8	4.0	25.0	600.1	4128.4
1992	4.3	1112.5	90.0	429.9	932.8	148.5	27.3	106.2	1.5	149.3	62.4	161.1	25.5	178.5	69.4	4.1	25.3	599.7	4128.4
1993	4.1	1114.7	90.3	429.1	931.2	148.0	27.3	105.0	1.4	149.1	62.3	161.1	25.5	180.1	69.9	4.1	25.6	599.4	4128.4
1994	3.8	1116.7	90.7	427.9	930.2	147.3	27.3	103.9	1.4	148.9	62.1	161.2	25.5	181.7	70.5	4.2	25.8	599.2	4128.4
1995	3.5	1118.5	91.1	426.3	929.9	146.6	27.2	102.8	1.3	148.8	62.0	161.2	25.6	183.3	71.3	4.2	25.8	598.9	4128.4
1996	3.3	1119.9	91.4	424.7	929.8	146.1	27.1	101.8	1.3	148.7	62.0	161.3	25.6	184.9	72.0	4.2	25.8	598.7	4128.4
1997	3.1	1121.3	91.7	423.0	929.8	145.7	27.0	100.8	1.3	148.6	61.9	161.3	25.6	186.4	72.8	4.2	25.7	598.4	4128.4
1998	2.8	1122.6	91.9	421.3	929.9	145.3	26.9	99.7	1.2	148.5	61.8	161.3	25.6	188.0	73.6	4.2	25.5	598.2	4128.4
1999	2.6	1123.8	92.2	419.5	930.0	144.9	26.8	98.7	1.2	148.5	61.7	161.4	25.6	189.5	74.4	4.2	25.4	598.0	4128.4
2000	2.3	1125.1	92.5	417.8	930.1	144.6	26.7	97.6	1.2	148.5	61.6	161.4	25.6	191.1	75.2	4.2	25.2	597.8	4128.4
2001	2.1	1126.3	92.7	416.1	930.1	144.2	26.6	96.6	1.1	148.4	61.5	161.4	25.6	192.6	76.0	4.2	25.1	597.6	4128.4
2002	1.9	1127.6	93.0	414.3	930.2	143.8	26.5	95.5	1.1	148.4	61.4	161.5	25.7	194.2	76.8	4.2	24.9	597.4	4128.4
2003	1.6	1128.9	93.2	412.6	930.3	143.5	26.4	94.5	1.1	148.4	61.3	161.5	25.7	195.7	77.6	4.2	24.8	597.2	4128.4
2004	1.4	1130.1	93.5	410.9	930.4	143.1	26.3	93.5	1.0	148.4	61.2	161.6	25.7	197.3	78.4	4.2	24.7	596.9	4128.4
2005	1.2	1132.0	93.8	410.4	930.6	142.5	26.0	91.8	1.0	148.3	61.0	161.6	25.7	198.7	78.8	4.2	24.2	596.6	4128.4
2006	1.1	1133.7	94.1	410.3	930.9	142.0	25.8	90.1	1.0	148.2	60.8	161.7	25.6	199.9	79.2	4.1	23.6	596.2	4128.4
2007	1.0	1135.4	94.3	410.5	931.1	141.7	25.5	88.6	0.9	148.1	60.6	161.7	25.6	200.9	79.4	4.0	23.2	595.8	4128.4
2008	1.0	1137.3	94.5	410.8	931.6	141.0	25.3	87.3	0.9	148.0	60.5	161.8	25.6	201.5	79.4	3.9	22.8	595.3	4128.4
2009	1.0	1138.2	94.7	409.2	931.4	140.7	25.2	86.5	0.9	148.0	60.4	161.8	25.6	203.0	80.1	3.9	22.7	595.1	4128.4
2010	1.0	1139.2	94.9	407.7	931.2	140.4	25.1	85.7	0.9	147.9	60.3	161.8	25.6	204.5	80.8	3.9	22.6	594.9	4128.4
2011	0.9	1140.1	95.1	406.1	931.0	140.1	25.0	84.9	0.8	147.9	60.2	161.9	25.6	205.9	81.4	3.9	22.6	594.7	4128.4
Change:	-80	3	7	-6	-1	-6	-8	-22	-46	-1	-4	1	0	18	19	0	-8	-1	0

The annual rates of change in the entire territory of Switzerland (change-matrices) are achieved by adding up the annual change rates of all hectares per combination category (CC). Each land-use change involves a decreasing ("from") and an increasing ("to") change. Because the respective areas may be spatially extrapolated by different area expansion factors (see Chapter 7.2.4), the resulting decreasing area may not be equal to the resulting increasing area for a specific land-use transition. The deviations between both values will diminish once the interpretation of AREA has been terminated. Meanwhile, the change matrices are established by calculating the mean of the increasing area and of the decreasing area for each land-use transition, as exemplarily shown in Table 7-10 for the years 1990 and 2011.

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 2013).

Table 7-10 Annual rates of land-use change in 1990 and in 2011 (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		424	2	0	1	1		0						0	0	0		0	429
12			142	6	133	95	6	87		13	19	12	7	123	30	11	18	52	754
13		560			144	42	0	45		4	2	1	1	6	0	0	1	10	817
21	8	1			662	6	184	40	1	4	4	4	4	634	321	21	18	22	1934
31	143	171	253	715		1026	119	569	4	47	50	9	11	885	496	25	43	70	4636
32	23	1062	732	3	140		9	345		14	15	7	0	26	9	4	3	31	2422
33	1	3		131	68	4		34	3	0	1	0		54	29	4	4	6	341
34	31	694	34	152	1102	62	40		11	11	24	4	4	207	113	7	53	16	2566
35		0		8	13	0	4	47						5	3	0	1	0	81
36	3	26	27	2	165	269	1	42			98	4	0	10	1	0		44	692
37	5	27	6	1	10	253	1	67		9		3	0	6	2		0	13	404
41	0	4	1	2	2	6	0	4		4	1		17	11	3	1	0	96	152
42	5	27	6	1	3	3	0	3			0	6		4	1	0	0	1	61
51	40	20	1	86	161	14	5	10		4	5	6	4		279	62	48	5	749
52	8	4		16	33	3	1	2		0	2	1	2	349		68	388	0	878
53	4	9	0	6	7	2	1	2				0	2	43	26		45	0	145
54	2	6		1	2	0	0	3			0	0	1	76	153	7		0	251
61	5	41	16	16	69	95	9	33		289	35	113	2	15	1	0	0		739
increase	279	3079	1219	1145	2713	1878	381	1334	19	399	256	172	56	2455	1467	211	623	366	18050

2011	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		70												0					70
12			226	1	182	155	2	114		29	22	17	12	88	24	12	10	74	970
13		524			177	60		28		4	3	1	1	3	0	0	1	10	811
21	2	0			1289	5	141	18	0	4	11	7	9	497	283	13	5	11	2295
31	19	82	191	440		609	70	331	2	74	30	6	9	772	401	14	9	83	3141
32	2	639	520	1	132		2	284		16	12	5	0	14	4	2	1	30	1666
33	0	1		139	95	4		20	1	1	0		0	37	26	1	2	7	334
34	3	512	30	53	780	65	14		4	10	23	6	1	125	70	2	21	18	1741
35				1	6		2	16						1	0				26
36	0	18	21	3	78	198	1	46			55	5		4	0			40	468
37	1	14	2	1	3	175	0	45		13		3	1	4	1			11	274
41	0	3	0	0	1	5		1		3	3		9	5	1	0		104	137
42	0	18	5		0	0		2		0		7		2	0			1	36
51	17	9	0	63	143	8	3	5		7	7	6	2		289	54	20	6	639
52	6	3	0	16	40	3	1	3		1	2	1	1	413		50	220	0	760
53	2	10		3	10	2	0	1			0	0	0	49	38		39	0	155
54	0	3		0	2	0		2			0		0	93	298	17			416
61	1	30	11	16	46	71	4	29		255	17	106	1	7	1	0			596
increase	54	1935	1008	740	2985	1362	239	944	6	417	185	171	49	2115	1437	166	328	396	14537

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 7.1.3.4, 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.

7.2.4 Methodological Issues – Spatial Extrapolation of AREA

The land-use surveys AREA1, AREA2 and AREA3 were launched in 2004 (see Chapter 7.2.2.1). Presently, a sample region covering 83% of the Swiss territory has been evaluated (see Figure 7-6). For the rest of the Swiss territory data availability is currently restricted to the LUcode classification (Table 7-11; see FOEN 2006b for details), i.e. a land-use classification that has been developed on the basis of the nomenclature used in ASCH1 and ASCH2 (SFSO 2005).

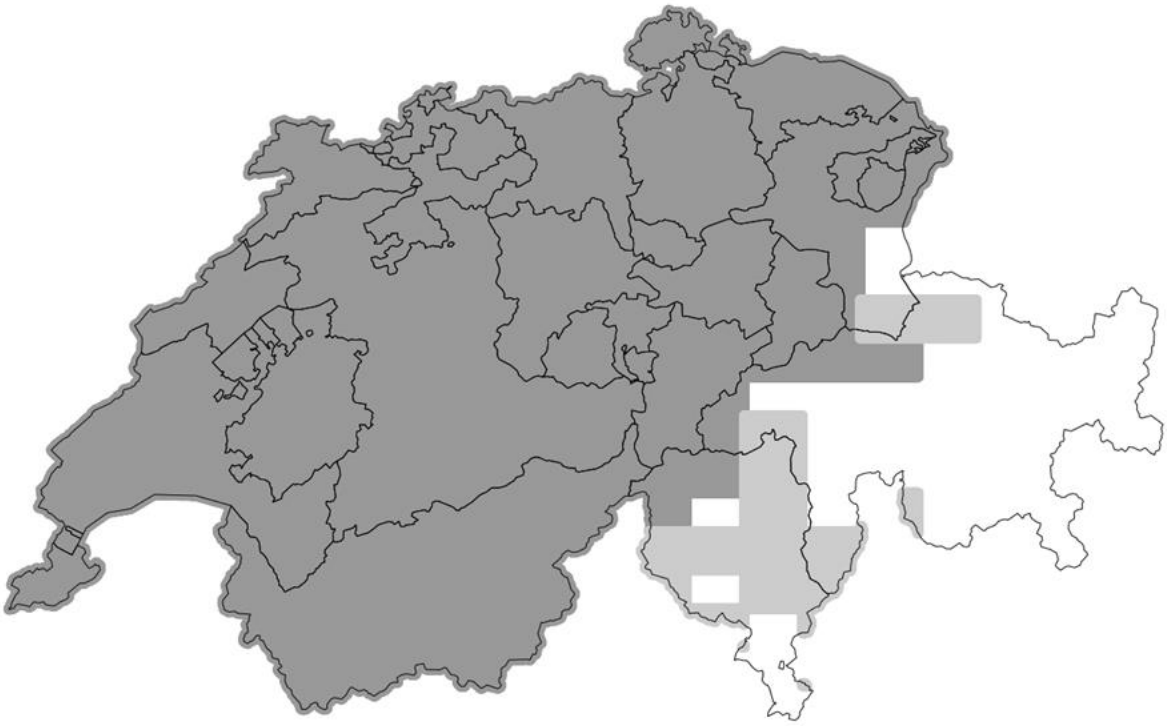

Figure 7-6 Map showing the regions (dark gray) that have already been evaluated in the land-use survey AREA3 (as of July 2012), including some unverified provisional data (light gray).

A spatial extrapolation of the AREA-derived CC data in the sample region (83%) to the total Swiss territory has been carried out, using ASCH2 as a reference basis. First, the CC data in the sample region ($AREA_{samp}$) were interpolated in time for each year (see Figure 7-4), and then the spatial extrapolation of the respective land-use categories was calculated. In the same way the land-use changes detected in the sample region were extrapolated.

The LUcode classification included the 6 main categories and 13 sub-divisions (LUcode), which are an aggregation of the 74 ASCH codes (FOEN 2006b). The CC classification is built of 6 main categories and 18 sub-divisions (Table 7-11). A direct correspondence of all LUcode and CC sub-divisions is not given. Therefore, an auxiliary categorisation, called ”excat” (extrapolation category) is introduced. Excat includes 11 sub-divisions. Each LUcode category and CC, respectively, can be definitely assigned to one excat code. The relation between LUcodes categories, CC and ”excat” is shown in Table 7-11.

Table 7-11 Relation between different land-use categorisations: IPCC main categories (IPCC 2003), LUcode sub-divisions, LUcode (aggregated ASCH code; FOEN 2006b), ASCH code and description (SFSO 2005), Excat code (extrapolation category; this report), combination category (CC), and CC code (FOEN 2007f).

Main Category	LUcode Sub-division	LUcode	ASCH-code	ASCH-description	Excat code	Combination Category (CC)	CC code
Forest Land	Afforestations	11	9	Afforestations	11	Afforestations	11
	Productive Forest	12	10	Damaged forest areas	12	Productive Forest	12
			11	Normal dense forest	12		
			13	Open forest (on agricultural areas)	12		
			14	Forest stripes, edges	12		
	Unproductive Forest	13	12	Forest on unproductive areas	13	Unproductive Forest	13
			15	Brush forest	13		
Cropland		20	52	Garden allotments	21		
			71	Regular vineyards	30		
			72	"Pergola" vineyards	30		
			73	Extensive vines	30		
			78	Horticulture	21		
			81	Favourable arable land and meadows	21		
					21	Cropland	21
Grassland	Permanent Grassland	31	32	Green motorway environs	31	Permanent Grassland	31
			38	Airfields, green airport environs	31		
			54	Golf courses	50		
			67	Green railway environs	31		
			68	Green road environs	31		
			82	Other arable land and meadows	31		
			83	Farm pastures	31		
			85	Mountain meadows	31		
			87	Remote and steep alpine	31		
			88	Favourable alpine pastures	31		
			89	Rocky alpine pastures	31		
	Grass with Perennial Woody Biomass	32	16	Scrub vegetation	30	Shrub Vegetation	32
			17	Groves, hedges	30		
			18	Clusters of trees (on agricultural areas)	30		
			19	Other woods	30		
			75	Intensive orchards	30		
			76	Rows of fruit trees	30		
			77	Scattered fruit trees	30		
			84	Brush meadows and farm pastures	30		
			86	Brush alpine pastures	30		
	Unproductive Grassland	33	97	Unproductive grass and shrubs	30		
					30	Vineyards, Low-Stem Orchards, Tree nurseries	33
					30	Copse	34
					30	Orchards	35
					30	Stony Grassland	36
					30	Unproductive Grassland	37
Wetlands	Surface Waters	41	91	Lakes	41	Surface Waters	41
			92	Rivers	41		
	Unproductive Wetland	42	95	Wetlands	42	Unproductive Wetland	42
			96	Water shore vegetation	42		
Settlements	Buildings/Constructions	51	20	Ruins	51	Buildings and Constructions	51
			21	Industrial buildings	51		
			23	Buildings in recreational areas	51		
			24	Buildings in special urban areas	51		
			25	One- and two-family houses	51		
			26	Terraced houses	51		
			27	Blocks of flats	51		
			28	Agricultural buildings	51		
			29	Unspecified buildings	51		
			31	Motorways	51		
			33	Roads and paths	51		
			34	Parking areas	51		
			35	Railway station grounds	51		
			36	Railway lines	51		
			37	Airports	51		
			51	Sport grounds	51		
			53	Camping, caravan sites	51		
			61	Other supply or waste treatment plants	51		
			62	Energy supply plants	51		
			63	Waste water treatment plants	51		
			64	Quarries, mines	51		
			65	Dumps	51		
			66	Construction sites	51		
	Surrounding of Buildings	52	41	Industrial grounds	50	Herbaceaus Biomass in Settlement	52
			45	Surroundings of one- and two-family	50		
			46	Surroundings of terraced houses	50		
			47	Surroundings of blocks of flats	50		
			48	Surroundings of agricultural buildings	50		
			49	Surroundings of unspecified buildings	50		
	Parks	53	56	Cemeteries	50	Shrubs in Settlements	53
			59	Public parks	50		
					50	Trees in Settlements	54
Other Land		60	69	River shores	61		
			90	Glaciers, perpetual snow	61		
			93	Flood protection structures	61		
			98	Avalanche protection structures	61		
			99	Rocks, sand, screes	61		
					61	Other Land	61

In the spatial extrapolation approach the whole Swiss territory is divided into three main sub-regions (see Figure 7-7):

- Sample region (samp): CC data are available on hectare-basis for AREA1, AREA2 and AREA3. Coverage: 83% of Swiss territory.
- Extrapolation region (extrapol): Land use can be quantified by extrapolating CC data in the sample region using excat. Coverage: 100% of Swiss territory (including the sample region).
- Substitution region (subst): This is the remaining area for which no or too little CC data in the sample region are available. Extrapolation of CC data is impossible and land-use data from ASCH2 survey (LUcode categories) is used instead. Coverage: <0.1% of Swiss territory. Changes in land use are neglected in the substitution region.

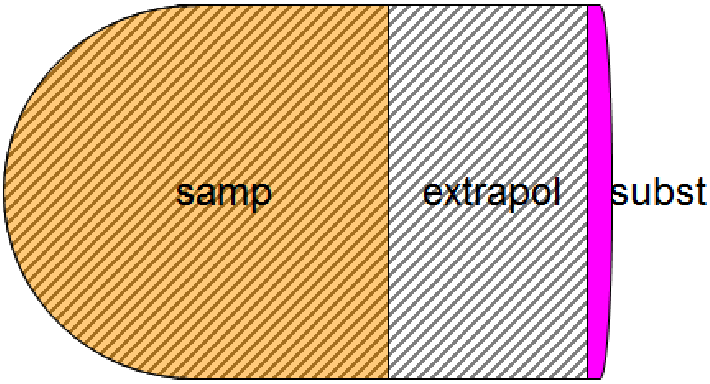

Figure 7-7 Scheme showing the three sub-regions of Switzerland used for the extrapolation: sampling region of AREA (samp), extrapolation region (extrapol, diagonal shading) and substitution region (subst).

As the spatial stratification is needed for the computation of CO_2 equivalent emissions/ removals the land use and land-use changes must be quantified for each stratum. The basic idea is to extrapolate the CC data of a certain stratum by applying a stratum-specific area expansion factor (AEF). As CC datasets are not available in ASCH2, excat is used instead. The AEF for a certain excat in stratum i(z,nfi,soil) can be formulated as:

$$AEF(excat,i) = ASCH2_{extrapol}(excat,i) \,/\, ASCH2_{samp}(excat,i) \qquad (7.4)$$

where:

$ASCH2_{extrapol}(excat,i)$: Number of hectares in the ASCH2 dataset covered by land-use type excat situated in stratum i for the whole extrapolation region

$ASCH2_{sample}(excat,i)$: Number of hectares in the ASCH2 dataset covered by land-use type excat situated in stratum i in the sample region

i: Spatial strata defined by a combination of z (altitude zone), nfi (NFI region) and soil (organic, mineral); i = i(z,nfi,soil).

To avoid arbitrary results caused by very small and unrepresentative areas in the sample region, a ”decision cascade” is introduced (see Figure 7-8). The idea is to apply a less differentiated AEF if the size of the sub-sample does not reach a specific threshold (T). The threshold of the most differentiated case (level A in Figure 7-8) is calculated as follows:

$$T(excat,i) = 10\% * ASCH2_{extrapol}(excat,i) \qquad (7.5)$$

Thresholds were empirically tested and it was decided to successively adjust the calculation of thresholds in later submissions to match approximately the half of the relative size of the sample region. The sample region exceeds 20% since the April 2008 submission (FOEN 2008). The thresholds are calculated with a (maximal) factor of 10% since then.

description	threshold	availability	number of categories
level A: excat, i	T (excat,i)	98%	271 (max. 504)
level B1: excat	T (excat)	100%	28 (max. 30)
level B2: i	T (i)	100%	11
level C: main category	T (main category)	100%	6
level D: general	-	100%	1

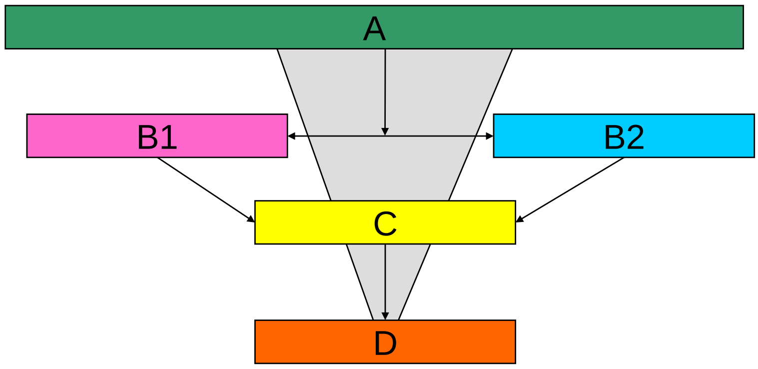

Figure 7-8 Extrapolation cascade for calculating area expansion factors (AEF) at different levels of differentiation.

If the size of the sub-sample $AREA_{samp}$(excat(CC),i,yr) is greater than the threshold T(excat,i), then the extrapolated area $AREA_{extrapol}$(CC,i,yr) is calculated by the most differentiated AEF (see Equation 7.4). This corresponds to level A in Figure 7-8. With these AEF values, the extrapolated area of the combination category CC in the stratum i in the year yr is calculated as follows:

$$AREA_{extrapol}(CC,i,yr) = AEF(excat(CC),i) * AREA_{samp}(CC,i,yr) \quad (7.6)$$

where:

$AREA_{samp}$(CC,i,yr): Number of all hectares in the AREA data sample (interpolated to the year yr) covered by land-use type CC situated in stratum i.

excat(CC): Stands for the excat to which the respective CC is assigned (see Table 7-11).

If the threshold is not reached at level A, then the threshold values of level B1 (T(excat)) and B2 (T(i)) are calculated (with an appropriately simplified version of Equation 7.5) and compared. The AEF of the level with the higher value for T is calculated (only if threshold is exceeded):

$$AEF(excat) = ASCH2_{extrapol}(excat) / ASCH2_{samp}(excat) \quad (7.7a)$$
$$AEF(i) = ASCH2_{extrapol}(i) / ASCH2_{samp}(i) \quad (7.7b)$$

where:

$ASCH2_{extrapol}$(excat): Number of all hectares in the ASCH2 dataset covered by land-use type excat within the extrapolation region, regardless of the stratum i.

$ASCH2_{samp}$(excat): Number of all hectares in the ASCH2 dataset covered by land-use type excat within the sample region, regardless of the stratum i.

$ASCH2_{extrapol}$(i): Number of all hectares in the ASCH2 dataset lying in the spatial stratum i within the extrapolation region, regardless of the land-use category.

$ASCH2_{samp}$(i): Number of all hectares in the ASCH2 dataset lying in the spatial stratum i within sample region, regardless of the land-use category.

If the size of the sub-sample size does not reach the thresholds T(excat) and T(i), the threshold of the main category T(maincat) is evaluated and the AEF(maincat) is used (level C in Figure 7-8). "Maincat" denotes the main land-use category according to Table 7-11:

$$AEF(maincat) = ASCH2_{extrapol}(maincat) / ASCH2_{samp}(maincat) \quad (7.8)$$

If also T(maincat) is not reached by the size of the generalised sub-sample, then the most general area expansion factor AEF(general) is used (level D in Figure 7-8), which is the ratio of the extrapolation region to the sample region:

$$AEF(general) = ASCH2_{extrapol} / ASCH2_{samp} \quad (7.9)$$

By applying area expansion factors of different accuracy levels, slight discrepancies in the total area result. Therefore, a calibration factor F is calculated *a posteriori* to adjust the sum of the calculated areas to the real total area of the extrapolation region:

$$F(yr) = ASCH2_{extrapol} / [\ \Sigma\ AREA_{extrapol}(CC,i,yr)\ ] \quad (7.10)$$

With the presently available sample data, the values of F(yr) are 0.99994.

In the substitution region only ASCH data are available (i.e. $AREA_{samp}(CC,i,yr) = 0$). ASCH2 data are chosen as a surrogate for AREA. They are converted by means of the excat classification to the CC by the function "part", which corresponds to the fraction of CC in excat:

$$AREA_{subst}(CC,i,yr) = ASCH2_{subst}(excat(CC),i) * part(CC,yr) \quad (7.11)$$

$$part(CC,yr) = AREA_{samp}(CC,yr) / AREA_{samp}(excat(CC),yr) \quad (7.12)$$

where:

$ASCH2_{subst}(excat(CC),i)$: Number of all hectares in the ASCH dataset covered by land-use excat and situated in stratum i in the substitution region.

$AREA_{samp}(CC,yr)$: Number of all hectares in the AREA dataset covered by land-use CC.

$AREA_{samp}(excat(CC),yr)$: Number of all hectares in the AREA dataset covered by land-use excat.

The total stratified area of the CC in Switzerland is the sum of the calibrated area in the extrapolation region and of the area in the substitution region:

$$AREA_{Switzerland}(CC,i,yr) = F(yr) * AREA_{extrapol}(CC,i,yr) + AREA_{subst}(CC,i,yr) \quad (7.13)$$

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) has been shown in Table 7-7. 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 subcategories.

In most cases (as highlighted in yellow in Table 7-7), 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 5B1 (Cropland remaining cropland) are due to net carbon stock changes 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 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 amount of lime was estimated based on a poll among the main producers in Switzerland (ART 2009; 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. 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 four main sources (Table 7-12). They have been quantified on the basis of the AREA data available by July 2012 (SFSO 2012) 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 2'055 (for 5D2) and 1'089'308 (for 5C1) leading to values of $U_{sampling}$ between 4.3% and 0.2%.

3) Extrapolation error: Remaining and converted land-use types in the sampling region may have a frequency that differs from the whole of Switzerland leading to a bias in the extrapolated areas. With the increase of the sampling region, the extrapolation error will converge to zero in the future. For quantifying this error, the relative change of proportions of the land-use types (5A1 to 5F2) between the AREA sample of the last year (72% of Switzerland; FOEN 2012) and the present sample (83% of Switzerland) was used. The values are between 0.8% and 29.7%.

4) Substitution error: The spatial strata that are not covered by the sample of the AREA survey are called substitution region, because the AREA data are substituted here by ASCH2 data. In the substitution region land-use changes are neglected. In order to quantify the uncertainty caused by this simplification, the land-use activities (5A1 to 5F2) taking place between AREA2 and AREA3 were compared with the activities observed between AREA1 and AREA2. The relative change among these two transitions (AREA1-AREA2 and AREA2-AREA3), weighted with the relative size of the substitution region, is used as an indicator for the uncertainty U_{subst} in the rate of change within the substitution area. As the substitution region in this submission is very small (<0.01% of country area) the substitution errors become zero (see Table 7-12).

The overall uncertainty was calculated as:

$$U_{overall} = (U_{interpret}^2 + U_{sampling}^2 + U_{extrapol}^2)^{0.5} + U_{subst}$$

As U_{subst} contains systematic components it was added linearly to the other uncertainties.

Finally, conservatively rounded values of the calculated overall uncertainties were chosen for further processing in the uncertainty analysis as the AREA data acquisition is still in progress and no fully updated dataset for Switzerland is available.

Table 7-12 Three sources of AD uncertainty and overall uncertainties in the area calculations, expressed as half of the 95% confidence intervals. Exceptions for subcategory 5B1 and 5D1 are mentioned in the main text above. Calculations are based on AREA data from SFSO (2012).

IPCC	Description	Interpretation uncertainty	Sampling uncertainty	Extrapolation uncertainty	Substitution uncertainty	Overall uncertainty, calculated value	Overall uncertainty, rounded value
5A1	Forest Land remaining Forest Land	1.1	0.2	1.4	0.0	1.79	2
5A2	Land converted to Forest Land	1.1	1.4	20.6	0.0	20.69	21
5B1	Cropland remaining Cropland	4.9	0.3	12.5	0.0	13.42	14
5B2	Land converted to Cropland	4.9	2.1	11.6	0.0	12.75	13
5C1	Grassland remaining Grassland	5.2	0.2	0.8	0.0	5.30	6
5C2	Land converted to Grassland	5.2	1.1	5.5	0.0	7.68	8
5D1	Wetlands remaining Wetlands	0.9	0.5	9.8	0.0	9.90	10
5D2	Land converted to Wetlands	0.9	4.3	6.1	0.0	7.52	8
5E1	Settlements remaining Settlements	4.4	0.4	9.0	0.0	10.05	11
5E2	Land converted to Settlements	4.4	1.2	9.2	0.0	10.30	11
5F1	Other Land remaining Other Land	1.4	0.3	29.7	0.0	29.69	NA
5F2	Land converted to Other Land	1.4	3.2	4.4	0.0	5.62	6

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 (2012) have been checked for suitability and consistency (Sigmaplan 2013).

The extrapolation of the AREA sample is quite a complex procedure, whose internal consistency is checked systematically as described in Sigmaplan (2013). Further checks (interannual comparisons, plausibility) are carried out after producing the land-use change tables presented in Chapter 7.2.3.2.

The sample sizes in the strata of NFI region 5 (Southern Alps) have further risen in this submission. This, inter alia, led to a lower AD extrapolation uncertainty for sector 5A1 (1.4% instead of 4.2% in FOEN (2012), see Table 7-12).

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.

7.2.7 Recalculations of Activity Data

The increment of available AREA activity data (SFSO 2012), currently reaching a coverage of 83% of Swiss territory in comparison to 72% that had been available in the previous submission (FOEN 2012), led to a recalculation in the LULUCF sector.

7.2.8 Planned Improvements for Activity Data

Switzerland will further reduce the uncertainty of its activity data for land areas by gradually increasing the AREA sample size. Full coverage is expected in 2013. By this improvement, it is expected that besides the substitution errors also the extrapolation errors will converge to zero (the spatial extrapolation becomes redundant). The statistical sampling error will decrease only slightly.

7.3 Category 5A – Forest Land

7.3.1 Description

Tier 2 Key category 5A1
CO_2 from Forest Land remaining Forest Land
(2011: level and trend)

Tier 2 Key category 5A2
CO_2 from Land converted to Forest Land
(2011: 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; FOEN 2007f; SFSO 2006a).

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 and stock of dead wood were derived from the first, second, third and phase a of the fourth Swiss National Forest Inventories (NFI, see Table 7-13). 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 2009-2011 (NFI 4a) were implemented in this submission.

Table 7-13 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	2009-2011
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	~2'000
Measured single trees	~130'000	~70'000	~70'000	~23'000

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 7-14).

Table 7-14 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 7-15.

Table 7-15 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 2006-2011(derived from NFI 3 and NFI 4a data; source: Abegg et al. 2012).

		1985 - 1994		1995 – 2005		2006-2011	
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	0.51	0.49
	>1200	0.74	0.26	0.72	0.28	0.72	0.28
2	<601	0.56	0.47	0.50	0.50	0.44	0.56
	601-1200	0.60	0.40	0.58	0.42	0.51	0.49
	>1200	0.90	0.10	0.90	0.10	0.82	0.19
3	<601	0.40	0.60	0.40	0.60	0.36	0.64
	601-1200	0.70	0.30	0.69	0.31	0.65	0.35
	>1200	0.92	0.08	0.91	0.09	0.90	0.10
4	<601	0.33	0.67	0.33	0.67	0.29	0.71
	601-1200	0.64	0.36	0.63	0.37	0.60	0.40
	>1200	0.97	0.03	0.96	0.04	0.95	0.35
5	<601	0.07	0.93	0.06	0.94	0.06	0.94
	601-1200	0.18	0.82	0.17	0.83	0.16	0.84
	>1200	0.84	0.16	0.83	0.17	0.80	0.20

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 7-16.

Table 7-16 Ratio of biomass in the eastern and western Alps (NFI production region 4) for the time periods 1985-1994,1995-2005 and 2006-2011, respectively, as derived from NFI data (Brändli 2010).

	1985 - 1994		1995 – 2005		2006-2011	
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	0.50	0.50
601-1200	0.62	0.38	0.61	0.39	0.60	0.40

7.3.4.4 Estimation of Growing Stock, Gains and Losses 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 7-17; 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 7-17).

Table 7-17 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 Growing Stock, Gross Growth and Cut and Mortality in Productive Forests (CC12)

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 1967 samples measured during NFI 3 and NFI 4a (Abegg et al. 2012). 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 7-5 as "gain in living biomass". Gross growth and cut and mortality (in Table 7-5 as "loss of living biomass") for the four NFIs are shown in Table 7-18 and Table 7-19 for coniferous and deciduous trees, respectively.

Table 7-18 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).

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	2.13	1.42	2.26	2.82	2.11	3.16
	601-1200	3.15	2.52	3.16	2.80	3.23	2.91
	>1200	2.68	2.16	2.67	1.71	3.10	0.96
2	<601	4.51	4.28	4.21	6.28	3.44	5.08
	601-1200	5.29	4.60	4.85	7.21	4.63	7.38
	>1200	2.40	1.40	1.49	2.20	2.62	1.28
3	<601	3.27	1.91	3.01	3.01	2.50	1.56
	601-1200	5.52	4.10	5.39	6.38	4.45	4.23
	>1200	4.50	3.57	4.52	4.64	4.69	3.71
4 east	<601	2.75	1.29	2.90	1.59	2.88	2.81
4 west	<601	0.72	0.84	1.23	0.92	0.66	1.39
4 east	601-1200	3.44	2.86	3.44	2.31	3.26	2.26
4 west	601-1200	2.40	2.02	2.17	1.76	2.18	1.02
4	>1200	3.36	5.59	3.50	2.43	3.67	2.12
5	<601	0.08	0.06	0.12	0.02	0.29	0.00
	601-1200	0.43	0.23	0.56	0.15	0.28	1.10
	>1200	2.38	0.75	2.46	0.78	3.54	1.44

Table 7-19 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).

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	5.03	4.09
	601-1200	3.27	1.80	2.91	2.13	3.74	3.18
	>1200	1.22	0.31	0.93	0.57	0.97	0.18
2	<601	4.75	3.36	4.87	3.93	4.83	3.89
	601-1200	3.98	2.65	4.27	2.79	4.37	3.82
	>1200	0.80	0.16	1.07	0.40	0.01	0.00
3	<601	5.84	3.85	5.46	2.61	4.49	6.74
	601-1200	2.77	1.41	2.92	1.61	3.12	1.30
	>1200	0.46	0.12	0.48	0.11	0.88	0.26
4 east	<601	4.66	6.41	5.09	2.18	7.77	6.24
4 west	<601	5.20	3.08	4.95	2.11	2.93	4.36
4 east	601-1200	2.11	0.95	2.05	1.10	3.01	1.59
4 west	601-1200	1.93	0.73	2.27	1.03	2.02	1.13
4	>1200	0.25	0.14	0.34	0.13	0.39	0.14
5	<601	5.39	2.29	3.96	2.72	6.56	3.30
	601-1200	3.97	1.40	3.79	1.11	4.16	2.21
	>1200	0.83	0.26	1.12	0.16	0.60	0.22

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 2006-2011. 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 7-5).

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 2006-2011. To calculate annual values of cut and mortality (CMy) for the years 1985 to 1994, 1995 to 2005 and 2006 to 2011, respectively, the average amount of cut and mortality was weighted by the percentage of the relative harvesting amounts taken from the forest statistics (Table 7-20; SFSO 2012c; FOEN 2012g, and former editions 1985-2011). 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 7-20 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 1990-2011 as derived from forest statistics (SFSO 2012c; FOEN 2012g, and former editions 1985-2011). 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
2'011	621'118	489'838	1'100'727	721'806	951'347	241'980	695'223	97'139	59'529	49'219

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).

$$GS_{iy} = GS2005 - \Sigma_y \text{ [annual gross growth}_y\text{]} + \Sigma_y \text{ [CM}_y\text{]} \qquad \text{for iy} < 2005$$

$$GS_{iy} = GS2005 \qquad \text{for iy} = 2005$$

$$GS_{iy} = GS2005 + \Sigma_y \text{ [annual gross growth}_y\text{]} - \Sigma_y \text{ [CM}_y\text{]} \qquad \text{for iy} > 2005$$

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 2011 specified for all spatial strata are displayed in Table 7-5.

All work steps and data required to reproduce the calculation of emission factors for productive forests (CC12) in the period 1990-2011 are summarized in FOEN (2013b).

7.3.4.7 Growing Stock, Gross Growth and Cut and Mortality in Unproductive Forests (CC13)

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 m^3 ha^{-1} was estimated. Multiplied by the mean BCEF for coniferous trees of 0.64, 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, an average growing stock (> 7 cm diameter) of 150 m^3 ha^{-1} was estimated. Multiplied by the mean BCEF for coniferous trees of 0.64, 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 Content of Unproductive Forests (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:

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

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

CS is the carbon content of brush forest (12.9 t C ha^{-1}),

CI is the carbon content of forest on unproductive areas (48.2 t C ha^{-1}).

Table 7-21 shows the carbon content per spatial stratum in t C ha^{-1}.

Table 7-21 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

Gross Growth and Cut and Mortality of Unproductive Forests (CC13)

As no harvesting is conducted in unproductive forests, gross growth and cut and mortality of unproductive forest are assumed to be in balance.

7.3.4.8 Carbon Stocks in Dead Wood, Litter and in Soils

Dead Wood Productive Forest - 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 degree 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 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. DRoots were estimated by applying biomass functions of roots of living trees.

The volume of CWD was calculated by applying biomass functions of living trees including bark, tree-top and stump and, according to the degree of decay, the volume of the branches ≥ 7 cm (see Cioldi et al. 2010: 109-112).

Since NFI 3, CWD is classified into 5 decay classes (Keller 2005) which are used to convert CWD volume to biomass following decay class specific models developed by Weggler et al. (2012). These models were established on the basis of measurements of spruce and beech dead wood density at 34 sites in Switzerland (Weggler et al. 2012; Dobbertin and Jüngling 2009). Models for spruce were used for coniferous CWD and models for beech were used for deciduous CWD. To convert CWD biomass into CWD carbon the C concentration of 48.3% and 46.8% was used for coniferous and deciduous CWD biomass, respectively.

Also since NFI 3, the amount of lying dead wood of at least 7 cm is measured following the line intersect method enabling the estimation for LIS (all dead wood ≥ 7 cm, except stem and branches ≥ 12 cm that where already included in the CWD). The volume of LIS is converted to carbon by applying the wood densities of living trees and a C concentration of 50%.

As observations for LIS and for CWD based on decay classes do not exist for the NFI 2 and an estimation of CWD based on decay classes for the NFI 4a was not possible due to technical reasons, TDW estimates for NFI 2 and 4a were approximated based on the estimate for the NFI 3:

$$TDW\_NFI_{j,\,s} = TDW\_NFI_{3,s} * (DWV\_NFI_{j,\,s} / DWV\_NFI_{3,s})$$

where

- DWV (dead wood volume) is the volume of dead wood with a diameter of at least 12 cm that can be estimated identically for each NFI,
- j indicates the NFI for which TDW is estimated (i.e. 2 and 4a) and
- s indicates the 15 spatial strata.

The resulting estimates of TDW in Swiss productive forests (CC12) for the NFI 2, NFI 3 and NFI 4a are shown in Table 7-22, differentiated for 15 spatial strata.

Table 7-22 Total Dead wood (TDW) stock in Swiss productive forests (CC12) with diameter>7 cm per spatial stratum in t C ha^{-1} in 1995 (NFI 2, Brassel and Brändli 1999, Brändli 2010), in 2005 (NFI 3, Cioldi et al. 2010) and 2009 (Didion et al. 2012).

NFI region	Altitude [m]	Carbon in dead wood stock > 7 cm in 1995 [t C ha^{-1}]	Carbon in dead wood stock > 7 cm in 2005 [t C ha^{-1}]	Carbon in dead wood stock > 7 cm in 2009 [t C ha^{-1}]
1	<601	3.57	5.10	6.05
	601-1200	4.43	5.96	7.56
	>1200	1.49	4.43	7.73
2	<601	1.32	4.10	3.65
	601-1200	2.38	5.66	5.45
	>1200	2.38	5.66	5.45
3	<601	0.78	5.29	6.32
	601-1200	2.84	7.13	6.41
	>1200	5.15	11.80	13.33
4	<601	2.20	5.17	3.54
	601-1200	6.33	7.35	7.32
	>1200	5.41	7.44	7.08
5	<601	5.41	8.81	8.48
	601-1200	2.93	4.94	6.17
	>1200	4.64	5.79	5.39
Switzerland		3.85	6.59	6.61

Dead Wood Unproductive Forest - Carbon Stock

So far, there are no data available about dead wood in unproductive forests (CC13) and dead wood stock is reported as not estimated “NE”.

Litter (Organic Soil Horizons) on Mineral Soils of Productive Forests - 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. 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. (Table 7-23)

Table 7-23 Carbon stock in organic soil horizons (litter; used for CC12 and 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 organic soil horizon (litter) [t C ha^{-1}]	SOC of mineral topsoil 0-30 cm [t C ha^{-1}]
1	<601	9.51 ± 1.57	82.65 ± 3.34
1	601-1200	7.53 ± 0.70	102.03 ± 3.56
1	>1200	7.76 ± 1.74	121.34 ± 5.39
2	<601	8.70 ± 0.68	55.40 ± 1.55
2	601-1200	11.42 ± 1.45	62.12 ± 1.68
2	>1200	11.42 ± 1.45	122.00 ± 7.07
3	<601	7.51 ± 1.25	66.10 ± 2.06
3	601-1200	16.29 ± 1.55	57.91 ± 2.00
3	>1200	26.21 ± 4.77	95.78 ± 3.27
4	<601	3.15 ± 0.47	66.47 ± 2.44
4	601-1200	19.99 ± 2.64	74.39 ± 2.42
4	>1200	33.37 ± 3.53	69.48 ± 1.85
5	<601	8.22 ± 1.62	102.37 ± 4.07
5	601-1200	11.03 ± 2.11	108.99 ± 4.09
5	>1200	30.77 ± 5.43	107.08 ± 4.11
Switzerland		16.73 ± 0.83	79.93 ± 1.52

Total Dead Organic Matter of Productive Forests (CC12), Unproductive Forests (CC13) and Afforestations (CC11) - 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 of mineral forest soils.

Table 7-5 shows annual data of DOM in productive forests (CC12) for 1990-2011. This dataset combines estimates of yearly changes for dead wood and for litter in productive forests.

Assuming no dead wood on CC13 sites, for unproductive forests the amount of dead organic matter is estimated as the carbon content in organic soil horizons of mineral forest soils. DOM values for CC13 are listed in Table 7-4 and were used for the period 1990-2011.

We conservatively estimate the stock of dead organic matter on Afforestations (CC11) to be zero (see Chapter 7.3.4.9 and 11.3.1.2).

Soil Carbon in Productive Forests (CC12), Unproductive Forests (CC13) and Afforestations (CC11) - Carbon Stock

In Nussbaum et al. (2012) an average carbon stock in mineral forest soils of 79.9 t C ha^{-1} in 0-30 cm topsoil was estimated. The data were stratified for the five NFI production regions and three elevation levels (Table 7-23). The resulting values (see Table 7-4) were derived for productive forests (CC12), but are also applied for unproductive forests (CC13) and to calculate the change in soil C stocks under afforestations (CC11).

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. 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}.

7.3.4.9 Changes in Carbon stocks in Dead Wood, Litter and in Soils

Soil, Organic Soil Horizons and Dead Wood in CC12 - Changes in Carbon Stocks

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 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).

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). For reporting carbon stocks the results of Nussbaum et al. (2012) were used (Chapter 7.3.4.8). For several reasons Yasso overestimates C stock in dead wood (see Didion et al. 2012). Dead wood data from NFI 2, 3 and 4a were used to scale C stock estimates in dead wood from Yasso07 (see Appendix IV in 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 7-9 shows the mean stock change in Swiss forests for these three C pools and the aggregated total. Annual and stratified values for CC12 can be found in Table 7-5, where net change in dead organic matter encompasses changes in dead wood and in the LFH layer. Stock changes were validated as described in Didion et al. (2012).

Carbon stock changes in the soil pool are small (Figure 7-9c), which corresponds to information from measurements (see Chapter 7.3.6). Carbon stock changes in the LFH layer pool are higher and more erratic than changes in the dead wood and soil pools (Figure 7-9b). 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 2nd (1993-1995) and 3rd (2004-2007) NFI, it strongly affects the results of the change analysis for dead wood volume between both NFIs, which determines the annually accumulating mass of carbon in dead wood that drives the Yasso07 simulation.

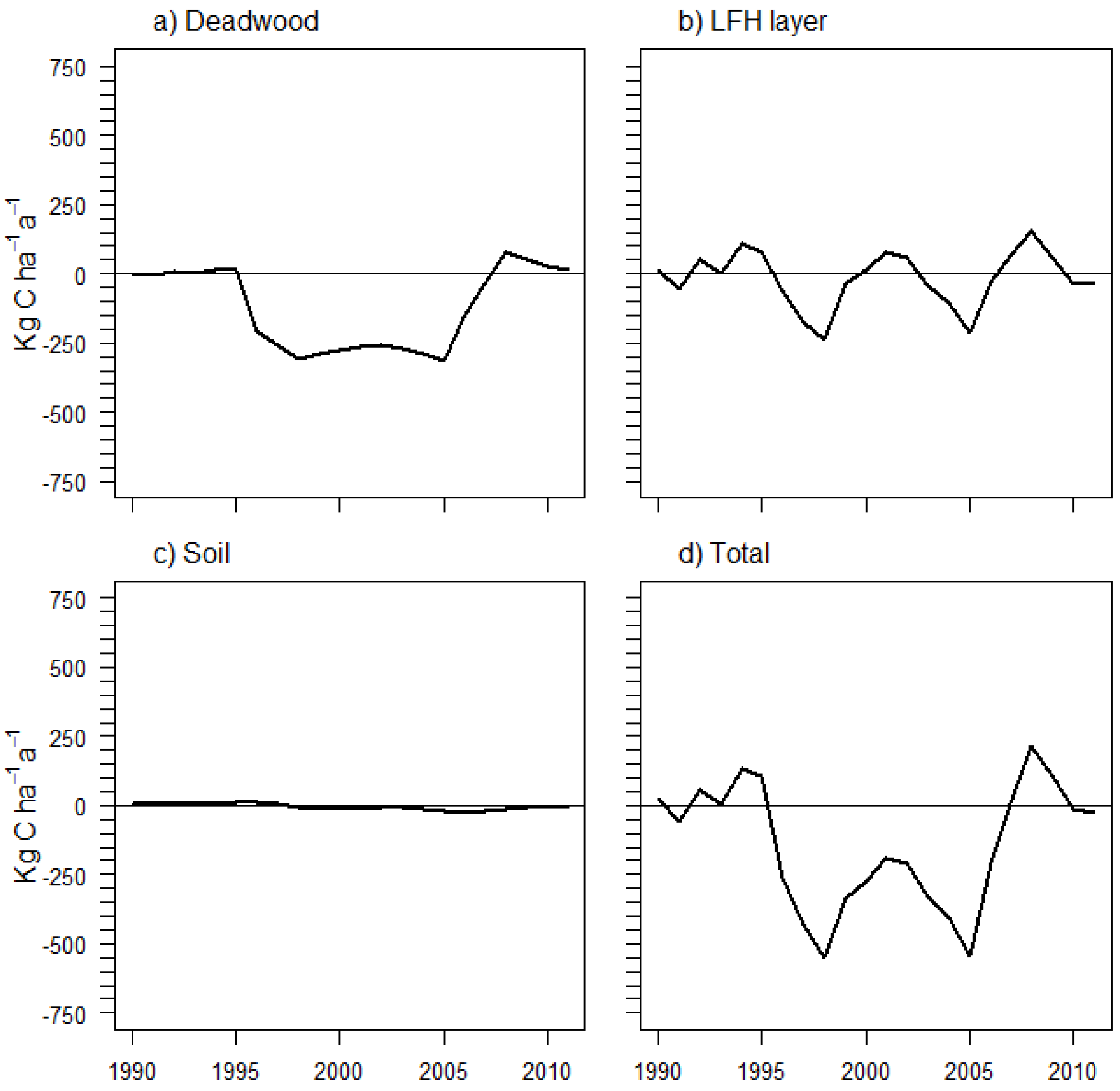

Figure 7-9 Annual mean C stock changes in a) dead wood, b) LFH layer (litter), c) mineral soil and d) total per hectare since 1989. Negative values indicate a sink and positive values a source (after Didion et al. 2012).

Total Dead Organic Matter of Productive (CC12) and Unproductive (CC13) Forests and Afforestations (CC11) - Changes in Carbon Stock

Table 7-5 shows annual data of dead organic matter in productive forests (CC12) for 1990-2011. The scaled temporal changes in dead wood derived from Yasso07 are added to the measured NFI data of dead wood (Table 7-22; Appendix IV in Didion et al. 2012). A time series of litter is derived by adding the temporal changes derived from Yasso07 to the estimates of Nussbaum et al. (2012; see alsoTable 7-23).

For unproductive forests (CC13), DOM is constant. It is assumed that there are no changes in the litter nor in the dead wood pool. DOM values for CC13 are listed in Table 7-4.

In Switzerland, afforestations (CC11) occur mostly on grasslands and settlements (see Table 7-10 in Chapter 7.2.3) where there is no litter and no dead wood. 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 also 7.3.4.8 and 11.3.1.2).

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}.

The impact of old drainages on organic soils can lead to non-CO_2 emissions from organic soils. However, the reporting of non-CO_2 emissions is not mandatory for Forest Land and as no data are available, Switzerland decided not to prepare estimates for these categories. Therefore, no non-CO_2 emissions are estimated ("NE") in CRF Table 5(II A) (see also Chapter 7.6.4.4).

7.3.4.10 Carbon Stock of Afforestations (CC11)

Growing Stock and Growth

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 7-24 shows the simulated growing stock and growth for the three altitudinal levels.

Table 7-24 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:

C 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 7-25 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

7.3.4.11 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).

The calculation of C losses due to drainage is described in Chapter 7.3.4.9.

7.3.4.12 Emissions from Wildfires

Data on wildfires affecting Swiss forest land are obtained from cantonal authorities and are compiled by FOEN (FOEN 2012g). Table 7-26 shows the annual number of fires and the burnt area from 1990 to 2011.

As controlled burning is not allowed in Switzerland all fires are assigned to “wildfires”. The number and are 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.

The emission factor for CH_4 is 0.354 Mg CH_4 ha^{-1} as proposed by EEA (2006).

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

The mass of available fuel 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 7-5 under “loss of living biomass" and under “net change in dead organic matter”.

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 7-22 and Table 7-23 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 7-26 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 7-26 Productive forest land affected by wildfires (FOEN 2012g) and resulting GHG emissions 1990-2011.

Year	Number	Area burnt [ha]	CH_4 [Mg]	N_2O [Mg]	CO_2 [Mg]
1990	216	1102	390.11	15.42	25'358.04
1991	157	148	52.39	2.07	3'405.62
1992	111	52	18.41	0.73	1'196.57
1993	99	42	14.87	0.59	966.46
1994	52	293	103.72	4.10	6'742.20
1995	56	438	155.05	6.13	10'078.79
1996	61	233	82.48	3.26	5'361.55
1997	77	1511	534.89	21.14	34'769.52
1998	88	249	88.15	3.48	5'729.72
1999	31	9	3.19	0.13	207.10
2000	41	36	12.74	0.50	828.39
2001	39	37	13.10	0.52	851.40
2002	75	410	145.14	5.74	9'434.48
2003	189	564	199.66	7.89	12'978.16
2004	46	20	7.08	0.28	460.22
2005	97	47	16.64	0.66	1'081.51
2006	70	101	35.75	1.41	2'324.10
2007	64	234	82.84	3.27	5'384.56
2008	47	53	18.76	0.74	1'219.58
2009	52	42	14.87	0.59	966.46
2010	59	25	8.85	0.35	575.27
2011	77	167	59.12	2.34	3'842.83

7.3.4.13 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 relative uncertainty was used:

- Stem wood of growth and Cut & Mortality:

  NFI 1, 2 and 3: NFI data without application of climate factor: 1% for gains and 2% for losses (Brändli, 2010)

  NFI 4a and 3-4a: 3% for gains and 6% for losses (Abegg et al. 2012)

- 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: 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 relative uncertainty of carbon losses and gains in living biomass (Uliv.biom) in terms of carbon per unit area can be calculated as:

- addition of uncertainties to derive uncertainty for gains and losses following equation 6.4 in chapter 'Quantifying Uncertainties in Practice' (IPCC 2000)

  $U_{liv.biom\_gains} = (1^2 + 10^2 + 15^2 + 30^2)^{0.5} = 35.01\%$ (NFI 1, 2, 3)

  $U_{liv.biom\_losses} = (2^2 + 10^2 + 15^2 + 30^2)^{0.5} = 35.06\%$ (NFI 1, 2, 3)

  $U_{liv.biom\_gains} = (3^2 + 10^2 + 15^2 + 30^2)^{0.5} = 35.13\%$ (NFI 4a, NFI 3-4a)

  $U_{liv.biom\_losses} = (6^2 + 10^2 + 15^2 + 30^2)^{0.5} = 35.51\%$ (NFI 4a, NFI 3-4a)

- weighting of uncertainties of gains and losses to derive uncertainty for change following equation 6.3 in chapter 'Quantifying Uncertainties in Practice' (IPCC 2000)

  $U_{total} = (((U_{liv.biom\_gains} \times mean_{living\ biomass\ of\ gains})^2 + U_{liv.biom\_losses} \times mean_{living\ biomass\ of\ losses})^2)^{0.5}) / (mean_{living\ biomass\ of\ gains} + mean_{living\ biomass\ of\ losses})$:

  $U_{total} = (((35.01 \times 8.75)^2 + (35.06 \times 8.24)^2)^{0.5}) / (8.75+8.24) = 24.78\%$ (NFI 1, 2 and 3)
  $U_{total} = (((35.13 \times 8.6)^2 + (35.51 \times 7.2)^2)^{0.5}) / (8.6+7.2) = 25.05\%$ (NFI 4a and NFI 3-4a)

The uncertainty in the estimates of annual stock changes derived with the Yasso07 model derives 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
- derivation of estimates for the soil, litter and dead wood pools from the pooled Yasso07 result for the total stock.

The uncertainty associated with the climate data and the derivation of estimates for individual pools could not be estimated.

The uncertainty associated with C inputs (dead wood and litterfall) was estimated based on NFI data and expert judgement: The uncertainty of applying biomass functions to obtain dead wood volume (U_{dw}) is similar to the uncertainty typical for BCEF and is estimated to be 30% (e.g. Monni et al. 2007). A conservative estimate of the uncertainty associated with allometries to obtain foliage and fine root estimates for the litter pool (Uli) is assumed to be also in the order of 30%.

Parameter uncertainty of the Yasso07 model was estimated based on independent simulations with varying parameter combinations from the MCMC (Markov Chain Monte Carlo) parameter estimates listings of Yasso07 (see alsoTuomi et al. 2011). The results for the annual changes were used to calculate the uncertainty related to model parameters for the period 1990 to 2011. This was calculated for the default output of Yasso07 (i.e. total C stock in soil, litter and dead wood (Upar_{total}) and for the individual pools that were derived from the total following the method described in Didion et al. 2012 ($Upar_{soil}$, $Upar_{litter}$, $Upar_{dw}$). The posterior separation of the Yasso07 results into the 3 pools soil, litter and dead wood is the reason why the uncertainty of the changes in the total stock is not calculated based on the uncertainties in the pools.

The total uncertainty from C inputs and model parameters was calculated following equation 6.4 in chapter 'Quantifying Uncertainties in Practice' in IPCC (2000).

Uncertainty of the change in soil carbon:

$$U_{total_{soil}} = \sqrt{U_{dw}^2 + U_{li}^2 + U_{par_{soil}}^2} = \sqrt{30^2 + 30^2 + 9.45^2} = 43\%$$

Uncertainty of the change in litter:

$$U_{total_{litter}} = \sqrt{U_{li}^2 + U_{par_{litter}}^2} = \sqrt{30^2 + 7.56^2} = 31\%$$

Uncertainty of the change in dead wood: .

$$U_{total_{dw}} = \sqrt{U_{dw}^2 + U_{par_{dw}}^2} = \sqrt{30^2 + 2.6^2} = 30\%$$

Uncertainty of the change in the total stock:

$$U_{total} = \sqrt{U_{dw}^2 + U_{li}^2 + U_{par_{total}}^2} = \sqrt{30^2 + 30^2 + 6.32^2} = 43\%$$

By weighting these emission factor uncertainties with the relative importance of the carbon pools and considering emission factor uncertainties of living and dead biomass (see also Table 7-7), an combined of 32% was calculated for Forest Land remaining Forest Land, 37% for Land converted to Forest Land, and 51% for Forest Land converted to non-Forest Land (see also 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.

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. 2012 and Chapter 7.3.4.9).

7.3.6 Category-Specific QA/QC and Verification

Expert Peer Review

The LULUCF sector was reviewed thoroughly at the end of 2010 by sectoral experts from the Johann Heinrich von Thünen-Institut, Germany (vTI 2011). The recommendations of the review report have contributed to the preparation of the LULUCF estimates for this submission.

Estimation of Growing Stock, Gains and Losses of Living Biomass

Revised root function:

Both Switzerland and Austria report gains and losses of biomass in the forest sector based on repeated single tree measurements of the NFI (see Umweltbundesamt 2012). Up to now, Austria and Switzerland used the same root function for conifers from Wirth et al. (2004a). In its NIR 2012, Austria indicated that the application of this root function can lead to an overestimation of the root mass of large conifers. Austria therefore decided to apply a different function from Wirth et al. (2004a) with tree age as a predictor variable, stabilizing the overestimation of larger trees. This solution cannot be implemented in Switzerland because tree age is not measured for all trees and the uncertainty of modeled tree age is unknown. We therefore had to develop a more conservative parameterization of the initial Wirth-function for large trees based on the single tree data from Wirth et al. (2004a). The parameter development and new values were described and discussed in the internal report from Zell and Thürig (2012).

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 7-27) 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 7-27). 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 7-27 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} y^{-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. Thus, the SOC dataset (n = 1’790 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 30.9 t C/ha (min) and 148.9 t C ha^{-1} (max) and were in average 63.0 t C ha^{-1}. Figure 7-10 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.

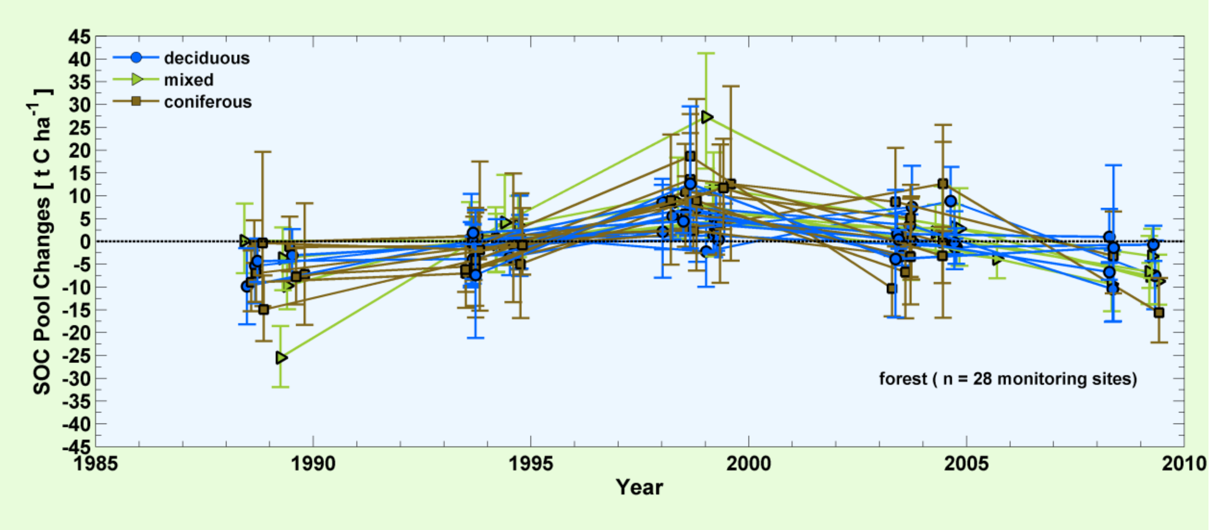

Figure 7-10 Time series of measured SOC pool changes in the top soil (0-20 cm) at the 28 NABO forest sites from the 1st to the 5th re-sampling campaigns. SOC pools were centred by the median SOC pool of all re-samplings of the monitoring site. Each pool value presents the median of four bulked soil samples 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 ± 1.1 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 7.3.4.9). Didion et al. (2012), who applied the Yasso07 model to Swiss forest soils, estimated a soil sink effect of 0.006 t C ha^{-1} a^{-1} for 2009 to 2010. For the monitoring period of 20 years this rate of change would correspond to 0.12 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 ten 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 increase of available AREA activity data (see Chapter 7.2) led to a recalculation in category 5A.

In response to discussions with the ERT during the 2012 individual review, the application of weighting factors was modified as described in Chapter 7.1.3.2:

- Afforestation (CC11): the carbon stock difference in living biomass (before minus after the land-use conversion) is not reported any more ($W_{l,ba}$ = 0). This is a more realistic approach because the afforestation event itself hardly changes the existing carbon pool.
- For areas that are converted to productive or unproductive forest (CC12, CC13), gains and losses in living biomass are not reported any more during the conversion time period of 20 years ($V_{l,ba}$ = 0) in order to avoid potential double counting of carbon sinks.

For the GHG inventoryat hand, the calculation of emission factors for the Swiss forest sector was revised in response to technical improvements and more recent data. Resulting differences between the old and the revised emission factors are documented in Thürig and Herold (2013). The technical improvements and their effect on the emission factors are reported in detail for 1) the further development of the formulation of NFI data derivations, 2) the use of a more accurate allometric function for calculating the volume of coniferous roots, and 3) a more precise approach to calculating gains and losses in biomass on a single-tree basis (instead of applying biomass expansion- and conversion factors; cf. ERT recommendation in Table 1-12). To ensure temporal consistency the revised methodology was used to recalculate emission factors for all years since 1990.

For the first time, NFI 4a data covering the years 2009-2011 were available for reporting (Table 7-13; Abegg et al. 2012). Gains and losses in living biomass for 2006-2011are calculated based on changes between NFI 3 and NFI 4a. The estimates of emissions and removals from living biomass are thus based on measurements and no longer on an extrapolation of NFI 3 data (cf. FOEN 2012). NFI4a also delivered estimates of stocks of dead wood (see Chapter 7.3.4.8). Both the methodological improvements and the availability of NFI 4a data shifted the forest sector towards a bigger sink (cf. CRF table 8a).

Nussbaum et al. (2012) provided updated data for carbon stocks of litter and soil organic carbon. They produced a map of organic carbon stocks of Swiss forest soils based on a WSL database containing data of 1'033 soil profiles by using geostatistical methods. Following ERT recommendations (cf. Table 1-12), the results were incorporated in this submission to improve estimates of carbon stocks in mineral forest soils.

Yearly changes in carbon stocks of soil organic carbon, dead wood and litter (LFH horizons) have been modeled with Yasso07 (Didion et al. 2012). The results were validated by another project named “Testing the Yasso07 model with long term litterbag data from five long term forest ecosystem research (LTFER) sites and two elevation gradients in the Swiss Prealps” (Frey 2011). Following ERT recommendations (cf. Table 1-12), the results were incorporated in this submission to, inter alia, improve estimates of carbon stocks changes in mineral forest soils.

7.3.8 Category-Specific Planned Improvements

In November 2011, ART 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 First tests in this direction have been carried out by Meteotest (2009a, 2011a).

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 2013.

Switzerland intends to make better use of the SOC data provided by the Swiss Soil Monitoring Network in forthcoming submissions. A contract has been 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.

Research from a new national research programme (NRP68 Sustainable Use of Soil as a Resource: "SOM control") 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
(2011: level and trend).

The category 5B2 Land converted to Cropland is not a key category.

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. 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 2011 5B1 Cropland remaining Cropland was a net sink of 265.5 Gg CO_2 due to a considerable increase in living biomass from 2010 to 2011. Average living biomass was increasing slightly over the period 1990-2011. However, annual fluctutations in net carbon stock changes of biomass are considerable (see Table 7-6). 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 are due to carbon mineralization in organic soils, mainly in the lowest altitudinal zone (z1: 98%). Overall, organic soils account for 2.8% of cropland area in Switzerland.

5B2 Land converted to Cropland was a small net sink of 6.8 Gg CO_2 in 2011.

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 7-28. 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 2012).

The resulting mean biomass stock for Swiss cropland over the whole inventory time period is 4.67 ± 0.34 (1 SD) t C ha^{-1}.

Table 7-28 Annual values for arable crop yields (i.e. carbon stocks) and area-weighted mean (t C ha^{-1} yr^{-1}) (SBV 2012), 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} yr^{-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} yr^{-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	mean 1990-2011
	CC21: yield [t C ha^{-1} yr^{-1}]		
Barley	2.56	2.75	2.55
Wheat	2.48	2.72	2.50
Maize	3.61	4.13	3.75
Silage maize	7.47	8.46	6.86
Sugar beet	8.03	10.38	7.90
Fodder beet	6.49	6.65	6.25
Potatoes	4.26	5.01	4.42
Leys	6.11	6.11	6.11
Mean	4.99	5.44	4.67

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 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).

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 5.44 t C ha^{-1} in 2011 (Table 7-28; SBV 2012). The difference in biomass stock between the current year and the preceding year is reported as gain or loss of carbon (see Table 7-6: "change"). This value is in the range between -0.32 and 0.49 t C ha^{-1} yr^{-1} with an average of 0.053 t C ha^{-1} yr^{-1} for the period 1990–2011.

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.

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):

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

where:

- deltaC$_s$: soil carbon change in soils induced by land-use conversion to cropland [Gg C]
- C:N: C:N ratio = 9.8 in grassland soils (Leifeld et al. 2007)
- EF1: IPCC default emission factor = 0.0125 kg N_2O-N (kg N)$^{-1}$

DeltaC$_s$ is calculated according to the methodology described in Chapter 7.1.3. If DeltaC$_s$ is zero or positive (carbon gain) there is no N_2O emission. On mineral soils this is the case for wetlands converted to cropland and other land converted to cropland (see CRF Table 5B2). In these cases, only areas are reported in Table 5(III), but no emissions. On organic soils the carbon stock differences for land-use conversions to cropland are zero or – in the case of other land (CC61) – positive (cf. Table 7-4).

The country specific C/N ratio of 9.8 for grassland proposed by Leifeld et al. (2007) has been used because the largest part of the area converted to cropland consisted of grassland (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 ART (2009) for the period 1990-2008 (see Table 7-29). For 2009–2011 the same value as for 2008 is used as no newer survey is available.

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 7-29 Amount of limestone applied on agricultural soils and resulting CO_2 emissions 1990-2011.

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

7.4.5 Uncertainties and Time-Series Consistency

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 C contents and predicted soil bulk densities, i.e., they consider only uncertainties in emission factors.

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 would be 0 ± 0.52 t C ha^{-1} (Keller 2013). Since carbon stock changes in mineral soils under cropland are assumed to be zero no relative uncertainty value can be calculated. In the course of the next submission it will be decided how to proceed with these estimates and how to integrate them in the overall uncertainty analysis.

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.

In the uncertainty analysis, a higher, conservative value of 50% was chosen for the overall emission factor uncertainty in sector 5B2 (Land converted to Cropland) (Table 7-7).

The uncertainty of the carbon stock change in organic soils is 23% as reported by Leifeld et al. (2003: 56). A rounded value of 25% is used for further processing.

For the uncertainty of the emission factor for N_2O on land converted to cropland a default value of 90% is used (Table 7-7).

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 (ART 2009). 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 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 did not show any significant change since 1985 (Figure 7-11). The range of the calculated SOC pools is quite large (23.7 - 522 t C ha^{-1}), as two cropland soil monitoring sites are on peat soils. Average SOC pool in the topsoils (0-20 cm) of the 38 cropland monitoring sites for all soil sampling campaigns was 56.5 t C ha^{-1} (44.3 t C ha^{-1} without the peat soils). At the two 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%), i.e. SOC pool changes were smaller than ± 1.5 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. Therefore, the temporal variation of the SOC content and SOC pools at the cropland sites indicate natural variation (noise) and the results suggest that Swiss cropland mineral soils did not act as a net carbon source or sink during the last 20 years.

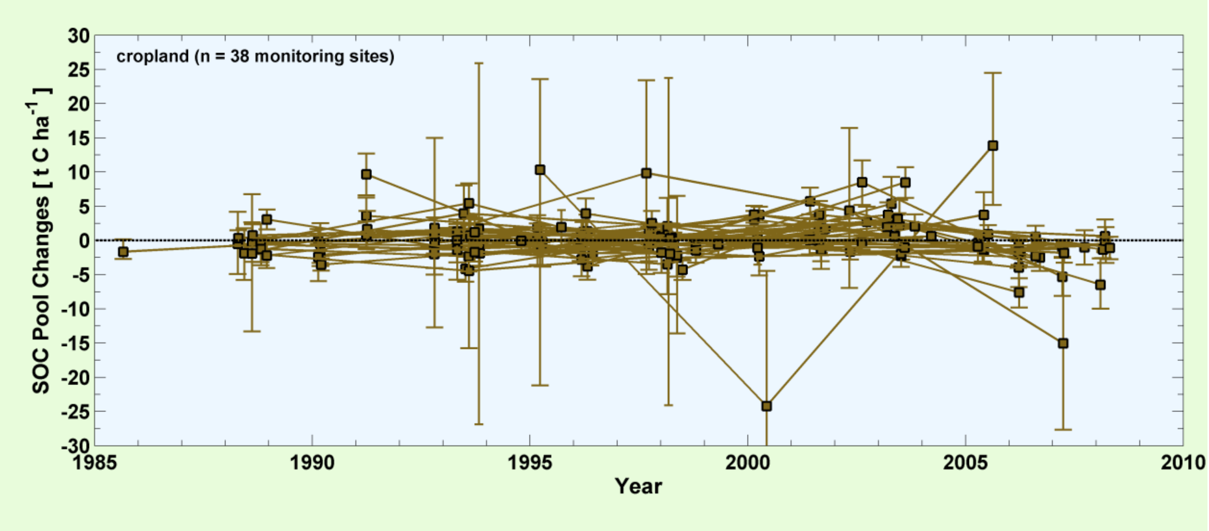

Figure 7-11 Time series of measured SOC pool changes in the top soil (0-20 cm) at the 38 NABO cropland sites from the 1st to the 5th re-sampling campaigns. SOC pools were centred by the median SOC pool of all re-samplings of the monitoring site. Each pool value presents the median of four bulked soil 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 increase of available AREA activity data (see Chapter 7.2) led to a recalculation in category 5B.

Annual values for carbon stock changes in living biomass have been calculated for the period 1990–2011 (Table 7-6 and Chapter 7.4.4.3). In former submissions, a constant value of zero was used for all years.

7.4.8 Category-Specific Planned Improvements

In November 2011, ART 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.

Switzerland intends to make better use of the SOC data provided by the Swiss Soil Monitoring Network (NABO) in forthcoming submissions. A contract has been 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).

Research from a new national research programme (NRP 68, "Sustainable Use of Soil as a Resource") focuses 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
(2011: level and trend).

Tier 2 Key category 5C2
CO_2 from Land converted to Grassland
(2011: 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). 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 2011 5C1 Grassland remaining Grassland was a net source of 135.2 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 came thus from carbon mineralization on organic soils under permanent grasslands in the lowest altitudinal zone (z1: 175.3 Gg CO_2), although only 0.45% of all grassland soils in Switzerland are organic soils. Contributions of other grassland subcategories remaining grassland were of minor importance.

5C2 Land converted to Grassland was a net source of 190.7 Gg CO_2 in 2011. The highest individual contribution came from 5C2.1 Forest Land converted to Grassland being responsible for a net source of 338.8 Gg CO_2. Most of this source (67%) is due to net changes in living biomass from deforestation. Land-use change subcategories 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 7-30), 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 7-30 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 7-31 shows the living biomass of permanent grassland for the three altitudinal zones presented as the cumulated annual yield including roots.

Table 7-31 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 7.3.4.7, 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, ASCH2) 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 tree height was assumed to be around 1 m. The bole shape of low-stem apple trees can be approximated by a cylinder shape.

Stem wood volume = $r^2 * \pi *$ height = $(5\ cm)^2 * 3.1 * 100\ cm = 7.75\ dm^3$

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 (ASCH2 data), 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. ASCH2 data showed that 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 7-31) 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 7-31), 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 7-32. 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 7-32 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 7-32) 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 7-32) 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 7-32) 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 (ASCH2) alpine grasslands. These grasslands are mainly located at altitudes > 1200m a.s.l. Thus, using the respective value from Table 7-32, 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 7-32) 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.

7.5.5 Uncertainties and Time-Series Consistency

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 C contents and predicted soil bulk densities, i.e., they consider only uncertainties in emission factors.

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 would be 0 ± 0.57 t C ha^{-1} (Keller 2013). Since carbon stock changes in mineral soils under grassland are assumed to be zero no relative uncertainty value can be calculated. In the course of the next submission it will be decided how to proceed with these estimates and how to integrate them in the overall uncertainty analysis.

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.

In the uncertainty analysis, a higher, conservative value of 50% was chosen for the overall emission factor uncertainty in sector 5C (see Table 7-7). Uncertainties of activity data of Grassland are described in Chapter 7.2.5.

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.

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 32 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 7-12). SOC pools ranged between 18.5 and 159.5 t C ha^{-1}, the average SOC pool for the 32 grassland monitoring sites was 63.8 t C ha^{-1} (0-20 cm). 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.

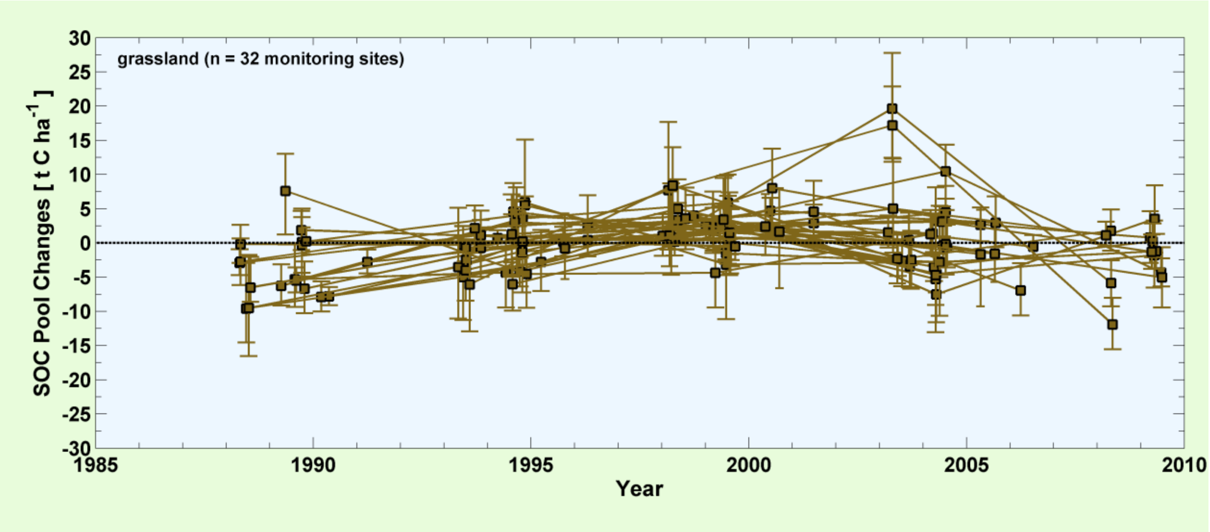

Figure 7-12 Time series of measured SOC pool changes in the top soil (0-20 cm) at the 32 NABO grassland sites from the 1st to the 5th re-sampling campaigns. SOC pools were centred by the median SOC pool of all re-samplings of the monitoring site. Each pool value presents the median of four bulked soil 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 increase of available AREA activity data (see Chapter 7.2) led to a recalculation in the category 5C.

The carbons stocks in living biomass for CC35 and CC37 were adjusted to the currently used CC31 values.

Meyer et al. (2012) investigated the effect of grassland abandonement on organic carbon in soils. They concluded that the abandonement of mountain grassland (i.e. land-use change from CC31 to CC32) does not provide a substantial carbon sink that can be accounted for in greenhouse gas inventories. This finding has been considered by harmonizing the mineral soil organic carbon stocks of CC31, CC32, and CC34. In former submissions an average value of 68.23 t C ha^{-1} for CC32 and CC34 was used.

7.5.8 Category-Specific Planned Improvements

In November 2011, ART 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.

The research project "Baumbiomasse in der Landschaft", which aimed to improve estimates of tree biomass in non-forest areas, has been completed (Mathys and Thürig 2010). A follow-up project is to be terminated in spring 2013. The applicability of the obtained data for reporting in category 5C will be evaluated.

Switzerland intends to make better use of the SOC data provided by the Swiss Soil Monitoring Network (NABO) in forthcoming submissions. A contract has been 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.

Research from a new national research programme (NRP 68 "Sustainable Use of Soil as a Resource") focuses 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)

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 research project “Baumbiomasse in der Landschaft” (Mathys and Thürig 2010) aimed to improve estimates of tree biomass in non-forest areas. For the mixed category CC42, the pool of living biomass was estimated to 6.50 t C ha^{-1}.

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 7-8), 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 these peatlands are located on organic soils (cf. Table 7-8) 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 N_2O Emissions from Drainage of Soils

The reporting of non-CO_2 emissions from drainage of soils and wetlands is not mandatory and due to the lack of data Switzerland decided not to prepare estimates for these categories. Therefore, no non-CO_2 emissions are reported in CRF Table 5(II D).

7.6.5 Uncertainties and Time-Series Consistency

As a first guess, a value of 50% was chosen for the overall emission factor uncertainty in sector 5D (Table 7-7).

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 increase of available AREA activity data (see Chapter 7.2) led to a recalculation in the category 5D.

7.6.8 Category-Specific Planned Improvements

In November 2011, ART 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.

Hiller et al. (in prep.) are currently compiling spatially explicit methane fluxes in Switzerland. For reservoirs >0.1 km^2 an emission of 0.43 Gg CH_4 yr^{-1} was estimated. It is planned to incorporate this figure into category 5D once the study has been published.

7.7 Category 5E – Settlements

7.7.1 Category Description

Tier 2 Key category 5E2 CO_2 from Land converted to Settlements (2011: 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.

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). These stocks were calculated as follows:

Mathys and Thürig (2010) used new digital terrain and surface models to assess specific crown cover areas for the land-use categories. For calculating the carbon stocks, a crown cover area based annual growth rate (CRW) is used.

In a Tier 1a approach, the IPCC provides a default value for CRW in settlements remaining settlements (IPCC 2003; p. 3.297).This value ranges from 1.8 to 3.4 t C ha^{-1} yr^{-1}, the arithmetic mean is 2.9 t C ha^{-1} yr^{-1}. In the GPG LULUCF (IPCC 2003), growth of trees in settlements is limited to the first 20 years.

Expert assessment in Switzerland estimated the average age of trees in settlements remaining settlements to be older than 20 years (Kuhn 2011). Therefore, the average carbon stock per tree crown cover area (t C ha^{-1} yr^{-1}) in settlements remaining settlements was assumed to be 20 times the crown cover area based annual growth rate.

7.7.4.2 Carbon in Soils

The carbon stock in soil for CC51 (buildings and construction) was set to zero. However, a weighting factor of 0.5 was applied to soil carbon changes due to land-use changes involving CC51 (see Chapter 7.1.3.2). The reason for this is that in general the soil organic matter on construction sites is stored temporarily and later used for replanting the surroundings or it is used to vegetate dumps for example. The oxidative carbon loss due to the disturbance of the soil structure may reach 50% (see discussion in Leifeld et al. 2003: 67).

The carbon stock in 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 first guess, a value of 50% was chosen for the overall emission factor uncertainty in sector 5E (Table 7-7).

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 increase of available AREA activity data (see Chapter 7.2) led to a recalculation in the category 5E.

In former submissions, no changes in carbon stocks of organic soils in settlements were reported. In this submission, the emission factor on areas with herbaceous biomass (CC52) was replaced with 9.52 t C ha^{-1} and the emission factor on areas with shrubs or trees (CC53, CC54) with 5.30 t C ha^{-1}.

7.7.8 Category-Specific Planned Improvements

Following improvements for CC52, CC53, and CC54 will be considered in subsequent submissions:

(1) So far, the understory vegetation was not considered in the estimation of the C stocks for CC52, CC53, and CC54. Accounting for understory vegetation will increase the estimated C stock of those categories.

(2) To convert tree crown coverage to carbon pool, the factor given by IPCC for settlements was applied. The accuracy of this factor is assumed to be low as it is only a Tier 1 default. More reliable estimates of this factor could significantly increase the accuracy of the estimation method.

The first point leads to an underestimation of C stocks in CC52, CC53, and CC54. In case of land-use changes, this underestimation influences the general carbon budget. In the land-use change tables, those categories show an increasing tendency (CC52 and CC53) or are more or less stable (CC54). This indicates that the inaccuracies of the present submission lead to a slight underestimation of the general sink effect in those categories.

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 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 7-7).

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 increase of available AREA activity data (see Chapter 7.2) led to a recalculation in the category 5F.

7.8.8 Category-Specific Planned Improvements

There are no planned improvements.

8 Waste

8.1 Overview

8.1.1 Greenhouse Gas Emissions

Within the waste sector, emissions from four source categories are considered:

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

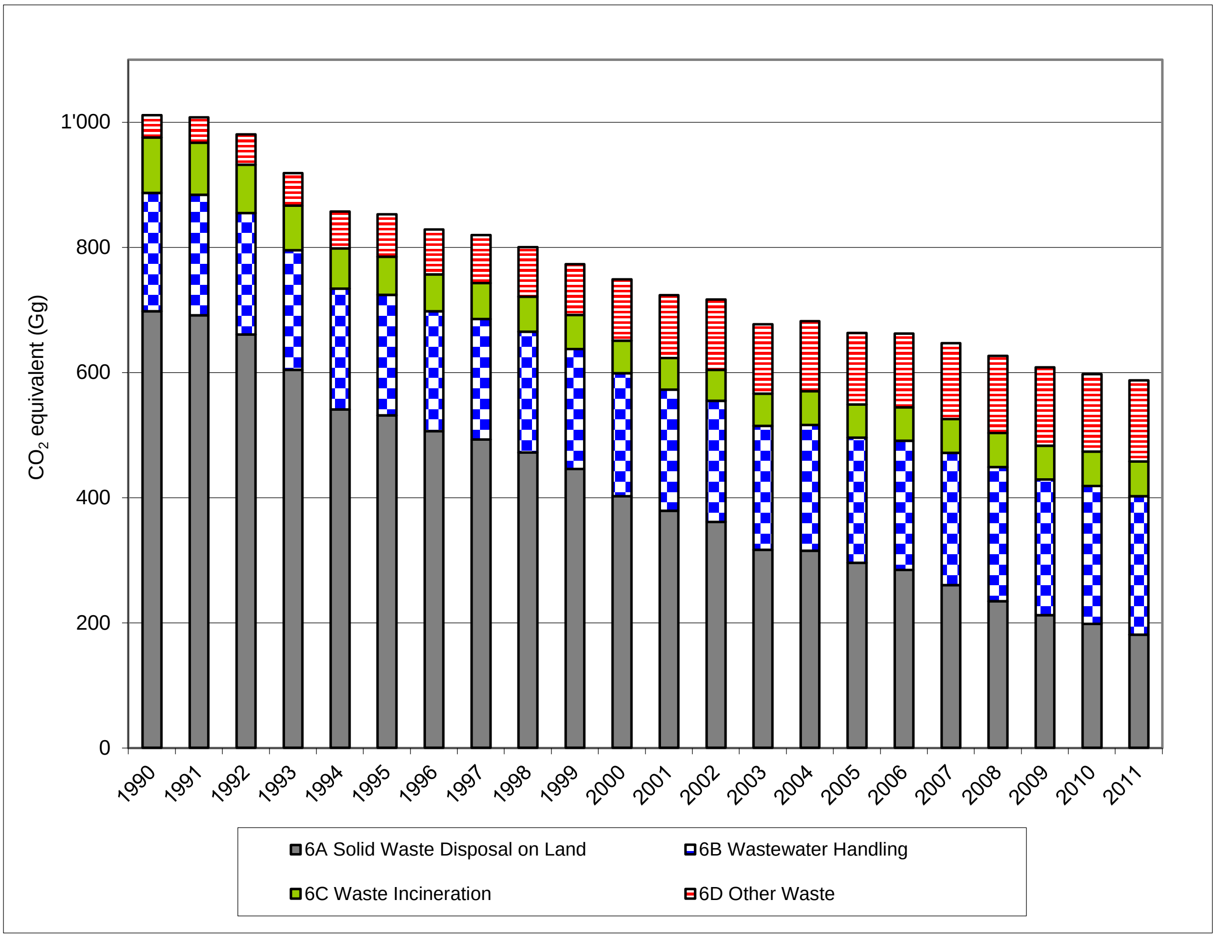

Figure 8-1 Switzerland’s greenhouse gas emissions in the waste sector 1990–2011.

Table 8-1 Trend of total GHG emissions from waste management in Switzerland 1990-2011.

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	737	734	709	657	604	604	582	572	554	531
N_2O	211	214	215	212	213	214	216	218	220	219
Sum	1011	1008	980	918	857	852	828	819	800	773

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	502	482	474	428	428	411	403	382	358	336
N_2O	227	226	229	236	242	241	246	252	256	260
Sum	748	723	716	677	682	663	662	646	626	608

Gas	2010	2011
	CO_2 eq (Gg)	
CO_2	13	12
CH_4	321	309
N_2O	264	265
Sum	597	587

As illustrated in Table 8-1, in the waste sector a total of 587 Gg CO_2 equivalents were emitted in the year 2011. 30.3% stem from category 6A Solid Waste Disposal on Land, 37.1% of the emissions stem from category 6B Wastewater Handling, 9.3% from 6C Waste Incineration and 21.7% from 6D Others.

The total greenhouse gas emissions in the waste sector show a decrease of 41.9% from 1990 until 2011. From 1990 – 2007, the greenhouse gas emissions were clearly dominated by the ones from the source category 6A Solid Waste Disposal on Land. In 2009, emissions of 6A Solid Waste Disposal on Land and 6B Wastewater Handling have become equivalent. Since then, 6B Wastewater Handling is the most important source category.

CH_4 is still the most important greenhouse gas in the waste sector. Emissions have however decreased from 1990 until 2011 by 58.0%. The second most important greenhouse gas in the waste sector is N_2O. N_2O emissions have increased by 26.0% from 1990 until 2011. CO_2 is of minor importance in the waste sector. CO_2 emissions remained rather constant since 2003 at a low level of about 12Gg. Since 1990 they were 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 Energy sector. Therefore the largest share of waste-related emissions in Switzerland is not reported under category 6 Waste, as the box below shows.

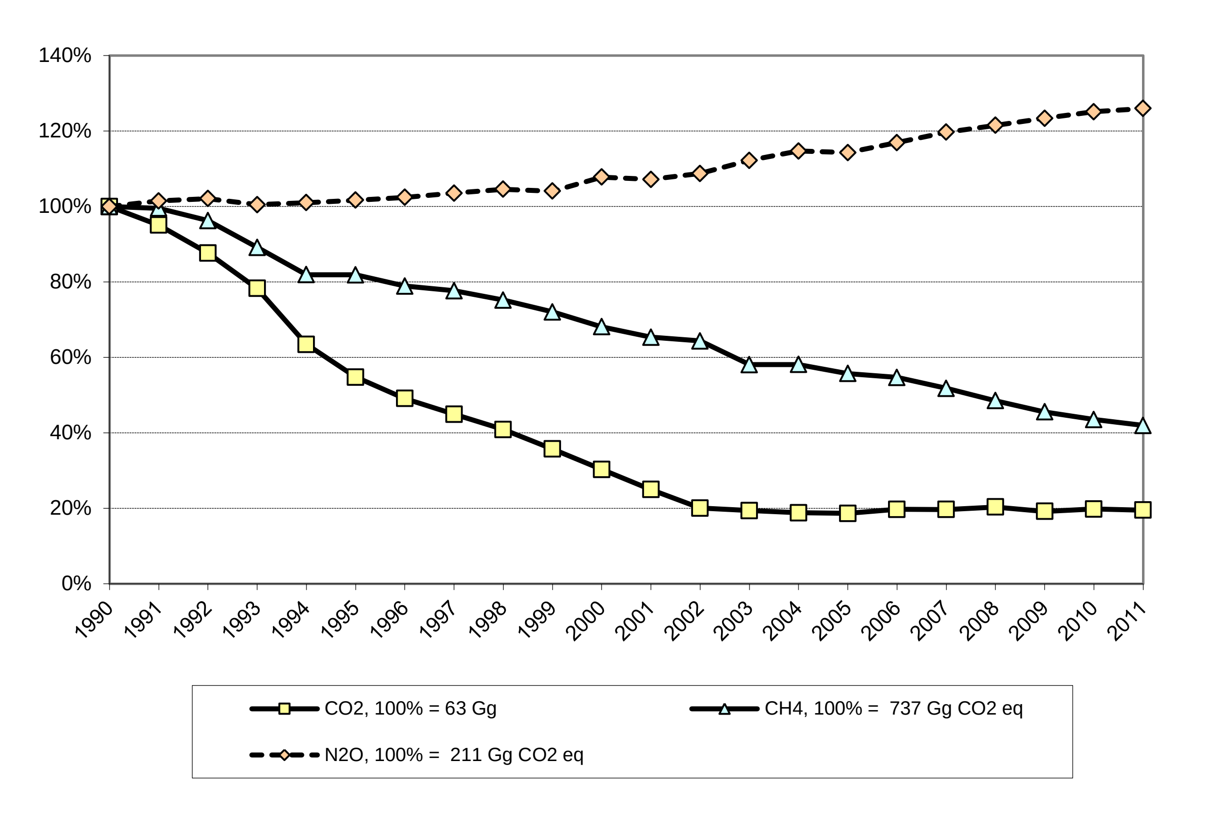

Figure 8-2 Trend of total GHG emissions from waste management in Switzerland 1990-2011.

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.

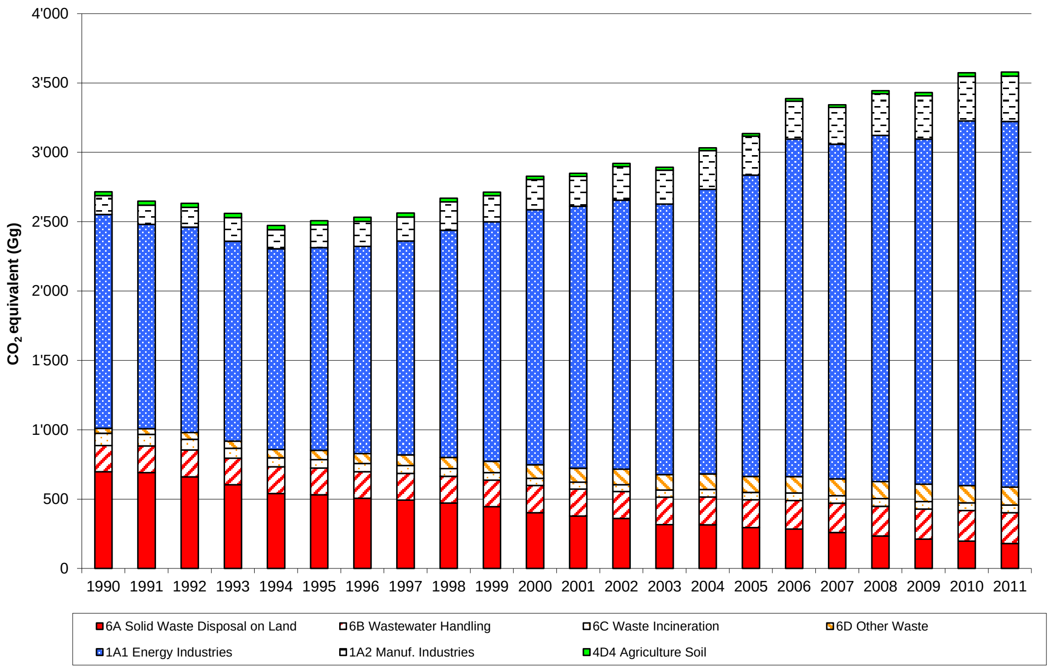

Figure 8-3 Waste related GHG emissions from 1990-2011.

8.1.2 Overview on Waste Management in Switzerland

The goals and principles regarding waste management in Switzerland are stated in the Guidelines on Swiss Waste Management (BUS 1986) and in the Waste Concept for Switzerland (SAEFL 1992). The four principles are:

1. The generation of waste shall be avoided as far as possible.
2. Pollutants from manufacturing processes and in products shall be reduced as far as possible.
3. Waste shall be recycled wherever this is environmentally beneficial and economically feasible.
4. Waste shall be treated in an environmentally sound way. In the long term only materials of final storage quality shall be disposed of in landfills.

Figure 8-4 gives a general overview on waste management and waste flow in Switzerland in 2011.

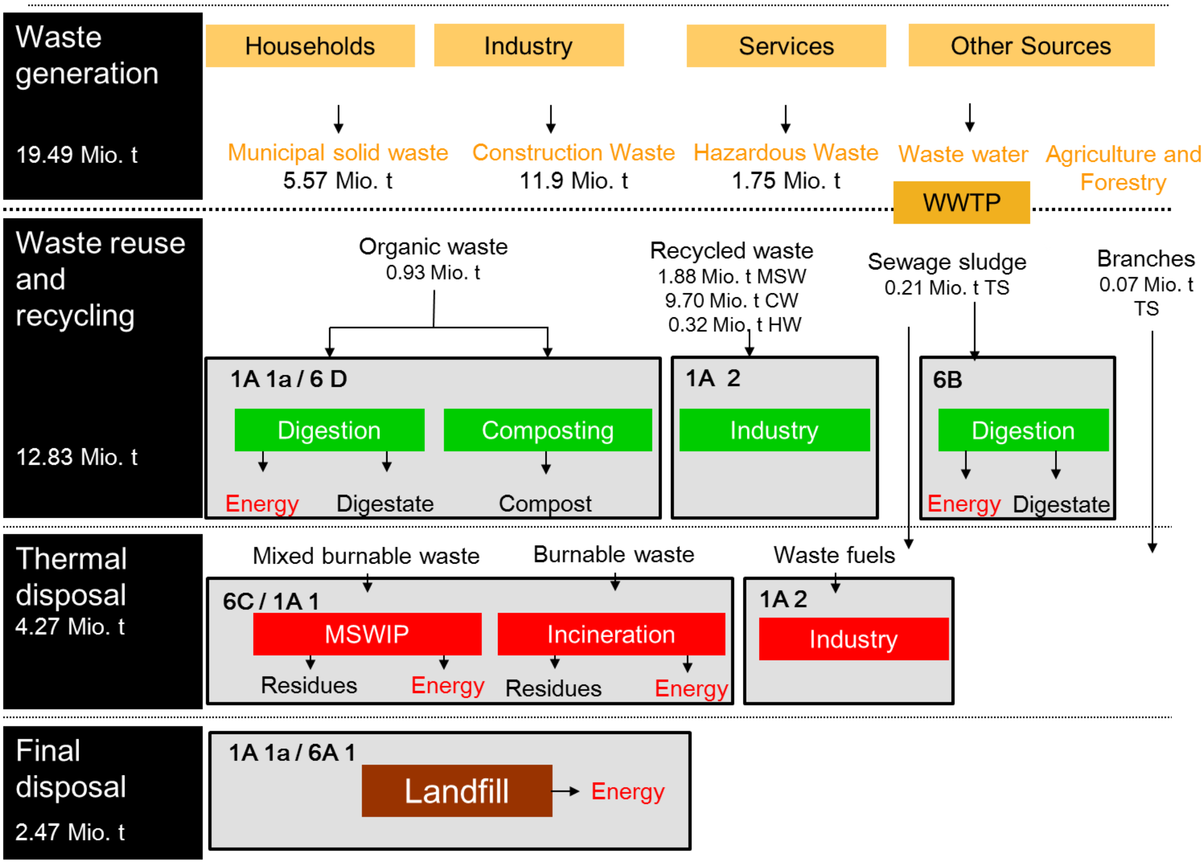

Figure 8-4 General overview on waste flow and waste management in Switzerland in 2010[15]
WWTP: Waste water treatment plant
MSWIP: Municipal solid waste incineration plant
MSW: Municipal solid waste
CW: Construction waste
HW: Hazardous waste

Figure 8-4 shows that only a few processes related to the waste management system are actually reported under the chapter waste. If waste is used as an alternative fuel or used for

[15] The data refer to the year 2010. Source: FOEN 2011c.

energy production, it is considered in the chapter 1A1 “Energy Industries”. Recycled waste, e.g. waste which is used as a resource entering a closed life cycle, is reported under 1A2 "Manufacturing Industries and Construction".

Please note, that the quantities in Figure 8-4 are indicative. For the calculation of greenhouse gas emissions for the present inventory, other activity data are used that consider imports and exports. A more detailed description of the treatment facilities is provided in the respective chapters [16]. As there is no data available for the waste quantities in Switzerland for the year 2011, it is assumed that numbers have not changed since 2010 and numbers reported in (FOEN 2011c) will be used.

Figure 8-4 shows that of the approx. 5'600 Gg of municipal solid waste (MSW) generated in 2011, 2'800 Gg or 50% were recycled. The main recycled waste types were paper/cardboard (1’300 Gg), organic waste (930 Gg treated in centralized composting and digestion plants, without backyard composting), and used glass (350 Gg) (FOEN 2011c). The part of MSW that was not recycled was mainly incinerated (2'800 Gg or 50%). The amount of MSW landfilled dropped down to zero (EMIS 2013/1A1a & 6 A1 Kehrichtdeponien).

It is assumed that the same quantities as in 2009, e.g. about 11'900 Gg construction waste (FOEN 2010j), was generated in Switzerland in 2011. From this quantity about 9’700 Gg (82%) was recycled[17]. About half of the recycling took place at the construction site, e.g. by reusing material left after breaking up the road cover. The other half was separated at the construction site and recycled individually, e.g. used glass, used metals, used concrete etc. A minor amount, 387 Gg, of the construction waste was incinerated (internal numbers provided by the waste section of FOEN) and the remaining, inert waste materials, 1’700 Gg were disposed of in landfills for inert waste (SAEFL 2001).

About 1’745 Gg hazardous waste was generated in Switzerland in 2011. About 320 Gg hazardous waste was recycled, 633 Gg were incinerated, 173 Gg were biologically treated, 477 Gg landfilled and approximately 214 Gg were exported (FOEN 2012l).

70 Gg are branches, e.g. residues from agriculture and forestry that that are used for heat recovery (EMIS 2013/6C1 Abfallverbrennung in der Land- und Forstwirtschaft).

About 210 Gg (dry matter) sewage sludge was generated in 2010 (FOEN 2011c). Since 2006 it is forbidden to use sewage sludge as a fertilizer in agriculture due to the content of organic contaminants. In 2011 100% of sewage sludge was incinerated (in municipal solid waste incineration plants and mono incineration plants).

Imports are not considered in Figure 8-4. Imports of burnable waste stem in the first place from neighbouring countries (Germany, France, Austria and Italy).The imported municipal solid waste is burned in municipal solid waste incineration plants. The import of waste into Switzerland requires a license from the Federal Office for the Environment. A company that wishes to import waste must demonstrate that a waste incinerator plant in Switzerland receives and burns the waste. The import of waste for final disposal in a landfill is in principle not permitted, except in the case of waste imported in terms of a contract on regional transboundary cooperation or of slag from the incineration of previously exported municipal solid waste.

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[16] Detailed data about the Swiss waste management sector can be found on the FOEN web-site (http://www.bafu.admin.ch/abfall/01517/01519/11645/index.html?lang=de).

[17] The latest available data for the shares of different types of treatments for construction waste on this general level refer to the year 2000 and are derived from a model, not from actual survey data (SAEFL 2001). Shares in the year 2010 are assumed to be the same as in the year 2000.

Table 8-2 Reporting of greenhouse gas emissions from waste management activities in present inventory.

Source	Waste Management Activity
1A1a Public Electricity/Heat	Co-generation of landfill gas Co-generation of biogas from fermentation Municipal solid waste incineration Special waste incineration
1A2d Pulp, Paper and Print	Waste derived fuel in paper industry and cellulose production
1A2f Other	Waste derived fuel in cement industry
4D4 Other	Sewage sludge and compost used as fertilizer
6A Solid Waste Disposal on Land	Waste disposal
6B Waste Water Handling	Waste water treatment
6C Waste Incineration	Waste incineration
6D Other Waste	Composting and digesting of organic waste, car shredding

8.2 Source Category 6A – Solid Waste Disposal on Land

8.2.1 Source Category Description

Key category 6A
CH_4 emissions from managed waste disposal on land (level and trend)

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

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

In Switzerland, in 2011 seven managed biogenic active landfills are equipped to recover landfill gas (SFOE 2012). The landfill gas is generally used in co-generation plants in order to produce electricity and heat. Some landfill gas is used to generate heat only. A very small portion of the landfill gas is flared.

Table 8-3 Specification of source category 6A “Solid Waste Disposal on Land”.

6A	Source	Specification	Data Source
6A1	Managed Waste Disposal on Land	Emissions from managed solid waste landfill sites.	EMIS 2013/1A1a & 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 occurring 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, $x \le t$
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. (see EMIS 2013/1A1a & 6A1 Kehrichtdeponien).

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 (see EMIS 2013/1A1a & 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]	DOC [-]
municipal solid waste	0.139	0.050	1990-1992: 0.15 1993-2002: linear interpolation 2003-2010: 0.12
construction waste	0.046	0.08	0.20
sewage sludge	0.069	0.068	0.17

ii) In a second step, the amount of CH_4 that is recovered and used as fuel for co-generation units as well as for flaring is subtracted from the CH_4 generated in landfills (resulting from step 1).

CH_4 emissions $_{\text{step ii)}}$ = CH_4 emissions $_{\text{step i)}}$ – (CH_4 emissions $_{\text{step i)}}$ * Fl(t)) – Qco-gen(t)

where

Fl(t) = portion of generated methane that is flared in the present year (fraction)

Qco-gen(t) = CH_4 which is recovered in co-generation units in the present (Gg)

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

CH_4 emissions $_{\text{step iii)}}$ = CH_4 emissions $_{\text{step ii)}}$ + 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 2013/1A1a & 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 2011.

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 2013/1A1a & 6A1 Kehrichtdeponien.

Table 8-6 Activity data in 6A1: Waste disposed of on Managed Landfill Sites from 1990 to 2011 (source EMIS 2013/1A1a & 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
6A1 Managed Waste Disposal on Land			
Municipal solid waste (MSW)	Gg	0.0	0.0
Construction waste	Gg	0.0	0.0
Sewage sludge	Gg (dry)	0.0	0.0
Open burned waste	Gg	0.0	0.0
Total waste quantity	Gg	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 – 2011.

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 2011 (source EMIS 2013/1A1a & 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
6A1 Managed Waste Disposal on Land			
CH_4 direct emissions	Gg	9.4	8.6
CH_4 flared	Gg	1.2	1.0
CH_4 used in co-generation units (reported under 1A1a)	Gg	1.0	0.7

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 2010 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 2013/1A1a & 6A1 Kehrichtdeponien).

For CO_2 a medium confidence of 10% in emissions estimates is assumed 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

In addition to the general QA/QC measures described in Chapter 1.6 subsequent source-specific activities have been carried out:

- Cross check of activity data (waste quantities disposed of on landfills) used in the FOD model, stated in the EMIS database and the primary source (FOEN 2011c).
- Verification of country specific degradable organic carbon DOC(x) calculations for municipal solid waste, construction waste and sewage sludge.

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 2011 are compared with the results 2010 within the current CRF
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

8.2.5 Source-Specific Recalculations

For the years 2008-2010 “population at year-end” instead of “average population” has been used for Swiss average population. This has been corrected. Values of activity data have slightly changed.

8.2.6 Source-Specific Planned Improvements

There are no source-specific planned improvements in this category.

8.3 Source Category 6B – Wastewater Handling

8.3.1 Source Category Description

Key category 6B
N_2O emissions from waste water handling (Tier 1 and 2 levels).

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 wastewater (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 about 22 Industrial wastewater pre-treatment plants (see EMIS 2013/ 6B1 industrielle Abwässer).

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). The pre-treated effluents from industries are also handled for final treatment in these waste water treatment plants. Switzerland's wastewater management infrastructure - comprising some 900 sewage plants and 40’000-50’000 km of public sewers - is now practically complete (FOEN 2011g). Municipal Wastewater treatment plants are treating wastewater from single cities or from several cities or municipalities together. Waste water in general is treated in three steps: 1. Mechanical treatment, 2. Biological treatment, and 3. Chemical treatment. Most of the MWWTP are using biogas as power and heat supply for their process.The treated waste water flows into a receiving system (lake, river or stream).

Table 8-8 Specification of source category 6B “Wastewater Handling”.

6B	Source	Specification	Data Source
6B1	Industrial Waste Water	Emissions from handling of liquid wastes and sludge from industrial processes.	AD: EMIS 2013/6B1 Kläranlagen Industriell and SFOE 2012 EF: EMIS 2013/6B1 Kläranlagen Industriell
6B2	Domestic and Commercial Waste Water	Emissions from liquid waste handling and sludge from housing and commercial sources	AD: EMIS 2013/6B2 Kläranlagen Kommunal and SFOE 2012 EF: EMIS 2013/6B2 Kläranlagen Kommunal
6B3	Others	Not occurring in Switzerland	

The emissions related to wastewater treatment are included in various categories as illustrated in Figure 8-5 below. The system boundaries of category 6B contain all emissions from direct wastewater handling. Emissions associated with sewage sludge drying are assumed to be negligible. For reasons of completeness these are nonetheless mentioned in Figure 8-5. No emissions from sewage sludge use or disposal occur. 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.

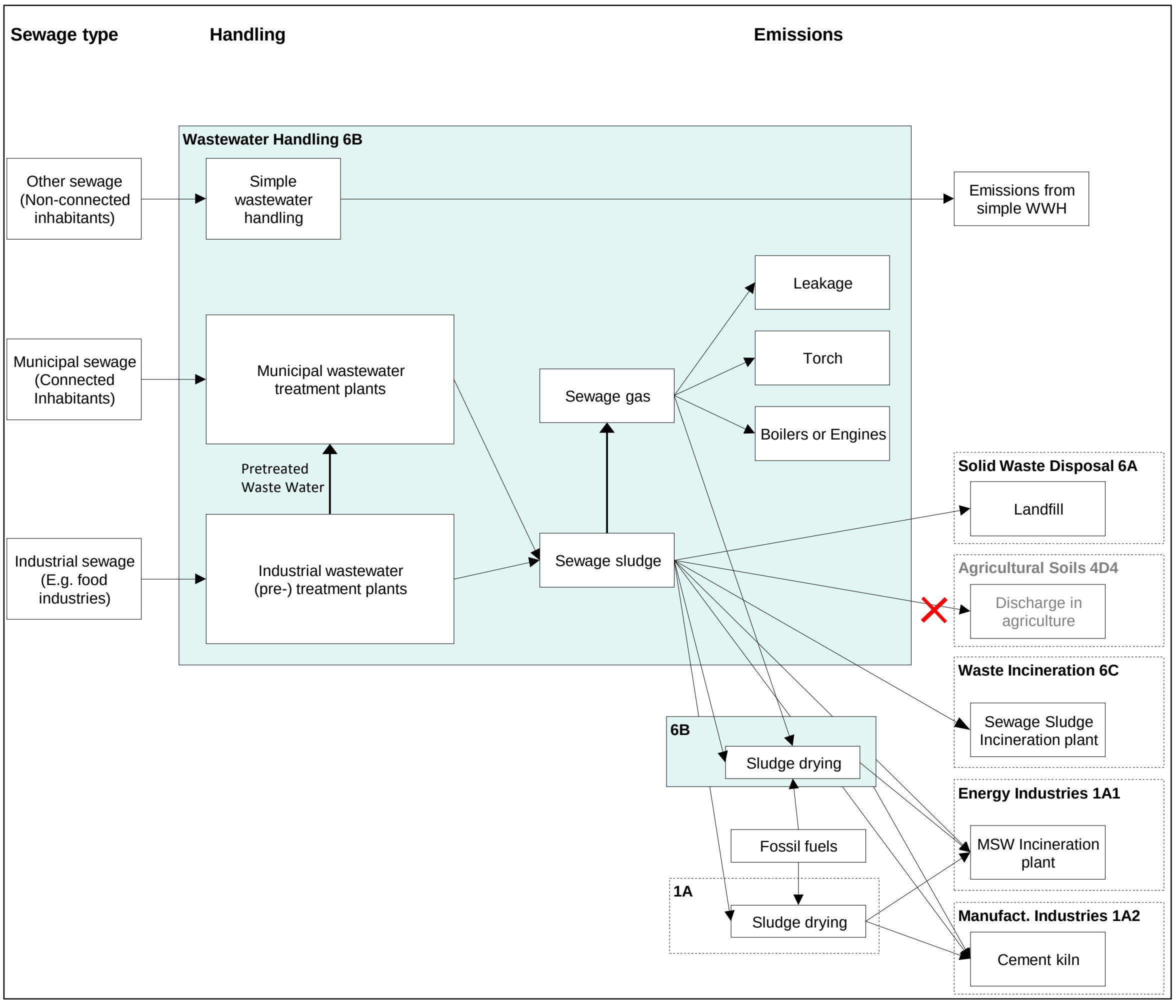

Figure 8-5 System boundaries of emissions related to wastewater treatment.

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 as well, with the exception of N_2O. The N_2O emissions are calculated based on 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 2013/6B1 Industrielle Abwässer and EMIS 2013/6B2 Kommunale Kläranlagen. Emission factors are adapted on a yearly basis due to respective changes in the fraction of inhabitants connected to waste water treatment plants. All emission factors have been converted and standardized for all emissions into g/inhabitants.

EF for N_2O is derived based on the IPCC-default method (see EMIS 2013 6B2 Kläranlage kommunal. According to the Swiss Farmer's Union, total protein consumption in Switzerland raised from 236 t in 1990 to 271 t in 2010 (SBV 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 86 g N_2O per inhabitant results for the year 2011. N2O-emissions are thus only an approximation. Expert interviews reveal that currently there is no better data or more accurate values available for Switzerland[18]. 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. Although the emission factor for CH_4 in kg/ TJ has not changed since 2007, rather brusque 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 14.92 to 25.80 GWh, SFOE 2012) thus the increase in emissions are mostly related to sewage gas upgrading.

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 2011.

Source	CO_2 biog.	N_2O	CH_4	NO_x	CO	NMVOC	SO_2
	kg/inhabitant	g/inhabitant	g/inhabitant				
6B1 Industrial Waste Water	2.2	NO	5.5	2.4	3.5	0.07	0.22
6B2 Municipal Waste Water	14.9	86	55	24	42	0.5	3

Please note that 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 2013/6B1 Industrielle Abwässer).

18 Telephone interview Denise Fussen with Pascal Wunderlin, PhD EAWAG, 11.09.2012

In 2011 96.9 % of the domestic waste water is being treated in waste water treatment plants. Emissions from wastewater 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) 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. 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 2013/6B2 Kläranlage kommunal from SFOE 2011. 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	96.8
connected inhabitants	inhabitants in 1000	6'877	6'972	7'049	7'131	7'201	7'253	7'309	7'368	7'457	7'551

Source/Parameter	Unit	2010	2011
6B2 Domestic and Commercial Waste Water			
Population	inhabitants in 1000	7'878	7'912
Fraction connected to waste water treatment plants	%	96.8	97.0
connected inhabitants	inhabitants in 1000	7'626	7'675

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 2013/6B1 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

In addition to the general QA/QC measures described in Section 1.6 subsequent source-specific activities have been carried out:

- Verification of CH4 emission factor
- Check of greenhouse gas emission calculations for 2011.

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 2011 are compared with the results 2010 within the current CRF
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

8.3.5 Source-Specific Recalculations

For the years 2008-2010 “population at year-end” instead of “average population” has been used for Swiss average population. This has been corrected. Values of activity data have slightly changed.

N_2O emission are calculated using year-specific values for protein consumption according to the numbers provided by the Swiss Farmer’s Union (SBV 2012). N_2O emission for the year 2010 were recalculated due to an update of total protein consumption by the Swiss Farmer's Union (SBV 2012) from 268 kt to 271 kt.

Losses of sewage gas treatment (upgrade) of CO_2 biogen and CH_4 have been overestimated in past submissions (100% instead of 5% of treated gas) and have been corrected. Recalculations were made for the years 2005-2010.

Emission factors of sewage gas combustion “Verbrauch Klärgas -Feuerungen” have been recalculated for the years 2000-2010 (SFOE 2012). This results in changes of emission factors in the EMIS database for CO_2 biog., CH_4, NOx, CO, NMVOC, SO_2, N_2O. Recalculations were made for both years.

AD of sewage gas treatment has changed for the years 2008 and 2009, according to SFOE 2012. This results in changed EF for CH_4 and recalculations of CH_4 emissions for both years.

8.3.6 Source-Specific Planned Improvements

There are no source-specific planned improvements in this category.

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 been reported in category 4F. 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. Accordingly the source category has been moved to 6C1 and is now reported under waste incineration as "Burning of residues in agriculture and forerstry".The following sources are included in source category 6C:

Table 8-11 Overview on waste incineration sources reported under 6C.

Waste incineration	Specification	Data Source
Hospital waste incineration	Emissions from incinerating hospital waste in hospital incinerators	AD, EF: EMIS 2013/6C2 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 2013/6C2 Abfallverbrennung illegal
Insulation material from cables	Emissions from incinerating cable insulation materials	AD, EF: EMIS 2013/6C2 Kabelabbrand
Sewage sludge	Emissions from sewage sludge incineration plants	AD, EF: EMIS 2013/6C2 Klärschlamm-Verbrennung
Crematoria	Emissions from the burning of bodies in crematoria	AD, EF: EMIS 2013/6C Krematorien
Burning of residues in agriculture and forestry	Emissions from burning of agricultural and silvicultural waste	AD, EF: EMIS 2013/6C1 Abfallverbrennung in der Land- und Forstwirtschaft

The following table gives an overview on other waste incineration activities in Switzerland and the respective source category, where the GHG emissions are reported in the national inventory.

Table 8-12 Overview of other waste incineration activities in Switzerland, and indication of source categories where the waste incineration activity is reported in the national inventory.

Waste incineration	Specification	Source category
Paper and pulp industries	Emissions from incineration of residues and sludge from industrial waste water treatment plants as fuel for paper/pulp production	1A2d Biomass
Municipal solid waste incineration plants	Emissions from waste incineration in municipal solid waste incineration plants	1A1a Other
Waste in cement plants	Emissions from waste used as alternative fuels in cement kilns	1A2f Other
Special waste	Emissions from incinerating industrial and hazardous waste	1A1a Other

8.4.2 Methodological Issues

Methodology

For the calculation of the greenhouse gas emissions a country specific Tier 2 method is used. In general, the GHG emissions are calculated by multiplying the waste quantity incinerated by emission factors. For crematoria, the GHG emissions are calculated by multiplying the number of cremations by emission factors.

For sewage sludge incineration plants the respective waste quantities are based on reliable statistical data and the emission factors take into account different flue gas cleaning standards.

For hospital waste incineration, illegal waste incineration and incineration of insulation material, the waste quantities used are based on rough expert estimates.

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 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 2013/6C database. The emission factors of burning of residues in agriculture and forestry are taken from EMEP/CORINAIR (EEA 2007). See also EMIS 2013/6C1 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 8-13 Emission Factors for 6C "Waste Incineration" in 2011 (source EMIS 2013/6C, 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	0.07	800	0.7	0.15	0.0038	0.29
Burning of residues in agriculture and forestry	NA	6.8	180	3.6	104.0	9.5	0.70
	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	0.17	0.014	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).
- 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.
- Insulation materials: The CO_2 emission factor is based on measurements of the flue gas quantity and the assumption, that the ratio CO_2/O_2 is the same as in municipal solid waste incineration plants.
- Sewage sludge plants: Sewage sludge is biodegradable waste. Emission factor for CO_2 is 0. 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. The emission factors of 2010 were calculated by linearly interpolating estimations for 2008 and 2020 respectively (see EMIS 2013 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 (see EMIS 2013 6C Krematorien).

Activity Data

The activity data for Waste Incineration (6C) are the quantities of waste incinerated.

Table 8-14 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 residues in agriculture and forestry	Gg	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
Total	Gg	196.8	189.1	181.2	172.8	163.2	163.9	166.0	166.7	167.4	166.4
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	94.7	96.6	98.6
Burning of residues in agriculture and forestry	Gg	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
Total	Gg	164.2	166.8	169.8	179.4	189.3	186.6	185.3	186.8	189.0	189.3
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
Hospital Waste Incineration	Gg	0.0	0.0
Illegal waste	Gg	21.0	20.3
Insulation material cables	Gg	0.0	0.0
Sewage sludge	Gg dry	100.5	102.5
Burning of residues in agriculture and forestry	Gg	70.0	70.0
Total	Gg	191.5	192.8
Cremations	Numb.	51'869	52'530

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

8.4.3 Uncertainties and Time-Series Consistency

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

A preliminary uncertainty assessment based on expert judgment results in 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. All activity data, implied emission factors and emissions undergo the triple check:

- the results for 2011 are compared with the results 2010 within the current CRF
- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

8.4.5 Source-Specific Recalculations

The Process “Field burning of agricultural wastes“ has been moved and from 4F to 6C1 (Waste incineration) in accordance to the EMEP guidebook 2009 (EEA 2010) and renamed into “Burning of residues in agriculture and forerstry”. Recalculations were made for the whole time series 1990-2010.

Activity data for "Cremations" in the year 2010 has been corrected according to updated data by the swiss crematory association.

8.4.6 Source-Specific Planned Improvements

No source specific planned improvements.

8.5 Source Category 6D – Other Waste

8.5.1 Source Category Description

Key category 6D
CH_4 from composting and digesting organic waste (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 2013 6D Kompostierung Industrie).

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 generated during the fermentation is used as fuel in co-generation plants or upgraded and used as fuel for cars. 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 from the biogas use in co-generation plants and as fuel for transportation are reported under the energy sector.

Table 8-15 Specification of source category 6D “Other Waste”.

6	Source	Specification	Data Source
6D	Car shredding plants	Emissions from car shredding plants	AD, EF: EMIS 2013/6D Shredder Anlagen
6D	Composting and digesting	Process related emissions from composting and digesting organic waste	AD, EF: EMIS 2013/6D Kompostierung Industrie, EMIS 2013/1A1a und 6D Vergärung IG und EMIS 2013/1A1a 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 the same constant emission factors have been applied. In addition, the methane emissions from biogas up-grading are calculated by multiplying the biogas quantity up-graded 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 2013/6D database.

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

Table 8-16 Emission Factors for 6D Others in 2011.

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	97	12			70	
Fermentation (industrial, losses)	g/t biogas losses	426'903					
Fermentation (industrial, power water)	g/t fermented waste (liquid)	1'948	2			400	
Fermentation (industrial, rotting)	g/t fermented waste (solid)	1'071	98			230	
Fermentation (industrial, flaring)	g/t CH4	44		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	1'100					

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. (See also EMIS 2013/1A1a und 6D Vergärung IG und EMIS 2013/1A1a und 6D Vergärung LW)

The NMVOC emissions from car shredding stem from residues of fuels in the tanks of shredded cars (EMIS 2013/6D Shredder). For emission factors of NMVOC constant values are used since 2005 (see EMIS 2013/6D Shredder Anlagen).

It is assumed that CH_4 emissions of biogas–upgrading, which occur due to leakage, can be reduced from 5 % of the total biogas production (value for 1990 – 2007) to 2.5% in the year 2020/2035 due to technical improvements. In between, the EF factor has been linearly interpolated.

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 2013/6D Shredder Anlagen and Kompostierung Industrie. Activity data of fermentation are extracted from EMIS 2013/1A1a und 6D Vergärung IG und EMIS 2013/1A1a 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 (see EMIS 2013/1A1a und 6D Vergärung IG und EMIS 2013/1A1a 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 8-17 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	51
Fermentation (ind., losses, biogas)	Gg	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.04	0.05	0.06
Fermentation (ind., power water, fermented waste liquid)	Gg	0	0	5	5	10	15	15	18	22	28
Fermentation (ind., rotting, fermented waste solid)	Gg	0	0	3	3	6	9	9	11	14	17
Fermentation (ind., flaring, CH4)	Gg	0.00	0.00	0.01	0.01	0.02	0.03	0.05	0.06	0.08	0.09
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	759	779
Fermentation (ind., storage, fermentable waste)	Gg	66	79	94	91	111	133	160	189	216	266
Fermentation (ind., losses, biogas)	Gg	0.08	0.09	0.11	0.11	0.13	0.16	0.19	0.22	0.24	0.30
Fermentation (ind., power water, fermented waste liquid)	Gg	37	44	52	51	62	74	89	106	120	148
Fermentation (ind., rotting, fermented waste solid)	Gg	22	27	32	31	38	45	55	65	74	91
Fermentation (ind., flaring, CH4)	Gg	0.11	0.13	0.17	0.16	0.19	0.23	0.28	0.33	0.38	0.47
Fermentation (agr., losses, biogas)	Gg	0.28	0.31	0.34	0.38	0.45	0.60	0.78	0.98	0.89	0.67
Fermentation (agr., rotting, fermented waste solid)	Gg	6	6	7	8	9	12	18	27	32	33
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
Shredding	Gg	300	300
Composting	Gg	799	819
Fermentation (ind., storage, fermentable waste)	Gg	291	354
Fermentation (ind., losses, biogas)	Gg	0.32	0.39
Fermentation (ind., power water, fermented waste liquid)	Gg	162	197
Fermentation (ind., rotting, fermented waste solid)	Gg	99	121
Fermentation (ind., flaring, CH4)	Gg	0.51	0.62
Fermentation (agr., losses, biogas)	Gg	0.42	0.44
Fermentation (agr., rotting, fermented waste solid)	Gg	33	35
Fermentation (agr., flaring, CH4)	Gg	0.09	0.09
Biogas up-grade	GJ	124'295	172'042

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

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 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 2011 are compared with the results 2010 within the current CRF

- the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 2012
- the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012

8.5.5 Source-Specific Recalculations

In last year's submission wrong emission factors of CH_4 and CO_2 have been used for the fermentation process (subprocess biogas losses) due to an unit error. Recalculations were made for the whole time series 1990-2010.

In last year's submission activity data of subprocesses "Vergärung IG, P3 Presswasser" and "Vergärung IG, P4 Nachrotte" have been switched. This has been corrected. See also" EMIS 2013 1 A 1 a und 6 D_Vergärung IG . Recalculations were made for the whole time series 1990-2010.

Activity data of processes "Vergärung LW, P2 Biogasverluste" and "Vergärung LW, P4 Nachrotte" have slightly changed due to error in interpolation in calculation file (EMIS 2013 1 A1a und 6D_Vergärung LW). Recalculations were made for the whole time series 1990-2010.

Values of activity data for methane losses (biogas upgrading) have slightly changed during the whole time series due to calculation with non-rounded values. This led to recalculations for the whole time series 1990-2010.

EF for 2010 has been missing, which resulted in an emission calculation with an interpolated value. Recalculations were made for the year 2010 with the correct value provided by SFOE 2012.

8.5.6 Source-Specific Planned Improvements

There are no source-specific planned improvements.

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

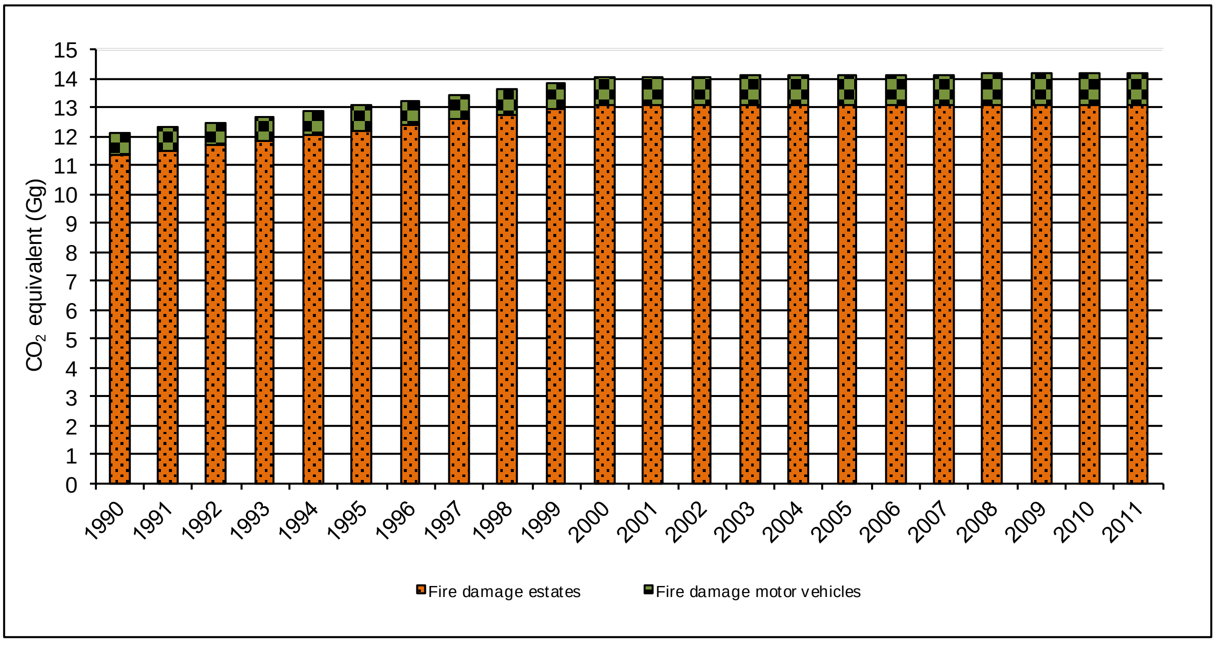

Figure 9-1 Switzerland’s greenhouse gas emissions in the sector 7 “Other” 1990–2011.

Table 9-1 Trend of total GHG emissions from 7 “Other” in Switzerland 1990-2011.

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	13.0	13.0	13.0	13.0	13.0
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	14.2	14.2	14.2	14.2

Gas	2010	2011
	CO_2 eq. (Gg)	
CO_2	13.0	13.0
CH_4	0.6	0.6
N_2O	0.6	0.6
Sum	14.2	14.2

In the sector “Other” a total of 14.2 Gg CO_2 equivalents was emitted in the year 2011. 92% 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 17% from 1990 until 2011.

9.2 Source Category – Other non-specified

9.2.1 Source Category Description

Tier 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 non-specified”

7	Source	Specification	Data Source
7 D	Fire damage estates	Emissions from fires in buildings.	EMIS 2013/7D “Brand- und Feuerschäden Immobilien”
7 D	Fire damage motor vehicles	Emissions from fires and fire damage in motor vehicles.	EMIS 2013/7D “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 2013/7D “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 1990-2011. Multiplied with the actual vehicle number, the number of burnt vehicles in Switzerland per year is obtained (EMIS 2013/7D “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 2013/7D “Brand- und Feuerschäden Immobilien”).

In this submission, emissions for CH_4 and N_2O are reported for the first time.

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 2013/7D “Brand- und Feuerschäden Motorfahrzeuge”.

Since last submission, 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 2011 (EMIS 2013/7D).

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 2013/7D “Brand- und Feuerschäden Immobilien”) and 100 kg of burnt goods per incidence of burnt vehicles (EMIS 2013/7D “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 2011 (source EMIS 2013/7D).

Source / Parameter	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
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
Fire damage motor vehicles	Gg	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6

Source / Parameter	**Unit**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
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
Fire damage motor vehicles	Gg	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7

Source / Parameter	**Unit**	**2010**	**2011**
7 Burnt goods			
Fire damage estates	Gg	8.0	8.0
Fire damage motor vehicles	Gg	0.7	0.7

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 1-13).

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 2011 are compared with the results 2010 within the current CRF
    - the CRF tables for the year 2010 are compared between the current CRF tables and the CRF tables of submission 20112.
    - the CRF tables for the base year 1990 are compared between the current CRF tables and the CRF tables of submission 2012.

9.2.5 Source-Specific Recalculations

No source-specific recalculations.

9.2.6 Source-Specific Planned Improvements

There are no source-specific planned improvements in this category.

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10 Recalculations

10.1 Explanations and Justifications for Recalculation

10.1.1 GHG Inventory

The Inventory Development Plan (IDP, see in FOEN 2013a) 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) 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: The activity data of all fuels of the overall time series have been recalculated based on the new data from SFOE 2012.
- 1A: The activity data of wood consumption have been recalculated for the overall time series based on the new data from SFOE 2012b.
- 1A: Activity data of sewage gas out of purification plants has changed between 2000 and 2007.
- 1A: The emissions factor of bituminous coal has changed because it was weighted with P-Coke before.
- 1A1: Activity data for municipal waste incineration for 2009 and 2010 have been recalculated based on new measurements of the net calorifc values.
- 1A1/6D: Emission factor of CH_4 in category Biogas has been corrected for the entire time series to 6g/GJ. In the previous submission, is was 6'000g/GJ due to an error in the unit conversion.
- 1A1: Activity data of 1A1a Boiler has been recalculated for the overall time series in order to correctly account for losses in gas distribution as reported under 1B2b. So far, the gas reported as fugitive emissions was also reported under 1A1a Boiler, i.e. there was a double-counting.
- 1A2: The activity data of LFO and LPG have been recalculated for the periods 1995 - 2010, respectively 2007 and 2010 based on changes in the energy consumption of Liechtenstein.
- 1A2: A new study of Prognos (2012) led to recalculations of the whole time series of the activity data of the industry energy consumption. While the total energy consumption in Switzerland remains unchanged, the allocation to the different subcategories has changed due to the new study. This concerns particularly sector 1A2 and 1A4a.
- 1A2: A new study of Prognos (2012) led to recalculations of the actvitiy data for LFO and LPG and permitted to eliminate the weighted emission factor of LFO and LPG. Now, the two fuels are listed separately.

- 1A2: The emission factor of the cellulose burning has been adapted.
- 1A2: Activity data has been corrected for wood waste consumtion over the whole time series in order to eliminate double counting in chipboard-fibreboard and cement production.
- 1A2: Activity data in brick and tile production has been corrected for wood consumption for 2000 - 2010.
- 1A2: Activity data and emission factor of coal consumption of the iron and steel industry has been recalculated for the whole time series based on the elimination of the former split into anthracite and petroleum coke. Now the entire coal consumption is attributed to anthracite.
- 1A2: Activity data and emission factors of the chipboard-fibreboard production has been recalculated for the whole time series based on the inclusion of the activity data of the second fibre board production plant. The emission factors have been adjusted.
- 1A2: Emission factors for all air polluants of industrial engines have been introduced for the whole time series.
- 1A2: Activity data and emission factors of the cement industry have been recalculated for the whole time series.. Emission factor for CO_2 of alternative fuels have been slightly adapted due to non-rounded values. Activity data has been adapted for 1990 - 2003 and 2007 - 2010 based on changes in the net calorific value of alternative fuels, respectively corrected data.
- 1A3a: an error in the number of occurrences of fuel dumping in the activity data for 2010 has been corrected (see Chapter 3.2.8.5).
- 1A3b: For diesel and gasoline, N_2O EF in g/km differentiated by vehicle category and technology from the Handbook of Emission Factors (INFRAS 2010) have been applied in this submission, in contrast to previous submissions that applied a constant value in g/TJ fuel consumption.
- 1A3b: the share of biogenic fuel use has been subtracted from the on-road activity data modelled with the handbook of emission factors (INFRAS 2010) in order to avoid double-counting, as the use of biogenic fuels is also separately accounted for. The entire time-series 1990-2010 has been recalculated (see Chapter 3.2.8.5).
- 1A3b: activity data on the use of biogenic fuels for the time-series 1997-2010 have been updated (see Chapter 3.2.8.5).
- 1A3b: A new EF for N_2O from gaseous fuels is used 1990-2010 in accordance with the default value provided in the IPCC Guidelines 2006 (IPCC 2006; see Chapter 3.2.8.5).
- 1A3e: Activity data from SFOE (2012) on fuel consumption of the gas pipeline compressor station in Ruswil for 1990-2010 have been updated (see Chapter 3.2.8.5).
- 1B2: The activity data of the oil distribution was recalculated for the whole time series based on a check of the energy file and the data from the fuel imports.
- 1B2: The emission factor of the oil distribution was recalculated for 2009 and 2010 due an error the CO_2 emission factor of NMVOC (oxidation). There where also small recalcutaions in the time serie of activity data.
- **Memo Item**: New activity data for Marine Bunker (Navigation international)

2 Industrial Processes

- 2A1: The cement industry association has provided updated EF values for geogenic CO_2 for 2009 and following years resulting in a slight increase in CO_2 emissions. See Chapter 4.2.5.
- 2A3: EF values of the geogenic CO2 from fine ceramics production have been revised for the years 1990-2000 and 2010. See Chapter 4.2.5.
- 2A6: EF values for NMVOC for the years 1991-2010 have been updated. See Chapter 4.2.5.
- 2A7: Cullet ratio in the glass wool production has been revised for the entire time series. See Chapter 4.2.5.
- 2B4: EF values for silicon carbide production have been revised due to corrected data from industry for the years 2008-2010. See Chapter 4.3.2.
- 2B5: The last year forgotten update of the EF values for 2010 of the ethylene production has been caught up. See Chapter 4.3.2.
- 2D1: Activity data of chipboard and fibreboard production have been revised. See Chapter 4.5.5.
- 2F: For the various recalculations in source category 2F see Chapter 4.7.5 Table 4-31.

3 Solvent and Other Product Use

- 3A-D: The carbon content fraction for calculating the indirect CO_2 emissions from decomposition of NMVOC in the atmosphere has been changed. See Chapter 5.2.5.
- 3A1 Paint Application in Construction: EF values for 1990 and 2010 have been updated. Activity data for 2010 has been updated. See Chapter 5.2.5.
- 3A1: Paint Applications in Households: The values for 2010 have been updated. See Chapter 5.2.5
- 3A2: Paint Application, others, industrial: The values for 2010 have been updated. See Chapter 5.2.5.
- 3A2: Paint Application car repair: EF values and activity data for 1995, 1998, 2001, 2004, 2007 and 2010 have been updated. See Chapter 5.2.5.
- 3A2: Paint Application, others, non-industrial: The values for 2010 have been updated. See Chapter 5.2.5.
- 3C Paint manufacturing: The values for 2010 have been updated. See Chapter 5.4.5.
- 3C Fine chemical production: Former so-called direct emissions have been converted into AD and EF time series. See Chapter 5.4.5.
- 3C Handling and storage of solvents: Former so-called direct emissions have been converted into AD and EF time series. See Chapter 5.4.5.
- 3C Pharmaceutical production: The values for 2011 have been updated. See Chapter 5.4.5.
- 3C Tanning: AD values for 2005, 2007, 2008 and 2011 have been updated. See Chapter 5.4.5.
- 3D1 and 3D3: EF values have been updated for N_2O emissions for the years 2004-2010. See Chapter 5.5.5.

- 3D5: AD and EF values of NMVOC have been updated for several source categories resulting in adjusted values for NMVOC emissions for the whole time series. See Chapter 5.5.5.

4 Agriculture

- 4A: Estimates for energy requirements of non-cattle animal populations have been revised based on a new dataset from the Swiss Farmers Union (Giuliani 2012). The years 1990-2010 are affected (see Chapter 6.2.5).
- 4A: A reassessment of the gross energy intake of horses, mules and asses has been undertaken based on recommendations from the annual review reports (UNFCCC 2011, UNFCCC 2012; see Chapter 6.2.5).
- 4B/4D: The share of manure excreted on pasture, range and paddock and the distribution of animal manure management systems has been recalculated due to new projections of the AGRAMMON model (see Chapters 6.3.5, 6.5.5).
- 4D: Crop parameters (crop and nitrogen yields, dry matter fractions) have been updated based on the Swiss fertilization guidance GruDAF (Flisch et al. 2009, see Chapter 6.5.5).
- 4D: The area of cultivated organic soils has been revised due to a recommendation during the 2011 review process (UNFCCC 2011, see Chapter 6.5.5).
- 4D: Input data from the Swiss ammonia model AGRAMMON has been updated to the most recent projections from October 2012. Recalculations concern mainly the years 2007-2010 but generally affect the whole time series (see Chapter 6.5.5).
- 4D: $Frac_{GASM}$ as reported in CRF table 4.Ds2 (the amount of nitrogen volatilized as NH_3 from housing, manure storage and manure application divided by the manure excreted in the stable) has been recalculated. The recalcualtion has no effects on overall emissions as $Frac_{GASM}$ is calculated retrospectively from the nitrogen flow model (see Chapter 6.5.5).
- 4D: The agricultural area used to estimate NH_3 volatilization from the plant canopy on agricultural lands has been revised based on consolidated data from the Swiss Federal Statistical Office (SFSO 2012, see Chapter 6.5.5).
- 4D: A general recalculation for the year 2010 has been carried out due to some updates of crop yield data from the Swiss Farmers Union (SBV 2012, see Chapter 6.5.5).
- 4D: New data on sewage sludge, compost and digestate (solid and liquid) provided by Kupper et al. (2013) have been used for fertilization (see Chapter 6.5.5).
- 4D: New interpolation of data for fertilization with urea. Changes of the amount of urea and related emissions are minimal (see Chapter 6.5.5).
- 4F: The process of field burning of agricultural waste has been moved to 6C (Waste incineration, Chapter 8.4) in accordance to the EMEP guidebook 2009 (EEA 2010).

5 Land Use, Land-Use change and Forestry

- 5: The increment of available AREA activity data (see Chapter 7.2.2.1, SFSO 2012) led to a recalculation in category 5 LULUCF.
- 5A1 and 5A2: The application of weighting factors 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)

- 5A: New values for gains and losses of living biomass and stocks of dead wood were used. They are based on a re-evaluation of former NFI data and the incorporation of NFI 4a data (Thürig and Herold 2012). A single-tree allometry for estimating gains and losses in biomass was introduced (instead of applying biomass expansion- and conversion factors).
- 5A: Yasso07-values for carbon stocks and annual net changes in the dead wood pool were reported as well as annual net changes in the LFH (litter) pool (Didion et al. 2012).
- 5A: Revised values for carbon stocks in mineral soils and in litter were reported based on Nussbaum et al. (2012).
- 5A: Annual net changes of carbon stocks in mineral soils were calculated with Yasso07 (Didion et al. 2012). In former submissions these values were assumed to be zero.
- 5B: Annual values of gains and losses in living biomass were reported instead of a constant value of zero.
- 5C: The carbons stocks in living biomass for CC35 and CC37 were adjusted to the currently used CC31 values.
- 5C: The mineral soil organic carbon stocks of CC31, CC32 and CC34 have been harmonized considering the results of Meyer et al. (2012). In former submissions an average value was used for CC32 and CC34.
- 5E: For settlement areas with herbaceous biomass (CC52), shrubs (CC53) or trees (CC54) CO_2 emissions from organic soils were reported. In former submissions no emissions had been considered.

6 Waste

- 6A, 6B: For the years 2008-2010 “population at year-end” instead of “average population” has been used for Swiss average population. This has been corrected. Values of activity data have slightly changed.
- 6B2: Emission factors of sewage gas combustion “Verbrauch Klärgas -Feuerungen” have been recalculated for the years 2000-2010 (Statistik der Erneuerbaren Energien). This results in changes of emission factors in the EMIS database for CO_2 biog., CH_4, NOx, CO, NMVOC, SO_2, N_2O. Recalculations were made for both years.
- 6B2: Losses of sewage gas treatment (upgrade) of CO_2 biogen and CH_4 have been overestimated in past submissions (100% instead of 5% of treated gas) and have been corrected. Recalculations were made for the years 2005-2010.
- 6B: N_2O emission are calculated using year-specific values for protein consumption according to the numbers provided by the Swiss Farmer’s Union (SBV 2012). N_2O emission for the year 2010 were recalculated due to an update of total protein consumption by the Swiss Farmer's Union (SBV 2012) from 268 kt to 271 kt. See Chapter 8.3.5.
- 6B: AD of sewage gas treatment has changed for the years 2008 and 2009, according to SFOE 2012. This results in changed EF for CH_4 and recalculations of CH_4 emissions for both years. See Chapter 8.3.5.
- 6C: Process “Field burning of agricultural wastes“ has been moved and from 4F to 6C1 (Waste incineration) in accordance to the EMEP guidebook 2009 and renamed into “Burning of residues in agriculture and forerstry”. Recalculations were made for the whole time series 1990-2010.
- 6C: Activity data for "Crematoria" in the year 2010 has been corrected due to updated data by the swiss crematory association.

- 6D: In last year's submission wrong emission factors of CH_4 and CO_2 have been used for the fermentation process (subprocess biogas losses) due to an unit error. Recalculations were made for the whole time series 1990-2010.
- 6D: In last year's submission activity data of subprocesses "Vergärung IG, P3 Presswasser" and "Vergärung IG, P4 Nachrotte" have been switched. This has been corrected. See also" EMIS 2013 1 A 1 a und 6 D_Vergärung IG . Recalculations were made for the whole time series 1990-2010.
- 6D: Activity data of processes "Vergärung LW, P2 Biogasverluste" and "Vergärung LW, P4 Nachrotte" have slightly changed due to error in interpolation in calculation file (EMIS 2013 1 A 1 a und 6 D_Vergärung LW). Recalculations were made for the whole time series 1990-2010.
- 6D: Values of activity data for methan losses (biogas upgrading) have slightly changed during the whole time series due to calculation with non-rounded values. See also Chapter 8.5.5.
- 6D: EF for 2010 has been missing, which resulted in an emission calculation with an interpolated value. Recalculations were made for the year 2010 with the correct value provided by SFOE 2012.

7 Other

- 7A1 and 7A2: For the years 2008-2010 now activity data for Human Ammonia Emissions, Respiration and Transpiration are used: "average population" is taken into account instead of "population at year-end", thus AD has slightly changed.

10.1.2 KP- LULUCF Inventory

A recalculation of the years 2008, 2009 and 2010 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). See 5 Land Use, Land-Use change and Forestry above.

10.2 Implications for Emission Levels 1990 and 2010

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 CO2 equivalents (without emissions/removals from CO2 from LULUCF) of 84.76 Gg CO2 eq. This corresponds to a decrease of the latest submission compared to the previous submission (2012,v2.1) by 0.16% of the national total. If the LULUCF sector is included, there is a increase of 606.98 Gg CO2 eq (1.23%) 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 2012 "Prev." (FOEN 2012) 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	41'136	41'104	-31.79	624.5	619.9	-4.62	283.9	283.1	-0.80	42'044	42'007	-37.21
2 Ind. Processes (without F-gases)	3'059	3'059	0.30	9.6	9.6	0.00	68.1	68.1	0.00	3'137	3'137	0.30
3 Solvent and Other Product Use	362	360	-1.94				110.1	110.1	0.00	472	470	-1.94
4 Agriculture				3'339.3	3'307.1	-32.28	2'799.0	2'785.0	-13.92	6'138	6'092	-46.20
5 LULUCF	-3'867	-3'174	692.8	8.2	8.2	0.00	11.4	10.4	-1.08	-3'847	-3'156	691.74
6 Waste	63	63	-0.01	724.5	737.0	12.50	206.7	210.6	3.91	995	1'011	16.40
7 Other	11	11	0.00	0.6	0.6	0.00	16.7	0.6	-16.10	28	12	-16.10
Sum (without F-gases)	40'764	41'423	659.4	4'707	4'682	-24.41	3'479	3'468	-27.99	48'967	49'574	606.98

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		**49'210**	**49'817**	**606.98**
		100%	101.23%	1.23%
Total CO_2 eq Em. without LULUCF		**53'058**	**52'973**	**-84.76**
		100%	99.84%	-0.16%

For 2010, the recalculation results in a decrease of the total emissions in CO_2 equivalents (without emissions/removals from LULUCF) of 162.43 Gg CO_2 eq. This corresponds to an decrease of 0.30% of the national total in the latest submission compared to the previous submission. If the LULUCF sector is included, a decrease of 1686.76 Gg CO_2 eq. (3.16%) results due to major recalculations in the LULUCF sector.

Table 10-2 Overview of implications of recalculations on 2010 data. Emissions are shown before the recalculation according to the previous submission in 2012 "Prev." (FOEN 2012) 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 2010	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
1 Energy	43'426	43'356	-69.92	271.5	268.7	-2.75	321.8	283.0	-38.78	44'020	43'908	-111.44
2 Ind. Processes (without F-gases)	2'355	2'369	13.77	8.4	8.4	0.00	60.3	60.3	0.00	2'424	2'438	13.77
3 Solvent and Other Product Use	157	152	-5.46				57.3	45.8	-11.54	215	198	-17.00
4 Agriculture				3'193	3'167	-26.15	2'495	2'480	-14.99	5'688	5'647	-41.14
5 LULUCF	-885	-2'409	-1'523.68	0.2	0.2	0.00	4.5	3.9	-0.64	-880	-2'405	-1'524.33
6 Waste	11	13	1.86	341.9	320.8	-21.13	258.9	263.6	4.64	612	597	-14.63
7 Other	13	13	0.00	0.6	0.6	0.00	13.6	0.6	-13.01	27	14	-13.01
Sum (without F-gases)	45'078	43'494	-1'583.43	3'816	3'766	-50.03	3'212	3'137	-74.31	52'105	50'397	-1'707.77

Recalculation	**HFC**			**PFC**			**SF6**			**Sum (synthetic gases)**		
Emissions for 2010	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)	1'072.97	1'094.14	21.17	36.5	36.7	0.20	155.1	154.8	-0.35	1'264.59	1'285.61	21.02

Recalculation		**Sum (all gases)**		
Emissions for 2010		Prev.	Latest	Differ.
Source and Sink Categories		CO_2 equivalent (Gg)		
Total CO_2 eq Em. with LULUCF		**53'370**	**51'683**	**-1'686.76**
		100%	96.84%	-3.16%
Total CO_2 eq Em. without LULUCF		**54'250**	**54'088**	**-162.43**
		100%	99.70%	-0.30%

10.2.2 KP- LULUCF Inventory

Data for 2008, 2009, 2010 and 2011 are reported. A recalculation of the years 2008, 2009 and 2010 was carried out. The methodological improvements are described in detail 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 1990–2010 reported in the 2012 submission (FOEN 2012) has slightly changed. Compared to 1990, 2010 emissions (national total without emissions/removals from LULUCF) showed a decrease of 2.25% before recalculation (previous submission). After recalculation, the decrease turns out to be lower with a change 2010/1990 of 2.10% (latest submission).

Table 10-3 Change of the emission trend 1990–2009 due to recalculation. “Previous” refers to data reported in FOEN (2011b), whereas “latest” refers to the present submission.

Recalculation	1990		2010		change 2010/1990	
Submission	previous	latest	previous	latest	previous	latest
Unit	CO_2 eq (Gg)				%	
Total excl. LULUCF	53'058	52'973	54'250	54'088	2.25%	2.10%

All-time series in the present submission are consistent.

10.3.2 KP- LULUCF Inventory

As for KP-LULUCF 2008, 2009, 2010 and 2011 data are submitted, recalculation was done for 2008, 2009 and 2010 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

1A3a: For the years to come, efficiency improvements in the fuel consumption of large aircrafts will be considered in the modelling approach in order to avoid overestimation of consumption.

1B2: Gradual improvement of the data quality in co-operation with industry is on-going.

2: In 2012 a national review on sector 2 Industrial Processes took place (CSD 2013). The final report will be evaluated in order to see which suggestions for improvement could be implemeted in future submissions. It will be checked whether the revised Swiss CO2-act and ordinance (FOEN 2013f) could provide an improved data base for the largest industrial emitters.2F: Gradual improvement of the data quality in co-operation with industry is on-going. The focus will be on improvements of HFC-emission calculations from refrigeration and air-conditioning equipment.

3: Gradual improvement of the data quality in co-operation with industry and industry associations is on-going.

4B: 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.

5 LULUCF Sector: Switzerland will further reduce the uncertainty of its activity data for land areas by gradually increasing the AREA sample size. Full coverage is expected in 2013 (see Chapter 7.2.8).

5 LULUCF Sector: Various other planned improvements are listed in the corresponding chapters (see Chapters 7.3.8, 7.4.8, 7.5.8, 7.6.8 and 7.7.8).

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 and 2011, 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 (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 NIR 1 – 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	IE	NR	NR	R	NO			NO	NO	NO	NO
	Deforestation	R	IE	R	R	R			R	NO	NO	NO	NO
Article 3.4 activities	Forest Management	R	IE	R	R	R	NO	NE		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 2011

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	2.36	NO						2.36
	Deforestation		6.99						6.99
Article 3.4 activities	Forest Management (if elected)		0.33	1'234.22					1'234.55
	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	1.22	NA	NA	NA	2'883.19	2'884.47
Total area at the end of the current inventory year		2.41	7.32	1'235.44	NA	NA	NA	2'883.19	4'128.37

(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 2011. 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; 2011).
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; 2011).

(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 equivalent 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 yearly 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). Fluctuations in the contribution of Forest Management can mainly be explained by changes in the losses of living biomass, dead wood and litter, whereas changes in the area of managed forest are relatively small (see Table 11-6). In 2000, 2001 and 2002, Forest Management was a very small sink of CO_2 eq compared to previous and following years due to the damage caused by the storm Lothar.

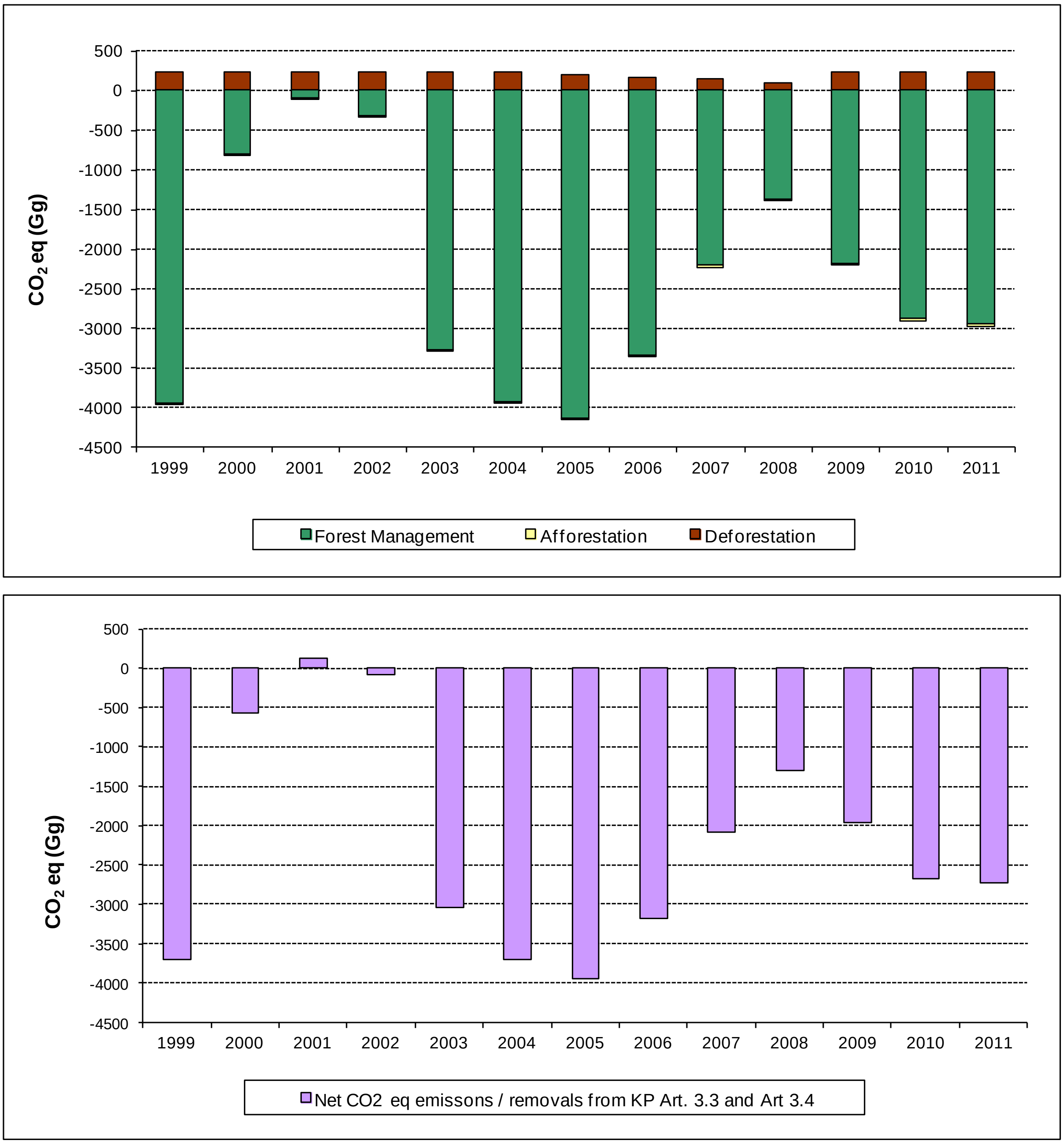

Figure 11-1 CO_2 eq emissions (positive sign) and removals (negative sign) from Afforestation and Deforestation under Article 3, paragraph 3 and Forest Management under Article 3, paragraph 4 (upper panel) and net CO_2 eq emissions and removals of these activities (lower panel), 1999-2011.

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, 1999-2011.

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	**228.20**	**228.19**	**227.28**	**225.85**	**224.10**	**222.61**	**177.08**
A.1. Afforestation and Reforestation	-6.40	-7.19	-8.23	-9.67	-11.41	-13.26	-15.60
A.1.1. Units of land not harvested since the beginning of the commitment period	-6.40	-7.19	-8.23	-9.67	-11.41	-13.26	-15.60
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	234.60	235.38	235.51	235.52	235.51	235.87	192.67
B. Article 3.4 activities	**-3941.42**	**-801.22**	**-96.70**	**-297.06**	**-3256.69**	**-3938.76**	**-4142.46**
B.1. Forest Management incl. biomass burning	-3941.42	-801.22	-96.70	-297.06	-3256.69	-3938.76	-4142.46
gains living biomass	-12538.67	-12548.99	-12558.14	-12567.19	-12576.31	-12586.43	-12602.52
losses living biomass	9955.69	12833.46	13232.16	13075.27	10612.85	10272.12	10719.66
changes litter	-183.95	55.92	310.98	236.12	-202.74	-442.97	-941.39
changes dead wood	-1114.46	-1079.98	-1025.80	-1009.55	-1062.07	-1115.30	-1226.30
changes soil C min. soils	-69.07	-71.80	-66.09	-57.11	-60.11	-75.71	-102.55
changes soil C org. soils	8.68	8.69	8.70	8.70	8.71	8.71	8.73
sum forest management excl. Biomass burning	-3941.78	-802.69	-98.20	-313.76	-3279.67	-3939.58	-4144.37
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	**145.24**	**119.76**	**77.43**	**207.07**	**202.07**	**200.66**	
A.1. Afforestation and Reforestation	-17.99	-20.99	-23.02	-25.15	-30.35	-32.55	
A.1.1. Units of land not harvested since the beginning of the commitment period	-17.99	-20.99	-23.02	-25.15	-23.67	-19.35	
A.1.2. Units of land harvested since the beginning of the commitment period	0.00	0.00	0.00	0.00	-6.68	-13.20	
A.2. Deforestation	163.22	140.75	100.45	232.23	232.43	233.22	
B. Article 3.4 activities	**-3339.56**	**-2200.43**	**-1374.82**	**-2178.56**	**-2884.02**	**-2936.20**	
B.1. Forest Management incl. biomass burning	-3339.56	-2200.43	-1374.82	-2178.56	-2884.02	-2936.20	
gains living biomass	-12707.70	-12805.29	-12904.16	-12915.75	-12920.06	-12924.49	
losses living biomass	10298.16	10749.27	10856.07	10447.87	10211.58	10188.90	
changes litter	-194.38	224.17	650.77	275.94	-125.54	-146.81	
changes dead wood	-628.87	-278.80	93.99	58.94	-11.42	-21.71	
changes soil C min. soils	-119.62	-108.06	-82.08	-55.77	-48.23	-46.67	
changes soil C org. soils	8.74	8.75	8.76	8.76	8.77	8.77	
sum forest management excl. Biomass burning	-3343.68	-2209.96	-1376.66	-2180.02	-2884.89	-2942.01	
B.2. Cropland Management (if elected)	NA	NA	NA	NA	NA	NA	
B.3. Grazing Land Management (if elected)	NA	NA	NA	NA	NA	NA	
B.4. Revegetation (if elected)	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 -1374.82 Gg CO_2 eq. The debit incurred from activities under Article 3.3 is 77.43 Gg CO_2 eq.
- In 2009 Forest Management in Switzerland caused removals of -2178.56 Gg CO_2 eq. The debit incurred from activities under Article 3.3 is 207.07 Gg CO_2 eq.

- In 2010 Forest Management in Switzerland caused removals of -2884.02 Gg CO_2 eq. The debit incurred from activities under Article 3.3 is 202.07 Gg CO_2 eq.
- In 2011 Forest Management in Switzerland caused removals of -2936.20 Gg CO2 eq. The debit incurred from activities under Article 3.3 is 200.66 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 (2013c).

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 subcategories were 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 7.2.4, Table 7-11). Those are:

- Vineyards, Low-Stem Orchards, Tree nurseries, Copses and Orchards in the category “Grassland”;
- Cemeteries and public parks in the 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 y^{-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).

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 2012; see also Chapter 7.2) are considered as Afforestation. Some 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.

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 stands limited in time and should be classified as "management interventions" rather than as real land-use changes. However, no reclassification was done. This shows that the area of Deforestations reported under KP Art. 3.3 is in fact slightly an overestimation.

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 Table 11-2).

All activity data for reporting the activities under the Kyoto Protocol are retrieved from the Swiss Land Use Statistics (SFSO 2012; see also Chapter 7.2.2.1).

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 Table 11-2).

Forest areas under Forest Management are subdivided into productive forests (CC12) and unproductive forests (CC13; Table 7-11). 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 7-5). 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, 2012; 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).

Briefly, 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 deforestations" and should be classified as "management interventions" rather than as real land-use changes. This shows, that the area of Deforestations reported under KP Art. 3.3 is in fact slightly an overestimation.
    - 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 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, 2012; 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), whereas under the Convention, these Afforestations older than 20 years move to the land-use category 5A1 “Forest Land remaining forest land”.
- Not all changes from a forest combination category 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 FL 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 activity data reported were checked and compared. It was shown that the differences in the CRF tables could be explained and that the resulting budget of areas reported under the Convention and the Kyoto Protocol are identical.

Table 11-5 Area budget (in kha) for KP-LULUCF and LULUCF under the Convention for the year 2010 for a) Afforestation vs. Land converted to forest land, b) Deforestation vs. Forest land converted to other land use, and c) Forest Management vs. total forest land. Data are explained in detail in Meteotest (2013a).

Land use or land-use change category (kha)		KP	UNFCCC
a) Afforestation vs. Land converted to forest land (cumm. 20 years)	**Land to forest land incl. nat. regener. (5.A.2)**	**-**	***51.86***
	Land to forest land nat. regener.(5.A.2)	*-*	*49.79*
	Direct human-Induced Afforestation CC11 KP A.1.1 + A.1.2.	***2.36***	**-**
	Direct human-Induced Afforestation CC11 KP A.1.1.	*2.08*	*2.08*
	Direct human-Induced Afforestation CC11 KP A.1.2.	*0.28*	*-*

Land use or land-use change category (kha)		KP	UNFCCC
b) Deforestation vs. forest land converted to other land use (cumm. 20 years)	KP-Deforestation as defined by KP	**6.99**	NA
	Forest land converted to other land use CRF 5.B-F.2	-	**17.81**
	non-KP-Deforestation		*10.82*

Land use or land-use change category (kha)		KP	UNFCCC
c) Forest Management vs. total forest land		1'234.55	1'234.12
Productive Forest	**remaining CC12 / FM**	1'128.47	1'090.89
	converted to CC12 total	**10.94**	**48.29**
	converted non-FL to CC12 (natural regeneration: 5A2)	*incl.remaining CC12*	*31.93*
	CC11 to CC12	*NA*	*5.43*
	CC13 to CC12	*10.94*	*10.94*
	non-Kyoto-deforestation	-0.51	NA
	afforestation > 20 yr KP A.1.1	0.28	NA
	Total	**1'139.18**	**1'139.18**
Unproductive Forest	**remaining CC13 / FM**	91.33	73.26
	converted to CC13	**3.81**	**21.68**
	converted non-FL to CC13 (natural regeneration; 5A2)	*NA*	*17.86*
	CC11 to CC13	*NA*	*0.02*
	CC12 to CC13	*3.81*	*3.81*
	non-Kyoto-deforestation	-0.20	0.00
	afforestation > 20 yr KP A.1.1	0.00	0.00
	Total	**94.94**	**94.94**

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, 1990-2011. Afforestation, Deforestation data and values depicting the area of Forest Management are derived from the Swiss Land Use Statistics (AREA) (derived from SFSO 2006a, 2012).

Year	Deforested area [kha]	Cumulated deforested area since 1990 [kha]	Afforested area [kha]	Cumulated afforested area since 1990 [kha]	Area Forest Management [kha]
1990	0.34	0.68	0.28	0.28	1184.32
1991	0.34	0.68	0.27	0.55	1187.00
1992	0.34	1.02	0.27	0.82	1189.69
1993	0.34	1.36	0.23	1.04	1192.23
1994	0.36	1.72	0.17	1.22	1194.57
1995	0.37	2.10	0.12	1.34	1196.74
1996	0.38	2.47	0.11	1.44	1198.46
1997	0.38	2.86	0.08	1.52	1200.16
1998	0.40	3.26	0.06	1.58	1201.70
1999	0.40	3.66	0.06	1.64	1203.19
2000	0.39	4.05	0.06	1.70	1204.67
2001	0.38	4.44	0.06	1.76	1206.16
2002	0.38	4.81	0.06	1.82	1207.64
2003	0.37	5.19	0.06	1.88	1209.13
2004	0.36	5.55	0.06	1.94	1210.62
2005	0.28	5.83	0.09	2.04	1212.64
2006	0.22	6.05	0.08	2.12	1214.38
2007	0.18	6.23	0.07	2.19	1216.11
2008	0.10	6.33	0.06	2.25	1218.04
2009	0.33	6.66	0.05	2.30	1219.72
2010	0.33	6.99	0.05	2.36	1220.55
2011	0.33	7.32	0.05	2.41	1221.40

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 and using equation 7.1-3.

- In case of land-use changes (Afforestation, Deforestation) and changes between CC12 and CC13 under Forest Management, V-factors ($V_{l,ba}$, $V_{d,ba}$ and $V_{s,ba}$) are zero for all pools and W-factors $W_{l,ba}$ and $W_{d,ba}$ are 1 for all pools. $W_{s,ba}$ is 1 for Afforestations and 0.5 for Deforestations.

This means that only the difference in carbon stocks are accounted for and conversion times of 20 years are applied. Thus, under the KP changes in dead wood, litter and soil carbon are reported more conservetavely than under the UNFCCC.

- For CC12 remaining and CC13 remaining and in the case of living biomass of Afforestations < 20 years, W-factors ($W_{l,ba}$, $W_{d,ba}$ and $W_{s,ba}$) are zero for all pools and V-factors ($V_{l,ba}$, $V_{d,ba}$ and $V_{s,ba}$) are 1 for all pools. Thus, the annual increase and decrease, respectively, is accounted for.

Annual values for carbon stocks and changes in the pools of living biomass (above and below ground; see Chapter 7.3.4.4), dead wood, litter and soil carbon of the land-use combination categories Afforestations (CC11), productive (CC 12) and unproductive forests (CC13) are displayed in Table 7-4 and Table 7-5. The methodological approach is summarized in Table 11-7. Additional methodological information can be found in FOEN (2013c).

Table 11-7 Application of equations 7.1-7.3 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). Losses in soil carbon due to disturbance caused by Deforestation 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). GG = gross growth; C&M= cut and mortality; SLB = stock living biomass; dDW = yearly change in dead wood pool; SDW = stock dead wood pool; dSOC = yearly change in soil carbon pool; SSOC = stock in soil carbon pool; dLitter = yearly change in litter pool. Suffices refer to the specific combination category or to the KP activity (see Table 7-2).

	Living biomass	Dead Wood	Soil-C	Litter
Afforestation CC11 ≤ 20 yr **($W_l = W_d = W_s = 1$)**	GG_{11} - $C\&M_{11}$ + 0*(SLB_{11}-SLB_{31})/CT = GG_{11} - 0 + 0 = GG_{11}	0 + 1*(SDW_{11} - SDW_{31})/ CT = 0 + (0 - 0)/CT	0 + 1*(SOC_{11} - $SOC_{31/51}$)/CT = (SOC_{11} - $SOC_{31/51}$)/CT	0 + 1*($Litter_{11}$-$Litter_{31}$)/CT = (0 - 0)/ CT
Afforestation CC11 > 20 yr **($W_l = W_d = W_s = 1$)**	0 + 1*($SLB_{12/13}$ - SLB_{11})/CT = ($SLB_{12/13}$ - SLB_{11})/CT	0 + 1*($SDW_{12/13}$ - SDW1_1)/ CT = 0 + ($SDW_{12/13}$ - 0)/CT = $SDW_{12/13}$ /CT	0 + 1*($SOC_{12/13}$ - SOC_{11})/CT = ($SOC_{12/13}$ - SOC_{11})/CT = 0/CT	0 + 1*($Litter_{12/13}$-$Litter_{11}$)/CT = ($Litter_{12/13}$- 0)/CT = $Litter_{12/13}$ / CT
Deforestation DEF **($W_l = W_d = 1$; $W_s = 0.5$)**	0 + 1*(0-SLB_{12})/ 1 = (0 - SLB_{12})/ 1 = - SLB_{12}/ 1	0 + 1*(0- SDW_{12})/ 1 = (0 - SDW CC_{12})/ 1 = - SDW_{12}/ 1	0 + 1*(0.5*SOC_{12} - SOC_{12}) = (- 0.5*SOC_{12})/ CT	0 + 1*(0 - $Litter_{12}$) / 1 = (0 - $Litter_{12}$)/ 1 = - $Litter_{12}$/ 1
FM CC12 remaining	GG_{12} - $C\&M_{12}$ + 0	dDW_{12} + 0	$dSOC_{12}$ + 0	$dLitter_{12}$ + 0
FM CC13 remaining	GG_{13} - $C\&M_{13}$ + 0 = 0	dDW_{13} + 0 = 0	$dSOC_{13}$ + 0 = 0	$dLitter_{13}$ + 0 = 0
FM CC1213 **($W_l = W_d = W_s = 1$)**	0 + 1*(SLB_{13}-SLB_{12})/ CT = (SLB_{13}-SLB_{12})/ CT	0 + 1*(SDW_{13}- SDW_{12})/ CT = (SDW_{13}- SDW_{12})/ CT = 0 - SDW12/ CT	0 + 1*(SOC_{13}- SOC_{12})/ CT = 0 + 0	0 + 1*($Litter_{13}$-$Litter_{12}$)/ CT = 0 + 0
FM CC1312 **($W_l = W_d = W_s = 1$)**	0 + 1*(SLB_{12}-SLB_{13})/ CT = (SLB_{12}-SLB_{13})/ CT	0 + 1*(SDW_{12}- SDW_{13})/ CT = (SDW_{12}- 0)/ CT = SDW_{12}/ CT	0 + 1*(SOC_{12}- SOC_{13})/ CT = 0 + 0	0 + 1*($Litter_{12}$-$Litter_{13}$)/ CT = 0 + 0

Reforestation

Reforestation does not occur in Switzerland (FOEN 2006h, Sect. E).

Afforestation ≤ 20 years

Living Biomass

- Annual increase/decrease: Gross growth of living biomass of Afforestations follows a logistical growth function. Values are available for three altitudinal levels (Table 7-24). 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 instead of age-speficic growth values were applied.

Soil Carbon

- Annual increase/decrease - Organic soils: In the case of organic soils, emissions due to drainage are calculated as described in Chapter 11.3.1.2.

- Change in carbon stock due to conversion - Mineral soils: In the case of land-use conversions to Afforestations, the difference in soil carbon stocks between land use before the conversion (81% permanent grasslands CC31 and 19% settlements CC51) and Afforestations CC11 is considered.

Dead Wood and Litter

- Change in carbon stock due to conversion: On grasslands and areas with settlements there are no dead wood and no litter available. 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 published values (see Chapter 11.3.1.2).

Afforestation > 20 years

In Table A.1.2 Afforestations older than 20 years are shown. Emissions and removals for the carbon pools of Afforestations older than 20 years are calculated as a stock change from CC11 to productive (FM CC12 remaining; 99% of the Afforestations) or unproductive forest (FM CC13 remaining).

Living Biomass

- Change in carbon stock due to conversion: The difference in carbon stock between Afforestation CC11 and productive or unproductive forest is accounted for. After 20 years, Afforestations are under normal Forest Management and the first thinings and treatments are conducted. These measurements normally don’t cause high losses of living biomass. Gains of these Afforestations exceed losses. This is reflected by the difference in living biomass which is calculated as the stock difference between Afforestations and productive forests and which is reported under “gains”, although losses occur on these areas.

Soil Carbon

- Annual increase/decrease - Organic soils: emissions due to drainage are calculated as described in Chapter 11.3.1.2.
- Change in carbon stock due to conversion - Mineral soils: The difference in soil carbon stocks between productive (CC12 remaining) or unproductive forest (CC13 remaining) and Afforestation CC11 is considered.

Dead Wood and Litter

- Change in carbon stock due to conversion: The differences in dead wood stocks and litter stocks are considered, where dead wood stock and litter stock on Afforestations at the age of 20 years is assumed to be zero.

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

The methodology used for calculating carbon stock changes in case of land-use changes within forest land is described in detail in Chapter 7.1.3.2 and summarized in Table 11-7.

Living Biomass

- By using single-tree allometric functions (see Chapter 0; Thürig and Herold 2012) stocks in below ground biomass are included in the stocks of above ground biomass.
- Annual increase, gains of living biomass: 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 7.3.4.7 and Table 7-5).
- Annual decrease, losses of living biomass: Cut and mortality reflect yearly losses of living biomass in productive forests “CC12 remaining”. Unproductive forests are not systematically harvested and since yearly harvesting amounts from forest statistics (FOEN 2012g) are divided over the productive forests. Thus losses of unproductive forests “CC13 remaining” are zero.
- Change in carbon stock due to conversion: For areas which changed from “CC13 to CC12” and from “CC12 to CC13” the difference in carbon stocks of living biomass was considered. In the case of a conversion from “CC12 to CC13”, a net loss in carbon stock of living biomass is reported; in the case of a conversion from “CC13 to CC12” a net gain.

Dead wood

- Annual increase/decrease: Estimates of yearly changes in dead wood were derived from Yasso07 (see Chapter 7.3.4.9). For productive forests CC12 remaining”, values for yearly changes in carbon stock of dead wood from Table 7-5 are used. For unproductive forests “CC 13 remaining”, yearly changes in dead wood stock are assumed to be zero (Table 7-22).
- Change in carbon stock due to conversion: For areas which changed from “CC13 to CC12” and from “CC12 to CC13” the difference in carbon stock of dead wood is taken into account (Table 7-5).

Litter and soil carbon pool

- Annual increase/decrease: For productive forests "CC12 remaining”, values for yearly changes in litter and soil carbon stock from Table 7-5 are used. Estimates of yearly changes in litter and soil carbon were derived from Yasso07 (see Chapter 7.3.4.9). For unproductive forests “CC 13 remaining”, yearly changes in litter and soil C-stock are assumed to be zero (see 7.4.3, 7.3.6, 11.3.1.2). In the case of organic soils, emissions due to drainage are calculated as described in Chapter 11.3.1.2.
- Change in carbon stock due to conversion: For areas which changed from “CC13 to CC12” and from “CC12 to CC13” the difference in carbon stock of litter and soil carbon stock is taken into account. For the conversion “CC12 to CC13”, we report a net loss in carbon stock, in the case of a conversion “CC13 to CC12”, we report a net gain (Table 7-4, Table 7-22 and Table 7-23).

Differences in accounting for “Forest Sector 5A1 and 5A2” under the UNFCCC and „Forest Management“ under KP Art. 3.4

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, i.e. 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.

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.

Change in Carbon Pool Reported

- The pool “above ground biomass” always reflects the total living biomass, which was calculated by applying single-tree allometric functions (see Chapter 7.3.4.4). Therefore, below ground biomass is included in the above ground biomass pool and always marked as “include elsewhere” (IE).
- Changes in litter after Afforestation: 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} y^{-1}. Other studies show even higher accumlation rates of 0.24-0.34 t C ha^{-1} y^{-1} for Afforestations with Norway spruce in Southern Alps (Thuille and Schulze 2006), 0.24 t C ha^{-1} y^{-1} for Afforestation with ash and maple (Alberti et al. 2008) and 0.36 t C ha^{-1} y^{-1} for Scotch pine (Vesterdal et al. 2002).

  Since Afforestation is not a key category, a conservative estimate (Tier1) is compliant to IPCC guidelines (IPCC 2003). Since no measurements are available, we further provide a reasoning based on sound knowledge of likely system responses (Grassi and Blujdea 2011): At stand level, the pools dead wood, litter on Afforestation on cropland and grassland cannot be a source (until the first thinning), 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.

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 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 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 7.3.4.12 according to the methodology of the Good Practice Guidance (IPCC 2003).

11.3.1.3 Information on whether or not indirect and natural GHG Emissions and Removals have been factored out

No anthropogenic greenhouse gas emissions and removals resulting from LULUCF activities under Article 3, paragraphs 3 and 4 have been factored out.

11.3.1.4 Changes in Data and Methods since the previous Submission (Recalculations)

A recalculation of the years 2008, 2009 and 2010 was carried out.

The increment of available AREA activity data (see Chapter 7.2.2.1, SFSO 2012) 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 10.1.2.

The following Kyoto-specific methodological modification was made for this submission:

- The application of weighting factors V and W has been changed as described in Chapter 11.3.1. and 7.1.3.2)
- New available NFI 4a data for the period 2007-2011 have been used in the calculations for changes in living biomas and the biomass data of NFI 1, NFI 2 and NFI 3 data have been recalculated.
- Nussbaum et al. (2012) provided updated data for carbon stocks of litter and soil organic carbon.
- Yearly changes in carbon stocks of soil organic carbon, dead wood and litter have been modeled with Yasso07 (Didion et al. 2012).

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 7-12. Uncertainty estimates of emission factors for the reported activities under the Kyoto Protocol are shown in Table 7-7, 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. An uncertainty of 32% was calculated for Afforestations, 50% for Deforestations and 32% 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	21	32	37
Deforestation	mainly 5E2 Land converted to Settlements	11	50	51
Forest Management	5A1 Forest Land remaining Forest Land	2	32	32

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.

- 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). A table (Table 11-5) transparently showing the relationship has been added in Chapter 11.2.3.
- Areas where tree loss is temporally limited are not classified as Deforestation under the Kyoto Protocol (Chapter 11.1.3). A study by Sigmaplan (2012a) showed that, although the aspect of "temporal limitiation" was considered, still 14% of the Kyoto Deforestations were in fact "short-term Deforestations" and should be classified as "management interventions" rahter than as real land-use changes. This shows, that the area of Deforestations reported under KP Art. 3.3 is in fact still slightly an overestimation and thus a conservative estimation.

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 1999-2011. The corresponding values are listed inTable 11-4. Most emission factors are retrieved from the Swiss National Forest Inventory (NFI, see also Chapter).

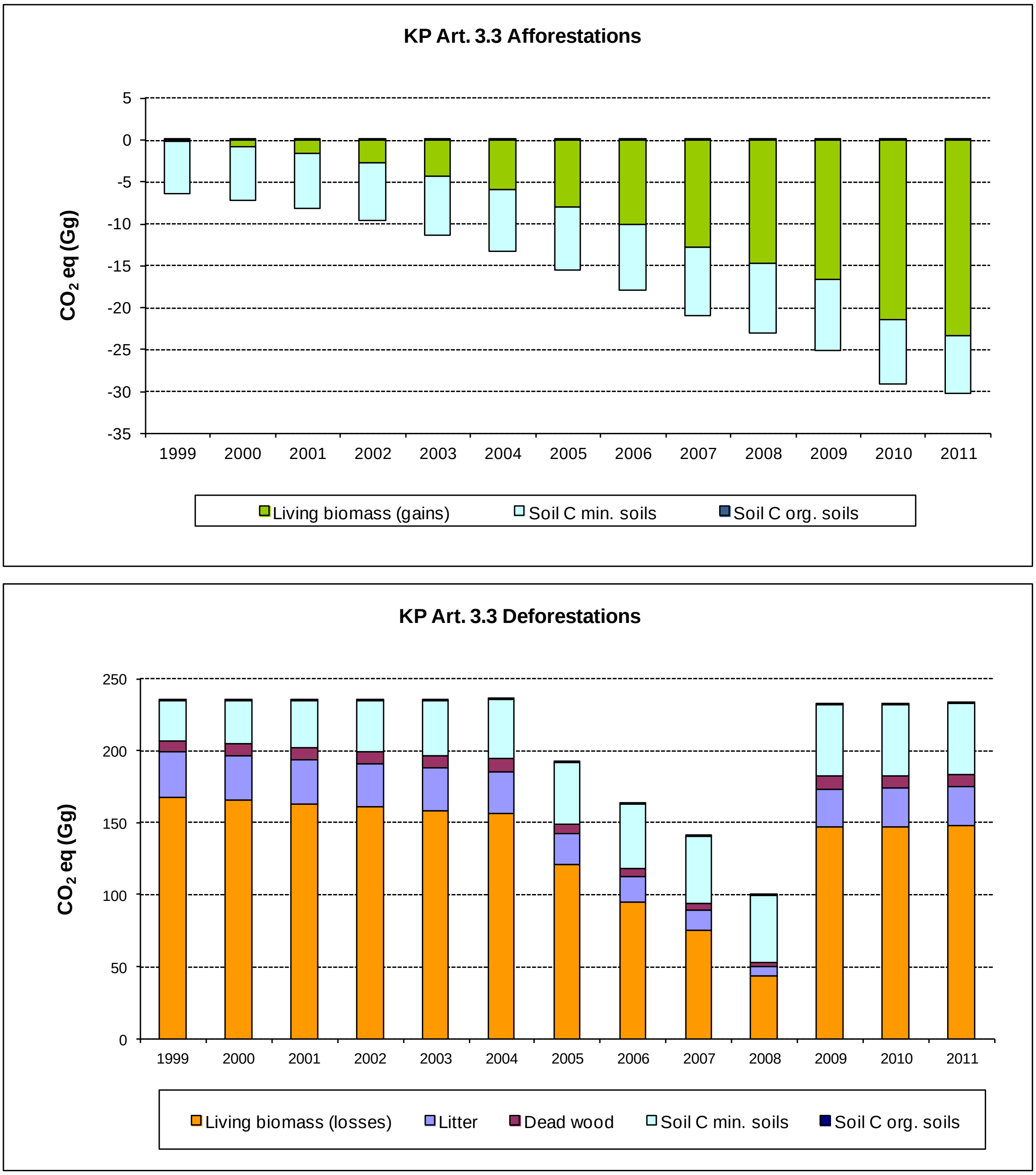

Figure 11-2 Removals (negative sign) and emissions (positive sign) of CO_2 eq from Afforestations (upper panel) and from Deforestations (lower panel) shown per carbon pool, 1999-2011.

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).

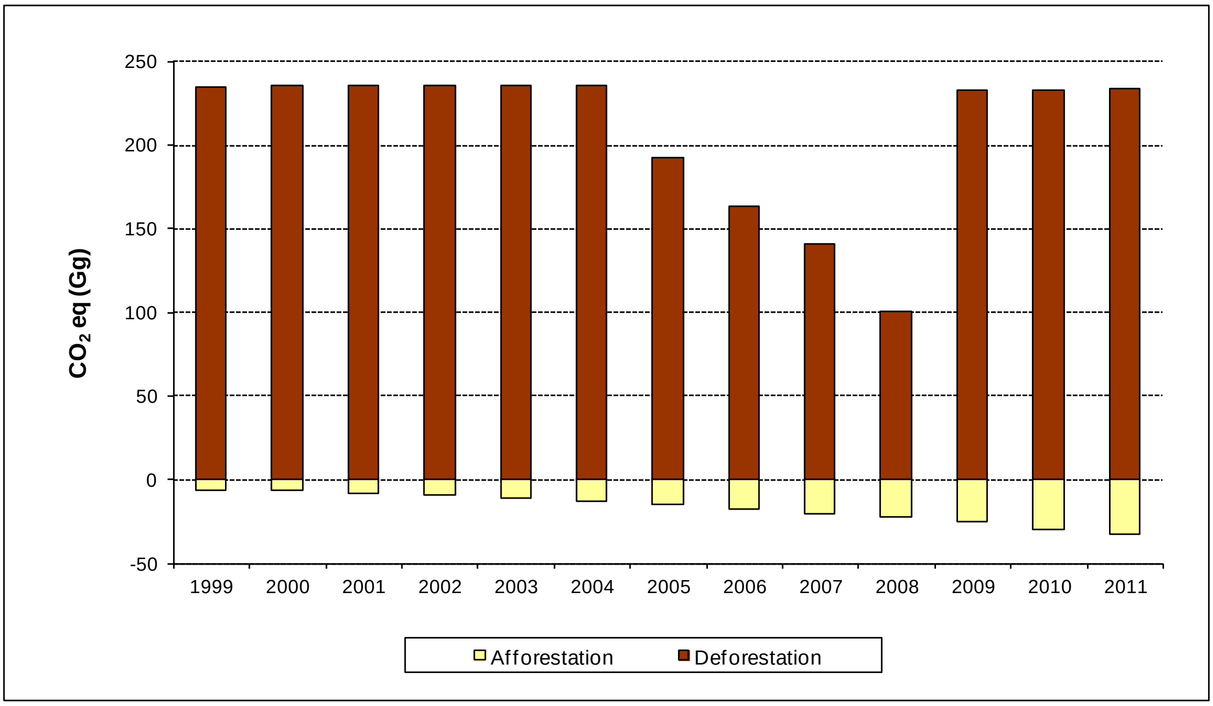

Figure 11-3 Removals (negative sign) and emissions (positive sign) of CO_2 eq of Afforestations and Deforestations, 1999-2011.

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. For the calculation of the changes in C-Stocks, a conversion time of 20 years is applied (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. 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.

Sigmaplan (2012a) screened the classification of all land-use changes classified as Deforestation under the Kyoto Protocol. The author 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 stands limited in time and should be classified as "management interventions" rahter than as real land-use changes. However, no reclassification was done. This shows, that the area of Deforestations reported under KP Art. 3.3 is in fact slightly an overestimation.

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

AREA 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 2011 are shown in Figure 11-4. The corresponding values are listed in Table 11-4. Most emission factors are retrieved from the Swiss National Forest Inventory (NFI, see also Chapter 7.3.4.1).

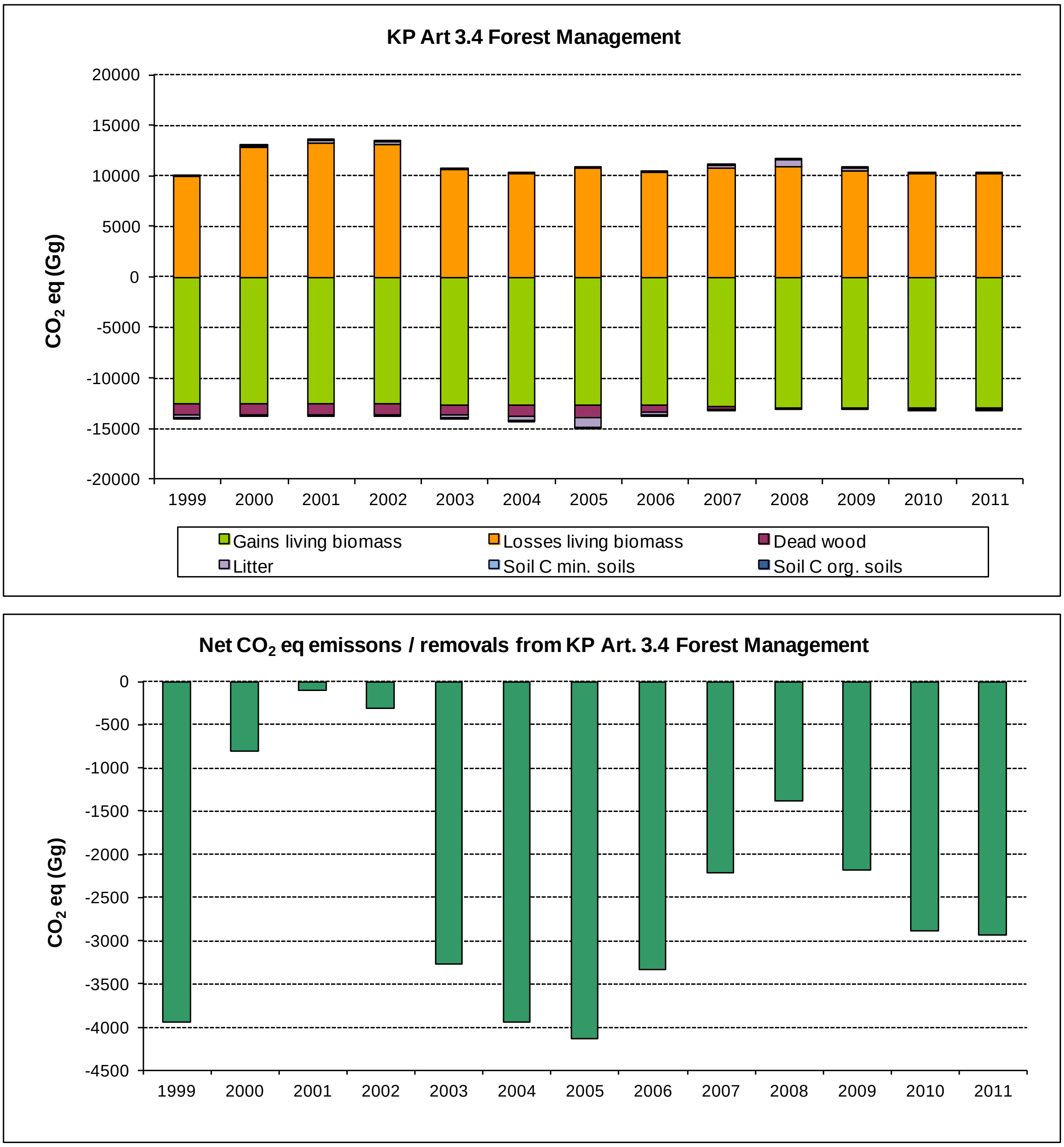

Figure 11-4 CO_2 eq emissions (positive sign) and removals (negative sign) from the reported carbon pools under Forest Management (upper panel) and the total CO_2 eq emissions and removals from Forest Management (lower panel), 1999-2011.

The yearly fluctuations in the greenhouse gas 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 2000, 2001 and 2002, Forest Management was a very small sink of CO2 eq. 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.

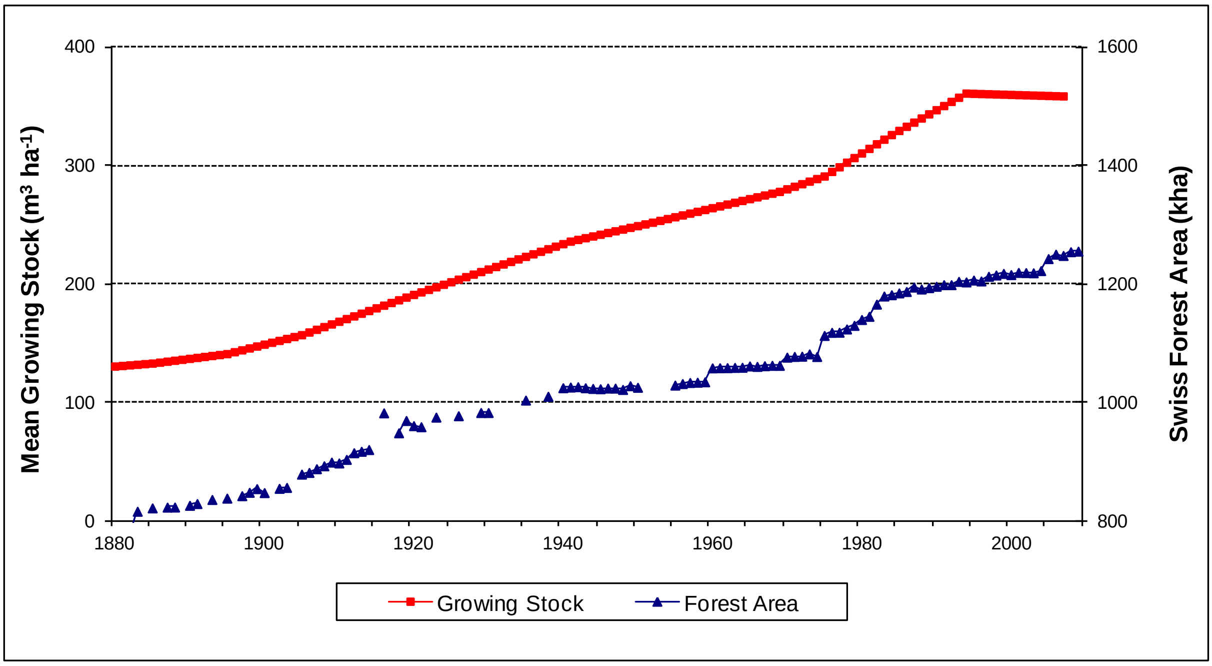

Figure 11-5: Historical mean growing stock and forest area in Switzerland since 1880.

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.

11.6 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 2011. The smallest UNFCCC category, and therefore also the smallest LULUCF category, considered key based on a Tier 2 level assessment is “5C1 LULUCF, Grassland, Grassland remaining Grassland” with a contribution of 135.19 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** (-2'936.20 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 (135.19 Gg CO_2 eq for Tier 2) in the UNFCCC inventory. This activity is associated with the UNFCCC category „Forest Land remaining Forest Land“ (-2'961.48 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 2011.

- **Afforestation and Reforestation** (-32.56 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 (135.19 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 1'025.34 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 2011 (Table 1-9).

- **Deforestation** (233.22 Gg CO_2 eq) is a key category under the Kyoto Protocol because its contribution is higher than the smallest UNFCCC category considered key (135.19 Gg CO_2 eq for Tier 2). The associated UNFCCC category is „Land converted to Settlements" (305.59 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 2011 (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 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.

The user interface is located on the Swiss national 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 these Parties 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 2012 has been submitted to the UNFCCC Secretariat electronically.

By the end of the reporting year 2012 a total balance of 271,521,724 Assigned Amount Units (AAUs) were held in the national registry (Fig. 1), which represents a decrease of approximately 19 million units compared to 2011. From the initial assigned amount of 242,838,402 AAUs, 16,449,802 units have been allocated to companies participating in the Swiss Emissions Trading Scheme in the first commitment period 2008-2012. 11,049,771 of those allocated units and 49,100 CERs have been surrendered by companies by the end of 2012.

56,967,362 Emission Reduction Units (ERUs) were held in the national registry, almost an eightfold increase compared to the previous reporting year. The amount of Certified Emission Reductions (CERs) has more than doubled to 44,312,511 units. A total of 84 AAUs and 750,158 CERs have been voluntarily cancelled in the period from 2008 to 2012.

Table 12-1 Total quantities of Kyoto Protocol units by account type at the end of 2012 (SEF table 4)

Party	Switzerland
Submission year	2013
Reported year	2012
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	237265784	NO	1523682	49100	NO	NO
Entity holding accounts	34083269	56967362	NO	43513253	74930	NO
Article 3.3/3.4 net source cancellation accounts	172587	NO	345431	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	84	NO	NO	750158	NO	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	271521724	56967362	1869113	44312511	74930	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 2012, the Swiss 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 registry makes non-confidential information available to the public via webpage or user-interface.

Non-confidential information is publicly available on the Swiss national 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 "Public reports". The Reports "List of legal entities holding an account in the national registry", "List of installations created in the 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 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 2010 emissions of sectors 1,2,3,4,6 times 5 [t CO_2 equivalent]
242 838 402 x 0.9 = **218 554 562**	54 222 722 x 5 = **271 113 610**

Method 1 results in the lower value.

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 2011” (http://unfccc.int/resource/docs/2012/arr/che.pdf), Switzerland cancelled 345,431 removal units (RMU) for its Afforestation and Reforestation as well as Deforestation activities into its Net Source Cancellation account (ITL notification ID: 1000230245), and subsequently issued 979,764 RMUs for Forest Management in its national registry (ITL notification ID: 1000230342). The transactions took place on 31 August 2012.

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 2013a). 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):
National inventory compiler:
Ms. Anouk Bass (as of 1. July 2012)
anouk.bass@bafu.admin.ch
Phone: +41 31 325 38 90
All other contacts remain unchanged.

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. Changes are marked in bold.

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 Reckenholz-Tänikon research station ART	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	The cooperation arrangement between Liechtenstein and Switzerland has been terminated, as Liechtenstein is now part of the Union Registry of the European Union (EU ETS). The cooperation arrangement included the hosting of Liechtenstein's Registry on Swiss Servers at the Federal Office of Information Technology, Systems and Telecommunication (FOITT). Both National Registries have been maintained as completely independent systems with independent registry administrators. Therefore, it was not necessary for the registry readiness documentation to be updated.
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	<u>Technical Changes</u> The two-person rule introduced on a voluntary basis in 2011 has become mandatory for all accounts by 1 April 2012. The two-factor authentication via text messages (smsTAN), implemented with the update of the registry software to version Seringas™ 5.3, has been activated on 8 March 2012, and has become mandatory for all registry users on 1 October 2012. <u>Administrative Changes</u> Since 1 January 2012, all account holders and users of person holding accounts opened after 1 January 2012, must have an address for service in Switzerland. On 1 October 2012, a minimum age limit (18 years of age) for all account holders and users has been introduced. The National Emissions Trading Registry General Terms and Conditions have been updated accordingly (http://www.bafu.admin.ch/ets-traders). Additional confidential material regarding the changes of security can be made available to reviewers on request.
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): Change of test results	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). 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. SECO's technical assistance for trade promotion amounts to CHF 42 million for the year 2010 (non-reimbursable grant contributions).

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 levies for heating and process fuels are important measures to put a price on emissions of greenhouse gases (see Fifth National Communication for more details), thus reflecting market prices and internalizing externalities.

Fiscal incentives, tax and duty exemptions and subsidies

Fiscal incentives are recognized as an essential instrument 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 have 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. 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 (up to CHF 200 million per year) of the revenues from the CO_2 levy to CO_2 relevant measures in the building sector (Building refurbishment programme).

The economic impact of the Swiss climate policy was analysed in two studies[19]. The impact is considered to be very small.

Switzerland generally does not subsidize fossil fuels. Meanwhile, there are some minor schemes in place that may be regarded as fossil fuel subsidies. In international comparison, however, these schemes are very limited: At the federal level, a few tax exemptions and reductions provide some form of support to users of fossil fuels. Farmers, foresters and fishermen are exempt from the mineral oil tax that is normally levied on sales of mineral oils, while 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 Energy Sector Management Program ESMAP. The Energy Efficiency Governance Handbook has been produced with Swiss financing (IEA/EBRD 2010).

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[19] Ecoplan (2009): Volkswirtschaftliche Auswirkungen der Schweizer Post-Kyoto-Politik, im Auftrag des BAFU. BAFU (2010): Synthesebericht zur Volkswirtschaftlichen Beurteilung der Schweizer Klimapolitik nach 2012.

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 competiveness 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 Fifth National Communication (FOEN 2009d).

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 frame their trade policies in line with multilateral trade agreements. The Swiss State Secretariat for Economic Affairs (SECO) promotes 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 advantage of all the 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 prudent use of natural resource wealth should be an important engine for sustainable economic growth that contributes to sustainable development and poverty reduction, but if not managed properly, can create negative economic and social impacts. 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

There have been no changes in chapter 15 compared to the latest submission.

16 Other Information

This Chapter contains Switzerland's public version of the response to the Saturday Paper (UNFCCC 2012a). Together with this response, Switzerland has also submitted a resubmission of the CRFs to the UNFCCC in November 2012 (FOEN 2012e):

Bonn 24 September 2011

Potential Problems and Further Questions from the ERT formulated in the course of the 2012 review of the greenhouse gas inventories of the Switzerland submitted in 2012.

For the ERT,

Mr. Kiyoto Tanabe,

Lead Reviewer

Mr. Hongwei Yang,

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 2010 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 5 November 2012.

Should Switzerland decide to submit by 5 November 2012, 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 2012 inventory submission, in particular in the year 2010 with respect to:
- N2O emissions from natural gas use for road transportation in the energy sector (1.A.3.b);
- N2O emissions from flaring associated with oil production in the energy sector (1.B.2.c);
- A complete resubmission of the 2012 CRF tables, reflecting the revised estimates;
- Party's revision of the calculation of the commitment period reserve, based on the recalculated emissions reported for 2010, 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 2008-2010

Annex A sources

2012 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
Energy, Transport, Road Transportation, gaseous fuels (1.A.3.b)	N_2O	Non-KC	X		

Description of problem identified:

Switzerland reports N_2O emissions from natural gas combustion for road transportation (1.A.3.b) using the notation key "NO" (not occurring). The ERT notes that Switzerland reported activity data (AD) for 2003-2010 in the CRF tables but it has not provided a justification for reporting "NO" in the NIR. The ERT notes that default N_2O emission factors (EFs) for natural gas combustion for road transportation are available in table 1-8 on page 1.36 of the Revised 1996 IPCC Guidelines.

In response to a question raised by the ERT during the review week, Switzerland acknowledged the missing estimates.

The ERT considers that the omission of N_2O emissions from natural gas use in road transportation is an underestimation of emissions for 2003–2010.

Recommendation by ERT:

The ERT recommends that Switzerland estimate N_2O emissions from natural gas combustion for road transportation for 2003–2010 and provide a description of the AD and EF used.

Switzerland may use country-specific EFs, if they reflect the equipment operated in Switzerland and are properly documented. If country-specific EFs are not available or are not properly documented, Switzerland should use IPCC default EFs provided in table 1-8 on page 1.36 of the Revised 1996 IPCC Guidelines.

Response / Information by Party:

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.

The N_2O emissions from natural gas combustion for road transportation originate from two vehicle categories: Bi-fuel CNG/petrol passenger cars and urban buses running purely on CNG.

Regarding activity data, 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.

Regarding emission factors, 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.

Table 1 shows activity data, emissions, emission factors and implied emission factors for the year 2010. Total emissions from this source category were 0.00564 Gg N_2O in 2010. In 1990, no vehicles in this category existed, therefore no emissions are reported. The complete time series from 2003-2010 is provided in the CRF tables and summarized in table 2 below.

Table 2: Acitivity data, emissions, emission factors and implied emission factors for the year 2010.

N_2O	**Activity data**	**Emissions**	**Emission factor**	**IEF**
	TJ	**t**		**kg/TJ**
Cars	198.56	2.140	0.027 g/km	10.78
Urban bus	180.28	0.872	0.101 g/km	4.84
Tank tourism	331.16	2.632	7.95 g/GJ	7.95
Total 1.A.3.b gaseous fuels	710.00	5.645	7.95 g/GJ	7.95

Table 3: Total N_2O emissions for source category 1.A.3.b Road transportation, gaseous fuels for the entire time series 2003-2010.

N_2O	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1.A.3.b Road transportation	Gg							
Gaseous Fuels	0.000069	0.000207	0.000621	0.000828	0.002138	0.003554	0.004664	0.005645

ATTACHMENT A

Overview of inventory potential problems identified for 2008-2010

Annex A sources

2011 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
Energy, Oil and Natural Gas, Venting and Flaring, Flaring, Oil (1.B.2.c.2.1)	N_2O	Non-KC	X		

Description of problem identified:

Switzerland reports N_2O emissions from flaring associated with oil production (1.B.2.c.2.1) using the notation key "NO" (not occurring). The ERT notes that Switzerland reported activity data (AD) in the CRF tables but it has not provided a justification for reporting "NO" in the NIR. The ERT notes that default emission factors (EFs) for flaring associated with oil production are available in table 2.16 on page 2.86-2.87 of the IPCC good practice guidance.

In response to a question raised by the ERT during the review, Switzerland acknowledged the missing estimates and indicated that it will apply the default EF for this category in its next annual submission.

The ERT considers that the omission of N_2O emissions from flaring associated with oil production is an underestimation of emissions for the entire time series 1990–2010.

Recommendation by ERT:

The ERT recommends that Switzerland estimate N_2O emissions from flaring associated with oil production for the entire time series 1990–2010 and provide a description of the AD and EF used.

Switzerland may use country-specific EFs, if they reflect the equipment operated in Switzerland and are properly documented. If country-specific EFs are not available or are not properly documented, Switzerland should use IPCC default EFs provided in table 2.16 on page 2.86-2.87 of the IPCC good practice guidance.

Response / Information by Party:

Switzerland has no oil production on its national territory. All emissions from source category 1.B.2.c Flaring – Oil result from activities in the two oil refineries. The IPCC does not provide default EFs for N_2O from flaring in oil refineries. However, the ERT clarified in an email received on 22. October 2012 that the default EF for N_2O from flaring in oil production could be used instead.

Based on this default EF, Switzerland estimated the N_2O emissions from flaring, using the crude oil used in the refinery (194.0 PJ in 2010) as activity data. This results in an implied emission factor of 14.81 kg N_2O/PJ.

The N_2O emissions from flaring in source category 1.B.2.c Flaring – Oil amount to

0.00200 Gg in 1990

0.00287 Gg in 2010

Complete time series 1990-2010 are provided in the CRF-tables that were submitted to the UNFCCC on 01.11.2012.

Potential problem unsolved? Rationale:

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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 uncertainty. All main source categories have been disaggregated into sub-sources (e.g. 2A, 2B, 2C etc.) and gases (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6).

For some important sources, an even more detailed level of disaggregation has been used in order to clearly identify and isolate the most important sources.

In the important source category 1A Energy Fuel Combustion sources have been disaggregated further to the level of sub-categories (e.g. 1A1 Fuel Combustion – Energy Industries, 1A2 Fuel Combustion – Manufacturing Industries, etc.) as well as fuels (e.g. gaseous fuels, liquid fuels, etc.). The source Transport (1A3) has been further split into Civil Aviation (1A3a), Road Transportation (1A3b), 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 subcategories. Consumption of Halocarbons and SF_6 (2F) has been split into its subcategories 2F1 to 2F9. Agricultural Soils (4D) have been split into its subcategories 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 2011 without LULUCF categories.

Results of Key Category Analysis Tier 1 – Level and Trend

Table A - 2 Key category analysis Tier 1 2011 (without LULUCF) regarding level and trend.

Tier 1 Key category analysis 2011 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 2011 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	11335.25	9358.64	18.71%	0.02844	6.9%	KC level	KC trend
2	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels		CO2	10248.78	6802.19	13.60%	0.06086	14.8%	KC level	KC trend
3	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel		CO2	2587.68	6348.51	12.69%	0.08272	20.1%	KC level	KC trend
4	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels		CO2	4614.55	2915.76	5.83%	0.03051	7.4%	KC level	KC trend
5	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels		CO2	1519.73	2591.93	5.18%	0.02451	6.0%	KC level	KC trend
6	4A	4. Agriculture	A. Enteric Fermentation				CH4	2635.45	2509.11	5.02%	0.00045	0.1%	KC level	-
7	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Liquid Fuels		CO2	3684.05	2484.54	4.97%	0.02104	5.1%	KC level	KC trend
8	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels		CO2	1409.10	2254.45	4.51%	0.01958	4.8%	KC level	KC trend
9	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Gaseous Fuels		CO2	1046.30	2015.43	4.03%	0.02177	5.3%	KC level	KC trend
10	2A1	2. Industrial Proc	A. Mineral Products; Cement Production-CO2				CO2	2524.77	1903.58	3.81%	0.01017	2.5%	KC level	KC trend
11	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels		CO2	961.96	1312.66	2.62%	0.00857	2.1%	KC level	KC trend
12	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions				N2O	1351.47	1163.25	2.33%	0.00239	0.6%	KC level	KC trend
13	2F1	2. Industrial Proc	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.				HFC	0.02	1046.30	2.09%	0.02216	5.4%	KC level	KC trend
14	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels		CO2	691.39	868.79	1.74%	0.00458	1.1%	KC level	KC trend
15	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions				N2O	822.48	691.74	1.38%	0.00179	0.4%	KC level	KC trend
16	4B	4. Agriculture	B. Manure Management				CH4	671.61	649.83	1.30%	0.00033	0.1%	KC level	-
17	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels		CO2	547.19	526.38	1.05%	0.00021	0.1%	KC level	-
18	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Solid Fuels		CO2	1220.95	514.65	1.03%	0.01351	3.3%	KC level	KC trend
19	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels		CO2	242.32	442.34	0.88%	0.00452	1.1%	KC level	KC trend
20	4B	4. Agriculture	B. Manure Management				N2O	454.68	336.43	0.67%	0.00197	0.5%	KC level	KC trend
21	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Other Fuels		CO2	134.15	321.33	0.64%	0.00412	1.0%	KC level	KC trend
22	4D2	4. Agriculture	D. Agricultural Soils; Pasture, Range and Paddock Manure				N2O	128.10	223.57	0.45%	0.00217	0.5%	KC level	KC trend
23	6B	6. Waste	B. Wastewater Handling				N2O	184.72	211.23	0.42%	0.00078	0.2%	KC level	-
24	2C1	2. Industrial Proc	C. Metal Production; Steel Production				CO2	110.80	185.08	0.37%	0.00170	0.4%	KC level	KC trend
25	6A	6. Waste	A. Solid Waste Disposal on Land				CH4	688.16	180.72	0.36%	0.00993	2.4%	-	KC trend
26	1B2	1. Energy	B. Fugitive Emissions fror	2. Oil and Natural Gas			CH4	380.43	173.32	0.35%	0.00394	1.0%	-	KC trend
27	3	3. Solvent and Other Product Use					CO2	359.98	155.28	0.31%	0.00391	0.9%	-	KC trend
28	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation			CO2	252.55	132.35	0.26%	0.00225	0.5%	-	KC trend
29	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation			CO2	111.88	117.52	0.24%	0.00025	0.1%	-	-
30	2B	2. Industrial Proc	B. Chemical Industry				CO2	109.80	110.55	0.22%	0.00015	0.0%	-	-
31	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels		CO2	203.58	106.92	0.21%	0.00181	0.4%	-	KC trend
32	6D	6. Waste	D. Other				CH4	29.94	105.75	0.21%	0.00164	0.4%	-	KC trend
33	2F9	2. Industrial Proc	F. Consumption of Halocarbons and SF6; Other				SF6	79.58	81.31	0.16%	0.00013	0.0%	-	-
34	2A3	2. Industrial Proc	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2				CO2	103.37	66.87	0.13%	0.00065	0.2%	-	-
35	2F9	2. Industrial Proc	F. Consumption of Halocarbons and SF6; Other				HFC	0.00	64.38	0.13%	0.00136	0.3%	-	-
36	2A2	2. Industrial Proc	A. Mineral Products; Lime Production-CO2				CO2	53.35	56.31	0.11%	0.00013	0.0%	-	-
37	2B	2. Industrial Proc	B. Chemical Industry				N2O	68.13	54.13	0.11%	0.00022	0.1%	-	-
38	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel		N2O	5.84	53.24	0.11%	0.00101	0.2%	-	-
39	1B2	1. Energy	B. Fugitive Emissions fror	2. Oil and Natural Gas			CO2	91.36	52.22	0.10%	0.00072	0.2%	-	-
40	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified			CO2	30.80	46.20	0.09%	0.00036	0.1%	-	-
41	3	3. Solvent and Other Product Use					N2O	110.14	44.15	0.09%	0.00127	0.3%	-	-
42	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline		N2O	137.27	43.85	0.09%	0.00182	0.4%	-	KC trend
43	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels		N2O	20.85	43.57	0.09%	0.00051	0.1%	-	-
44	2F8	2. Industrial Proc	F. Consumption of Halocarbons and SF6; Electrical Eq.				SF6	64.04	43.55	0.09%	0.00036	0.1%	-	-
45	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass		N2O	27.72	42.43	0.08%	0.00034	0.1%	-	-
46	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas		CO2	0.00	39.60	0.08%	0.00084	0.2%	-	-
47	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways			CO2	28.69	38.12	0.08%	0.00023	0.1%	-	-
48	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels		CO2	55.36	34.07	0.07%	0.00039	0.1%	-	-
49	2C	2. Industrial Proc	C. Metal Production; Magnesium Foundries				SF6	0.00	30.28	0.06%	0.00064	0.2%	-	-
50	6C	6. Waste	C. Waste Incineration				N2O	20.10	30.26	0.06%	0.00024	0.1%	-	-
51	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass		CH4	95.89	29.98	0.06%	0.00128	0.3%	-	-
52	4D4	4. Agriculture	D. Agricultural Soils; Use of sewage sludge as fertilizers				N2O	28.30	29.61	0.06%	0.00006	0.0%	-	-
53	6D	6. Waste	D. Other				N2O	5.82	23.96	0.05%	0.00039	0.1%	-	-
54	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline		CH4	101.15	20.95	0.04%	0.00158	0.4%	-	-
55	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels		CO2	40.64	19.10	0.04%	0.00041	0.1%	-	-
56	2F9	2. Industrial Proc	F. Consumption of Halocarbons and SF6; Other				PFC	0.00	18.30	0.04%	0.00039	0.1%	-	-
57	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels		N2O	25.94	17.25	0.03%	0.00015	0.0%	-	-
58	2F4	2. Industrial Proc	F. Consumption of Halocarbons and SF6; Metered Dose Inhalers and Other				HFC	0.00	16.94	0.03%	0.00036	0.1%	-	-
59	2F2	2. Industrial Proc	F. Consumption of Halocarbons and SF6; Hard Foam				HFC	0.00	13.43	0.03%	0.00028	0.1%	-	-
60	7	7. Other					CO2	10.96	13.03	0.03%	0.00006	0.0%	-	-
61	6C	6. Waste	C. Waste Incineration				CH4	14.25	12.71	0.03%	0.00002	0.0%	-	-
62	6C	6. Waste	C. Waste Incineration				CO2	54.10	12.34	0.02%	0.00082	0.2%	-	-
63	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Liquid Fuels		N2O	14.61	11.75	0.02%	0.00004	0.0%	-	-
64	6B	6. Waste	B. Wastewater Handling				CH4	4.65	10.02	0.02%	0.00012	0.0%	-	-
65	2F7	2. Industrial Proc	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture				SF6	0.00	9.23	0.02%	0.00020	0.0%	-	-
66	2B	1. Industrial Proc	B. Chemical Industry				CH4	9.63	8.61	0.02%	0.00001	0.0%	-	-
67	2F7	2. Industrial Proc	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture				PFC	0.00	8.18	0.02%	0.00017	0.0%	-	-
68	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass		N2O	10.64	8.14	0.02%	0.00004	0.0%	-	-
69	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels		N2O	11.72	7.48	0.01%	0.00008	0.0%	-	-
70	2A7	2. Industrial Proc	A. Mineral Products; Other non-specified-CO2				CO2	15.30	6.59	0.01%	0.00017	0.0%	-	-
71	2F1	2. Industrial Proc	F. Consumption of Halocarbons and SF6; Refrigeration				PFC	0.04	6.58	0.01%	0.00014	0.0%	-	-
72	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Biomass		N2O	1.68	6.39	0.01%	0.00010	0.0%	-	-
73	2F5	2. Industrial Proc	F. Consumption of Halocarbons and SF6; Solvents				PFC	0.00	6.26	0.01%	0.00013	0.0%	-	-
74	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Other Fuels		N2O	2.28	5.81	0.01%	0.00008	0.0%	-	-
75	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels		CH4	3.26	5.32	0.01%	0.00005	0.0%	-	-
76	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels		N2O	4.97	5.30	0.01%	0.00001	0.0%	-	-
77	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Gaseous Fuels		CH4	2.65	4.64	0.01%	0.00005	0.0%	-	-
78	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass		CH4	9.74	3.72	0.01%	0.00012	0.0%	-	-
79	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels		CH4	2.40	3.53	0.01%	0.00003	0.0%	-	-

Table A - 2 continued. Key category analysis Tier 1 2011 (without LULUCF) regarding level and trend.

Tier 1 Key category analysis 2011 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 2011 Estimate [Gg CO2 eq]	Level Assessm	Trend Assessm	% Contrib. in Trend	Result level Assessm	Result trend Assessm
80	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	3.06	0.01%	0.00002	0.0%	-	-
81	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	1.45	2.83	0.01%	0.00003	0.0%	-	-
82	2F5	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Solvents			HFC	0.00	2.73	0.01%	0.00006	0.0%	-	-
83	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Solid Fuels	N2O	6.44	2.70	0.01%	0.00007	0.0%	-	-
84	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.71	2.28	0.00%	0.00003	0.0%	-	-
85	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	6.00	2.09	0.00%	0.00008	0.0%	-	-
86	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	N2O	0.00	1.87	0.00%	0.00004	0.0%	-	-
87	2C5	2. Industrial Pro	C. Metal Production; Non-ferrous metals-CO2			CO2	1.65	1.55	0.00%	0.00000	0.0%	-	-
88	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Biomass	CH4	2.46	1.49	0.00%	0.00002	0.0%	-	-
89	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.62	1.36	0.00%	0.00000	0.0%	-	-
90	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	3.06	1.35	0.00%	0.00003	0.0%	-	-
91	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.49	1.30	0.00%	0.00002	0.0%	-	-
92	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.27	0.00%	0.00001	0.0%	-	-
93	2G	2. Industrial Pro	G. Other			CO2	1.04	1.15	0.00%	0.00000	0.0%	-	-
94	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Gaseous Fuels	N2O	0.58	1.13	0.00%	0.00001	0.0%	-	-
95	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	2.01	1.06	0.00%	0.00002	0.0%	-	-
96	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.56	1.01	0.00%	0.00001	0.0%	-	-
97	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Liquid Fuels	CH4	2.32	0.98	0.00%	0.00003	0.0%	-	-
98	1B2	1. Energy	B. Fugitive Emissions fror	2. Oil and Natural Gas		N2O	0.62	0.87	0.00%	0.00001	0.0%	-	-
99	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	N2O	0.66	0.79	0.00%	0.00000	0.0%	-	-
100	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.54	0.74	0.00%	0.00000	0.0%	-	-
101	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.65	0.00%	0.00000	0.0%	-	-
102	7	7. Other				N2O	0.62	0.62	0.00%	0.00000	0.0%	-	-
103	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.36	0.62	0.00%	0.00001	0.0%	-	-
104	7	7. Other				CH4	0.55	0.58	0.00%	0.00000	0.0%	-	-
105	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	N2O	0.60	0.53	0.00%	0.00000	0.0%	-	-
106	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	CH4	0.58	0.51	0.00%	0.00000	0.0%	-	-
107	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	N2O	0.38	0.49	0.00%	0.00000	0.0%	-	-
108	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.35	0.00%	0.00001	0.0%	-	-
109	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Biomass	N2O	0.21	0.29	0.00%	0.00000	0.0%	-	-
110	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.31	0.28	0.00%	0.00000	0.0%	-	-
111	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.26	0.00%	0.00000	0.0%	-	-
112	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.14	0.25	0.00%	0.00000	0.0%	-	-
113	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.29	0.18	0.00%	0.00000	0.0%	-	-
114	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Solid Fuels	CH4	0.40	0.16	0.00%	0.00000	0.0%	-	-
115	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Biomass	CH4	0.80	0.14	0.00%	0.00001	0.0%	-	-
116	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.16	0.11	0.00%	0.00000	0.0%	-	-
117	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	CH4	0.00	0.05	0.00%	0.00000	0.0%	-	-
118	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.04	0.00%	0.00000	0.0%	-	-
119	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CH4	0.06	0.04	0.00%	0.00000	0.0%	-	-
120	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		N2O	0.02	0.03	0.00%	0.00000	0.0%	-	-
121	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.02	0.00%	0.00000	0.0%	-	-
122	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	CH4	0.01	0.02	0.00%	0.00000	0.0%	-	-
123	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.02	0.01	0.00%	0.00000	0.0%	-	-
124	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	CH4	0.01	0.01	0.00%	0.00000	0.0%	-	-
125	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	45.47	0.00	0.00%	0.00000	0.0%	-	-
126	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.00	0.00%	0.00000	0.0%	-	-
127	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.24	0.00	0.00%	0.00000	0.0%	-	-
128	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constructi	Other Fuels	CH4	0.00	0.00	0.00%	0.00000	0.0%	-	-
129	2C	2. Industrial Pro	C. Metal Production; Aluminium Foundries			SF6	0.00	0.00	0.00%	0.00000	0.0%	-	-
130	2C3	2. Industrial Pro	C. Metal Production; Aluminium Production-CO2			CO2	139.26	0.00	0.00%	0.00000	0.0%	-	-
131	2C3	2. Industrial Pro	C. Metal Production; Aluminium Production-PFC			PFC	100.17	0.00	0.00%	0.00000	0.0%	-	-
132	6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.24	0.00	0.00%	0.00000	0.0%	-	-
133	6D	6. Waste	D. Other			CO2	0.00	0.00	0.00%	0.00000	0.0%	-	-

A1.3 KCA Tier 1 2011 including LULUCF categories

Results of Key Category Analysis Tier 1 – Level and Trend

Table A - 3 Key category analysis Tier 1 2011 (with LULUCF) regarding level and trend.

Tier 1 Key category analysis 2011 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 2011 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	11335.25	9358.64	17.00%	0.02578	6.6%	KC level	KC trend
2	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.78	6802.19	12.36%	0.05525	14.2%	KC level	KC trend
3	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2587.68	6348.51	11.53%	0.07518	19.4%	KC level	KC trend
4	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	3018.12	2961.48	5.38%	0.00218	0.6%	KC level	KC trend
5	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institut	Liquid Fuels	CO2	4614.55	2915.76	5.30%	0.02770	7.1%	KC level	KC trend
6	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1519.73	2591.93	4.71%	0.02228	5.7%	KC level	KC trend
7	4A	4. Agricultu	A. Enteric Fermentation			CH4	2635.45	2509.11	4.56%	0.00042	0.1%	KC level	-
8	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Liquid Fuels	CO2	3684.05	2484.54	4.51%	0.01910	4.9%	KC level	KC trend
9	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1409.10	2254.45	4.10%	0.01779	4.6%	KC level	KC trend
10	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Gaseous Fuels	CO2	1046.30	2015.43	3.66%	0.01978	5.1%	KC level	KC trend
11	2A1	2. Industrial	A. Mineral Products; Cement Production-CO2			CO2	2524.77	1903.58	3.46%	0.00922	2.4%	KC level	KC trend
12	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institut	Gaseous Fuels	CO2	961.96	1312.66	2.38%	0.00779	2.0%	KC level	KC trend
13	4D1	4. Agricultu	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.47	1163.25	2.11%	0.00216	0.6%	KC level	KC trend
14	2F1	2. Industrial	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	1046.30	1.90%	0.02014	5.2%	KC level	KC trend
15	5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO2	1236.12	1025.34	1.86%	0.00272	0.7%	KC level	KC trend
16	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.39	868.79	1.58%	0.00416	1.1%	KC level	KC trend
17	4D3	4. Agricultu	D. Agricultural Soils; Indirect Emissions			N2O	822.48	691.74	1.26%	0.00163	0.4%	KC level	KC trend
18	4B	4. Agricultu	B. Manure Management			CH4	671.61	649.83	1.18%	0.00031	0.1%	KC level	-
19	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	547.19	526.38	0.96%	0.00019	0.0%	KC level	-
20	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Solid Fuels	CO2	1220.95	514.65	0.93%	0.01227	3.2%	KC level	KC trend
21	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	242.32	442.34	0.80%	0.00411	1.1%	KC level	KC trend
22	4B	4. Agricultu	B. Manure Management			N2O	454.68	336.43	0.61%	0.00178	0.5%	KC level	KC trend
23	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Other Fuels	CO2	134.15	321.33	0.58%	0.00375	1.0%	KC level	KC trend
24	5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	390.23	305.59	0.56%	0.00121	0.3%	KC level	KC trend
25	5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	346.67	232.92	0.42%	0.00181	0.5%	KC level	KC trend
26	4D2	4. Agricultu	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	223.57	0.41%	0.00198	0.5%	KC level	KC trend
27	6B	6. Waste	B. Wastewater Handling			N2O	184.72	211.23	0.38%	0.00071	0.2%	KC level	-
28	5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO2	66.41	190.66	0.35%	0.00246	0.6%	KC level	KC trend
29	2C1	2. Industrial	C. Metal Production; Steel Production			CO2	110.80	185.08	0.34%	0.00155	0.4%	KC level	KC trend
30	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	180.72	0.33%	0.00902	2.3%	-	KC trend
31	1B2	1. Energy	B. Fugitive Emissions fro	2. Oil and Natural Gas		CH4	380.43	173.32	0.31%	0.00357	0.9%	-	KC trend
32	3	3. Solvent and Other Product Use				CO2	359.98	155.28	0.28%	0.00355	0.9%	-	KC trend
33	5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	97.65	135.19	0.25%	0.00083	0.2%	-	-
34	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	132.35	0.24%	0.00204	0.5%	-	KC trend
35	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	111.88	117.52	0.21%	0.00023	0.1%	-	-
36	5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land		CO2	95.63	113.35	0.21%	0.00044	0.1%	-	-
37	2B	2. Industrial	B. Chemical Industry			CO2	109.80	110.55	0.20%	0.00013	0.0%	-	-
38	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	203.58	106.92	0.19%	0.00164	0.4%	-	KC trend
39	6D	6. Waste	D. Other			CH4	29.94	105.75	0.19%	0.00149	0.4%	-	KC trend
40	2F9	2. Industrial	F. Consumption of Halocarbons and SF6; Other			SF6	79.58	81.31	0.15%	0.00012	0.0%	-	-
41	2A3	2. Industrial	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2			CO2	103.37	66.87	0.12%	0.00059	0.2%	-	-
42	2F9	2. Industrial	F. Consumption of Halocarbons and SF6; Other			HFC	0.00	64.38	0.12%	0.00124	0.3%	-	KC trend
43	2A2	2. Industrial	A. Mineral Products; Lime Production-CO2			CO2	53.35	56.31	0.10%	0.00011	0.0%	-	-
44	2B	2. Industrial	B. Chemical Industry			N2O	68.13	54.13	0.10%	0.00020	0.1%	-	-
45	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	5.84	53.24	0.10%	0.00092	0.2%	-	-
46	1B2	1. Energy	B. Fugitive Emissions fro	2. Oil and Natural Gas		CO2	91.36	52.22	0.09%	0.00065	0.2%	-	-
47	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CO2	30.80	46.20	0.08%	0.00033	0.1%	-	-
48	3	3. Solvent and Other Product Use				N2O	110.14	44.15	0.08%	0.00115	0.3%	-	-
49	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	137.27	43.85	0.08%	0.00165	0.4%	-	KC trend
50	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	20.85	43.57	0.08%	0.00046	0.1%	-	-
51	2F8	2. Industrial	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	43.55	0.08%	0.00033	0.1%	-	-
52	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	27.72	42.43	0.08%	0.00031	0.1%	-	-
53	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	CO2	0.00	39.60	0.07%	0.00076	0.2%	-	-
54	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	28.69	38.12	0.07%	0.00021	0.1%	-	-
55	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	55.36	34.07	0.06%	0.00035	0.1%	-	-
56	5E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements		CO2	0.91	32.22	0.06%	0.00060	0.2%	-	-
57	2C	2. Industrial	C. Metal Production; Magnesium Foundries			SF6	0.00	30.28	0.06%	0.00058	0.2%	-	-
58	6C	6. Waste	C. Waste Incineration			N2O	20.10	30.26	0.05%	0.00022	0.1%	-	-
59	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	95.89	29.98	0.05%	0.00116	0.3%	-	-
60	5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands		CO2	21.54	29.74	0.05%	0.00018	0.0%	-	-
61	4D4	4. Agricultu	D. Agricultural Soils; Use of sewage sludge as fertilizers			N2O	28.30	29.61	0.05%	0.00006	0.0%	-	-
62	6D	6. Waste	D. Other			N2O	5.82	23.96	0.04%	0.00036	0.1%	-	-
63	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	101.15	20.95	0.04%	0.00143	0.4%	-	KC trend
64	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	40.64	19.10	0.03%	0.00037	0.1%	-	-
65	2F9	2. Industrial	F. Consumption of Halocarbons and SF6; Other			PFC	0.00	18.30	0.03%	0.00035	0.1%	-	-
66	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.94	17.25	0.03%	0.00014	0.0%	-	-
67	2F4	2. Industrial	F. Consumption of Halocarbons and SF6; Metered Dose Inhalers and Other			HFC	0.00	16.94	0.03%	0.00033	0.1%	-	-
68	2F2	2. Industrial	F. Consumption of Halocarbons and SF6; Hard Foam			HFC	0.00	13.43	0.02%	0.00026	0.1%	-	-
69	7	7. Other				CO2	10.96	13.03	0.02%	0.00005	0.0%	-	-
70	6C	6. Waste	C. Waste Incineration			CH4	14.25	12.71	0.02%	0.00001	0.0%	-	-
71	6C	6. Waste	C. Waste Incineration			CO2	54.10	12.34	0.02%	0.00075	0.2%	-	-
72	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Liquid Fuels	N2O	14.61	11.75	0.02%	0.00004	0.0%	-	-
73	6B	6. Waste	B. Wastewater Handling			CH4	4.65	10.02	0.02%	0.00011	0.0%	-	-
74	2F7	2. Industrial	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture			SF6	0.00	9.23	0.02%	0.00018	0.0%	-	-
75	2B	1. Industrial	B. Chemical Industry			CH4	9.63	8.61	0.02%	0.00001	0.0%	-	-
76	2F7	2. Industrial	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture			PFC	0.00	8.18	0.01%	0.00016	0.0%	-	-
77	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.64	8.14	0.01%	0.00004	0.0%	-	-
78	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institut	Liquid Fuels	N2O	11.72	7.48	0.01%	0.00007	0.0%	-	-
79	5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO2	38.65	6.76	0.01%	0.00057	0.1%	-	-

Table A – 3 continued. Key category analysis Tier 1 2011 (with LULUCF) regarding level and trend.

Tier 1 Key category analysis 2011 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 2011 Estimate [Gg CO2 eq]	Level Assessm	Trend Assessm	% Contrib. in Trend	Result level Assessm	Result trend Assessm
80	2A7	2. Industrial	A. Mineral Products; Other non-specified-CO2			CO2	15.30	6.59	0.01%	0.00015	0.0%	-	-
81	2F1	2. Industrial	F. Consumption of Halocarbons and SF6; Refrigeration			PFC	0.04	6.58	0.01%	0.00013	0.0%	-	-
82	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Biomass	N2O	1.68	6.39	0.01%	0.00009	0.0%	-	-
83	2F5	2. Industrial	F. Consumption of Halocarbons and SF6; Solvents			PFC	0.00	6.26	0.01%	0.00012	0.0%	-	-
84	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Other Fuels	N2O	2.28	5.81	0.01%	0.00007	0.0%	-	-
85	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.26	5.32	0.01%	0.00004	0.0%	-	-
86	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	4.97	5.30	0.01%	0.00001	0.0%	-	-
87	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Gaseous Fuels	CH4	2.65	4.64	0.01%	0.00004	0.0%	-	-
88	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	Biomass Burnin	CO2	25.36	3.84	0.01%	0.00039	0.1%	-	-
89	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institut	Biomass	CH4	9.74	3.72	0.01%	0.00011	0.0%	-	-
90	5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		N2O	5.58	3.66	0.01%	0.00003	0.0%	-	-
91	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institut	Gaseous Fuels	CH4	2.40	3.53	0.01%	0.00002	0.0%	-	-
92	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	3.06	0.01%	0.00002	0.0%	-	-
93	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institut	Biomass	N2O	1.45	2.83	0.01%	0.00003	0.0%	-	-
94	2F5	2. Industrial	F. Consumption of Halocarbons and SF6; Solvents			HFC	0.00	2.73	0.00%	0.00005	0.0%	-	-
95	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Solid Fuels	N2O	6.44	2.70	0.00%	0.00007	0.0%	-	-
96	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.71	2.28	0.00%	0.00002	0.0%	-	-
97	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	6.00	2.09	0.00%	0.00007	0.0%	-	-
98	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	N2O	0.00	1.87	0.00%	0.00004	0.0%	-	-
99	2C5	2. Industrial	C. Metal Production; Non-ferrous metals-CO2			CO2	1.65	1.55	0.00%	0.00000	0.0%	-	-
100	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Biomass	CH4	2.46	1.49	0.00%	0.00002	0.0%	-	-
101	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.62	1.36	0.00%	0.00000	0.0%	-	-
102	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institut	Liquid Fuels	CH4	3.06	1.35	0.00%	0.00003	0.0%	-	-
103	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.49	1.30	0.00%	0.00002	0.0%	-	-
104	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.27	0.00%	0.00001	0.0%	-	-
105	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CH4	8.19	1.24	0.00%	0.00012	0.0%	-	-
106	2G	2. Industrial	G. Other			CO2	1.04	1.15	0.00%	0.00000	0.0%	-	-
107	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Gaseous Fuels	N2O	0.58	1.13	0.00%	0.00001	0.0%	-	-
108	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	2.01	1.06	0.00%	0.00002	0.0%	-	-
109	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.56	1.01	0.00%	0.00001	0.0%	-	-
110	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Liquid Fuels	CH4	2.32	0.98	0.00%	0.00002	0.0%	-	-
111	1B2	1. Energy	B. Fugitive Emissions fro	2. Oil and Natural Gas		N2O	0.62	0.87	0.00%	0.00001	0.0%	-	-
112	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	N2O	0.66	0.79	0.00%	0.00000	0.0%	-	-
113	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institut	Gaseous Fuels	N2O	0.54	0.74	0.00%	0.00000	0.0%	-	-
114	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		N2O	4.77	0.71	0.00%	0.00007	0.0%	-	-
115	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.65	0.00%	0.00000	0.0%	-	-
116	5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands		CO2	3.00	0.65	0.00%	0.00004	0.0%	-	-
117	7	7. Other				N2O	0.62	0.62	0.00%	0.00000	0.0%	-	-
118	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.36	0.62	0.00%	0.00001	0.0%	-	-
119	7	7. Other				CH4	0.55	0.58	0.00%	0.00000	0.0%	-	-
120	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	N2O	0.60	0.53	0.00%	0.00000	0.0%	-	-
121	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	CH4	0.58	0.51	0.00%	0.00000	0.0%	-	-
122	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	N2O	0.38	0.49	0.00%	0.00000	0.0%	-	-
123	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.35	0.00%	0.00001	0.0%	-	-
124	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Biomass	N2O	0.21	0.29	0.00%	0.00000	0.0%	-	-
125	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.31	0.28	0.00%	0.00000	0.0%	-	-
126	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.26	0.00%	0.00000	0.0%	-	-
127	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.14	0.25	0.00%	0.00000	0.0%	-	-
128	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.29	0.18	0.00%	0.00000	0.0%	-	-
129	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Solid Fuels	CH4	0.40	0.16	0.00%	0.00000	0.0%	-	-
130	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Biomass	CH4	0.80	0.14	0.00%	0.00001	0.0%	-	-
131	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.16	0.11	0.00%	0.00000	0.0%	-	-
132	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	CH4	0.00	0.05	0.00%	0.00000	0.0%	-	-
133	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.04	0.00%	0.00000	0.0%	-	-
134	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CH4	0.06	0.04	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	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.02	0.00%	0.00000	0.0%	-	-
137	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	CH4	0.01	0.02	0.00%	0.00000	0.0%	-	-
138	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.02	0.01	0.00%	0.00000	0.0%	-	-
139	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	CH4	0.01	0.01	0.00%	0.00000	0.0%	-	-
140	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	45.47	0.00	0.00%	0.00000	0.0%	-	-
141	2C3	2. Industrial	C. Metal Production; Aluminium Production-CO2			CO2	139.26	0.00	0.00%	0.00000	0.0%	-	-
142	6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.24	0.00	0.00%	0.00000	0.0%	-	-
143	6D	6. Waste	D. Other			CO2	0.00	0.00	0.00%	0.00000	0.0%	-	-
144	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.00	0.00%	0.00000	0.0%	-	-
145	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Cons	Other Fuels	CH4	0.00	0.00	0.00%	0.00000	0.0%	-	-
146	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.24	0.00	0.00%	0.00000	0.0%	-	-
147	2C3	2. Industrial	C. Metal Production; Aluminium Production-PFC			PFC	100.17	0.00	0.00%	0.00000	0.0%	-	-
148	2C	2. Industrial	C. Metal Production; Aluminium Foundries			SF6	0.00	0.00	0.00%	0.00000	0.0%	-	-
149	6D	6. Waste	D. Other			CO2	0.00	0.00	0.00%	0.00000	0.0%	-	-

A1.4 KCA Tier 2 2011 without LULUCF categories.

Results of Key Category Analysis Tier 2 – Level and Trend

Table A - 4 Key category analysis Tier 2 2011 (without LULUCF) regarding level and trend.

Tier 2 Key category analysis 2011 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 2011 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	691.74	2.19%	0.00284	5.2%	KC level	KC trend
2	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.47	1163.25	1.77%	0.00182	3.3%	KC level	KC trend
3	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1519.73	2591.93	1.64%	0.00775	14.1%	KC level	KC trend
4	2A1	2. Industrial Pro	A. Mineral Products; Cement Production-CO2			CO2	2524.77	1903.58	1.52%	0.00407	7.4%	KC level	KC trend
5	4A	4. Agriculture	A. Enteric Fermentation			CH4	2635.45	2509.11	0.91%	0.00008	0.1%	KC level	-
6	4B	4. Agriculture	B. Manure Management			CH4	671.61	649.83	0.71%	0.00018	0.3%	KC level	-
7	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportati	Gasoline	CO2	11335.25	9358.64	0.48%	0.00073	1.3%	KC level	KC trend
8	4B	4. Agriculture	B. Manure Management			N2O	454.68	336.43	0.42%	0.00123	2.2%	KC level	KC trend
9	4D2	4. Agriculture	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	223.57	0.41%	0.00201	3.7%	KC level	KC trend
10	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportati	Diesel	CO2	2587.68	6348.51	0.28%	0.00185	3.4%	KC level	KC trend
11	2F1	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	1046.30	0.25%	0.00266	4.8%	KC level	KC trend
12	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1409.10	2254.45	0.23%	0.00098	1.8%	KC level	KC trend
13	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.78	6802.19	0.22%	0.00100	1.8%	KC level	KC trend
14	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Solid Fuels	CO2	1220.95	514.65	0.21%	0.00282	5.1%	KC level	KC trend
15	6D	6. Waste	D. Other			CH4	29.94	105.75	0.21%	0.00165	3.0%	KC level	KC trend
16	6B	6. Waste	B. Wastewater Handling			N2O	184.72	211.23	0.21%	0.00039	0.7%	KC level	-
17	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	180.72	0.21%	0.00579	10.5%	KC level	KC trend
18	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Other Fuels	CO2	134.15	321.33	0.20%	0.00130	2.4%	KC level	KC trend
19	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Gaseous Fuels	CO2	1046.30	2015.43	0.20%	0.00109	2.0%	KC level	KC trend
20	1B2	1. Energy	B. Fugitive Emissions from F	2. Oil and Natural Gas		CH4	380.43	173.32	0.17%	0.00197	3.6%	KC level	KC trend
21	3	3. Solvent and Other Product Use				CO2	359.98	155.28	0.16%	0.00195	3.6%	KC level	KC trend
22	2C1	2. Industrial Pro	C. Metal Production; Steel Production			CO2	110.80	185.08	0.15%	0.00069	1.3%	KC level	KC trend
23	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/In	Gaseous Fuels	CO2	961.96	1312.66	0.13%	0.00043	0.8%	KC level	KC trend
24	2F9	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Other			SF6	79.58	81.31	0.13%	0.00010	0.2%	-	-
25	2F9	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Other			HFC	0.00	64.38	0.10%	0.00109	2.0%	-	KC trend
26	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/In	Liquid Fuels	CO2	4614.55	2915.76	0.10%	0.00050	0.9%	-	KC trend
27	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Liquid Fuels	CO2	3684.05	2484.54	0.08%	0.00035	0.6%	-	-
28	3	3. Solvent and Other Product Use				N2O	110.14	44.15	0.07%	0.00101	1.8%	-	KC trend
29	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	20.85	43.57	0.07%	0.00040	0.7%	-	-
30	2A3	2. Industrial Pro	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2			CO2	103.37	66.87	0.07%	0.00033	0.6%	-	-
31	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	27.72	42.43	0.07%	0.00028	0.5%	-	-
32	4D4	4. Agriculture	D. Agricultural Soils; Use of sewage sludge as fertilizers			N2O	28.30	29.61	0.05%	0.00005	0.1%	-	-
33	2B	2. Industrial Pro	B. Chemical Industry			N2O	68.13	54.13	0.04%	0.00009	0.2%	-	-
34	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	242.32	442.34	0.04%	0.00023	0.4%	-	-
35	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportati	Gasoline	N2O	137.27	43.85	0.04%	0.00091	1.7%	-	KC trend
36	6D	6. Waste	D. Other			N2O	5.82	23.96	0.04%	0.00031	0.6%	-	-
37	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	95.89	29.98	0.04%	0.00082	1.5%	-	KC trend
38	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.39	868.79	0.03%	0.00008	0.1%	-	-
39	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.94	17.25	0.03%	0.00012	0.2%	-	-
40	6C	6. Waste	C. Waste Incineration			N2O	20.10	30.26	0.02%	0.00010	0.2%	-	-
41	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportati	Diesel	N2O	5.84	53.24	0.02%	0.00022	0.4%	-	-
42	2B	2. Industrial Pro	B. Chemical Industry			CO2	109.80	110.55	0.02%	0.00001	0.0%	-	-
43	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Liquid Fuels	N2O	14.61	11.75	0.02%	0.00003	0.1%	-	-
44	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fo	Liquid Fuels	CO2	547.19	526.38	0.02%	0.00000	0.0%	-	-
45	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportati	Gasoline	CH4	101.15	20.95	0.02%	0.00059	1.1%	-	KC trend
46	6C	6. Waste	C. Waste Incineration			CH4	14.25	12.71	0.02%	0.00001	0.0%	-	-
47	2F9	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Other			PFC	0.00	18.30	0.01%	0.00016	0.3%	-	-
48	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	55.36	34.07	0.01%	0.00008	0.1%	-	-
49	2F2	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Hard Foam			HFC	0.00	13.43	0.01%	0.00014	0.3%	-	-
50	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.64	8.14	0.01%	0.00003	0.1%	-	-
51	2C	2. Industrial Pro	C. Metal Production; Magnesium Foundries			SF6	0.00	30.28	0.01%	0.00013	0.2%	-	-
52	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/In	Liquid Fuels	N2O	11.72	7.48	0.01%	0.00006	0.1%	-	-
53	1B2	1. Energy	B. Fugitive Emissions from F	2. Oil and Natural Gas		CO2	91.36	52.22	0.01%	0.00007	0.1%	-	-
54	7	7. Other				CO2	10.96	13.03	0.01%	0.00002	0.0%	-	-
55	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Biomass	N2O	1.68	6.39	0.01%	0.00008	0.1%	-	-
56	6C	6. Waste	C. Waste Incineration			CO2	54.10	12.34	0.01%	0.00033	0.6%	-	-
57	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Other Fuels	N2O	2.28	5.81	0.01%	0.00006	0.1%	-	-
58	2F8	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	43.55	0.01%	0.00004	0.1%	-	-
59	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fo	Liquid Fuels	N2O	4.97	5.30	0.01%	0.00001	0.0%	-	-
60	2F7	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture			SF6	0.00	9.23	0.01%	0.00008	0.1%	-	-
61	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	132.35	0.01%	0.00006	0.1%	-	-
62	2F7	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture			PFC	0.00	8.18	0.01%	0.00007	0.1%	-	-
63	6B	6. Waste	B. Wastewater Handling			CH4	4.65	10.02	0.01%	0.00004	0.1%	-	-
64	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	111.88	117.52	0.01%	0.00001	0.0%	-	-
65	2B	1. Industrial Pro	B. Chemical Industry			CH4	9.63	8.61	0.01%	0.00000	0.0%	-	-
66	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	3.06	0.00%	0.00002	0.0%	-	-
67	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CO2	30.80	46.20	0.00%	0.00002	0.0%	-	-
68	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/In	Biomass	N2O	1.45	2.83	0.00%	0.00002	0.0%	-	-
69	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Solid Fuels	N2O	6.44	2.70	0.00%	0.00006	0.1%	-	-
70	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportati	Natural Gas	CO2	0.00	39.60	0.00%	0.00004	0.1%	-	-
71	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.49	1.30	0.00%	0.00003	0.1%	-	-
72	2F4	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Metered Dose Inhalers and Other			HFC	0.00	16.94	0.00%	0.00004	0.1%	-	-
73	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	203.58	106.92	0.00%	0.00003	0.1%	-	-
74	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.26	5.32	0.00%	0.00001	0.0%	-	-
75	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	2.01	1.06	0.00%	0.00003	0.0%	-	-
76	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportati	Natural Gas	N2O	0.00	1.87	0.00%	0.00003	0.1%	-	-
77	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Gaseous Fuels	CH4	2.65	4.64	0.00%	0.00001	0.0%	-	-
78	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	N2O	0.66	0.79	0.00%	0.00001	0.0%	-	-
79	2A2	2. Industrial Pro	A. Mineral Products; Lime Production-CO2			CO2	53.35	56.31	0.00%	0.00000	0.0%	-	-

Table A – 4 continued. Key category analysis Tier 2 2011 (without LULUCF) regarding level and trend.

Tier 2 Key category analysis 2011 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 2011 Estimate [Gg CO2 eq]	Level Assessm. with Uncertainty	Trend Assessm. with Uncertainty	% Contrib. in Trend	Result level assessm	Result trend assessm
80	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/In	Biomass	CH4	9.74	3.72	0.00%	0.00003	0.1%	-	-
81	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/In	Gaseous Fuels	CH4	2.40	3.53	0.00%	0.00001	0.0%	-	-
82	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.27	0.00%	0.00001	0.0%	-	-
83	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fo	Gaseous Fuels	CO2	40.64	19.10	0.00%	0.00002	0.0%	-	-
84	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Gaseous Fuels	N2O	0.58	1.13	0.00%	0.00001	0.0%	-	-
85	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	28.69	38.12	0.00%	0.00001	0.0%	-	-
86	2F1	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Refrigeration			PFC	0.04	6.58	0.00%	0.00002	0.0%	-	-
87	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	N2O	0.60	0.53	0.00%	0.00000	0.0%	-	-
88	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	N2O	0.38	0.49	0.00%	0.00000	0.0%	-	-
89	1B2	1. Energy	B. Fugitive Emissions from F	2. Oil and Natural Gas		N2O	0.62	0.87	0.00%	0.00000	0.0%	-	-
90	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.71	2.28	0.00%	0.00001	0.0%	-	-
91	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	6.00	2.09	0.00%	0.00002	0.0%	-	-
92	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/In	Gaseous Fuels	N2O	0.54	0.74	0.00%	0.00000	0.0%	-	-
93	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatio	Biomass	N2O	0.00	0.35	0.00%	0.00001	0.0%	-	-
94	7	7. Other				N2O	0.62	0.62	0.00%	0.00000	0.0%	-	-
95	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Biomass	CH4	2.46	1.49	0.00%	0.00001	0.0%	-	-
96	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fo	Liquid Fuels	CH4	1.62	1.36	0.00%	0.00000	0.0%	-	-
97	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/In	Liquid Fuels	CH4	3.06	1.35	0.00%	0.00001	0.0%	-	-
98	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.56	1.01	0.00%	0.00000	0.0%	-	-
99	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Liquid Fuels	CH4	2.32	0.98	0.00%	0.00001	0.0%	-	-
100	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fo	Biomass	N2O	0.21	0.29	0.00%	0.00000	0.0%	-	-
101	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.14	0.25	0.00%	0.00000	0.0%	-	-
102	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.65	0.00%	0.00000	0.0%	-	-
103	7	7. Other				CH4	0.55	0.58	0.00%	0.00000	0.0%	-	-
104	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.26	0.00%	0.00000	0.0%	-	-
105	2C5	2. Industrial Pro	C. Metal Production; Non-ferrous metals-CO2			CO2	1.65	1.55	0.00%	0.00000	0.0%	-	-
106	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	CH4	0.58	0.51	0.00%	0.00000	0.0%	-	-
107	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.29	0.18	0.00%	0.00000	0.0%	-	-
108	2A7	2. Industrial Pro	A. Mineral Products; Other non-specified-CO2			CO2	15.30	6.59	0.00%	0.00000	0.0%	-	-
109	2F5	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Solvents			PFC	0.00	6.26	0.00%	0.00000	0.0%	-	-
110	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatio	Diesel	CH4	1.36	0.62	0.00%	0.00000	0.0%	-	-
111	2G	2. Industrial Pro	G. Other			CO2	1.04	1.15	0.00%	0.00000	0.0%	-	-
112	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.31	0.28	0.00%	0.00000	0.0%	-	-
113	2F5	2. Industrial Pro	F. Consumption of Halocarbons and SF6; Solvents			HFC	0.00	2.73	0.00%	0.00000	0.0%	-	-
114	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Solid Fuels	CH4	0.40	0.16	0.00%	0.00000	0.0%	-	-
115	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fo	Biomass	CH4	0.80	0.14	0.00%	0.00000	0.0%	-	-
116	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.16	0.11	0.00%	0.00000	0.0%	-	-
117	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		N2O	0.02	0.03	0.00%	0.00000	0.0%	-	-
118	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CH4	0.06	0.04	0.00%	0.00000	0.0%	-	-
119	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatio	Natural Gas	CH4	0.00	0.05	0.00%	0.00000	0.0%	-	-
120	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fo	Gaseous Fuels	CH4	0.09	0.04	0.00%	0.00000	0.0%	-	-
121	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatio	Biomass	CH4	0.00	0.02	0.00%	0.00000	0.0%	-	-
122	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fo	Gaseous Fuels	N2O	0.02	0.01	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	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	CH4	0.01	0.01	0.00%	0.00000	0.0%	-	-
125	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	45.47	0.00	0.00%	-	0.0%	-	-
126	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.00	0.00%	-	0.0%	-	-
127	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.24	0.00	0.00%	-	0.0%	-	-
128	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	Other Fuels	CH4	0.00	0.00	0.00%	-	0.0%	-	-
129	2C	2. Industrial Pro	C. Metal Production; Aluminium Foundries			SF6	0.00	0.00	0.00%	-	0.0%	-	-
130	2C3	2. Industrial Pro	C. Metal Production; Aluminium Production-CO2			CO2	139.26	0.00	0.00%	-	0.0%	-	-
131	2C3	2. Industrial Pro	C. Metal Production; Aluminium Production-PFC			PFC	100.17	0.00	0.00%	-	0.0%	-	-
132	6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.24	0.00	0.00%	-	0.0%	-	-
133	6D	6. Waste	D. Other			CO2	0.00	0.00	0.00%	-	0.0%	-	-

A1.5 KCA Tier 2 2011 including LULUCF categories

Results of Key Category Analysis Tier 2 – Level and Trend

Table A - 5 Key category analysis Tier 2 2011 (with LULUCF) regarding level and trend.

Tier 2 Key category analysis 2011 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 2011 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	691.74	1.99%	0.00257	4.6%	KC level	KC trend
2	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	3018.12	2961.48	1.72%	0.00070	1.2%	KC level	KC trend
3	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1351.47	1163.25	1.61%	0.00164	2.9%	KC level	KC trend
4	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1519.73	2591.93	1.49%	0.00705	12.6%	KC level	KC trend
5	2A1	2. Industrial P	A. Mineral Products; Cement Production-CO2			CO2	2524.77	1903.58	1.38%	0.00369	6.6%	KC level	KC trend
6	4A	4. Agriculture	A. Enteric Fermentation			CH4	2635.45	2509.11	0.83%	0.00008	0.1%	KC level	-
7	5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO2	1236.12	1025.34	0.71%	0.00104	1.9%	KC level	KC trend
8	4B	4. Agriculture	B. Manure Management			CH4	671.61	649.83	0.64%	0.00017	0.3%	KC level	-
9	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11335.25	9358.64	0.44%	0.00066	1.2%	KC level	KC trend
10	4B	4. Agriculture	B. Manure Management			N2O	454.68	336.43	0.38%	0.00112	2.0%	KC level	KC trend
11	4D2	4. Agriculture	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	128.10	223.57	0.38%	0.00183	3.3%	KC level	KC trend
12	5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	390.23	305.59	0.28%	0.00062	1.1%	KC level	KC trend
13	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2587.68	6348.51	0.26%	0.00168	3.0%	KC level	KC trend
14	2F1	2. Industrial P	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	1046.30	0.23%	0.00242	4.3%	KC level	KC trend
15	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1409.10	2254.45	0.21%	0.00089	1.6%	KC level	KC trend
16	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10248.78	6802.19	0.20%	0.00091	1.6%	KC level	KC trend
17	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Solid Fuels	CO2	1220.95	514.65	0.20%	0.00256	4.6%	KC level	KC trend
18	6D	6. Waste	D. Other			CH4	29.94	105.75	0.19%	0.00150	2.7%	KC level	KC trend
19	6B	6. Waste	B. Wastewater Handling			N2O	184.72	211.23	0.19%	0.00036	0.6%	KC level	KC trend
20	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	688.16	180.72	0.19%	0.00526	9.4%	KC level	KC trend
21	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Other Fuels	CO2	134.15	321.33	0.18%	0.00119	2.1%	KC level	KC trend
22	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Gaseous Fuels	CO2	1046.30	2015.43	0.18%	0.00099	1.8%	KC level	KC trend
23	5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO2	66.41	190.66	0.18%	0.00125	2.2%	KC level	KC trend
24	5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	346.67	232.92	0.17%	0.00071	1.3%	KC level	KC trend
25	1B2	1. Energy	B. Fugitive Emissions from F	2. Oil and Natural Gas		CH4	380.43	173.32	0.16%	0.00179	3.2%	KC level	KC trend
26	3	3. Solvent and Other Product Use				CO2	359.98	155.28	0.14%	0.00178	3.2%	KC level	KC trend
27	2C1	2. Industrial P	C. Metal Production; Steel Production			CO2	110.80	185.08	0.14%	0.00062	1.1%	KC level	KC trend
28	5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	97.65	135.19	0.12%	0.00042	0.7%	KC level	KC trend
29	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Gaseous Fuels	CO2	961.96	1312.66	0.12%	0.00039	0.7%	-	KC trend
30	2F9	2. Industrial P	F. Consumption of Halocarbons and SF6; Other			SF6	79.58	81.31	0.12%	0.00010	0.2%	-	-
31	5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land		CO2	95.63	113.35	0.10%	0.00022	0.4%	-	-
32	2F9	2. Industrial P	F. Consumption of Halocarbons and SF6; Other			HFC	0.00	64.38	0.09%	0.00099	1.8%	-	KC trend
33	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Liquid Fuels	CO2	4614.55	2915.76	0.09%	0.00045	0.8%	-	KC trend
34	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Liquid Fuels	CO2	3684.05	2484.54	0.07%	0.00031	0.6%	-	-
35	3	3. Solvent and Other Product Use				N2O	110.14	44.15	0.06%	0.00092	1.6%	-	KC trend
36	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	20.85	43.57	0.06%	0.00037	0.7%	-	KC trend
37	2A3	2. Industrial P	A. Mineral Products; Limestone and Dolomite Use, Emissions, CO2			CO2	103.37	66.87	0.06%	0.00030	0.5%	-	-
38	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	27.72	42.43	0.06%	0.00025	0.4%	-	-
39	4D4	4. Agriculture	D. Agricultural Soils; Use of sewage sludge as fertilizers			N2O	28.30	29.61	0.04%	0.00004	0.1%	-	-
40	2B	2. Industrial P	B. Chemical Industry			N2O	68.13	54.13	0.04%	0.00008	0.1%	-	-
41	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	242.32	442.34	0.04%	0.00021	0.4%	-	-
42	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	137.27	43.85	0.04%	0.00083	1.5%	-	KC trend
43	6D	6. Waste	D. Other			N2O	5.82	23.96	0.03%	0.00028	0.5%	-	-
44	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	95.89	29.98	0.03%	0.00074	1.3%	-	KC trend
45	5E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements		CO2	0.91	32.22	0.03%	0.00031	0.6%	-	-
46	5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands		CO2	21.54	29.74	0.03%	0.00009	0.2%	-	-
47	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.39	868.79	0.03%	0.00007	0.1%	-	-
48	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.94	17.25	0.03%	0.00011	0.2%	-	-
49	6C	6. Waste	C. Waste Incineration			N2O	20.10	30.26	0.02%	0.00009	0.2%	-	-
50	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	5.84	53.24	0.02%	0.00020	0.4%	-	-
51	2B	2. Industrial P	B. Chemical Industry			CO2	109.80	110.55	0.02%	0.00001	0.0%	-	-
52	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Liquid Fuels	N2O	14.61	11.75	0.02%	0.00003	0.1%	-	-
53	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	547.19	526.38	0.02%	0.00000	0.0%	-	-
54	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	101.15	20.95	0.01%	0.00053	0.9%	-	KC trend
55	6C	6. Waste	C. Waste Incineration			CH4	14.25	12.71	0.01%	0.00001	0.0%	-	-
56	2F9	2. Industrial P	F. Consumption of Halocarbons and SF6; Other			PFC	0.00	18.30	0.01%	0.00014	0.3%	-	-
57	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	55.36	34.07	0.01%	0.00007	0.1%	-	-
58	2F2	2. Industrial P	F. Consumption of Halocarbons and SF6; Hard Foam			HFC	0.00	13.43	0.01%	0.00013	0.2%	-	-
59	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.64	8.14	0.01%	0.00003	0.1%	-	-
60	2C	2. Industrial P	C. Metal Production; Magnesium Foundries			SF6	0.00	30.28	0.01%	0.00012	0.2%	-	-
61	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Liquid Fuels	N2O	11.72	7.48	0.01%	0.00006	0.1%	-	-
62	1B2	1. Energy	B. Fugitive Emissions from F	2. Oil and Natural Gas		CO2	91.36	52.22	0.01%	0.00007	0.1%	-	-
63	7	7. Other				CO2	10.96	13.03	0.01%	0.00002	0.0%	-	-
64	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Biomass	N2O	1.68	6.39	0.01%	0.00007	0.1%	-	-
65	6C	6. Waste	C. Waste Incineration			CO2	54.10	12.34	0.01%	0.00030	0.5%	-	-
66	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Other Fuels	N2O	2.28	5.81	0.01%	0.00006	0.1%	-	-
67	2F8	2. Industrial P	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	43.55	0.01%	0.00003	0.1%	-	-
68	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	4.97	5.30	0.01%	0.00001	0.0%	-	-
69	2F7	2. Industrial P	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture			SF6	0.00	9.23	0.01%	0.00007	0.1%	-	-
70	5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO2	38.65	6.76	0.01%	0.00030	0.5%	-	-
71	5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		N2O	5.58	3.66	0.01%	0.00003	0.1%	-	-
72	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	132.35	0.01%	0.00005	0.1%	-	-
73	2F7	2. Industrial P	F. Consumption of Halocarbons and SF6; Semiconductor Manufacture			PFC	0.00	8.18	0.01%	0.00006	0.1%	-	-
74	6B	6. Waste	B. Wastewater Handling			CH4	4.65	10.02	0.01%	0.00003	0.1%	-	-
75	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	111.88	117.52	0.00%	0.00001	0.0%	-	-
76	2B	1. Industrial P	B. Chemical Industry			CH4	9.63	8.61	0.00%	0.00000	0.0%	-	-
77	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	3.06	0.00%	0.00002	0.0%	-	-
78	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	Biomass Burnin	CO2	25.36	3.84	0.00%	0.00024	0.4%	-	-
79	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CO2	30.80	46.20	0.00%	0.00002	0.0%	-	-

Table A – 5 continued. Key category analysis Tier 2 2011 (with LULUCF) regarding level and trend.

Tier 2 Key category analysis 2011 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 2011 Estimate [Gg CO2 eq]	Level Assessm. with Uncertainty	Trend Assessm. with Uncertainty	% Contrib. in Trend	Result level assessm	Result trend assessm
80	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Biomass	N2O	1.45	2.83	0.00%	0.00002	0.0%	-	-
81	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Solid Fuels	N2O	6.44	2.70	0.00%	0.00005	0.1%	-	-
82	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	CO2	0.00	39.60	0.00%	0.00004	0.1%	-	-
83	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.49	1.30	0.00%	0.00003	0.1%	-	-
84	2F4	2. Industrial P	F. Consumption of Halocarbons and SF6; Metered Dose Inhalers and Other			HFC	0.00	16.94	0.00%	0.00004	0.1%	-	-
85	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	203.58	106.92	0.00%	0.00003	0.0%	-	-
86	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.26	5.32	0.00%	0.00001	0.0%	-	-
87	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	2.01	1.06	0.00%	0.00002	0.0%	-	-
88	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	N2O	0.00	1.87	0.00%	0.00003	0.1%	-	-
89	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Gaseous Fuels	CH4	2.65	4.64	0.00%	0.00001	0.0%	-	-
90	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	N2O	0.66	0.79	0.00%	0.00000	0.0%	-	-
91	2A2	2. Industrial P	A. Mineral Products; Lime Production-CO2			CO2	53.35	56.31	0.00%	0.00000	0.0%	-	-
92	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Biomass	CH4	9.74	3.72	0.00%	0.00003	0.1%	-	-
93	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Gaseous Fuels	CH4	2.40	3.53	0.00%	0.00001	0.0%	-	-
94	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.27	0.00%	0.00001	0.0%	-	-
95	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	40.64	19.10	0.00%	0.00002	0.0%	-	-
96	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Gaseous Fuels	N2O	0.58	1.13	0.00%	0.00001	0.0%	-	-
97	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CH4	8.19	1.24	0.00%	0.00009	0.2%	-	-
98	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	28.69	38.12	0.00%	0.00000	0.0%	-	-
99	2F1	2. Industrial P	F. Consumption of Halocarbons and SF6; Refrigeration			PFC	0.04	6.58	0.00%	0.00002	0.0%	-	-
100	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	N2O	0.60	0.53	0.00%	0.00000	0.0%	-	-
101	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	N2O	0.38	0.49	0.00%	0.00000	0.0%	-	-
102	1B2	1. Energy	B. Fugitive Emissions from I	2. Oil and Natural Gas		N2O	0.62	0.87	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	5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands		CO2	3.00	0.65	0.00%	0.00004	0.1%	-	-
105	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	6.00	2.09	0.00%	0.00002	0.0%	-	-
106	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Gaseous Fuels	N2O	0.54	0.74	0.00%	0.00000	0.0%	-	-
107	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.35	0.00%	0.00001	0.0%	-	-
108	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		N2O	4.77	0.71	0.00%	0.00005	0.1%	-	-
109	7	7. Other				N2O	0.62	0.62	0.00%	0.00000	0.0%	-	-
110	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Biomass	CH4	2.46	1.49	0.00%	0.00000	0.0%	-	-
111	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.62	1.36	0.00%	0.00000	0.0%	-	-
112	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institution	Liquid Fuels	CH4	3.06	1.35	0.00%	0.00001	0.0%	-	-
113	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.56	1.01	0.00%	0.00000	0.0%	-	-
114	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Liquid Fuels	CH4	2.32	0.98	0.00%	0.00001	0.0%	-	-
115	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Biomass	N2O	0.21	0.29	0.00%	0.00000	0.0%	-	-
116	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.14	0.25	0.00%	0.00000	0.0%	-	-
117	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.65	0.00%	0.00000	0.0%	-	-
118	7	7. Other				CH4	0.55	0.58	0.00%	0.00000	0.0%	-	-
119	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.26	0.00%	0.00000	0.0%	-	-
120	2C5	2. Industrial P	C. Metal Production; Non-ferrous metals-CO2			CO2	1.65	1.55	0.00%	0.00000	0.0%	-	-
121	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gasoline	CH4	0.58	0.51	0.00%	0.00000	0.0%	-	-
122	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.29	0.18	0.00%	0.00000	0.0%	-	-
123	2A7	2. Industrial P	A. Mineral Products; Other non-specified-CO2			CO2	15.30	6.59	0.00%	0.00000	0.0%	-	-
124	2F5	2. Industrial P	F. Consumption of Halocarbons and SF6; Solvents			PFC	0.00	6.26	0.00%	0.00000	0.0%	-	-
125	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.36	0.62	0.00%	0.00000	0.0%	-	-
126	2G	2. Industrial P	G. Other			CO2	1.04	1.15	0.00%	0.00000	0.0%	-	-
127	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.31	0.28	0.00%	0.00000	0.0%	-	-
128	2F5	2. Industrial P	F. Consumption of Halocarbons and SF6; Solvents			HFC	0.00	2.73	0.00%	0.00000	0.0%	-	-
129	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Solid Fuels	CH4	0.40	0.16	0.00%	0.00000	0.0%	-	-
130	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Biomass	CH4	0.80	0.14	0.00%	0.00000	0.0%	-	-
131	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	0.16	0.11	0.00%	0.00000	0.0%	-	-
132	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		N2O	0.02	0.03	0.00%	0.00000	0.0%	-	-
133	1A3ei	1. Energy	A. Fuel Combustion	3. Transport; Other non-specified		CH4	0.06	0.04	0.00%	0.00000	0.0%	-	-
134	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Natural Gas	CH4	0.00	0.05	0.00%	0.00000	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	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.02	0.00%	0.00000	0.0%	-	-
137	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.02	0.01	0.00%	0.00000	0.0%	-	-
138	1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	Gas/Diesel Oil	CH4	0.01	0.02	0.00%	0.00000	0.0%	-	-
139	1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	Liquid Fuels	CH4	0.01	0.01	0.00%	0.00000	0.0%	-	-
140	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	45.47	0.00	0.00%	-	0.0%	-	-
141	2C3	2. Industrial P	C. Metal Production; Aluminium Production-CO2			CO2	139.26	0.00	0.00%	-	0.0%	-	-
142	6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.24	0.00	0.00%	-	0.0%	-	-
143	6D	6. Waste	D. Other			CO2	0.00	0.00	0.00%	-	0.0%	-	-
144	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.00	0.00%	-	0.0%	-	-
145	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Constru	Other Fuels	CH4	0.00	0.00	0.00%	-	0.0%	-	-
146	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.24	0.00	0.00%	-	0.0%	-	-
147	2C3	2. Industrial P	C. Metal Production; Aluminium Production-PFC			PFC	100.17	0.00	0.00%	-	0.0%	-	-
148	2C	2. Industrial P	C. Metal Production; Aluminium Foundries			SF6	0.00	0.00	0.00%	-	0.0%	-	-
149	6D	6. Waste	D. Other			CO2	0.00	0.00	0.00%	-	0.0%	-	-

Annex 2: Detailed discussion of methodology and data for estimating CO_2 emissions from fossil fuel combustion

A2.1 Carbon Dioxide (CO_2)

Net calorific values and CO_2 emission factors of fuels

The main sources for calculating CO_2 emissions of Switzerland are:

a) net calorific values NCV of the fuels (SFOE 2001, Intertek 2008)

b) CO_2 emission factors of the fuels (SFOE 2001, Intertek 2008)

c) Swiss overall energy statistics 2011 (SFOE 2012).

All parameters of fuels are assumed to be constant for the period 1990 to 2011. The value for natural gas also holds for CNG (compressed natural gas). The NCV originate from SFOE (2001). An extended measurement campaign, commissioned by FOEN and carried out by Intertek (2008) compared measured values with former measurements (EMPA 1999) and showed that the assumption of constant NCV and emission factor is widely fulfilled for fuels sold in Switzerland. The authors write in their report, that only small deviations were found, which are hardly larger than the uncertainties of the measurements. Further measurements in 2011 confirmed that the values do not deviate significantly from the values used (Intertek 2012). Measurements will be repeated periodically and the values will be adjusted if a systematic difference should emerge. The NCV of wood depends on the wood product used as fuel, i.e. wood chips, pellets etc.

Table A - 6 NCV and CO_2 emission factors (EMPA 1999, SFOE 2001, Intertek 2008) of fossil and biofuels. The CO_2 emission factor of fossil fuels is assumed to be constant from 1990 to 2011.

Fuel	Net calorific values (NCV)	CO2 Emission Factors 1990-2010		Data sources
	GJ / t	t CO_2 / TJ	t CO_2 / t	
Diesel Oil	42.8	73.6	3.15	SFOE (2001), Intertek (2008)
Gas Oil	42.6	73.7	3.14	SFOE (2001), Intertek (2008)
Gasoline	42.5	73.9	3.14	SFOE (2001), Intertek (2008)
Lignite	20.1	96.0	2.26	FOEN (2011k)
Bituminous Coal	26.3	94.0	2.36	FOEN (2011k)
Jet Kerosene	43.0	73.2	3.15	SFOE (2001), Intertek (2008)
Natural Gas	46.5	55.0	2.56	SFOE (2001)
Propane/Butane (LPG)	46.0	65.5	---	SFOE (2001)
Residual Fuel Oil	41.2	77.0	3.17	SFOE (2001), Intertek (2008)
Fuel	**GJ/t**	**t CO2 / TJ**	**t CO2 / t**	
Biodiesel		73.6		EMIS (2012/1A3b)
Bioethanol		73.9		EMIS (2013/1A3b)
Biogas		55.0		EMIS (2013/1A3b)
Wood	11.7-15.3 GJ/t	92.0		EMIS (2012/1A solid fuels/wood) SFOE (2001, 2011b)

A2.2 Sulphur Dioxide (SO_2)

Table A - 7 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

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

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

Explanation to Table A - 7

- For liquid and solid fuels the SO_2 emission factors are determined by the sulphur content. The upmost lines in Table A - 7 “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 - 7 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 - 7 give the emission factors in kg/TJ. They are calculated from the sulphur content S, the net calorific value NCV and the quotient of the molar masses of S and SO_2

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

- Coal: Note that the legal limit of sulphur content depends on the size of the heat capacity of the combustion system. The value shown in the table above (1%, 350 kg/TJ SO_2) holds for heat capacity below 1 MW; see OAPC Annex 4, §513 (Swiss Confederation 1985). For larger capacities the value is 3% (OAPC Annex 5, §2, Swiss Confederation 1985). For industrial combustion plants, the limit 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 2011 and 1990 as published by the Swiss Federal Office of Energy (SFOE 2012). Diagram languages are German and French.

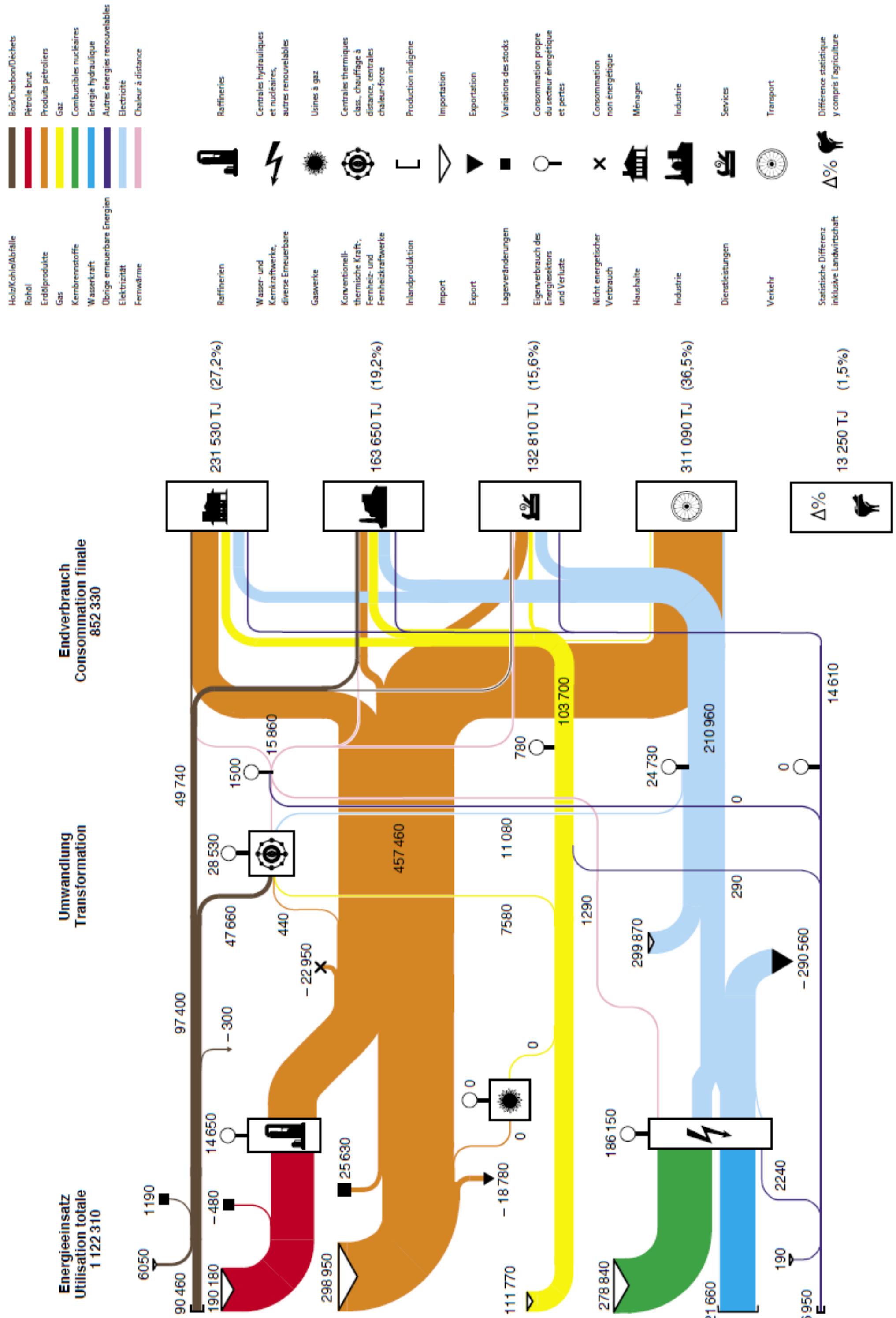

Figure A - 1 Energy flow in Switzerland 2011 in TJ (SFOE 2012)

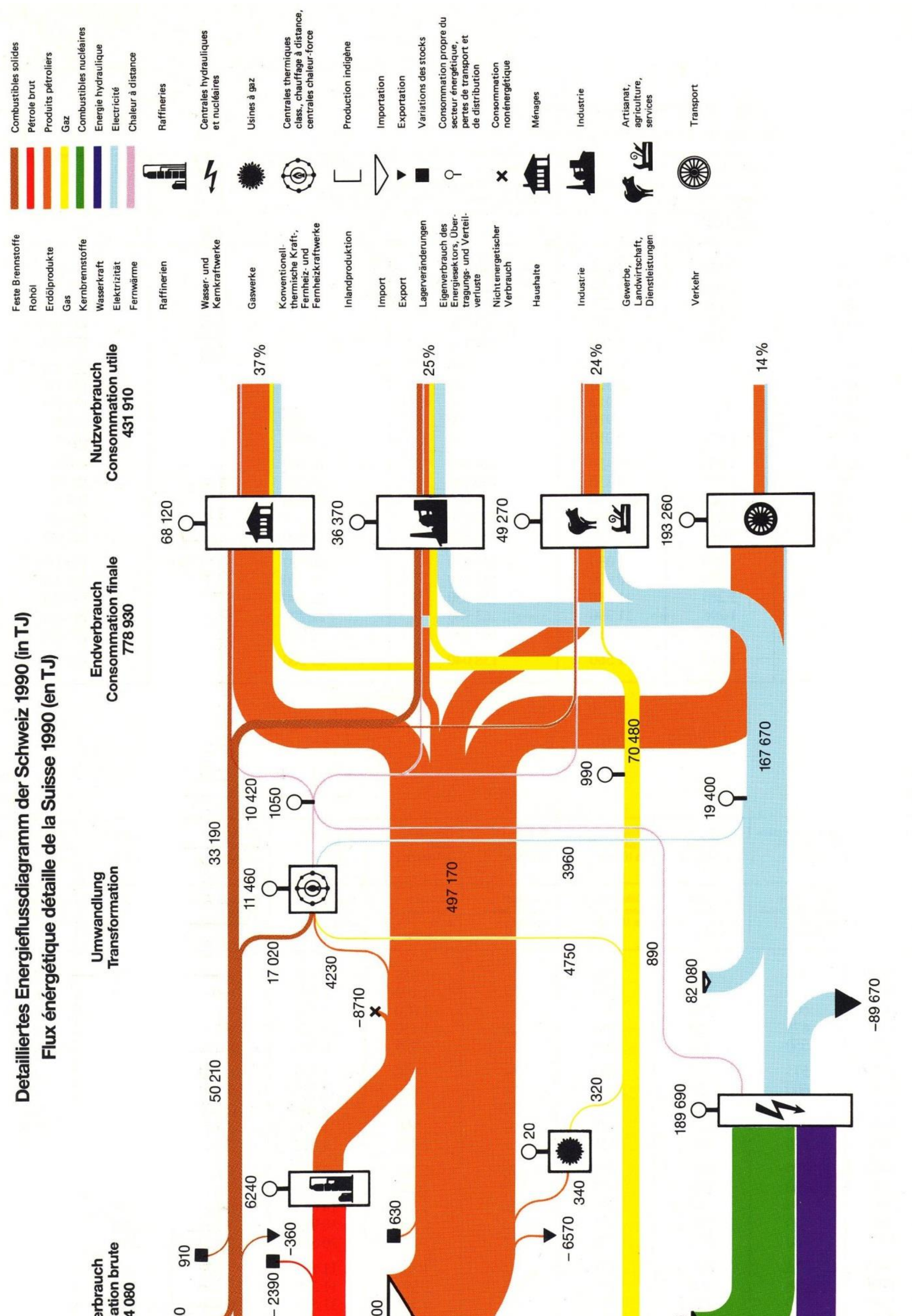

Figure A - 2 Energy flow in Switzerland 1990 in TJ (SFOE 1991)

A3.1.2 Emissions from Fuel Consumption: Disaggregation of Fuel Consumption

Swiss overall energy statistics 2011

The consumption of Solid, Liquid, Gaseous and Other Fuels in the Swiss overall energy statistics 2011 (SFOE 2012) are the basis for the calculations of GHG emissions in source category 1A “Energy”. The statistics provide annual aggregated consumption data for different fuels for categories of sources. The categories in the Swiss overall energy statistics are more aggregated than in CRF (e.g. the energy statistics provide data for "industry" as a whole, whereas the CRF differentiate between different industrial activities in source categories 1A2a to 1A2f).

The aggregated data on fuel consumption in the Swiss overall energy statistics are derived from the following sources:

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

For a first disaggregation of fuel consumption data in the three categories (i) Energy Industries, (ii) industry, services and institutional and (iii) households, estimates based on selected surveys in industry and households, modelling, and expert judgments are used, including

- Survey on consumption of light fuel oil (“Erdöl Panel”); based on the survey, stocks are estimated; however, larger uncertainties about stock changes remain.
- Survey on consumption of natural gas to differentiate the consumption for heat, power and co-generation purposes.
- Survey with suppliers on amount and type of newly installed wood boilers and data on buildings. This data is then fed into a model that provides estimates of annual wood consumption.

Models for fuel consumption in industry and services/institutional

As the Swiss overall energy statistics provide only the sum of the combined fuel consumption in industry, services and institutional sector, the disaggregation into the categories 1A2a-f is made based on a bottom-up model run by Prognos, while 1A4a corresponds to the residual fuel consumption. Compared to previous submissions, the energy consumption is now based on an updated an recalibrated model for the entire time series. This led to the redistribution of energy consumption between different categories in sector 1A2.

Modelling of fuel consumption in Manufacturing Industries and Construction (Prognos)

The modelling of fuel consumption in Manufacturing Industries and Construction in Switzerland from 1990 to 2011 by *Prognos* (Prognos 2012) is based on several long- and short-term bottom-up energy-economic models. Starting from 164 individual industrial processes and further 64 processes related to infrastructure, the fuel consumption of 16 branches of industry is calculated as the product of activity data (e.g. tons of chocolate produced) and a specific fuel consumption factor (e.g. kWh natural gas per ton of chocolate). The model is adjusted and scaled to fit available energy data and statistics, including the Swiss overall energy statistics, the statistics of the large energy consumers

(Energiekonsumenten-Verband EKV; for 1990-1998), data from soundings of Helbling Ltd. (since 1999), data from Cemsuisse for 1990 and 2000 to 2010, industry data from annual reports, fuel supply data from CARBURA for 1985 to 2010, data on full-time-jobs and on industrial production from SFSO, as well as expert estimates.

For the context of the Swiss GHG inventory, the model output provides annual consumption (in TJ) for light fuel oil (gas oil), heavy fuel oil, coal, petroleum coke, LPG, natural gas, and biomass in the source categories 1A2a to 1A2f:

F_{1A2a}^{Model}, F_{1A2b}^{Model}, F_{1A2c}^{Model}, F_{1A2d}^{Model}, F_{1A2e}^{Model}, F_{1A2f}^{Model}, and total consumption $F_{1A2}^{Model} = \sum_{i=a}^{f} F_{1A2i}^{Model}$.

Fuel consumption in services sector (1A4a)

For the context of the Swiss GHG inventory, all commercial and institutional categories are considered jointly. Therefore, the energy consumption of category 1A4a is taken as the difference between the total energy consumption according to the Swiss overall energy statistics in the sector industrial/commercial/institutional and the industrial energy use according to the modelled energy use in industries described above. This procedure makes the normalization of the modelled energy use, which was applied in previous submissions that used modelled energy use for category 1A4a, redundant.

A3.1.3 Emission from Manufacturing Industries and Construction

The precursors of the emission factors from Table 3-22 in 3.2.7.2 are as follows:

Table A - 8 Precursors of the emission factors 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				
Light fuel oil	33	8	2	22
Liquefied petroleum gas	33	8	2	22
Heavy fuel oil	125	14	4	291
Coal	14	2'282	8	311
Natural gas	43	3	2	0.5
1A2b Non-Ferrous Metals				
Light fuel oil	33	196	40	22
Liquefied petroleum gas	33	8	2	22
Heavy fuel oil (including petrolkoks)	NO	NO	NO	NO
Natural gas	19	10	2	0.5
1A2c Chemicals				
Light fuel oil	33	8	2	22
Liquefied petroleum gas	33	8	2	22
Heavy fuel oil	125	14	4	291
Coal	NO	NO	NO	NO
Natural gas	19	10	2	0.5
1A2d Pulp, Paper and Print				
Light fuel oil	33	8	2	22
Liquefied petroleum gas	33	8	2	22
Heavy fuel oil	125	14	4	291
Natural gas	19	10	2	0.5
1A2e Food Processing, Beverages and Tobacco				
Light fuel oil	33	8	2	22
Liquefied petroleum gas	33	8	2	22
Heavy fuel oil (including petrolkoks)	NO	NO	NO	NO
Coal	NO	NO	NO	NO
Natural gas	19	10	2	0.5
1A2fi Other				
Light fuel oil	33	8	2	22
Liquefied petroleum gas	33	8	2	22
Heavy fuel oil (including petrolkoks)	198	98	10	495
Coal	205	100	10	500
Natural gas	19	10	2	0.5
Biomass	136	287	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)	252	452	20	125
1A2fii Construction and industrial machinery	**NO_x**	**CO**	**NMVOC**	**SO_2**
	kg/h	kg/h	kg/h	kg/h
Diesel and gasoline	465	811	80	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 - 9 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 - 10 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 - 11 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	Ty pe	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 - 12 Extract of the output file of FOCA emission and fuel consumption modelling. Upper part: LTO, lower part: cruise (example for 2004). Emissions and fuel consumption in tons.

Airport	Distance	Type Traffic	Move-ments	Type	Aircraft ICAO	Engine Name	Fuel (LTO) tons	Emissions (LTO) in tons					
	Km		No.					CO_2	H_2O	SO_2	NO_x	VOC	CO
LSGG	181501.69	Taxi	165	2B	C550	JT15D-4	5673.492	17871.5	6978.395	5.673	26.04	139	359.2
LSGG	164165.197	Taxi	77	2J	B752	RB211-535E4	47470.5	149532.1	58388.72	47.47	554.91	0	361.47
LSGG	133166.837	Taxi	118	2B	F2TH	CFE738-1-1B	6164.2728	19417.46	7582.056	6.164	87.539	40.59	185.53
LSGG	117228.943	Taxi	99	3B	F900	TFE731-60-1C	5668.542	17855.91	6972.307	5.669	46.937	28.13	163.44
LSGG	114258.902	Taxi	134	2B	LJ45	TFE731-20R	4725.108	14884.09	5811.883	4.725	31.31	53.62	169.01
LSGG	112510.267	Taxi	100	2B	F2TH	CFE738-1-1B	5223.96	16455.47	6425.471	5.224	74.186	34.4	157.23
LSGG	107945.477	Taxi	96	2B	C560	JT15D-5D	3795.3216	11955.26	4668.246	3.795	16.959	271.6	287.98
Airport	Distance km	Type Traffic	Move-ments	Type	Aircraft ICAO	Engine Name	Fuel (cruise) tons	Emissions (cruise) in tons					
LSGG	181501.69	Taxi	165	2B	C550	JT15D-4	307732.68	969357.9	378511.2	307.7	4513	29.43	274.71
LSGG	164165.197	Taxi	77	2J	B752	RB211-535E4	673698.47	2122150	828649.1	673.7	7986.4	647.8	1038.2
LSGG	133166.837	Taxi	118	2B	F2TH	CFE738-1-1B	225781.85	711212.8	277711.7	225.8	3311.2	21.59	201.55
LSGG	117228.943	Taxi	99	3B	F900	TFE731-60-1C	298139.18	939138.4	366711.2	298.1	4372.3	28.52	266.14
LSGG	114258.902	Taxi	134	2B	LJ45	TFE731-20R	193723.81	610230	238280.3	193.7	2841	18.53	172.93
LSGG	106761.289	Taxi	100	2B	F2TH	CFE738-1-1B	181011.75	570187	222644.4	181	2654.6	17.31	161.58
LSGG	103217.159	Taxi	96	2B	C560	JT15D-5D	175002.74	551258.6	215253.4	175	2566.5	16.74	156.22

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 - 13 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, Chpt. 4).

Table A - 14 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). 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 - 15 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). CO_2 (rep.) refers to the fossil part, CO_2 (total) includes fossil and biomass.

Emission	Year	PC	LDV	HDV	Coach	Bus	MC
	grams per vehicle kilometre, incl. cold starts and evaporation						
CH_4	1990	0.084	0.09	0.02	0.017	0.053	0.236
CH_4	1995	0.053	0.065	0.017	0.016	0.046	0.159
CH_4	2000	0.033	0.039	0.013	0.014	0.034	0.12
CH_4	2005	0.02	0.02	0.009	0.011	0.018	0.103
CH_4	2010	0.013	0.01	0.004	0.006	0.007	0.094
CO	1990	10.43	20.16	2.37	2.09	5.99	14.7
CO	1995	5.94	14.6	2.16	2.01	5.68	14.14
CO	2000	3.72	8.86	1.75	1.84	4.64	13.62
CO	2005	2.48	4.39	1.63	1.73	2.92	11.68
CO	2010	1.62	2.27	1.47	1.7	1.48	8.02
CO_2 (rep.)	1990	236	249	809	871	1,194	82
CO_2 (rep.)	1995	236	252	804	860	1,199	90
CO_2 (rep.)	2000	226	254	763	833	1,162	92
CO_2 (rep.)	2005	210	246	800	823	1,127	94
CO_2 (rep.)	2010	189	238	776	812	1,087	97
CO_2 (total)	1990	236	249	809	871	1,194	82
CO_2 (total)	1995	236	252	804	860	1,199	90
CO_2 (total)	2000	226	255	764	834	1,163	92
CO_2 (total)	2005	210	246	803	826	1,131	94
CO_2 (total)	2010	193	242	785	821	1,103	99
VOC	1990	1.69	2.02	0.83	0.7	2.2	3.69
VOC	1995	0.98	1.38	0.73	0.66	1.93	2.65
VOC	2000	0.59	0.77	0.55	0.6	1.42	2.08
VOC	2005	0.36	0.38	0.38	0.47	0.73	1.64
VOC	2010	0.23	0.2	0.18	0.26	0.57	1.16
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	0.026	0.014	0.001	0.002
NMVOC	1990	1.607	1.93	0.814	0.681	2.151	3.451
NMVOC	1995	0.931	1.32	0.711	0.64	1.88	2.489
NMVOC	2000	0.555	0.735	0.532	0.582	1.383	1.964
NMVOC	2005	0.336	0.362	0.372	0.459	0.714	1.538
NMVOC	2010	0.213	0.194	0.177	0.259	0.265	1.063
NO_x	1990	1.179	2.084	11.274	11.465	16.948	0.147
NO_x	1995	0.865	1.742	10.382	10.824	16.42	0.196
NO_x	2000	0.664	1.534	9.116	9.969	14.999	0.212
NO_x	2005	0.481	1.297	7.615	8.68	12.351	0.222
NO_x	2010	0.345	1.085	5.158	6.642	9.749	0.2
SO_2	1990	0.04	0.093	0.719	0.774	1.061	0.01
SO_2	1995	0.031	0.041	0.174	0.186	0.26	0.011
SO_2	2000	0.022	0.034	0.132	0.144	0.201	0.008
SO_2	2005	0.001	0.001	0.005	0.005	0.007	0
SO_2	2010	0.001	0.001	0.005	0.005	0.007	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.

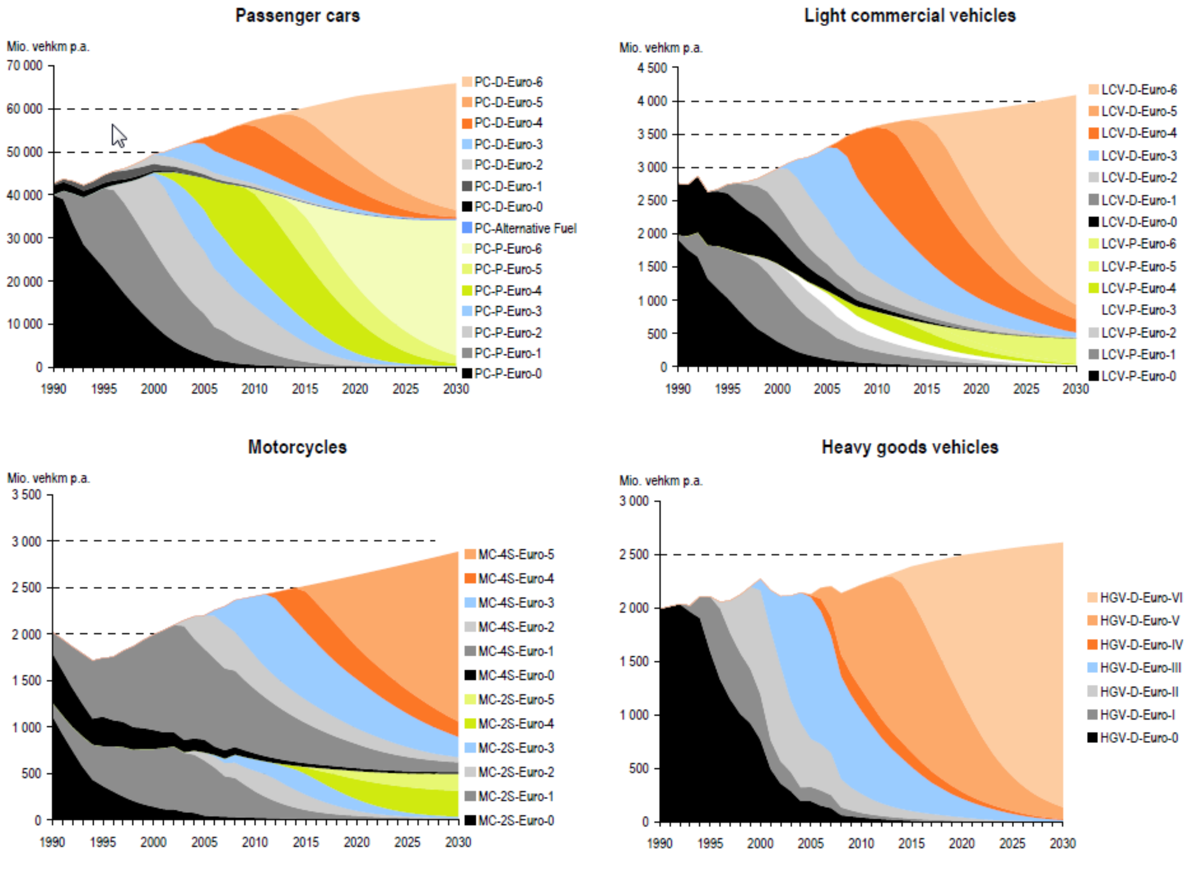

Figure A - 3 Mileage composition by emission concept (in million vehicle kilometres per year), FOEN 2010i.

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 have been updated and the results for the emissions have been used since inventory submission 2010. The modelling is carried out in a database that is structured in analogy to the on-road database (INFRAS 2008). The off-road sector has been allocated to 1A2 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 - 16 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 4-stroke, 210 mg/kWh gasoline 2-stroke. For N_2O IPCC gives 2 mg/kWh (diesel oil and gasoline 4-stroke) and 6 mg/kWh (gasoline 2-stroke).

Table A - 17 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 (NOx)						
<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 - 18 Emission and consumption factors for gasoline 4-stroke engines. PreEU-A etc. indicate emission standards.

Basic emission factors of equipment with 4-stroke gasoline engines (g/kWh).					
power class	PreEU-A <1995	PreEU-B 1995	PreEU-C 2000	EU-I 2004	EU-II 2005/2007
Carbon monoxide (CO)					
<66 ccm	645	640	620	519	500
66-100 ccm	645	640	600	550	550
100-225 ccm	350	350	350	350	300
>225 ccm	350	350	350	350	350
VOC					
<66 ccm	260	250	150	45	45
66-100 ccm	260	250	150	35	35
100-225 ccm	20	20	20	12	12
>225 ccm	20	20	20	9	8
Nitrogen oxides (NOx)					
<66 ccm	1.5	2	3	5	5
66-100 ccm	1.5	2	3	5	5
100-225 ccm	3.5	3.5	3.5	3.5	3.5
>225 ccm	3.5	3.5	3.5	3.5	3.5
Fuel consumption (FC)					
<66 ccm	678	670	650	640	630
66-100 ccm	678	670	650	640	630
100-225 ccm	460	460	460	460	460
>225 ccm	460	460	460	460	460

Table A - 19 Emission and consumption factors for gasoline 2-stroke engines. PreEU-A etc. indicate emission standards.

Basic emission factors of equipment with 2-stroke gasoline engines (g/kWh)					
gas/fuel consumption	**PreEU-A <1995**	**PreEU-B 1995**	**PreEU-C 2000**	**EU-I 2004**	**EU-II 2009/2011**
Carbon monoxide (CO)	645	640	620	600	600
VOC	260	250	150	100	45
Nitrogen oxides (NOx)	1.5	2.0	3.0	5.0	5
Fuel consumption (FC)	678	670	650	640	460

Table A - 20 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 2007/2009**
Carbon monoxide (CO)				
<560 kW	3.1	3	2.5	3.5
>560 kW	4	4	3	3
VOC				
<560 kW	1.3	0.8	0.6	0.4
>560 kW	2.5	1.6	0.8	0.8
Nitrogen oxides (NOx)				
<560 kW	14.3	12	6	3.6
>560 kW	20	15	12	9.5
Fuel consumption (FC)				
<560 kW	285	283	283	283
>560 kW	285	285	283	283

Table A - 21 Emission and consumption factors for ships with diesel engines. PreSAV etc. indicate emission standards.

Basal emission factors of diesel-driven ships (g/kWh)					
power class	**PreSAV <1995**	**SAV I 1995**	**SAV II 1997**	**EU I 2005**	**EU II 2010**
Carbon monoxide (CO)					
<18 kW	5	5	5	2.3	2.3
18-37 kW	5	5	4	1.9	1.9
37-75 kW	5	5	2.2	1.7	2
75-130 kW	5	4.9	1.64	1.7	2
>130 kW	2	2	1.3	1	0.5
Volatile organic compounds (VOC)					
< 100 kW	10	10	10	5	5
>130 kW	5	5	5	5	5
Nitrogen oxides (NOx)					
< 100 kW	15	15	10	9.8	5
>130 kW	15	15	10	6.5	4.5
Fuel consumption (FC)					
<18 kW	400	400	400	400	360
18-37 kW	400	380	380	380	360
37-75 kW	380	350	350	350	350
75-130 kW	400	330	330	330	330
>130 kW	300	300	300	300	300

Table A - 22 Emission and consumption factors for boats with diesel engines. PreSAV etc. indicate emission standards.

Basal emission factors of diesel-driven boats (gkWh)					
power class	PreSAV <1995	SAV I 1995I	EU 1997	PreSAV 2005	SAV II 2010
Carbon monoxide (CO)					
<4.4 kW	5	5	5	2.6	2.6
4.4-7.4 kW	5	5	5	2.3	2.3
7.4-37 kW	5	5	4	1.9	1.9
37-74 kW	5	5	2.2	1.7	2
74-100 kW	5	4.9	1.64	1.7	2
>100 kW	2	2	1.3	1	0.5
Volatile organic compounds (VOC)					
< 100 kW	10	10	10	5	5
>100 kW	5	5	5	5	5
Nitrogen oxides (NOx)					
< 100 kW	15	15	10	9.8	5
>100 kW	15	15	10	6.5	4.5
Fuel consumption (FC)					
<4.4 kW	400	400	400	400	360
4.4-7.4 kW	400	400	400	400	360
7.4-37 kW	400	380	380	380	360
37-74 kW	380	350	350	350	350
74-100 kW	400	330	330	330	330
>100 kW	300	300	300	300	300

Table A - 23 Emission and consumption factors for boats with gasoline engines. PreSAV etc. indicate emission standards.

Basic emission factors of gasoline engine boats (g/kWh)						
power class	2-stroke gasoline engine			4-stroke gasoline engine		
	PreSAV <1997	SAV II 1997	EU 2005	PreSAV <1997	SAV II 1997	EU 2005
Carbon monoxide (CO)						
<4.4 kW	650	300	300	300	162	162
4.4-7.4 kW	650	245	245	245	125	125
7.4-37 kW	650	128	128	256	107	107
37-74 kW				80	29.5	29.5
74-100 kW				64.3	21.9	21.9
>100 kW				120	40	40
VOC						
<4.4 kW	250	20	20	20	12	12
4.4-7.4 kW	250	17	17	17	9.3	9.3
7.4-37 kW	250	9.2	9.2	18.4	8	8
37-74 kW				6.1	2.2	2.2
74-100 kW				4.9	1.64	1.64
>100 kW				8.2	2.6	2.6
Nitrogen oxides (NOx)						
<4.4 kW	2	2	2	15	8	5
4.4-7.4 kW	2	2	2	15	7.6	5
7.4-37 kW	2	2	2	30	12.4	10
37-74 kW				15	5.1	5
74-100 kW				15	5.1	5
>100 kW				30	10	10
Fuel consumption (FC)						
<4.4 kW	700	400	400	400	500	500
4.4-7.4 kW	700	400	400	400	500	500
7.4-37 kW	650	380	380	760	980	940
37-74 kW				350	460	440
74-100 kW				330	450	430
>100 kW				600	840	840

Table A - 24 Emission and consumption factors (FC) for ships with steam engines (gas oil). steam 1 etc. indicate emission standards.

Basic emission factors of steam (gas oil) engine ships (g/kWh)							
pollutant	steam 1 <1950	steam 2 1950	steam 3 1980	steam 4 1990	steam 5 1995	steam 6 2005	steam 7 2005
CO	0.3	0.3	0.3	0.09	0.09	0.09	0.09
HC	0.45	0.45	0.45	0.33	0.33	0.33	0.33
NOx	2.34	2.34	2.34	1.77	1.56	1.26	1.03
PM	0.033	0.024	0.015	0.009	0.006	0.006	0.006
FC	1406	1012	787	703	703	703	703

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 - 25 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	45'849	44'690
Industry	13'947	18'372	22'748	22'748	22'599	21'800
Agriculture	324'567	324'047	337'869	339'948	342'230	321'976
Forestry	13'844	13'357	13'055	12'749	11'945	11'106
Garden/Hobby	659'828	719'118	779'052	763'881	748'708	816'671
Navigation	93'395	89'042	82'674	82'647	82'622	82'564
Railway	1'300	1'305	1'255	1'255	1'255	1'255
Military	1'340	1'340	1'340	1'340	1'340	1'340
Sum	**1'164'291**	**1'219'024**	**1'285'988**	**1'271'922**	**1'256'548**	**1'301'402**

Table A - 26 Operating hours per vehicle per year and (million) 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	658
Agriculture	119	118	112	108	104	145
Forestry	199	201	203	202	202	250
Garden/Hobby	22	25	27	27	27	60
Navigation	40	39	40	40	40	39
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	16.70	18.50	18.40	18.30	17.80	17.36
Industry	8.80	11.90	15.00	15.00	14.90	14.35
Agriculture	38.80	38.20	37.70	36.60	35.50	46.64
Forestry	2.80	2.70	2.60	2.60	2.40	2.78
Garden/Hobby	14.40	17.70	21.10	20.80	20.50	49.10
Navigation	3.70	3.50	3.30	3.30	3.30	3.26
Railway	0.80	0.82	0.77	0.77	0.77	0.77
Military	0.07	0.07	0.07	0.07	0.07	0.06
Sum	**86.00**	**93.40**	**99.00**	**97.40**	**95.20**	**134.33**

Table A - 27 Fuel consumption of several off-road activities in 1'000 t/a (INFRAS 2008).

Fuel	**Family**	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**
		Fuel consumption in 1000 t/a					
Diesel	Construction	91.1	105.5	112.7	116.9	119.3	118.0
Diesel	Industry	33.5	40.6	47.7	48.3	46.6	44.2
Diesel	Agriculture	113.8	119.5	124.8	125.8	126.2	125.8
Diesel	Forestry	5.6	5.9	6.5	7.6	8.5	9.4
Diesel	Navigation	16.5	16.2	17.9	18.4	19.2	19.2
Diesel	Railway	9.1	10.3	10.6	11.3	12.0	12.5
Diesel	Military	1.1	1.1	1.2	1.1	1.1	1.0
Diesel	**Sum**	**270.7**	**299.2**	**321.5**	**329.5**	**332.8**	**330.2**
Gasoline	Construction	3.0	3.1	2.8	2.6	2.4	2.3
Gasoline	Industry	1.2	1.7	2.2	2.2	2.1	2.1
Gasoline	Agriculture	24.0	22.0	19.8	18.8	18.0	17.2
Gasoline	Forestry	3.4	3.2	3.1	2.3	1.9	1.5
Gasoline	Garden/Hobby	8.3	10.0	11.5	10.5	9.8	9.3
Gasoline	Navigation	16.5	15.4	14.5	14.3	14.3	14.2
Gasoline	Military	0.0	0.0	0.0	0.0	0.0	0.0
Gasoline	**Sum**	**56.4**	**55.4**	**53.7**	**50.6**	**48.5**	**46.5**
Gas Oil	**Navigation**	**2.6**	**3.3**	**3.5**	**3.8**	**3.8**	**3.8**
CNG	**Industry**	**3.4**	**5.1**	**6.8**	**6.8**	**6.9**	**6.9**

A3.2 Industrial Processes

Illustrative Example of modelling Mobile Air-Conditioning / Cars

Table A - 28 Model structure and assumptions for calculating emissions from mobile air conditioning in cars. The example represents data for the year 2010. The basic parameters have not changed for the present inventory.

Parameters for Car Air-Conditioning		
Initial charge in kg	1994	0.81
	2002	0.70
	Other years inter-/extrapolated	
All units are imported with refrigerant charged		
Emission factor 1995	Annual loss	8.5%
	Share recharged regularly	6.0%
	Share not recharged	2.5%
Charge at end of life		58%
Disposal emissions	up to 1999	100%
	from 2000	50%
Export of second hand cars		50%
Reuse of recovered refrigerant (estimate value)		80%
Servicing emission factor		10%
Product lifetime		15
Market growth rate		1.0%

Year	**New registered vehicles**	**Vehicles in use**	**Disposed vehicles**	**AC units in new registered cars**			**Stock - AC units in use**		**Disposal**	**Initial charge**
0	(VSAI, EFKO)	(B. f. Statistik)		Portion of vehicles with air-cond. [%]	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	297'181	4'160'564	255'988	96	100	285'294	90	3'736'344	97'275	0.70

R 134a	Activity			Emissions				Recharge	Reuse
	Input with vehicles	Stock	Disposed	Stock incl. Recharge	Disposal	Servicing	Total	import in bulk	recovered
	[t]	[t]	[t]	[t]	[t]	[t]	[t]	[t]	[t]
1990	0	0	0.0	0	0.0	0	0	0	0.0
1991	2	2	0.0	0	0.0	0	0	0.06	0.0
1992	7	8	0.0	0	0.0	0	0	0.3	0.0
1993	20	28	0.0	2	0.0	0	2	1.1	0.0
1994	37	65	0.0	4	0.0	0	4	2.8	0.0
1995	51	115	0.0	8	0.0	0	8	5.4	0.0
1996	79	191	0.0	14	0.0	1	14	9.2	0.0
1997	107	294	0.0	23	0.0	2	25	14.6	0.0
1998	151	437	0.0	35	0.0	4	39	21.9	0.0
1999	175	599	0.0	49	0.0	5	54	31.1	0.0
2000	176	757	0.0	65	0.0	8	73	40.7	0.0
2001	192	924	0.0	82	0.0	11	93	50.4	0.0
2002	180	1'072	0.0	100	0.0	15	115	59.9	0.0
2003	169	1'201	0.0	114	0.0	18	132	68.2	0.0
2004	171	1'326	0.0	125	0.0	18	143	75.8	0.0
2005	167	1'444	0.0	137	0.0	19	156	83.1	0.0
2006	181	1'571	0.8	146	0.2	18	164	90.5	0.2
2007	191	1'706	3.0	156	0.7	17	174	98.3	0.6
2008	194	1'839	9.5	168	2.4	17	187	106.4	1.9
2009	179	1'947	19.9	178	5.0	17	199	113.6	4.0
2010	198	2'061	24.8	188	6.2	18	213	120.2	5.0
2011	200	2'168	43.7	199	10.9	19	229	126.9	8.7

A3.3 Agriculture

Additional data for estimating enteric fermentation emission factors for cattle

Table A - 29 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] %**	**Digestibility of Feed[d] %**	**CH_4 Conversion[d] %**	**Em. Factor kg/head/ year[e]**
Mature Dairy Cattle	NA	650	0		16.1 - 22.7 [c]	0	305 days of lactation	60	6.00	123.03
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

Additional data for estimating manure management CH_4 emission factors

Table A - 30 Data for estimating manure management CH_4 emission factors. Reference: IPCC 1997c, Tables B-1-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 - 313	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	1.21-1.25 [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 - 31 Additional data for N_2O emission calculation of agricultural soils.

2011	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	453'826'050	1'901	37.35			
Barley	155'858'550	795	15.61			
Maize	128'596'500	1'226	24.09			
Oats	7'409'450	46	0.90			
Rye	10'823'900	46	0.90			
Other:						
Triticale	52'737'400	259	5.08			
Spelt	16'209'500	148	2.91			
Mix of Fodder Cereals	858'500	4	0.09			
Mix of Bread Cereals	157'250	1	0.01			
2. Pulse						
Dry Beans	1'000'450	40	0.78	0.0521	52'082	1.02
Peas (Eiweisserbsen)	11'975'650	352	6.92	0.0424	507'204	9.96
Soybeans	2'805'000	116	2.27	0.0671	188'100	3.69
Other:						
Leguminous Vegetables	2'976'246	432	8.49	0.1170	348'097	6.84
3. Tuber and Root						
Potatoes	109'772'800	401	7.88			
Other:						
Fodder Beet	15'024'000	120	2.36			
Sugar Beet	402'200'480	3'620	71.10			
5. Other						
Fruit	71'938'390	288	5.65	0.0000		
Grass	6'273'017'245	22'332	438.66	0.0051	32'164'349	631.80
Green Corn	117'172'137	54	1.05	0.0000		
Non-Leguminous Vegetables	59'241'468	552	10.84	0.0000		
Rape	63'270'000	924	18.15	0.0000		
Renewable Energy Crops	5'166'000	75	1.48	0.0000		
Silage Corn	689'247'863	396	7.78	0.0000		
Sunflowers	8'415'000	178	3.50	0.0000		
Tobacco	1'238'000	32	0.63	0.0000		
Vine	25'788'000	155	3.04	0.0000		
Total Non-leguminous	2'394'951'238	11'220	220.39	0.0000		
Total Leguminous	18'757'346	939	18.45	0.0000	1'095'484	21.5
Total excluding grass	2'413'708'584	12'160	238.85	0.0000	1'095'484	21.5
Total including grass	8'686'725'829	34'491	677.51	0.0000	33'259'833	653.3

Table A - 32 Additional data for N_2O emission calculation of agricultural soils.

2011	Residue/ Crop ratio	Dry matter (dm) fraction of residue	Nitrogen content of residues
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.

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.

LPG

The reporting of LPG 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 LPG, white spirit and lamp oil used as fuels are reported under LPG. 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 - 33 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.

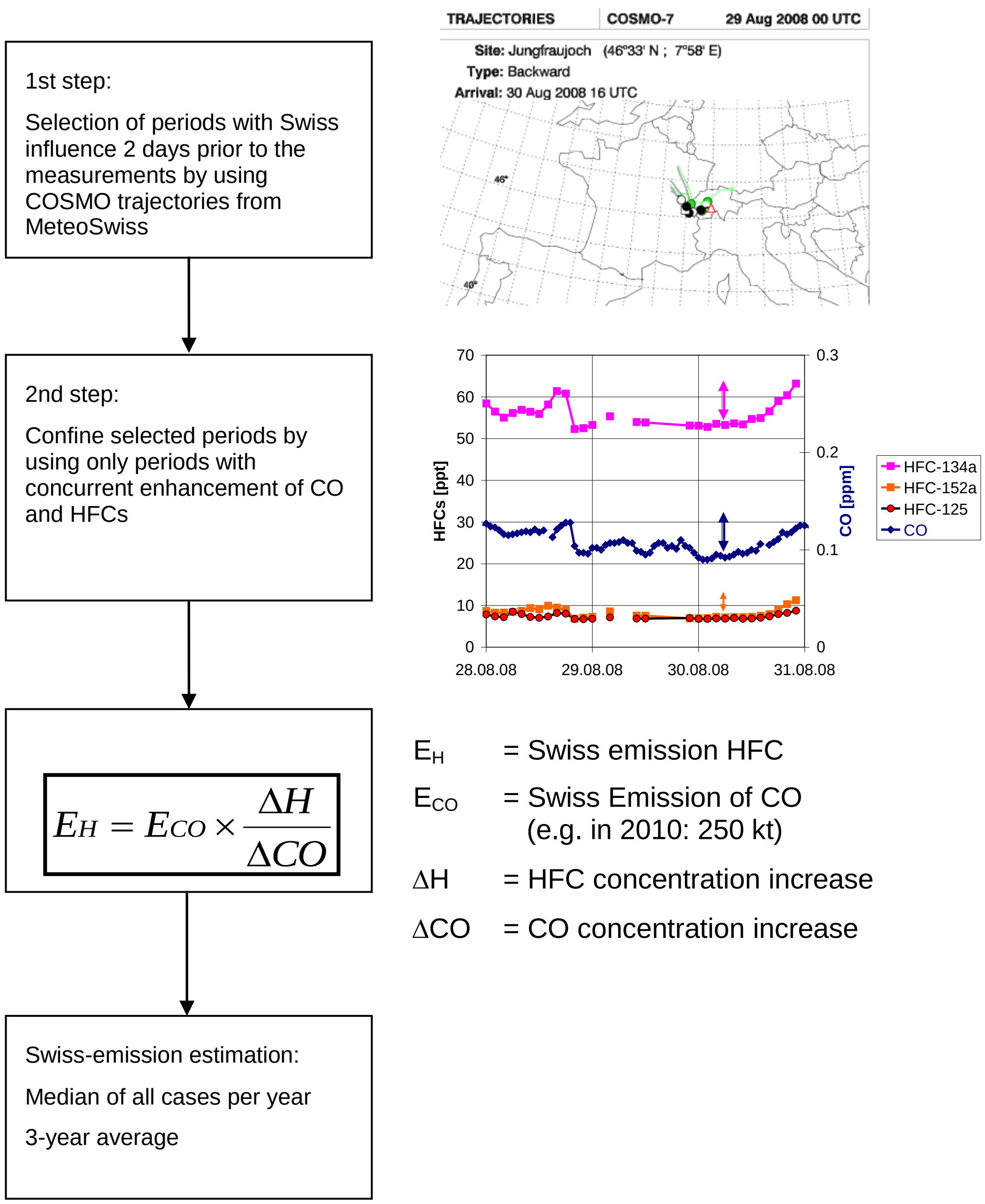

Figure A - 4 Description of the procedure to estimate annual emissions of HFCs from Switzerland by using continuous measurements of HFCs at Jungfraujoch (Switzerland).

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 2011 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 2 years.

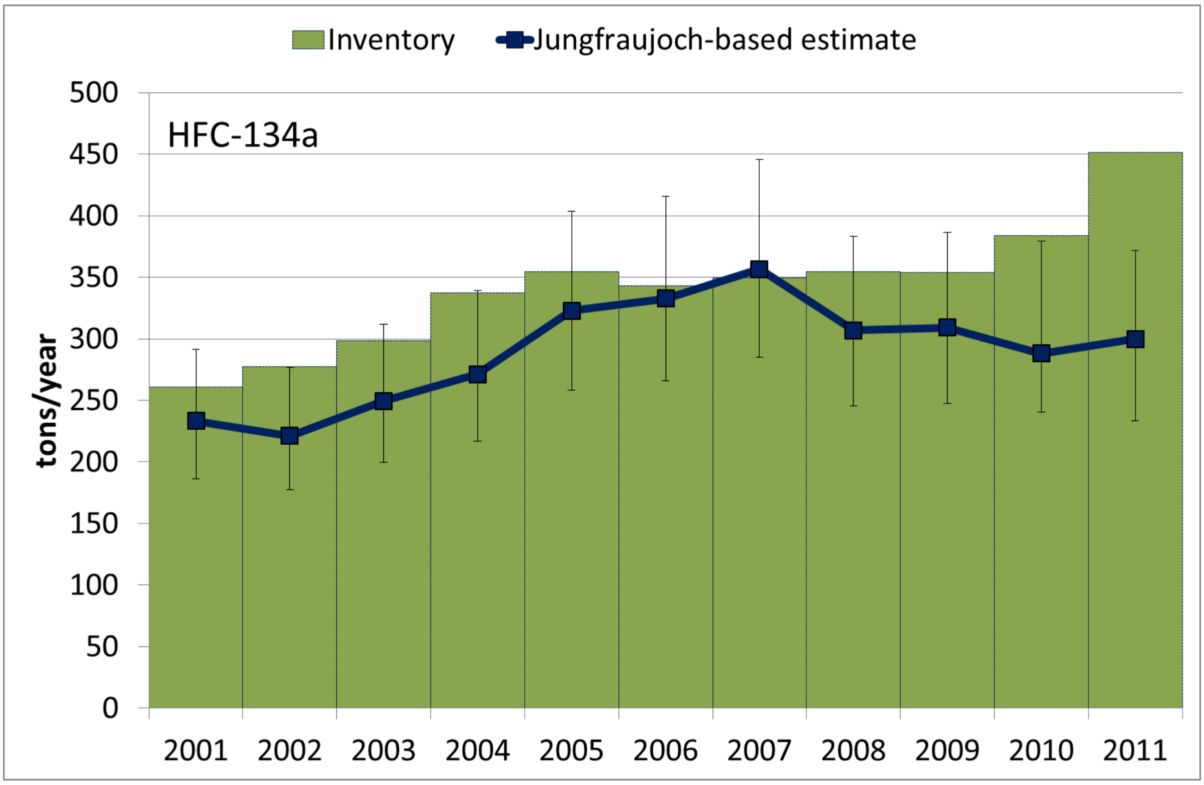

Figure A - 5 Comparison of HFC-134a emissions from Switzerland: Inventory and estimates from measurements at Jungfraujoch.

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.

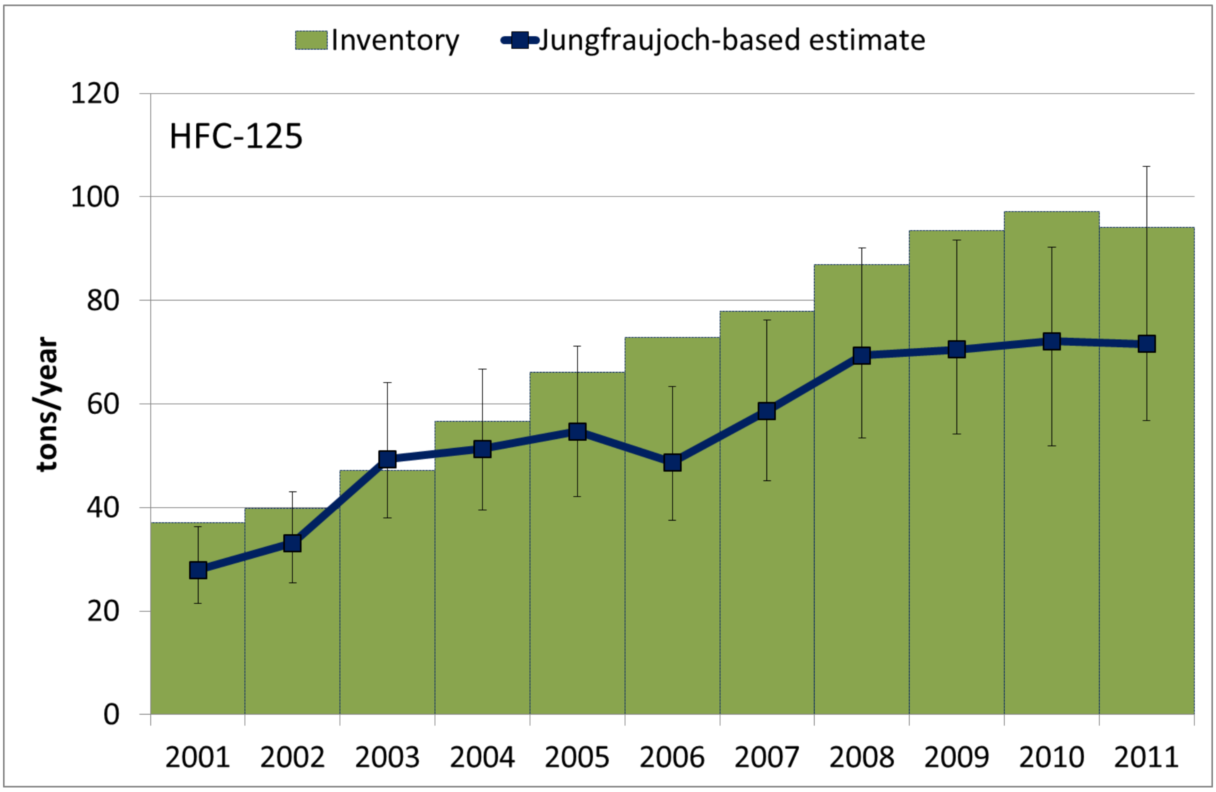

Figure A - 6 Comparison of HFC-125 emissions from Switzerland: Inventory and estimates from measurements at Jungfraujoch.

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. 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[20]. Emissions estimated from Jungfraujoch show a negative trend related to the partial phase-out of HFC-152a from the foam-blowing applications.

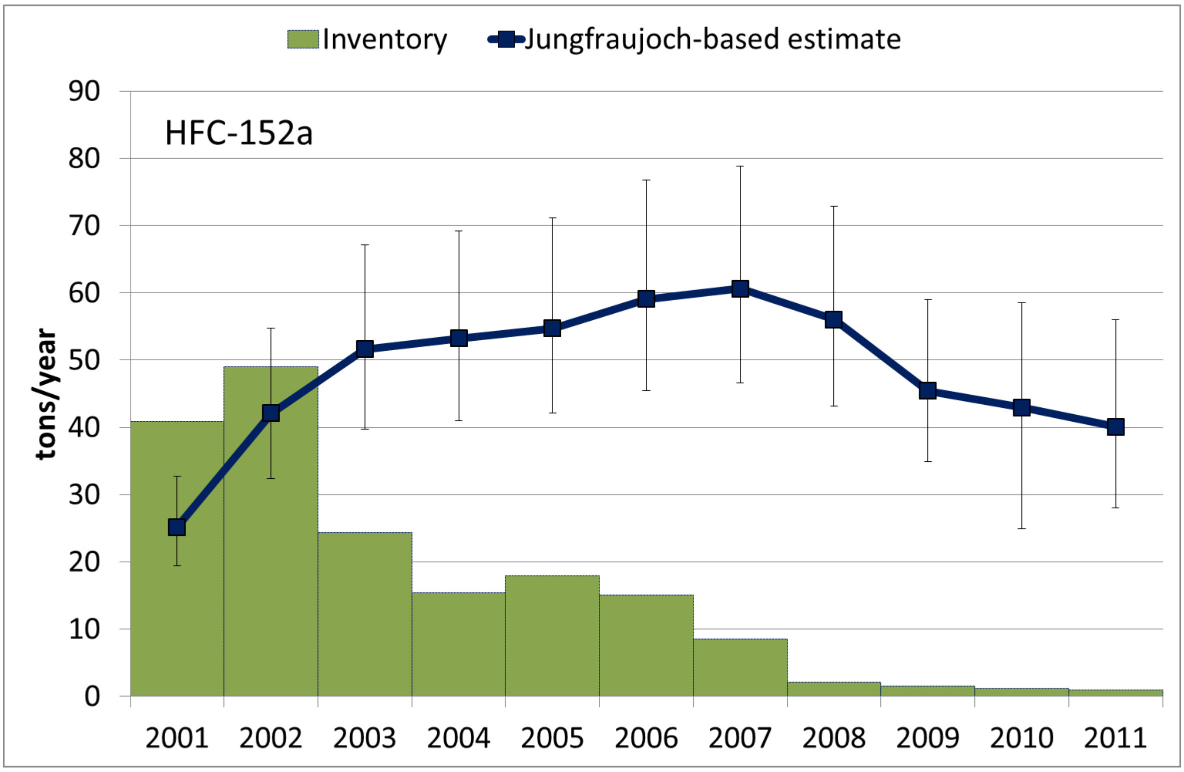

Figure A - 7 Comparison of HFC-152a emissions from Switzerland: Inventory and estimates from measurements at Jungfraujoch.

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.

[20] 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.

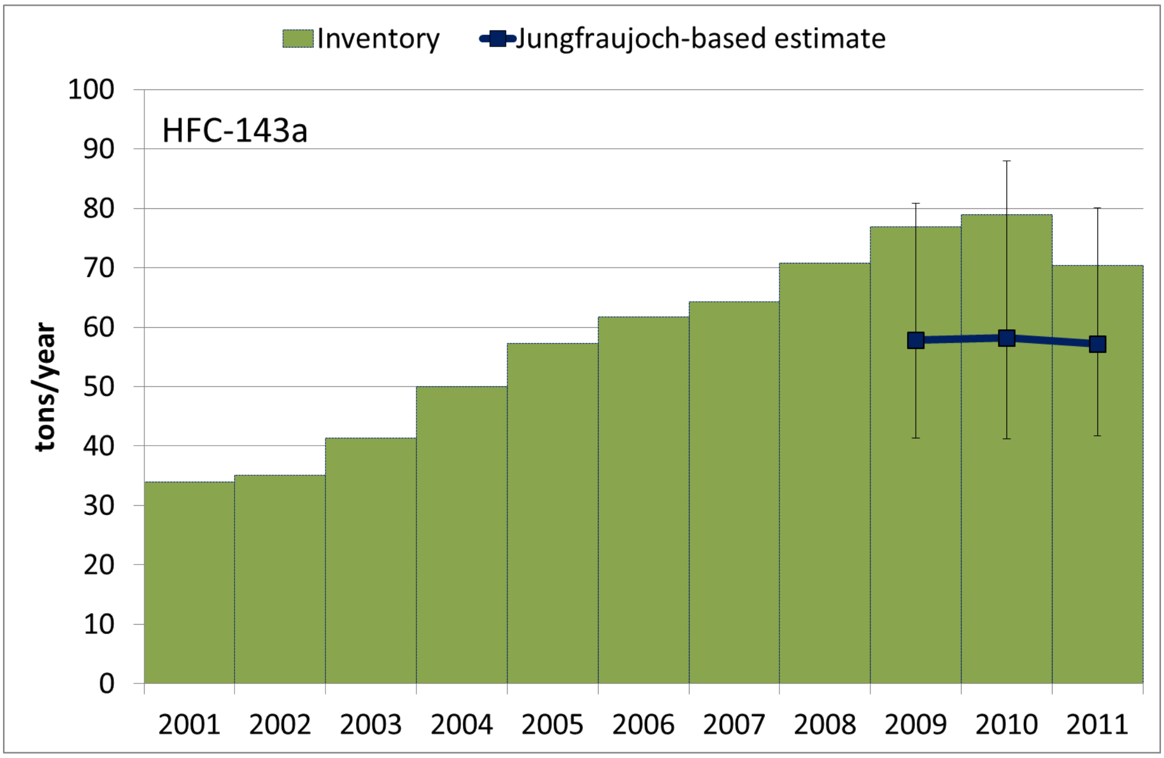

Figure A - 8 Comparison of HFC-143a emissions from Switzerland: Inventory and estimates from measurements at Jungfraujoch.

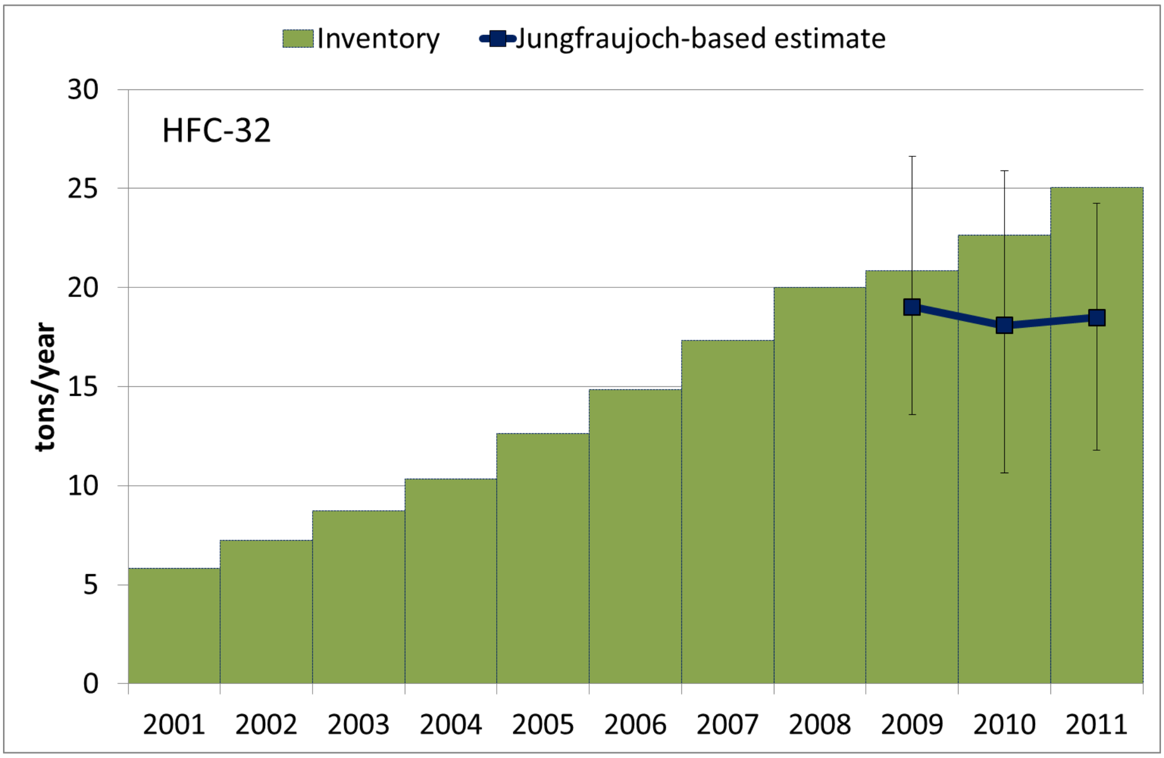

Figure A - 9 Comparison of HFC-32 emissions from Switzerland: Inventory and estimates from measurements at Jungfraujoch.

Annex 7: Supplementary Information on the Uncertainty Analysis

A7.1 Uncertainty Evaluation Tier 1

A quantitative **Tier 1** analysis (following Good Practice Guidance; IPCC 2000: p. 6.13ff) was used to estimate uncertainties in the NIR. First, uncertainties of activity data and emission factors were estimated separately. The combined uncertainty for each source was then calculated using a Rule B approximation (IPCC 2000 p. 6.12). Furthermore, the Rule A approximation was used to arrive at the overall uncertainty in national emissions and the trend in national emissions between the base year and the current year.

Uncertainties of activity data and emission factors are derived from a mixture of empirical data and expert judgment. All uncertainties are consistently defined as half the 95% confidence interval.

A7.2 Uncertainty evaluation Tier 2 (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. The Monte Carlo simulation will be repeated every second year (i.e. again for the 2014 submission). Therefore, **the results shown below do not compare with the Tier 1 uncertainty results for 2011** given in the Section 1.7.1.4.

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

A7.2.1 Uncertainty in emissions

For Tier 2 analysis (of the submission 2012) exactly the same source categories and the same uncertainty estimates were used as in the corresponding Tier 1 analysis.

As a first step, the shape and extent of the probability distributions were derived for the activity data and emission factors, based on measured data, literature or expert judgement. The mean value of the probability distributions was set equal to the value of the GHG inventory. In most cases, normal distributions were assumed. However, for data with a high level of uncertainty, normal distribution would allow negative emissions. For these cases, triangular distributions were used. The triangular distributions are positively skewed and produce only positive values, while the upper bound of emissions may be poorly known.

As a second step, emissions were calculated from emission factors multiplied by the corresponding activity data. For those cases where the activity data or emission factor for a specific source category were not available, emissions were modelled directly with the mean value set equal to the value of the GHG inventory and an adequate probability distribution of the emissions.

The Monte Carlo simulation (of the submission 2012) then provided information on the simulated distribution of every single source category and its statistical characteristics (e.g. the corresponding 2.5 and 97.5 percentiles) as well as on the uncertainty of the national total emissions 2010 and base year 1990 (and its statistical characteristics) as well as on the trend uncertainty 1990–2010.

A7.2.2 Dependent uncertainties

Uncertainties that are dependent on one another (correlations) may have a significant effect on the overall inventory uncertainty.

Special care was taken when deriving the correlations of the source categories of 1A Energy – fuel combustion. In this sector, the uncertainty of the total source category per fuel type is well known, whereas the uncertainty of the sub-categories is not known. According to rules of error propagation, the uncertainty of each subcategory is larger (on the relative level) than the uncertainty of the total. To account for this fact, (negative) correlations between the different fuel activity data were introduced as the uncertainty estimates for the different fuels used are valid only for the total of the respective fuel use in Switzerland.

Further correlations between activity data and emission factors in the agricultural sector and between various other emission factors were included.

Correlations between 1990 and 2010 were also accounted for (see below).

Note that the setting of correlation coefficients may lead to inconsistencies in the Monte Carlo simulation. In those cases, Crystal Ball software automatically adjusts the corresponding correlation coefficients and sends a message to the user.

Correlation coefficients had to be chosen on a semi-quantitative basis. The following assumptions were made for the coefficients of the submission 2012

- very weak correlations: ± 0.2
- weak correlations: ± 0.4
- medium correlations: ± 0.6
- strong correlations: ± 0.8
- perfect correlations: ± 1

A7.2.3 Uncertainty in emission trends

The trend is defined as the difference between the base year and the year of interest (2010). Hence for estimation of the uncertainty in the emission trends, the Monte Carlo simulation was run for the year 2010 and for the base year 1990. The trend was then derived for the source categories as well as for the total emissions. It was assumed that the activity data of 1990 are positively correlated with the activity data of 2010 (weak correlation coefficients 0.4). Furthermore, the emission factors of the two years are assumed to be positively correlated (strong correlation coefficient 0.8). The probability distributions of the 1990 data are assumed to be of equal shape as the distributions derived for 2010.

A7.2.4 Results: Uncertainties of national total emissions excluding LULUCF in 2010 and of trend 1990–2010

The Monte Carlo simulations of the submission 2012 revealed that the uncertainty distribution of the total emissions for 2010 (year t) is slightly narrower than the distribution for the base year 1990. Due to the higher emissions in 2010, it is shifted towards higher mean emissions (see Figure below).

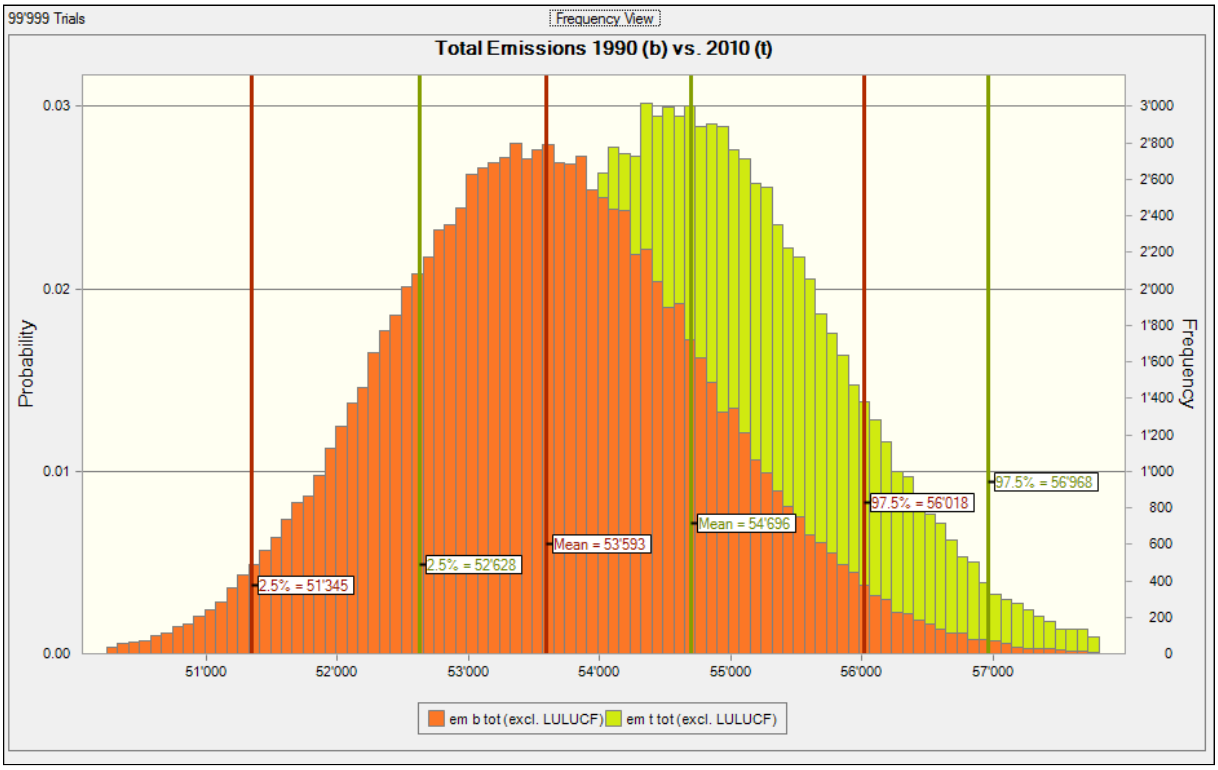

Figure A - 10 Probability distributions of total emissions (excl. LULUCF) for the base year (1990, in orange) and for year t (2010, in green). On the x-axis, the total emissions reported in the Swiss inventory (excluding LULUCF) are given in Gg CO2 equivalent. Number of Monte Carlo runs: 99'999. The vertical lines show simulated mean values (Mean) and the 2.5 and 97.5 percentile values. Note that mean and percentile values correspond to the simulated values and differ slightly from the reported inventory values.

The main results of the Monte Carlo simulation (submission 2012) were

- The total level uncertainty of the 2010 Swiss emissions is 3.97% of the total GHG emissions excluding LULUCF. The 95% confidence interval is almost symmetric and lies between 96.2% and 104.2% of the total GHG emissions.
- The trend uncertainty of the 2.24% increase of total emissions excluding LULUCF between 1990 and 2010 is 3.2%. With a probability of 95%, the change lies within the range of -1.19% to +5.27%,

Taking into account the correlations in Tier 2 analysis between activity data and between emission factors leads to a slight increase in the overall level uncertainty of the GHG emissions compared to Tier 1 analysis.

A7.2.5 Results: Uncertainties including LULUCF

Like in Tier 1 uncertainty analysis, the LULUCF categories are also included for the Tier 2 uncertainty analysis (submission 2012). The total emissions of sector 5 LULUCF categories equal -880 Gg CO2 eq, increasing the overall level uncertainty by 0.27%. Thus level uncertainty for 2010 including LULUCF is 4.23%.

The trend uncertainty of the national total emissions is increased by the inclusion of LULUCF by 1.16%. Trend uncertainty including LULUCF amounts to 4.36%.

A7.2.6 Results: Uncertainties by gas

For the uncertainties by gas, the Monte Carlo simulation of the submission 2012 provided results shown in the table below. The relative uncertainty of CO_2 is very low in accordance with the high precision of fuel statistics and carbon contents of fuels. CH_4 and F-gases have medium uncertainties while N_2O has the highest uncertainty in relative and absolute terms.

Table A - 34 Uncertainties by gas 2010

Gas	Mean relative uncertainty 2010 %
CO2	3%
CH4	18%
N2O	44%
HFC	12%
PFC	18%
SF6	27%
Total	**3.97%**

A7.2.7 Tornado Diagram

The following chart shows the results of a sensitivity analysis, depicting the most important sources of uncertainty including LULUCF (submission 2012). This can either be a single EF, AD or emissions as a total. The bars depict the amount of uncertainty introduced compared to total emissions (on x-axis).

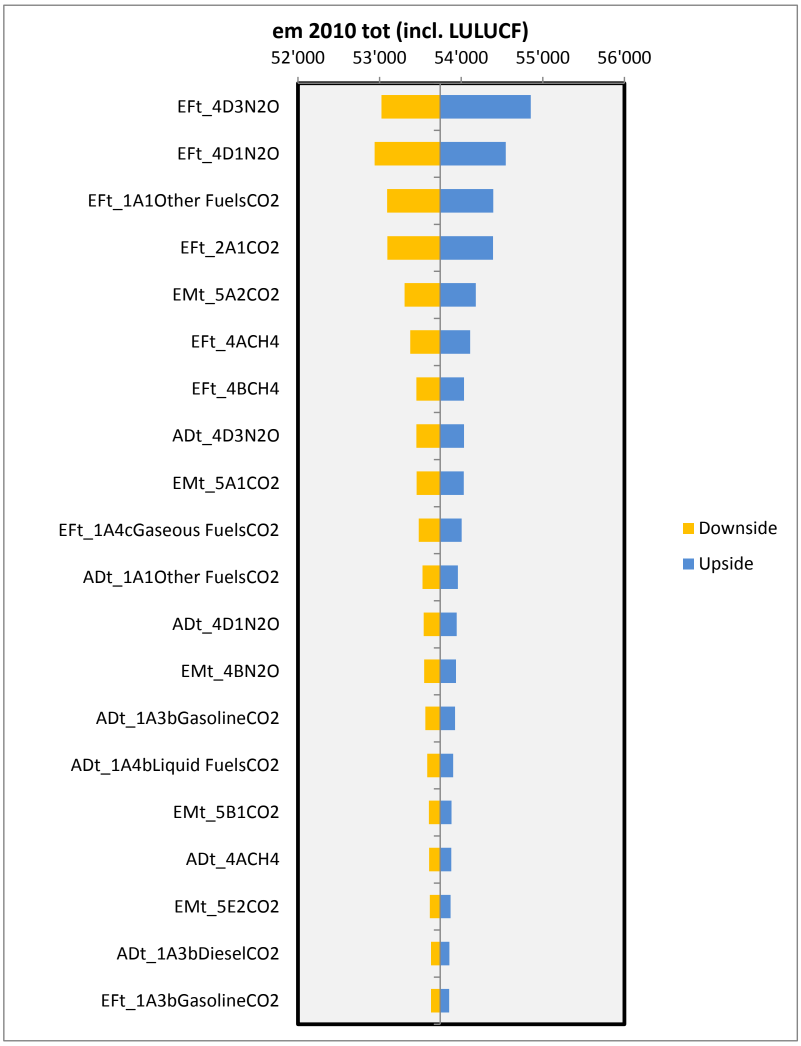

Figure A - 11 Most important sources of uncertainty in 2010 (incl. LULUCF). The bars depict the amount of uncertainty introduced compared to total emissions on x-axis. (The letter “t” in the abbreviation of the sources indicates year t –2010 in the current submission – to distinguish from the base year 0.) Abreviations EF, AD, EM refer to emission factor, activity data and emission.

A7.3 Comparison of Tier 1 with Tier 2 results of the submission 2012

In the GHG inventory, some of the uncertainties may become large and their statistical distribution may clearly deviate from normal distributions. Tier 1 uncertainty analysis is based on simple error propagation, which assumes only small and normally distributed uncertainties. The application of the Tier 1 method is therefore not the optimal instrument for determining the uncertainties of a GHG inventory. The more appropriate choice is the Monte Carlo simulation, which is designed for uncertainties of any shape, for any size of uncertainties, any correlated variables and which is recommended by the IPCC Good Practice Guidance (IPCC 2000) as the Tier 2 method. The results of the Monte Carlo simulation (submission 2012) are therefore considered to provide a more realistic picture of the uncertainties than the results of the Tier 1 method.

Results from Tier 1 and Tier 2 (submission 2012) analysis are fully comparable as they are based on the same categories with the same uncertainty estimates for each of the categories.

The Tier 2 overall level uncertainty of 3.97% for 2010 emissions (excluding LULUCF) is somewhat larger than the 3.84% of the Tier 1 uncertainty analysis.
For the overall trend uncertainty (excl. LULUCF), the Tier 2 result of 3.2% is significantly higher than Tier 1 level uncertainty of 2.0%.

The differences between Tier 1 and Tier 2 analyses arise to the following reasons: The Monte Carlo simulation produces different results as it treats large uncertainties correctly and accounts for other than normal distributions. Furthermore, the correlations between activity data and between emission factors are considered, which is not the case in the Tier 1 analysis. As shown above, the correlations lead to an overall expansion of the uncertainty, especially in trend analysis due to the consideration of correlations in time. Setting the correlations to zero and using normal distributions only, the Tier 2 level uncertainty is identical to Tier 1 level uncertainty.

Annex 8: Supplementary Information under Article 7, paragraph 1 of the Kyoto Protocol

No supplementary information under this item.