Switzerland's Informative Inventory Report 2017 (IIR)

Submission under the UNECE Convention on Long-range Transboundary Air Pollution

Submission of March 2017
to the United Nations ECE Secretariat

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Glossary

AD	Activity data
BaP	Benzo(a)pyrene (CLRTAP: POP)
BbF	Benzo(b)fluoranthene (CLRTAP: POP)
BC	Black Carbon
BkF	Benzo(k)fluoranthene (CLRTAP: POP)
Carbura	Swiss organisation for the compulsory stockpiling of oil products.
CEIP	EMEP Centre on Emission Inventories and Projections
Cd	Cadmium (CLRTAP: priority heavy metal)
Cemsuisse	Association of the Swiss Cement Industry
CHP	Combined heat and power production
CLRTAP	UNECE Convention on Long-Range Transboundary Air Pollution
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
CRF	Common reporting format (UNFCCC)
CSD	Engineering company, Bern (author of IIR)
CSS	Mix of special waste with saw dust; used as fuel in cement kilns
DDPS	Federal Department of Defense, Civil Protection and Sport
DETEC	Department of the Environment, Transport, Energy and Communications
DPF	Diesel particle filter
EF	Emission factor
EMIS	Swiss Emission Information System
EMEP	Co-operative programme for monitoring and evaluation of the long-range transmissions of air pollutants in Europe (under the CLRTAP)
EMPA	Swiss Federal Laboratories for Material Testing and Research
EPA	Federal Act on the Protection of the Environment
EV	Erdöl-Vereinigung (Union Pétrolière)
IcdP	Indeno(1,2,3-cd)pyrene (CLRTAP: POP)
FAL	Swiss Federal Research Station for Agroecology and Agriculture (since 2013 Agroscope)
FCA	Federal Customs Administration
FEDRO	Swiss Federal Roads Office
FOCA	Federal Office of Civil Aviation
FOEN	Federal Office for the Environment (former name SAEFL until 2005)
FSKB	Fachverband der Schweizerischen Kies- und Betonindustrie

Gas oil	Light Fuel Oil
GHG	Greenhouse gas
GVS	Giesserei Verband der Schweiz / Swiss Foundry Association
ha	Hectare
HAFL	School of Agricultural, Forest and Food Sciences at Bern University of Applied Sciences
HCB	Hexachlorobenzene
Hg	Mercury (CLRTAP: priority heavy metal)
HM	Heavy metals
INFRAS	Research and consulting company, Zurich (authors of IIR)
IPCC	Intergovernmental Panel on Climate Change
IIR	Informative Inventory Report (CLRTAP)
ICAO	International Civil Aviation Organization
I-Teq	International Toxic Equivalent
kha	Kilo hectare
kt	Kilo tonne (1000 tonnes)
LTO	Landing-Takeoff-Cycle (Aviation)
LUBW	Baden-Württemberg State Institute for Environmental Protection (Landesanstalt für Umweltschutz Baden-Württemberg), Germany
LULUCF	Land Use, Land-Use Change and Forestry
MOFIS	Swiss federal vehicle registration database run by FEDRO
MSW	Municipal solid waste
NCV	Net calorific value
NH_3	Ammonia
NIR	National Inventory Report
NIS	National Inventory System
NMVOC	Non-methane volatile organic compounds
NO_x, NO_2, NO	Nitrogen oxides, nitrogen dioxide, nitrogen monoxide
NA, NE, IE, NO, NR	(official notation keys) not applicable, not estimated, implied elsewhere, not occuring, not relevant
nx	(in combination with PM2.5 nx and PM10 nx) non-exhaust fraction of PM2.5 or PM10 emission
OAPC	Ordinance on Air Pollution Control
PAH	Polycyclic aromatic hydrocarbons (CLRTAP: POP)
PCDD/PCDF	Polychlorinated dibenzodioxins and -furanes (CLRTAP: POP)
Pb	Lead (CLRTAP: priority heavy metal)
PCB	Polychlorinated biphenyls
PM, PM2.5, PM10	Suspended particulate matter (PM) with an aerodynamic diameter of less than 2.5 µm or 10 µm, respectively.
POPs	Persistent organic pollutants

QA/QC	Quality assurance/quality control: QA includes a system of review procedures conducted by persons not directly involved in the inventory development process. QC is a system of routine technical activities to control the quality of the inventory.
QMS	Quality management system
SAEFL	Swiss Agency for the Environment, Forests and Landscape (since 2006: Federal Office for the Environment FOEN)
SFOE	Swiss Federal Office of Energy
SFSO	Swiss Federal Statistical Office
SGCI/SSCI	Schweiz. Gesellschaft für Chemische Industrie / Swiss Society of Chemical Industries
SO_x, SO_2	Sulphur oxides (sum of SO_2 and SO_3), sulphur dioxide
SGWA	Swiss Gas and Water Industry Association
SWISSMEM	Swiss Mechanical and Electrical Engineering Industries (Schweizer Maschinen-, Elektro- und Metallindustrie)
TAN	Total ammonia nitrogen
TEQ/WHO 1998-TEQ	Toxic Equivalent (unit of toxic equivalent factors for PCB's, PCDDs, PCDFs for Humand and Wildlife. By WHO)
TFEIP	Task Force on Emission Inventory and Projections
TSP	Total suspended particulate matter
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compounds
VTG	Verteidigung Luftwaffe (Swiss Air Force Administration)
VSG/SGIA	Swiss Gas Industry Association
VSTB	Swiss Association of Grass Drying Plants
WAM	Scenario "With Additional Measures" (see chp. 9.2)
WM	Scenario "With Measures" (see chp. 9.2)

Executive Summary

Switzerland and CLRTAP

Switzerland has signed and ratified the 1979 Geneva Convention on Long-range Transboundary Air Pollution (CLRTAP). The aim of the Convention is to protect the population and the environment against air pollution and to limit and gradually reduce and prevent air pollution including long-range transboundary air pollution. Under the seven CLRTAP Protocols including the Gothenburg Protocol, require an annual emission reporting. The Gothenburg Protocol is a multi-pollutant protocol designed to reduce acidification, eutrophication and ground-level ozone by setting national emissions ceilings for sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia, which were to be met by 2010 and maintained afterwards. Negotiations on a revision of the Protocol resulted in emission reduction commitments for 2020 and beyond expressed as a percentage reduction from the 2005 emission level have been finalised in 2012. This amended protocol has not yet entered into force.

Following its obligations under the CLRTAP, Switzerland annually submits its air pollution emission inventory (“CLRTAP Inventory”) as well as an Informative Inventory Report (IIR) according to the revised emission reporting guidelines of EMEP. The emission inventory exists since the mid 80’s while the very first IIR as a report was submitted in 2008 (FOEN 2008) in accordance with the Guidelines for Reporting Emission Data under the Convention. The report on hand is now the tenth IIR of Switzerland.

The report has substantially improved over the years due to recurring external and internal reviews. Stage 1 and stage 2 centralized reviews took place annually, centralized stage 3 reviews in 2010 (UNECE 2010) and 2016 (UNECE 2016a). For the current submission and driven by this last centralized stage 3 review, specific improvements have been implemented. For a list of the most important improvements, see chapter 1.4.1. Additional information on specific improvements are given in the chapters of the respective secors and source categories.

Swiss CLRTAP Inventory system

The Swiss inventory system has been developed and is managed by the Federal Office for the Environment (FOEN) under the auspices of the Federal Department of the Environment, Transport, Energy and Communications (DETEC).

FOEN’s Air Pollution Control and Chemicals Division maintains a database called EMIS (**EM**issions**I**nformationssystem **S**chweiz, Swiss Emission Information System) containing all basic data needed to prepare the CLRTAP inventory. Background information on data sources, activity data, emission factors and methods used for emission estimation are documented in EMIS.

A number of data suppliers provide input data that is fed into EMIS. The inventory’s most relevant data sources are the Swiss overall energy statistics, existing models for road transportation and non-road vehicles and machines, data from industry associations and agricultural statistics and models.

Typically, emissions are calculated according to standard methods and procedures as described in the revised UNECE Guidelines 2014 for Estimating and Reporting Emission Data under the Convention on Long Range Transboundary Air Pollution (ECE 2014) and in the EMEP/EEA Air Pollutant Emission Inventory Guidebook — editions 2009 and 2013 (EMEP/EEA 2013). With a few exceptions, calculations of emissions are consistent with methodological approaches in the greenhouse gas (GHG) inventory under the UNFCCC.

However, some relevant discrepancies exist. For example, the Swiss CLRTAP Inventory system applies the “fuel used” principle for road traffic emissions for estimating compliance with the emission reduction ceilings, while for the GHG inventory, the “fuel sold” principle applies. This means that fuel tourism and statistical difference is accounted for in the emissions of the GHG inventory, but not in the CLRTAP Inventory. Note that in the official emission reporting templates the Swiss “national total” is reported as “fuel sold” in order to be comparable to other countries. But the Swiss “national total for compliance” is the national total based on the “fuel used” as mentioned before. The difference between the two approaches can amount to several percent, but deviations varied considerably in the period 1990–2015 due to fluctuating fuel price differences between Switzerland and its neighbouring countries. Also methodological approaches to determine emissions from aviation under the CLRTAP deviate from the GHG inventory: so-called landing and take-off (LTO) emissions of domestic and international flights are taken into account for the national total CLRTAP while emissions of international and domestic cruise flights are reported under memo items only.

Key categories, uncertainties and completeness

Two Tier 1 level assessments for years 2015 and 1990 and a Tier 1 trend assessment for the period 1990-2015 were performed in this submission. The most relevant source categories for both, the level assessment 2015 and the trend assessment 1990-2015 stem predominantly from sectors 1 Energy and 3 Agriculture.

Uncertainties are evaluated on the Tier 1 level for the main pollutants (NO_x, NMVOC, SO_x, NH_3), for PM2.5, and PM10. The analysis has been carried out for level uncertainties 2015 and trend uncertainties 1990-2015. Level uncertainty estimations range from 6% to 21%, trend uncertainties from 1% to 7%. The level and trend uncertainty estimations are very similar compared to the values of the previous submission 2016 for all the pollutants, the differences lie between 0.1 (NMVOC) and 1.4 percentage points (NH_3).

Complete emission estimates are accomplished for all known sources and air pollutants. According to current knowledge, the Swiss CLRTAP Inventory is complete.

Quality assurance and quality control (QA/QC)

A QA/QC system for the GHG inventory is in place that also covers most of the preparation process of the CLRTAP Inventory. The National GHG Inventory, which is also derived from the Swiss Emission Information System (EMIS), complies with the ISO 9001:2008 standard (Swiss-TS 2013). It was certified by the Swiss Association for Quality and Management Systems in December 2007 and has been re-audited annually, last time on 13th October 2016. A separate and formalized CLRTAP Inventory quality system is not foreseen. However, a centralised plausibility check for emissions was established recently that compares past emissions with those for the current submission.

Emission Trends

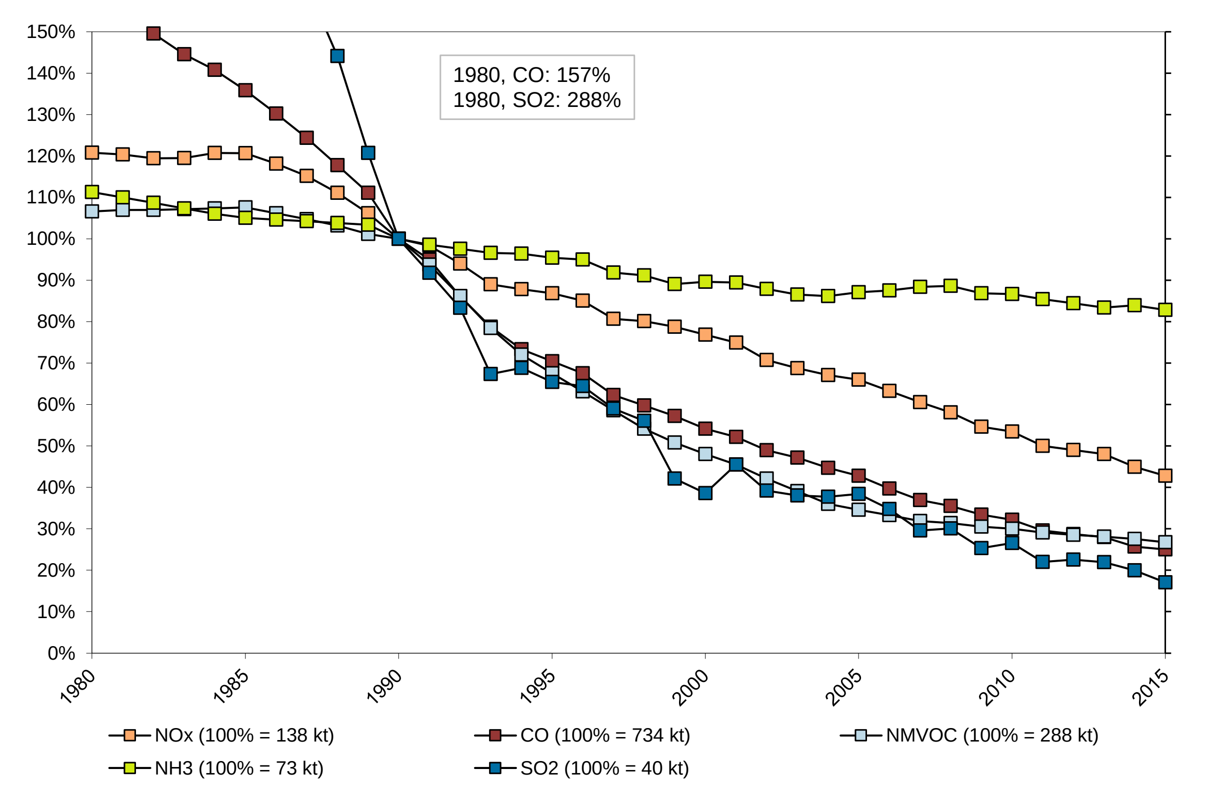
Characteristics of the sectors

- 1 Energy: the energy sector encompasses both, fuel combustion activities (stationary/mobile) and fugitive emissions from fuels. Compared to the other sectors, fuel combustion activities are the main emission source of all air pollutants reported in the IIR except for NH_3 and NMVOC. Within sector 1 Energy, source category 1A3 Transport is the predominant source of all main pollutants except for SO_2 and PM2.5, where 1A2 and

1A4, respectively, are the most important sources. Apart from NH_3, the emissions of all pollutants decreased continuously and significantly since 1990. NH_3 increased until 2000 and slightly decreased, too, since then.

- 2 Industrial processes and product use: this sector comprises process emissions from the mineral, chemical and metal industry. Included are also other production industries such as pulp and paper industry and food and beverages industry as well as other solvent and product use, e.g. emissions from paint applications and domestic solvent use. Emissions from industrial processes and product use are the main emission source of NMVOC and an important source of PM2.5 and Hg emissions. NMVOC emissions originate mainly from source category 2D3 Other solvent use. 2A1 Cement production, 2A5a Quarrying and mining other than coal, 2G Other product use (i.e. use of fireworks) and 2H1 Pulp and paper industry are responsible for considerable amounts of PM2.5 emissions, whereas 2C1 Iron and steel production is a crucial source of heavy metal emissions. SO_x is generated mainly by 2B5 Carbide production as well as 2C3 Aluminium production (up to 2006). Since 1990 the emissions of all pollutants decreased more or less continuously but remained about constant in the past few years.
- 3 Agriculture: this sector encompasses emissions from livestock production and agricultural soils. Overall, sector 3 Agriculture clearly is the predominant contributor to total Swiss NH_3 emissions, also contributing to a relevant share of NMVOC, NO_x, and PM2.5. Within the sector, the NH_3 emissions are attributed to the source categories 3B Manure management and 3D Agricultural soils. Most NH_3 emission reductions occurred between 1980 and 2002, but since 2003 they remain more or less stable. Emissions of NO_x on the other hand reveal a continuous decreasing trend since 1990. Finally, the PM2.5 emissions show an increasing trend since 1996.
- 4 Land Use, Land-Use Change and Forestry: The emissions of this sector are not accounted for in the commitments of the Gothenburg Protocol. Only forest fires are reported under 11B in memo items.
- 5 Waste: This sector encompasses solid waste disposal on land, biological treatment of solid waste, waste incineration and open burning of waste, wastewater handling and other waste. Overall, emissions of the main pollutants are minor when compared to the other sectors. The heat generated in waste incineration plants has to be recovered in Switzerland, and in accordance with the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013), emissions from the combustion of waste-to-energy activities are therefore dealt within 1A Fuel combustion. The most important pollutants are PM2.5, NMVOC, PCDD/PCDF and heavy metals (Pb, Hg). PM2.5 and PCDD/PCDF emissions mainly stem from 5C Incineration and open burning of waste, while NMVOC emissions are mainly caused by 5B Biological treatment of solid waste. Illegal waste incineration is the largest source of heavy metals such as Pb and Hg. With the exception of NMVOC, the emissions in sector 5 Waste have declined since 1990, in particular PM2.5.
- 6 Other: In this sector mainly emissions from human and pet ammonia, private application of synthetic fertilizer and urea as well as fire damages in estates and in motor vehicles are reported. This sector is a relevant source of heavy metals, PCDD/PCDF and PAHs. Regarding the main pollutants however, emissions from sector 6 Other are minor when compared to sectors 1 to 5. Overall, emissions show more or less fluctuations without significant trends.

Emission Trends 1980-2015



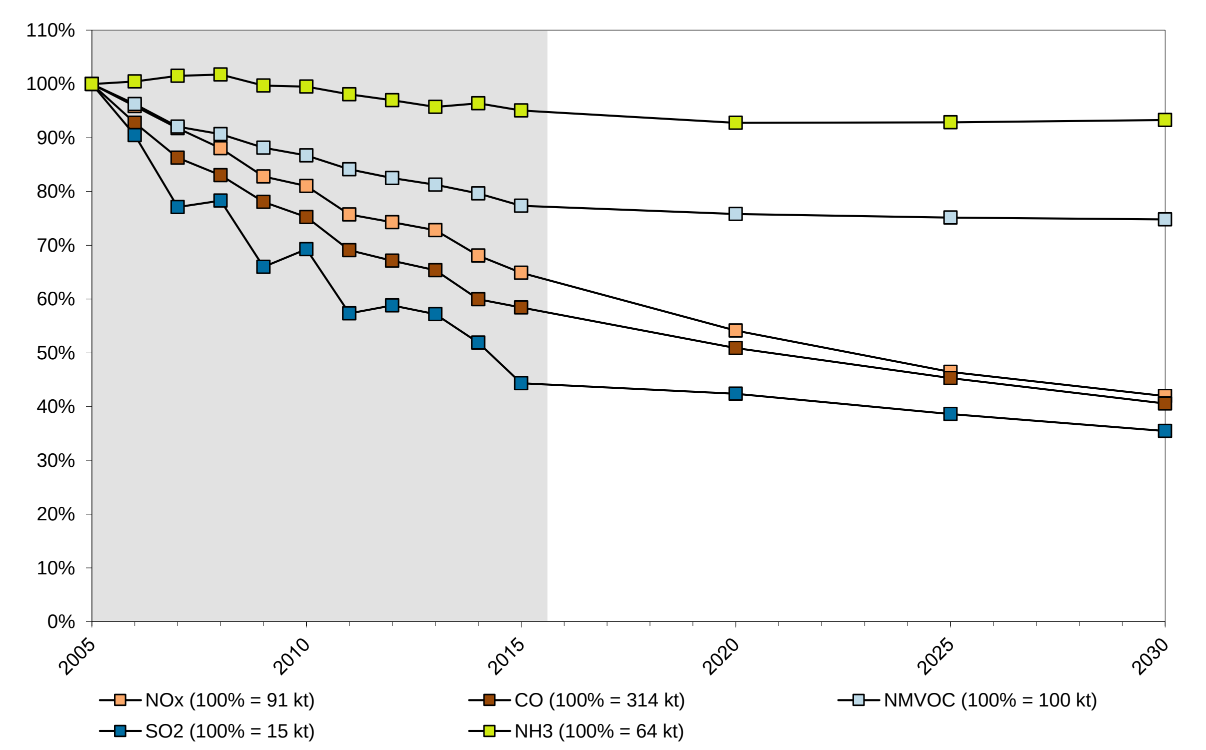
ES Figure 1.1 Relative trends for the total emissions of main pollutants and CO in Switzerland 1980-2015.

Overall, ES Figure 1.1 shows a decreasing trend of all main air pollutants and CO. The significant decline of NO_x, NMVOC and CO emissions is caused by effective reduction measures: abatement of exhaust emissions from road vehicles and stationary installations, taxation of solvents and voluntary agreements with industry sectors. As a result of the legal restriction of sulphur content in liquid fuels and the decrease of coal consumption, SO_x emissions decreased significantly as well. In contrast to the other main pollutants, NH_3 emissions only show a slight reduction mainly due to the decrease of animal numbers and changes in agricultural production techniques. Emission trends for PM2.5 (not included in ES Figure 1.1, see Figure 2-3) reveal a significant decline between 1980 and 2015 mainly as a result of the abatement of exhaust emissions from road vehicles and also to a minor extent from non-road machinery and from improved residential heating equipment.

Projections for Emissions until 2030

Two scenarios are reported: “With Measures (WM)” and “With Additional Measures (WAM)”. Both are based on the projected energy consumption of the Energy Perspectives 2050 (Prognos 2012a) and on further assumption for the activity data. The emission projections of air pollutants in Switzerland have been fully revised in the course of submission 2014. The data for the energy sector are in accordance with the scenarios of the Energy Perspectives 2050 (Prognos 2012a) from 2020 onwards. For Road transportation, modelled data for the whole period is available (FOEN 2010i). For the sectors IPPU and Waste the latest perspectives for Switzerland’s inhabitants are integrated (SFSO 2015c), and for the agricultural sector, independent scenarios were developed (FOAG 2011). Chp. 9 provides detailed assumptions for both scenarios, and the results for the WM scenario are depicted for all pollutants.

ES Figure 1.2 shows the past emissions from 2005-2015 and the projected emissions until 2030 for main air pollutants relative to 2005 levels under the “with measures” scenario.



ES Figure 1.2 Relative trends for the total emissions from 2005-2015 and the projected emissions until 2030 for main pollutants and CO. 100% corresponds to 2005 levels (base year).

Total emissions of the main air pollutants show differing decreases from the reporting year onwards until 2030. For several pollutants, a further distinct decrease is forecast: NO_x, SO_x and CO. For NMVOC, a very moderate decrease is expected between 2015 and 2030. NH_3 emissions on the other hand are expected to remain mostly stable in the very same period. Forecasts for suspended particulate matter predict a declining trend in emissions as well, whereas emissions of heavy metals are expected to stabilize (Pb, Hg) or increase slightly (Cd) on a low level.

Gothenburg Protocol

Under the CLRTAP, the Gothenburg Protocol requires that parties shall reduce and maintain the reduction in annual emission in accordance with emission ceilings set for 2010 and beyond. The following table shows the emission ceilings, the reported emissions for 2010 and the respective compliance. Accordingly, Switzerland is in compliance with the Gothenburg Protocol emission ceilings for all pollutants in 2010, with the exception of NH_3 where slightly higher emissions are reported according to recalculations. All emissions 2015 are in compliance with the emission ceilings.

ES Table 1.1 Emission ceilings of the Gothenburg Protocol for 2010 and beyond compared to the reported emissions for 2010 and 2015 of the current submission (2017).

Pollutants	National emission ceilings for 2010 kt	Emissions 2010 (Subm. 2017) kt	Emissions 2015 (Subm. 2017) kt	Compliance with emission ceilings 2010 in 2015
SO_x	26.0	10.5	6.7	yes
NO_x	79.0	73.8	59.1	yes
NMVOC	144.0	86.5	77.2	yes
NH_3	63.0	63.4	60.6	yes

Negotiations on a revised Gothenburg Protocol resulted in emission reduction commitments for 2020 and beyond expressed as a percentage reduction from the 2005 emission level. However, the amended Protocol has not yet entered into force. ES Table 1.2 shows the emission reduction commitments for 2020 and the corresponding level of the emissions 2015.

ES Table 1.2 Emission reduction commitments 2020 compared to the reported emission levels for 2015. Emission commitments 2020 are defined as reductions in percentages from 2005 (see second row).

Pollutant	Emission reduction commitments 2020	Reduction 2005-2015
	%-reduction of 2005 level	*%*
SO_x	21%	56%
NO_x	41%	35%
NMVOC	30%	23%
NH_3	8%	5%
PM2.5	26%	27%

Recalculations and improvements

Recalculations cause a lower emission level in 2014 for NO_x, SO_x, NH_3, PM10, TSP, CO, Pb. Cd, Hg, PCDD/PCDF and total PAH emissions. An increase due to recalculations is observed for NMVOC, PM2.5, BC and HCB. In 1990, the direction of the impact of recalculations is identical as compared to 2014. An opposite sign is observed for recalculations of PM2.5, BC, Hg and Pb. Detailed information on recalculations is provided in chapter 8.1.

In the current submission, several improvements were conducted following recommendations and encouragements of the ERT stated at the end of the UNECE centralized Stage 3 review in 2016.

A number of further improvements are identified but could not yet be realised. They are documented as planned improvements in the corresponding sector chapters and summarised in chp. 8.2.

1 Introduction

1.1 National inventory background

Switzerland has signed and ratified the 1979 Geneva Convention on Long-range Transboundary Air Pollution (CLRTAP) and its Protocols (Swiss Confederation 2004):

- The 1985 Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30%.
- The 1988 Sofia Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes.
- The 1991 Geneva Protocol on the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes.
- The 1994 Oslo Protocol on Further Reduction of Sulphur Emissions.
- The 1998 Aarhus Protocol on Heavy Metals.
- The 1998 Aarhus Protocol on Persistent Organic Pollutants.
- The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone.

According to the obligations of the CLRTAP, Switzerland is annually submitting its emission inventory (CLRTAP Inventory). For the present submission in March 2017, Switzerland provides for the tenth time an Informative Inventory Report (IIR) with the documentation on hand. For this submission, the entire document was updated.

1.2 Institutional arrangements

The Swiss inventory system for the CLRTAP is developed and managed under the auspices of the the Federal Office for the Environment (FOEN). As stipulated in the Ordinance on Air Pollution Control of 16 December 1985 (Swiss Confederation 1985), this Office has the lead within the Federal administration regarding air pollution policy and its implementation.

The FOEN publishes overviews of emissions and air quality levels. It has also built up and maintains the Swiss Emission Information System (EMIS) that contains all basic data needed to prepare the CLRTAP Inventory (and which contains also all greenhouse gas emissions as required for the preparation of the UNFCCC Greenhouse Gas Inventory).

1.3 Inventory preparation process

Various data suppliers collect the data needed for the preparation of the CLRTAP Inventory. The individual data suppliers are in charge for the quality of the data provided, so they are also responsible for the collection of activity data and for the selection of emission factors and methods. However, the relevant guidelines including the Guidelines for Reporting Emissions and Projections data under the Convention on Long-range Transboundary Air Pollution (ECE 2014, ECE 2014a) and IPCC Guidelines 2006 (IPCC 2006), are also required to be taken into account. Various QA/QC activities (see Chapter 1.6) provide provisions for maintaining and successively improving the quality of inventory data.

As mentioned above, the Air Pollution Control and Chemicals Division at FOEN maintains the EMIS database, which contains all basic data needed for the preparation of the CLRTAP Inventory. Simultaneously, background information on data sources, activity data, emission factors and methods used for emission estimation is also documented in EMIS and cited in the subsequent chapters as EMIS 2017/(*NFR-Code*).

Figure 1-1 illustrates in a simplified manner the data collection and processing steps leading to the EMIS database and its main outputs into the CLRTAP air pollution emission inventory and into the IPCC/UNFCCC greenhouse gas inventory.

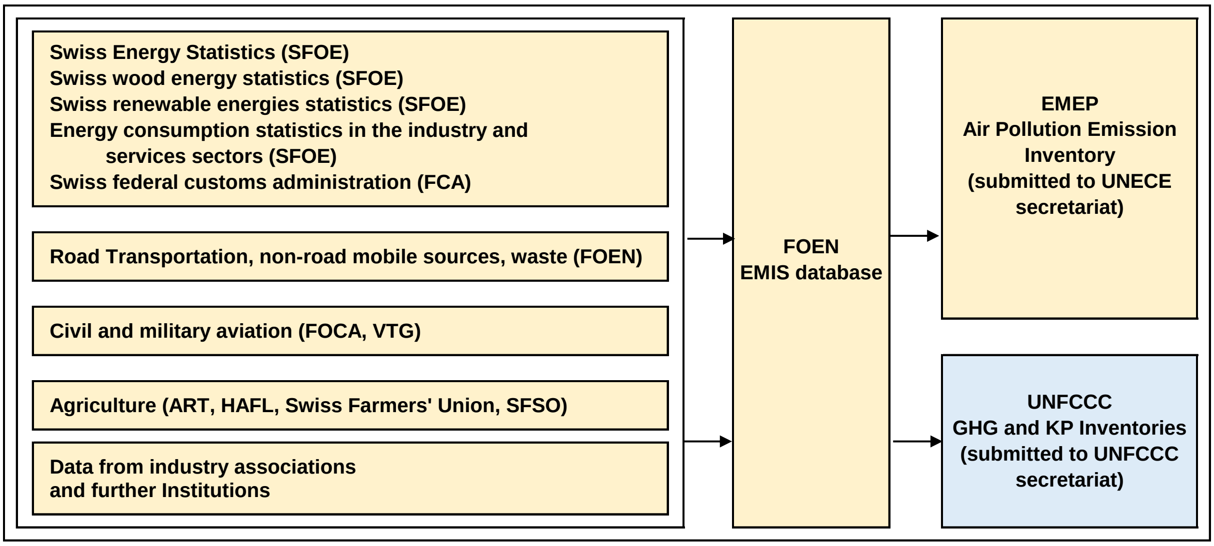


Figure 1-1: Data collection for EMIS database and CLRTAP air pollution emission inventory (GHG: Greenhouse Gas, KP: Kyoto Protocol).

Since the preparation of the CLRTAP Inventory is very closely connected to the preparation of the GHG inventory, there are many parallel working steps. Also, the compilation of the Informative Inventory Report (IIR, the document on hand) and of the National Inventory Report (NIR, see FOEN 2017) are going on simultaneously and are, partly, updated by the same persons. Therefore, both reports are structured similarly.

Annual Stage 1 and 2 reviews were carried out by the CEIP and documented on the EMEP Website (UNECE 2016). Additionally, two in-depth Stage 3 reviews took place in 2010 and 2016 (documented in UNECE (2010) and UNECE (2016)). The recommendations of the latest Stage 1, 2 and 3 reviews were implemented in the current emission inventory and the IIR as far as possible.

Archiving of the database and related internal documentation is carried out by the inventory compiler, while any other material is archived on the internal data management system by the QA/QC officer. Publicly available material will be published after submission on the website owned by the FOEN (www.climatereporting.ch).

1.4 Methods and data sources

1.4.1 Improvements conducted for this submission

The following issues were mentioned as planned improvements in the IIR of submission 2016 in chp. 8.2 (FOEN 2016b). The list shows the current state of realisation:

- *Updating the territorial road transportation model based on the last update of the handbook of emissions factors for road vehicles. This will lead to a recalculation of the past and the projected emissons of 1A3b.*

Current state: The update process is ongoing, but the new results are not yet avaliable for this submission.

- *In 2015 another survey on farm and manure management was carried out. The results will be analysed in 2016 and will lead to a recalculation of NH_3 emissions of sector 3 Agriculture.*
  Current state: The Agrammon model (see chp. 5.2.2) was updated with new data in 2015. Accordingly, NH_3 and NO_x emission factors have been revised and the emissions have been recalcultated for 2011-2014.
- *A study is planned to assess the PCB emissions from main emission sources, e.g. joint sealings, electrical equipment in Switzerland in order to be able to report PCB emissions in future.*
  Current state: A comprehensive study to asses the so-far missing PCB emissions in Switzerland is on going. The study is based on a mass balance model that tracks PCB used in transformers, capacitors, joint sealants and anti-corrosive paints through their lifecycle of import, usage and disposal. A still open point that has to be resolved by TFEIP is whether the dioxin-like, the so-called indicator or all PCB have to be reported.

After the UNECE Stage 3 Review, FOEN started a list including all encouragements and recommendations of the ERT (UNECE 2016a). It contains comments on how and when FOEN plans to tackle ERT's comments (FOEN 2017a). Improvements that have been carried out for submission 2017 are mentioned in the corresponding sector chapters.

1.4.2 General description

Emission key categories and uncertainties are calculated on the basis of the standard methods and procedures as described in:

- UNECE: Guidelines for Estimating and Reporting Emission Data under the Convention on Long Range Transboundary Air Pollution, Edition 2014 (ECE 2014).
- EMEP/EEA air pollutant emission inventory guidebook — version 2013 (EMEP/EEA 2013), including.
  - Chp. 2. Key category analysis and methodological choice
  - Chp. 5. Uncertainties

Note that there is an important statement regarding the system boundaries for emission modelling in chapter V. "Methods", section A. "Emission estimation methods and principles" of the Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution. Paragraph 24 states:

"For Parties for which emission ceilings are derived from national energy projections based on the amount of fuels sold, compliance checking will be based on fuels sold in the geographic area of the Party. Other Parties within the EMEP region (i.e., Austria, Belgium, Ireland, Lithuania, Luxembourg, the Netherlands, Switzerland and the United Kingdom of Great Britain and Northern Ireland) may choose to use the national emission total calculated on the basis of fuels used in the geographic area of the Party as a basis for compliance with their respective emission ceilings." (ECE 2014)

This means that the national totals of the emissions as reported in the NFR tables as "National total for the entire territory (based on fuel sold)" (row 141 in the corresponding template) deviate from "National total for compliance assessment) as reported in row 144 of the template because Switzerland's compliance assessment refers to "fuel used" and not to "fuel sold". Differences exclusively occur in sector 1A3b Road transport (see Figure 3-6).

When comparing numbers from the IIR with the NFR tables, please refer to the blue coloured line in the NFR table reporting the national compliance assessment. However, the KCA and the uncertainty analysis were carried out with emission numbers based on fuel sold.

The methods used for the NFR sectors are given in the following Table 1-1. The classification follows the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013) in the respective chapters for the source categories.

Table 1-1: Overview of applied methods, emission factors and activity by NFR category. CS = country-specific, D default, T1 = Tier 1, T2 = Tier 2, T3 = Tier 3.

Sector	Source category	Method applied	Emission factors	Activity data
1	**Energy**			
1A1	Energy industries	T1, T2	CS	CS
1A2	Manufacturing industries and construction	T1, T2, T3	CS	CS
1A3	Transport	T1, T2, T3	CS	CS
1A4	Other Sectors	T1, T2, T3	CS	CS
1A5	Other (including military)	T2 (non-road military), T1 (military aviation)	CS	CS
2	**Industrial processes and product use**			
2A	Mineral products	T2	CS	CS
2B	Chemical industry	T2	CS	CS
2C	Metal production	T2	CS	CS
2D	Other solvent use	T2	CS	CS
2G	Other product use	T2	CS	CS
2H	Other	T2	CS	CS
2I	Wood processing	T1	CS	CS
2L	Other production, consumption, storage, transportation or handling of bulk products	T2	CS	CS
3	**Agriculture**			
3B	Manure management	T1, T3	CS, D	CS
3D	Crop production and agricultural soils	T1, T3	CS	CS
5	**Waste**			
5A	Biological treatment of waste - Solid waste disposal on land	T2	CS	CS
5B	Biological treatment of waste - Composting and anaerobic digestion at biogas facilities	T2	CS	CS
5C	Waste incineration and open burning of waste	T2	CS, D	CS
5D	Wastewater handling	T2	CS	CS
5E	Other waste	T1	CS	CS
6	**Other**			
6A	Other sources	T2	CS	CS
11	**Natural emissions**			
11B	Forest fires	T2	CS	CS

1.4.3 Swiss emission inventory system

Emission data is extracted from the Swiss emission information system (EMIS), which is operated by FOEN (see FOEN 2006). EMIS was established at SAEFL (former name of FOEN) in the late 1980s. Its initial purpose was to record and monitor emissions of air pollutants. Since then, it has been extended to cover greenhouse gases, too. Its structure corresponds to the EMEP/EEA system for classifying emission-generating activities. EMEP/EEA uses the Nomenclature for Reporting ("NFR code", ECE 2014).

EMIS calculates emissions for various pollutants using emission factors and activity data according to the EMEP/EEA methodology. Pollutants in EMIS include NO_x, NMVOC, SO_x, NH_3, particulate matter (PM2.5, PM10, TSP and BC), CO, priority heavy metals (Pb, Cd, and Hg), POPs such as PCDD/PCDF, PAHs and HCB, as well as the greenhouse gases CO_2 (fossil/geogenic origin and CO_2 from biomass), CH_4, N_2O and F-gases. The input data originates from a variety of sources such as production data and emission factors from the industry, industry associations and research institutions, as well as population, employment, waste and agriculture statistics: 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 non-road activities, waste statistics and agricultural models and statistics (see Figure 1-1).

EMIS is documented in an internal FOEN manual for the database (FOEN 2006).

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. Simultaneously, activity data and emission factors were being checked and updated. Ever since then, updating is an ongoing process. Therefore, the data used in this submission are referenced to the specific EMIS data source.

1.4.4 Data suppliers

Table 1-2: Primary and secondary data suppliers: 1–13 provide annual updates, 14–19 provide sporadic updates.

No.	Institution	Subject	Data supplied for inventory category										
			1A1	1A2	1A3	1A4	1A5	1B	2	3	5	6	11
	Data suppliers (annual updates)												
1	FOEN, Air Pollution Control	EMIS Database	x	x		x	x	x	x	x	x	x	x
2	FOEN, Climate	Swiss ETS monitoring reports	x	x		x		x	x				
3	FOEN, Waste and Raw Materials	Waste Statistics	x	x							x		
4	SFOE	Swiss overall energy statistics	x	x	x	x		x			x		
5	SFOE	Swiss wood energy statistics	x	x		x							
6	SFOE	Swiss renewable energy statistics	x	x	x	x							
7	SFOE	Energy consumption statistics in the industry and services sectors		x									
8	FOCA	Civil Aviation			x								
9	DDPS	Military machinery and aviation					x						
10	SFSO	Transport, Solvents, Agriculture, Waste, Other			x				x	x	x	x	
11	HAFL	Agriculture, LULUCF								x			
12	Industry Associations	Ind. processes and solvents							x				
13	Swiss Petroleum Association	Oil Statistics						x	x				
	Data suppliers (sporadic updates)												
14	FOEN, Air Pollution Control	Non-road Database		x	x	x	x						
15	SGWA	Gas Distribution Losses						x					
16	Empa	Various Emission Factors	x	x	x	x							
17	INFRAS	On-road Emission Model			x								
18	INFRAS	Non-road Emission Model		x	x	x	x						
19	Carbotech	Solvents							x				

1.5 Key categories

In order to identify the source categories which are the main contributors to the emissions of each pollutant, a Key Category Analysis (KCA) is performed according to the methodology described in the EMEP/EEA Emission Inventory Guidebook 2013 (EMEP/EEA 2013).

A key category is prioritised within the inventory system because its estimate has a significant influence on a national total. Depending on the scope of the inventory, the KCA can be performed on different levels: on the inventory total emission level, the emission trend or the emission level uncertainty.

Note that the key category analysis is performed based on the approach “fuels sold” (“National total for compliance” in the reporting tables) instead of “fuels used” (”National total” in reporting tables; for differentiation of the two approaches see chapter 3.1.6.1).

Two Approach 1 level assessments for the year 2015 and the base year 1990 were performed for all emission sources accounting for 80% of the total national emissions. Additionally, an Approach 1 trend assessment 1990–2015 was applied. The following pollutants are included in these analyses: NO_x, NMVOC, SO_x, NH_3, PM2.5, PM10.

1.5.1 Level Key Category Analysis

The results of the level KCA 2015 in percent are summarized in Table 1-3. Categories are ranked per pollutant. The pollutants are shown in an alphabetical order beginning on top with NO_x and ending up with SO_2.

The results of the level KCA of the base year 1990 are represented in the same structure in Table 1-4.

The following source categories contribute with 20% or more to the **level** analysis 2015

- 1A3biii Heavy Duty Trucks and Busses NO_x 23.5%
- 1A3bi Passenger Cars NO_x 22.6%
- 3Da2a Animal manure applied to soils NH_3 37.6%
- 1A4bi Stationary Combustion PM2.5 24.2%
- 1A4bi Stationary Combustion SO_2 25.8%
- 1A2f Non Metallic Minerals SO_2 20.3%

Table 1-3: List of Switzerland's Approach 1 level key categories 2015 for the most important pollutants, their percentage contributions to pollutant totals and the cumulative total.

NFR	Source Category	Pollutant	Ex,t (kt)	|Ex,t| (kt)	Lx,t	Cumulative Total
1A3biii	Heavy Duty Trucks and Busses	NOx	15183	15183	23.5%	23.5%
1A3bi	Passenger Cars	NOx	14593	14593	22.6%	46.2%
1A4bi	Stationary Combustion	NOx	5296	5296	8.2%	54.4%
1A2f	Non Metallic Minerals	NOx	3723	3723	5.8%	60.2%
1A3bii	Light Duty Trucks	NOx	3361	3361	5.2%	65.4%
1A2gvii	Off Road Vehicles and Other Machinery	NOx	3210	3210	5.0%	70.4%
1A4ai	Stationary Combustion	NOx	2731	2731	4.2%	74.6%
1A4cii	Off Road Machinery	NOx	2648	2648	4.1%	78.7%
1A1a	Public Electricity and Heat Production	NOx	2219	2219	3.4%	82.1%
3Da2a	Animal manure applied to soils	NH3	22815	22815	37.6%	37.6%
3B1a	Manure management - Dairy cattle	NH3	11542	11542	19.0%	56.7%
3B1b	Manure management - Non-dairy cattle	NH3	7830	7830	12.9%	69.6%
3B3	Swine	NH3	4687	4687	7.7%	77.3%
3Db	Indirect Emissions from managed soils	NH3	2837	2837	4.7%	82.0%
2D3d	Coating applications	NMVOC	11993	11993	15.5%	15.5%
2D3a	Domestic solvent use	NMVOC	11157	11157	14.4%	29.9%
1A3bi	Passenger Cars	NMVOC	8672	8672	11.2%	41.1%
2G	Other Product Use	NMVOC	7619	7619	9.8%	50.9%
3Db	Indirect Emissions from managed soils	NMVOC	3899	3899	5.0%	55.9%
2D3g	Chemical products	NMVOC	3614	3614	4.7%	60.6%
2H2	Food and beverages industry	NMVOC	3160	3160	4.1%	64.7%
2D3h	Printing	NMVOC	2956	2956	3.8%	68.5%
2D3b	Road paving with asphalt	NMVOC	2619	2619	3.4%	71.9%
2D3i	Other Solvent Use	NMVOC	2367	2367	3.1%	74.9%
1A4bi	Stationary Combustion	NMVOC	2364	2364	3.1%	78.0%
2D3e	Degreasing	NMVOC	1977	1977	2.6%	80.5%
1A3bvi	Tyre and Brake Wear	PM10	3006	3006	16.9%	16.9%
1A2gvii	Off Road Vehicles and Other Machinery	PM10	2302	2302	12.9%	29.8%
1A4cii	Off Road Machinery	PM10	1927	1927	10.8%	40.6%
1A4bi	Stationary Combustion	PM10	1820	1820	10.2%	50.8%
1A3c	Railways	PM10	1260	1260	7.1%	57.9%
3B3	Swine	PM10	1086	1086	6.1%	64.0%
3B4gi	Layers	PM10	931	931	5.2%	69.2%
1A4ai	Stationary Combustion	PM10	530	530	3.0%	72.2%
2A5a	Quarrying and mining of minerals	PM10	463	463	2.6%	74.8%
1A3bi	Passenger Cars	PM10	386	386	2.2%	76.9%
1A2gviii	Other Boilers and Engines Industry	PM10	384	384	2.2%	79.1%
2G	Other Product Use	PM10	374	374	2.1%	81.2%
1A4bi	Stationary Combustion	PM2.5	1777	1777	24.2%	24.2%
1A4ai	Stationary Combustion	PM2.5	516	516	7.0%	31.2%
1A4cii	Off Road Machinery	PM2.5	488	488	6.6%	37.8%
1A3bvi	Tyre and Brake Wear	PM2.5	451	451	6.1%	43.9%
1A2gvii	Off Road Vehicles and Other Machinery	PM2.5	412	412	5.6%	49.5%
1A3bi	Passenger Cars	PM2.5	386	386	5.2%	54.8%
1A2gviii	Other Boilers and Engines Industry	PM2.5	372	372	5.1%	59.8%
5C1a	5 C 1 a - Municipal Waste Incineration	PM2.5	278	278	3.8%	63.6%
1A3biii	Heavy Duty Trucks and Busses	PM2.5	263	263	3.6%	67.2%
2A5a	Quarrying and mining of minerals	PM2.5	231	231	3.1%	70.3%
2G	Other Product Use	PM2.5	229	229	3.1%	73.5%
2H1	Pulp and paper	PM2.5	220	220	3.0%	76.4%
1A3c	Railways	PM2.5	195	195	2.7%	79.1%
2H2	Food and beverages industry	PM2.5	171	171	2.3%	81.4%
1A4bi	Stationary Combustion	SO2	1743	1743	25.8%	25.8%
1A2f	Non Metallic Minerals	SO2	1372	1372	20.3%	46.1%
1A4ai	Stationary Combustion	SO2	736	736	10.9%	57.0%
1A2gviii	Other Boilers and Engines Industry	SO2	631	631	9.3%	66.3%
1A1b	Petroleum Refining	SO2	574	574	8.5%	74.8%
2B5	Carbide production	SO2	510	510	7.6%	82.4%

Table 1-4: List of Switzerland's Approach 1 level key categories of the base year 1990 for the most important pollutants, their percentage contributions to pollutant totals and the cumulative total.

NFR	Source Category	Pollutant	Ex,0 (kt)	|Ex,0| (kt)	Lx,0	Cumulative Total
1A3bi	Passenger Cars	NOx	52160	52160	36.3%	36.3%
1A3biii	Heavy Duty Trucks and Busses	NOx	25993	25993	18.1%	54.4%
1A4bi	Stationary Combustion	NOx	11552	11552	8.0%	62.4%
1A2f	Non Metallic Minerals	NOx	10535	10535	7.3%	69.7%
1A2gvii	Off Road Vehicles and Other Machinery	NOx	6334	6334	4.4%	74.1%
1A1a	Public Electricity and Heat Production	NOx	6317	6317	4.4%	78.5%
1A3bii	Light Duty Trucks	NOx	5747	5747	4.0%	82.5%
3Da2a	Animal manure applied to soils	NH3	36102	36102	49.2%	49.2%
3B1a	Manure management - Dairy cattle	NH3	10086	10086	13.7%	63.0%
3B1b	Manure management - Non-dairy cattle	NH3	6012	6012	8.2%	71.2%
3B3	Swine	NH3	5799	5799	7.9%	79.1%
3Da1	Inorganic N-fertilizers (includes also urea application)	NH3	4309	4309	5.9%	84.9%
1A3bi	Passenger Cars	NMVOC	61832	61832	20.7%	20.7%
2D3d	Coating applications	NMVOC	54168	54168	18.2%	38.9%
2D3g	Chemical products	NMVOC	28314	28314	9.5%	48.4%
2G	Other Product Use	NMVOC	22146	22146	7.4%	55.8%
2D3h	Printing	NMVOC	20354	20354	6.8%	62.6%
1B2av	Distribution of Oil Products	NMVOC	17279	17279	5.8%	68.4%
1A3bv	Other and Evaporation	NMVOC	13602	13602	4.6%	73.0%
2D3e	Degreasing	NMVOC	11218	11218	3.8%	76.8%
2D3a	Domestic solvent use	NMVOC	9311	9311	3.1%	79.9%
1A4bi	Stationary Combustion	NMVOC	7977	7977	2.7%	82.5%
1A4bi	Stationary Combustion	PM10	5020	5020	18.7%	18.7%
1A4cii	Off Road Machinery	PM10	2503	2503	9.3%	28.1%
1A3bvi	Tyre and Brake Wear	PM10	2289	2289	8.5%	36.6%
1A2gvii	Off Road Vehicles and Other Machinery	PM10	2173	2173	8.1%	44.7%
2C1	Iron and steel production	PM10	1485	1485	5.5%	50.3%
3B3	Swine	PM10	1297	1297	4.8%	55.1%
1A3biii	Heavy Duty Trucks and Busses	PM10	1073	1073	4.0%	59.1%
1A1a	Public Electricity and Heat Production	PM10	1010	1010	3.8%	62.9%
1A3c	Railways	PM10	970	970	3.6%	66.5%
2I	Wood processing	PM10	951	951	3.6%	70.1%
1A2f	Non Metallic Minerals	PM10	833	833	3.1%	73.2%
1A3bi	Passenger Cars	PM10	718	718	2.7%	75.9%
1A4ci	Stationary Combustion	PM10	530	530	2.0%	77.8%
1A2gviii	Other Boilers and Engines Industry	PM10	521	521	1.9%	79.8%
5C1a	5 C 1 a - Municipal Waste Incineration	PM10	517	517	1.9%	81.7%
1A4bi	Stationary Combustion	PM2.5	4915	4915	31.6%	31.6%
1A3biii	Heavy Duty Trucks and Busses	PM2.5	1073	1073	6.9%	38.5%
2C1	Iron and steel production	PM2.5	818	818	5.3%	43.7%
1A1a	Public Electricity and Heat Production	PM2.5	750	750	4.8%	48.5%
1A4cii	Off Road Machinery	PM2.5	734	734	4.7%	53.3%
1A2gvii	Off Road Vehicles and Other Machinery	PM2.5	729	729	4.7%	57.9%
1A3bi	Passenger Cars	PM2.5	718	718	4.6%	62.6%
1A4ci	Stationary Combustion	PM2.5	528	528	3.4%	66.0%
1A2gviii	Other Boilers and Engines Industry	PM2.5	513	513	3.3%	69.2%
5C1a	5 C 1 a - Municipal Waste Incineration	PM2.5	465	465	3.0%	72.2%
1A2f	Non Metallic Minerals	PM2.5	438	438	2.8%	75.0%
1A4ai	Stationary Combustion	PM2.5	428	428	2.7%	77.8%
1A3bvi	Tyre and Brake Wear	PM2.5	343	343	2.2%	80.0%
1A3bii	Light Duty Trucks	PM2.5	333	333	2.1%	82.1%
1A4bi	Stationary Combustion	SO2	10736	10736	27.0%	27.0%
1A4ai	Stationary Combustion	SO2	4367	4367	11.0%	38.0%
1A1a	Public Electricity and Heat Production	SO2	3690	3690	9.3%	47.3%
1A2gviii	Other Boilers and Engines Industry	SO2	3612	3612	9.1%	56.4%
1A2f	Non Metallic Minerals	SO2	3530	3530	8.9%	65.3%
1A2d	Pulp Paper and Print	SO2	3279	3279	8.2%	73.5%
1A3bi	Passenger Cars	SO2	1863	1863	4.7%	78.2%
1A3biii	Heavy Duty Trucks and Busses	SO2	1646	1646	4.1%	82.3%

1.5.2 Trend Key Category Analysis

Table 1-5: List of Switzerland's Approach 1 trend key categories 1990–2015 for the most important pollutants, their percentage contributions to pollutant totals and the cumulative total

NFR Code	Source Category	Pollutant	Ex,0 (kt)	Ex,t (kt)	Trend Assessm.	Contr. to Trend	Cumulative Total
1A3bi	Passenger Cars	NOx	52160	14593	0.061%	38.9%	38.9%
1A3biii	Heavy Duty Trucks and Busses	NOx	25993	15183	0.025%	15.5%	54.4%
1A3ai(i)	International Aviation	NOx	1214	1888	0.009%	5.9%	60.4%
1A2f	Non Metallic Minerals	NOx	10535	3723	0.007%	4.4%	64.8%
1A2gviii	Other Boilers and Engines Industry	NOx	2502	1972	0.006%	3.7%	68.5%
1A3bii	Light Duty Trucks	NOx	5747	3361	0.005%	3.5%	72.0%
1A4cii	Off Road Machinery	NOx	4358	2648	0.005%	3.1%	75.0%
1A3d	Domestic Navigation	NOx	1055	1113	0.004%	2.8%	77.9%
3Da2a	Animal manure applied to soils	NOx	1992	1513	0.004%	2.7%	80.6%
3Da2a	Animal manure applied to soils	NH3	36102	22815	0.096%	34.6%	34.6%
3B1a	Manure management - Dairy cattle	NH3	10086	11542	0.044%	15.8%	50.4%
3B1b	Manure management - Non-dairy cattle	NH3	6012	7830	0.039%	14.1%	64.5%
3Da1	Inorganic N-fertilizers (includes also urea application)	NH3	4309	2209	0.018%	6.7%	71.2%
3Da2b	Sewage sludge applied to soils	NH3	1169	0	0.013%	4.8%	76.0%
3Da3	Urine and dung deposited by grazing animals	NH3	788	1387	0.010%	3.6%	79.6%
1A3bi	Passenger Cars	NH3	1432	1858	0.009%	3.3%	82.9%
2D3a	Domestic solvent use	NMVOC	9311	11157	0.029%	18.5%	18.5%
1A3bi	Passenger Cars	NMVOC	61832	8672	0.025%	15.7%	34.2%
2D3g	Chemical products	NMVOC	28314	3614	0.013%	7.9%	42.2%
3Db	Indirect Emissions from managed soils	NMVOC	3954	3899	0.010%	6.1%	48.3%
1A3bv	Other and Evaporation	NMVOC	13602	759	0.009%	5.9%	54.1%
1B2av	Distribution of Oil Products	NMVOC	17279	1731	0.009%	5.9%	60.0%
2H2	Food and beverages industry	NMVOC	2827	3160	0.008%	5.1%	65.1%
2D3h	Printing	NMVOC	20354	2956	0.008%	5.0%	70.1%
2D3d	Coating applications	NMVOC	54168	11993	0.007%	4.4%	74.5%
2G	Other Product Use	NMVOC	22146	7619	0.006%	4.0%	78.5%
2D3b	Road paving with asphalt	NMVOC	4895	2619	0.005%	2.9%	81.3%
1A4bi	Stationary Combustion	PM10	5020	1820	0.057%	14.8%	14.8%
1A3bvi	Tyre and Brake Wear	PM10	2289	3006	0.055%	14.5%	29.3%
2C1	Iron and steel production	PM10	1485	15	0.036%	9.5%	38.8%
1A2gvii	Off Road Vehicles and Other Machinery	PM10	2173	2302	0.032%	8.4%	47.1%
1A3c	Railways	PM10	970	1260	0.023%	6.0%	53.1%
1A1a	Public Electricity and Heat Production	PM10	1010	70	0.022%	5.9%	59.0%
3B4gi	Layers	PM10	511	931	0.022%	5.8%	64.8%
1A2f	Non Metallic Minerals	PM10	833	80	0.018%	4.6%	69.4%
1A3biii	Heavy Duty Trucks and Busses	PM10	1073	263	0.017%	4.4%	73.8%
2I	Wood processing	PM10	951	364	0.010%	2.6%	76.4%
1A4cii	Off Road Machinery	PM10	2503	1927	0.010%	2.6%	79.0%
1A4ai	Stationary Combustion	PM10	436	530	0.009%	2.3%	81.3%
1A4bi	Stationary Combustion	PM2.5	4915	1777	0.035%	13.9%	13.9%
2C1	Iron and steel production	PM2.5	818	10	0.024%	9.6%	23.5%
1A4ai	Stationary Combustion	PM2.5	428	516	0.020%	8.0%	31.5%
1A3bvi	Tyre and Brake Wear	PM2.5	343	451	0.019%	7.4%	38.9%
1A1a	Public Electricity and Heat Production	PM2.5	750	70	0.018%	7.3%	46.1%
1A3biii	Heavy Duty Trucks and Busses	PM2.5	1073	263	0.016%	6.2%	52.3%
1A2f	Non Metallic Minerals	PM2.5	438	43	0.011%	4.2%	56.5%
2A5a	Quarrying and mining of minerals	PM2.5	183	231	0.009%	3.7%	60.2%
1A4cii	Off Road Machinery	PM2.5	734	488	0.009%	3.6%	63.8%
2G	Other Product Use	PM2.5	207	229	0.008%	3.3%	67.2%
1A2gviii	Other Boilers and Engines Industry	PM2.5	513	372	0.008%	3.3%	70.5%
1A3c	Railways	PM2.5	173	195	0.007%	2.9%	73.3%
1A4ci	Stationary Combustion	PM2.5	528	137	0.007%	2.9%	76.2%
2H1	Pulp and paper	PM2.5	236	220	0.007%	2.8%	79.0%
3B4gi	Layers	PM2.5	77	141	0.007%	2.7%	81.6%
1A2f	Non Metallic Minerals	SO2	3530	1372	0.019%	18.4%	18.4%
1A2d	Pulp Paper and Print	SO2	3279	14	0.014%	13.0%	31.4%
1A1b	Petroleum Refining	SO2	660	574	0.012%	11.0%	42.4%
2B5	Carbide production	SO2	445	510	0.011%	10.4%	52.7%
1A1a	Public Electricity and Heat Production	SO2	3690	259	0.009%	8.8%	61.5%
1A3bi	Passenger Cars	SO2	1863	54	0.007%	6.3%	67.8%
1A3biii	Heavy Duty Trucks and Busses	SO2	1646	23	0.006%	6.1%	73.9%
1A2e	Food Processing Beverages and Tobacco	SO2	1106	47	0.004%	3.4%	77.3%
1A3ai(i)	International Aviation	SO2	100	150	0.003%	3.2%	80.4%

The following source categories contribute with 20% or more to the **trend** analysis 1990-2015

- 1A3bi Passenger Cars NO_x 38.9%
- 3Da2a Animal manure applied to soils NH_3 34.6%

1.6 QA/QC and verification methods

The national inventory system (NIS), which covers air pollutant as well as greenhouse gases - has an established quality management system (QMS) that complies with the requirements of ISO 9001:2008 standard. Certification has been obtained in 2007 and is upheld since through annual audits by the Swiss Association for Quality and Management Systems (Swiss TS 2013). The QMS is designed to comply with the UNFCCC reporting guidelines (UNFCCC 2014a) to ensure and continuously improve transparency, consistency, comparability, completeness, accuracy, and confidence in national GHG emission and removal estimates. Since the inventory system also covers air pollutants, the same quality requirement that are ensured for GHG also hold for air pollutants.

The NIS quality management system covers data compilation and inventory preparation based on the EMIS database, which is – as mentioned above – not only the tool for modelling the GHG emissions but also at the same time for modelling the air pollution emissions, which means that the process of emission modelling of air pollutants is also part of the quality management system.

Integrity of the database is ensured by creating a new database for every single submission and comparing the results from the new database with those from the previous version. Consistency of data between categories is to a large extent ensured by the design of the database, where specific emission factors and activity data that apply to various categories are used jointly by all categories to calculate emissions.

Checks regarding the correct aggregation are done on initial set-up of the various aggregations. There are also automated checks implemented in the database in order to identify incorrect internal aggregation processes.

Recalculations are compiled in a document and made available to the data compilers and the authors of the IIR. The recalculations file is of great importance in the QC procedures regarding the reporting tables (NFR) and in the preparation of the IIR. QC procedures regarding the reporting tables (NFR) comprise a detailed comparison of the reporting tables (NFR) of the previous submission with those of the current submission for the base year and the latest common year. In addition, the time-series consistency is incrementally checked by comparing the latest inventory year with the preceding year. Any exceptional deviations are investigated by the sectoral or the EMIS database experts. These checks are performed in a multi-step process, first by the EMIS database experts and then, after the required changes were implemented, by the IIR authors.

The QA/QC process can therefore be summarised as follows: The preparation steps for the production of the CLRTAP Inventory including data collection, compilation, emission modelling within the EMIS database and generating the official emission reporting templates are part of the existing quality management system. So far, informal QC activities have been performed by the FOEN experts involved in the CLRTAP Inventory preparation and by the external authors of the Informative Inventory Report on hand. A separate and formalised CLRTAP Inventory quality system as it exists for the GHG emission inventory is not foreseen, however, a centralised plausibility check is in place.

Diverse QC procedures are implemented in the process of data-collection and generation of reporting tables and tables for the IIR. For example:

- Checks of consistency of activity data and emission factors in the individual sectors and subsectors while collecting data every year.
- Crosschecks of input and output (in particular within the energy model)
- Crosschecks between EMIS database and reporting tables
- Crosschecks with the greenhouse gas inventory concerning activity data and precursors (NO_x, CO, MNVOC and SO_2)
- Selective checks of emission factors of the inventory. For example, in 2015 all emission factors from boilers have been systematically compared with the guidebook values.
- Every year specific projects are implemented to improve the inventory in particular sections.

The continuous improvement of the inventory is in particular addressing recommendations and encouragements from the stage 3 in-depth review of Switzerland's emission inventory (UNECE 2016a).

1.7 General Uncertainty Evaluation

1.7.1 Tier 1 analysis of the main air pollutants and particulate matter

Based on the uncertainties for the activity data of the Swiss GHG Inventory (FOEN 2017) and on further information about emission factor uncertainty, an uncertainty analysis Tier 1 for main pollutants and particulate matter has been carried out for the current submission. Note that for NH_3 emissions of agriculture a Tier 2 uncertainty analysis was performed (see next chapter)

Uncertainties are assessed in accordance with the EMEP/EEA Emission Inventory Guidebook 2013 (EMEP/EEA 2013: Part A, chapter 5) and with the IPCC Guidelines 2006 (IPCC 2006).

1.7.2 Data sources and data used

Activity data and emission factors are analysed on the same level of aggregation as used for the NFR tables (classification according to EMEP/EEA 2013).

Several sources for uncertainties are utilised and shown in the list below. Uncertainty values for activity data and emission factors were updated where appropriate.

- Uncertainty analysis of Switzerland's GHG Inventory: Uncertainties of activity data are used (FOEN 2017).
- Uncertainties for the emission factors and emissions of mobile sources from the study IFEU/INFRAS (2009), in which uncertainties are evaluated for road and non-road categories.
- Uncertainties for sector 3 Agriculture had been thoughly investigated in 2013 by a Tier 2 approach (Monte Carlo simulation) applied to the data of the Agrammon model from 2010. New uncertainty results per livestock category had been derived which turned out to be much smaller than previous estimates of uncertainties and which showed that the results for NH_3 emissions were more precise than reported before (INFRAS 2015b). A new study reassessed these uncertainties by taking into account additional factors such as correlations and uncertainties due to extrapolation (INFRAS 2017). The results show

slightly higher uncertainties but they generally confirm the results of the previous study (INFRAS 2015b). For this submission, uncertainties provided by INFRAS (2017) are used for the uncertainty analysis.

- Uncertainties from France's and Sweden's Informative Inventory Reports (Citepa 2012, SEPA 2010) for a few source categories - mainly emission factors for sector 2 Industrial Processes and Solvent and Other Product Use.
- Some default uncertainty values of EMEP/EEA (2013) of activity data and emission factors are used.
- Detailed references for the uncertainties are shown in Annex 5.

1.7.3 Results of Tier 1 uncertainty evaluation

Table 1-6 shows the results of the uncertainty evaluation. Due to the availability of uncertainty data, the analysis was restricted to the main pollutants NO_x, NMVOC, SO_x, NH_3 and PM2.5 as well as PM10. The emission trends of these pollutants 1990-2015 are also shown in the table to give a quantitative meaning to the trend uncertainties.

Table 1-6: Relative Tier 1 uncertainties for total emission levels 2015 and for emission trends 1990-2015 of the main pollutants, PM2.5 and PM10. The last column shows the emission trends 1990-2015. Legend for example NO_x: Trend uncertainty is 2.5%, emission trend is -55.1%: This means that the emission trend 1990-2015 lies in the interval -52.6% and -57.6% with a probability of 95%.

Pollutant	**Level uncertainty 2015**	**Trend uncertainty 1990-2015**	**Emission trend 1990-2015**
NO_x	10.2%	2.5%	-55.1%
NMVOC	15.5%	3.1%	-74.0%
SO_x	5.9%	0.7%	-83.0%
NH_3	12.8%	4.7%	-17.3%
PM2.5	21.3%	4.4%	-52.7%
PM10	17.1%	6.5%	-33.5%

The detailed information on the uncertainties of activity data and the emission factors are shown in Annex 5.

For the other air pollutants such as heavy metals, the uncertainties are assumed to be in the range of 20% to 50% - for PAHs and PCDD/PCDF uncertainties might be even higher.

Compared with the uncertainty results of the last submission 2016, only minor changes within maximally plus or minus three percentage points occurred.

1.8 General assessment of completeness

Complete estimates were accomplished for all known sources for all gases. Compared with the obligations of the EMEP/EEA handbook, the Swiss CLRTAP Inventory is complete.

1.8.1 Sources not estimated (NE)

Emissions of additional heavy metals and PCB in all sectors as well as emissions of NMVOC (3B), PM2.5, PM10, TSP (3Dc), BC (in a couple of source categories within sector 2 Industrial processes and product use) and CO (2B5) are not estimated and are thus specified as "not estimated" (NE), see respective list in Annex 3:

1.8.2 Sources included elsewhere (IE)

A number of emissions are specified as "included elsewhere" (IE). For further information about the whereabouts of the emissions from these source categories please refer to the respective list in Annex 3:

1.8.3 Other notation keys

Not occurring (NO)

Various pollutants or emissions do not occur in Switzerland since related processes do not exist or did not exist in the reporting period in Switzerland. Therefore, the activity data are not occurring and specific emissions are reported as "NO".

Not applicable (NA)

A number of source categories do occur within in the Swiss inventory but do not result in emissions of one or several specific pollutants. For example, all pollutants except NMVOC from source categories under 1B2 Fugitive emissions.

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2 Emission Trends 1980-2015

General remark concerning emission results presented in this chapter:
Note that all the values for emissions in this chapter refer to the "national total for compliance assessment" based on "fuel used", which deviates from the "national total for the entire territory" based on "fuel sold". Be aware that the reporting tables contain information on both, "national total emissions for the entire territory" (based on "fuel sold") as well as "national total for compliance assessment" (based on "fuel used"). When comparing numbers from this chapter with the reporting tables, please refer to the blue coloured lines in the reporting tables, which relate to the "national total for compliance assessment".
For further information concerning this differentiation, see chapter 3.1.6.1.

2.1 Comments on trends

2.1.1 General trend

Switzerland's emissions of air pollutants are decreasing in the period 1980-2015 (see Table 2-1). Note that there is a methodological discrepancy between data before 1990 and data from 1990 onward due to a lower data availability before 1990. This can lead to interpolation-based edges in the time series.

Table 2-1: Total emissions of main pollutants, particulate matter, CO, priority heavy metals and POPs for 1980-2015 including trends 1980-2015 and 2005-2015.

Pollutant		1980	2005	2015	1980-2015	2005-2015
NO_x	kt	166.63	91.05	59.06	-64.6%	-35.1%
NMVOC	kt	307.46	99.79	77.15	-74.9%	-22.7%
SO_2	kt	114.03	15.21	6.75	-94.1%	-55.6%
NH_3	kt	81.46	63.77	60.63	-25.6%	-4.9%
PM2.5	kt	31.36	9.86	7.17	-77.1%	-27.2%
PM10	kt	43.79	19.72	17.36	-60.3%	-11.9%
TSP	kt	45.92	23.81	21.46	-53.3%	-9.8%
BC	kt	5.42	3.20	1.50	-72.3%	-53.2%
CO	kt	1155.19	314.13	183.56	-84.1%	-41.6%
Pb	t	1304.98	20.12	15.38	-98.8%	-23.6%
Cd	t	5.54	0.93	1.02	-81.6%	10.3%
Hg	t	7.69	0.72	0.66	-91.4%	-8.6%
PCDD/PCDF	g I-Teq	453.80	32.58	20.92	-95.4%	-35.8%
BaP	t	3.60	2.34	0.89	-75.3%	-62.0%
BbF	t	3.64	2.39	0.92	-74.8%	-61.6%
BkF	t	1.84	1.28	0.60	-67.7%	-53.3%
IcdP	t	1.92	1.38	0.53	-72.3%	-61.3%
PAH tot	t	11.01	7.38	2.94	-73.3%	-60.2%
HCB	kg	97.39	0.35	0.34	-99.6%	-1.8%

2.1.2 Legal basis for the implementation of reduction measures

The decreasing trend is the result of the implementation of a consistent clean air policy of the Swiss government. It is based on the Federal Environmental Protection Act (EPA) and the Ordinance on Air Pollution Control (OAPC), which entered into force in 1985 and 1986, respectively. Main goals of OAPC are to protect people against harmful effects or nuisances of air pollution. The Act (EPA) contains the fundamental principles whereas the ordinance (OAPC) contains the detailed prescriptions on air pollution control, e.g. specific emission limit values for stationary sources, ambient air quality standards, prescriptions on enforcement, etc. In addition, OAPC exclusively contains a limit value for particle number emissions for construction machinery operating on construction sites. For other non-road machinery, in general, the same legislation holds as in the European Union specified by Directive 97/68/EC and five amending Directives adopted from 2002 to 2012. Requirements for road vehicles are integrated into the Swiss road traffic legislation and are all in accordance with the European Union (Euro standards).

The air pollution control policy is based on:

- Federal Act on the Protection of the Environment (EPA) (Swiss Confederation 1983).
- Ordinance on Air Pollution Control (OAPC) (Swiss Confederation 1985, see Figure 2-1 for an overview of the revisions).
- Federal Council's "Air Pollution Control Strategy": On behalf of the Swiss Parliament, the Federal Council has adopted a strategy containing national emission reduction targets, actions and measures at the national level, which will allow for reaching the air quality standards and an improved air quality in general. The strategy is regularly updated, the last version dates from 2009 (Swiss Confederation 2009).
- Ordinance on the Technical Standards for Motor Vehicles and their Trailers (Swiss Confederation 1995).
- Ordinance on the VOC incentive tax since 2000 (Swiss Confederation 1997).
- Federal Law on the reduction of the CO_2 emissions (Swiss Confederation 1999a).
- Ratification of the seven additional protocols containing emission reduction commitments to the 1979 CLRTAP (Swiss Confederation 2004).

Generally, revisions and amendments of the Air Pollution Control Strategy and the Ordinance on Air Pollution Control (OAPC) in Switzerland are driven by scientific findings or advancements in state-of-the-art abatement technologies. In addition, the harmonization of specific regulations (e.g. placing on the market of combustion installations, placing on the market of machinery) with the European Union leads to revisions and amendments. Main steps of revisions and amendments of the OAPC and its driving facts are outlined in Figure 2-1 below.

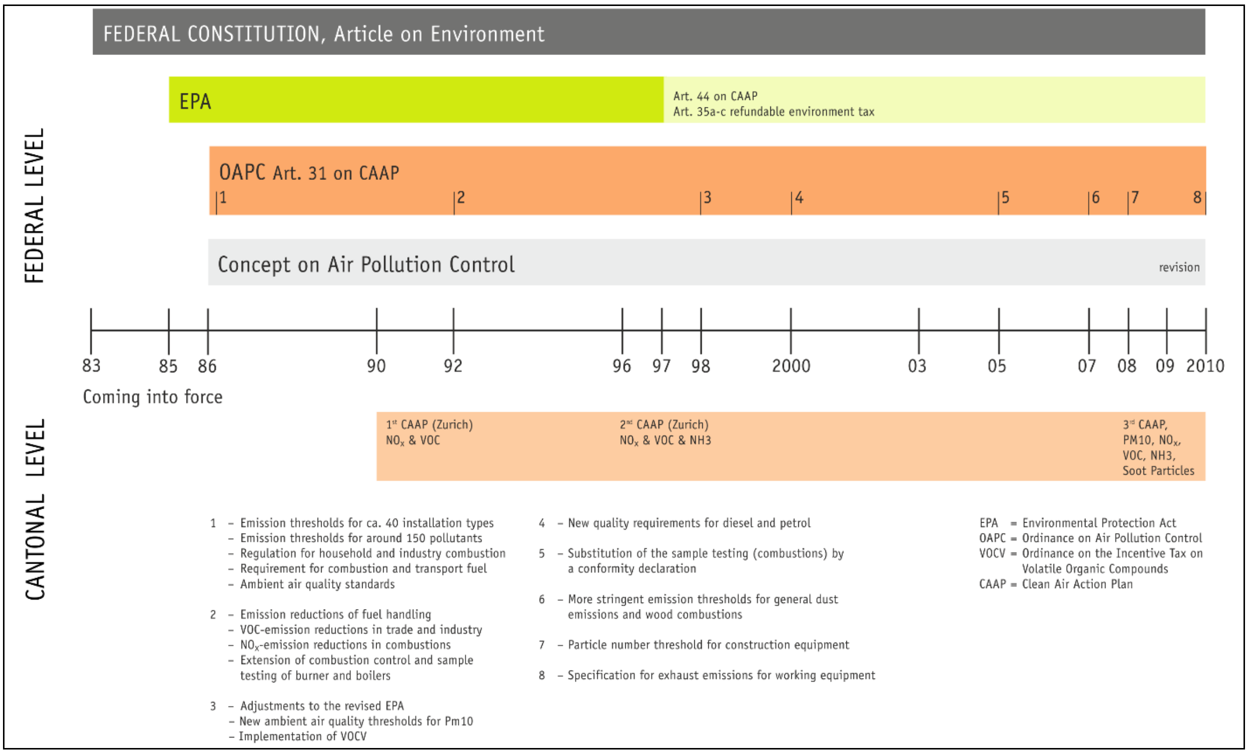

Figure 2-1: Overview of the OAPC Revisions in Switzerland. The Concept on Air Pollution Control is also referred to as the Air Pollution Control Strategy.

For further information on legislation on the abatement of air pollution, see: https://www.bafu.admin.ch/bafu/en/home/topics/air/law.html.

2.2 Overall trends of total emissions

2.2.1 Main air pollutants and CO

Emission trends of the main air pollutants and CO show a significant decline (Figure 2-2 and Table 2-2) over the past 30 years as a result of the strict air pollution control policy and the implementation of a large number of emission reduction measures.

Overall, the most effective reduction measures were the abatement of exhaust emissions from road vehicles and stationary installations, the incentive tax on VOC and voluntary agreements with industry sectors. As a result, NO_x, NMVOC and CO emissions declined between 1980 and 2015.

A decreasing trend can also be observed for SO_x emissions due to legal restriction of sulphur content in liquid fuels and decrease in coal consumption. The lowering of the maximum sulphur content in liquid fuels is shown in Table 3-8, whereas the time series of Switzerland's coal consumption is given in Table 3-3. Both trends resulted in a considerable reduction of the SO_x emissions. Fluctuations of SO_x emissions occur due to warm winters with low numbers of heating degree days (1993, 2000, 2007, 2011), which reduces the consumption of gas oil.

The reduction of ammonia emissions (NH_3) in the past 30 years is not as pronounced as for the pollutants mentioned above. NH_3 emissions are influencedby a decrease of farm animal numbers, changes in housing systems due to developments in animal welfare regulations, changes in agricultural production techniques including a decline in the use of mineral fertilizers (see Figure 2-2).

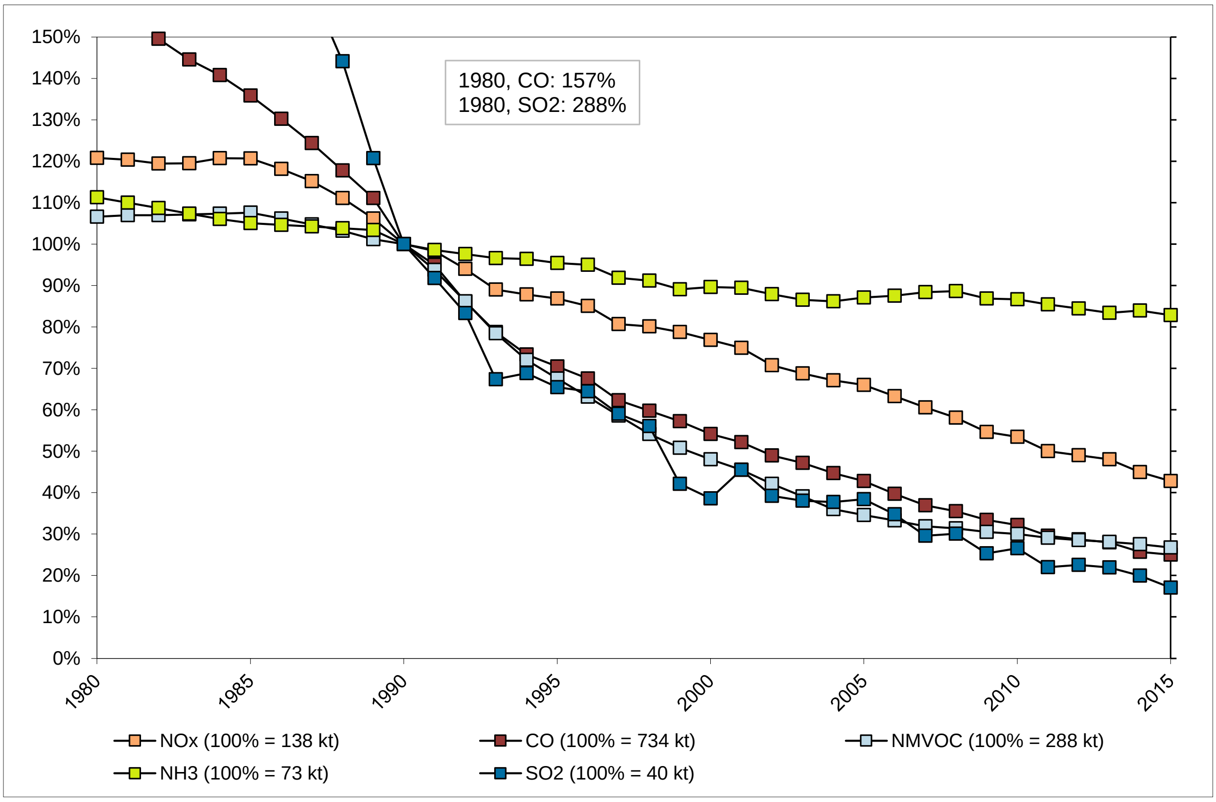

Figure 2-2: Relative trends for the total emissions of main air pollutants and CO in Switzerland 1980–2015 (in percentage of 1990). Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

Table 2-2: Main pollutants: Total emissions 1980–2015 in kt. Note that numbers refer to the national total for compliance assessment (based on fuel used), which deviate from the national total for the entire territory based on fuel sold.

Year	NO_x	NMVOC	SO_2	NH_3	CO
	kt	kt	kt	kt	kt
1980	166.63	307.46	114.03	81.46	1155.19
1985	166.45	310.25	73.37	76.88	996.83
1990	137.93	288.34	39.62	73.20	733.87
1995	119.82	194.82	25.92	69.86	517.04
2000	106.03	138.49	15.30	65.59	397.51
2004	92.58	103.81	14.96	63.07	328.19
2005	91.05	99.79	15.21	63.77	314.13
2006	87.28	96.06	13.77	64.06	291.36
2007	83.53	91.86	11.73	64.72	270.99
2008	80.16	90.45	11.91	64.88	260.76
2009	75.39	87.94	10.04	63.59	245.17
2010	73.77	86.51	10.54	63.44	236.31
2011	68.95	83.95	8.72	62.53	217.05
2012	67.62	82.34	8.95	61.83	210.92
2013	66.29	81.08	8.70	61.04	205.23
2014	61.98	79.46	7.90	61.47	188.41
2015	59.06	77.15	6.75	60.63	183.56
2005 to 2015 (%)	-35%	-23%	-56%	-5%	-42%

2.2.2 Suspended particulate matter

Emissions for suspended particulate matter (PM2.5, PM10, TSP and BC) show a significant decline since 1980 (Figure 2-3). The implementation of various emission reduction measures led to a decrease of PM2.5, PM10, TSP, and BC primary emissions. Main reduction measures were abatement of exhaust emissions from road vehicles and from residential heating equipment, which mainly affect the fractions of fine particles (PM2.5, BC). Also in 2006, the Federal Council initiated an action plan to reduce particulate matter, including 14 measures on national level. Some of these measures led to an OAPC revision in 2007 with more stringent emission limit values for general dust emissions and dust emission limit values for wood combustion installations. Another OAPC revision in 2008 introduced a particle number emission limit value for construction equipment. It aims at reducing the fine fraction of particulate matter (PM2.5) and soot (see also Figure 2-1).

Since 2005, emissions for suspended particulate matter are still slightly decreasing due to the most recent OAPC measures and Euro standards for road and non-road vehicles.

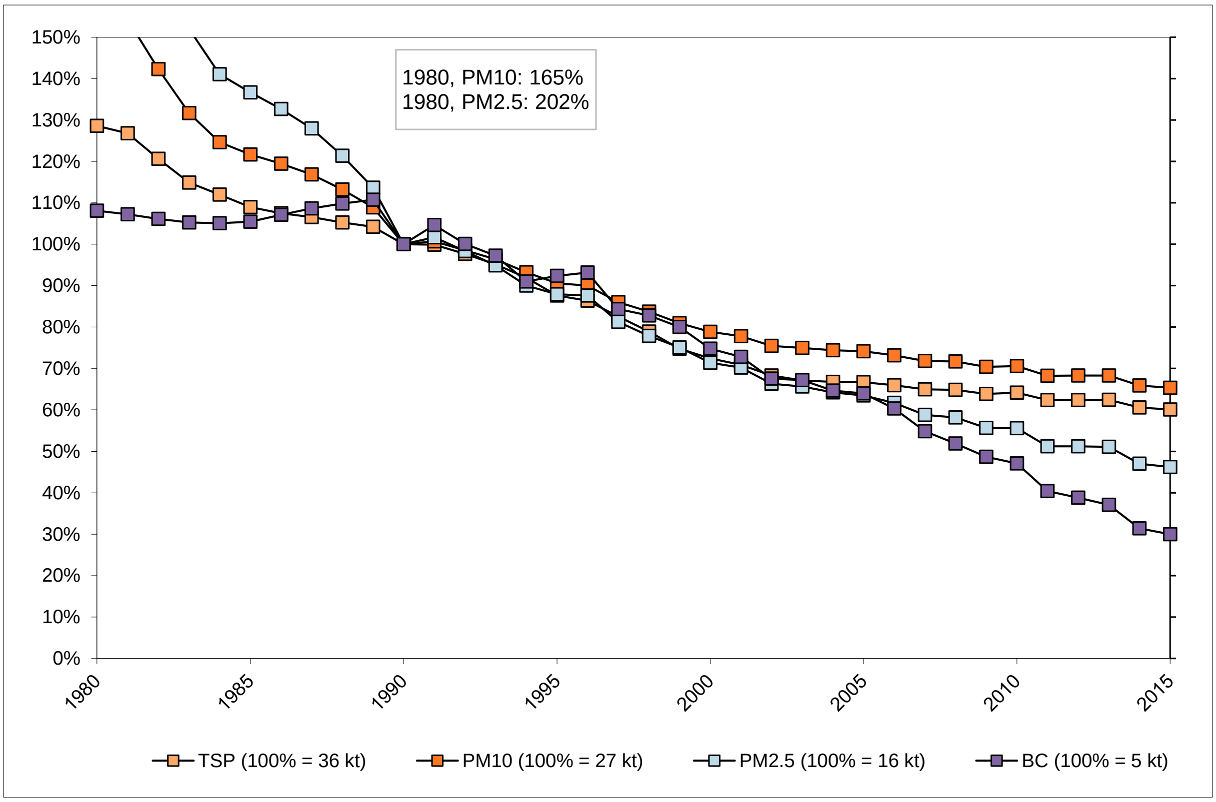

Figure 2-3: Total emissions of suspended particulate matter TSP, PM10, PM2.5 and BC in Switzerland 1980–2015 (in percentage of 1990). Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

Table 2-3: Total emissions of particulate matter 1980–2015 in kt. Note that numbers refer to the national total for compliance assessment (based on fuel used), which deviate from the national total for the entire territory based on fuel sold.

Year	PM2.5	PM10	TSP	BC
	kt	kt	kt	kt
1980	31.36	43.79	45.92	5.42
1985	21.21	32.34	38.90	5.28
1990	15.52	26.58	35.71	5.01
1995	13.64	24.07	31.28	4.63
2000	11.09	20.95	25.87	3.75
2005	9.86	19.72	23.81	3.20
2006	9.58	19.45	23.54	3.02
2007	9.13	19.09	23.19	2.75
2008	9.03	19.06	23.16	2.60
2009	8.64	18.70	22.81	2.44
2010	8.63	18.76	22.92	2.36
2011	7.95	18.14	22.27	2.02
2012	7.95	18.15	22.27	1.94
2013	7.93	18.15	22.30	1.86
2014	7.30	17.51	21.64	1.57
2015	7.17	17.36	21.46	1.50
2005 to 2015 (%)	-27%	-12%	-10%	-53%

2.2.3 Priority heavy metals

Between 1980 and 2003, emissions of priority heavy metals (Pb, Cd and Hg) show a pronounced decline (Figure 2-4, Table 2-4) because of various reduction measures. The continuous decrease of the lead content in gasoline and the final ban on leaded gasoline in 2000 resulted in an important decrease of Pb emissions recognizable since the 80's. The decrease of Cd and Hg emissions is mainly due to the strict emission limit values for waste incineration plants. Since 2003, Pb emissions show a less pronounced decreasing trend, Hg emissions have stabilised with minor fluctuations and Cd emissions show a slightly increasing trend.

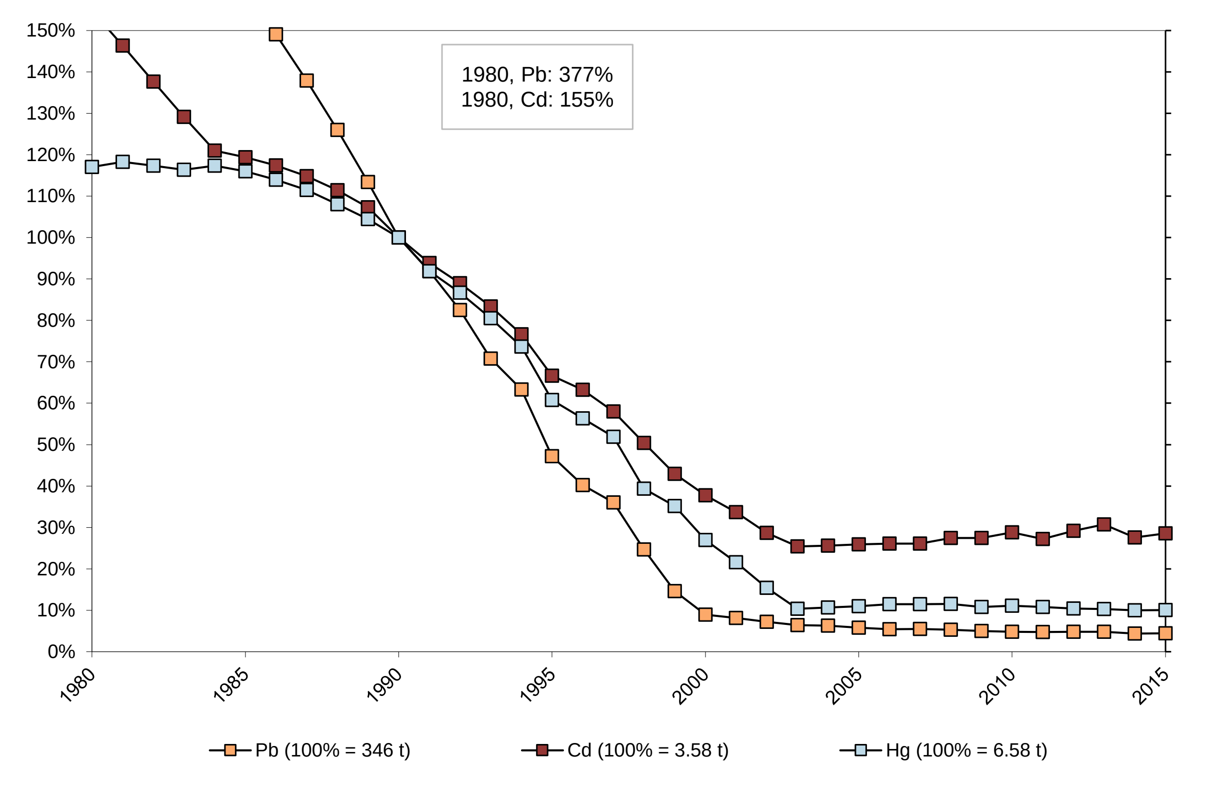

Figure 2-4: Emissions of priority heavy metals in Switzerland 1980–2015 (in percentage of 1990). Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

Table 2-4: Total emissions of priority heavy metal 1980–2015 in t. Note that numbers refer to the national total for compliance assessment (based on fuel used), which deviate from the national total for the entire territory based on fuel sold.

Year	**Pb**	**Cd**	**Hg**
	t	t	t
1980	1304.98	5.54	7.69
1985	552.20	4.28	7.63
1990	346.29	3.58	6.58
1995	163.34	2.39	4.00
2000	30.87	1.35	1.77
2005	20.12	0.93	0.72
2006	18.79	0.93	0.75
2007	19.05	0.93	0.75
2008	18.35	0.98	0.76
2009	17.26	0.98	0.71
2010	16.70	1.03	0.73
2011	16.45	0.97	0.71
2012	16.60	1.05	0.69
2013	16.71	1.10	0.68
2014	15.02	0.99	0.66
2015	15.38	1.02	0.66
2005 to 2015 (%)	-24%	10%	-9%

2.2.4 Persistent organic pollutants (POPs)

Figure 2-5 shows the emission trends for persistent organic pollutants (POP) between 1980 and 2015.

Between 1980 and 2003 PCDD/PCDF emissions decreased as result of an indirect effect of the retrofitting of waste incineration plants with DeNOx techniques. From 2003 onward, emissions continue to decrease on a low level (see also Table 2-5).

Emissions of (total) PAH increased slightly in the period 1980-1991, but since then strongly decreased due to reduction measures for waste incineration plants and improvements of wood combustion installations in 1A Fuel combustion.

The HCB emissions are strongly influenced by activity data of the secondary aluminium production. The trend shown in Figure 2-5 is primarily a reflection of the activity of the only plant for secondary aluminium production in Switzerland.The reason for the striking and sudden decline in total HCB emissions between 1992 and 1993 is the decommissioning of the only plant in Switzerland. The remaining sources of HCB emissions are waste incineration plants in source category 1A1 Energy industries, all wood combustion installations in 1A Fuel combustion and with a smaller share the use of coal (other bituminous coal and lignite) in 1A Energy combustion. HCB emissions from 1A4bi are strongly influenced by climate variabilities, in particular by the winter mean temperatures.

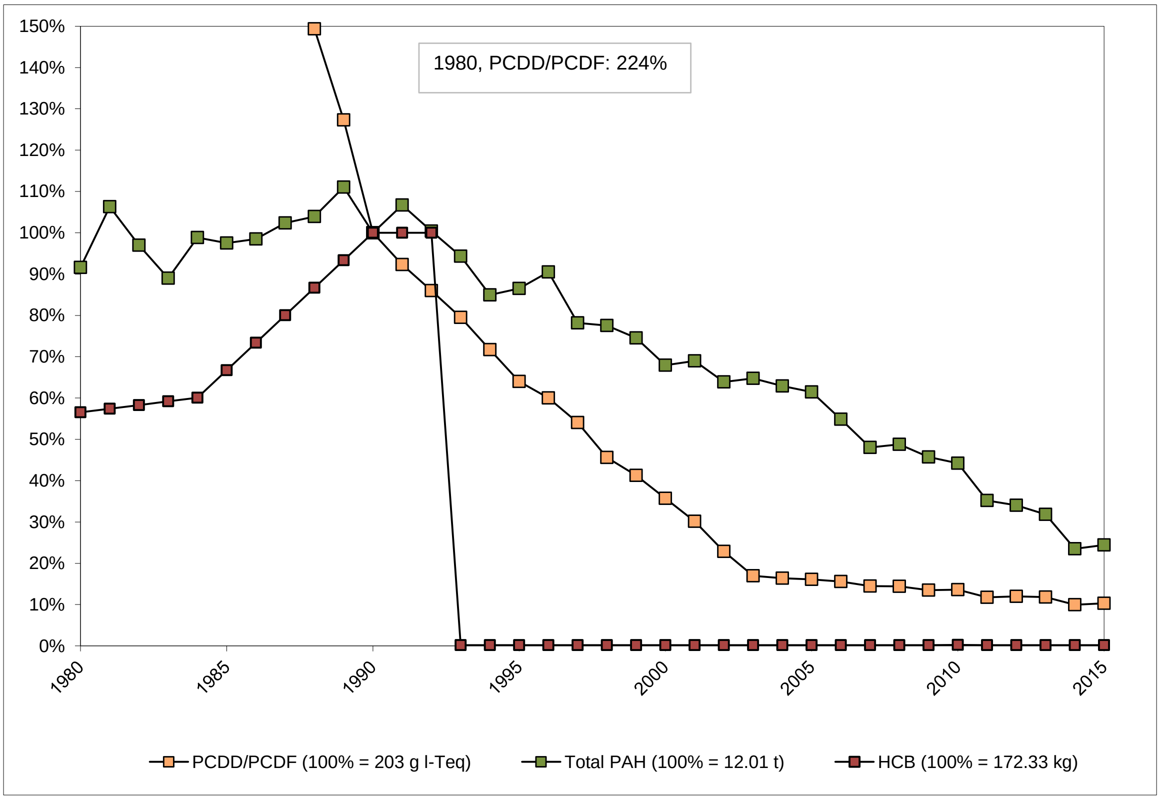

Figure 2-5: Emissions of POPs Annex III[1]: PAH – as the sum of benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene – PCDD/PCDF (PCDD/F) and HCB in Switzerland 1980–2015. Note that values for PCDD/PCDF before 1988 are not displayed here but illustrated in the table below. Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

[1] Annex III of the 1998 Aarhus Protocol on Persistent Organic Pollutants (POPs)

Table 2-5: Total emissions of POPs Annex III (see footnote 1, p. 35) 1980–2015. Please consider the different units. Note that numbers refer to the national total for compliance assessment (based on fuel used), which deviate from the national total for the entire territory based on fuel sold.

Year	PCDD/PCDF	BaP	BbF	BkF	IcdP	PAH tot	HCB
	g I-Teq	t	t	t	t	t	kg
1980	454	3.60	3.64	1.84	1.92	11.01	97.39
1985	408	3.83	3.84	1.90	2.15	11.72	115.01
1990	203	3.88	3.90	1.98	2.25	12.01	172.33
1995	130	3.46	3.34	1.59	2.01	10.40	0.32
2000	72	2.64	2.63	1.33	1.56	8.16	0.31
2005	33	2.34	2.39	1.28	1.38	7.38	0.35
2006	32	2.14	2.11	1.08	1.26	6.59	0.36
2007	29	1.89	1.84	0.93	1.11	5.77	0.35
2008	29	1.91	1.87	0.95	1.12	5.86	0.36
2009	27	1.79	1.75	0.91	1.05	5.50	0.36
2010	28	1.72	1.69	0.90	1.01	5.31	0.38
2011	24	1.35	1.34	0.74	0.80	4.23	0.34
2012	24	1.29	1.29	0.74	0.77	4.09	0.36
2013	24	1.19	1.20	0.72	0.71	3.83	0.37
2014	20	0.85	0.89	0.57	0.51	2.83	0.33
2015	21	0.89	0.92	0.60	0.53	2.94	0.34
2005 to 2015 (%)	-36%	-62%	-62%	-53%	-61%	-60%	-2%

2.3 Trends of main pollutants per gas and sectors

2.3.1 Trends for NO_x

Switzerland's emissions of NO_x (sum of NO and NO_2, expressed as NO_2 equivalents) per sector are given in Table 2-6 and Figure 2-6.

The decrease of emissions in sector 1 Energy is primarily due to the abatement of exhaust emissions from road vehicles and fuel combustion for residential, commercial and institutional heating:

- The most important reduction measure was the implementation of new strict emission standards for road vehicles. The first step happened in the late 80's when Switzerland reduced the standards to a level that required the equipment of three-way catalysts of new passenger cars. Later, when the European Union introduced the Euro standards, Switzerland adopted the subsequent reduction path. However, the effect of the Euro emission standards on the real driving NO_x emissions of passenger cars has not yet been as pronounced as expected in the past few years. The feature has become even more pronounced with the latest generation of the emission standard (Euro 6) for diesel passenger cars when the United States Environmental Protection Agency (EPA) issued a notice of violation of the Clean Air Act to automaker Volkswagen Group[2]. Meanwhile, similar abuse of diesel paasenger cars has been found in other makes than Volkswagen. Politics is about to adapt the checking procedures such that the compliance with the standards can be controlled more strictly.
- In the past, the number of buildings and apartments increased, as well as the average floor space per person and workplace. Both phenomena resulted in an increase of the total heated area. Over the same period, however, higher standards were specified for

[2] Dieselgate: «The EPA had found that Volkswagen had intentionally programmed turbocharged direct injection diesel engines to activate certain emissions controls only during laboratory emissions testing. ….Volkswagen deployed this programming in about eleven million cars worldwide» Source: https://en.wikipedia.org/wiki/Volkswagen_emissions_scandal

insulation and for combustion equipment efficiency for both new and renovated buildings including low-NO_x standards, compensating for the emissions of all air pollutants (and GHG) from the additional heated area.

- In addition, the substitution of residual fuel oil and coal by gas oil and natural gas in manufacturing industries as well as the nitrogen oxide reduction in municipal solid waste incineration plants by technical improvements (e.g. DeNOx technology) have significantly contributed to the general reduction of NO_x emissions since 1990.

Table 2-6: NO_x emissions per sector, their trends in 1990–2010, 2005-2015 and their shares in total emissions 2015 as well as the emission ceiling from the Gothenburg Protocol.

NO_x emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	133.06	87.20	69.75	55.27	-63.31	-31.93	-36.6%	93.6%
1A Fuel combustion	132.92	87.02	69.68	55.24	-63.24	-31.78	-36.5%	93.5%
1A1 Energy industries	6.81	3.00	3.27	2.68	-3.55	-0.32	-10.6%	4.5%
1A2 Manufacturing industries	22.86	14.83	12.48	9.72	-10.38	-5.11	-34.5%	16.5%
1A3 Transport	81.55	52.43	39.52	31.66	-42.03	-20.77	-39.6%	53.6%
1A4 Other sectors	21.12	16.32	14.04	10.85	-7.08	-5.47	-33.5%	18.4%
1A5 Other (Military)	0.58	0.44	0.38	0.33	-0.20	-0.11	-24.9%	0.6%
1B Fugitive emissions from fuels	0.13	0.18	0.07	0.03	-0.06	-0.15	-83.0%	0.1%
2 IPPU	0.46	0.28	0.34	0.30	-0.11	0.02	8.8%	0.5%
3 Agriculture	3.89	3.15	3.24	3.02	-0.65	-0.12	-3.9%	5.1%
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.43	0.35	0.36	0.38	-0.08	0.03	9.2%	0.6%
6 Other	0.09	0.08	0.08	0.08	-0.01	0.01	8.7%	0.1%
National total	137.93	91.05	73.77	59.06	-64.16	-31.99	-35.1%	100.0%
Gothenburg Protocol, emission ceiling			79.00					

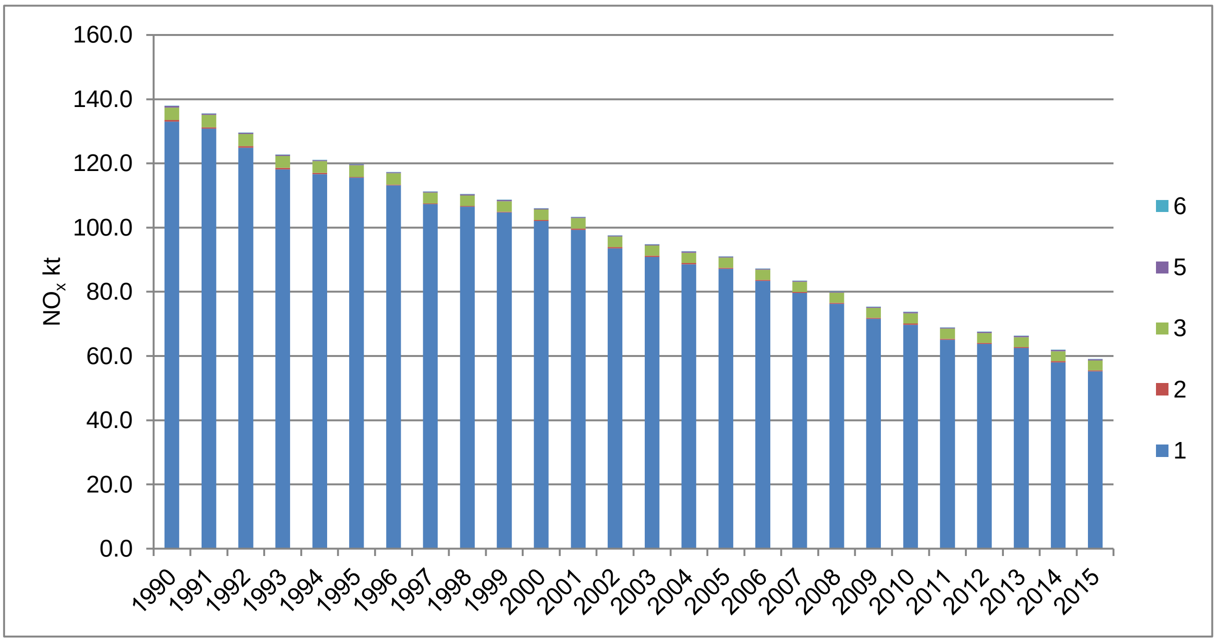

Figure 2-6: Trend of NO_x emissions (kt) in Switzerland 1990–2015 by sectors 1-6.

2.3.2 Trends for NMVOC

Switzerland's emissions of NMVOC per sector are given in Table 2-7 and Figure 2-7.

The NMVOC emissions of the sector 2 Industrial processes and product use have diminished since 1990 due to emission limit values enforced by the Ordinance on Air Pollution Control (Swiss Confederation 1985) (e.g. emission reductions in fuel handling, see Revision 1992 in

Figure 2-1) and due to the introduction of the VOC incentive tax in 2000 (Swiss Confederation 1997).

In sector 1 Energy, the decrease of emissions is triggered by the implementation of Euro standards for road vehicles.

Table 2-7: NMVOC emissions per sector, their trends 1990–2010, 2005-2015 and their shares in total emissions 2015 as well as the emission ceiling from the Gothenburg Protocol.

NMVOC emissions	**1990**	**2005**	**2010**	**2015**	**1990-2010**	**2005-2015**	**2005-2015**	**share in 2015**
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	118.65	41.85	30.04	22.00	-88.61	-19.85	-47.4%	28.5%
1A Fuel combustion	98.76	35.82	25.01	18.26	-73.75	-17.56	-49.0%	23.7%
1A1 Energy industries	0.30	0.24	0.22	0.17	-0.08	-0.07	-29.6%	0.2%
1A2 Manufacturing industries	2.34	1.99	1.49	1.04	-0.85	-0.96	-48.0%	1.3%
1A3 Transport	80.59	23.79	16.08	12.24	-64.51	-11.55	-48.5%	15.9%
1A4 Other sectors	15.39	9.68	7.12	4.73	-8.26	-4.94	-51.1%	6.1%
1A5 Other (Military)	0.14	0.11	0.09	0.07	-0.05	-0.04	-33.5%	0.1%
1B Fugitive emissions from fuels	19.89	6.03	5.03	3.74	-14.86	-2.29	-38.0%	4.9%
2 IPPU	164.52	52.05	50.41	48.72	-114.11	-3.33	-6.4%	63.2%
3 Agriculture	3.95	3.96	3.91	3.90	-0.04	-0.06	-1.6%	5.1%
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	1.08	1.80	2.05	2.42	0.96	0.62	34.4%	3.1%
6 Other	0.13	0.12	0.11	0.11	-0.02	-0.01	-9.7%	0.1%
National total	288.34	99.79	86.51	77.15	-201.83	-22.64	-22.7%	100.0%
Gothenburg Protocol, emission ceiling			144.00					

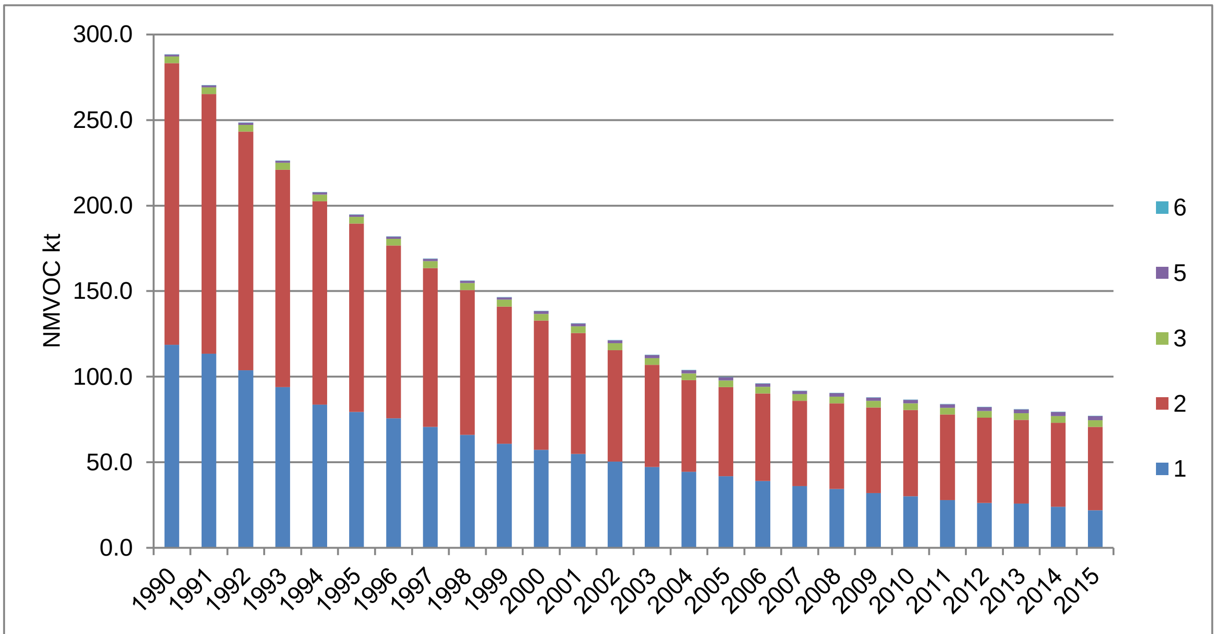

Figure 2-7: Trend of NMVOC emissions (kt) in Switzerland 1990–2015 by sectors 1-6.

2.3.3 Trends for SO_x

Switzerland's emissions of SO_x (sum of SO_2 and SO_3, expressed as SO_2 equivalents) per sector are given in Table 2-8 and Figure 2-8.

Three main measures lead to a reduction of SO_x emissions in Switzerland. First, a limitation of the sulphur content in fuels (stepwise lowering in 1993, 1999 and 2000) by the Ordinance on Air Pollution Control (Swiss Confederation 1985) resulted in a significant decrease of the sulphur oxide emissions from fuel combustion (gas oil, diesel and gasoline, see Table 3-8). Second, a substantial substitution of gas oil by natural gas under 1A4 (natural gas consumption almost doubled from 1990 to 2015) resulted in further reductions of sulphur emissions. Third, a similar substitution of residual fuel oil, coal and gas oil under 1A2 Manufacturing industries (from about 2005 onwards) by natural gas has reduced sulphur emissions as well.

Table 2-8: SO_x emissions per sector, their trends 1990–2010, 2005-2015 and their shares in total emissions 2015 as well as the emission ceiling from the Gothenburg Protocol.

SO_x emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	37.95	14.05	9.65	5.99	-28.30	-8.05	-57.3%	88.8%
1A Fuel combustion	37.34	13.60	9.38	5.84	-27.96	-7.76	-57.0%	86.6%
1A1 Energy industries	4.35	1.82	1.59	0.83	-2.76	-0.99	-54.2%	12.3%
1A2 Manufacturing industries	13.53	4.33	2.89	2.21	-10.64	-2.11	-48.8%	32.8%
1A3 Transport	3.88	0.21	0.22	0.24	-3.66	0.03	12.4%	3.5%
1A4 Other sectors	15.51	7.21	4.64	2.53	-10.87	-4.68	-65.0%	37.4%
1A5 Other (Military)	0.08	0.04	0.04	0.04	-0.04	0.00	-3.6%	0.5%
1B Fugitive emissions from fuels	0.61	0.45	0.28	0.15	-0.34	-0.29	-65.9%	2.3%
2 IPPU	1.46	1.07	0.79	0.65	-0.67	-0.43	-39.8%	9.6%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.20	0.08	0.09	0.10	-0.11	0.02	19.9%	1.5%
6 Other	0.01	0.01	0.01	0.01	0.00	0.00	-1.9%	0.2%
National total	39.62	15.21	10.54	6.75	-29.08	-8.47	-55.6%	100.0%
Gothenburg Protocol, emission ceiling			26.00					

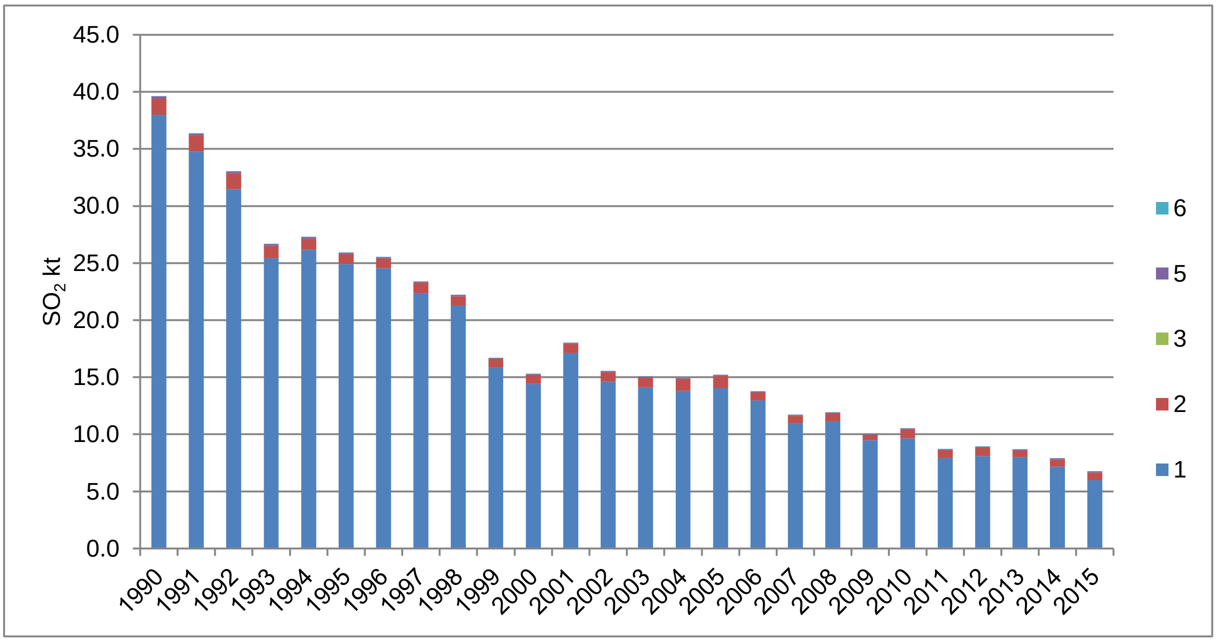

Figure 2-8: Trend of SO_2 emissions (kt) in Switzerland 1990–2015 by sectors 1-6 (SO_x as SO_2).

2.3.4 Trends for NH_3

Switzerland's emissions of NH_3 per sector are given in Table 2-9 and Figure 2-9.

The decrease of agricultural ammonia emissions between 1990 and 1995 is explained by a decline in the number of animals and in the use of mineral fertilizers. From 1995 onward, the trend is influenced by a combination of different factors: changes in animal numbers, introduction of new housing systems due to developments in animal welfare regulations, increase of animal productivity and changes in production techniques. From 2004-2008, agricultural emissions slightly increased, and since then they are again decreasing.

Table 2-9: NH_3 emissions per sector, their trends 1990–2010, 2005-2015 and their shares in total emissions 2015 as well as the emission ceiling from the Gothenburg Protocol.

NH_3 emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	1.59	3.89	2.93	2.28	1.34	-1.62	-41.5%	3.8%
1A Fuel combustion	1.59	3.89	2.93	2.28	1.34	-1.62	-41.5%	3.8%
1A1 Energy industries	0.00	0.03	0.04	0.04	0.03	0.01	49.7%	0.1%
1A2 Manufacturing industries	0.16	0.19	0.25	0.23	0.09	0.04	22.6%	0.4%
1A3 Transport	1.28	3.56	2.52	1.89	1.24	-1.67	-47.0%	3.1%
1A4 Other sectors	0.14	0.12	0.13	0.12	-0.01	0.00	0.6%	0.2%
1A5 Other (Military)	0.00	0.00	0.00	0.00	0.00	0.00	5.5%	0.0%
1B Fugitive emissions from fuels	NA	NA	NA	NA	–	–	–	–
2 IPPU	0.37	0.35	0.21	0.17	-0.16	-0.19	-53.1%	0.3%
3 Agriculture	69.56	57.99	58.76	56.48	-10.80	-1.51	-2.6%	93.2%
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.76	0.68	0.66	0.67	-0.11	0.00	-0.3%	1.1%
6 Other	0.92	0.86	0.89	1.03	-0.03	0.18	20.7%	1.7%
National total	73.20	63.77	63.44	60.63	-9.76	-3.14	-4.9%	100.0%
Gothenburg Protocol, emission ceiling			63.00					

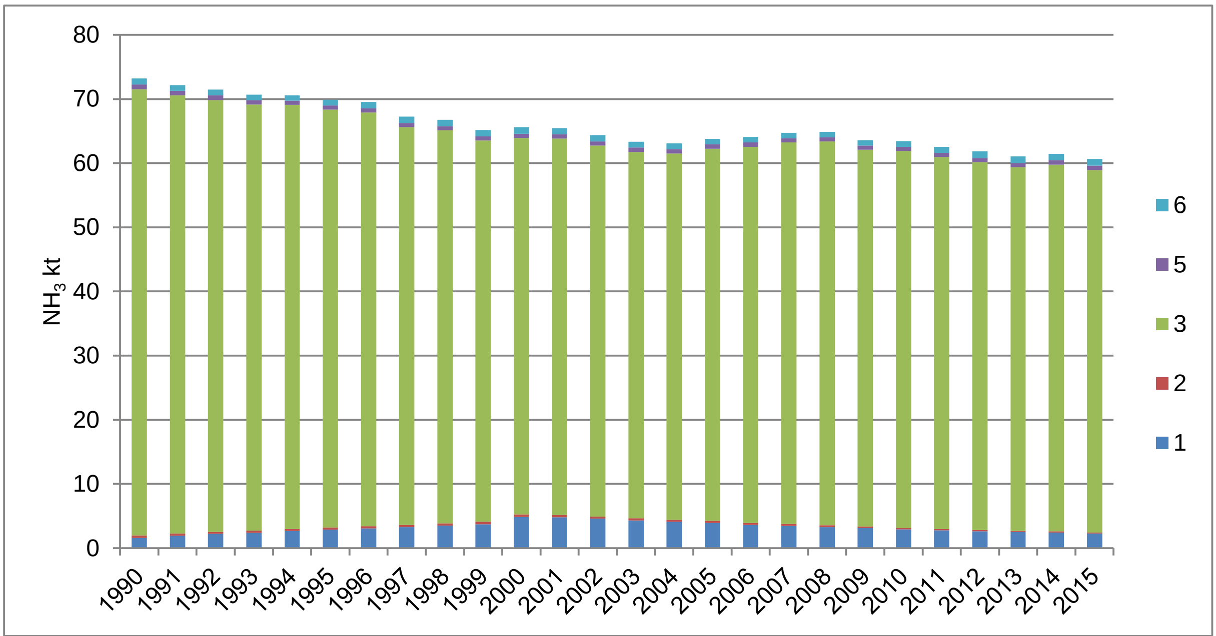

Figure 2-9: Trend of NH_3 emissions (kt) in Switzerland 1990–2015 by sectors 1-6.

2.4 Trends of particulate matter per pollutant

2.4.1 Features commonly holding for all particulate matter fractions PM2.5, PM10, TSP, BC

Switzerland's particulate matter emissions per sector are given in Table 2-10 and Figure 2-10 for PM2.5, in Table 2-11 for PM10, in Table 2-12 for TSP and in Table 2-13 for BC. The observed reduction of emissions in all fractions is mainly due to a reduction of exhaust emissions from 1A4 Other sectors, 1A3 Transport and 1A2 Manufacturing industries and construction that result from technical improvements and fuel switch (from residual fuel oil to gas oil and to natural gas).

echnological improvements of wood furnaces and a reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves) contributed to a substantial decrease. In addition, substitution of gas oil by natural gas (its consumption almost doubled from 1990 to 2015) contributed to a small reduction in emissions.

For mobile sources, the reduction is caused by the abatement of exhaust emissions from road vehicles and construction machineries. Throughout the years, a continuous reduction of these emissions has been achieved with the stepwise adoption of the Euro standards. Since 2009, new diesel cars and new construction machineries must be equipped with diesel particle filters, leading to significant reductions.

In 1A2, substitution of coal, residual fuel oil and gas oil by natural gas contributed to the decrease in emissions of particulate matter.

2.4.2 Trends for PM2.5

Contrary to the decreasing trends mentioned above, there is a small increasing trend in PM2.5 due to non-exhaust particulate emissions from growing activity data of mobile sources. The effect, however, is much weaker than the overall decreasing trend, and it is less pronounced for PM2.5 than for PM10 and TSP (see below in chp. 2.4.3).

Table 2-10: PM2.5 emissions per sector, their trends 1990–2010, 2005-2015 and their shares in total emissions 2015.

PM2.5 emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	12.18	7.82	6.57	5.24	-5.61	-2.58	-33.0%	73.0%
1A Fuel combustion	12.18	7.82	6.57	5.24	-5.61	-2.58	-33.0%	73.0%
1A1 Energy industries	0.80	0.14	0.16	0.11	-0.64	-0.03	-18.5%	1.6%
1A2 Manufacturing industries	1.92	1.44	1.05	0.84	-0.87	-0.60	-41.5%	11.7%
1A3 Transport	2.77	2.19	1.72	1.32	-1.05	-0.87	-39.9%	18.3%
1A4 Other sectors	6.61	3.99	3.59	2.92	-3.02	-1.07	-26.9%	40.7%
1A5 Other (Military)	0.08	0.06	0.05	0.05	-0.03	-0.01	-17.9%	0.7%
1B Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	-4.9%	0.0%
2 IPPU	2.40	1.32	1.35	1.24	-1.06	-0.08	-6.1%	17.3%
3 Agriculture	0.34	0.34	0.35	0.36	0.01	0.02	6.0%	5.0%
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.60	0.38	0.36	0.33	-0.24	-0.05	-12.0%	4.6%
6 Other	0.00	0.00	0.00	0.00	0.00	0.00	-3.5%	0.0%
National total	15.52	9.86	8.63	7.17	-6.90	-2.69	-27.2%	100.0%

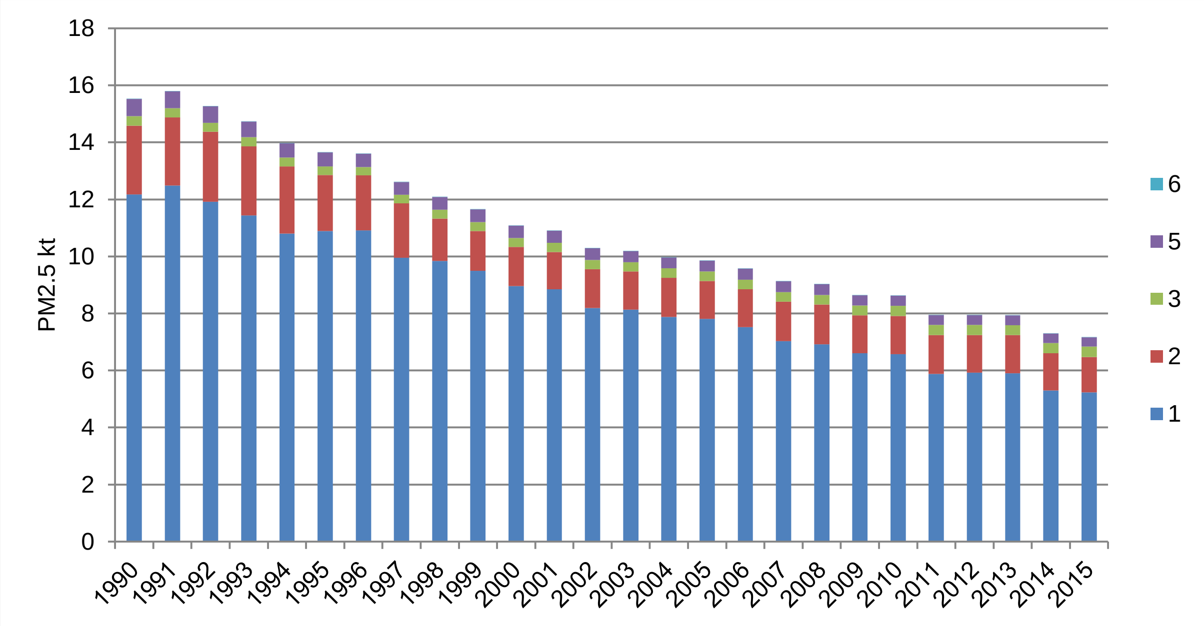

Figure 2-10: Trend of PM2.5 emissions (kt) in Switzerland 1990–2015 by sectors 1-6.

2.4.3 Trends for PM10

Switzerland's emissions of PM10 per sector are given in Table 2-11. Driving factors of the observed trend in PM10 emissions are described in chp. 2.4.1. In addition, an increase in the activity data e.g. annual mileage in 1A3, 1A2g vii and 1A4 cii leads to an increase in non-exhaust emissions. The latter consist mainly of particles with a diameter larger than 2.5 micrometers and are therefore affecting mainly the trend in PM10 emissions rather than the trend in PM2.5 emissions. Since the increase in non-exhaust emissions is less pronounced than the decrease in exhaust emissions, total PM10 emissions are decreasing. However, this decreasing trend is less pronounced as compared to the decrease in PM2.5 emissions (see chp. 2.4.2) due to the increase in non-exhaust PM10 emissions.

Table 2-11: PM10 emissions per sector, their trend 1990–2010, 2005-2015 and their shares in total emissions 2015.

PM10 emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	18.99	14.61	13.55	12.24	-5.43	-2.37	-16.2%	70.5%
1A Fuel combustion	18.99	14.61	13.55	12.24	-5.43	-2.37	-16.2%	70.5%
1A1 Energy industries	1.06	0.14	0.16	0.12	-0.90	-0.03	-18.5%	0.7%
1A2 Manufacturing industries	3.79	3.30	2.95	2.78	-0.84	-0.52	-15.7%	16.0%
1A3 Transport	5.36	5.24	5.00	4.66	-0.36	-0.58	-11.2%	26.8%
1A4 Other sectors	8.49	5.65	5.16	4.41	-3.33	-1.23	-21.8%	25.4%
1A5 Other (Military)	0.28	0.27	0.28	0.27	-0.01	0.00	-0.6%	1.6%
1B Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	-4.9%	0.0%
2 IPPU	4.46	2.23	2.32	2.18	-2.14	-0.06	-2.5%	12.5%
3 Agriculture	2.24	2.26	2.32	2.40	0.07	0.13	6.0%	13.8%
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.69	0.42	0.40	0.37	-0.29	-0.05	-11.9%	2.1%
6 Other	0.20	0.19	0.18	0.18	-0.03	-0.02	-9.4%	1.0%
National total	26.58	19.72	18.76	17.36	-7.82	-2.35	-11.9%	100.0%

2.4.4 Trends for TSP

Switzerland's emissions of TSP per sector are given in Table 2-12.

The decreasing trend in TSP emisisons is less pronounced as compared to the decrease in PM10 emissions. This is due to a larger share of non-exhaust emissions with a particle diameter of more than 10 micrometers from mobile souces in 1A3, 1A2g vii and 1A4 cii.

Table 2-12: TSP emissions per sector, their trend 1990–2010, 2005-2015 and their shares in total emissions 2015.

TSP emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	22.14	17.31	16.27	14.92	-5.87	-2.39	-13.8%	69.5%
1A Fuel combustion	22.14	17.31	16.27	14.92	-5.87	-2.39	-13.8%	69.5%
1A1 Energy industries	1.08	0.16	0.18	0.13	-0.91	-0.03	-19.6%	0.6%
1A2 Manufacturing industries	5.13	4.37	4.07	3.93	-1.06	-0.45	-10.2%	18.3%
1A3 Transport	5.67	5.62	5.41	5.07	-0.26	-0.55	-9.8%	23.6%
1A4 Other sectors	9.84	6.75	6.20	5.39	-3.64	-1.37	-20.2%	25.1%
1A5 Other (Military)	0.41	0.40	0.41	0.41	0.00	0.00	0.8%	1.9%
1B Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	-4.9%	0.0%
2 IPPU	10.24	3.49	3.63	3.48	-6.61	-0.01	-0.2%	16.2%
3 Agriculture	2.24	2.26	2.32	2.40	0.07	0.13	6.0%	11.2%
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.84	0.51	0.49	0.45	-0.35	-0.06	-11.8%	2.1%
6 Other	0.24	0.23	0.21	0.21	-0.03	-0.02	-9.2%	1.0%
National total	35.71	23.81	22.92	21.46	-12.79	-2.34	-9.8%	100.0%

2.4.5 Trends for BC

Switzerland's emissions of BC per sector are given in Table 2-13.

The emissions are decreasing, which is the success of measures in order to reduce BC emissions from fuel combustion, e.g. strengthened wood combustion standards, increasing number of road vehicles and non-road mobile machinery equipped with DPF.

Table 2-13: BC emissions per sector, their trends 1990–2010, 2005-2015 and their shares in total emissions 2015.

BC emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	4.96	3.17	2.33	1.48	-2.63	-1.70	-53.5%	98.4%
1A Fuel combustion	4.96	3.17	2.33	1.48	-2.63	-1.70	-53.5%	98.4%
1A1 Energy industries	0.03	0.01	0.01	0.01	-0.03	0.00	-28.0%	0.4%
1A2 Manufacturing industries	0.31	0.27	0.13	0.07	-0.18	-0.20	-74.6%	4.6%
1A3 Transport	1.09	1.13	0.82	0.41	-0.27	-0.72	-64.0%	27.0%
1A4 Other sectors	3.51	1.76	1.37	0.99	-2.14	-0.76	-43.5%	66.1%
1A5 Other (Military)	0.02	0.01	0.01	0.00	-0.01	-0.01	-66.6%	0.2%
1B Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	-4.9%	0.0%
2 IPPU	0.00	0.00	0.00	0.00	0.00	0.00	-69.3%	0.0%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.04	0.03	0.03	0.02	-0.02	0.00	-11.9%	1.6%
6 Other	0.00	0.00	0.00	0.00	0.00	0.00	-9.1%	0.0%
National total	5.01	3.20	2.36	1.50	-2.65	-1.70	-53.2%	100.0%

2.5 Trends of other gases

2.5.1 Trends for CO

Switzerland's emissions of CO per sector are given in Table 2-14.

The decrease of emissions in sector 1 Energy is primarily a result of the abatement of exhaust emissions from road vehicles and fuel combustion for residential, commercial and institutional heating, as mentioned above for NO_x.

Table 2-14: CO emissions per sector, their trends 1990–2010, 2005-2015 and their shares in total emissions 2015.

CO emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	717.80	303.50	227.70	175.33	-490.10	-128.17	-42.2%	95.5%
1A Fuel combustion	717.77	303.46	227.68	175.32	-490.09	-128.14	-42.2%	95.5%
1A1 Energy industries	1.54	1.20	1.49	1.01	-0.04	-0.19	-15.7%	0.6%
1A2 Manufacturing industries	28.15	20.73	18.63	15.04	-9.53	-5.69	-27.5%	8.2%
1A3 Transport	518.79	179.19	124.70	95.28	-394.10	-83.92	-46.8%	51.9%
1A4 Other sectors	167.41	100.71	81.30	62.49	-86.11	-38.22	-37.9%	34.0%
1A5 Other (Military)	1.88	1.63	1.56	1.50	-0.32	-0.12	-7.6%	0.8%
1B Fugitive emissions from fuels	0.03	0.04	0.02	0.01	-0.01	-0.04	-83.0%	0.0%
2 IPPU	12.23	7.64	5.83	5.55	-6.39	-2.09	-27.3%	3.0%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	3.04	2.24	2.09	2.00	-0.95	-0.24	-10.6%	1.1%
6 Other	0.80	0.76	0.68	0.68	-0.12	-0.08	-10.0%	0.4%
National total	733.9	314.13	236.31	183.56	-497.57	-130.57	-41.6%	100.0%

2.6 Trends for priority heavy metals per pollutant

2.6.1 Lead (Pb)

Switzerland's emissions of Pb per sector are shown in Table 2-15.

A pronounced decrease of Pb emissions in the energy sector was achieved due to the introduction of unleaded gasoline in the OAPC revision of the year 2000 (see Figure 2-1). Another measure that resulted in a significant decrease of the emissions was retrofitting the steelworks in the years 1998/1999. Furthermore, a significant reduction was achieved in the period 1990–2003 by equipping municipal solid waste incineration plants with flue gas treatment or improving the technology installed already. Since then, the emissions further decrease on a low level.

Table 2-15: Pb emissions per sector, their trend 1990–2010, 2005-2015 and their shares in total emissions 2015.

Pb emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	t	t	t	t	t	t	%	%
1 Energy	267.66	9.18	7.79	6.59	-259.87	-2.59	-28.2%	42.8%
1A Fuel combustion	264.11	9.18	7.79	6.59	-256.31	-2.59	-28.2%	42.8%
1A1 Energy industries	29.53	1.68	1.57	1.40	-27.96	-0.28	-16.7%	9.1%
1A2 Manufacturing industries	5.20	2.06	1.35	0.82	-3.85	-1.24	-60.3%	5.3%
1A3 Transport	228.23	4.38	3.74	3.29	-224.49	-1.09	-24.9%	21.4%
1A4 Other sectors	1.14	1.05	1.12	1.07	-0.02	0.02	2.1%	7.0%
1A5 Other (Military)	0.00	0.00	0.00	0.00	0.00	0.00	-0.1%	0.0%
1B Fugitive emissions from fuels	3.55	NO	NO	NO	–	–	–	–
2 IPPU	67.14	2.10	0.69	0.68	-66.45	-1.41	-67.4%	4.4%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	4.70	2.28	2.21	2.06	-2.49	-0.22	-9.7%	13.4%
6 Other	6.78	6.57	6.01	6.05	-0.77	-0.52	-7.9%	39.4%
National total	346.29	20.12	16.70	15.38	-329.59	-4.74	-23.6%	100.0%

2.6.2 Cadmium (Cd)

Switzerland's emissions of Cd per sector are given in Table 2-16.
One of the measures resulting in a significant decrease of emissions was the retrofitting of the steelworks in the year 1999. Additionally, a significant reduction has been achieved in the period 1990–2003 by equipping municipal solid waste incineration plants with flue gas treatment or improving the technology installed already. However, since 2003 the emissions of Cd rise again which is mainly due to an increase in emissions from special hazardous waste incineration plants.

Table 2-16: Cd emissions per sector, their trend 1990–2010, 2005-2015 and their shares in total emissions 2015.

Cd emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	t	t	t	t	t	t	%	%
1 Energy	2.89	0.73	0.84	0.83	-2.05	0.10	13.7%	81.0%
1A Fuel combustion	2.89	0.73	0.84	0.83	-2.05	0.10	13.7%	81.0%
1A1 Energy industries	1.75	0.18	0.23	0.24	-1.52	0.05	29.2%	23.2%
1A2 Manufacturing industries	0.74	0.14	0.17	0.16	-0.57	0.01	8.9%	15.4%
1A3 Transport	0.07	0.08	0.08	0.08	0.01	0.01	9.5%	8.1%
1A4 Other sectors	0.33	0.32	0.37	0.35	0.03	0.03	8.1%	34.2%
1A5 Other (Military)	NA	NA	NA	NA	–	–	–	–
1B Fugitive emissions from fuels	NA	NA	NA	NA	–	–	–	–
2 IPPU	0.47	0.02	0.02	0.03	-0.45	0.01	27.1%	2.5%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.05	0.01	0.02	0.02	-0.03	0.00	19.2%	1.7%
6 Other	0.17	0.16	0.15	0.15	-0.02	-0.01	-7.9%	14.8%
National total	3.58	0.93	1.03	1.02	-2.55	0.10	10.3%	100.0%

2.6.3 Mercury (Hg)

Switzerland's emissions of Hg per sector are shown in Table 2-17.

Retrofitting of the steelworks in the years 1999 was a leading measure in reducing emissions. Furthermore, a significant reduction has been achieved in the period 1990–2003 by equipping municipal solid waste incineration plants with flue gas treatment or improving the technology installed already. Since then, the decreasing trend goes on but on a lower level.

Table 2-17: Hg emissions per sector, their trends 1990–2010, 2005-2015 and their shares in total emissions 2015.

Hg emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	t	t	t	t	t	t	%	%
1 Energy	4.22	0.51	0.53	0.48	-3.69	-0.03	-5.5%	72.9%
1A Fuel combustion	4.22	0.51	0.53	0.48	-3.69	-0.03	-5.5%	72.9%
1A1 Energy industries	3.92	0.34	0.32	0.29	-3.60	-0.06	-16.4%	43.3%
1A2 Manufacturing industries	0.25	0.12	0.16	0.15	-0.09	0.03	29.5%	22.9%
1A3 Transport	0.00	0.00	0.00	0.00	0.00	0.00	-29.0%	0.0%
1A4 Other sectors	0.05	0.05	0.05	0.04	0.00	-0.01	-12.6%	6.6%
1A5 Other (Military)	NA	NA	NA	NA	–	–	–	–
1B Fugitive emissions from fuels	NA	NA	NA	NA	–	–	–	–
2 IPPU	1.50	0.07	0.07	0.08	-1.44	0.02	24.8%	12.7%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.77	0.07	0.07	0.03	-0.71	-0.04	-61.1%	4.2%
6 Other	0.08	0.08	0.07	0.07	-0.01	-0.01	-10.0%	10.3%
National total	6.58	0.72	0.73	0.66	-5.85	-0.06	-8.6%	100.0%

2.7 Trends for POPs

2.7.1 PCDD/PCDF

Switzerland's emissions of PCDD/PCDF per sector are given in Table 2-18. A significant reduction was achieved in the period 1990–2003 by retrofitting municipal solid waste incineration plants with flue gas treatment or improving the technology installed already. Since then, emissions continue to decrease.

Table 2-18: Emissions of PCDD/PCDF per sector, their trends 1990–2010, 2005-2015 and their shares in total emissions 2015.

PCDD/PCDF emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	g I-Teq	g I-Teq	g I-Teq	g I-Teq	g I-Teq	g I-Teq	%	%
1 Energy	162.95	23.50	19.73	13.88	-143.21	-9.62	-40.9%	66.3%
1A Fuel combustion	162.95	23.50	19.73	13.88	-143.21	-9.62	-40.9%	66.3%
1A1 Energy industries	130.35	5.16	3.56	1.94	-126.79	-3.23	-62.5%	9.2%
1A2 Manufacturing industries	7.95	2.25	1.80	0.98	-6.15	-1.28	-56.7%	4.7%
1A3 Transport	1.88	0.22	0.21	0.21	-1.67	-0.02	-7.5%	1.0%
1A4 Other sectors	22.76	15.86	14.16	10.76	-8.60	-5.10	-32.1%	51.4%
1A5 Other (Military)	NA	NA	NA	NA	–	–	–	–
1B Fugitive emissions from fuels	NA	NA	NA	NA	–	–	–	–
2 IPPU	16.98	2.11	1.23	0.80	-15.75	-1.31	-61.9%	3.8%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	20.08	4.53	4.41	4.00	-15.67	-0.53	-11.7%	19.1%
6 Other	2.54	2.46	2.25	2.27	-0.29	-0.19	-7.9%	10.8%
National total	202.55	32.60	27.62	20.95	-174.93	-11.65	-35.7%	100.0%

2.7.2 Polycyclic aromatic hydrocarbons (PAHs)

Switzerland's emissions of PAH per sector are given in Table 2-19.

The energy sector, especially wood combustion in 1A4 Other stationary combustion, is the main contributor to PAH emissions. A significant reduction was achieved in the period 1990–2003 by retrofitting municipal solid waste incineration plants with flue gas treatment or improving the technology installed already. Since then, emissions continue to decrease.

Table 2-19: Emissions of PAHs per sector, their trends 1990–2010, 2005-2015 and their shares in total emissions 2015.

PAHs emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	t	t	t	t	t	t	%	%
1 Energy	10.60	6.53	4.98	2.59	-5.62	-3.94	-60.3%	88.3%
1A Fuel combustion	10.60	6.53	4.98	2.59	-5.62	-3.94	-60.3%	88.3%
1A1 Energy industries	0.10	0.11	0.18	0.01	0.07	-0.10	-89.0%	0.4%
1A2 Manufacturing industries	1.11	0.87	0.60	0.09	-0.51	-0.79	-90.0%	3.0%
1A3 Transport	0.13	0.16	0.17	0.18	0.04	0.03	15.7%	6.3%
1A4 Other sectors	9.26	5.39	4.03	2.31	-5.23	-3.08	-57.1%	78.7%
1A5 Other (Military)	0.00	0.00	0.00	0.00	0.00	0.00	0.9%	0.0%
1B Fugitive emissions from fuels	NA	NA	NA	NA	–	–	–	–
2 IPPU	0.97	0.51	0.03	0.02	-0.94	-0.49	-95.4%	0.8%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.371	0.25	0.21	0.21	-0.16	-0.04	-15.1%	7.2%
6 Other	0.07	0.09	0.10	0.11	0.03	0.01	15.2%	3.7%
National total	12.01	7.38	5.31	2.94	-6.70	-4.45	-60.2%	100.0%

2.7.3 HCB

Switzerland's emissions of HCB per sector are shown in Table 2-20. Between the years 1992 and 1993, a significant emission reduction occurred in category 1A2b Non-ferrous metals due to the shutdown of the secondary aluminium production plant.

Table 2-20: Emissions of HCB by sectors, their trends 1990–2010, 2005-2015 and their shares in total emissions 2015.

HCB emissions	1990	2005	2010	2015	1990-2010	2005-2015	2005-2015	share in 2015
	kg	kg	kg	kg	kg	kg	%	%
1 Energy	172.33	0.35	0.38	0.34	-171.95	-0.01	-1.8%	100.0%
1A Fuel combustion	172.33	0.35	0.38	0.34	-171.95	-0.01	-1.8%	100.0%
1A1 Energy industries	0.11	0.15	0.17	0.18	0.06	0.03	17.8%	52.2%
1A2 Manufacturing industries	172.04	0.04	0.04	0.03	-172.00	-0.01	-18.9%	9.7%
1A3 Transport	NA	NA	NA	NA	–	–	–	–
1A4 Other sectors	0.17	0.16	0.16	0.13	-0.01	-0.03	-16.4%	38.1%
1A5 Other (Military)	NA	NA	NA	NA	–	–	–	–
1B Fugitive emissions from fuels	NA	NA	NA	NA	–	–	–	–
2 IPPU	NA	NA	NA	NA	–	–	–	–
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	NA	NA	NA	NA	–	–	–	–
6 Other	NA	NA	NA	NA	–	–	–	–
National total	172.33	0.35	0.38	0.34	-171.95	-0.01	-1.8%	100.0%

2.8 Compliance with the Gothenburg Protocol

2.8.1 Emission ceilings 2010

Under the CLRTAP, the Gothenburg Protocol requires that parties shall reduce and maintain the reduction in annual emissions in accordance with emission ceilings set for 2010 and beyond. Table 2-21 shows the emission ceilings, the reported emissions for 2010 and the respective compliance. Accordingly, Switzerland is in compliance with the Gothenburg Protocol emission ceilings for all pollutants in 2010, except NH_3 where minor additional emissions are reported according to recalculations. All emissions 2015 are in compliance with the emission ceilings.

Table 2-21: Emission ceilings of the Gothenburg Protocol for 2010 and beyond compared to the reported emissions for 2010 and 2015 of the current submission (2017).

Pollutants	National emission ceilings for 2010 kt	Emissions 2010 (Subm. 2017) kt	Emissions 2015 (Subm. 2017) kt	Compliance with emission ceilings 2010 in 2015
SO_x	26.0	10.5	6.7	yes
NO_x	79.0	73.8	59.1	yes
NMVOC	144.0	86.5	77.2	yes
NH_3	63.0	63.4	60.6	yes

2.8.2 Emission reduction commitments 2020

After five years of negotiations, a revised Gothenburg Protocol was successfully finalised on 4 May 2012 at a meeting of the parties to the Convention on Long-range Transboundary Air Pollution (CLRTAP) in Geneva. The Gothenburg Protocol dates back to 1999 and establishes mandatory emission reductions for four major air pollutants, to be achieved by 2010 and not exceeded thereafter.

While the original protocol sets national emission ceilings for 2010 and beyond for each pollutant, the revised protocol specifies emission reduction commitments in terms of percentage reductions from the reference year 2005 to 2020. It has also been extended to cover one additional air pollutant, namely particulate matter (PM2.5), and thereby also black carbon as a component of PM2.5. However, the amended protocol including new reduction commitments for 2020 has not yet entered into force.

Table 2-22 shows the emission reduction commitments of the amended Gothenburg protocol and the corresponding emissions in 2015.

Table 2-22 Emission reduction commitments 2020 compared to the reported emissions levels for 2015. Emission commitments 2020 are defined as reductions in percentages from 2005 (see second row).

Pollutant	Emission reduction commitments 2020	Reduction 2005-2015
	%-reduction of 2005 level	*%*
SO_x	-21%	-56%
NO_x	-41%	-35%
NMVOC	-30%	-23%
NH_3	-8%	-5%
PM2.5	-26%	-27%

3 Energy

3.1 Overview of emissions

In this introductory chapter, an overview of emissions separated by most relevant pollutants in sector 1 Energy is presented. In the sector 1 Energy the substances NO_x, NMVOC and PM2.5 and SO_2 are the main contributors to air pollution. The following source categories are reported:

- 1A Fuel combustion
- 1B Fugitive emissions from fuels

3.1.1 Overview and trend for NO_x

According to Figure 3-1 emissions from 1A3 Transport contribute most to NO_x emissions in the energy sector for all years. The largest share by 1A3 Transport was reached in the year 2000 and decreased afterwards. Emissions from 1A2 Manufacturing industries and construction and 1A4 Other (Commercial/institutional, residential, agriculture/forestry/fishing) are also contributing a noticeable amount.

Various measures led to a total NO_x reduction between 1990 and 2015. As a consequence of the air pollution ordinance endorsed in 1985 (Swiss Confederation 1985), NO_x emissions steadily decreased ever since. The legislation prescribes clear reduction targets that are mirrored in the trends of most energy related sectors. Particularly emission reductions in the transport source category are striking (1990–2015). The main reasons for this are strict emissions regulations according to the EURO norms (Swiss Confederation 1995) as well as technological progress (e.g. low NO_x burners and new filter systems). As a result of the legislation and technological improvements over the past two decades, emissions also decreased in 1A2 and 1A4. Emissions from 1A1 Energy industries and 1A5 Military are minor and decreased as well.

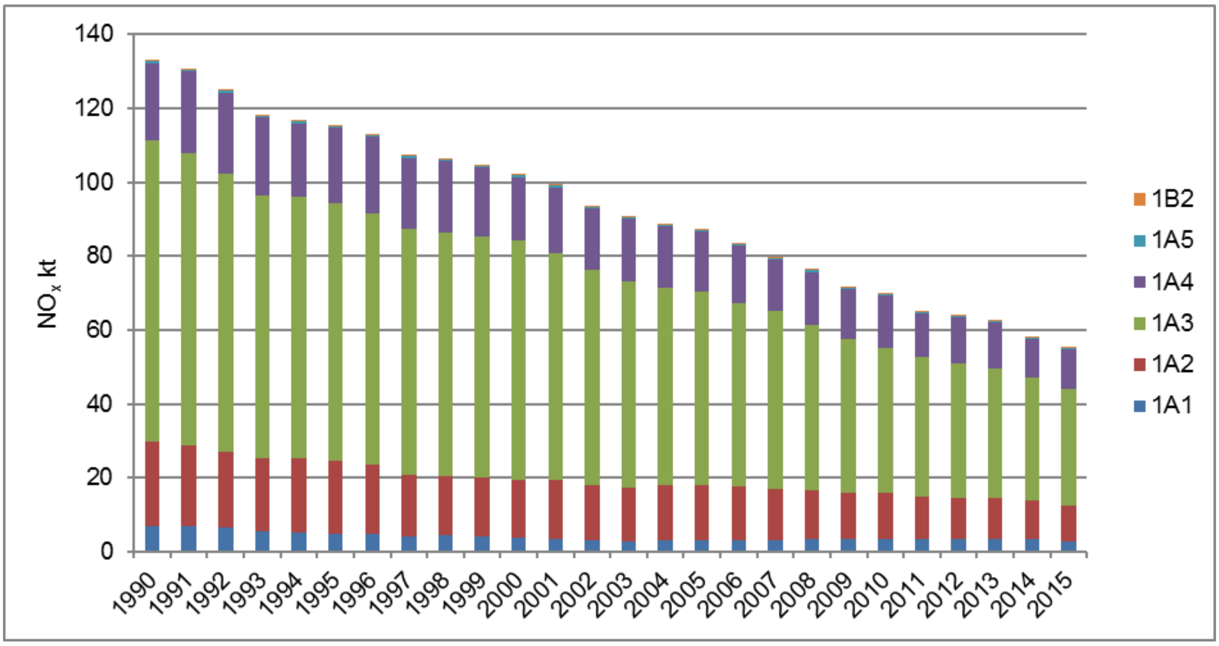

Figure 3-1: Switzerland's NO_x emissions from the energy sector by source categories 1A1-1A5 and 1B2 between 1990 and 2015. The corresponding data table can be found in Annex 6.2.

3.1.2 Overview and trend for NMVOC

Figure 3-2 depicts the NMVOC emissions in energy related sectors since 1990. 1A3 Transport contributes the largest share of total emissions in the period between 1990 and 2015. Furthermore, 1A4 Other sectors have become increasingly relevant sources of NMVOC emissions since NMVOC emissions from 1A3 Transport are decreasing and thus the relative importance of 1A4 Other sectors is increasing. Nevertheless, there is a clear and continuous decreasing trend of total NMVOC emissions between 1990 and 2015. Before the year 2000, the decrease also occurred due to technological improvements in respective source categories. In recent years however, relative reductions declined, since effects from technological improvements are fading out. Emission reductions in 1A3 Transport are noticeable, however relative annual abatement declines in recent years. Also in source category 1A4, emissions declined in the same period.

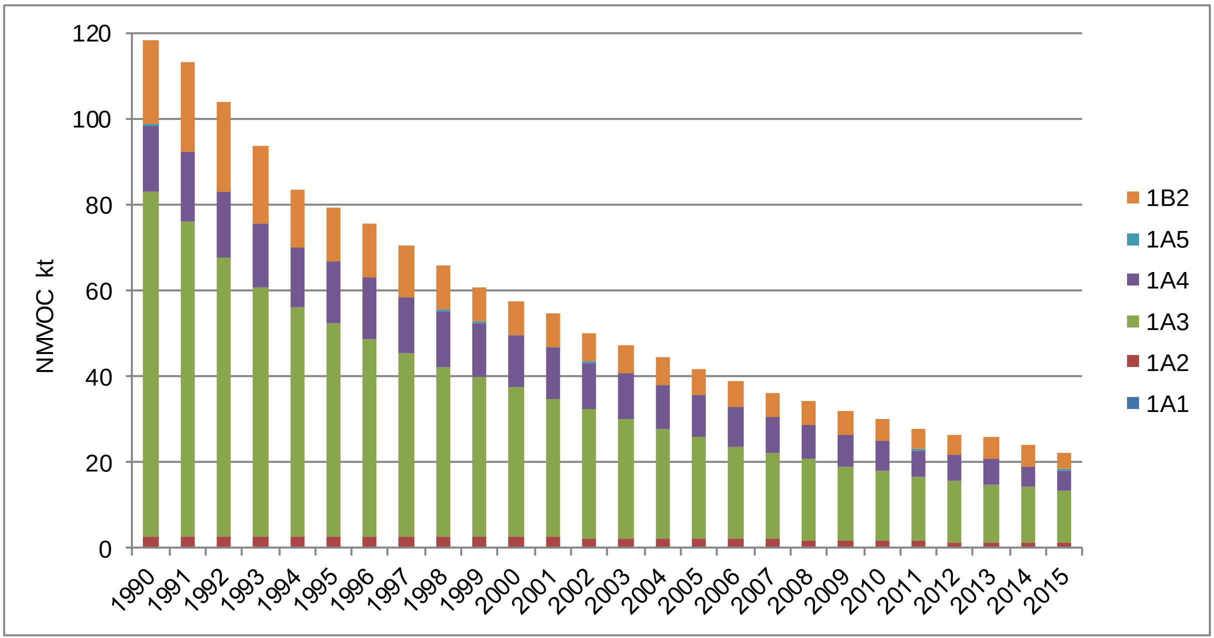

Figure 3-2: Switzerland's NMVOC emissions from the energy sector by source categories 1A1-1A5 and 1B2 between 1990 and 2015. The corresponding data table can be found in Annex 6.2.

3.1.3 Overview and trend for PM2.5

Figure 3-3 depicts the PM2.5 emissions in energy related sectors since 1990. The main contributor is source category 1A4 Other (1990–2015), followed by 1A3 Transport and 1A2 Manufacturing industries and construction. Within source category 1A4, mainly wood combustion in small and mid-sized wood furnaces contribute to PM2.5 emissions. Overall emissions declined since 1990. Most significant reductions between 1990 and 2015 in terms of absolute emissions occur in 1A4, 1A3 and 1A2. Reductions in 1A3 can be referred to the introduction of stringent EURO norms. The reductions in 1A4 are mainly attributable to technological improvements of engines and of wood furnaces in particular. Also the gradual introduction of diesel oil particle filters contributed to this trend. Slight increase of emissions in 1A1 Energy industries since 2004 is a result of augmented use of wood combustion.

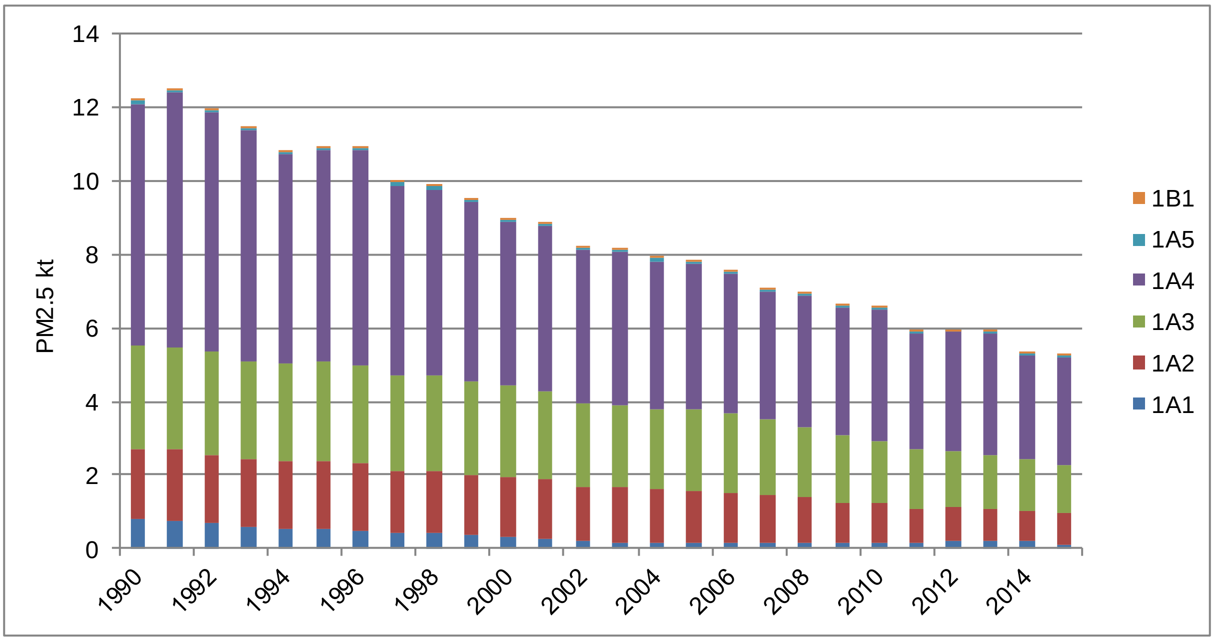

Figure 3-3: Switzerland's PM2.5 emissions from the energy sector by source categories 1A1-1A5 and 1B1 between 1990 and 2015. The corresponding data table can be found in Annex 6.2.

3.1.4 Overview and trend for NH_3

Figure 3-4 depicts the NH_3 emissions in energy related sectors since 1990. Note: The contribution of the energy sector is small in comparison to the national total. Therefore, the energy sector is not a key category for NH_3. For all years, the main contributor among categories of sector 1 Energy is 1A3 Transport. Emissions from the other source categories are comparably small and there are no emissions from source category 1B. Since 1990, total emissions underwent a twofold trend: Overall emissions increased continuously until 2000. This is mainly attributable to changes of sulphur contents in fuels used in road transportation: with low sulphur petrol in use, higher NH_3 emissions result (Mejía-Centeno 2007). This effect manifests mainly for car fleets with EURO standards 1, 2 and 3. For cars registered as EURO 2 this effect becomes particularly evident and causes the model to reveal a pronounced jump in emission levels between 1999 and 2000. Afterwards emissions decreased, because the car fleet changes again towards stricter EURO standards, where the sulphur content in fuels has less influence on the NH_3 emissions.

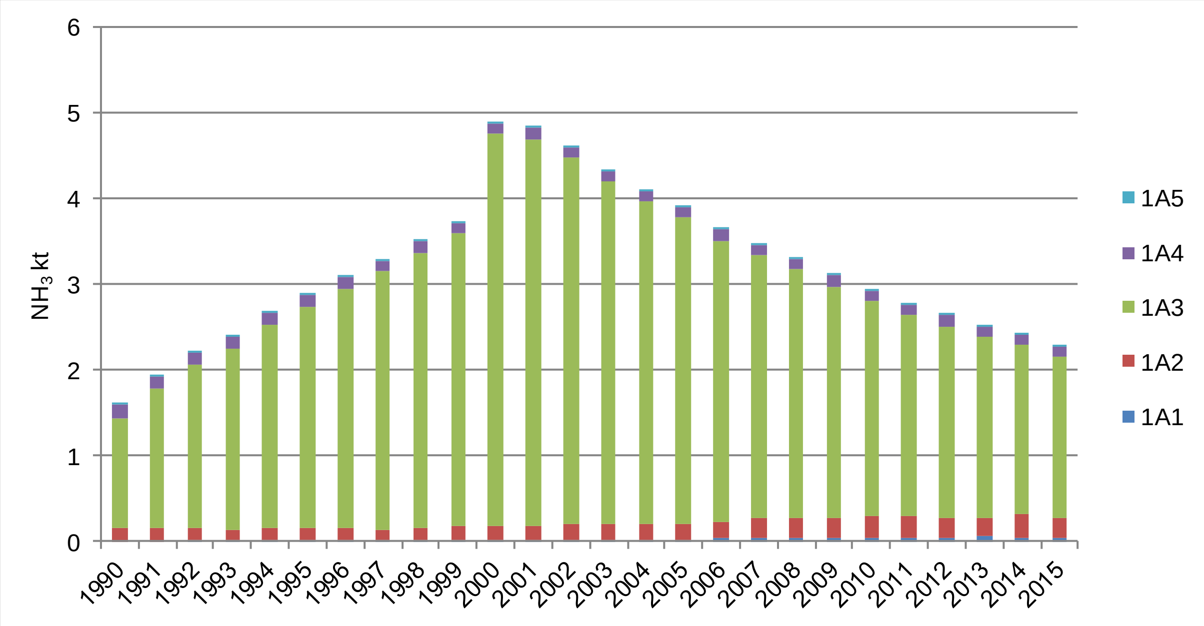

Figure 3-4: Switzerland's NH_3 emissions from the energy sector by source category 1A1-1A5 between 1990 and 2015. There are no emissions from 1B. The detailed corresponding data table can be found in Annex 6.2.

3.1.5 Overview and trend for SO_2

Figure 3-4 depicts the SO_2 emissions in energy related sectors since 1990. Overall, there is a decreasing trend since 1990. The strongest decrease can be observed between 1990 and 2000. The time series show also some fluctuations from year to year. These fluctuations are mainly due to annual variations in the number of heating degree days, which causes fluctations in the SO_2 emissions from fossil fuel based heating systems in sector 1A4 Other.

In 2015, the main contributions from the sector 1 Energy are SO_2 emissions from the source categories 1A1 Energy industries, 1A2 Manufacturing industries and construction and 1A4 Other. SO_2 emissions from the other source categories (1A3, 1A5 and 1B2) are comparably small. Since 1990, a strong decreasing trend can be observed, the strongest reduction happening for 1A4 due to decreasing consumption and substitution of liquid and solid by gaseous fuels. The latter also holds for 1A2 with the second strongest reduction. Also emissions of 1A1 are decreasing caused by substitution (e.g. no more consumption of residual fuel oil since 2011 and no more bituminous coal since 2000) and by closing of a refinery plant. 1A3 Transport is decreasing due to lower sulphur contents in transportation fuels (diesel oil and gasoline, see Table 3-8).

The SO_2 emissions from 1B2 are mainly due to Claus units in refineries. The decrease between 1990 and 1995 can be explained by retrofittings due to the enactment of the "Ordinance on Air Pollution Control" in 1985.

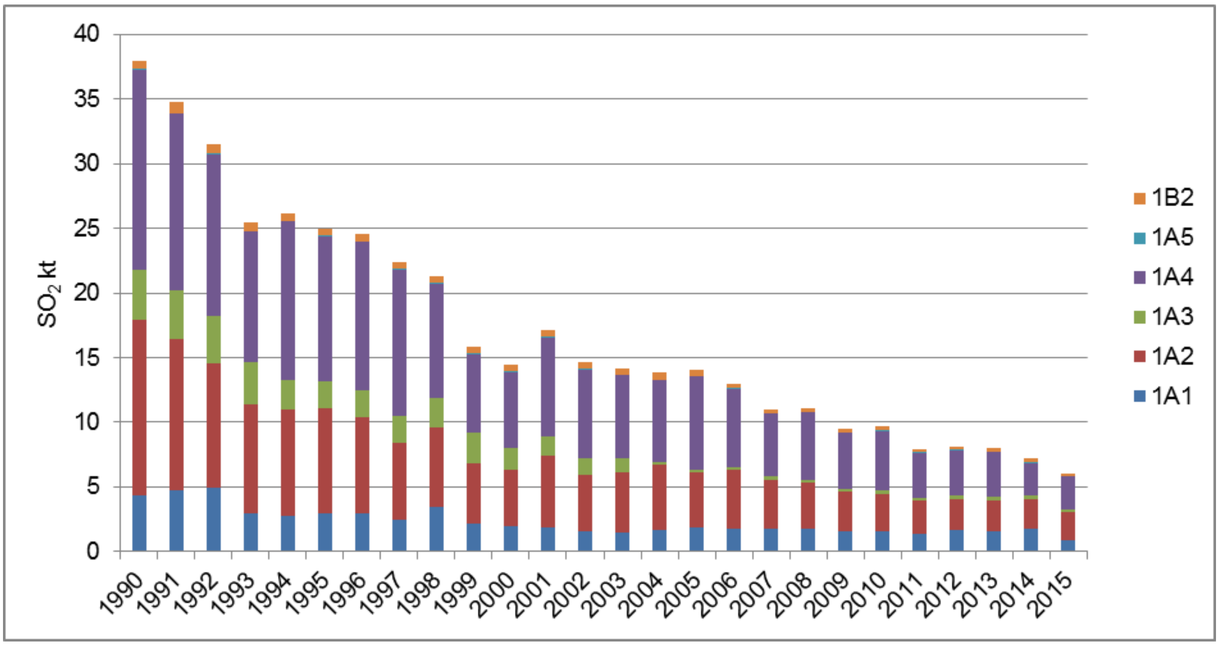

Figure 3-5: Switzerland's SO_2 emissions from the energy sector by source category 1A1-1A5 between 1990 and 2015. The detailed corresponding data table can be found in Annex 6.2.

3.1.6 General method and disaggregation of energy consumption

3.1.6.1 System boundaries: Differences between CLRTAP and UNFCCC reporting

Switzerland reports its greenhouse gas emissions according to the requirements of the UNFCCC as well as air pollutants according to the requirements of the CLRTAP. The nomenclature for both reportings is (almost) the same (NFR), but there are differences concerning the system boundaries. Under the UNFCCC, the national total for assessing compliance is based on fuel sold within the national territory, whereas under the CLRTAP, the national total for assessing compliance is based on fuel used within the territory. The only difference occurs for 1A3b Road transportation as can be seen from Figure 3-6, columns CLRTAP / NFR Template "national total" compared to "national total for compliance". The national total for compliance does not contain the amount of fuel sold in Switzerland but consumed abroad, which is called "fuel tourism", and which is accounted for in Switzerland's GHG inventory, but not in the reporting under the CLRTAP. The difference between the two approaches amounts to several percent, with considerable variation from year to year due to fluctuating fuel price differences between Switzerland and its neighbouring countries (since 2015 it almost vanishes, see chp. 3.2.6.2.2).

Also emissions from civil aviation are accounted for differently under the UNFCCC and the CLRTAP: Only emissions from domestic flights are accounted for in the GHG inventory, while emissions from international flights are reported as memo items. For the reporting under the CLRTAP, landing and takeoff (LTO) emissions of domestic and international flights are accounted for, while emissions of international and domestic cruise flights are reported under memo items only (see Figure 3-6).

Differences between reporting under CLRTAP and UNFCCC concerning the accounting to the national total			CLRTAP / NFR-Templates			UNFCCC / CRF-Tables	
			accounted to				
			National total	National total for compliance	Memo item	National total	Bunker 1 D
Road transportation 1 A 3 b	Fuel sold in 1 A 3 b	Fuel used 1 A 3 b i-vii	Yes	Yes	Yes	Yes	No
		Fuel tourism and statistical difference 1 A 3 b viii	Yes	No	No	Yes	No
Aviation 1 A 3 a	Civil/Domestic aviation	Landing and Take-Off (LTO)	Yes	Yes	No	Yes	No
		Cruise	No	No	Yes	Yes	No
	International aviation	Landing and Take-Off (LTO)	Yes	Yes	No	No	Yes
		Cruise	No	No	Yes	No	Yes

Figure 3-6: Accounting rules for emissions from 1A3a Civil aviation and 1A3b Road transportation for CLRTAP and UNFCCC.

3.1.6.2 Memo items

The following memo items are reported for Switzerland:

- 1A3ai(ii) International aviation cruise (civil) Emission modelling see chp. 3.2.6.2.1
- 1A3aii(ii) Domestic aviation cruise (civil) Emission modelling see chp. 3.2.6.2.1
- 1A3b Road Transportation (fuel used) Emission modelling see chp. 3.2.6.2.2
- 1A3di(i) International maritime navigation Emission modelling see chp. 3.2.6.2.4
- 11B Forest fires Emission modelling see chp. 7.3

3.1.6.3 Net calorific values (NCV)

Table 3-1 summarizes the net calorific values (NCV) which are used in order to convert from energy amounts in tonnes into energy quantities in gigajoules (GJ).

- For gasoline, jet kerosene, diesel oil and gas oil, NCV for 1998 and 2013 are based on measurements. Constant values are used for the period 1990 to 1998 and from 2013 onwards.
- For residual fuel oil measurements of NCV for 1998 are available.
- For liquefied petroleum gas, petroleum coke, other bituminous coal, lignite and wood, NCV are given by Swiss Federal Office for Energy (SFOE 2016, 2016b) partly based on measurements from the cement industry (Cemsuisse 2010a).
- For natural gas NCV is annually reported by the Swiss Gas and Water Industry Association (SGWA), see Table 3-2.

More detailed explanations including information about the origin of the NCV for individual energy sources are given below.

Table 3-1: Net calorific values of fuels (NCV) 1990-1998 and from 2013 onwards. For years between 1998 and 2013, the NCVs are linearly interpolated. Natural gas see Table 3-2. Data source SGWA stands for annually updated reports of the Swiss Gas and Water Industry Association, latest report stems from 2015.See text for further explanations for each fuel.

Net calorific values (NCV)		**1990-1998**	**2013-2015**
Fuel	**Data Sources**	**NCV [GJ/t]**	**NCV [GJ/t]**
Gasoline	EMPA (1999), SFOE/FOEN (2014)	42.5	42.6
Jet kerosene	EMPA (1999), SFOE/FOEN (2014)	43.0	43.2
Diesel oil	EMPA (1999), SFOE/FOEN (2014)	42.8	43.0
Gas oil	EMPA (1999), SFOE/FOEN (2014)	42.6	42.9
Residual fuel oil	EMPA (1999)	41.2	41.2
Liquefied petroleum gas	SFOE (2016)	46.0	46.0
Petroleum coke	SFOE (2016), Cemsuisse (2010a)	35.0	31.8
Other bituminous coal	SFOE (2016), Cemsuisse (2010a)	28.1	25.5
Lignite	SFOE (2016), Cemsuisse (2010a)	20.1	23.6
Natural gas	SGWA	*see table below*	
Biofuel	**Data Sources**	**NCV [GJ/t]**	**NCV [GJ/t]**
Biodiesel	assumed equal to diesel oil	42.8	43.0
Bioethanol	assumed equal to gasoline	42.5	42.6
Biogas	assumed equal to natural gas	*see table below*	
Wood	SFOE (2016b)	9.4-10.4	9.4-10.4

Gasoline, jet kerosene, diesel oil and gas oil

The net calorific values for gasoline, jet kerosene, diesel oil and gas oil are based on measurements of various fuel samples by the EMPA (Swiss Federal Laboratories for Materials Science and Technology) in 1998 (EMPA 1999). As no earlier data are available, the values for 1990-1998 are assumed constant at the 1998 levels. A more comprehensive study was commissioned by the Federal Office for the Environment (FOEN) and the Federal Office of Energy (SFOE) in 2013 (SFOE/FOEN 2014). This study was based on a representative sample covering summer and winter fuel qualities from the main import streams. The sampling started in July 2013 for a duration of six months. Samples were taken fortnightly from nine different sites (large-scale storage facilities and the two Swiss refineries) and analysed for their calorific value amongst other. These updated values are used from 2013 onwards, while the NCVs 1999 – 2012 are linearly interpolated between the values of 1998 and 2013.

Residual fuel oil

Residual fuel oil plays only a minor role in energy supply. Therefore, this fuel type was not analysed in the most recent measurement campaign in 2013. Thus, respective NCVs refer to the measurement campaign by EMPA (1999) in 1998. The NCV for residual fuel oil is assumed to be constant for the entire time series.

Liquefied petroleum gas

The net calorific value (NCV) attributed to liquefied petroleum gas is taken from the Swiss overall energy statistics (SFOE 2016) [3] and is therefore country-specific.

[3] It is assumed that LPG consists of 50% propane and 50% butane.

Petroleum coke, other bituminous coal, lignite

NCVs of petroleum coke, other bituminous coal and lignite are based on data from the SFOE and on measurements of samples taken from Switzerland's cement plants. Cement plants are the largest consumers of these fuels in Switzerland. The samples from the individual plants were compiled over nine months in 2009 and analysed for calorific value by an independent analytical laboratory. The original data is collected in an internal documentation provided by the Swiss Association of the Swiss Cement Industry – Cemsuisse (Cemsuisse 2010a). For each fuel type, the measurements from the individual plants were weighted according to the relative consumption of each plant. Between 1999 and 2010 the values are linearly interpolated (see SFOE 2016, p. 61).

Natural gas / biogas

The net calorific value of natural gas is calculated based on measurements of gas properties and corresponding import shares of individual gas import stations. Measurements of gas properties are available on an annual basis since 2009 and for selected years before (see Table 3-2). Import shares are available for 2003, 2006, 2009, and from 2011 onwards on an annual basis. Estimated import shares for the years 1991, 1995 and 2000 are taken from Quantis (2014). Missing values for the years in between are interpolated. The entire calculated time series is documented in FOEN (2016h).

Table 3-2: Net calorific values of natural gas and biogas for selected years. Years in-between are linearly interpolated. Data source: annual reports of the Swiss Gas and Water Industry Association SGWA. Spreadsheet to determine national averages: FOEN 2016h.

Year	NCV [GJ/t]
1990	46.5
1991	46.5
1995	47.5
2000	47.2
2005	46.6
2007	46.3
2009	46.4
2010	46.3
2011	46.1
2012	45.8
2013	45.7
2014	45.7
2015	46.6

Wood

The net calorific value of wood depends on the type of wood fuel (for e.g. log wood, wood chips, pellets) and are based on the Swiss wood energy statistics (SFOE 2016b). Table 3-1 illustrates the range of the NCV for all wood fuel types.

Biofuels

Regarding the small amount of biofuels used in Switzerland, the NCV values are assumed to be equal to the corresponding values of the fossil fuels substituted (i.e. biodiesel – diesel oil, bioethanol – gasoline, biogas – natural gas). For further details, see above in the paragraphs of the corresponding fossil fuel.

3.1.6.4 Swiss energy model and final Swiss energy consumption

3.1.6.4.1 Swiss overall energy statistics

The fundamental data on final energy consumption is provided by the Swiss overall energy statistics (SFOE 2016). However, since Switzerland and Liechtenstein form a customs and monetary union governed by a customs treaty, data regarding liquid fuels in the Swiss overall energy statistics also cover liquid fuel consumption in Liechtenstein. In order to calculate the correct Swiss fuel consumption, Liechtenstein's liquid fossil fuel consumption, given by Liechtenstein’s energy statistics (OS 2016), is subtracted from the figures provided by the Swiss overall energy statistics. In all years of the reporting period, the sum of liquid fossil fuels used in Liechtenstein was less than half a percent of the Swiss consumption.

The energy related activity data correspond to the energy balance provided in the Swiss overall energy statistics (SFOE 2016). The energy statistics are updated annually and contain all relevant information about primary and final energy consumption. This includes annual aggregated consumption data for various fuels and main consumers such as households, transport, energy industries, industry, and services (see energy balance in Annex 4).

The main data sources of the Swiss overall energy statistics are:

- The Swiss organisation for the compulsory stockpiling of oil products - Carbura and the Swiss petroleum association (EV) 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 the Swiss gas industry association (VSG).
- Annual import data for petroleum products and coal from the Swiss federal customs administration (FCA).
- Data provided by industry associations (GVS, SGWA, Cemsuisse, VSG, VSTB etc.).
- Swiss renewable energies statistics (SFOE).
- Swiss wood energy statistics (SFOE)
- Swiss statistics on combined heat and power generation (SFOE)

As can be seen in Figure 3-7, fossil fuels amount to slightly more than half of primary energy consumption. The main end-users of fossil fuels are the transport and the housing sector, as electricity generation is predominantly based on hydro- and nuclear power stations. The most recent energy balance is given in Annex A4.

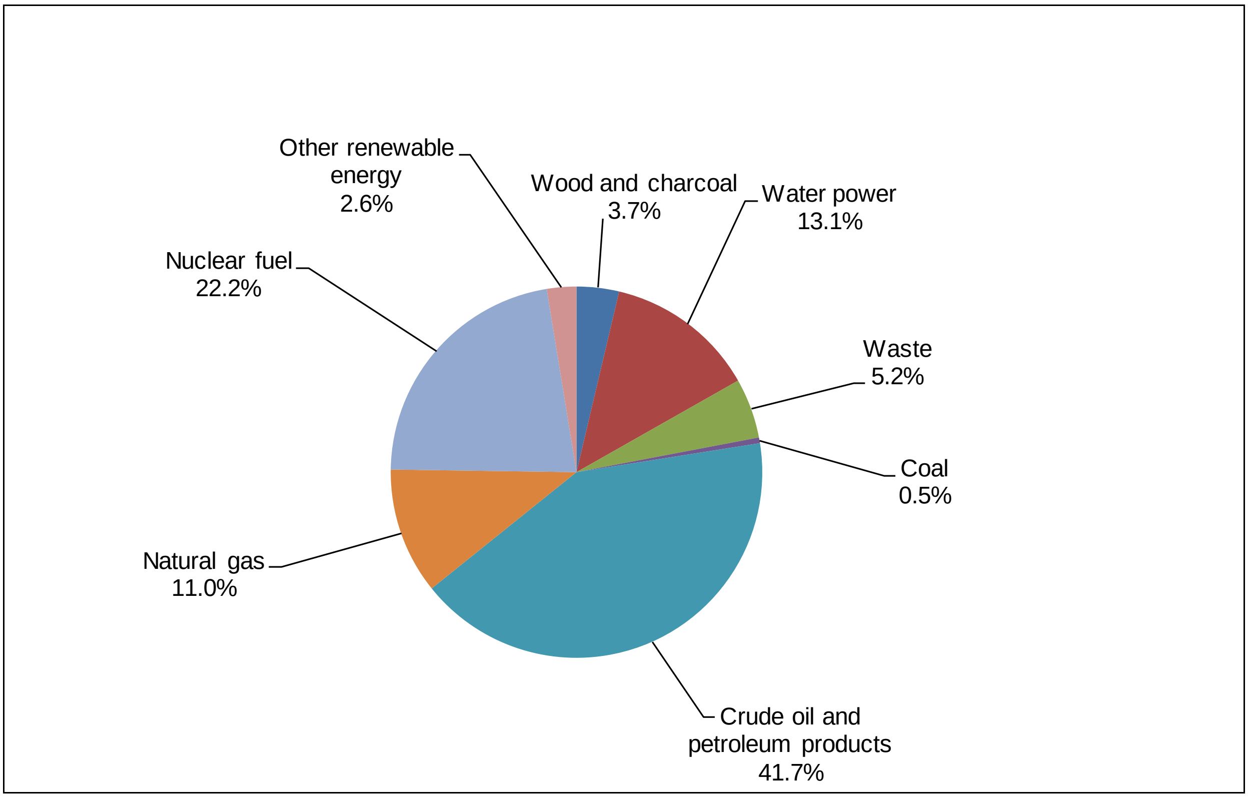

Figure 3-7: Switzerland's energy consumption in 2015 by fuel type (see corresponding data in SFOE 2016).

As can be seen from Table 3-3, liquid fossil fuel consumption changed only little since 1990. This is the combined effect of a marked increase of the consumption in the transport sector and a substantial decrease of gas oil use in the residential and industry sector. Natural gas consumption increased since 1990, compensating to some extent the decreasing use of gas oil.

Table 3-3: Switzerland’s energy consumption in 1990–2015 by fuel type. Only those fuels are shown that are implemented in the EMIS database (no water or nuclear power). The numbers are based on the fuels sold principle, thus they include consumption from fuel tourism, all fuels sold for domestic and international aviation as well as liquid fuels consumed in Liechtenstein.

Year	Gaso-line	Kero-sene	Diesel	Gas oil	Residual fuel oil	Refinery gas & LPG	Petro-leum coke	Solid fuels	Natural gas	Other fuels	Bio fuels	Total
	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ
1990	155'785	48'067	47'557	218'510	23'342	8'890	1'400	14'901	68'599	19'160	46'684	652'895
1991	162'225	46'562	48'154	238'602	23'590	12'437	980	12'662	76'902	18'596	48'662	689'372
1992	168'100	49'099	46'706	236'809	24'170	11'492	315	8'758	80'808	19'009	47'562	692'828
1993	155'897	50'776	44'978	225'920	17'165	12'388	1'120	7'342	84'758	19'158	47'837	667'338
1994	156'087	52'109	47'748	207'141	17'860	13'455	1'470	7'432	83'587	19'154	45'785	651'828
1995	151'290	54'947	48'604	217'523	17'278	12'756	1'260	7'962	92'123	19'687	47'772	671'204
1996	155'209	56'753	45'597	226'289	15'097	13'939	1'015	5'956	99'710	20'584	51'240	691'388
1997	161'171	58'774	47'385	212'223	12'581	14'236	280	4'590	96'260	21'655	48'162	677'317
1998	162'477	61'268	49'209	222'407	15'882	15'259	455	3'810	99'065	23'803	49'717	703'352
1999	168'025	65'224	52'184	212'349	11'058	15'805	521	3'875	102'588	24'403	50'421	706'454
2000	168'165	68'019	55'677	196'137	7'923	13'649	551	5'970	101'970	26'536	50'087	694'684
2001	163'543	64'150	56'709	213'089	9'942	14'069	410	6'073	106'132	27'068	53'410	714'596
2002	160'375	59'335	58'721	196'655	6'446	15'584	679	5'325	104'170	27'877	53'010	688'178
2003	159'636	53'358	62'251	208'040	7'061	13'642	202	5'713	110'116	27'643	55'456	703'118
2004	156'812	50'350	66'893	203'370	7'561	16'429	1'819	5'420	113'615	28'845	56'345	707'460
2005	152'062	50'994	73'065	205'729	5'805	16'432	2'906	6'040	116'646	29'236	58'416	717'331
2006	147'436	53'443	79'063	195'926	6'419	18'578	3'324	6'517	113'412	31'233	61'381	716'732
2007	146'012	57'010	84'885	171'313	5'179	15'587	2'830	7'296	110'395	30'015	60'335	690'859
2008	142'801	60'967	93'143	178'833	4'606	16'288	3'516	6'562	117'589	30'854	63'979	719'138
2009	138'968	58'471	94'569	173'219	3'575	16'301	3'254	6'193	112'807	29'811	64'005	701'172
2010	134'043	61'397	98'247	182'305	3'027	15'463	3'498	6'208	126'013	31'185	68'519	729'905
2011	128'856	65'438	100'876	143'760	2'292	14'856	2'957	5'842	111'774	30'882	64'875	672'409
2012	124'301	67'021	106'996	154'448	2'780	12'247	3'148	5'269	122'521	31'145	70'773	700'651
2013	118'634	68'068	111'824	162'532	1'959	15'053	2'735	5'667	129'027	30'925	74'346	720'769
2014	113'875	68'541	114'688	122'704	1'701	14'473	3'148	5'904	111'770	31'320	70'021	658'145
2015	105'592	70'788	113'161	129'159	892	9'822	1'145	5'406	119'420	32'084	73'706	661'174

3.1.6.4.2 Energy model – Conceptual overview

For the elaboration of the greenhouse gas and air pollutants inventories, information about energy consumption is needed at a much more detailed level than provided by the Swiss overall energy statistics (SFOE 2016). Activity data in sector 1 Energy are therefore calculated and disaggregated by the Swiss energy model, which is an integral part of the emission database EMIS. The model is developed and updated annually by the Swiss Federal Office for the Environment (FOEN). It relies on the Swiss overall energy statistics and is complemented with further data sources, e.g. Liechtenstein’s liquid fuel sales (OS 2016), the Swiss renewable energy statistics (SFOE 2016a), the energy consumption statistics in the industry and services sectors (SFOE 2016d) as well as additional information from the industry and the Swiss wood energy statistics (SFOE 2016b).

The Swiss overall energy statistics are not only the main data input into the energy model, but also serve as calibration and quality control instrument: The total energy consumption given by the Swiss overall energy statistics has to be equal to the sum of the disaggregated activity data of all source categories within the energy sector (including memo items/bunker). Differences are explicitly taken into account as “statistical differences” (see chp. 3.2.6.2.2 Road transportation).

As shown in Figure 3-8 the energy model consists of several sub-models, such as the industry model, the civil aviation model, the road transportation model, the non-road transportation model, and the energy model for wood combustion. A brief overview of each of these models is given below. However, depending on the scope of these sub-models, they are either described in the corresponding source category chapter or in an overarching chapter preceding the detailed description of the individual source-categories. In chapter 3.1.6.4.3, the resulting sectoral disaggregation is shown separately for each fuel type.

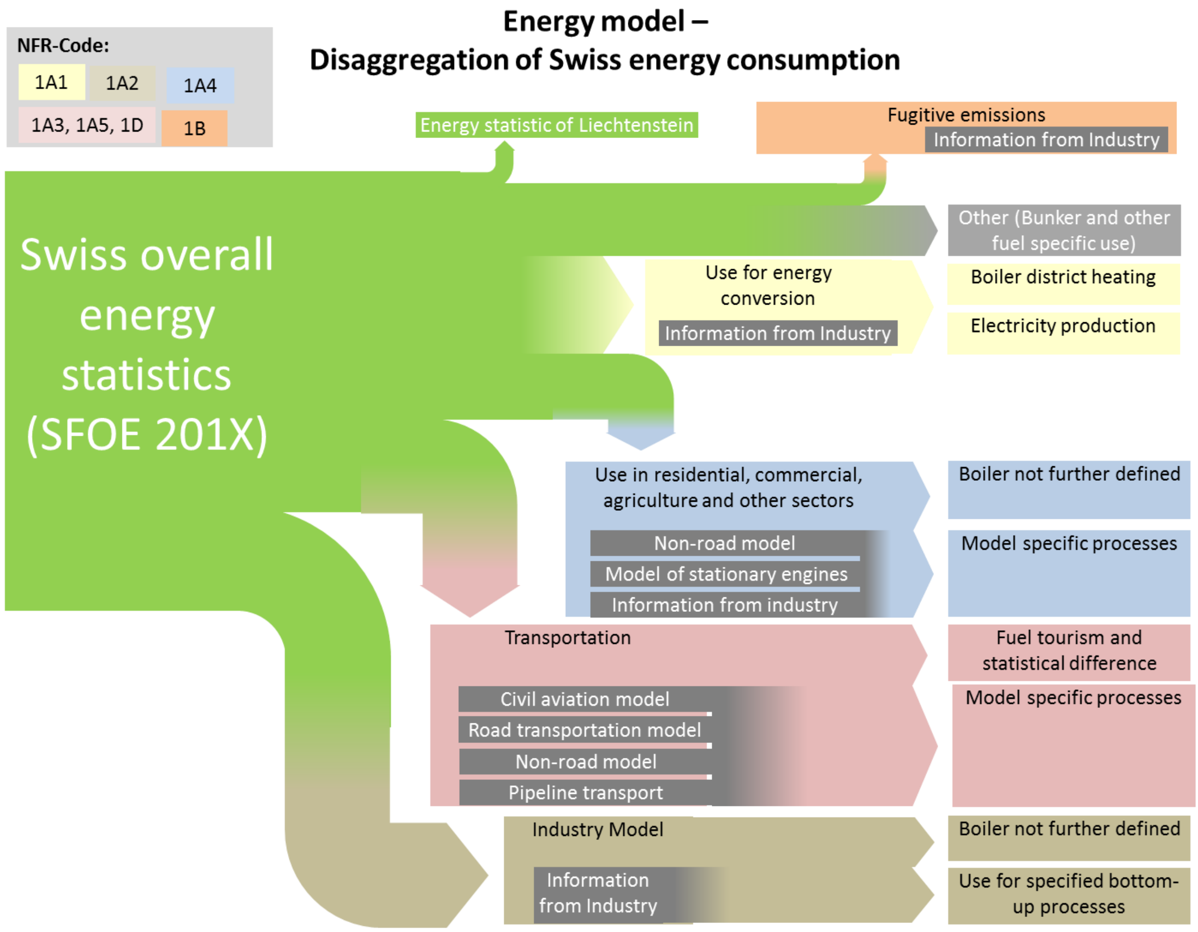

Figure 3-8 Overview of Switzerland's energy model. In the abbreviation SFOE 201X the "X" refers to the latest edition of the Swiss overall energy statistics.

Industry model (Details are given in chp.3.2.3.2)

In order to produce consistent time-series, the industry model is a composite of the energy consumption statistics in the industry and services sectors (SFOE 2016d), which is based on a comprehensive annual survey, and a bottom-up industry model (Prognos 2013), which is periodically calibrated to the Swiss overall energy statistics. The resulting industry model provides a split of energy consumption by source category and fuel type. Further disaggregation is then achieved by using plant-level industry data for specific processes, as far as available.

Civil aviation model (Details are given in chp. 3.2.6.2.1)

The civil aviation model is developed and updated by the Federal Office for Civil Aviation FOCA. It aggregates single aircraft movements according to detailed movement statistics of the Swiss airports. Differentiation of domestic and international aviation is based on the information on departure and destination of each flight in the movement database.

Road transportation model (Details are given in chp 3.2.6.2.2)

The road transportation model is a territorial model, accounting for traffic on Swiss territory only. The model is based on detailed vehicle stock data (from the vehicle registration database of the Federal Roads Office FEDRO), mileage per vehicle category differentiated into different driving patterns and specific consumption and emission factors. The difference between fuel sales and the territorial model (road and non-road models combined) is reported under fuel tourism and statistical difference.

Non-road transportation model (Details are given in chp 3.2.1.1.1)

The non-road transportation model covers all remaining mobile sources, i.e. industrial vehicles, construction machinery, agricultural and forestry machinery, gardening machinery as well as railways, navigation and military vehicles (except for military aviation, which is considered separately, see chp. 3.2.8). The model combines vehicle numbers, their operation hours, engine power, and load factors to derive specific fuel consumption, emission factors and resulting emissions. Data stem from surveys among producers, various user associations, and the national database of non-road vehicles run by FEDRO.

Energy model for wood combustion (Details are given in chp 3.2.1.1.2)

Based on the Swiss wood energy statistics (SFOE 2016b), total wood consumption is disaggregated into source categories (public electricity and heat production, industry, commercial/institutional, residential, agriculture/forestry/fisheries) and into 24 different combustion installations (ranging from open fireplaces to large-scale automatic boiler or heat and power plants). Where available, industry data on wood combustion is taken into account to allocate parts of the wood consumption as given by the Swiss wood energy statistics to a specific source category.

3.1.6.4.3 Disaggregation of the energy consumption by source category and fuel types

The energy model as outlined above disaggregates total energy consumption as provided by the Swiss overall energy statistics (SFOE 2016) into the relevant source categories 1A1-1A5 (Figure 3-9). For each fuel type, the disaggregation process of the energy model as shown schematically in Figure 3-8, the interaction between the different sub-models and additional data sources are visualized separately in Figure 3-10 to Figure 3-18.

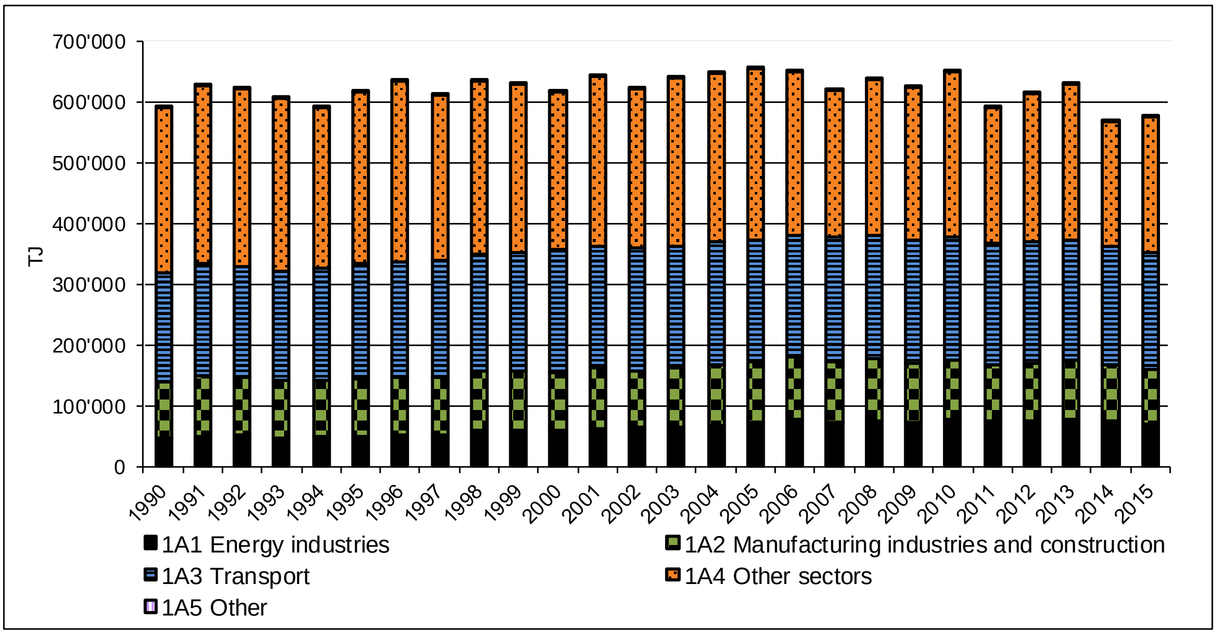

Figure 3-9 Switzerland's energy consumption 1990–2015 by source categories 1A1-1A5 based on the Swiss energy model. Note that in the same period population increased by almost 20%, industrial production by almost 70% and the motor vehicle fleet by 50% (SFOE 2016, table 43b)

Starting from the total energy consumption from the Swiss overall energy statistics, for each fuel type, the energy is assigned to the relevant source categories based on the various sub-models of the energy model, mentioned above in chp. 3.1.6.4.2. In addition, the following assignments are considered as well.

Within source categories 1A4ai and 1A4bi, the amount of used gas oil and natural gas for co-generation in turbines and engines is derived from a model of stationary engines developed by Eicher + Pauli (Kaufmann 2015) for the statistics on combined heat and power generation (SFOE 2016c). The residual energy is then assigned to boilers which are not further specified.

For source category 1A4ci Other sectors – Agriculture/forestry/fishing, specific bottom-up industry information is available for grass drying. Its fuel consumption is determined by the Swiss association of grass drying plants (VSTB) and is subtracted from the total fuel consumption of 1A2.

In order to report all energy consumption, the statistical differences as reported in the Swiss overall energy statistics are allocated to source category 1A4a Other sectors – Commercial/institutional (stationary combustion) and 1A3b viii Fuel tourism and statistical differences.

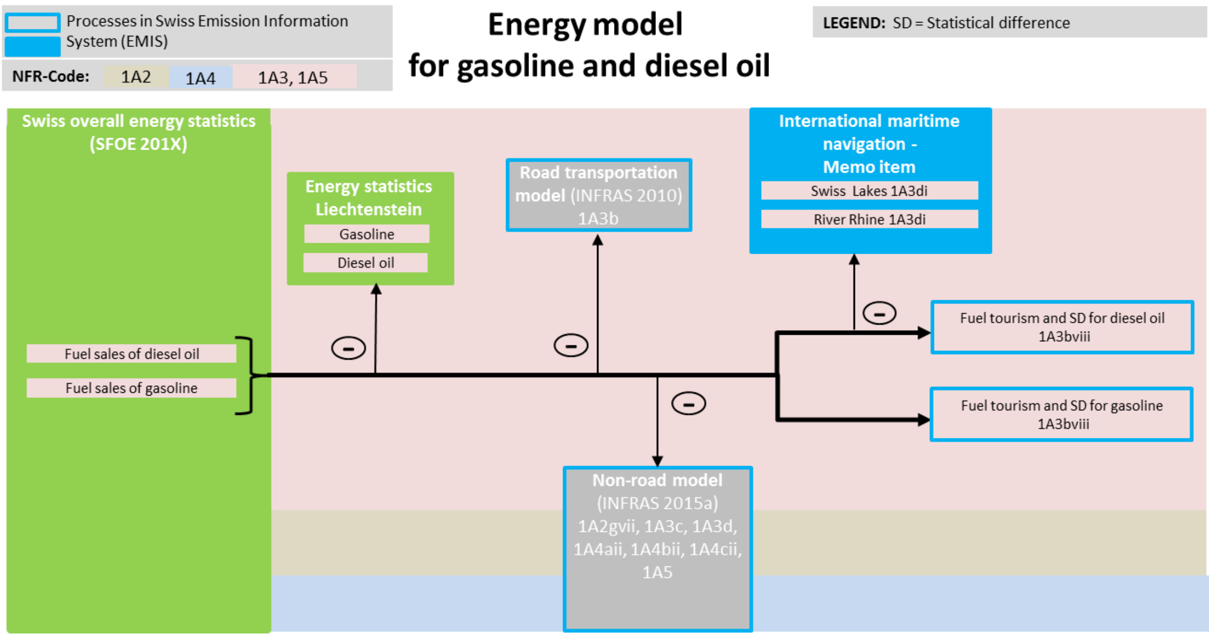

Figure 3-10 Schematic disaggregation of 1A Fuel consumption for gasoline and diesel oil. Marine bunker fuel consumption is based on the national customs statistics (see chapter 3.1.6.2 on memo items)

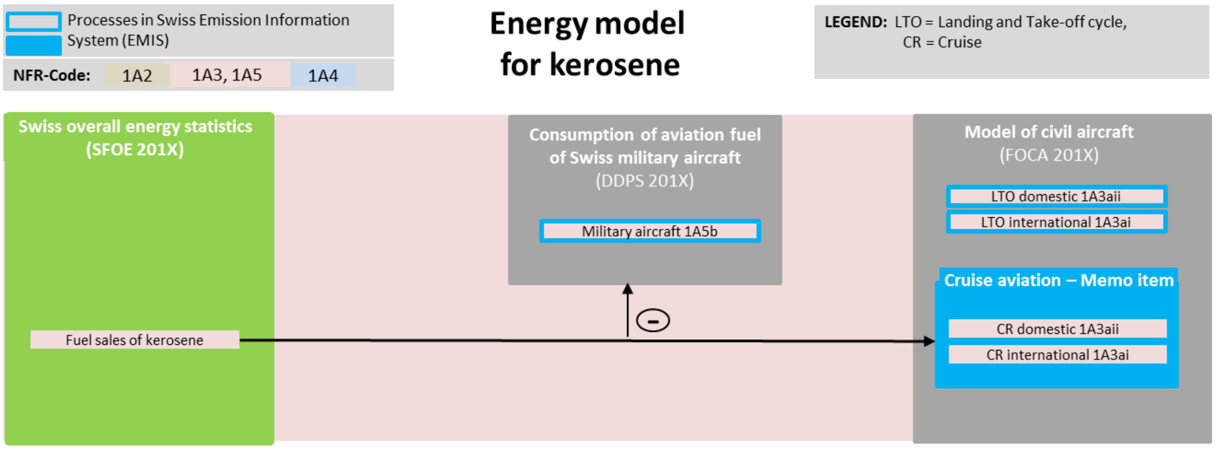

Figure 3-11 Schematic disaggregation of 1A Fuel consumption for kerosene. Fuel consumption for military aircraft is provided by the Federal Department of Defence, Civil Protection and Sport (DDPS). The differentiation between domestic and international aviation as well as between CR and LTO is provided by the civil aviation model (see chp. 3.2.6.2.1)

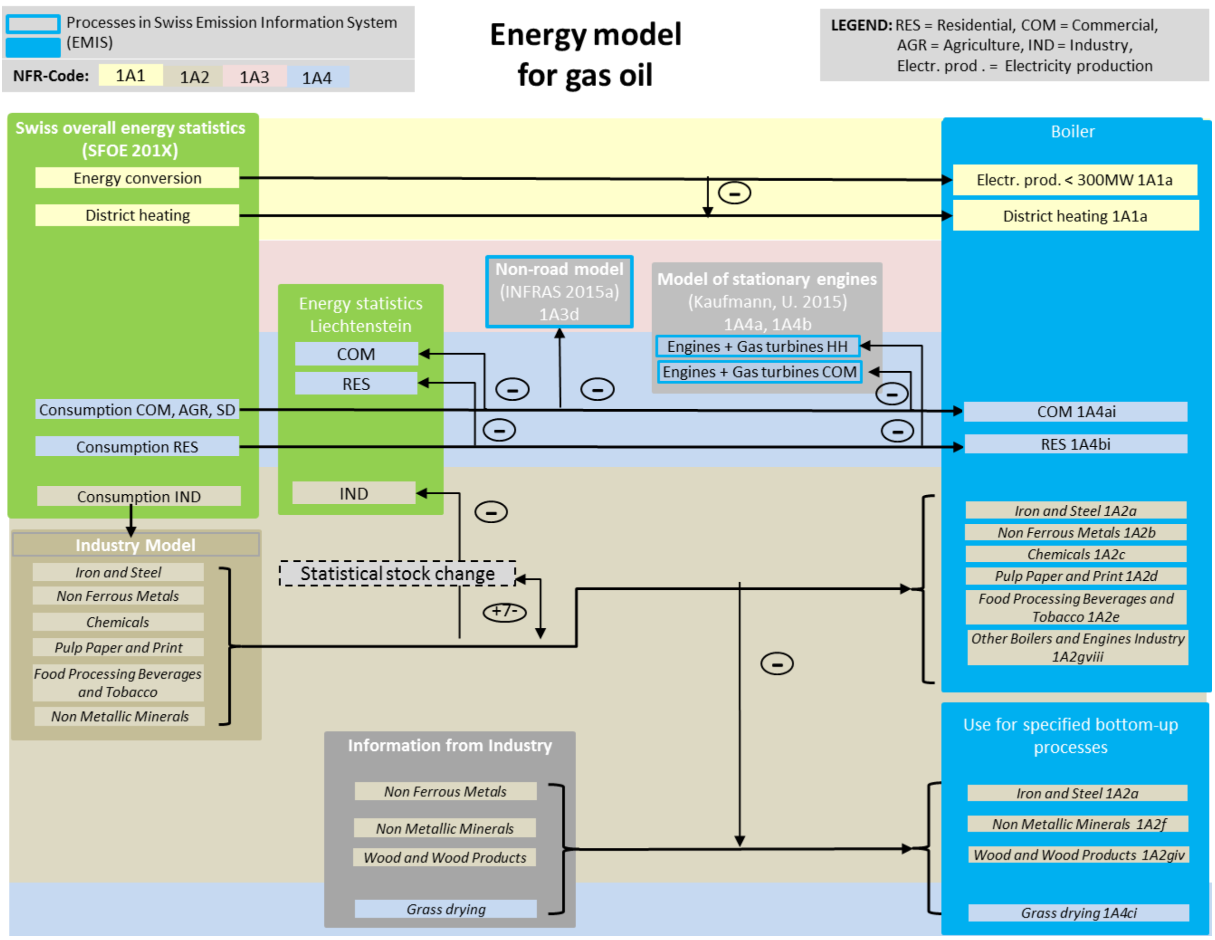

Figure 3-12 Schematic disaggregation of 1A Fuel consumption for gas oil. The Swiss overall energy statistics provide gas oil use for energy conversion and the amount thereof being used for district heating. Based on this information, gas oil use is split into 1A1a i Electricity generation and 1A1a iii Heat plants. According to the non-road model, a small amount of gas oil is consumed in source category 1A3d navigation (steam-powered vessels).

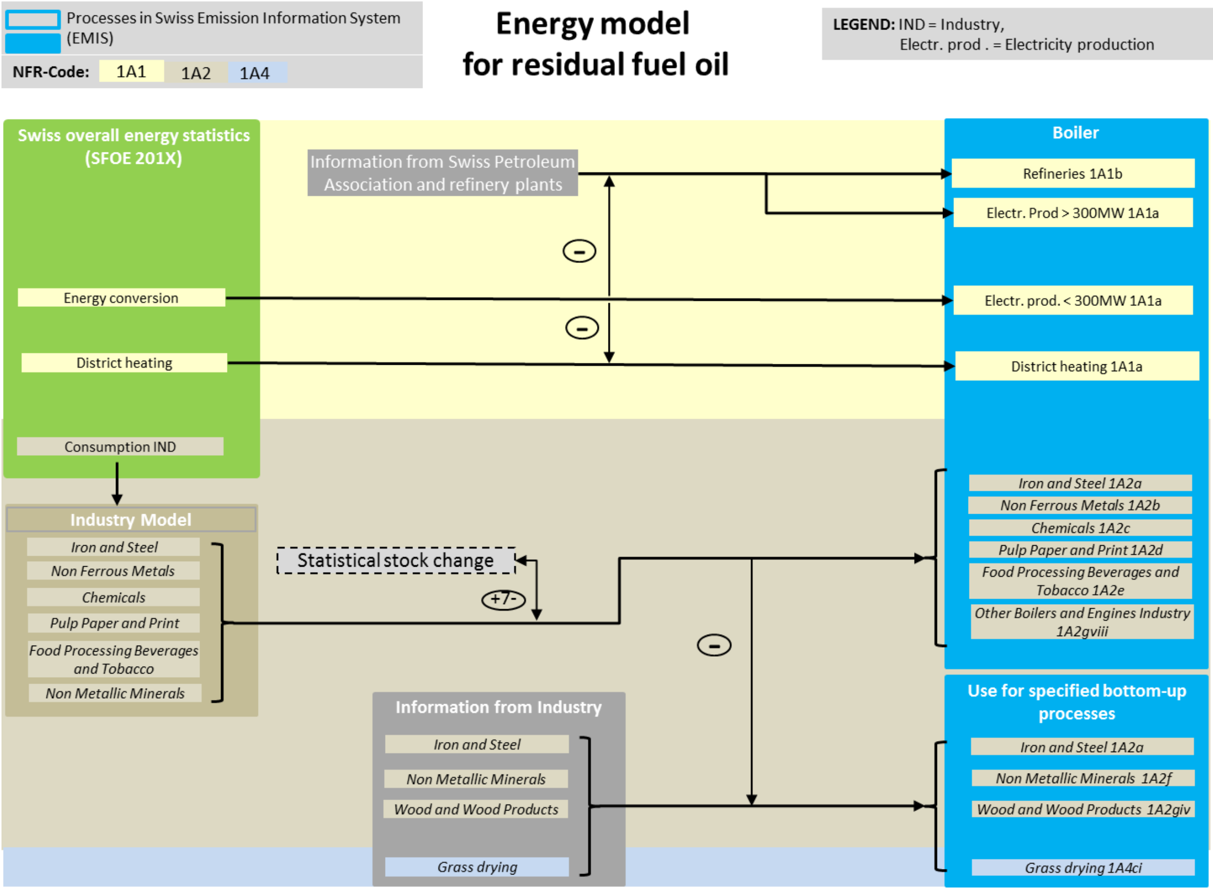

Figure 3-13 Schematic disaggregation of 1A Fuel consumption for residual fuel oil. The Swiss overall energy statistics report residual fuel oil use in energy conversion and the amount thereof consumed in electricity production (one single fossil fuel power station, operational from 1985 to 1994), district heating, and in petroleum refineries. Based on this information, residual fuel oil use in Energy industries is split into 1A1a i Electricity generation, 1A1a iii Heat plants and 1A1b Petroleum refining.

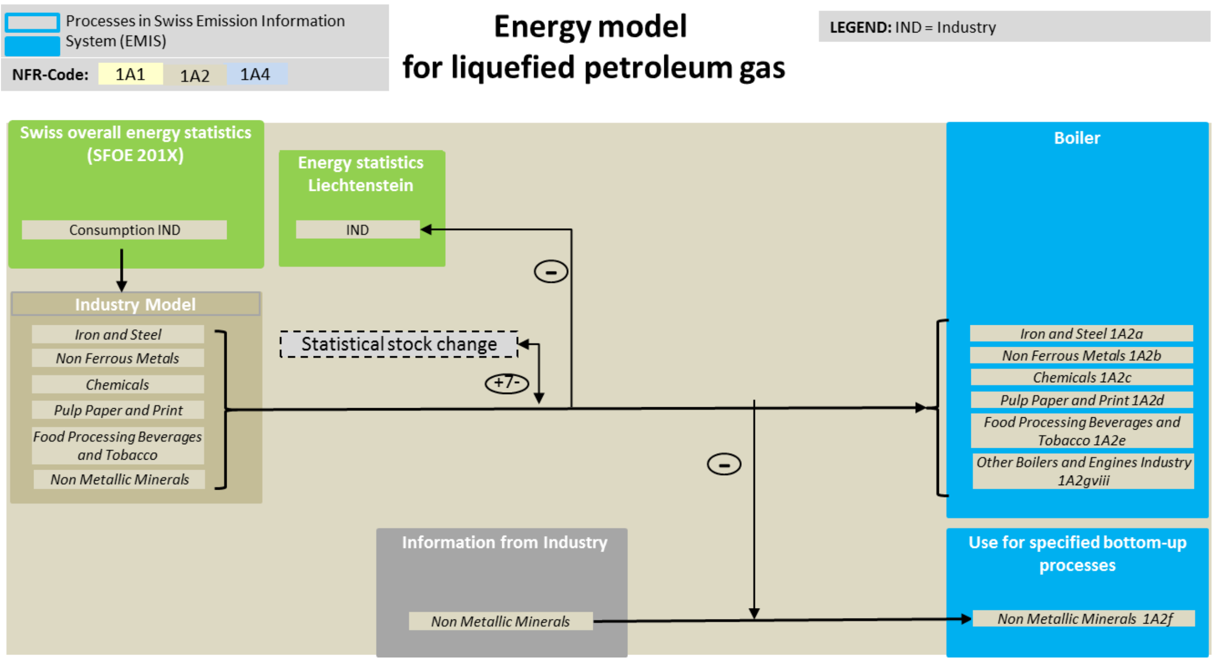

Figure 3-14 Schematic disaggregation of 1A Fuel consumption for liquefied petroleum gas.

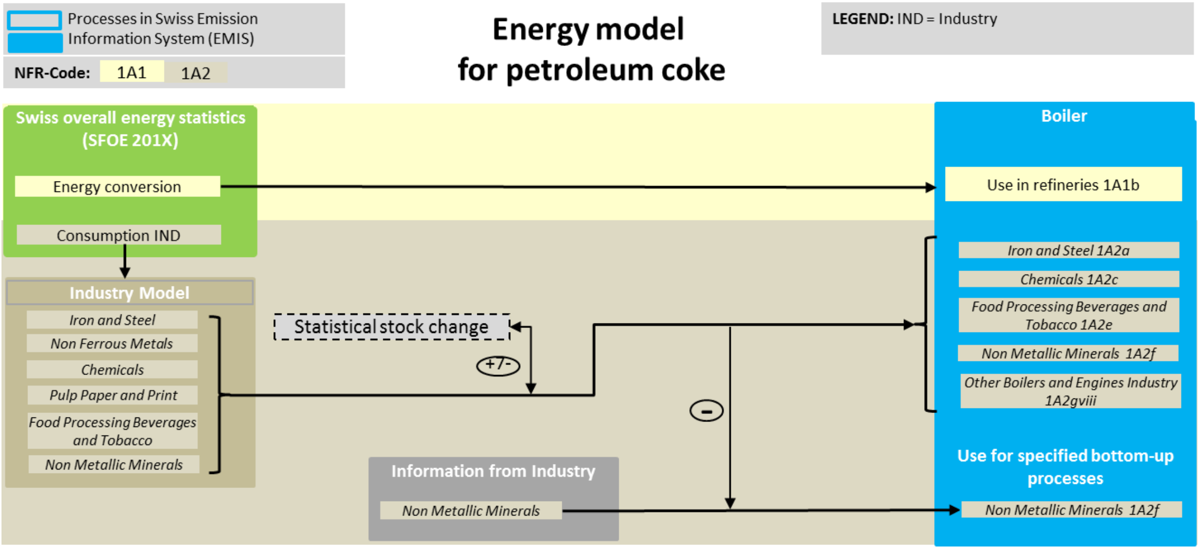

Figure 3-15 Schematic disaggregation of 1A Fuel consumption for petroleum coke.

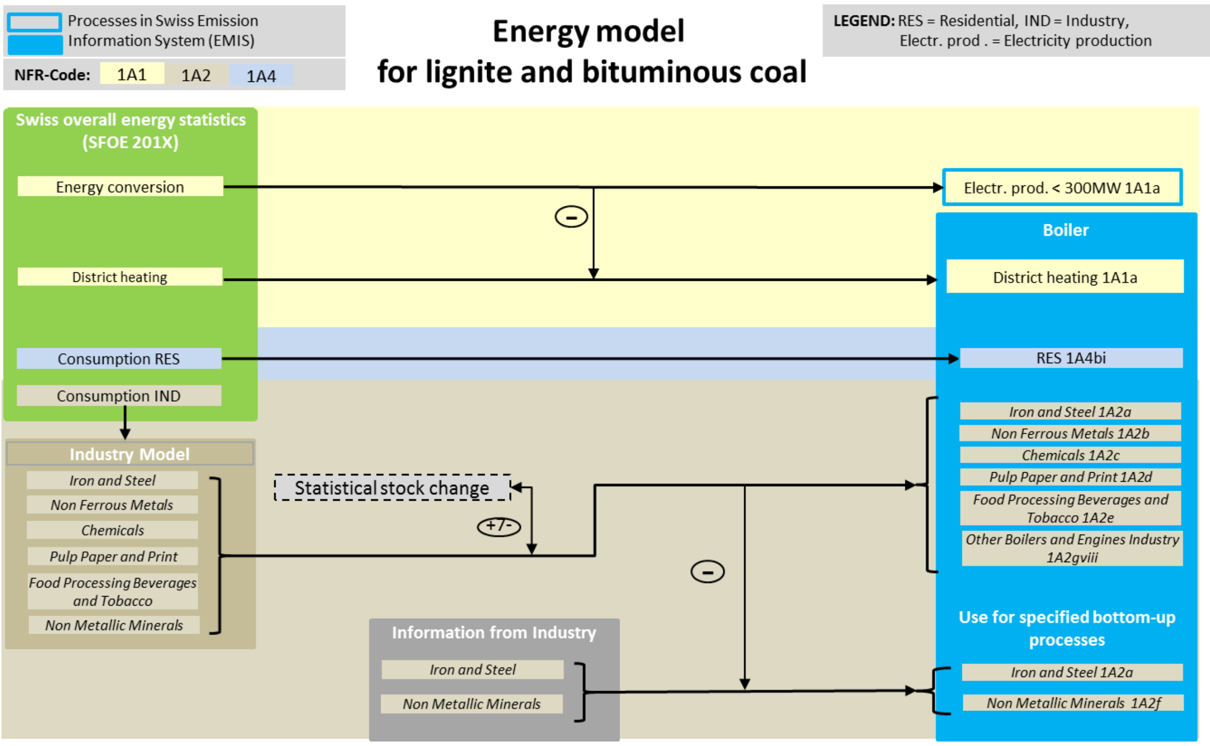

Figure 3-16 Schematic disaggregation of 1A Fuel consumption for lignite and bituminous coal. The Swiss overall energy statistics provide bituminous coal use for energy conversion and the amount thereof being used for district heating. Based on this information, use of bituminous coal in energy industries is split into 1A1a i Electricity generation and 1A1a iii Heat plants up to 1995. Coal consumption for Public electricity and heat production ceased thereafter.

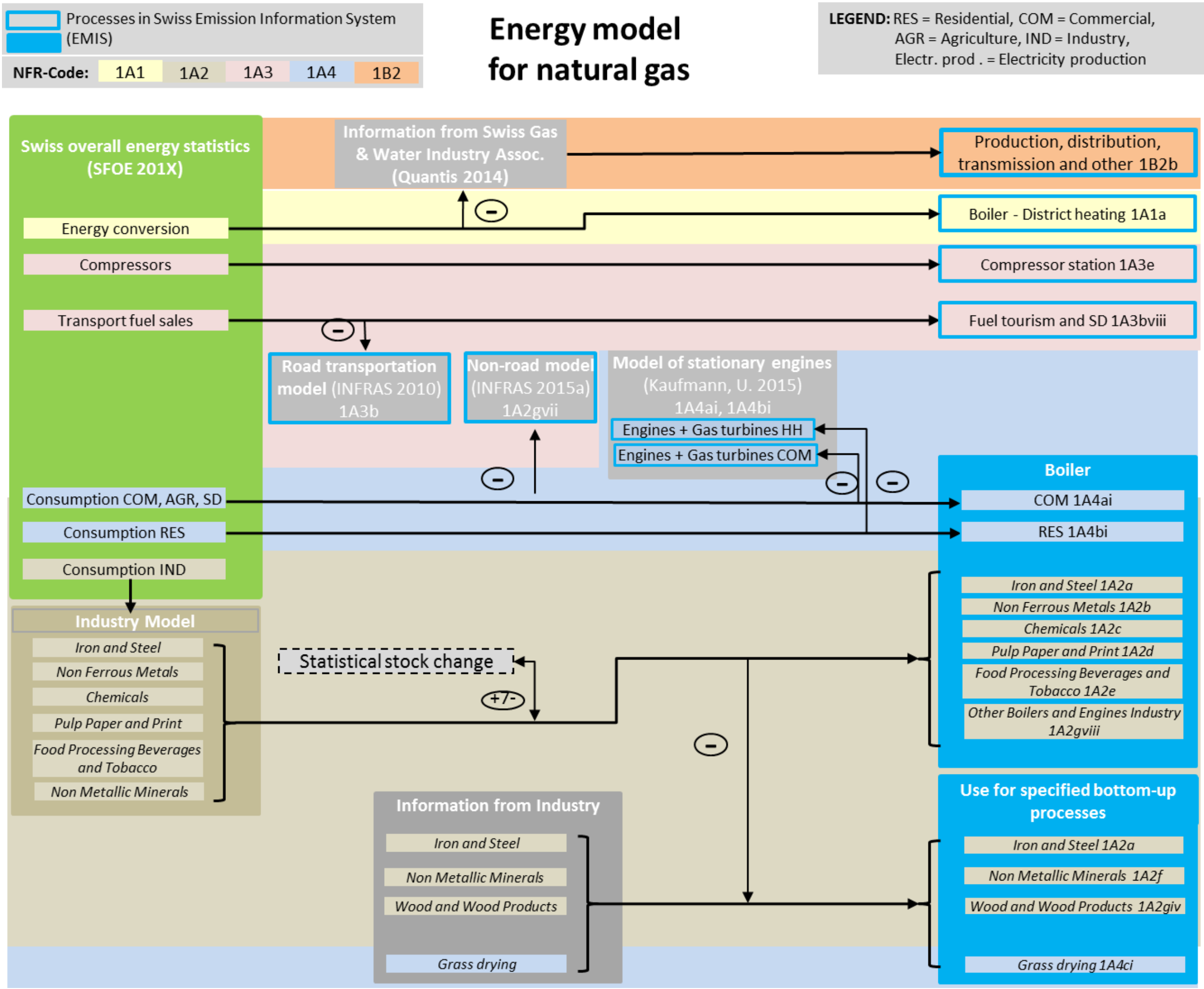

Figure 3-17 Schematic disaggregation of 1A Fuel consumption for natural gas. The Swiss overall energy statistics (SFOE 2016) provide gas use in the transformation sector (energy conversion and distribution losses). Distribution losses as estimated by the Swiss Gas and Water Industry Association SGWA are subtracted and reported under source category 1B2 Fugitive emissions from fuels. The remaining fuel consumption for natural gas is reported under 1A1a Public electricity and heat production.

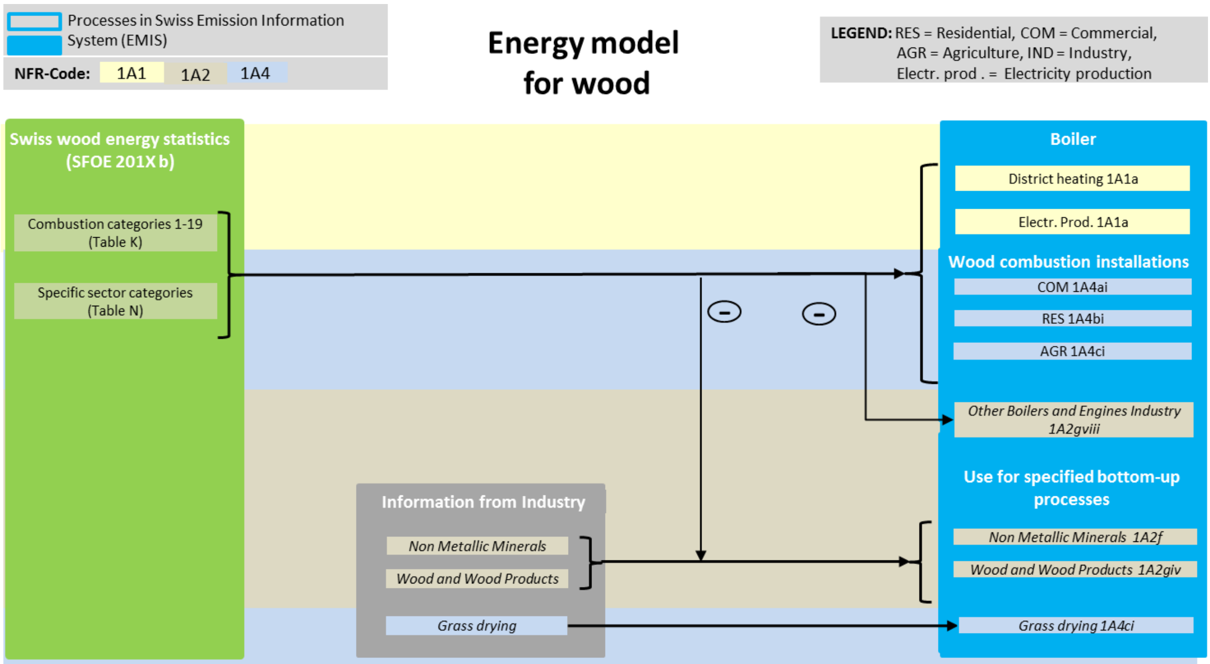

Figure 3-18 Schematic disaggregation of 1A Fuel consumption for wood. For a detailed description of the Energy model for wood combustion, see chapter 3.2.1.1.2.

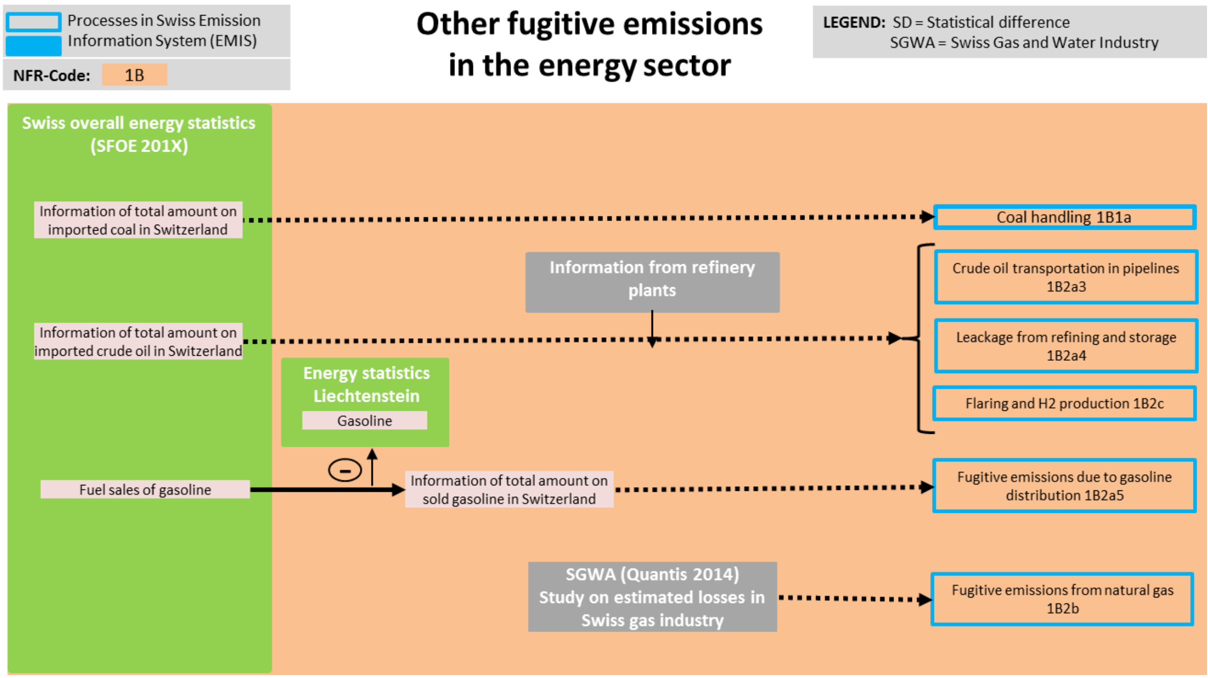

Figure 3-19 Schematic disaggregation of 1B Other fugitive emissions in the energy sector. For detailed description see chp. 3.3.

3.2 Source category 1A - Fuel combustion activities

3.2.1 Country-specific issues of 1A Fuel combustion

In the following chapter, the general country-specific approach of determining activity data and emission factors is presented. Specific information about each source category is included in the respective chapters 3.2.2 to 3.2.8.

3.2.1.1 Models overlapping more than one source category

3.2.1.1.1 Non-road transportation model (excl. aviation)

Choice of method

For all source categories, for which the non-road transportation model is applied (Table 3-4), the air pollutant emissions are calculated by a Tier 3 method based on the corresponding decision trees given in EMEP/EEA Guidebook 2013 (EMEP/EEA 2013). The detailed references to the related chapters of the Guidebook are shown in the chps. 3.2.5.2, 3.2.6.2, 3.2.7.2, and 3.2.8.2.

Methodology

The emissions of the non-road sector underwent an extensive revision in 2014/2015. Results are documented in FOEN (2015j). The following non-road categories are considered, all of them including several fuels, technologies, and emission standards.

Table 3-4 Non-road categories (FOEN 2015j) and the corresponding NFR nomenclature (reporting tables).

Non-road categories (by Corinair)	Nomenclature NFR
Construction machinery	1A2gvii Mobile Combustion in manufacturing industries and construction
Industrial machinery	1A2gvii Mobile Combustion in manufacturing industries and construction
Railway machinery	1A3c Railways
Navigation machinery	1A3dii National navigation (shipping)
Garden-care/professional appliances	1A4aii Commercial/institutional: Mobile
Garden-care/hobby appliances	1A4bii Residential: Household and gardening (mobile)
Agricultural machinery	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery
Forestry machinery	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery
Military machinery (excl. aviation)	1A5b Other, Mobile (including military, land based)

Within each non-road category the non-road database (INFRAS 2015a) uses the following classification structure:

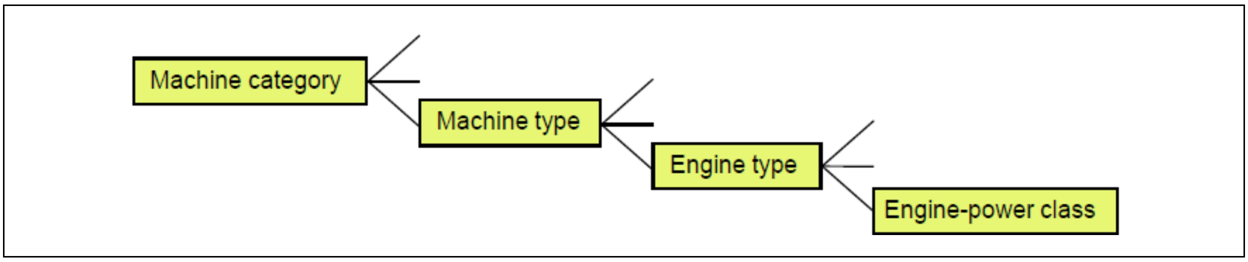

Figure 3-20 Each non-road vehicle is classified by its engine-power class, engine type, machine type and machine category.

The emission modelling is based on activity data and emission factors by means of the following equation, which holds on the most disaggregated level of engine power class (Figure 3-20):

$$Em = N \cdot H \cdot P \cdot \lambda \cdot \varepsilon \cdot CF_1 \cdot CF_2 \cdot CF_3$$

with

Em	=	emission by engine type, pollutant/GHG (in g/a)
N	=	number of vehicles (--)
H	=	number of operation hours per year (h/a)
P	=	engine power output (kW)
λ	=	effective load factor (--)
ε	=	emission factor (g/kWh), fuel consumption factor (g/kWh)
CF_1	=	correction factor for the effective load (--)
CF_2	=	correction factor for dynamical engine use (--)
CF_3	=	degradation factor due to aging (--)

The same equation also holds for the calculation of the fuel consumption, where ε is the consumption instead of emission factor (in g/kWh) and *Em* the consumption (in g/a). A more detailed description of the analytical details is given in the Annex of FOEN (2015j).

The total emission and consumption per non-road family is calculated by summing over all classes of the categories families.

The method holds for CO, VOC, NO_x and exhaust particulate matter (PM). For the calculation of emissions of non-regulated air pollutants, the following approaches are applied:

- NMVOC is calculated as a share of VOC dependent on fuel and engine type.
- Further pollutants follow the methodology documented in IFEU (2010) and references therein

Note that the emissions are only calculated in steps of 5 years 1980, 1985…2050. Emissions for years in-between are interpolated linearly.

Emission factors

Emission factors are taken from various sources based on measurements, modelling and literature. SO_2 is country-specific, see Table 3-8. For other air pollutants, the main data sources are EPA (2010), IFEU (2010), EMEP/EEA (2013) and Integer (2013).

For a detailed description of emission factors and their origin, see tables in the annex of FOEN (2015j). Note that all emission factors of NO_x, NMVOC, PM2.5 (exhaust), and CO can be downloaded by query from the public part of the non-road database INFRAS (2015a)[4], which is the data pool of FOEN (2015j). They can be queried by vehicle type, fuel type, power class and emission standard either at aggregated or disaggregated levels. In Annex A2.1.1 an excerpt of a query is shown to illustrate the results that can be downloaded from the database.

[4] https://www.bafu.admin.ch/bafu/en/home/topics/air/state/non-road-datenbank.html

Activity data

Activity data were collected by surveys among producers and several user associations in Switzerland (FOEN 2015j), and by evaluating information from the national database of non-road vehicles (MOFIS) run by the the Federal Roads Office (FEDRO 2013). In addition several publications serve as further data source:

- SBV (2013) for agricultural machinery
- SFSO (2013a) for agricultural machinery
- Jardin Suisse (2012) for garden care /hobby and professional appliances
- KWF (2012) for forestry machinery
- The national statistics on imports/exports of non-road vehicles was assessed by FCA (2015c)
- Off-Highway Research (2005, 2008, 2012) provided information on the number of non-road vehicles.
- Federal Department of Defence, Civil Protection and Sport: List of military machinery with vehicle stock, engine-power classes and operating hours (DDPS 2014a).

From these data sources, all necessary information like size distributions, modelling of the fleets, annual operating hours (age-dependent), load factors, year of placing on the market, and age distribution was derived. All details are documented in FOEN (2015j). Note that all activity data (vehicle stocks, operating hours, consumption factors) can be downloaded by query from the public part of the non-road database INFRAS (2015a), which is the data pool of FOEN (2015j). They can be queried by vehicle type, fuel type, power class and emission standard either at aggregated or disaggregated levels.

In Annex 2.1.2 (Table A-5) the stock numbers and the operating hours of non-road vehicles are summarised for each non-road category.

3.2.1.1.2 Energy model for wood combustion

Choice of method

The emissions from wood combustion in 1A Fuel combustion activities are calculated by a Tier 2 method based on chapter 1A4 Small combustion in EMEP/EEA (2013).

Methodology

The Swiss wood energy statistics (SFOE 2016b) provide both the annual wood consumption for specified categories of combustion installations (table K, categories 1-19) and the allocations of the combustion categories to the sectoral consumer categories (table N, household, agriculture/forestry, industry, services, electricity and district heating). This allows for assigning the annual wood consumption at the level of combustion installation categories (Table 3-5) to the source categories 1A1a Public Electricity and Heat Production, 1A2gviii Other, 1A4ai Commercial/Institutional, 1A4bi Residential and 1A4ci Agriculture/Forestry/Fishing.

Table 3-5 Categories of wood combustion installations based on SFOE 2016b.

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

Emission factors

- NO_x, NMVOC, SO_2, NH_3, BC (% PM2.5), CO: Emission factors are taken from Nussbaumer and Hälg (2015)
- PM2.5, PM10, TSP: TSP emission factors are taken from Nussbaumer and Hälg (2015), but shares of PM2.5 and PM10 on TSP are taken from EMEP/EEA (2013).
- Cd, Hg, Pb: Default emission factors from EMEP/EEA (2013) are used (chp. 1A4).
- PCDD/PCDF, PAH, HCB: Emission factors for 1990 are taken from EMEP/EEA (2013) (chp. 1A4) and for 2014 from Nussbaumer and Hälg (2015). Years in-between are linearly interpolated.

Table 3-6: Emission factors 2015 of pollutants due to wood combustion from source categories 1A1-1A4 (“w/o wood comp.” stands for “without wood processing companies”).

1A Wood combustion	NO_x	NMVOC	SO_x	NH_3	PM2.5 exh.	PM10 exh.	TSP	BC exh.	CO
	g/GJ								
Open fireplaces	80	179	10	5	92	94	99	64	2976
Closed fireplaces, log wood stoves	80	147	10	5	90	92	97	62	2452
Pellet stoves	60	17	10	2	54	55	58	21	290
Log wood hearths	70	236	10	5	182	185	195	127	3929
Log wood boilers	80	73	10	2	45	46	48	13	1214
Log wood dual chamber boilers	70	231	10	5	179	183	193	126	3857
Automatic chip boilers < 50 kW	120	12	10	2	91	93	98	9	581
Automatic pellet boilers < 50 kW	60	4	10	2	45	46	48	9	193
Automatic chip boilers 50-500 kW w/o wood proc. companies	120	10	10	2	72	74	77	7	483
Automatic pellet boilers 50-500 kW	60	3	10	2	36	37	39	7	145
Automatic chip boilers 50-500 kW within wood proc. companies	219	10	10	2	72	74	77	7	483
Automatic chip boilers > 500 kW w/o wood proc. companies	134	6	10	2	62	64	67	2	290
Automatic pellet boilers > 500 kW	70	3	10	2	32	32	34	3	144
Automatic chip boilers > 500 kW within wood proc. companies	219	6	10	2	62	64	67	2	290
Combined chip heat and power plants	119	2	10	5	11	11	12	0	98
Plants for renewable waste from wood products	100	2	20	5	7	8	8	0	98

1A Wood combustion	Pb	Cd	Hg	PCDD/PCDF	BaP	BbF	BkF	IcdP	HCB
	mg/GJ			ng/GJ	mg/GJ				
Open fireplaces	27	13	0.6	990	50	50	30	30	0.005
Closed fireplaces, log wood stoves	27	13	0.6	981	49	49	30	30	0.005
Pellet stoves	27	13	0.6	49	5	5	3	3	0.005
Log wood hearths	27	13	0.6	981	98	98	59	59	0.005
Log wood boilers	27	13	0.6	97	24	24	15	15	0.005
Log wood dual chamber boilers	27	13	0.6	967	97	97	58	58	0.005
Automatic chip boilers < 50 kW	27	13	0.6	97	5	5	3	3	0.005
Automatic pellet boilers < 50 kW	27	13	0.6	48	2	2	2	2	0.005
Automatic chip boilers 50-500 kW w/o wood proc. companies	27	13	0.6	97	3	3	2	2	0.005
Automatic pellet boilers 50-500 kW	27	13	0.6	48	2	2	2	2	0.005
Automatic chip boilers 50-500 kW within wood proc. companies	27	13	0.6	97	3	3	2	2	0.005
Automatic chip boilers > 500 kW w/o wood proc. companies	27	13	0.6	97	2	2	2	2	0.001
Automatic pellet boilers > 500 kW	27	13	0.6	48	2	2	2	2	0.001
Automatic chip boilers > 500 kW within wood proc. companies	27	13	0.6	97	2	2	2	2	0.001
Combined chip heat and power plants	27	13	0.6	49	1	1	1	1	0.001
Plants for renewable waste from wood products	27	13	0.6	49	1	1	1	1	0.001

Activity data

In submission 2010, the categories of wood combustion installations have been revised entirely according to the Swiss Wood Energy statistics (SFOE 2016b, see there in chp. 3.1.7) and since then all activity data is based on those statistics, see Table 3-7.

As additional data source, specific bottom-up information from the industry are used in order to allocate wood combustion emissions directly. Thus, activity data of wood combustion of 1A2f, 1A2g viii and 1A4ci are allocated on the basis of industry information. The information on the specific processes is documented in the respective EMIS database (EMIS 2017/1A Holzfeuerungen). Note that this specific industry data is subtracted from the activity data of the respective combustion installation category in order to avoid double counting within source category 1A2 and 1A4 (see Figure 3-18):

- Wood energy consumption in source categories 1A2f Brick and tile production, 1A2f Cement production and 1A2gviii Fibreboard are subtracted from the activity data of 1A2gviii Automatic chip boiler >500 kW without wood processing companies and 1A2gviii Plants for renewable waste from wood products, respectively.
- From 2013 onwards, also the wood energy consumption in 1A4ci Grass drying has been subtracted from the activity data in 1A4ci Automatic chip boiler >500 kW without wood processing companies.

Table 3-7: Wood energy consumption in 1A Fuel combustion from 1990-2015.

1A Wood combustion	Unit	1990	1995	2000	2005
Total	TJ	28'165	29'419	27'041	30'785
Open fireplaces	TJ	227	271	196	181
Closed fireplaces, log wood stoves	TJ	7'275	7'178	6'493	7'047
Pellet stoves	TJ	0	0	7	48
Log wood hearths	TJ	8'524	7'030	4'744	4'029
Log wood boilers	TJ	5'308	5'571	5'109	5'366
Log wood dual chamber boilers	TJ	1'964	1'779	978	481
Automatic chip boilers < 50 kW	TJ	239	434	550	754
Automatic pellet boilers < 50 kW	TJ	0	0	56	805
Automatic chip boilers 50-500 kW w/o wood proc. companies	TJ	688	1'332	1'793	2'707
Automatic pellet boilers 50-500 kW	TJ	0	0	2	99
Automatic chip boilers 50-500 kW within wood proc. companies	TJ	1'287	1'720	1'755	1'918
Automatic chip boilers > 500 kW w/o wood proc. companies	TJ	327	992	1'596	2'244
Automatic pellet boilers > 500 kW	TJ	0	0	0	9
Automatic chip boilers > 500 kW within wood proc. companies	TJ	1'347	2'048	2'232	2'531
Combined chip heat and power plants	TJ	0	3	186	127
Plants for renewable waste from wood products	TJ	979	1'060	1'345	2'438

1A Wood combustion	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	TJ	31'163	29'879	33'879	35'274	37'634	33'283	37'595	41'360	35'412	36'922
Open fireplaces	TJ	171	150	150	137	123	87	84	83	62	64
Closed fireplaces, log wood stoves	TJ	6'939	6'282	6'827	7'011	7'913	6'586	7'468	8'333	6'737	7'451
Pellet stoves	TJ	65	72	93	109	140	127	156	184	157	182
Log wood hearths	TJ	3'604	2'914	2'839	2'491	2'268	1'576	1'485	1'351	900	918
Log wood boilers	TJ	5'162	4'586	4'892	4'751	4'905	3'691	3'826	3'884	2'822	2'972
Log wood dual chamber boilers	TJ	423	348	338	289	272	195	190	181	125	119
Automatic chip boilers < 50 kW	TJ	775	727	833	861	1'008	801	867	943	740	787
Automatic pellet boilers < 50 kW	TJ	1'193	1'248	1'562	1'731	2'104	1'814	2'153	2'499	2'102	2'378
Automatic chip boilers 50-500 kW w/o wood proc. companies	TJ	2'914	2'828	3'224	3'288	3'780	3'251	3'821	4'329	3'561	4'100
Automatic pellet boilers 50-500 kW	TJ	184	259	365	434	540	515	624	726	692	871
Automatic chip boilers 50-500 kW within wood proc. companies	TJ	1'882	1'751	1'872	1'874	2'012	1'744	1'885	2'026	1'676	1'832
Automatic chip boilers > 500 kW w/o wood proc. companies	TJ	2'443	2'511	3'122	3'400	3'963	3'631	4'350	5'065	4'425	5'200
Automatic pellet boilers > 500 kW	TJ	39	56	80	84	92	139	161	186	192	214
Automatic chip boilers > 500 kW within wood proc. companies	TJ	2'470	2'348	2'451	2'459	2'689	2'348	2'510	2'684	2'250	2'470
Combined chip heat and power plants	TJ	242	1'058	2'467	3'423	2'756	3'900	5'010	5'421	5'325	3'792
Plants for renewable waste from wood products	TJ	2'657	2'740	2'764	2'933	3'071	2'877	3'005	3'465	3'647	3'573

3.2.1.2 Emission factors for 1A Fuel combustion

There are no general emission factors for all sources belonging to source category 1A Fuel combustion except for SO_2 per fuel type, as shown in Table 3-8. Explanations to the table:

- Upper part: Maximum legal limit of sulphur content (in ppm or percent) due to the Federal Ordinance on Air Pollution Control (Swiss Confederation 1985).
- Middle part: Effective sulphur content as national average based on measurements: Summary and annual reports of the Swiss Petroleum Association (EV), reports by the Federal Customs Administration (FCA) since 2000.
- Lower part: Effective SO_x emission factors based on the effective sulphur content.

Table 3-8 Sulphur contents and SO_2 emissions factors. For explanation see text.

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
2010-2015	10	10	1000	190	1.0	1.0

year	Effective sulphur content		
	Diesel oil	Gasoline	Gas oil
	ppm	ppm	ppm
1990	1400	200	1600
1991	1300	200	1300
1992	1200	200	1200
1993	1000	200	1000
1994	434	200	1350
1995	341	200	1170
1996	372	200	1160
1997	353	200	1250
1998	402	200	926
1999	443	200	650
2000	272	142	680
2001	250	121	830
2002	235	101	798
2003	200	81	700
2004	10	8.0	700
2005	10	8.0	799
2006	10	8.0	699
2007	10	8.0	630
2008	10	8.0	641
2009	7.2	5.2	603
2010	9	6	548
2011	5	8	116
2012	7	6	617
2013	8	5	253
2014	7	3	385
2015	7	3	384

year	Effective SO_2 emission factor							
	Diesel oil (average in road transportation)	Gasoline	Gas oil	Natural gas	Res. fuel oil	Lignite	Bituminous coal Boiler 1A1, 1A2, 1A3 / Boiler 1A4	Kerosene (average)
	kg/TJ							
1990	65.4	9.4	75.1	0.5	473.2	500.0	500/350	25.6
1991	60.8	9.4	61.0	0.5	432.0	500.0	500/351	25.1
1992	56.1	9.5	56.3	0.5	417.5	500.0	500/352	25.3
1993	46.8	9.5	46.9	0.5	422.3	500.0	500/353	25.3
1994	20.3	9.5	63.4	0.5	374.3	500.0	500/354	25.2
1995	15.9	9.3	54.9	0.5	377.2	500.0	500/355	25.3
1996	17.3	9.2	54.5	0.5	378.6	500.0	500/356	25.2
1997	16.4	9.3	58.7	0.5	339.8	500.0	500/357	25.0
1998	18.7	9.3	43.5	0.5	402.9	500.0	500/358	24.9
1999	20.6	9.3	30.5	0.5	301.0	500.0	500/359	25.0
2000	12.6	6.6	31.9	0.5	320.4	500.0	500/360	24.9
2001	11.6	5.7	39.0	0.5	398.1	500.0	500/361	24.3
2002	10.9	4.7	37.5	0.5	398.1	500.0	500/362	23.6
2003	9.3	3.7	32.9	0.5	383.5	500.0	500/363	23.2
2004	0.5	0.4	32.9	0.5	368.9	500.0	500/364	23.2
2005	0.5	0.4	37.5	0.5	378.6	500.0	500/365	22.8
2006	0.5	0.4	32.8	0.5	361.2	500.0	500/366	21.4
2007	0.5	0.4	29.6	0.5	343.7	500.0	500/367	21.6
2008	0.5	0.4	30.1	0.5	326.2	500.0	500/368	21.5
2009	0.5	0.4	25.3	0.5	308.7	500.0	500/369	21.4
2010	0.5	0.4	25.7	0.5	291.3	500.0	500/370	21.4
2011	0.5	0.4	24.1	0.5	291.1	500.0	500/371	21.5
2012	0.5	0.4	22.4	0.5	291.0	500.0	500/372	21.6
2013	0.5	0.4	20.8	0.5	290.9	500.0	500/373	21.7
2014	0.5	0.4	19.2	0.5	290.9	500.0	500/374	21.7
2015	0.5	0.4	17.6	0.5	290.9	500.0	500/375	21.7

3.2.2 Source category 1A1 - Energy industries (stationary)

3.2.2.1 Source category description for 1A1 Energy industries (stationary)

The most important source category in Energy industries is 1A1a Public electricity and heat production, followed by 1A1b Petroleum refining. Activities in source category 1A1c Manufacture of solid fuels and other energy industries are virtually not occurring in Switzerland apart from a very small charcoal production activity in traditional and historic trade.

Table 3-9: Specification of source category 1A1 Energy industries.

1A1	Source	Specification
1A1a	Public electricity and heat production	Main sources are waste incineration plants with heat and power generation (Other fuels) and public district heating systems, including a small fraction of combined heat and power. The only fossil fuelled public electricity generation unit "Vouvry" (300 MW_e; no public heat production) ceased operation in 1999.
1A1b	Petroleum refining	Combustion activities supporting the refining of petroleum products, excluding evaporative emissions.
1A1c	Manufacture of solid fuels and other energy industries	Emissions from charcoal production

Table 3-10: Key categories, level 2015 (L1) and trend 1990-2015 (T1), for source category 1A1 Energy Industries.

NFR	Source Category	Pollutant	Identification Criteria
1A1a	Public Electricity and Heat Production	NOx	L1
1A1a	Public Electricity and Heat Production	PM10	T1
1A1a	Public Electricity and Heat Production	PM2.5	T1
1A1a	Public Electricity and Heat Production	SO2	T1
1A1b	Petroleum Refining	SO2	L1, T1

3.2.2.2 Methodological issues for 1A1 Energy industries (stationary)

3.2.2.2.1 Public electricity and heat production (1A1a)

Methodology (1A1a)

Within source category 1A1a, heat and electricity production in waste incineration plants cause the largest emissions, as electricity production in Switzerland is dominated by hydroelectric power plants (almost 60%) and nuclear power stations (more than 30%). Emissions from industries producing heat and/or power (CHP) for their own use are included in category 1A2 Manufacturing industries and construction.

Energy recovery from municipal solid waste incineration is mandatory in Switzerland and plants are equipped with energy recovery systems (Schwager 2005). The emissions from municipal solid waste and special waste incineration plants are therefore reported under category 1A1a.

Emissions from fuel combustion in Public electricity and heat production (1A1a) are estimated using a Tier 2 method (see decision tree in chapter 1A1 Energy industries in EMEP/EEA Guidebook 2013 (EMEP/EEA 2013)).

Emission factors (1A1a)

Municipal solid waste incineration plants and special waste incineration plants with heat and power generation (reported under "Other fuels"):

Emission factors are expressed in pollutant per energy content of waste incinerated. They are all country-specific and based on an extensive measurement campaign in municipal waste incineration and special waste incineration plants (TBF 2015) as well as on expert estimates. Both sources are also documented in the EMIS database (EMIS 2017/1A1a Kehrichtverbrennungsanlagen and EMIS 2017/1A1a Sonderabfallverbrennungsanlagen). Emission factors are taking into account flue gas cleaning standards in incineration plants. In addition, the burn-out efficiency in modern municipal solid and special waste incineration plants is very high.

Until 2003 the same emission factors for special waste and municipal solid waste incineration plants have been applied. The emission factors were evaluated in the year 2015 (TBF 2015). The emission factors for the present inventory have been revised according to this latest study. For special waste incineration plants considerable higher emission factors are now estimated (in average factor 2 to 4, Cd about factor 10).

Biogas for combined heat and power generation:

Emission factors for combined heat and power generation with biogas (landfill gas and digestion gas) are considered to be the same as for natural gas engines in commercial and institutional buildings (EMIS 2017/1A1a Vergärung LW, EMIS 2017/1A1a I+G, EMIS 2017/1A1a Kehrichtdeponien).

Wood for combined heat and power generation as well as for heat production:

Emission factors for wood as fuel for combined heat and power generation as well as in plants for renewable waste from wood products are based on a study for wood use in the sector 1A (EMIS 2017/1A Holzfeuerungen) as described in chapter 3.2.1.1.2.

Fossil fuels for heat production and for power generation:

Emission factors for NO_x, CO, NMVOC, SO_x and PM2.5/PM10/TSP are country-specific and are 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 gas oil are based on Leupro (2012).

Between 1992 and 1993 the emission factor for SO_2 is reduced according to a strong decline of using residual fuel oil as fuel for district heating systems and for electricity production. Furthermore, compared to other countries, the Swiss emission factors for SO_2 are low for the following two reasons: first, there is only little use of residual fuel oil in factories, of which a very big one shut down in 2000. Second, a compulsory limitation of sulphur content in liquid fuels (extra-light, medium and residual fuel oil) leads to a significant reduction in SO_2 emissions since 1985.

Emission factors for Hg, Pb, Cd and PAH are taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013).

Table 3-11: Emission factors for 1A1a Public electricity and heat production of energy industries in 2015.

1A1a Public electricity and heat production	NO_x	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
Gas oil	34	2	17.6	0.002	0.2	0.2	0.2	0.0078	6.5
Residual fuel oil	NO	NO	NO	NO	NO	NO	NO	NO	NO
Petroleum coke	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other bituminous coal	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lignite	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	18.0	2.00	0.5	0.001	0.1	0.1	0.1	0.0054	10.0
Other fuels (MSW)	31.8	2.14	3.6	0.46	0.62	0.62	0.62	0.0055	7.7
Other fuels (special waste)	37.4	5.04	4.33	0.61	1.43	1.43	1.43	0.013	16
Biomass (wood)	116	1.95	11.5	5	10.2	10.4	11.2	0.39	97.6
Biogas	47.3	2.99	14.8	NE	1.15	1.15	1.15	0.029	63.9

1A1a Public electricity and heat production	Pb	Cd	Hg	PCDD/PCDF	BaP	BbF	BkF	IcdP	HCB
	g/TJ	g/TJ	g/TJ	mg/TJ	g/TJ	g/TJ	g/TJ	g/TJ	mg/TJ
Gas oil	0.012	0.001	0.12	0.0018	0.0019	0.015	0.0017	0.0015	0.22
Residual fuel oil	NO	NO	NO	NO	NO	NO	NO	NO	NO
Petroleum coke	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other bituminous coal	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lignite	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	0.0015	0.00025	0.1	0.00050	0.00056	0.0008	0.00084	0.00084	NA
Other fuels (MSW)	25.7	2.57	5.4	0.034	NE	NE	NE	NE	3.87
Other fuels (special waste)	28.7	15.6	7.3	0.043	NE	NE	NE	NE	NE
Biomass (wood)	27	13	0.6	0.049	0.98	0.98	0.98	0.98	0.98
Biogas	0.0015	0.00025	0.1	0.00057	0.0012	0.0090	0.0017	0.0018	NA

Activity data (1A1a)

Municipal solid waste incineration

Activity data for waste and special waste incineration are based on annual waste statistics (FOEN 2016a) and provided in the table below.

Table 3-12: Activity data for 1A1a Other fuels: municipal solid waste and special waste incineration plants (with heat and/or power generation) 1990-2015.

1A1a Other fuels	Unit	1990	1995	2000	2005
Total Other fuels	kt	2'603	2'433	3'040	3'527
Municipal solid waste	kt	2'470	2'270	2'801	3'297
Special waste	kt	133	163	239	230

1A1a Other fuels	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total Other fuels	kt	3'896	3'816	3'865	3'827	3'968	3'924	4'104	4'035	4'066	4'150
Municipal solid waste	kt	3'646	3'580	3'610	3'597	3'717	3'676	3'841	3'773	3'817	3'889
Special waste	kt	250	236	255	230	252	247	263	262	249	261

Other public electricity and heat production

Apart from Other Fuels, fuel consumption (TJ) for Public electricity and heat production (1A1a) activity data are extracted from the Swiss overall energy statistics (SFOE 2016; Tables 21, 26, and 28).

Activity data for combined heat and power generation from landfills and engines from digestion plants are taken from the Swiss renewable energies statistics (SFOE 2016a). Activity data for wood as fuel for combined heat and power generation and for plants for renewable waste from wood products are taken from the Swiss wood energy statistics (SFOE 2016b) as described in chapter 3.2.1.1.2 Energy model for wood combustion.

Table 3-13: Activity data of 1A1a Public electricity/heat, 1990–2015.

1A1a Public electricity and heat production	Unit	1990	1995	2000	2005
Total fuel consumption	TJ	40'414	39'216	50'018	57'230
Gas oil	TJ	980	554	790	1'300
Residual fuel oil	TJ	3'214	1'813	340	290
Petroleum coke	TJ	NO	NO	NO	NO
Other bituminous coal	TJ	530	46	NO	NO
Lignite	TJ	NO	NO	NO	NO
Natural gas	TJ	4'339	5'422	8'292	9'827
Other fuels (waste-to-energy)	TJ	30'768	30'264	39'371	44'508
Biomass (wood)	TJ	301	466	547	844
Biogas	TJ	282	651	679	462

1A1a Public electricity and heat production	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total fuel consumption	TJ	60'574	58'220	59'487	58'518	62'638	60'837	64'728	64'861	61'013	62'958
Gas oil	TJ	1'280	800	490	540	500	400	800	670	780	470
Residual fuel oil	TJ	300	220	180	130	40	10	NO	NO	NO	NO
Petroleum coke	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other bituminous coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	TJ	8'663	7'910	8'468	8'073	9'926	7'512	8'213	8'460	5'092	7'070
Other fuels (waste-to-energy)	TJ	48'880	47'206	47'344	46'102	48'277	47'847	49'313	48'228	49'161	50'548
Biomass (wood)	TJ	939	1'458	2'311	2'877	2'958	3'982	5'032	5'948	4'324	3'072
Biogas	TJ	511	625	695	796	937	1'086	1'370	1'556	1'657	1'798

3.2.2.2.2 Petroleum refining (1A1b)

In Switzerland, there were originally two petroleum refining plants. One of the two Swiss refineries operated at reduced capacity in 1990 and resumed full production in later years. In 2012, one of the refineries was closed over six months due to insolvency and the search for a new buyer (EV 2014). Since one of the refineries ceased operation in 2015, the data are considered confidential. Data are available to reviewers on request. In addition, operation was interrupted several times in 2014.

Methodology (1A1b)

Based on the decision tree Fig. 4.1 in chapter 1A1b Petroleum refining of the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013), emissions from fuel combustion are calculated by a Tier 2 bottom-up approach. The calculations are generally based on measurements and data from individual point sources from the refining industry.

Since 2013, the refineries in Switzerland are participating in the Swiss Emissions Trading Scheme (ETS). Starting from 2013, fuel consumption data are available from annual monitoring reports, which provides plant-specific information on activity data, and an allocation report, which provide plant specific information between 2005 and 2011.

Emission factors (1A1b)

Emission factors for NO_x and NMVOC, PM2.5/PM10/TSP and CO are based on SAEFL (2000). Emission factors for Pb, Cd, Hg and PAH are taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013). Emission factors are confidential, but are available to reviewers on request.

Activity data (1A1b)

Activity data on fuel combustion for petroleum refining (1A1b) is provided by the refining industry (bottom-up data). The data from the industry is collected by Carbura and forwarded to the Swiss Federal Office of Energy for inclusion in the Swiss overall energy statistics (SFOE 2016). Since one of the refineries ceased operation in 2015, the data are considered confidential since 2014. Data are available to reviewers on request.

Net calorific values are provided by the annual monitoring reports of the refining industries for the years 2005-2011 and 2013-2015 that are required under the Swiss Federal Act and Ordinance on the Reduction of CO_2 Emissions (Swiss Confederation 2011, Swiss Confederation 2012). For years with missing data (1990-2004 and 2012), the weighted mean of the net calorific value is applied for residual fuel oil and petroleum coke. The net calorific value value of refinery gas is based on an estimate provided by one of the two refining plants for the years 1990-2004, which is assumed to be constant. The use of a plant-specific net calorific value leads to a slight difference to the energy consumption data provided by the Swiss overall energy statistics (SFOE 2016).

Refinery gas is the most important fuel used in source category 1A1b. Energy consumption, in particular use of refinery gas has increased substantially since 1990. 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. Between 2004 and 2015, one of the Swiss refineries is also using petroleum coke as a fuel.

Table 3-14: Activity data of 1A1b Petroleum Refining in 2015.

1A1b Petroleum refining	Unit	1990	1995	2000	2005
Total fuel consumption	TJ	5'629	9'836	9'636	14'548
Residual fuel oil	TJ	1'259	1'786	1'908	902
Refinery gas	TJ	4'370	8'050	7'728	11'833
Petroleum coke	TJ	NO	NO	NO	1'813

1A1b Petroleum refining	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total fuel consumption	TJ	16'013	13'774	15'118	14'473	14'176	13'169	11'242	13'834	14'173	7'232
Residual fuel oil	TJ	692	1'182	692	733	891	764	1'212	1'094	C	C
Refinery gas	TJ	13'508	11'033	11'978	11'706	11'282	10'720	8'249	11'055	C	C
Petroleum coke	TJ	1'813	1'558	2'449	2'035	2'003	1'685	1'781	1'685	C	C

3.2.2.2.3 Manufacture of solid fuels and other energy industries (1A1c)

Methodology (1A1c)

Based on the decision tree Fig. 4.1 in chapter 1A1c Manufacture of solid fuels and other energy industries of the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013), the emissions are calculated by a Tier 2 approach. The only activity in this source category is charcoal production and is only of minor importance in Switzerland.

Emission factors (1A1c)

Emission factors for NO_x, NMVOC, CO are based on the revised 1996 IPCC Guidelines and for PM10 exhaust based on US-EPA (1995). PM2.5 exhaust is supposed to be 95% from PM10 exhaust (EMIS 2017/1A1c).

Table 3-15 Emission factors of 1A1c charcoal production in 2015.

1A1c Charcoal	Unit	NO_x	NMVOC	SO2	NH3	PM2.5 exh.	PM10 exh.	TSP	BC exh.	CO
Charcoal production	g/GJ	10	1'700	NA	NA	3'700	3'900	4'800	555	7'000

1A1c Charcoal	Unit	Pb	Cd	Hg	PCDD/PCDF	BaP	BbF	BkF	IcdP	HCB
Charcoal production	g/GJ	NA	NA	NA	NA	NA	NA	NA	NA	NA

Activity data (1A1c)

Activity data on annual charcoal production are provided by the Swiss association of charcoal producers (Köhlerverband Romoos) and individual producers as documented in the EMIS database (EMIS 2017/1A1c).

Table 3-16 Activity data of 1A1c charcoal production.

1A1c Charcoal	Unit	1990	1995	2000	2005
Charcoal production	GJ	1'254	1'431	2'198	3'372

1A1c Charcoal	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Charcoal production	GJ	3'334	3'478	3'519	3'484	3'186	3'301	3'617	2'820	3'820	3'304

3.2.2.3 Category-specific recalculations in 1A1 Energy industries (stationary)

- 1A: Small recalculations due to rounding in SFOE 2016 (Swiss overall energy statistics) concerning other bituminous coal and natural gas (2013, 2014).
- 1A: In 1A1a AD of automatic boilers and stoves have been revised for 1990-2014 and 2011-2014, respectively due to minor recalculations in Swiss wood energy statistics (SFOE 2016b) (1990-2014).
- 1A1a: The time series value of waste generation rate for 2013 has slightly changed due to the correction of an error in waste statistics.
- 1A1a: Emission factors for PM for municipal waste incineration plants have slightly changed for the year 2014. EF for the year 2013 are based on measurements and are assumed to be constant for the years 2014 and onwards.
- 1A1a: EF for all air pollutants have changed for special waste incineration plants for the years 1991 - 2012. EF from 2013 have been adopted for the year 2003 because they are based on measurements and seem more plausible than the original values that have been taken over from municipal waste incineration.
- 1A1a: Recalculation in residual fuel oil boilers due to mistake in calculations in the energy model (1990-2014).

3.2.3 Source category 1A2 - Stationary combustion in manufacturing industries and construction

3.2.3.1 Source category description for 1A2 Stationary combustion in manufacturing industries and construction

The source category 1A2 Stationary combustion in manufacturing industries and construction comprises all emissions from the combustion of fuels in stationary boilers and cogeneration facilities within manufacturing industries and construction. This includes use of conventional fossil fuels as well as waste fuels and biomass. Within this category, only activities involving fuel combustion are taken into account. Note that information regarding vehicles and machinery of source category 1A2gvii Mobile combustion in manufacturing industries and construction are provided in chapter 3.2.5.

Table 3-17: Specification of source category 1A2 Stationary combustion in manufacturing industries and construction (stationary without 1A2gvii) in Switzerland.

1A2	Source	Specification
1A2a	Iron and steel	Fuel combustion in iron and steel industry (cupola furnaces of iron foundries, reheating furnaces in steel plants, boilers)
1A2b	Non-ferrous metals	Fuel combustion in non-ferrous metals industry (non-ferrous metals foundries, aluminium production (ceased in 2006), boilers)
1A2c	Chemicals	Fuel combustion in chemical industry (steam production from cracker byproducts, boilers)
1A2d	Pulp, paper and print	Fuel combustion in pulp, paper and print industry (furnaces of cellulose production (ceased in 2008), boilers)
1A2e	Food processing, beverages and tobacco	Fuel combustion in food processing, beverages and tobacco industry (boilers)
1A2f	Non-metallic minerals	Fine ceramics, container glass, tableware glass, glass wool, lime, mineral wool, mixed goods, cement, brick and tile
1A2gviii	Other	Fibreboard production, industrial fossil fuel and biomass boilers and engines

Table 3-18: Key Categories, level 2015 (L1) and trend 1990-2015 (T1), for source category 1A2 Manufacturing Industries and Construction.

NFR	Source Category	Pollutant	Identification Criteria
1A2d	Pulp Paper and Print	SO2	T1
1A2e	Food Processing Beverages and Tobacco	SO2	T1
1A2f	Non Metallic Minerals	NOx	L1, T1
1A2f	Non Metallic Minerals	PM10	T1
1A2f	Non Metallic Minerals	PM2.5	T1
1A2f	Non Metallic Minerals	SO2	L1, T1
1A2gviii	Other Boilers and Engines Industry	NOx	T1
1A2gviii	Other Boilers and Engines Industry	PM10	L1
1A2gviii	Other Boilers and Engines Industry	PM2.5	L1, T1
1A2gviii	Other Boilers and Engines Industry	SO2	L1

3.2.3.2 Methodological issues for 1A2 Stationary combustion in manufacturing industries and construction

3.2.3.2.1 Methodology (1A2) and Industry model

Based on the decision tree Fig. 3.1 in chapter 1A2 Combustion in manufacturing industries and construction of EMEP/EEA (2013), the emissions are calculated according to a Tier 2 approach based on country-specific emission factors. The industry model described below is used in order to disaggregate the stationary energy consumption into the source categories under 1A2 Manufacturing industries and construction and further it allocates energy consumption to the different processes of a specific source category.

Overview Industry Model

The industry model is one sub-model of the Swiss energy model (see chp. 3.1.6.4.2). The industry model disaggregates the stationary energy consumption into the source categories and processes under 1A2 Manufacturing industries and construction. The following figure visualizes the disaggregation process.

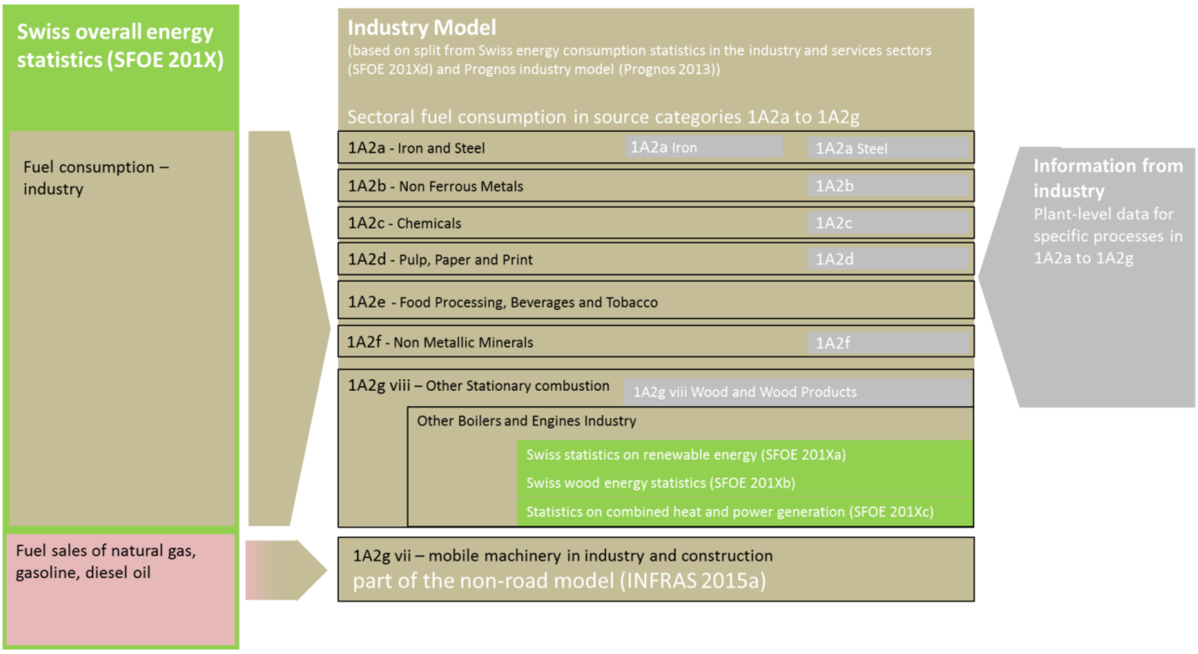

Figure 3-21 Schematic presentation of the data sources used for the industrial sectors 1A2a – 1A2g. The reference SFOE 201X refers to the 2016 edition of the corresponding energy statistics. For each fuel type, the Swiss overall energy statistics provide the total consumption for industry. The total consumption is then distributed to the different source categories based on information from industry surveys (SFOE 2016d) and the Prognos industry model. The grey boxes on the right show the specific bottom-up industry information.

The total energy consumption regarding each fuel type in the industry sector is provided by the Swiss overall energy statistics (see description of the Swiss overall energy statistics in chp. 3.1.6.4.2). The energy disaggregation into the source categories 1A2a to 1A2g is carried out for each fuel type individually based on the energy consumption statistics in the industry and services sectors (SFOE 2016d). These statistics are available since 1999 for gas oil and natural gas. For all other fossil fuels (i.e. residual fuel oil, liquefied petroleum gas, petroleum coke, other bituminous coal and lignite) data are available since 2002. In order to generate consistent time series since 1990, additional data from another industry model is applied (Prognos 2013) as described in the following chapters.

In addition, the share of fuel used for co-generation in turbines and engines within 1A2 is derived from a model of stationary engines developed by Eicher + Pauli (Kaufmann 2015) for the statistics on combined heat and power generation (SFOE 2016c).

Energy consumption statistics in the industry and services sectors

The energy consumption statistics in the industry and services sectors (SFOE 2016d) refers to representative surveys with about 12’000 workplaces in the industry and services sectors that are then grossed up or extrapolated to the entire industry branch. For certain sectors and fuel types (i.e. industrial waste, residual fuel oil, other bituminous coal and lignite) the surveys represent a census covering all fuel consumed. The surveys are available for all years since 1999 or 2002, depending on the fuel type.

In 2015, a change in the survey method of the energy consumption statistics in the industry and services sectors was implemented (SFOE 2015d). In brief, the business and enterprise register, which forms the basis for the samples of the surveys, was revised. While previously the business and enterprise register was based on direct surveys with work places, it is now based on annual investigations of registry data (e.g. from the old-age and survivors' insurance). In the course of this revision, a comparative assessment was conducted for the year 2013. This comparison shows that the energy consumption in the source categories of 1A2 stationary are modified by less than 1 percent, but also that the differences between the new and the old results for 2013 are not statistically significant (SFOE 2015d). As these statistics are only used for allocation of total energy consumption to different source categories, the impact on the different source categories consists only of a reallocation of the energy consumption and does not affect the total of the sector. Moreover, only consumption of gas oil and natural gas is affected. For all these reasons, the time series consisting of data based on the old (1990-2012) and new (2013-2015) survey method are therefore considered consistent.

Modelling of industry categories

The energy consumption statistics in the industry and services sectors are complemented by a bottom-up industry model (Prognos 2013). The model is based on 164 individual industrial processes and further 64 processes related to infrastructure in industry. Fuel consumption of a specific process is calculated as the product of the process activity data and the process-specific fuel consumption factor.

It provides data on the disaggregation of total energy consumption according to different industries and services between 1990 and 2012. For the time period where the two industry models overlap, systematic differences between the two time series can be detected. These two data sets have been combined in order to obtain consistent time series of the shares of each source category 1A2a-1A2g for each fuel type. For this purpose, the approach to “generate consistent time series from overlapping time series” is used according to the 2006 IPCC Guidelines, Volume 1, Chapter 5, consistent overlap (IPCC 2006). To illustrate the approach, an example for gas oil attributed to source category 1A2c is provided in the following figure. A detailed description for all fuel types and source categories (1A2a-1A2g), including further assumptions, is provided in the underlying documentation of the EMIS database (EMIS 2017/1A2_Sektorgliederung Industrie).

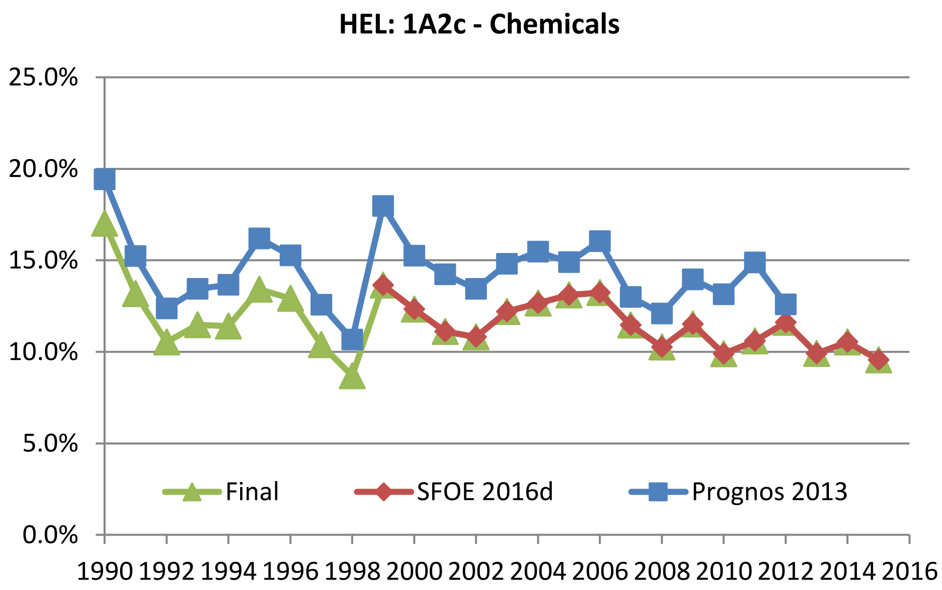

Figure 3-22 Illustrative example for combining time series with consistent overlap according to EMEP/EEA Guidebook 2013 (EMEP/EEA 2013, Part A, chapter 4: Time series consistency). The y-axis indicates the share of source category 1A2c of total gas oil consumption in the industry sector. The green line, which is based on the combination of the shares from the energy consumption statistics in the industry and services sectors (SFOE 2016d, red line from 1999 to 2015) and the bottom-up industry model (Prognos 2013, blue line from 1990 to 2012), corresponds to the share finally used to calculate the energy consumption in 1A2c. Similar calculations are performed for each source category and fuel type, see also EMIS database documentation (EMIS 2017/1 A 2_Sektorgliederung Industrie).

Bottom-up industry data

Grey colored boxes in Figure 3-21 represent source categories, i.e. 1A2a-d, 1A2f and 1A2gviii for which bottom-up data from the industry are used in order to disaggregate the fuel consumption within a particular source category. These data consist of validated and verified monitoring data from the Swiss emissions trading scheme implemented under the Ordinance for the Reduction of CO_2 Emissions (Swiss Confederation 2012) and are discussed in depth in the following chapters 3.2.3.2.2 – 3.2.3.2.8. Thus these bottom-up information provides activity data for specific industrial production processes and form a subset of the total fuel consumption allocated to each source category by the approach described above. Therefore, the fuel consumptions of the bottom-up industry processes are subtracted from the total fuel consumption of the respective source category and the remaining fuel consumptions are considered as fuels used in boilers of each source category (exclusion principle). This method ensures that the sum of fuel consumptions over all processes of a source category corresponds to the total fuel consumption as documented in the energy consumption statistics in the industry and services sectors (SFOE 2016d).

Please note that there is a difference in calculating the emissions from boilers and bottom-up industry processes. For boilers fuel consumption is used as activity data whereas for bottom-up processes production data is used.

Further specific statistical data

Fuel consumption of wood, wood waste, biogas and sewage gas in manufacturing industries is based on the Swiss wood energy statistics (SFOE 2016b) as well as on data from the Swiss renewable energy statistics (SFOE 2016a) and the Statistics on combined heat and power generation in Switzerland (SFOE 2016c), respectively. Emissions from these sources are reported under 1A2gviii Other due to insufficient information regarding sectoral disaggregation.

Emission factors (1A2)

This chapter describes the emission factors of fossil fuel consumption in boilers. Emission factors are identical for all source categories. Emission factors of bottom-up industry processes and other relevant processes are described in the following chapters for each source category.

The emission factors of NO_x and CO for natural gas and gas oil are derived from a large number of air pollution control measurements of combustion installations in several Swiss cantons in 1990, 2000 and 2010 (Leupro 2012). The emission factors for residual fuel oil, petroleum coke, other bituminous coal and lignite are country-specific and documented in the Handbook on emission factors for stationary sources (SAEFL 2000).

The emission factors for NMVOC, SO_2, NH_3, PM2.5, PM10 and TSP are country-specific and documented in the Handbook on emission factors for stationary sources (SAEFL 2000).

Emission factors for BC (% PM2.5), Pb, Cd, Hg, PCDD/PCDF and PAH are taken from EMEP/EEA Guidebook 2013 (EMEP/EEA 2013). The emission factor of HCB is taken from the Danish emission inventory for HCB (Nielsen et al. 2013).

For gas oil boilers emission factors of BC (% PM2.5), PCDD/PCDF, Pb, Cd and Hg are taken from table 3-21 chp. 1A4 Tier 2 Residential plants, boilers burning liquid fuels (Gas Oil) of the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013). Emission factors of PAHs are taken from table 3-37 (Tier 2 emission factors for non-residential sources, reciprocating engines burning gas oil) and 3-9 (Tier 1 emission factors for NFR source category 1.A.4.a/c, 1.A.5.a, using liquid fuels), respectively, as stated in the Guidebook representing an average of Tier 2 EFs for liquid fuel combustion for all technologies. These PAH EF values have been taken since the proposed values in table 3-21 are based on a relatively old reference from 1995 and are rather high compared to other PAH values within the Guidebook.

Table 3-19: Emission factors for boilers of 1A2 Stationary combustion in manufacturing industries and construction in 2015

1A2 Boiler	NO_x	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	g/GJ								
Boiler gas oil	32	2	18	0.002	0.2	0.2	0.2	0.008	7
Boiler residual fuel oil	125	4	291	0.002	20	20	23	2	10
Boiler liquefied petroleum gas	19	2	0.5	0.001	0.1	0.1	0.1	0.005	9
Boiler petroleum coke	125	4	291	0.002	20	20	23	2	10
Boiler other bituminous coal	200	10	500	0.003	45	45	50	2.88	100
Boiler lignite	208	10	500	0.003	45	45	50	2.88	100
Boiler natural gas	19	2	0.5	0.001	0.1	0.1	0.1	0.005	9

1A2 Boiler	Pb	Cd	Hg	PCDD/PCDF	BaP	BbF	BkF	IcdP	HCB
	mg/GJ			ng/GJ	mg/GJ				ng/GJ
Boiler gas oil	0.01	0.001	0.12	1.8	0.0019	0.015	0.0017	0.0015	220
Boiler residual fuel oil	4.6	1.2	0.34	2.5	0.0045	0.0045	0.0045	0.0069	220
Boiler liquefied petroleum gas	0.0015	0.00025	0.1	0.5	0.00056	0.00084	0.00084	0.00084	NA
Boiler petroleum coke	4.6	1.2	0.34	2.5	0.0045	0.0045	0.0045	0.0069	220
Boiler other bituminous coal	167	1	16	40	0.079	1.244	0.85	0.62	620
Boiler lignite	167	1	16	40	0.079	1.244	0.85	0.62	620
Boiler natural gas	0.0015	0.00025	0.1	0.5	0.00056	0.00084	0.00084	0.00084	NA

Activity data (1A2)

Table 3-20 shows the total fuel consumption in 1A2 and Table 3-21 shows fuel consumption in boilers of each source category 1A2a-1A2gviii as described above in the Industry model (chp. 3.2.3.2.1). Consumption of other fuels occurs mainly in source category 1A2f, where they refer to fossil waste fuels in cement production. But also the cracker by-products, i.e. gasolio and heating gas used for steam production in a chemical plant in source category 1A2c are included in other fuels of 1A2. Please note that there is no fuel consumption in boilers of source category 1A2f Non-metallic minerals since this source category consists of specific bottom-up industry processes only.

Table 3-20: Fuel consumption of 1A2 Stationary combustion in manufacturing industries and construction.

Source	Unit	1990	1995	2000	2005
1A2 Manufacturing industries and constr. (stationary sources)	TJ	88'183	89'133	87'861	91'679
Gas oil	TJ	21'754	23'529	25'145	24'711
Residual fuel oil	TJ	18'870	13'678	5'675	4'613
Liquefied petroleum gas	TJ	4'520	4'706	5'921	4'599
Petroleum coke	TJ	1'400	1'260	551	1'093
Other bituminous coal	TJ	13'476	7'303	5'716	4'899
Lignite	TJ	265	153	124	742
Natural gas	TJ	18'721	27'898	31'383	34'372
Other fossil fuels	TJ	2'555	2'817	4'054	4'525
Biomass	TJ	6'622	7'788	9'292	12'126

Source	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1A2 Manufacturing industries and constr. (stationary sources)	TJ	94'261	92'370	93'523	87'935	90'678	84'257	85'523	87'527	82'231	80'734
Gas oil	TJ	23'539	21'602	21'386	21'005	20'686	16'771	17'157	17'902	12'340	12'636
Residual fuel oil	TJ	5'427	3'776	3'734	2'713	2'096	1'518	1'568	848	351	226
Liquefied petroleum gas	TJ	5'070	4'554	4'310	4'595	4'181	4'136	3'998	3'998	3'538	3'584
Petroleum coke	TJ	1'512	1'271	1'067	1'219	1'495	1'272	1'367	1'049	1'240	795
Other bituminous coal	TJ	4'186	4'959	4'445	4'263	4'348	3'818	3'694	3'910	2'403	1'946
Lignite	TJ	1'931	1'937	1'717	1'531	1'460	1'624	1'175	1'357	3'102	3'060
Natural gas	TJ	35'840	36'910	38'719	35'126	38'042	36'903	38'013	39'400	39'946	39'137
Other fossil fuels	TJ	4'293	4'224	4'975	4'958	5'183	5'307	4'883	5'186	5'270	5'252
Biomass	TJ	12'462	13'135	13'170	12'527	13'188	12'909	13'667	13'877	14'042	14'098

Table 3-21: Fuel consumption in boilers of 1A2 Stationary combustion in manufacturing industries and construction

Source (Boilers)	Unit	1990	1995	2000	2005
1A2a Iron and steel	TJ	1'625	1'438	1'643	1'602
Gas oil	TJ	480	262	338	401
Residual fuel oil	TJ	26	131	20	39
Liquefied petroleum gas	TJ	408	193	286	217
Petroleum coke	TJ	NO	NO	NO	NO
Other bituminous coal	TJ	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO
Natural gas	TJ	711	852	999	946
Other fossil fuels	TJ	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO
1A2b Non-ferrous metals	TJ	2'244	1'957	1'546	971
Gas oil	TJ	452	334	222	119
Residual fuel oil	TJ	NO	NO	NO	NO
Liquefied petroleum gas	TJ	27	17	15	7
Petroleum coke	TJ	NO	NO	NO	NO
Other bituminous coal	TJ	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO
Natural gas	TJ	1'765	1'605	1'309	845
Other fossil fuels	TJ	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO
1A2c Chemicals	TJ	14'436	15'158	13'500	15'477
Gas oil	TJ	3'942	3'313	3'215	3'345
Residual fuel oil	TJ	1'434	693	252	36
Liquefied petroleum gas	TJ	15	13	12	10
Petroleum coke	TJ	NO	NO	NO	NO
Other bituminous coal	TJ	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO
Natural gas	TJ	9'044	11'138	10'020	12'086
Other fossil fuels	TJ	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO
1A2d Pulp, paper and print	TJ	9'677	12'343	9'886	9'326
Gas oil	TJ	1'188	1'751	1'403	1'456
Residual fuel oil	TJ	5'250	3'061	1'417	2'092
Liquefied petroleum gas	TJ	86	141	148	100
Petroleum coke	TJ	NO	NO	NO	NO
Other bituminous coal	TJ	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO
Natural gas	TJ	3'153	7'389	6'918	5'678
Other fossil fuels	TJ	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO
1A2e Food processing, beverages and tobacco	TJ	9'859	8'784	10'439	10'239
Gas oil	TJ	7'410	5'511	5'515	4'070
Residual fuel oil	TJ	1'160	466	137	NO
Liquefied petroleum gas	TJ	204	308	535	534
Petroleum coke	TJ	NO	NO	NO	NO
Other bituminous coal	TJ	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO
Natural gas	TJ	1'085	2'500	4'251	5'635
Other fossil fuels	TJ	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO
1A2g viii Other	TJ	16'536	21'077	22'058	23'645
Gas oil	TJ	6'262	10'684	12'738	13'890
Residual fuel oil	TJ	5'237	3'605	47	5
Liquefied petroleum gas	TJ	3'256	3'536	4'457	3'407
Petroleum coke	TJ	850	960	71	456
Other bituminous coal	TJ	378	256	34	380
Lignite	TJ	NO	NO	NO	5
Natural gas	TJ	43	1'486	4'113	4'893
Other fossil fuels	TJ	NO	NO	NO	NO
Biomass	TJ	509	550	596	610

Continuation of fuel consumption in boilers of 1A2 Stationary combustion in manufacturing industries and construction.

Source (Boilers)	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1A2a Iron and steel	TJ	2'293	2'472	2'128	1'804	1'994	1'870	1'817	1'989	2'088	2'494
Gas oil	TJ	311	326	307	279	315	271	172	139	86	221
Residual fuel oil	TJ	52	36	51	39	51	2	NO	NO	NO	NO
Liquefied petroleum gas	TJ	313	295	246	214	219	226	438	438	388	393
Petroleum coke	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other bituminous coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	TJ	1'616	1'815	1'524	1'272	1'410	1'371	1'207	1'412	1'614	1'880
Other fossil fuels	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2b Non-ferrous metals	TJ	1'156	1'016	1'038	1'004	1'214	1'174	1'743	1'592	1'915	1'763
Gas oil	TJ	66	89	107	164	108	73	150	127	89	73
Residual fuel oil	TJ	NO	NO	0.02	0.02	0.02	0.02	0.8	23	NO	44
Liquefied petroleum gas	TJ	10	8	7	7	8	8	11	11	10	10
Petroleum coke	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other bituminous coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	TJ	1'080	920	924	833	1'098	1'093	1'581	1'430	1'817	1'636
Other fossil fuels	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2c Chemicals	TJ	14'995	14'810	14'610	12'611	11'814	12'167	13'909	14'125	12'128	12'951
Gas oil	TJ	3'210	2'556	2'261	2'498	2'103	1'847	2'055	1'797	1'321	1'226
Residual fuel oil	TJ	71	6	79	91	66	0.2	0.2	1	NO	NO
Liquefied petroleum gas	TJ	11	10	9	9	8	7	10	10	9	9
Petroleum coke	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other bituminous coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	TJ	11'704	12'239	12'261	10'014	9'637	10'312	11'845	12'317	10'798	11'716
Other fossil fuels	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2d Pulp, paper and print	TJ	11'336	9'598	9'372	7'675	8'024	7'337	6'806	6'560	5'668	4'433
Gas oil	TJ	3'210	2'556	2'261	2'498	2'103	1'847	2'055	1'797	1'321	1'226
Residual fuel oil	TJ	3'305	1'885	1'887	1'084	279	4.0	2.8	0.02	21.82	19
Liquefied petroleum gas	TJ	79	71	60	62	61	62	67	67	60	60
Petroleum coke	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other bituminous coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	TJ	4'742	5'085	5'164	4'030	5'581	5'424	4'681	4'696	4'265	3'128
Other fossil fuels	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2e Food processing, beverages and tobacco	TJ	11'519	11'221	10'975	12'558	13'161	11'374	11'310	13'079	12'440	11'600
Gas oil	TJ	3'811	3'500	3'376	3'687	3'778	3'197	3'237	3'681	2'395	2'413
Residual fuel oil	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liquefied petroleum gas	TJ	678	596	535	736	659	675	935	935	828	838
Petroleum coke	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other bituminous coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	TJ	7'031	7'126	7'064	8'135	8'723	7'502	7'138	8'463	9'218	8'348
Other fossil fuels	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2g viii Other	TJ	24'042	22'740	24'667	24'165	24'416	21'267	21'563	21'149	18'290	18'888
Gas oil	TJ	13'295	12'680	13'007	12'166	12'255	9'581	9'821	10'267	6'875	7'147
Residual fuel oil	TJ	262	38	58	49	69	2	0.3	2	120	33
Liquefied petroleum gas	TJ	3'753	3'392	3'293	3'473	3'124	3'031	2'428	2'424	2'199	2'222
Petroleum coke	TJ	609	360	31	224	365	191	447	234	189	173
Other bituminous coal	TJ	375	452	355	252	293	270	236	376	378	403
Lignite	TJ	97	147	121	152	111	131	95	75	189	204
Natural gas	TJ	5'013	5'015	7'131	7'134	7'415	7'163	7'557	6'792	7'334	7'707
Other fossil fuels	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	TJ	638	656	673	716	784	899	979	979	1'006	999

3.2.3.2.2 Iron and steel (1A2a)

Methodology (1A2a)

Emission factors and activity data of fuel consumption in boilers of this source category are documented in Table 3-19 and Table 3-21, respectively. In the following chapters, only those source categories are described, that are directly based on bottom-up industry data as outlined above in chapter 3.2.3.2.1. In addition, the chapter on activity data provides an overview on the fuel consumption within 1A2a.

Reheating furnaces in steel production

There is no primary iron and steel production in Switzerland. Only secondary steel production using recycled steel scrap occurs. Today, steel is produced in two steel production plants only, after two plants closed down in 1994. The remaining plants use electric arc furnaces (EAF) with carbon electrodes for melting the steel scrap. Therefore, only emissions from the reheating furnaces are reported in source category 1A2a. These furnaces use mainly natural gas for reheating the ingot moulds prior to the rolling mills. Process emissions from steel production are included in source category 2C1 Iron and steel production.

Cupola furnaces in iron foundries

Iron is produced in 14 iron foundries. About 75% of the iron is processed in induction furnaces and 25% in cupola furnaces. The share of induction furnaces increased since 1990 with a sharp increase in 2009 based on the closure of at least one cupola furnace. Induction furnaces use electricity for the melting process and therefore only process emissions occur, which are reported in source category 2C1 Iron and steel production.

Emission factors (1A2a)

Reheating furnaces in steel production

For NO_x, PM2.5/PM10, TSP and CO production weighted emission factors are derived from data that are based on various air pollution control measurements under the Ordinance on Air Pollution Control (Swiss Confederation 1985). In years with missing data, emission factors are estimated by interpolation. For NMVOC, SO_2 and Hg country-specific emission factors are used. Emission factors for Pb and Cd are available for selected years. Since 1995, emission factors are assumed to be constant. The emission factor of BC (% PM2.5) is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013) (EMIS 2017/1A2a Stahl-Produktion Wärmeöfen).

Cupola furnaces in iron foundries

Emission factors of NO_x, NMVOC, SO_2, PM2.5/PM10, TSP, CO, Pb, Cd and PCDD/PCDF are provided by the Swiss foundry association (Schweizerischer Giessereiverband GVS) and are assumed constant. The emission factors of BC (% PM2.5) is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013). Emission factors of PAH are based on data from literature (US-EPA 1998a) (EMIS 2017/1A2a Eisengiessereien Kupolöfen). The so far Hg emission factor is newly introduced and based on the default value for other bitumonius coal of the EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013).

Table 3-22: Emission factors of 1A2a Iron and Steel in 2015.

1A2a Iron and steel	NO_x	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	g/t								
Iron foundries, cupola	67	40	1'500	NE	60	110	120	3.8	11'000
Steel plants, reheating furnaces	75	2.8	0.71	NE	2.1	2.1	4.1	0.11	0.5

1A2a Iron and steel	Pb	Cd	Hg	PCDD/PCDF	BaP	BbF	BkF	IcdP	HCB
	mg/t			ng/t	mg/t				ng/t
Iron foundries, cupola	4'800	24	80	1'300	0.13	1.4	1.2	1.6	NE
Steel plants, reheating furnaces	32	3.4	0.07	NE	NE	NE	NE	NE	NE

Activity data (1A2a)

Activity data of iron and steel production that is used to calculate emissions from cupola ovens in iron foundries and reheating furnaces in steel plants is provided by the industry as documented in the EMIS database (EMIS 2017/1A2a).

Reheating furnaces in steel production

Since 1995, steel production increased continuously until 2004 to reach the same production level as 1990. Since then, steel production is constant. Only in 2009, the production was significantly lower due to the economic crisis. One steel producer switched its production to high quality steel and therefore the specific energy use per tonne of steel produced increased between 1995 and 2000. This led to higher natural gas consumption. Data on annual steel production is provided by the steel production plant. Since 2009, activity data refer to monitoring reports of the Swiss ETS.

In steel production, mainly natural gas is used as fuel. Until 1994, the Swiss steel industry also used residual fuel oil in one steel production plant. Due to the closure of two steel production plants in 1994, the amount of fuel used in Swiss steel plants decreased significantly. Fuel consumption is derived from specific energy consumption per tonne of steel or iron and the annual production of steel or iron respectively.

Cupola furnaces in iron foundries

Annual production data are provided by the Swiss foundry association (Schweizerischer Giessereiverband GVS). The use of other bituminous coal decreased significantly due to a switch from cupola furnaces to induction furnaces.

Table 3-23: Activity data from production of iron and steel that is used to calculate bottom-up emissions from sources of 1A2a.

1A2a Iron and steel	Unit	1990	1995	2000	2005
Iron foundries, cupola	kt iron	90	60	55	32
Steel plants, reheating furnaces	kt steel	1'108	716	1'022	1'158

1A2a Iron and steel	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Iron foundries, cupola	kt iron	31	33	37	15	13	15	11	11	11	9
Steel plants, reheating furnaces	kt steel	1'252	1'264	1'312	933	1'217	1'320	1'250	1'229	1'313	1'295

3.2.3.2.3 Non-ferrous metals (1A2b)

Methodology (1A2b)

Emission factors and activity data of fuel consumption in boilers of this source category are documented in Table 3-19 and Table 3-21, respectively. In the following chapters, only those source categories are described, that are directly based on bottom-up industry data as outlined above in chapter 3.2.3.2.1. In addition, the chapter on activity data provides an overview on the fuel consumption within 1A2b.

Source category 1A2b Non-ferrous metals includes secondary aluminium production plants as well as non-ferrous metal foundries, producing mainly copper alloys.

Secondary aluminium production plants:

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

Non-ferrous metals smelters and furnaces

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

Emission factors (1A2b)

Emissions from non-ferrous metals smelters and furnaces are derived from the emission factors per tonne of metal as shown in the following table as documented in the EMIS database (EMIS 2017/1A2b Buntmetallgiessereien übriger Betrieb). The emission factors are based on information of the Swiss foundry association (GVS).

Table 3-24: Emission factors of 1A2b Non-ferrous metals in 2015.

1A2b Non-ferrous metals	NO_x	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	g/t								
Foundries	7	420	4	NE	160	170	170	6.2	2'100

1A2b Non-ferrous metals	Pb	Cd	Hg	PCDD/PCDF	BaP	BbF	BkF	IcdP	HCB
	mg/t			ng/t	mg/t				ng/t
Foundries	510	85	NE	4'900	NE	NE	NE	NE	NE

Activity data (1A2b)

The production data for the non-ferrous metal industry is provided by the largest company (Swissmetal) and the annual statistics of the Swiss Foundry Association (GVS). The non-ferrous metal foundries continuously increased their production from 1990 to 2000. Since 2000, the production has strongly decreased. The decrease in production is also reflected in its fuel consumption (Table 3-21).

Activity data of the secondary aluminium production plant (ceased in 1993) were based on data from the Swiss aluminium association (www.alu.ch).

Table 3-25: Activity data from production of Non-ferrous metals that are used to calculate bottom-up emissions from sources of 1A2b.

1A2b Non-ferrous metals	Unit	1990	1995	2000	2005
Aluminium production	kt aluminium	34	NO	NO	NO
Foundries	kt non-ferrous metals	55	60	70	33

1A2b Non-ferrous metals	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Aluminium production	kt aluminium	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Foundries	kt non-ferrous metals	30	28	21	15	20	12	18	7	7	7

3.2.3.2.4 Chemicals (1A2c)

Methodology (1A2c)

In Switzerland, there are more than thirty chemical companies mainly producing fine chemicals and pharmaceuticals. Fossil fuels are mostly used for steam production.

Emission factors and activity data of fuel consumption in boilers of this source category are documented in

Table 3-19 and Table 3-21, respectively. In the following chapters, only those source categories are described, that are directly based on bottom-up industry data as outlined above in chapter 3.2.3.2.1. In addition, the chapter on activity data provides an overview on the fuel consumption within 1A2c.

Steam production from cracker by-products

There is one large company producing ammonia and ethylene by thermal cracking of liquefied petroleum gas and light virgin naphtha. The ammonia and ethylene production by thermal cracking produces two by-products, the so-called heating gas and gasolio. These cracker by-products are used thermally for steam production within the same plant and are accounted for within source category 1A2c as other fossil fuels. Process emissions from ammonia and ethylene production are reported in source category 2B5 Ethylene production.

Emission factors (1A2c)

Since the fuel quality of gasolio and heating gas are of similar quality as residual fuel oil and gas oil, respectively, the same emission factors as of those boilers are assumed for all air pollutants, see Table 3-19.

Activity data (1A2c)

Activity data on gasolio and heating gas are provided by the industry. Since 2013, they are based on monitoring reports of the Swiss ETS as documented in the EMIS database (EMIS 2017/1A2c ethylene production). The activity data are confidential but available to reviewers on request.

3.2.3.2.5 Pulp, paper and print (1A2d)

Methodology (1A2d)

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

Emission factors and activity data of fuel consumption in boilers of this source category are documented in

Table 3-19 and Table 3-21, respectively. In the following chapters, only those source categories are described, that are directly based on bottom-up industry data as outlined above in chapter 3.2.3.2.1. In addition, the chapter on activity data provides an overview on the fuel consumption within 1A2d.

Emission factors (1A2d)

For the cellulose production plant, NO_x and SO_2 emission factors are derived from air pollution control measurements. The emission factor of BC (% PM2.5) is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013) as documented in the EMIS database (EMIS 2017/1A2d).

Activity data (1A2d)

Activity data on annual cellulose production are provided by the industry as documented in the EMIS database (EMIS 2017/1A2d Zellulose-Produktion Feuerung). The plant closed in 2008.

In 2015, natural gas is the most important fuel in this category. Biomass used in paper production is reported in source category 1A2gviii, because no comprehensive data exist to distribute biomass consumption to the specific industries within 1A2.

The overall fuel consumption within the Swiss pulp and paper industry has decreased significantly due to the closure of the cellulose production plant in 2008 and the closure of different paper producers in the last years.

3.2.3.2.6 Food processing, beverages and tobacco (1A2e)

Methodology (1A2e)

In Switzerland, the source category 1A2e Food, beverages and tobacco includes around 200 companies. According to the national food industry association, the major part of revenues is provided by meat production, milk products and convenience food. Further productions comprise chocolate, sugar or baby food (Fial 2013). Fossil fuels are used for steam production and drying processes.

Emission factors and activity data of fuel consumption in boilers of this source category are documented in

Table 3-19 and Table 3-21, respectively.

In 2015, the fuels used in this category were mainly natural gas, gas oil and liquefied petroleum gas. All fuel is consumed in boilers. Activity data are provided in Table 3-21.

3.2.3.2.7 Non-metallic minerals (1A2f)

Source category 1A2f Non-metallic minerals includes several large fuel consumers from mineral industry as for example cement, lime or brick and tile, glass and rock wool production (EMIS 2017/1A2f). Emission factors and activity data of some source categories reported under 1A2f Non-metallic minerals are considered confidential and are available to reviewers on request.

Emission factors (1A2f)

The following table provides an overview of the emission factors applied for source category 1A2f. Data sources are described for each process in the following chapters and are documented in the EMIS database (EMIS 2017/1A2f).

Table 3-26: Emission factors for Non-metallic minerals 1A2f in 2015.

1A2f Non-metallic minerals	NO_x	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	g/t								
Cement	930	59	270	50	3	6	7	0.3	1'900
Lime	C	C	C	C	C	C	C	C	C
Container glass	C	C	C	C	C	C	C	C	C
Glass wool	5'000	14	3	NE	340	610	630	18	80
Tableware glass	C	C	C	C	C	C	C	C	C
Brick and tile	530	140	80	NE	19	29	32	0.9	560
Fine ceramics	C	C	C	C	C	C	C	C	C
Rock wool	C	C	C	C	C	C	C	C	C
Mixed goods	10	32	17	NE	1	3	3	0.04	85

1A2f Non-metallic minerals	Pb	Cd	Hg	PCDD/PCDF	BaP	BbF	BkF	IcdP	HCB
	mg/t			ng/t	mg/t				ng/t
Cement	40	2	30	40	0.5	1	0.04	0.3	4'000
Lime	C	C	C	C	C	C	C	C	C
Container glass	C	C	C	C	C	C	C	C	C
Glass wool	860	90	0.3	NE	NE	NE	NE	NE	NE
Tableware glass	C	C	C	C	C	C	C	C	C
Brick and tile	45	0.7	7	18	NE	NE	NE	NE	NE
Fine ceramics	C	C	C	C	C	C	C	C	C
Rock wool	C	C	C	NE	NE	NE	NE	NE	NE
Mixed goods	20	2	2	5	0.04	0.06	0.04	0.04	NE

Activity data (1A2f)

The following table provides an overview of activity data in source category 1A2f. Data sources are described for each process in the following chapters and are documented in the EMIS database (EMIS 2017/1A2f).

Table 3-27: Activity data for Non-metallic minerals 1A2f.

1A2f Non-metallic minerals	Unit	1990	1995	2000	2005
Cement	kt	4'808	3'706	3'214	3'442
Lime	kt	C	C	C	C
Container glass	kt	C	C	C	C
Glass wool	kt	24	24	31	37
Tableware glass	kt	C	C	C	C
Brick and tile	kt	1'271	1'115	959	1'086
Fine ceramics	kt	C	C	C	C
Rock wool	kt	C	C	C	C
Mixed goods	kt	5'500	4'800	5'170	4'780

1A2f Non-metallic minerals	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cement	kt	3'452	3'512	3'461	3'443	3'642	3'587	3'368	3'415	3'502	3'195
Lime	kt	C	C	C	C	C	C	C	C	C	C
Container glass	kt	C	C	C	C	C	C	C	C	C	C
Glass wool	kt	38	44	44	33	36	41	39	33	32	31
Tableware glass	kt	C	C	C	C	C	C	C	C	C	C
Brick and tile	kt	1'065	975	865	701	879	800	792	785	765	726
Fine ceramics	kt	C	C	C	C	C	C	C	C	C	C
Rock wool	kt	C	C	C	C	C	C	C	C	C	C
Mixed goods	kt	5'400	5'100	5'160	5'200	5'250	5'300	4'770	4'770	5'260	4'850

Cement (1A2f)

Methodology

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.

Cement industry emissions stem from incineration of fossil and waste derived fuels used to generate high temperatures needed for the clinker production process. Fossil fuels used in cement industry are coal (other bituminous coal and lignite), petroleum coke and, to a lesser extent, gas oil, residual fuel oil and natural gas. Waste derived fuels can be of fossil or biogenic origin and include for example industrial wastes, waste wood, animal residues or used tyres. The fuels consumed in this category are very diverse and depend on the fuel use within the specific plant (see detailed documentation below). Between 1990 and 2015 there has been a diversification in fuel consumption from mainly other bituminous coal and residual fuel oil to other fuels, biomass and natural gas.

Emission factors

Table 3-26 shows product-specific emission factors for cement production (EMIS 2017/1A2f Zementwerke Feuerung). Since 2008, emission factors are based on various air pollution control measurements under the Ordinance on Air Pollution Control (Swiss Confederation 1985).

Activity data

Activity data of annual clinker production of each cement production plant in Switzerland are provided by the association of the Swiss cement industry (Cemsuisse 2016a) (see Table 3-27). Since 2008, activity data are available from monitoring reports of the Swiss ETS.

For information purposes, annual fuel consumption of the cement production plants in Switzerland are shown in the following table. The amount of fuels consumed in the Swiss cement production plants (in TJ) is also provided in the annual monitoring reports of the cement production plants as documented in the respective EMIS 2017/1A2f Zementwerke Feuerung.

Table 3-28: Fuel consumption of cement industry (fossil without waste, fossil waste derived and biomass waste derived).

Cement industry	Unit	1990	1995	2000	2005
Cement, total incl. waste	TJ	17'193	12'772	11'018	11'623
Cement fossil without waste	TJ	15'319	9'993	7'332	6'208
Gas oil	TJ	NO	NO	NO	72
Residual fuel oil	TJ	1'907	2'825	1'530	637
Petroleum coke	TJ	550	300	480	638
Other bituminous coal	TJ	12'235	6'547	5'176	4'120
Lignite	TJ	265	153	124	737
Gas	TJ	362	168	22	4
Cement, waste derived fuel	TJ	1'874	2'780	3'686	5'415
Used oil	TJ	1'169	1'485	1'519	1'411
Sewage sludge (dry)	TJ	9	128	332	494
Used wood	TJ	NO	321	NO	NO
Solvents	TJ	284	181	427	976
Used tires	TJ	330	415	421	645
Plastics	TJ	NO	55	572	841
Animal meal	TJ	NO	NO	198	856
CSS	TJ	23	136	158	133
Used charcoal	TJ	59	59	59	58
Other fossil waste fuels	TJ	NO	NO	NO	NO
Industrial waste	TJ	NO	NO	NO	NO
Agricultural waste	TJ	NO	NO	NO	NO
Other biomass	TJ	NO	NO	NO	NO

Cement industry	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cement, total incl. waste	TJ	11'719	12'022	11'954	11'816	12'388	12'187	11'462	11'866	12'339	11'348
Cement fossil without waste	TJ	6'401	6'914	6'389	6'127	6'278	5'859	5'406	5'512	5'847	4'917
Gas oil	TJ	57	NO	NO	NO	5	1	0.1	88	75	87
Residual fuel oil	TJ	220	175	135	100	112	101	297	86	58	45
Petroleum coke	TJ	903	912	1'036	994	1'130	1'081	920	815	1'052	622
Other bituminous coal	TJ	3'383	4'033	3'618	3'650	3'662	3'167	3'097	3'203	1'713	1'267
Lignite	TJ	1'834	1'790	1'596	1'379	1'348	1'493	1'081	1'283	2'912	2'856
Gas	TJ	4	4	4	4	21	16	11	38	37	41
Cement, waste derived fuel	TJ	5'319	5'108	5'565	5'689	6'109	6'329	6'056	6'354	6'492	6'431
Used oil	TJ	1'279	844	866	1'278	1'253	1'170	839	876	923	1'142
Sewage sludge (dry)	TJ	560	549	511	475	477	483	527	418	428	420
Used wood	TJ	NO	NO	NO	61	292	409	586	732	886	896
Solvents	TJ	981	1'295	1'476	1'032	1'189	1'264	1'294	1'414	1'273	1'292
Used tires	TJ	568	525	794	828	842	1'033	964	985	1'021	958
Plastics	TJ	926	1'013	995	1'119	1'252	1'163	1'092	1'299	1'360	1'177
Animal meal	TJ	799	664	658	621	624	614	572	479	457	412
CSS	TJ	146	164	157	131	123	96	100	96	103	80
Used charcoal	TJ	60	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other fossil waste fuels	TJ	NO	48	105	137	45	55	36	25	19	12
Industrial waste	TJ	NO	2	1	1	NO	NO	NO	NO	NO	NO
Agricultural waste	TJ	NO	5	2	7	7	18	28	NO	NO	NO
Other biomass	TJ	NO	NO	NO	NO	6	24	17	32	21	42

Fuel consumption in cement plants has decreased between 1990 and 2015. This is partly due to a decrease in production since 1990 and an increase in energy efficiency. In the same period, the fuel mix has changed significantly from mainly fossil fuels to the above mentioned mix of fuels. The fossil fuels used in 1990 were bituminous coal, residual fuel oil and petroleum coke.

Please note that all fossil waste derived fuels are reported as “Other fuels” in the emission reporting templates, whereas the biogenic waste derived fuels belong to “Biomass”.

Container glass (1A2f)

Methodology

Today, there exists only one production plant for container glass in Switzerland. Therefore, emission factors and activity data are considered confidential and are available to reviewers on request.

Emission factors

For container glass production, emission factors of NO_x and PM2.5/PM10/TSP are based on various air pollution control measurements under the Ordinance on Air Pollution Control (EMIS 2017/1A2f Hohlglas Produktion EMIS) and partly on information from industry. The SO_2 emission factor is based on air pollution control measurements from 2011. The emission factor of BC (% PM2.5) is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013).

Emission factors are derived based on air pollution control measurements at the production plants and therefore emission factors include both emission from fuel combustion as well as process emissions. Therefore, emissions from glass production are reported only in source category non-metallic minerals (1A2f). The same holds for tableware glass and glass wool.

Activity data

Activity data consist of annual production data provided by the industry (Table 3-27). Since 2008, activity data are available from monitoring reports of the Swiss ETS.

In 2015, fuel consumption for container glass production includes only natural gas. Since 1990, fuel consumption for container glass has drastically decreased due to reduction in production. Until 2003, only residual fuel oil was used in container glass production. Since 2004, the share of natural gas has increased to reach a stable share between 2006 and 2012. The large increase in natural gas share between 2012 and 2013 is due to the fact that the plant has switched its glass kiln completely to natural gas in autumn 2013.

Tableware glass (1A2f)

Methodology

Today, there exists only one production plant for tableware glass in Switzerland after the other one ceased production in 2006. Therefore, emission factors and activity data are considered confidential and are available to reviewers on request.

Emission factors

For tableware glass production, emission factors of NO_x and PM2.5/PM10/TSP are based on various air pollution control measurements under the Ordinance on Air Pollution Control whereas those of SO_2, NMVOC, CO are based on information from industry (EMIS 2017/1A2f Glas übrige Produktion). Emission factors of Pb and Cd are assumed proportional to the emissions of TSP. The emission factor of Hg is calculated proportional to the composition of fuels consumed in the production process (LPG and residual fuel oil until 1995). The emission factor of BC (% PM2.5) is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013).

Activity data

For tableware glass production, activity data are provided by monitoring reports of the Swiss ETS (Table 3-27). Activity data of tableware glass are considered confidential and are available to reviewers on request.

Fuel consumption for tableware glass currently includes only liquefied petroleum gas. Since 1990, fuel consumption for tableware glass strongly decreased because of the closure of one production plant in 2006. In addition, the consumption of residual fuel oil was eliminated in 1995.

Glass wool (1A2f)

Methodology

In Switzerland, glass wool is produced in two plants.

Emission factors

Table 3-26 shows product-specific emission factors for glass wool production. For glass wool, emission factors of NO_x and PM2.5/PM10/TSP are based on various air pollution control measurements under the Ordinance on Air Pollution Control (EMIS 2017/1A2f Glaswolle Produktion) and partly on information from industry. The emission factor for SO_2 is based on measurements and analysis of fuel samples carried out by the Swiss Federal Laboratories for Materials Testing and Research EMPA (EMPA 1999). The emission factor of BC (% PM2.5) is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013).

Activity data

Activity data consist of annual production data provided by monitoring reports from the industry (Table 3-27). Currently, fuel consumption for glass wool production includes only natural gas. Production of glass wool has increased since 1990, but the natural gas consumption decreased. This can be explained by an increase in energy efficiency in the production process.

Lime (1A2f)

Methodology

In Switzerland there is only one plant producing lime. Therefore, emission factors and activity data are considered confidential and are available to reviewers on request. Fossil fuels are used for the burning process (calcination) of limestone. The fuel consumption of two sugar plants that autoproduce lime is reported in category 1A2e.

Emission factors

For lime production, emission factors of NO_x, SO_2, PM2.5/PM10/TSP and CO are based on various air pollution control measurements under the Ordinance on Air Pollution Control (Swiss Confederation 1985) between 1990 and 2011 (EMIS 2017/1A2f). The emission factor of BC (% PM2.5) is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013) (EMIS2017/1A2f Kalkproduktion Feuerung).

Activity data

Activity data consist of annual production data provided by the industry. Since 2008, activity data are available from monitoring reports of the Swiss ETS.

Between 1994 and 2012, fuel consumption in lime production was mainly based on residual fuel oil. However, in 2013, the main kiln has been switched to natural gas. Since 1995, no other bituminous coal is used anymore as it was replaced by residual fuel oil.

Brick and Tile (1A2f)

Methodology

In Switzerland there are about 20 plants producing bricks and tiles. Mainly fossil fuels but also wood, paper pulp and animal fat are used for drying and burning of the clay blanks.

Emission factors

Table 3-26 shows emission factors for brick and tile production. Emission factors of NO_x, NMVOC, SO_2, PM2.5/PM10/TSP, CO, Pb, Cd und Hg are derived from air pollution control measurements as described in the EMIS database (EMIS2016/aA2f Ziegeleien). The emission factor of BC (% PM2.5) is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013).

Activity data

Activity data consist of annual production data provided by the industry (Table 3-27). Since 2013, for one large plant activity data are available from monitoring reports of the Swiss ETS.

Fuels used in the brick and tile production in 2015 are mainly natural gas as well as small amounts of residual fuel oil, gas oil and liquefied petroleum gas. Apart from a production recovery in the years around 2004, the production has gradually decreased since 1990, which is also represented in the overall fuel consumption decrease. Regarding the fuels used, there has been a considerable shift from residual fuel oil to natural gas from 1990 onwards as well as a minor shift from gas oil and liquefied petroleum gas to natural gas from 2004 onwards. Paper production residues, wood and animal grease are used since 2000.

Fine Ceramics (1A2f)

Methodology

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

Emission factors

Emission factors of NO_x, NMVOC, SO_2 and CO are based on air pollution control measurements from 2001, 2005, 2009 and 2012. The emission factor of PM is based on production weighted air pollution control measurements from 2005 and 2009 and the share of PM2.5/PM10 is assumed 95% and 60% of total PM emissions, respectively. Emission factors of Pb and Cd are calculated based on the assumption that they are proportional to the TSP emissions. The emission factor of Hg and SO_2 is assumed to be constant. The emission factor of BC (% PM2.5) is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013) (EMIS 2017/1A2f Feinkeramik Produktion).

Activity data

Activity data consist of annual production data provided by monitoring reports of the industry. Activity data are considered confidential and are available to reviewers on request.

Since 2010, fuel consumption within fine ceramics production is natural gas only. In 2001 the fuel-mix consisted of natural gas and gas oil. Since then, fuel mix has continuously shifted to natural gas. Compared to the production of other fine ceramics, the production of sanitary ware is more energy-intensive. Therefore, the specific energy use per tonne of produced fine ceramics has increased since 1990. This results in a lower reduction of fuel consumption compared to the reduction in production between 1990 and 2014.

Rock Wool (1A2f)

Methodology

In Switzerland, there is one single producer of rock wool. Therefore, emission factors and activity data are considered confidential and are available to reviewers on request. Fossil fuels are used for the melting of rocks at a temperature of 1500 °C in cupola furnaces.

Emission factors

All emission factors (e.g. NO_x, NH_3, SO_2,) for rock wool production are based on annual flux analysis from industry - except for the emission factor of BC (% PM2.5), which is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013) (EMIS 2017/1A2f Steinwolle Produktion).

Activity data

Activity data consist of annual production data provided by the industry (monitoring reports of the Swiss ETS).

Currently, other bituminous coal and natural gas are used in the production process. Until 2004 also gas oil and liquefied petroleum gas were used. In 2005, these fuels were substituted by natural gas. Between 1990 and 2015, there was a decrease in the specific energy consumption of rock wool production.

Mixed Goods (1A2f)

Methodology

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

Emission factors

Table 3-26 shows product-specific emission factors for production of mixed goods. Emission factors of NO_x, NMVOC, CO, PM2.5/PM10/TSP, Pb and Cd are based on air pollution control measurements from the time period between 2001 and 2015. This includes about 150 measurements from 55 out of 110 Swiss producers. As these mesurements show no clear trend in the emission factors, a constant country-specific, average emission factor is used between 2001 and 2015 Emission factors of SO_2, Hg and PCCD/PCDF are based on data from the industry association (Schweizerische Mischgut-Industrie) (EMIS 2017/1A2f Mischgut Produktion).

Activity data

Activity data consist of annual production data provided by the industry association (Schweizerische Mischgut-Industrie) (Table 3-27).

The main fuel types used are gas oil and natural gas. There has been a fuel switch from gas oil to natural gas in this time period.

3.2.3.2.8 Other (1A2g viii)

Methodology (1A2g viii)

Source category 1A2gviii Other covers fossil fuel combustion in boilers of manufacturing industries and construction mainly within non-metallic mineral industries as well as combustion of wood, wood waste, biogas and sewage gas in all manufacturing industries.

In addition, also the emissions from fibreboard production are reported in 1A2gviii. Please note that they are calculated based on fuel consumption and not on production data as for all other bottom-up industry processes. Fibreboard is produced in two plants in Switzerland, where thermal energy is used for heating and drying processes.

Methodologically, the fossil fuel consumption in boilers comprises also all the residual entities of the industry installations that could not be allocated to any other source categories 1A2a-f.

Emission factors (1A2g viii)

Emission factors of fossil fuel consumption in 1A2gviii in boilers and in fibreboard production are determined top-down (see

Table 3-19). Emission factors of consumption of wood waste in fibreboard production are documented in Table 3-6.

For wood combustion in 1A2gviii in both, installations and fibreboard production, the emission factors are described in chp. 3.2.1.1.2. They are shown in Table 3-6.

Emission factors of biogas and sewage gas are assumed to be the same as for natural gas. For boilers the emission factors are thus the same as documented above in chapter 3.2.3.2: Emission factors 1A2. For engines the emission factors of NO_x, NMVOC, SO_2, NH_3, PM2.5, PM10. TSP and CO are documented in the Handbook on emission factors for stationary sources (SAEFL 2000) whereas those of BC (% PM2.5), Pb, Cd, Hg, PCDD/PCDF and PAH are taken from EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

Table 3-29: Emission factors in 2015 for 1A2gviii

1A2gviii Other	NO_x	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	g/GJ								
Boiler biogas	19	2	0.5	0.001	0.1	0.1	0.1	0.0054	9
Boiler industrial wastewater, biogas	19	2	0.5	0.001	0.1	0.1	0.1	0.0054	9
Boiler sewage gas	19	2	0.5	0.001	0.1	0.1	0.1	0.0054	9
Engines biogas	24	1	0.5	NE	0.1	0.1	0.1	0.0025	57
Engines sewage gas	15	1	0.5	NE	0.1	0.1	0.1	0.0025	45

1A2gviii Other	Pb	Cd	Hg	PCDD/PCDF	BaP	BbF	BkF	IcdP	HCB
	mg/GJ			ng/GJ	mg/GJ				ng/GJ
Boiler biogas	0.0015	0.00025	0.1	0.5	0.00056	0.00084	0.00084	0.00084	NA
Boiler industrial wastewater, biogas	0.0015	0.00025	0.1	0.5	0.00056	0.00084	0.00084	0.00084	NA
Boiler sewage gas	0.0015	0.00025	0.1	0.5	0.00056	0.00084	0.00084	0.00084	NA
Engines biogas	0.0015	0.00025	0.1	0.57	0.0012	0.009	0.0017	0.0018	NA
Engines sewage gas	0.0015	0.00025	0.1	0.57	0.0012	0.009	0.0017	0.0018	NA

Activity data (1A2g viii)

In 2015, fuel consumption of 1A2g viii Other comprises mainly biomass, gas oil and natural gas. Overall, there has been a switch in fuel consumption between 1990 and 2015 from liquid and solid fuels to liquid fuels, biomass and natural gas. Activity data of fossil fuels is derived from the industry model and given in Table 3-21. Fuel consumption of wood, wood waste, biogas and sewage gas in manufacturing industries is based on the Swiss wood energy statistics (SFOE 2016b) as well as on data from the Swiss renewable energy statistics (SFOE 2016a) and the Statistics on combined heat and power generation in Switzerland (SFOE 2016c) (see also chp. 3.2.1.1.2).

In source category fibreboard production, the main fuels currently used are wood waste and natural gas. Since 1990, the production of fibreboard and thus the fuel consumption have increased significantly. The fuel mix has strongly shifted between 1990 and 2015 from fossil fuels to biomass (wood waste). Between 2001 and 2013, also animal grease was used for fibreboard production. Since 2012, data on annual fibreboard production is taken from monitoring reports of the industry as documented in the EMIS database (EMIS 2017/1A2g iv).

3.2.3.3 Category-specific recalculations for 1A2 Stationary combustion in manufacturing industries and construction

- 1A: Small recalculations due to rounding in SFOE 2016 (Swiss overall energy statistics) concerning other bituminous coal and natural gas (2013, 2014).
- 1A: In 1A2gviii AD of automatic boilers and stoves have been revised for 1990-2014 and 2011-2014, respectively due to minor recalculations in Swiss wood energy statistics (SFOE 2016b) (1990-2014).
- 1A2: Recalculations due to new available statistical data (Energy consumption statistics in the industry and services sectors SFOE 2016d) (2013, 2014).
- 1A2: Amount of used gas oil in households, industry and commercial sector in Liechtenstein has been redistributed. Therefore, the amount of used gas oil in boilers in households, industry and in the commercial sector has changed for Switzerland too (1990-2014).
- 1A2a: The so far missing Hg emission factor of 1A2a Iron foundries, cupola furnaces is now included in the inventory for the entire time series based on the default value for other bituminous coal of the EMEP/EEA Guidebook 2013.
- 1A2f: AD of 1A2f Production of mixed goods has been revised for 2014 based on corrected data from industry association.
- 1A2f: The emission factors of BaP, BbF, BkF and IcdP of 1A2f Production of mixed goods have been revised for the entire time series based on air pollution control measurements (2001-2015).
- 1A2f: The emission factors of NO_x, NMVOC, PM2.5, PM10, TSP, BC, CO and Cd of 1A2f Production of mixed goods have been revised from 1991 onwards based on air pollution control measurements (2001-2015).
- 1A2f: Revised interpolated emission factors for CO, Pb and Cd of 1A2f Rockwool production in 2014 due to new plant-specific data for 2015.
- 1A2f: The emission factors of NMVOC, SO_x, Pb, Cd and Hg as well as CO from 1A2f Glass production (specialty tableware) have been revised from 1991 and 1996, respectively, onwards.
- 1A2f: AD of 1A2f Container glass have been revised for 2003-2006 based on monitoring reports of the Swiss emissions trading scheme.
- 1A2f: The conversion factor used for calculation of NMVOC emissions from total carbon based on air pollution control measurements has been revised resulting in adjusted NMVOC emission factors of 1A2f Brick and tile production and 1A2f Fine ceramics production for the entire time series.

- 1A2g: Recalculations in AD (1990-2008: gas oil, residual oil, 1990-1994: petroleum coke, other bituminous coal) of 1A2gviii Industrial boilers due to revised fuel mix and consumption in 1A2f Lime production.

3.2.4 Source category 1A4 - Other sectors (stationary 1A4 ai/bi/ci)

3.2.4.1 Source category description for 1A4 Other sectors (stationary 1A4 ai/bi/ci)

Table 3-30: Specification of source category 1A4 Other sectors (stationary).

1A4	Source	Specification
1A4ai	Commercial/institutional: Stationary	Emissions from stationary combustion in commercial and institutional buildings.
1A4bi	Residential: Stationary	Emissions from stationary fuel combustion in households.
1A4ci	Agriculture/Forestry/Fishing: Stationary	Emissions from stationary fuel combustion of agriculture and grass drying.

Table 3-31: Key Categories, level 2015 (L1) and trend 1990-2015 (T1), for source category 1A4 Other Sectors (stationary)

NFR	Source Category	Pollutant	Identification Criteria
1A4ai	Stationary Combustion	NOx	L1
1A4ai	Stationary Combustion	PM10	L1, T1
1A4ai	Stationary Combustion	PM2.5	L1, T1
1A4ai	Stationary Combustion	SO2	L1
1A4bi	Stationary Combustion	NMVOC	L1
1A4bi	Stationary Combustion	NOx	L1
1A4bi	Stationary Combustion	PM10	L1, T1
1A4bi	Stationary Combustion	PM2.5	L1, T1
1A4bi	Stationary Combustion	SO2	L1
1A4ci	Stationary Combustion	PM2.5	T1

3.2.4.2 Methodological issues for 1A4 Other sectors (stationary 1A4 ai/bi/ci)

Methodology (1A4 ai/bi/ci stationary)

For the calculation of the emissions from the use of gas oil and natural gas, the following sources are differentiated: (a) heat only boilers, (b) combined heat and power production in turbines and (c) combined heat and power production in engines. Beside the main energy sources, also charcoal use and bonfires are considered in source category 1A4bi. Emissions from 1A4ci originate from fuel combustion for grass drying and wood combustion for heating in agriculture and forestry.

The methodology to estimate emissions from stationary combustion in source categories 1A4ai, 1A4bi and 1A4ci, follows a Tier 2 approach according to the decision tree for small combustion, Figure 3-1 in the chapter 1A4 small combustion in EMEP/EEA (2013). Emission factors and activity data are specified for different technologies. Direct emission measurements are not available.

Emission factors (1A4 ai/bi/ci stationary)

Source categories 1A4ai and 1A4bi (without charcoal and bonfires) and 1A4ci

The table below presents the emission factors applied for emission calculations of source categories 1A4ai, 1A4bi and 1A4ci. Please note the following additional information:

- Emission factors for Pb, Cd, Hg and PAH are taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013).
- 1A4bi Hg emission factors for other bituminous coal stem from Table 3-29 (EMEP/EEA 2013). 1A4ai Pb gas oil turbines/boilers EF stems from Table 3-35 (EMEP/EEA 2013).
- 1A4ai wood and 1A4bi biomass: for the emission factor of Hg a rounded value of 0.6 g/TJ compared to the guidebook EF (0.56 mg/GJ) is used in accordance with the recent comprehensive reevaluation of the emission factors of the Swiss wood combustion installations (Nussbaumer, T., Hälg, L. 2015).
- 1A4ai biogas emission factors are taken from table 3-23/33 (EMEP/EEA 2013) for boilers burning natural gas. The Cd and Hg emission factors are the same as for natural gas.
- 1A4ai/bi Pb/Cd and PAH NG engine: the EF for Pb/Cd are taken from table 3-34 (boilers), since these emission factors are mainly determined by the Pb and Cd content of the fuel used but for PAH from table 3-36 (engines), which are determined mainly by the combustion technology. Therefore, for combustion of natural gas the same emission factors are taken for Pb and Cd independent of the combustion device (boiler, engine, etc).
- 1A4ai/bi gas oil boiler Pb/Cd/Hg: emission factors are taken from table 3-21 (EMEP/EEA 2013) but PAHs are from table 3-37 and 3-9 (Tier 1 emission factors for NFR source category 1.A.4.a/c, 1.A.5.a, using liquid fuels), respectively, as stated in the Guidebook repre-senting average of Tier 2 EFs for commercial/institutional liquid fuel combustion for all technologies. These PAH EF values have been taken since the proposed values in table 3-21 are based on a relatively old reference from 1995 and are rather high compared to other PAH values within the Guidebook.
- Emission factors for SO_2 are based on measurements and analysis of fuel samples carried out by the Swiss Federal Laboratories for Materials Science and Technology - EMPA (1999) (see chp. 3.2.1.2).
- HCB emission factors of boilers, stationary engines, turbines and CCGT-plants using gaseous and liquid fuels are based on the approach of the Danish Emission Inventory for hexachlorobenzene and polychlorinated biphenyls (Nielsen et al. 2013).
- Emission factors for NMVOC for combustion boilers, turbines and engines in the residential, commercial institutional and agricultural sectors are documented in SAEFL (2000).
- For boilers, the emission factors of NO_x and CO for natural gas and gas oil are based on a study by Leupro (2012). Within this study, measurements from the control of combustion installations in eight Swiss cantons were analysed. Emission factors are thus country specific.
- Emission factors for NO_x, NMVOC and CO for combined heat and power generation in turbines and engines are based on measurements documented in the Handbook on emission factors for stationary sources (SAEFL 2000).
- Emission factors for grass drying in source category 1A4ci are based on air pollution control measurements (NO_x since 2002, NMVOC since 1990, TSP and CO since 2000). The emission factors of wood combustion are described in chapter 3.2.1.1.2.

Table 3-32: Emission factors for 1A4ai and 1A4bi (without charcoal and bonfires) and 1A4ci for 2015.

Source/fuel	NO_x	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	kg/TJ	kg/TJ	kg/TJ	g/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
1A4ai Other sectors (stationary): Commercial/institutional									
Gas oil (weighted average)	34.0	6.0	17.5	2.4	0.24	0.24	0.24	0.01	6.6
Gas oil (heat only boilers)	34	6.0	17.6	1.0	0.2	0.2	0.2	0.0078	6.5
Gas oil (turbines)	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gas oil (engines)	40	8.0	16.6	600	20	20	20	0.78	30
Natural gas (weighted average)	22.1	1.9	0.5	1.1	0.1	0.1	0.1	0.005	12.7
NG (heat only boilers)	17.5	2.0	0.5	1.0	0.1	0.1	0.1	0.005	10
NG (turbines)	60	0.1	0.5	400	0.2	0.2	0.2	0.005	15
NG (engines)	97	1.0	0.5	NA	0.1	0.2	0.1	0.003	57.1
Other bituminous coal	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lignite	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass (weighted average)	100	29	9.0	2'354	53	55	57	13	628
Biomass (wood)	116	34.9	10.7	2'828	64	66	69	15	752
Biomass (biogas)	17.5	2.0	0.5	1.0	0.1	0.1	0.1	0.01	10.0
1A4bi Other sectors (stationary): Residential									
Gas oil (weighted average)	36	6.0	17.55	1.2	0.2	0.2	0.2	0.0081	12.0
Gas oil (heat only boilers)	36	6.0	17.55	1.0	0.2	0.2	0.2	0.0078	12.0
Gas oil (turbines)	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gas oil (engines)	40	8.0	16.63	600	20	20	20	0.78	30
Natural gas (weighted average)	17	4.0	0.5	1.0	0.1	0.1	0.1	0.0054	13.4
NG (heat only boilers)	16.5	4.0	0.5	1.0	0.1	0.1	0.1	0.0054	13.0
NG (turbines)	NO	NO	NO	NO	NO	NO	NO	NO	NO
NG (engines)	34	1.0	0.5	NA	0.1	0.1	0.1	0.0025	57.1
Other bituminous coal	65	100	350	1'600	73	80	108	4.7	2'000
Lignite	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass (wood, charcoal, bonfires)	92	91	10	5'264	95	97	102	34	1'504
1A4ci Other sectors (stationary): Agriculture/forestry/fishing									
Drying of grass	27	37.1	31	NA	106	106	106	59	212
Biomass (wood)	159	34	20	4'501	66	69	72	10	779

Continuation of Emission factors for 1A4ai and 1A4bi (without charcoal and bonfires) and 1A4ci for 2015.

Source/fuel	Pb	Cd	Hg	BaP	BbF	BkF	IcdP	PCDD/PCDF	HCB
	g/TJ	g/TJ	g/TJ	mg/TJ	mg/TJ	mg/TJ	mg/TJ	mg/TJ	mg/TJ
1A4ai Other sectors (stationary): Commercial/institutional									
Gas oil (weighted average)	0.012	0.00102	0.12	1.9	15	1.7	1.5	0.0018	0.2
Gas oil (heat only boilers)	0.012	0.001	0.12	1.9	15	1.7	1.5	0.0018	0.2
Gas oil (turbines)	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gas oil (engines)	0.15	0.01	0.11	1.9	15	1.7	1.5	0.00099	0.2
Natural gas (weighted average)	0.002	0.00025	0.1	0.6	1.31	0.9	0.9	0.0005	NA
NG (heat only boilers)	0.002	0.00025	0.1	0.56	0.84	0.84	0.84	0.0005	NA
NG (turbines)	0.002	0.00025	0.1	0.56	0.84	0.84	0.84	0.0005	NA
NG (engines)	0.002	0.00025	0.1	1.2	9.0	1.7	1.8	0.00057	NA
Other bituminous coal	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lignite	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass (weighted average)	22	11	0.52	9'682	9'682	6'177	6'177	0.22	3.00
Biomass (wood)	27	13	0.60	11'631	11'631	7'420	7'420	0.26	3.00
Biomass (biogas)	0.002	0.00025	0.1	0.56	0.84	0.84	0.84	0.0005	NE
1A4bi Other sectors (stationary): Residential									
Gas oil (weighted average)	0.012	0.001	0.12	1.9	15	1.7	1.5	0.0018	0.2
Gas oil (heat only boilers)	0.012	0.001	0.12	1.9	15	1.7	1.5	0.0018	0.2
Gas oil (turbines)	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gas oil (engines)	0.15	0.01	0.11	1.9	15	1.7	1.5	0.00099	0.2
Natural gas (weighted average)	0.0015	0.00025	0.1	0.57	0.92	0.85	0.85	0.0015	NA
NG (heat only boilers)	0.0015	0.00025	0.1	0.56	0.84	0.84	0.84	0.0015	NA
NG (turbines)	NO	NO	NO	NO	NO	NO	NO	NO	NO
NG (engines)	0.0015	0.00025	0.1	1.2	9.0	1.7	1.8	0.00057	NA
Other bituminous coal	200	3.0	16	270'000	250'000	100'000	90'000	0.5	0.62
Lignite	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass (wood, charcoal, bonfires)	27	13	0.6	29'437	29'155	17'087	17'905	0.45	4.35
1A4ci Other sectors (stationary): Agriculture/forestry/fishing									
Drying of grass	2.3	0.47	0.24	NE	NE	NE	NE	NE	NE
Biomass (wood)	40	19	0.90	11'755	11'755	7'519	7'519	0.13	4.3

Charcoal and bonfires

Emission factors of NO_x, NMVOC, SO_2, PM2.5/PM10, TSP, CO, NH_3, Pb, Cd, Hg, PCDD/PCDF, PAH and HCB for bonfires and use of charcoal within 1A4bi are taken from EMEP/EEA Guidebook 2013 (EMEP/EEA 2013). More details are described in the EMIS database documentation (EMIS2017/1A4bi Lagerfeuer and EMIS2017/1A4bi Holzkohle Verbrauch).

Table 3-33 Emission factors of 1A4bi (bonfires and charcoal use) in 2015.

1A4bi Other sectors (stationary): Residential	NO_x	NMVOC	SO_2	NH_3	PM10	PM2.5	TSP	BC	CO
	g/GJ								
Use of charcoal	50	600	11	74	840	820	880	57.4	6000
Bonfires	50	600	11	74	840	820	880	57.4	6000

1A4bi Other sectors (stationary): Residential	Pb	Cd	Hg	BaP	BbF	BkF	IcdP	PCDD/PCDF	HCB
	g/GJ								
Use of charcoal	0.027	0.013	0.00056	0.121	0.111	0.042	0.071	0.0000008	0.000006
Bonfires	0.027	0.013	0.00056	0.121	0.111	0.042	0.071	0.0000008	0.000006

Activity data (1A4 ai/bi/ci stationary)

Source categories 1A4ai, 1A4bi (without charcoal and bonfires) and 1A4ci

Activity data on consumption of gas oil, residual fuel oil, natural gas and biomass are calculated by the energy model (see chp. 3.1.6.4 for further information) and the Energy model for wood combustion (see chp. 3.2.1.1.2). For other energy sources such as other bituminous coal, activity data are provided directly by the Swiss overall energy statistics (SFOE 2016).

Activity data for grass drying in source category 1A4ci are reported by the Swiss association of grass drying plants VSTB (as standard tonne of dried grass, confidential report) see also illustrations Figure 3-13 and Figure 3-17. Since submission 2015, data on fuel consumption for grass drying are available and used for emission calculations (see EMIS2017/ 1A4ci Grastrocknung).

Table 3-34: Activity data of 1A4ai Commercial/institutional and 1A4bi Residential and 1A4ci Agriculture/forestry/fishing.

Source/fuel	Unit	1990	1995	2000	2005
1A4ai Other sectors (stationary): Commercial/institutional	TJ	78'037	85'328	81'618	87'754
Gas oil	TJ	57'622	58'811	53'013	54'937
Gas oil heat only boilers	TJ	57'599	58'635	52'662	54'620
Gas oil turbines	TJ	NO	NO	NO	NO
Gas oil engines	TJ	24	175	351	318
Natural gas	TJ	17'495	22'715	24'234	27'440
NG heat only boilers	TJ	17'219	21'544	22'498	25'407
NG turbines	TJ	85	78	NO	28
NG engines	TJ	192	1'093	1'737	2'004
Other bituminous coal	TJ	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO
Biomass (total)	TJ	2'919	3'802	4'371	5'377
Biomass (wood)	TJ	2'895	3'780	4'313	5'231
Biomass (biogas)	TJ	24	23	58	146
1A4bi Other sectors (stationary): Residential	TJ	185'285	189'244	170'409	185'917
Gas oil	TJ	136'887	133'548	116'295	124'024
Gas oil heat only boilers	TJ	136'887	133'544	116'242	123'961
Gas oil turbines	TJ	NO	NO	NO	NO
Gas oil engines	TJ	1	4	53	63
Natural gas	TJ	25'841	34'074	36'256	42'623
NG heat only boilers	TJ	25'781	33'815	35'817	42'093
NG turbines	TJ	NO	NO	NO	NO
NG engines	TJ	60	258	439	530
Other bituminous coal	TJ	630	460	130	400
Lignite	TJ	NO	NO	NO	NO
Biomass (wood, charcoal, bonfires)	TJ	21'926	21'162	17'728	18'869
1A4ci Other sectors (stationary): Agriculture/forestry/fishing	TJ	2'323	2'051	1'728	1'644
Drying of grass	TJ	1'895	1'544	1'223	994
Gas oil	TJ	1'156	942	746	607
Residual fuel oil	TJ	NO	NO	NO	NO
Natural gas	TJ	739	602	477	388
Biomass	TJ	NO	NO	NO	NO
Biomass (wood)	TJ	428	508	505	649

Source/fuel	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1A4ai Other sectors (stationary): Commercial/institutional	TJ	82'577	74'772	79'010	77'017	83'372	69'084	75'946	80'829	64'454	70'715
Gas oil	TJ	51'554	45'450	47'585	45'699	48'778	38'900	41'814	44'328	34'191	36'406
Gas oil heat only boilers	TJ	51'260	45'269	47'416	45'545	48'660	38'796	41'720	44'242	34'109	36'324
Gas oil turbines	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gas oil engines	TJ	293	181	169	154	119	105	94	86	82	82
Natural gas	TJ	25'034	23'511	24'987	24'496	27'207	23'805	26'783	28'213	21'946	24'837
NG heat only boilers	TJ	23'082	21'585	23'130	22'683	25'503	22'224	25'231	26'715	20'510	23'401
NG turbines	TJ	23	28	29	26	23	17	5	7	7	7
NG engines	TJ	1'929	1'898	1'829	1'787	1'681	1'564	1'548	1'490	1'429	1'429
Other bituminous coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lignite	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass (total)	TJ	5'990	5'810	6'437	6'822	7'387	6'379	7'348	8'288	8'317	9'472
Biomass (wood)	TJ	5'773	5'497	6'007	6'323	6'742	5'647	6'521	7'238	6'975	7'885
Biomass (biogas)	TJ	216	313	431	499	644	732	827	1'050	1'341	1'587
1A4bi Other sectors (stationary): Residential	TJ	178'757	159'075	170'193	166'819	180'901	145'330	160'343	171'385	134'415	144'108
Gas oil	TJ	118'885	102'729	108'715	105'296	111'731	86'989	94'103	99'373	75'136	79'406
Gas oil heat only boilers	TJ	118'823	102'663	108'663	105'254	111'695	86'955	94'072	99'344	75'109	79'379
Gas oil turbines	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gas oil engines	TJ	63	65	52	42	36	34	32	29	27	27
Natural gas	TJ	40'914	39'147	42'377	42'462	48'222	40'903	47'036	50'946	42'367	46'107
NG heat only boilers	TJ	40'372	38'605	41'840	41'924	47'717	40'433	46'570	50'498	41'937	45'677
NG turbines	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
NG engines	TJ	542	542	537	538	506	470	466	448	430	430
Other bituminous coal	TJ	400	400	400	400	400	400	400	400	400	400
Lignite	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass (wood, charcoal, bonfires)	TJ	18'557	16'798	18'701	18'661	20'547	17'037	18'804	20'665	16'513	18'195
1A4ci Other sectors (stationary): Agriculture/forestry/fishing	TJ	1'437	1'507	1'445	1'486	1'435	1'461	1'398	1'107	1'237	1'232
Drying of grass	TJ	845	948	822	856	739	891	685	458	524	431
Gas oil	TJ	516	579	502	522	451	543	418	106	104	89
Residual fuel oil	TJ	NO	NO	NO	NO	NO	NO	NO	17	20	22
Natural gas	TJ	330	370	321	334	288	347	267	220	264	233
Biomass	TJ	NO	NO	NO	NO	NO	NO	NO	114	136	88
Biomass (wood)	TJ	592	558	622	630	697	570	713	649	714	801

Charcoal and bonfires

Charcoal is only used for barbecues. The total charcoal consumption under 1A4bi is very small compared to other fuels used for heating purposes. The activity data are the sum of charcoal production under 1A1c and net imports provided by the Swiss overall energy statistics (SFOE 2016).

The total wood demand for bonfires is assumed to be constant over time. As a consequence, the total amount of energy remains stable. Per capita wood demand is decreasing since 1990 due to an increasing number of inhabitants (for further details see documentation in EMIS2017/1A4bi Lagerfeuer).

Table 3-35 Activity data of 1A4bi (bonfires and charcoal use).

1A4bi Other sectors (stationary): Residential	Unit	1990	1995	2000	2005
Use of charcoal	GJ	311'254	291'431	292'198	313'372
Bonfires	GJ	160'000	160'000	160'000	160'000

1A4bi Other sectors (stationary): Residential	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Use of charcoal	GJ	303'334	313'478	353'519	343'484	343'186	343'301	343'617	342'820	353'820	353'304
Bonfires	GJ	160'000	160'000	160'000	160'000	160'000	160'000	160'000	160'000	160'000	160'000

3.2.4.3 Category-specific recalculations for 1A4 Other sectors (stationary 1A4 ai/bi/ci)

- 1A: Small recalculations due to rounding in SFOE 2016 (Swiss overall energy statistics) concerning other bituminous coal and natural gas (2013, 2014).
- 1A: In 1A4ai, 1A4bi and 1A4ci Wood combustion AD of automatic boilers and stoves have been revised for 1990-2014 and 2011-2014, respectively due to minor recalculations in Swiss wood energy statistics (SFOE 2016b) (1990-2014).
- 1A4ci: The missing emission factors in last year's submission of all air pollutants for 1A4ci Plants for renewable waste from wood products in 2014 are now included in the inventory.
- 1A4ci: The emission factors of NMVOC as well as NO_x, PM2.5, PM10, TSP, BC and CO from 1A4ci Drying of grass have been revised from 1990 and 1991, respectively, onwards based on air pollution control measurements (2005-2015).

3.2.5 Source category 1A2 - Mobile Combustion in manufacturing industries and construction

3.2.5.1 Source category description for 1A2 Mobile combustion in manufacturing industry and construction

Table 3-36: Specification of source category 1A2 Mobile combustion in manufacturing industry and construction.

1A2	Source	Specification
1A2g vii	Mobile Combustion in manufacturing industries and construction	industry sector: forklifts and snow groomers etc. construction machines: excavators, loaders, dump trucks, mobile compressors etc.

Table 3-37: Key Categories, level 2015 (L1) and trend 1990-2015 (T1), for source categories 1A2 Mobile combustion in manufacturing industry and construction

NFR	Source Category	Pollutant	Identification Criteria
1A2gvii	Off Road Vehicles and Other Machinery	NOx	L1
1A2gvii	Off Road Vehicles and Other Machinery	PM10	L1, T1
1A2gvii	Off Road Vehicles and Other Machinery	PM2.5	L1

3.2.5.2 Methodological issues for 1A2 Mobile combustion in manufacturing industry and construction

Methodology (1A2g vii)

Based on the decision tree Fig. 3.1 in chapter Non-road mobile sources and machinery of the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013), the emissions of industry and construction vehicles and machinery are calculated by a Tier 3 method with the non-road transportation model described in chapter 3.2.1.1.1.

Emission factors (1A2g vii)

- The emission factors are country-specific. Power class and emission standard specific emission factors are shown in Table 3-38 to Table 3-41.
- Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated from the difference of VOC and CH_4 emissions.
- For SO_x the emission factors are country- and fuel-specific, see implied emission factors 2015 below and Table 3-8 (column diesel oil, gasoline, natural gas)
- Emission factors for PAH are given in INFRAS (2015a) for diesel oil: BaP 0.5 ng/kWh, BbF 0.4 ng/kWh, BkF 0.6 ng/kWh.
- Implied emission factors 2015 are shown in Table 3-42.

Note that all emission factors (in g/hr) of NO_x, NMVOC, PM2.5 (exhaust), CO can be visualised and downloaded (tables in CSV format) by a query from the public part of the non-road database INFRAS (2015a)[5]. They can be queried by vehicle type, fuel type, power class and emission standard either at aggregated or disaggregated levels.

[5] https://www.bafu.admin.ch/bafu/en/home/topics/air/state/non-road-datenbank.html

Table 3-38: Emission factors for diesel-powered machinery (1A2gvii)

engine power	Pre-EU A	Pre-EU B	EU I	EU II	EU IIIA	EU IIIB	EU IV	EU V
	g/kWh							
Carbon monoxide (CO)								
<18 kW	6.71	6.71	2.90	2.90	2.90	2.90	2.90	*2.90*
18–37 kW	6.71	6.71	2.76	2.42	2.06	1.76	1.50	*1.50*
37–56 kW	4.68	4.68	1.87	1.63	1.39	1.19	1.01	*1.01*
56–75 kW	4.68	4.68	1.87	1.63	1.39	1.19	1.01	*1.01*
75–130 kW	3.62	3.62	1.28	1.01	0.86	0.73	0.62	*0.62*
130–560 kW	3.62	3.62	1.04	0.91	0.77	0.66	0.50	*0.50*
>560 kW	3.62	3.62	1.04	0.91	0.77	0.66	0.50	*0.50*
Hydrocarbons (HC)								
<18 kW	2.28	2.28	1.60	1.00	0.59	0.59	0.59	*0.53*
18–37 kW	2.41	2.41	0.92	0.56	0.37	0.37	0.37	*0.37*
37–56 kW	1.33	1.33	0.65	0.46	0.33	0.33	0.33	*0.33*
56–75 kW	1.33	1.33	0.65	0.46	0.33	0.13	0.13	*0.13*
75–130 kW	0.91	0.91	0.45	0.35	0.28	0.17	0.17	*0.13*
130–560 kW	0.91	0.91	0.43	0.30	0.22	0.17	0.17	*0.13*
>560 kW	0.91	0.91	0.43	0.30	0.22	0.17	0.17	*0.13*
Nitrogen oxides (NO_X)								
<18 kW	10.31	8.20	5.95	5.95	5.95	5.95	5.95	*5.95*
18–37 kW	10.31	8.20	6.34	6.34	6.34	6.34	6.34	*6.34*
37–56 kW	12.40	9.87	8.95	6.56	3.90	3.90	3.90	*3.90*
56–75 kW	12.40	9.87	8.95	6.56	3.90	3.30	0.40	*0.40*
75–130 kW	12.52	9.96	8.44	5.67	3.32	3.30	0.40	*0.40*
130–560 kW	12.52	9.96	8.19	5.66	3.38	2.00	0.40	*0.40*
>560 kW	12.52	9.96	8.19	5.66	5.66	5.66	5.66	*3.50*
Particulate matter (PM)								
<18 kW	1.51	1.18	1.00	0.80	0.70	0.60	0.60	*0.40*
18–37 kW	1.20	0.94	0.74	0.60	0.54	0.54	0.54	*0.01*
37–56 kW	1.09	0.85	0.47	0.32	0.32	0.03	0.03	*0.01*
56–75 kW	1.09	0.85	0.47	0.32	0.32	0.03	0.03	*0.01*
75–130 kW	0.61	0.47	0.35	0.24	0.24	0.03	0.03	*0.01*
130–560 kW	0.61	0.47	0.22	0.16	0.16	0.03	0.03	*0.01*
>560 kW	0.61	0.47	0.22	0.16	0.16	0.16	0.16	*0.05*
Fuel consumption								
<18 kW	248	248	248	248	248	248	248	*248*
18–37 kW	248	248	248	248	248	248	248	*248*
37–75 kW	248	248	248	248	248	248	248	*248*
75–130 kW	223	223	223	223	223	223	223	*223*
>130 kW	223	223	223	223	223	223	223	*223*

Table 3-39: Emission factors for gasoline-powered machinery (4-stroke engines) (1A2gvii). cc: cubic centimetres

Capacity range	Pre-EU A	Pre-EU B	Pre-EU C	EU I	EU II	EU V
Carbon monoxide (CO)						
<66 cc	470	470	470	467	467	467
66–100 cc	470	470	470	467	467	467
100–225 cc	470	470	470	467	467	467
>225 cc	470	470	470	467	467	467
Hydrocarbons (HC)						
<66 cc	60	60	60	41	41	8
66–100 cc	40	40	40	32	32	8
100–225 cc	20	20	20	12	12	8
>225 cc	20	20	20	10	9	6
Nitrogen oxides (NO_X)						
<66 cc	1.5	2.0	3.0	4.5	4.5	0.9
66–100 cc	1.5	2.0	3.0	3.6	3.6	0.9
100–225 cc	3.5	3.5	3.5	2.8	2.8	0.9
>225 cc	3.5	3.5	3.5	2.2	1.9	0.72
Fuel consumption (FC)						
<66 cc	500	500	500	480	480	460
66–100 cc	480	480	480	470	470	460
100–225 cc	460	460	460	450	450	450
>225 cc	460	460	460	450	450	450
Assumptions regarding introduction of emission stages						
<66 cc	<1996	1996	2000	2004	2005	2019
66–100 cc	<1996	1996	2000	2004	2005	2019
100–225 cc	<1996	1996	2000	2004	2009	2019
>225 cc	<1996	1996	2000	2004	2007	2019

Table 3-40: Emission factors for gasoline-powered machinery (2-stroke engines) (1A2gvii). cc: cubic centimetres

Capacity range	Pre-EU A	Pre-EU B	Pre-EU C	EU I	EU II	EU V
Carbon monoxide (CO)						
<20 cc	650	640	620	600	600	500
20–50 cc	650	640	620	600	600	500
>50 cc	650	640	620	540	540	500
Hydrocarbons (HC)						
<20 cc	260	250	150	100	41	41
20–50 cc	260	250	150	100	41	41
>50 cc	260	250	150	100	58	58
Nitrogen oxides (NO_X)						
<20 cc	1.5	2.0	3.0	4.8	4.5	4.5
20–50 cc	1.5	2.0	3.0	4.8	4.5	4.5
>50 cc	1.5	2.0	3.0	4.8	6.3	6.3
Fuel consumption						
<20 cc	660	650	550	500	440	410
20–50 cc	660	650	550	500	440	410
>50 cc	660	650	550	500	460	410
Assumptions regarding the introduction of emission stages						
<20 cc	<1996	1996	2000	2004	2009	2019
20–50 cc	<1996	1996	2000	2004	2009	2019
>50 cc	<1996	1996	2011	2004	2011	2019

Table 3-41: Emission factors for gas-operated machinery (1A2gvii).

Pollutant	Without catalyst	With oxidation catalysts	50% with 3-way catalysts	100% with 3-way catalysts
	g/kWh			
CO	10	0.2	0.2	0.2
HC	8	0.5	0.5	0.5
NOx	10	10	6	2
PM	0.02	0.01	0.01	0.01
Fuel consumption	450	450	455	460
Assumptions regarding introduction of emission stages				
All capacities		1980	1994	2000

Table 3-42: Implied emission factors for 1A2gvii in 2015.

1A2gvii Non-road vehicles and other machinery	NO_x	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	g/GJ								
Gasoline	107	769	1.8	2.6	0.1	0.1	0.1	NA	19'589
Diesel oil	372	31	0.5	0.2	9.2	9.2	9.2	4.6	156
Natural gas	NA	NA	NA	NA	NA	NA	NA	NA	NA
Biodiesel	323	27	0.4	0.2	8.0	8.0	8.0	NA	136
Bioethanol	53	278	0.2	1.9	0.1	0.1	0.1	NA	11'843

1A2gvii Non-road vehicles and other machinery	Pb	Cd	Hg	PCDD/ PCDF	BaP	BbF	BkF	IcdP	HCB
	mg/GJ			ng/GJ	mg/GJ				ng/t
Gasoline	0.240	NA	NA	NA	NA	NA	NA	NA	NA
Diesel oil	0.001	NA	NA	NA	0.049	0.059	0.039	0.019	NA
Natural gas	NA	NA	NA	NA	NA	NA	NA	NA	NA
Biodiesel	0.001	NA	NA	NA	0.043	0.051	0.034	0.016	NA
Bioethanol	0.139	NA	NA	NA	NA	NA	NA	NA	NA

Activity data (1A2g vii)

Table 3-43 shows the activity data of 1A2g vii taken from FOEN (2015j). Diesel oil is the main fuel type consumed in this category. Data on biofuels are provided by the statistics of renewable energies (SFOE 2016a). Detailed activity data can be downloaded from the online database INFRAS (2015a).

Table 3-43: Activity data for 1A2g vii.

Source/Fuel	Unit	1990	1995	2000	2005
1A2gvii Non-road vehicles and other machinery	TJ	5'722	6'861	7'644	8'170
Gasoline	TJ	196	224	227	225
Diesel oil	TJ	5'359	6'380	7'108	7'629
Natural gas	TJ	167	257	301	292
Biodiesel	TJ	NO	NO	8	24
Bioethanol	TJ	NO	NO	NO	0.02

Source/Fuel	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1A2gvii Non-road vehicles and other machinery	TJ	8'292	8'414	8'536	8'657	8'779	8'810	8'841	8'873	8'904	8'935
Gasoline	TJ	224	223	222	221	220	212	205	197	189	182
Diesel oil	TJ	7'755	7'881	8'007	8'133	8'259	8'295	8'331	8'367	8'403	8'440
Natural gas	TJ	288	283	279	274	270	261	252	243	234	225
Biodiesel	TJ	25	27	28	29	31	42	53	63	74	85
Bioethanol	TJ	0.03	0.04	0.05	0.07	0.08	0.72	1.36	2.00	2.64	3.29

3.2.5.3 Category-specific recalculations for 1A2 Mobile combustion in manufacturing industry and construction (mobile)

No recalculations were carried out for this source category.

3.2.6 Source category 1A3 - Transport

3.2.6.1 Source category description for 1A3 Transport

Table 3-44: Specification of source category 1A3 Transport.

1A3	Source	Specification
1A3ai(i)	International aviation LTO (civil)	memo item - not to be included in national total
1A3aii(i)	Domestic aviation LTO (civil)	Large (jet, turboprop) and small (piston) aircrafts, helicopters
1A3bi	Road transport: Passenger cars	
1A3bii	Road transport: Light duty vehicles	
1A3biii	Road transport: Heavy duty vehicles and buses	
1A3biv	Road transport: Mopeds & motorcycles	
1A3bv	Road transport: Gasoline evaporation	
1A3bvi	Road transport: Automobile tyre and brake wear	
1A3bvii	Road transport: Automobile road abrasion	not reported separately but included in 1A3bvi
1A3c	Railways	Diesel locomotives, abrasion by merchandise and person traffic
1A3di(ii)	International inland waterways	memo item - not to be included in national total
1A3dii	National navigation (shipping)	Passenger ships, motor and sailing boats on the Swiss lakes and the river Rhine
1A3ei	Pipeline transport	Compressor station in Ruswil, Lucerne

Note that emissions from bunkers fuels (international aviation and international inland waterways) are reported under “memo items” but are not considered for the national total.

Table 3-45: Key categories, level 2015 (L1) and trend 1990-2015 (T1), for source categories 1A3 Transport.

NFR	Source Category	Pollutant	Identification Criteria
1A3ai(i)	International Aviation	NOx	T1
1A3ai(i)	International Aviation	SO2	T1
1A3bi	Passenger Cars	NH3	T1
1A3bi	Passenger Cars	NMVOC	L1, T1
1A3bi	Passenger Cars	NOx	L1, T1
1A3bi	Passenger Cars	PM10	L1
1A3bi	Passenger Cars	PM2.5	L1
1A3bi	Passenger Cars	SO2	T1
1A3bii	Light Duty Trucks	NOx	L1, T1
1A3biii	Heavy Duty Trucks and Busses	NOx	L1, T1
1A3biii	Heavy Duty Trucks and Busses	PM10	T1
1A3biii	Heavy Duty Trucks and Busses	PM2.5	L1, T1
1A3biii	Heavy Duty Trucks and Busses	SO2	T1
1A3bv	Other and Evaporation	NMVOC	T1
1A3bvi	Tyre and Brake Wear	PM10	L1, T1
1A3bvi	Tyre and Brake Wear	PM2.5	L1, T1
1A3c	Railways	PM10	L1, T1
1A3c	Railways	PM2.5	L1, T1
1A3d	Domestic Navigation	NOx	T1

3.2.6.2 Methodological issues for 1A3 Transport

3.2.6.2.1 Domestic aviation (1A3a)

Methodology (1A3a)

According to the decision tree Figure 3-1 in chapter 1A3a Aviation in EMEP/EEA (2013), Switzerland uses a Tier 3 Approach because data on start and final destination are available by aircraft type. Emission factors are also used on a detailed level stratified by engine type.

All civil flights from and to Swiss airports are separated into domestic (national, 1A3aii) and international (1A3ai) flights. The Landing/Take-off (LTO) emissions of domestic and international flights are reported under category 1A3a. The emissions of domestic cruise as well as overflights (international cruise) are also reported as memo item and are therefore not accounted for in the national total.

A complete emission modelling (LTO and cruise emissions for domestic and international flights) has been carried out by FOCA for 1990, 1995, 2000, 2002, 2004–2015. The results of the emission modelling have been transmitted from FOCA to FOEN in an aggregated form (FOCA 2006, 2006a, 2007a, 2008-2016). FOEN calculated the implied emission factors 1990, 1995, 2000, 2002, 2004–2007 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 2016), providing the missing emissions of domestic aviation for the years 1991-1994, 1996-1999, 2001 and 2003. Also, the split of domestic/international is linearly interpolated.

International aviation (memo item): The Tier 3A method follows standard modelling procedures on the level of single aircraft movements based on detailed movement statistics including departure/arrival airports and LTO/cruise separation. Further details of emission modelling are described in FOEN (2017).

Emission factors (1A3a)

The emission factors used are country-specific or are taken from the ICAO engine emissions database from EMEP/CORINAIR databases (EMEP/EEA 2013), Swedish Defence Research

Agency (FOI) and Swiss FOCA measurements (precursors). Emission factors are case sensitive and for that reason separated into emission factors concerning the LTO cycle and cruise phase.

Particulate matter emissions estimations have been updated by FOCA (2016a). The updated emission factors for non-exhaust emissions are considerably lower than the former ones. Based on new findings the Swiss FOCA estimates the non-exhaust emissions to be 0.1g per LTO-cycle (based on 0.08 g per landing of a short-distant flight and 0.27 g per landing of a long-distant flight). Whereas so far 191 g per LTO-cycle was implemented. The new value for non-exhaust particulate matter emission factor has been applied for the calculation of the 2015 emission and a recalculation of the time series 1990-2014. The emission factors for exhaust emissions have also been updated. The new values are used from 2015 onwards only.

LTO

The Swiss FOCA engine emissions database consists of more than 520 individual engine data sets. Jet engine factors for engines above 26.7 kN thrust (emission certificated) are identical to the ICAO engine emissions database. Emission factors for lower thrust engines, piston engines and helicopters are taken from manufacturers or from own (FOCA) measurements. Emission factors for turboprops could be obtained in collaboration with the Swedish Defence Research Agency (FOI).

Cruise

Part of the cruise emission factors are taken from EMEP/EEA Guidebook 2013 (EMEP/EEA 2013). Aircraft cruise emission factors are dependent on representative flight distances per aircraft type. A load factor of 65% is assumed. Part of the cruise factors are also taken from former CROSSAIR (FOCA 1991). The whole Airbus fleet (which accounts for a large share of the Swiss inventory) has been modelled on the basis of real operational aircraft data from flight data recorders (FDR) of Swiss International Airlines.

So far, VOC emissions were split into 90% NMVOC and 10% of methane as given in IPCC 2006 Guidelines (IPCC 2006). As recommended by the ERT in the stage 3 review there are no more CH_4 emissions for cruise activities. This implies more NMVOC emissions for cruise activities. The emission factors for NMVOC have been adapted to the recommendation. NMVOC emissions 2015 are calculated with the new values and the whole time series 1990-2014 has been recalculated correspondingly.

Some of the old or missing aircraft cruise factors had to be modelled on the basis of the ICAO engine emissions database. For piston engine aircraft, FOCA has produced its own data, which were measured under real flight conditions.

Table 3-46: Emission factors for 1A3a Domestic aviation, year 2015. (LTO: Landing take-off cycle, CR: cruise.)

1A3a Civil aviation	NO_x	NMVOC	SO_2	PM2.5	PM10	TSP	BC
	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
Kerosene, domestic, LTO	193	121.5	20.7	8.6	8.6	8.6	8.1
Kerosene, domestic, CR	282	48.1	22.0	2.6	2.6	2.6	1.2
Kerosene, international, LTO	292	31.2	23.2	3.2	3.2	3.2	2.1
Kerosene, international, CR	310	9.0	23.2	0.3	0.3	0.3	0.3

1A3a Civil aviation	CO	Pb	PCDD/PCDF	HCB
	kg/TJ	kg/TJ	kg/TJ	kg/TJ
Kerosene, domestic, LTO	2'890	1.94	NE	NE
Kerosene, domestic, CR	684	0.92	NE	NE
Kerosene, international, LTO	304	0.01	NE	NE
Kerosene, international, CR	44	0.01	NE	NE

Activity data (1A3a)

Activity data are derived from detailed movement statistics by FOCA. The statistics distinguish between scheduled and charter aviation as well as non-scheduled, non-charter and general aviation (including helicopters).

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 are the movement statistics, which record for every movement information 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. All annual aircraft movements recorded are split into domestic and international flights.

Non-scheduled, non-charter and general aviation (including helicopters)

Airports and most of the airfields report individual aircraft data (aircraft registration). FOCA is therefore able to compute also the inventory for small aircraft with a Tier 3 approach. However, for 1990 and 1995, the emissions for non-scheduled, non-charter and general aviation (helicopters etc.) could not be calculated with a Tier 3 approach. Its fuel consumption is estimated to be 10% of the domestic fuel consumption. Data were taken from two studies by FOCA (FOCA 1991, FOCA 1991a). Since 2000, all movements from airfields are registered, which allows a more detailed modelling of the emissions.

Helicopter flights which do not take off from an official airport or airfield such as transport flights, flights for lumbering, animal transports, supply of alpine huts, heli-skiing and flight trainings in alpine regions cannot be recorded with the movement data base from airports and airfields. Although these helicopter movements only account for 0.1% of the total domestic aviation emissions, these emissions are taken into account using the statistics of the Swiss Helicopter Association (Unternehmensstatistik der Schweizer Helikopterunternehmen). These statistics are officially collected by FOCA and updated annually (see FOCA 2004 as illustrative example for all subsequent years). Since 2007, the data of these statistics are included electronically in the data warehouse of the model and undergo first some plausibility checks (E-plaus software). In order to distinguish between single engine helicopters and twin engine helicopters a fix split of 87 % for single engine helicopters and 13 % for twin engine helicopters is applied for the entire commitment period based on investigations in 2004 (FOCA 2004). Note that all emissions from helicopter flights without using an official airport or an official airfield are considered as domestic emissions. There is also a helicopter base in the Principality of Liechtenstein consuming a very small amount of fuel contained in the Swiss statistics. Thus, its consumption leads to domestic instead of international bunker emissions. 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.

Table 3-47 summarises the activity data for domestic (1A3a) and international (cruise) aviation (international bunker – memo item). The increase in energy consumption is due to an increasing number of flights.

Table 3-47: Kerosene consumption of domestic and international aviation in TJ. Note that domestic and international LTO emissions are reported and included in the national total, whereas domestic and international cruise emissions are reported under memo items only. (LTO: Landing take-off cycle, CR: cruise.)

1A3a Civil aviation	1990	1995	2000	2005
	Fuel consumption in TJ			
Kerosene, domestic, LTO	1'050	935	772	517
Kerosene, domestic, CR (not part of national total)	2'401	2'139	1'767	1'182
Kerosene, international, LTO	4'277	5'097	6'503	4'868
Kerosene, international, CR (not part of national total)	37'608	44'821	57'184	42'804
Total Civil aviation	45'334	52'993	66'225	49'370
1990 = 100%	100%	117%	146%	109%

1A3a Civil aviation	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Fuel consumption in TJ									
Kerosene, domestic, LTO	506	544	512	497	463	507	502	494	525	387
Kerosene, domestic, CR (not part of national total)	1'152	1'347	1'106	1'207	1'225	1'301	1'365	1'323	1'396	1'500
Kerosene, international, LTO	5'095	5'401	5'737	5'449	5'622	6'017	6'199	6'208	6'142	6'459
Kerosene, international, CR (not part of national total)	45'013	48'142	52'107	49'789	52'496	56'194	57'428	58'501	58'864	60'874
Total Civil aviation	51'766	55'434	59'462	56'942	59'805	64'019	65'494	66'526	66'927	69'220
1990 = 100%	114%	122%	131%	126%	132%	141%	144%	147%	148%	153%

3.2.6.2.2 Road Transportation (1A3b)

Methodology (1A3b)

- The exhaust air pollutant emissions are calculated by a Tier 3 method based on the decision trees Figs. 3.1 in the chapters 1A3b i-iv Exhaust emissions from road transport, 1A3b v Gasoline evaporation in EMEP/EEA (2013).
- The non-exhaust air pollutant emissions are calculated by a Tier 2 method based on the decision trees Figs. 3.1 in the chapter 1A3b vi-vii Road vehicle tyre and break wear, road surface wear EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

The total emissions are reported in two versions, the first one based on fuel used to account to the national total for compliance assessment and the second version based on fuel sold to be shown in the reporting tables and thereby contributing to the national total (but not for compliance assessment). See also chapters 3.1.6.1 and 3.1.6.2 on system boundaries and **memo items**. The difference between fuel sold and fuel used is attributed to fuel tourism (foreigners buy gasoline close to Swiss borders and use it abroad when fuel prices are lower in Switzerland) and statistical difference. Implied emission factors of the territorial road model are used to calculate emissions resulting from fuel tourism. Emissions from fuel used and from fuel tourism and statistical difference add up to emissions from fuel sold. Further details to emission modelling of fuel tourism and statistical difference are described in FOEN (2017).

The emission computation is based on emission factors and activity data (FOEN 2010i). Emission factors are expressed as specific emissions in grams per unit, where the unit depends on the set of traffic activity data: vehicle kilometres travelled (hot emissions), number of starts/stops and vehicle stock (cold start, evaporation emissions and running losses) or fuel consumption per vehicle category.

hot emissions: $E_{hot} = VKT \cdot EF_{hot}$

start emissions: $E_{start} = N_{start} \cdot EF_{start}$

evaporative emissions: $E_{evap,i} = N_{evap,i} \cdot EF_{evap,i}$,

with

EF_{hot}, EF_{start}, EF_{evap}: Emission factors for ordinary driving conditions (hot motor), cold start and evaporative (VOC) emissions (after stops, running losses, diurnal losses)

VKT: Vehicle kilometres travelled

N_{start}: Number of starts

i runs over three evaporation categories: stops, running losses, diurnal losses

$N_{evap,i}$: Number of stops (i= "after stops") or number of vehicles (i = "running losses" and "diurnal losses")

Emission Factors (1A3b)

Emission factors 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 database called "Handbook of Emission Factors for Road Transport" (INFRAS 2010, TUG 2009). Version 3.1 is presented and documented on the website http://www.hbefa.net/. A later version (3.2) has recently been made available but is not applied yet due to scheduling reasons. The general emission factor methodology is documented in TUG (2009). The resulting emission factors are published on CD ROM. They refer to the so-called "traffic situations", which represents characteristic patterns of driving behaviour and which serve as a key to the disaggregation of the activity data. 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.

Emission factors for fuel tourism and statistical difference: From the territorial model implied emission factors for all pollutants are derived per vehicle category and per fuel type corresponding to mean emission factors for Switzerland. These factors are then applied to calculate the emissions resulting from fuel tourism. To verify this approach, a comparison of these emission factors with implied emission factors of the neighbouring countries have been carried out. The differences are small between Switzerland, Austria, and Germany because all three countries use the same emission factors (INFRAS 2010, TUG 2009), whereas there are some differences when compared to France and Italy that use other emission factors (COPERT[6]). Nevertheless, the use of the mean Swiss emission factors seems to be the consistent approach.

Emission factors for non-exhaust emissions of particulate matter (TSP, PM10 and PM2.5) have been determined in a measurement campaign (EMPA/PSI 2009). Details to non-exhaust emission factors can be found in EMIS 2017/1A3b-Strassenverkehr.

Emission factors for PAH are taken from the EMEP Guidebook (EMEP/EEA 2013). For PCDD/PCDF three basic emission factors were used: gasoline/conventional 1 ng/kg fuel, gasoline with catalyst 0.027 ng/kg, diesel oil 0.060 ng/kg fuel (FOEN 2010i). See chp. 8.2 for planned improvements.

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.
- Bioethanol: The implied emission factors 1A3b for gasoline are used.
- Biogas: The implied emission factors 1A3b for CNG are used.

[6] see Euopean Environment Agency http://www.eea.europa.eu/publications/TEC05 [09.02.2017]

Table 3-48 shows a selection of mean emission factors for 2015.

Note that an inconsistency in the attribution of natural gas to the vehicle categories leads to an error in the implied emission factors for gas-driven light duty vehicles. The error will be corrected for the next submission.

The ERT of the Stage 3 Review (UNECE 2016a) recommended that Switzerland increases the completeness of the inventory by estimating emissions of cadmium and mercury for the transport sector. FOEN explained that a general update of 1A3b Road transportation is ongoing. The new results are expected for 2017 and are supposed to be integrated in the EMIS inventory for submission 2018 including also cadmium and mercury emissions.

Table 3-48: Implied emission factors for road transport, passenger cars in 2015.

1A3b Road Transportation Gasoline / Bioethanol	NO_X	NMVOC	SO_2	NH_3	PM2.5 ex	PM2.5 nx	PM10 ex	PM10 nx	TSP ex	TSP nx
	kg/TJ									
1A3bi: Passenger cars	54.2	82.1	0.36	18.5	1.01	NA	1.01	NA	1.01	NA
1A3bii: Light duty vehicles	159.9	163.3	0.38	19.2	2.62	NA	2.62	NA	2.62	NA
1A3biii: Heavy duty vehicles	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3biv: Motorcycles	134.6	486.8	0.38	1.4	NE	NA	NE	NA	NE	NA
1A3bv: Gasoline evaporation	NA	7.3	NA	NA	NA	NA	NA	NA	NA	NA
1A3bvi: Automobile tyre and brake wear	NA	NA	NA	NA	NA	2.06	NA	13.73	NA	13.73
1A3bvii: Automobile road abrasion	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1A3bi: Fuel tourism and statistical differnces	58.7	103.7	0.36	18.0	1.00	2.06	1.00	13.7	1.00	13.7

1A3b Road Transportation Gasoline / Bioethanol	BC ex	BC nx	CO	Pb	Cd nx	PCDD/PCDF
	kg/TJ			g/TJ	g/TJ	mg/TJ
1A3bi: Passenger cars	0.17	NA	642	22.8	NA	0.001
1A3bii: Light duty vehicles	0.48	NA	2'211	24.2	NA	0.002
1A3biii: Heavy duty vehicles	NO	NO	NO	NO	NO	NO
1A3biv: Motorcycles	NE	NA	4'344	24.2	0.38	NE
1A3bv: Gasoline evaporation	NA	NA	NA	NA	NA	NA
1A3bvi: Automobile tyre and brake wear	NA	0.21	NA	NA	0.37	NA
1A3bvii: Automobile road abrasion	IE	IE	IE	IE	IE	IE
1A3bi: Fuel tourism and statistical differnces	0.17	0.21	786	22.8	0.37	0.001

1A3b Road Transportation Diesel / Biodiesel	NO_X	NMVOC	SO_2	NH_3	PM2.5 ex	PM2.5 nx	PM10 ex	PM10 nx	TSP ex	TSP nx
	kg/TJ									
1A3bi: Passenger cars	223.5	11.7	0.45	0.4	6.95	NA	6.95	NA	6.95	NA
1A3bii: Light duty vehicles	327.6	10.8	0.48	0.3	14.57	NA	14.57	NA	14.57	NA
1A3biii: Heavy duty vehicles	328.6	7.4	0.47	0.3	4.34	NA	4.34	NA	4.34	NA
1A3biv: Motorcycles	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3bvi: Automobile tyre and brake wear	NA	NA	NA	NA	NA	2.35	NA	15.7	NA	15.7
1A3bvii: Automobile road abrasion	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1A3bi: Fuel tourism and statistical differnces	274.6	10.0	0.46	0.4	6.87	2.35	6.87	15.7	6.87	15.7

1A3b Road Transportation Diesel / Biodiesel	BC ex	BC nx	CO	Pb	Cd nx	PCDD/PCDF
	kg/TJ			g/TJ	g/TJ	mg/TJ
1A3bi: Passenger cars	3.38	NA	58	NA	NA	0.001
1A3bii: Light duty vehicles	9.15	NA	64	NA	NA	0.001
1A3biii: Heavy duty vehicles	2.81	NA	117	NA	NA	0.001
1A3biv: Motorcycles	NO	NO	NO	NO	NO	NO
1A3bvi: Automobile tyre and brake wear	NA	0.23	NA	NA	0.55	NA
1A3bvii: Automobile road abrasion	IE	IE	IE	IE	IE	IE
1A3bi: Fuel tourism and statistical differnces	3.34	0.23	80	0.0	0.55	0.001

1A3b Road Transportation Gas / Biogas	NO_X	NMVOC	SO_2	NH_3	PM2.5 ex	PM2.5 nx	PM10 ex	PM10 nx	TSP ex	TSP nx
	kg/TJ									
1A3bi: Passenger cars	29.5	0.6	0.02	NA	1.0	NA	1.0	NA	1.0	NA
1A3bii: Light duty vehicles	0.02	0.01	0.000008	NA	0.0002	NA	0.0002	NA	0.0002	NA
1A3biii: Heavy duty vehicles	154.4	0.2	0.01	0.1	1.93	NA	1.93	NA	1.93	NA
1A3biv: Motorcycles	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3bvi: Automobile tyre and brake wear	NA	NA	NA	NA	NA	2.22	NA	14.8	NA	14.8
1A3bvii: Automobile road abrasion	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1A3bi: Fuel tourism and statistical differnces	174.6	0.2	0.01	0.1	2.2	2.3	2.2	15.2	2.2	15.2

1A3b Road Transportation Gas / Biogas	BC ex	BC nx	CO	Pb	Cd nx	PCDD/PCDF
	kg/TJ			g/TJ	g/TJ	mg/TJ
1A3bi: Passenger cars	0.16	NA	204	1.4	NA	NA
1A3bii: Light duty vehicles	0.00003	NA	0.7	0.0005	NA	NA
1A3biii: Heavy duty vehicles	0.35	NA	108	0.5	NA	NA
1A3biv: Motorcycles	NO	NO	NO	NO	NO	NO
1A3bvi: Automobile tyre and brake wear	NA	0.22	NA	NA	0.40	NA
1A3bvii: Automobile road abrasion	IE	IE	IE	IE	IE	IE
1A3bi: Fuel tourism and statistical differnces	0.36	0.23	123	0.6	0.42	NO

Activity data (1A3b)

The activity data are derived from different data sources:

- Vehicle stock: The federal vehicle registration database MOFIS (run by the Federal Roads Office FEDRO) contains vehicle stock data including all parameters needed for the emission modelling (vehicle category, engine capacity, fuel type, total weight, vehicle age and exhaust technology). The data are not public, but the ordinary vehicle stock numbers are published by the Swiss Federal Statistical Office (SFSO 2016c). The stock numbers from MOFIS are used for 1990-2010, whereas for 2011-2015 numbers are provided from a vehicle fleet projection by Prognos (2012a). With the help of a fleet turnover model, the vehicle categories are split up into "sub-segments", which are used to link with the specific emission factors of the same categorisation (vehicle category, size class, fuel type, emission standard ["Euro classes"], see also INFRAS 2010, TUG 2009).
- The transport performance, i.e. the mileage is calculated from the specific mileage per vehicle category (based on 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). For the period 2010-2015 the mileages are modelling results from Prognos (2012a) and ARE (2012).
- Numbers of starts/stops: Derived from vehicles stock, with data on trip length distributions and parking time distributions (ARE/SFSO 2005).
- Also the consumption of biofuels for 1A3b Road Transportation is reported. Fuel types involved, emission factors and activity data are summarised in a comment to the EMIS database (EMIS/2015 1A3bi-viii "Strassenverkehr"), Consumption of biofuels is provided by the statistics of renewable energies (SFOE 2016a).

The transport performance is attributed to "traffic situations" (characteristic patterns of driving behaviour) which serve as a key to select the appropriate emission factor which are also available per traffic situation (see above). The relative shares of the 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 (395 stations all over Switzerland, FEDRO 2010), and top-down by the total of the mileage per vehicle category. Furthermore, it supplies all the attributes needed for assigning a "traffic situation" to each road segment. The traffic model in combination with consumption factors (per vehicle category, size class, fuel type, emission standard and per traffic situation) allows to calculate the territorial road traffic consumption of gasoline and diesel oil.

The mileage driven serves as activity data in the national traffic model. Table 3-49 shows the National Energy Strategy 2050 mileage per vehicle category for the period 1990–2015 (ARE 2012). The numbers hold for the version "fuel used" and represent the vehicle kilometres driven within the Swiss territory.

Table 3-49: Mileages in millions of vehicle kilometres. PC: passenger cars, LDV: light duty vehicles, HDV: heavy duty vehicles.

Veh. category	1990	1995	2000	2005
	million vehicle-km			
PC	42'650	43'824	48'063	50'465
LDV	2'758	2'746	2'978	3'300
HDV	1'992	2'107	2'273	2'127
Coaches	108	110	99	106
Urban Bus	174	192	200	229
2-Wheelers	2'025	1'744	1'999	2'204
Sum	49'707	50'724	55'612	58'432
(1990=100%)	100%	102%	112%	118%

Veh. category	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	million vehicle-km									
PC	50'812	51'208	51'949	52'852	53'341	54'000	54'730	55'424	56'085	56'731
LDV	3'374	3'473	3'529	3'584	3'621	3'663	3'701	3'735	3'765	3'793
HDV	2'189	2'203	2'223	2'172	2'210	2'250	2'290	2'329	2'369	2'407
Coaches	118	120	114	119	119	119	118	118	118	118
Urban Bus	233	240	245	249	251	254	257	261	264	267
2-Wheelers	2'262	2'300	2'366	2'385	2'407	2'436	2'465	2'494	2'523	2'552
Sum	58'989	59'544	60'426	61'361	61'950	62'722	63'562	64'362	65'123	65'868
(1990=100%)	119%	120%	122%	123%	125%	126%	128%	129%	131%	133%

The total mileage has constantly been growing by 1.1 per cent per year on an average. The overwhelming part of vehicle kilometres was driven by passenger cars. In the whole reporting period, on-road fuel consumption increased less strongly indicating improved fuel efficiency. This effect is also reflected in Table 3-50 that depicts the specific fuel consumption per vehicle-km. For most vehicle categories, the specific consumption has decreased in the period 1990–2015.

Table 3-50: Specific fuel consumption of road transport. Data are adopted from the territorial road transportation model.

Veh. cat.	Fuel	1990	1995	2000	2005
		MJ/veh-km			
PC	Gasoline	3.18	3.23	3.14	3.04
	Diesel	2.91	2.90	2.80	2.46
	CNG	0.00	0.00	0.00	0.00
LDV	Gasoline	3.17	3.18	3.18	3.19
	Diesel	3.86	3.86	3.75	3.42
HDV	Diesel	10.91	10.85	10.33	10.77
Coach	Diesel	11.84	11.69	11.33	11.22
Urban Bus	Diesel	16.22	16.29	15.80	15.37
	CNG	0.00	0.00	0.00	0.00
2-Wheeler	Gasoline	1.11	1.22	1.25	1.28
Average		**3.46**	**3.54**	**3.42**	**3.24**
		100%	**102%**	**99%**	**94%**

Veh. cat.	Fuel	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		MJ/veh-km									
PC	Gasoline	2.99	2.97	2.93	2.90	2.86	2.81	2.77	2.71	2.66	2.61
	Diesel	2.46	2.41	2.40	2.35	2.33	2.30	2.28	2.24	2.21	2.17
	CNG	0.00	0.00	2.91	2.88	2.85	2.83	2.53	2.51	2.49	2.46
LDV	Gasoline	3.19	3.21	3.21	3.20	3.19	3.18	3.17	3.15	3.13	3.10
	Diesel	3.42	3.37	3.34	3.32	3.31	3.31	3.30	3.29	3.26	3.22
HDV	Diesel	10.77	10.71	10.73	10.65	10.59	10.55	10.50	10.46	10.41	10.37
Coach	Diesel	11.22	11.23	11.22	11.18	11.16	11.16	11.15	11.14	11.12	11.11
Urban Bus	Diesel	15.37	15.24	15.23	15.05	14.94	14.81	14.76	14.72	14.68	14.64
	CNG	0.00	0.00	20.34	20.32	20.36	20.58	20.52	20.46	20.38	20.31
2-Wheeler	Gasoline	1.28	1.29	1.31	1.33	1.35	1.34	1.34	1.34	1.34	1.33
Average		**3.24**	**3.20**	**3.17**	**3.12**	**3.07**	**3.03**	**2.99**	**2.94**	**2.89**	**2.85**
		94%	**92%**	**91%**	**90%**	**89%**	**87%**	**86%**	**85%**	**84%**	**82%**

For modelling of cold start and evaporative emissions of passenger cars and light duty vehicles, also vehicle stock and start numbers are used for activity data. The corresponding numbers are summarised in Table 3-51. Vehicle stock figures correspond to registration data. The starts per vehicle are based on specific household surveys (ARE/SFSO 2005).

Table 3-51: Vehicle stock numbers and average number of starts per vehicle per day (PC passenger cars, LDV light duty vehicles).

Veh. Category	1990	1995	2000	2005
	stock in 1000 vehicles			
PC	2'985	3'229	3'545	3'862
LDV	221	238	260	291
2-Wheelers	764	704	732	770
	starts per vehicle per day			
PC	2.61	2.53	2.46	2.40
LDV	1.97	1.97	1.96	1.96
2-Wheelers	1.59	1.54	1.50	1.54

Veh. Category	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	stock in 1000 vehicles									
PC	3'894	3'956	3'990	4'010	4'076	4'195	4'302	4'396	4'477	4'548
LDV	298	307	312	317	326	328	331	334	337	339
2-Wheelers	784	789	804	807	816	815	815	816	818	820
	starts per vehicle per day									
PC	2.39	2.38	2.37	2.35	2.34	2.34	2.33	2.33	2.32	2.32
LDV	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96
2-Wheelers	1.54	1.55	1.56	1.56	1.57	1.57	1.57	1.58	1.58	1.58

3.2.6.2.3 Railways (1A3c)

Methodology (1A3c)

Based on the decision tree Fig. 3.1 in chapter 1A3c Railways of the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013), the exhaust emissions of rail vehicles are calculated by a Tier 3 method with the non-road transportation model described in chp. 3.2.1.1.1.

The entire Swiss railway system is electrified (except some short feeder tracks to private companies). Electric locomotives are used in passenger as well as freight railway traffic. Diesel locomotives are used for shunting purposes in marshalling yards and for construction activities only. Their emissions are quantified as exhaust emissions.

The non-exhaust emissions have been estimated with a separate method documented in SBB (2005) and INFRAS (2007). Several concepts have been applied including mass balances e.g. mass loss of break blocks and wheels, measurements on a test bench, ambient PM10 concentration measurements combined with receptor model. The emissions were quantified as a sum of brake, wheel, track and contact wire abrasion and were split into passenger and freight train origins. For projection purposes, the PM10 emissions were divided into emission factors per person-kilometre (passenger rail-transport) and tonne-kilometre (freight rail transport) and corresponding activity data. The share of PM2.5 was estimated to 15% of the PM10 emissions.

Emission factors (1A3c)

Exhaust emission factors

- Only diesel is being used as fuel, therefore all emission factors refer to diesel except for PM2.5 non-exhaust:

- The emission factors are country-specific. Power class and emission standard specific emission factors are shown in Table 3-52.
- Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated from the difference of VOC and CH_4 emissions.
- For SO_x the emission factors are country- and fuel-specific, see implied emission factors 2015 below and Table 3-8 (column diesel oil)
- PM2.5 non-exhaust emission factors distinguish between passenger and freight rail transport.
- Emission factors for PAH are given in INFRAS (2015a) for diesel oil: BaP 0.5 ng/kWh, BbF 0.4 ng/kWh, BkF 0.6 ng/kWh.
- Details to non-exhaust emission factors can be found in EMIS 2017/1A3c-Schienenverkehr.
- Implied emission factors 2015 are shown inTable 3-53.

Note that all emission factors (in g/hr) of NO_x, NMVOC, PM2.5 (exhaust), CO can be visualised and downloaded (tables in CSV format) by query from the public part of the non-road database INFRAS (2015a). They can be queried by vehicle type, fuel type, power class and emission standard either at aggregated or disaggregated levels.

Table 3-52: Illustration of emission and consumption factors for rail vehicles with diesel engines per emission standard and engine power (PreEU etc.)

engine power	**Pre-EU**	**UIC I**	**UIC II**	**EU IIIA**	**EU IIIB**	***EU V***
	g/kWh					
Carbon monoxide (CO)						
<560 kW	4.0	3.0	2.5	2.5	2.5	*2.5*
>560 kW	4.0	3.0	3.0	3.0	3.0	*3.0*
Hydrocarbons (HC)						
<560 kW	1.60	0.80	0.60	0.40	0.17	*0.17*
>560 kW	1.60	0.80	0.80	0.50	0.40	*0.36*
Nitrogen oxides (NO_X)						
<560 kW	13	12	6	3.2	1.8	*1.8*
>560 kW	16	12	9.5	5.4	3.2	*3.2*
Particulate matter (PM)						
<560 kW	0.600	0.500	0.250	0.180	0.025	*0.025*
>560 kW	0.600	0.500	0.250	0.180	0.025	*0.025*
Fuel consumption						
<560 kW	223	223	223	223	223	*223*
>560 kW	223	223	223	223	223	*223*
Assumptions regarding the introduction of EU emission stages						
<560 kW		2000	2003	2006	2012	*2020*
>560 kW		2000	2003	2009	2012	*2020*

Table 3-53: Implied emission factors in 2015 for 1A3c Railways.

1A3c Railways	**NO_x**	**NMVOC**	**SO_2**	**NH_3**	**PM2.5 ex**	**PM2.5 nx**	**PM10 ex**	**PM10 nx**	**TSP ex**	**TSP nx**	**BC ex**	**BC nx**
Fuel	kg/TJ	kg/TJ	kg/TJ	g/TJ	kg/TJ	g/km	kg/TJ	g/km	kg/TJ	g/km	kg/TJ	g/km
Diesel oil	1005	116	0.5	203	9.2	0.017	9.2	0.109	9.2	0.145	6.5	NA
Biodiesel	874	101	0.4	177	8.0	NE	8.0	NE	8.0	NE	NE	NA

1A3c Railways	**CO**	**Pb**	**Cd**	**Hg**	**BaP**	**BbF**	**BkF**	**IcdP**	**PCDD/PCDF**	**HCB**
Fuel	kg/TJ	g/TJ	g/TJ	g/TJ	mg/TJ	mg/TJ	mg/TJ	mg/TJ	mg/TJ	mg/TJ
Diesel oil	530.7	1.0	NA	NA	64.4	77.3	51.6	20.3	NE	NA
Biodiesel	461.3	0.9	NA	NA	56.0	67.2	44.8	17.7	NE	NA

Activity data (1A3c)

Table 3-53 shows the activity data of 1A3d taken from FOEN (2015j). Detailed activity data can be downloaded from the online database INFRAS (2015a).

Table 3-54: Activity data (diesel oil consumption) for railways. Data in TJ refer to exhaust emissions, whereas data in km refer to non-exhaust emissions.

1A3c Railways	Unit	1990	1995	2000	2005
Diesel	TJ	390	441	455	472
Biodiesel	TJ	NO	NO	0.5	1.5
Total Railways	TJ	390	441	456	474
1990=100%		100%	113%	117%	121%
tonne-kilometers	Mio. km	8'674	8'622	9'680	10'590
passenger-kilometers	Mio. km	13'748	13'748	14'400	15'900

1A3c Railways	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Diesel	TJ	476	480	484	488	492	472	452	432	412	392
Biodiesel	TJ	1.5	1.6	1.7	1.8	1.8	2.3	2.7	3.1	3.5	4
Total Railways	TJ	478	482	486	490	494	474	455	435	415	396
1990=100%		123%	124%	125%	126%	127%	122%	117%	112%	107%	102%
tonne-kilometers	Mio. km	10'772	10'954	11'136	11'318	11'500	11'500	11'500	11'500	11'500	11'500
passenger-kilometers	Mio. km	16'200	16'500	16'800	17'100	17'400	17'400	17'400	17'400	17'400	17'400

3.2.6.2.4 Domestic navigation (1A3d)

Methodology (1A3d)

Based on the decision tree Fig. 3.1 in the chapter 1A3d Navigation-shipping in the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013), the air pollutant emissions are calculated by a Tier 3 method Emissions are calculated in line with the non-road transportation model described in chp. 3.2.1.1.1.

There are passenger ships, dredgers, fishing boats, motor and sailing boats on the lakes and rivers of Switzerland.

On the river Rhine and on the lakes of Geneva and Konstanz, some of the boats cross the border and go abroad (Germany, France). Fuels bought in Switzerland will therefore become bunker fuel. Accordingly, the amount of bunker diesel oil is reported as a memo item “International maritime navigation”. The emissions are calculated with a Tier 1 approach with implied emission factors from domestic navigation. Only diesel oil is concerned from navigating on the river Rhine (FCA 2015a) and of navigating two border lakes (Lake Constance, Lake Geneva) for which bunker fuel consumption was reported in INFRAS (2011a) after having performed surveys among the shipping companies involved.

Emission factors (1A3d)

- Power class and emission standard specific emission factors are shown in Table 3-55 to Table 3-58 (FOEN 2015j).
- Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated from the difference of VOC and CH_4 emissions.
- For SO_x the emission factors are country- and fuel-specific, see implied emission factors 2015 below and Table 3-8 (column diesel oil).
- Emission factors for PAH are given in INFRAS (2015a) for diesel oil: BaP 0.5 ng/kWh, BbF 0.4 ng/kWh, BkF 0.6 ng/kWh.
- Implied emission factors 2015 are shown in Table 3-59.

Table 3-55: Emission factors for diesel-powered ships

engine power	Pre-SAV	SAV	EU I	EU II	EU IIIA	*EU V*
	g/kWh					
Carbon monoxide (CO)						
<18 kW	6.7	6.7	6.7	6.7	6.7	6.7
18–37 kW	6.7	6.7	6.7	6.7	6.7	6.7
37–75 kW	5.9	5.9	5.9	4.5	4.5	4.5
75–130 kW	5.0	5.0	4.5	4.5	4.5	4.5
130–300 kW	5.0	5.0	4.5	4.5	4.5	3.15
300–560 kW	5.0	5.0	4.5	4.5	4.5	3.15
>560 kW	5.0	5.0	4.5	4.5	4.5	3.15
Hydrocarbons (HC)						
<18 kW	10	7.2	5.0	3.0	2.0	2.0
18–37 kW	10	7.2	5.0	3.0	2.0	2.0
37–75 kW	10	5.4	1.2	1.2	1.1	0.42
75–130 kW	10	4.1	1.2	0.9	0.8	0.49
130–300 kW	5.0	3.6	1.2	0.9	0.8	0.80
300–560 kW	5.0	3.2	1.2	0.9	0.8	0.17
>560 kW	5.0	2.8	1.2	0.9	0.8	0.17
Nitrogen oxides (NO_X)						
<18 kW	10.3	10.3	10.3	10.3	10.3	10.3
18–37 kW	10.3	10.3	10.3	10.3	10.3	10.3
37–75 kW	12.4	12.4	8.3	6.3	5.7	4.23
75–130 kW	12.5	12.5	8.3	6.3	5.7	4.86
130–300 kW	12.5	12.5	8.3	6.3	5.7	2.10
300–1000 kW	12.5	12.5	8.3	6.3	5.7	1.20
>1000 kW	12.5	12.5	8.3	6.3	5.7	0.40
Particulate matter (PM)						
<18 kW	1.50	1.20	1.00	0.80	0.70	0.70
18–37 kW	1.20	0.90	0.74	0.60	0.54	0.54
37–75 kW	1.10	0.58	0.77	0.36	0.36	0.30
75–130 kW	0.60	0.47	0.63	0.27	0.27	0.14
130–300 kW	0.60	0.47	0.49	0.18	0.18	0.11
300–1000 kW	0.60	0.47	0.49	0.18	0.18	0.02
>1000 kW	0.60	0.47	0.49	0.18	0.18	0.01
Fuel consumption						
<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
Assumptions regarding introduction of emission stages						
All capacities	(<1995)	1995	2003	2008	2009	2019

Table 3-56: Emission factors for diesel-powered boats.

engine power	Pre-SAV	SAV	EU I	EU II
	g/kWh			
Carbon monoxide (CO)				
<4.4 kW	6.7	6.7	4.5	4.5
4.4–7.4 kW	6.7	6.7	4.5	4.5
7.4–37 kW	6.7	6.7	4.5	4.5
37–74 kW	5.9	5.9	4.5	4.5
74–100 kW	5.0	5.0	4.5	4.5
>100 kW	5.0	3.6 (6%)	3.6	3.6
Hydrocarbons (HC)				
<4.4 kW	10	10	2.4	2.40
4.4–7.4 kW	10	10	2.1	2.10
7.4–37 kW	10	2.0 (23%)	1.7	1.70
37–74 kW	10	1.4 (23%)	1.4	0.42
74–100 kW	10	1.2 (23%)	1.2	0.52
>100 kW	5	1.2 (30%)	1.2	0.52
Nitrogen oxides (NO_X)				
<4.4 kW	13	11	8.8	8.80
4.4–7.4 kW	13	11 (71%)	8.8	8.80
7.4–37 kW	13	11 (71%)	8.8	8.80
37–74 kW	13	11 (71%)	8.8	4.23
74–100 kW	13	11 (71%)	8.8	5.22
>100 kW	13	11 (73%)	8.8	5.22
Particulate matter (PM)				
<4.4 kW	1.5	1.2	0.9	0.9
4.4–7.4 kW	1.5	1.2	0.9	0.9
7.4–37 kW	1.2	1.1	0.9	0.9
37–74 kW	1.1	1.0	0.9	0.3
74–100 kW	0.9	0.9	0.9	0.15
>100 kW	0.9	0.9	0.9	0.15
Fuel consumption				
<4.4 kW	400	400	400	400
4.4–7.4 kW	400	400	400	400
7.4–37 kW	400	380	380	380
37–74 kW	380	350	350	350
74–100 kW	400	330	330	330
>100 kW	300	300	300	300
Assumptions regarding the introduction of emission stages				
All pow. classes	(<1995)	1995	2007	2015

Table 3-57: Emission factors for gasoline-powered boats.

engine power	2-stroke gasloline engines			4-stroke gasoline engines		
	g/kWh					
	Pre-SAV	SAV	SAV/EU	Pre-SAV	SAV	EU
Carbon monoxide (CO)						
<4.4 kW	645	315	315	350	315	315
4.4–7.4 kW	645	200 (79%)	225	350	200 (79%)	225
7.4–37 kW	645	100 (79%)	162	350	100 (79%)	162
37–74 kW	645	65 (79%)	144	350	65 (79%)	144
74–100 kW	645	55 (79%)	141	350	55 (79%)	141
>100 kW	645	45 (73%)	139	350	45 (73%)	139
Hydrocarbons (HC)						
<4.4 kW	260	22	25	25	22	25
4.4–7.4 kW	260	12 (66%)	13	20	12 (66%)	13
7.4–37 kW	260	6.0 (66%)	8	20	6.0 (66%)	8
37–74 kW	260	4.0 (66%)	6	20	4.0 (66%)	6
74–100 kW	260	3.3 (66%)	5	20	3.3 (66%)	5
>100 kW	260	2.1 (52%)	5	20	2.1 (52%)	5
Nitrogen oxides (NO_X)						
<4.4 kW	15	13	13	3.5	13	13
4.4–7.4 kW	15	9.3 (62%)	9.3	3.5	9.3 (62%)	9.3
7.4–37 kW	15	9.3 (62%)	9.3	3.5	9.3 (62%)	9.3
37–74 kW	15	9.3 (62%)	9.3	3.5	9.3 (62%)	9.3
74–100 kW	15	9.3 (62%)	9.3	3.5	9.3 (62%)	9.3
>100 kW	15	9.6 (64%)	9.6	3.5	9.6 (64%)	9.6
Fuel consumption						
<4.4 kW	700	400	400	400	400	400
4.4–7.4 kW	700	400	400	400	400	400
7.4–37 kW	650	380	380	380	380	380
37–74 kW	650	380	380	380	380	380
74–100 kW	650	380	380	380	380	380
>100 kW	650	380	380	380	380	380
Assumptions regarding the introduction of emission stages						
All capacities	(<1995)	1995	2007	(<1995)	1995	2007
Source of consumption factors: SAEFL, 1996a						

Table 3-58: Emission factors for steam-powered vessels.

Pollutant	Steam 1	Steam 2	Steam 3	Steam 4	Steam 5	Steam 6	Steam 7
	g/kWh						
CO	0.30	0.30	0.30	0.09	0.09	0.09	0.09
HC	0.449	0.449	0.449	0.330	0.330	0.330	0.330
NO_X	2.336	2.336	2.336	1.770	1.558	1.257	1.027
PM2.5	0.033	0.024	0.015	0.009	0.006	0.006	0.006
Fuel cons.	1406	1115	1115	1115	1115	1115	1115
Assumptions regarding the date of introduction of improvements of steamships							
All classes	<1950	1950	1980	1990	1995	2000	2005

Table 3-59: Implied emission factors in 2015 for 1A3d Navigation.

1A3d Navigation	NO_X	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	kg/TJ								
Gasoline	542	368	0.67	0.13	0.55	0.55	0.55	0.028	7'471
Diesel oil	933	293	0.47	0.20	43.5	43.5	43.5	23.0	533
Gas oil	26.4	1.6	12.4	0.042	0.13	0.13	0.13	0.073	6.9
Biodiesel	811	255	0.40	0.17	37.8	37.8	37.8	NE	463
Bioethanol	343	221	0.24	0.083	NA	NA	NA	NA	4'619

1A3d Navigation	Pb	Cd	Hg	BaP	BbF	BkF	IcdP	PCDD/PCDF	HCB
	g/TJ			mg/TJ					
Gasoline	284	NA	NA	NA	NA	NA	NA	NA	NA
Diesel oil	0.98	NA	NA	58.9	70.7	47.1	19.6	NA	NA
Gas oil	NA	NA	NA	NA	NA	NA	NA	NA	NA
Biodiesel	0.85	NA	NA	51.2	61.4	40.9	17.0	NA	NA
Bioethanol	179	NA	NA	NA	NA	NA	NA	NA	NA

Note that all emission factors (in g/hr) of NO_x, NMVOC, PM2.5 (exhaust), CO can be visualised and downloaded (tables in CSV format) by query from the public part of the non-road database INFRAS (2015a). They can be queried by vehicle type, fuel type, power class and emission standard either at aggregated or disaggregated levels.

Activity data (1A3d)

Table 3-60 shows the activity data of 1A3di taken from FOEN (2015j). Detailed activity data can be downloaded from the online database INFRAS (2015a).

Table 3-60: Activity Data for domestic navigation.

1A3d Domestic navigation	Unit	1990	1995	2000	2005
Gasoline	TJ	701	654	616	565
Diesel	TJ	738	724	792	800
Gas oil	TJ	110	139	147	150
Biodiesel	TJ	NO	NO	1	2
Bioethanol	TJ	NO	NO	NO	0.1
Total Domestic navigation	TJ	1'550	1'517	1'556	1'518
1990 = 100%		100%	98%	100%	98%

1A3d Domestic navigation	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Gasoline	TJ	559	553	547	541	534	529	524	518	513	508
Diesel	TJ	814	827	841	855	868	871	874	877	879	882
Gas oil	TJ	152	154	155	157	159	157	156	154	153	151
Biodiesel	TJ	3	3	3	3	3	4	5	7	8	9
Bioethanol	TJ	0.1	0.1	0.1	0.2	0.2	2	4	6	8	10
Total Domestic navigation	TJ	1'527	1'537	1'546	1'556	1'565	1'564	1'563	1'562	1'561	1'560
1990 = 100%		99%	99%	100%	100%	101%	101%	101%	101%	101%	101%

3.2.6.2.5 Other transportation – pipeline compressors (1A3e)

Methodology (1A3e)

For source 1A3e Pipeline Compressor, the emissions of main pollutants, particulate matter, CO, Hg and PCDD/PCDF from a compressor station located in Ruswil are considered.

The emissions are calculated with a Tier 2 method (note that the EMEP/EEA Guidebook 2013 does not contain a decision tree to determine theTier level specifically) using country-specific emission factors.

Emission factors (1A3e)

The emission factors are used as for gas turbines (see Table 3-32) and are are based on different sources which are listed in the section “Gasturbinen; Erdgas” of SAEFL (2000).

Table 3-61: Emission factors of 1A3e for 2015.

1A3ei Pipeline transport	Pollutant	Fuel	Unit	Emission factor 2015
	NO_x	Gas	g/GJ	60
	NMVOC	Gas	g/GJ	0.1
	SO_2	Gas	g/GJ	0.5
	NH_3	Gas	g/GJ	0.6
	PM2.5 exh.	Gas	g/GJ	0.2
	PM10 exh.	Gas	g/GJ	0.2
	TSP exh.	Gas	g/GJ	0.2
	BC exh.	Gas	g/GJ	NA
	CO	Gas	g/GJ	15
	Hg	Gas	mg/GJ	0.2
	PCDD/PCDF	Gas	ng/GJ	0.03

Activity data (1A3e)

The data on fuel consumption for the operation of the compressor station in Ruswil is based on the Swiss overall energy statistics (SFOE 2016; Table 17).

Table 3-62: Activity data of 1A3e.

1A3ei Pipeline transport	Unit	1990	1995	2000	2005
Natural gas	TJ	560	310	340	1'070
1990=100%		100%	55%	61%	191%

1A3ei Pipeline transport	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Natural gas	TJ	1'700	1'430	1'460	950	830	840	810	410	830	760
1990=100%		304%	255%	261%	170%	148%	150%	145%	73%	148%	136%

3.2.6.3 Category-specific recalculations for 1A3 Transport

- 1A3a: Particulate matter emissions estimations have been updated. New and considerably lower emission factors for non-exhaust emissions have been used for a recalculation of PM2.5, PM10 and TSP for the years 1990-2014.
- 1A3a: As recommended by the ERT during the stage 3 review (UNECE 2016a), there are no more CH_4 emissions for cruise activities. This implies that the NMVOC emissions for cruise activities are increasing correspondingly.
- 1A3b/1A3d: Small recalculation due to a change in the NCV of diesel used in international navigation to equalise with other diesel processes. Therefore, small changes occurred 1990-2014 in fuel tourism and statistical difference for diesel which is integrated in 1A3biii.

3.2.7 Source category 1A4 - Non-road mobile sources and machinery

3.2.7.1 Source category description for 1A4 – Non-road mobile sources and machinery

Table 3-63: Specification of source category 1A4 – Non-road mobile sources and machinery).

1A4	Source	Specification
1A4aii	Commercial/institutional: Mobile	Emission from non-road vehicles (professional gardening) and motorised equipment
1A4bii	Residential: Household and gardening (mobile)	Emissions from mobile machinery (hobby, gardening) and motorised equipment
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	Emisions from non-road vehicles and machinery in agriculture and forestry

Table 3-64: Key Categories, level 2015 (L1) and trend 1990-2015 (T1), for source categories 1A4 – Non-road mobile sources and machinery.

NFR	Source Category	Pollutant	Identification Criteria
1A4cii	Off Road Machinery	NOx	L1, T1
1A4cii	Off Road Machinery	PM10	L1, T1
1A4cii	Off Road Machinery	PM2.5	L1, T1

3.2.7.2 Methodological issues for 1A4 Non-road mobile sources and machinery

Methodology (1A4)

Based on the decision tree Fig. 3.1 in chapter 1A4 Non-road mobile sources and machinery of the EMEP Guidebook 2013 (EMEP/EEA 2013), the emissions of mobile combustion in 1A4 Other sectors are calculated by a Tier 3 method with the non-road transportation model described in chp. 3.2.1.1.1.

Emission factors (1A4)

In the categories 1A4a ii and 1A4b ii only gasoline and bioethanol being used as fuel. In category 1A4c ii mainly diesel oil is consumed and only small amounts of gasoline (e.g. chainsaws) and biodiesel.

- The emission factors are country-specific. Power class and emission standard specific emission factors are shown in Table 3-38 to Table 3-40 (see chp. 3.2.5.2).
- Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated from the difference of VOC and CH_4 emissions.
- For SO_x the emission factors are country- and fuel-specific, see implied emission factors 2015 below and Table 3-8 (column gasoline, diesel oil).
- PM2.5 non-exhaust emission factors apply for vehicles in agriculture and forestry.
- Emission factors for PAH are given in INFRAS (2015a) for diesel oil: BaP 0.5 ng/kWh, BbF 0.4 ng/kWh, BkF 0.6 ng/kWh.
- Implied emission factors 2015 for all pollutants are shown in Table 3-65.

Note that all emission factors (in g/hr) of NO_x, NMVOC, PM2.5 (exhaust), CO can be visualised and downloaded (tables in CSV format) by query from the public part of the non-road database INFRAS (2015a). They can be queried by vehicle type, fuel type, power class and emission standard either at aggregated or disaggregated levels.

Table 3-65: Implied emission factors 1A4 Other sectors (mobile) in 2015.

Source/fuel	NO_x	NMVOC	SO_2	NH_3	PM2.5 ex	PM2.5 nx	PM10 ex	PM10 nx	TSP ex	TSP nx	BC ex	BC nx
	kg/TJ	kg/TJ	kg/TJ	g/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ	kg/TJ
1A4aii Other sectors (mobile): Commercial/institutional												
Gasoline	185	1'500	5.2	102	NA	IE	NA	IE	NA	IE	NA	IE
1A4bii Other sectors (mobile): Residential												
Gasoline	159	25'023	2	102	NA	IE	NA	IE	NA	IE	NA	IE
Bioethanol	94	493	0.2	65	NA	NA	NA	NA	NA	NA	NA	NA
1A4cii Other sectors (mobile): Agriculture/forestry/fishing												
Gasoline	174	1'645	4	93	NA	451	NA	3'009	NA	4'514	NA	1
Diesel	518	61	0.5	172	48	IE	48	IE	48	IE	38	IE
Biodiesel	450	53	0.4	150	41	IE	41	IE	41	IE	NE	IE
Bioethanol	83	687	0.2	58	NA	IE	NA	IE	NA	IE	NA	IE

Source/fuel	CO	Pb	Cd	Hg	BaP	BbF	BkF	IcdP	PCDD/PCDF	HCB
	kg/TJ	g/TJ	g/TJ	g/TJ	mg/TJ	mg/TJ	mg/TJ	mg/TJ	mg/TJ	mg/TJ
1A4aii Other sectors (mobile): Commercial/institutional										
Gasoline	26'422	296	NA	NA	NA	NA	NA	NA	NA	NA
1A4bii Other sectors (mobile): Residential										
Gasoline	25'023	269	NA	NA	NA	NA	NA	NA	NA	NA
Bioethanol	15'311	163	NA	NA	NA	NA	NA	NA	NA	NA
1A4cii Other sectors (mobile): Agriculture/forestry/fishing										
Gasoline	23'900	258	NA	NA	NA	NA	NA	NA	NA	NA
Diesel	307	0.9	NA	NA	49	58.8	39	17.2	NA	NA
Biodiesel	267	0.7	NA	NA	43	51.1	34	15.0	NA	NA
Bioethanol	14'434	144	NA	NA	NA	NA	NA	NA	NA	NA

Activity data (1A4)

Table 3-66 shows the activity data of 1A4 – Non-road mobile sources and machinery taken from FOEN (2015j). Detailed activity data can be downloaded from the online database INFRAS (2015a).

Table 3-66: Activity Data for 1A4 Other sectors (mobile).

Source/Fuel	Unit	1990	1995	2000	2005
1A4aii Other sectors (mobile): Commercial/institutional	TJ	191	245	295	295
Gasoline	TJ	191	245	295	295
1A4bii Other sectors (mobile): Residential	TJ	142	155	165	166
Gasoline	TJ	142	155	165	165
Bioethanol	TJ	NO	NO	NO	0.01
1A4cii Other sectors (mobile): Agriculture/forestry/fishing	TJ	5'429	5'674	5'889	5'642
Gasoline	TJ	1'160	1'070	963	823
Diesel	TJ	4'269	4'604	4'921	4'804
Biodiesel	TJ	NO	NO	5	15
Bioethanol	TJ	NO	NO	NO	0.06

Source/Fuel	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1A4ai Other sectors (mobile): Commercial/institutional	TJ	293	292	290	288	287	280	272	265	258	251
Gasoline	TJ	293	292	290	288	287	280	272	265	258	251
1A4bii Other sectors (mobile): Residential	TJ	165	164	164	163	163	162	161	160	159	158
Gasoline	TJ	165	164	164	163	163	161	160	158	156	155
Bioethanol	TJ	0.02	0.03	0.04	0.05	0.06	0.59	1.1	1.7	2.2	2.7
1A4cii Other sectors (mobile): Agriculture/forestry/fishing	TJ	5'632	5'622	5'612	5'602	5'592	5'573	5'554	5'535	5'516	5'497
Gasoline	TJ	797	770	743	716	689	664	638	613	588	562
Diesel	TJ	4'820	4'836	4'852	4'868	4'884	4'883	4'881	4'880	4'878	4'876
Biodiesel	TJ	16	16	17	17	18	24	31	37	43	49
Bioethanol	TJ	0.09	0.12	0.14	0.17	0.20	1.8	3.5	5.1	6.8	8.4

3.2.7.3 Category-specific recalculations for 1A4 – Non-road mobile sources and machinery

No recalculations were carried out for source category 1A4a ii, 1A4b ii, 1A4c ii (mobile).

The ERT noted during the Stage 3 review that the IEF for NMVOC, CO, PM2.5 from the non-road sector are much higher compared to other developed countries. Switzerland explained that only garden care and hobby mobile machinery are included in source categories 1A4a ii and 1A4b ii and they consume gasoline only, and indeed consist mainly of 2-stroke gasoline engines, which explains that the relatively high IEF is justified. (The ERT encouraged the Party to include the explanation of this issue in the IIR.)

3.2.8 Source category 1A5b - Other, mobile (Military)

3.2.8.1 Source category description for 1A5b Other, mobile (Military)

Table 3-67: Specification of source category 1A5 Other, mobile (Military)

1A5	Source	Specification
1A5bi	Military aviation	Emissions from military aircrafts
1A5bii	Military non-road vehicles and machines	Emissions from machines like power generators, tanks, bulldozers, boats etc.

Source category 1A5 “Other, mobile (Military) is not a key category.

3.2.8.2 Methodological issues for 1A5b Other, mobile (Military)

1A5bi military aviation

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

1A5bii military non-road vehicles and machines

Based on the decision tree Fig. 3.1 in chapter 1A4 Non-road mobile sources and machinery of the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013), the emissions of military non-road vehicles and machines are calculated by a Tier 3 method with the non-road transportation model described in chp. 3.2.1.1.1.

Emission factors (1A5b)

Emissions factors 1A5bi military aviation

- 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 2000. For 1991-1999 the values are linearly interpolated between 1990 and 2000. For 2001-2015, the values 2000 are used.
- 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 1996-2015, the values 1995 are used. The division of VOC into CH_4 and NMVOC is carried out by a constant split of 10% to 90% (country-specific).
- SO_x: emission factor is taken from the IPCC Guidelines 2006, 23.3 kg/TJ, and is assumed to be constant over the period 1990–2015 (IPCC 2006).

- Implied emission factors 2015 are shown in Table 3-68.

Emission factors of military non-road vehicles and machines

- The emission factors are country-specific.
- Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated as the difference of VOC and CH_4 emissions.
- SO_x emission factors are country-specific and provided in Table 3-8.
- Emission factors for PAH are given in INFRAS (2015a) for diesel oil: BaP 0.5 ng/kWh, BbF 0.4 ng/kWh, BkF 0.6 ng/kWh.
- Implied emission factors 2015 are shown in Table 3-68.

Note that all emission factors (in g/hr) of NO_x, NMVOC, PM2.5 (exhaust), CO can be visualised and downloaded (tables in CSV format) by query from the public part of the non-road database INFRAS (2015a). They can be queried by vehicle type, fuel type, power class and emission standard either at aggregated or disaggregated levels.

Table 3-68: Emission factors for 1A5b Other (Military, mobile) 2015.

1A5b Other: Military (mobile)	NO_x	NMVOC	SO_2	NH_3	PM2.5 ex	PM2.5 nx	PM10 ex	PM10 nx	TSP ex	TSP nx	BC ex	BC nx
	kg/TJ											
Gasoline	134	827	1.8	0.11	NA	NA	NA	NA	NA	NA	NA	NA
Kerosene	133	32	23.3	NA	2.8	0.9	2.8	6.2	2.8	9.3	1.4	NA
Diesel	465	37	0.5	0.17	9.8	NA	9.8	NA	9.8	NA	5.7	NA
Biodiesel	404	32	0.4	0.15	8.5	NA	8.5	NA	8.5	NA	NA	NA
Bioethanol	72	305	0.2	0.07	NA	NA	NA	NA	NA	NA	NA	NA

1A5b Other: Military (mobile)	CO	Pb	Cd	Hg	BaP	BbF	BkF	IcdP	PCDD/PCDF	HCB
	kg/TJ	g/TJ			mg/TJ					
Gasoline	24'077	267.4	NA	NA	NA	NA	NA	NA	NA	NA
Kerosene	672	NA	NA	NA	NA	NA	NA	NA	NA	NA
Diesel	194	0.86	NA	NA	48	57	38	17	NA	NA
Biodiesel	169	0.75	NA	NA	41	50	33	15	NA	NA
Bioethanol	15'052	163.8	NA	NA	NA	NA	NA	NA	NA	NA

Activity data (1A5b)

The fuel consumption of 1A5bi Military aviation is copied from the logbooks of the military aircrafts, is summed up yearly by DDPS (2016) and provided to FOEN.

The fuel consumption of 1A5bii military non-road vehicles and machines is based on activity data provided by DDPS (2014a) and calculated bottom-up by the non-road transportation model (chp. 3.2.1.1.1). Detailed activity data can be downloaded from the online database INFRAS (2015a).

Table 3-69 shows activity data of both categories 1A5bi and 1A5bii.

Table 3-69: Activity data (fuel consumption) for 1A5b Other (Military, mobile).

1A5b	1990	1995	2000	2005
	fuel consumption in TJ			
Military aviation				
Jet kerosene	2'733	1'955	1'794	1'624
Military non-road	239	248	252	257
Gasoline	19	19	19	19
Diesel oil	220	228	233	238
Biodiesel	NO	NO	0.3	0.7
Bioethanol	NO	NO	NO	0.002

1A5b	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	fuel consumption in TJ									
Military aviation										
Jet kerosene	1'676	1'577	1'505	1'529	1'592	1'420	1'527	1'542	1'615	1'567
Military non-road	261	265	268	272	275	275	275	275	275	275
Gasoline	19	19	18	18	18	18	17	17	17	17
Diesel oil	241	245	249	253	256	256	256	256	255	255
Biodiesel	0.8	0.8	0.9	0.9	1.0	1.3	1.6	1.9	2.3	2.6
Bioethanol	0.003	0.004	0.004	0.01	0.01	0.1	0.1	0.2	0.2	0.3

3.2.8.3 Category-specific recalculations for 1A5b Other, mobile (Military)

No recalculations were carried out for source category 1A5b Other, mobile (Military).

3.3 Source category 1B - Fugitive emissions from fuels

3.3.1 Source category 1B1 - Fugitive emissions from solid fuels

3.3.1.1 Source category description for 1B1 – Fugitive emissions from solid fuels

Table 3-70: Specification of source category 1B1a Coal mining and handling.

1B1	Source	Specification
1B1 a	Coal mining and handling	PM emissions from handling of coal.

Source category 1B1 Fugitive emission from solid fuels is not a key category.

3.3.1.2 Methodological issues for 1B1 – Fugitive emissions from solid fuels

Methodology (1B1)

There is no coal mining in Switzerland and therefore only PM emissions from coal handling occur.

Based on EMEP/EEA (2013), emissions from coal handling are determined by a Tier 2 method using technology-specific activity data and emission factors.

Emission factors (1B1)

Emission factors for PM10 are based on EMEP/EEA (2013).

Table 3-71: Emission factors in 1B1 Fugitive emissions from solid fuels in 2015.

1B1 Fugitive emissions from solid fuels	Pollutant	Fuel	Unit	Emission factor
1B1a Coal handling	PM2.5 nonexh.	Other bituminous coal imported	g/t	0.3
	PM10 nonexh.	Other bituminous coal imported	g/t	3.0
	PM nonexh.	Other bituminous coal imported	g/t	7.5
	BC nonexh.	Other bituminous coal imported	g/t	0.18

Activity data (1B1)

Activity data are provided by the energy model as described in chapter 3.1.6.4 and are based on the Swiss overall energy statistics (SFOE 2016).

Table 3-72: Activity data in 1B2 Fugitive emissions from solid fuels

1B1 Fugitive emissions from solid fuels	Fuel	Unit	1990	1995	2000	2005
1B1a Coal handling	Other bituminous coal imported	t	534'938	286'007	210'347	232'974

1B1 Fugitive emissions from solid fuels	Fuel	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1B1a Coal handling	Other bituminous coal imported	t	260'129	290'286	261'466	247'002	248'060	234'226	210'357	226'520	241'331	221'661

3.3.1.3 Category-specific recalculations for 1B1 Fugitive emissions from solid fuels

- The emission factors are taken from the EMEP/EEA Guidebook (EMEP/EEA 2013).

3.3.2 Source category 1B2 - Fugitive emissions from oil and natural gas, venting/flaring

3.3.2.1 Source category description for 1B2 Fugitive emissions from oil and natural gas, venting/flaring

Within this source category, fugitive emissions from the production, processing, transmission, storage and use of fuels are reported. According to the EMEP/EEA Guidebook (EMEP/EEA 2013) transport vehicle emissions whilst travelling are negligible because the vapour and pressure retention capability of the tank or compartment will be above the level at which breathing will be induced by the temperature variations that may occur.

Table 3-73: Specification of source category 1B2 Fugitive Emissions from oil and natural gas venting and flaring.

1B2	Source	Specification
1B2a iv	Fugitive emissions from oil	Refining and storage of oil. Claus-units in refineries
1B2a v	Distribution of oil products	Distribution of oil products including transport of crude oil.
1B2b	Fugitive emissions from natural gas	Fugitive emissions from natural gas (production, processing, transmission, storage, distribution and other)
1B2c	Venting and flaring (oil, gas, combined oil and gas)	The release/combustion of excess gas at the oil refinery.

Table 3-74: Key Category trend 1990-2015, for source category 1B2 Oil and Natural Gas

NFR	Source Category	Pollutant	Identification Criteria
1B2av	Distribution of Oil Products	NMVOC	T1

3.3.2.2 Methodological issues for 1B2 Oil, natural gas, venting/flaring

Methodology (1B2)

1B2a Fugitive emissions from oil

In Switzerland, oil production is not occurring. Fugitive emissions in the oil industry result exclusively from the two refining plants and several fuel handling stations. At the beginning of 2015 one of the refining plants ceased its operation. The length of the two oil pipelines in Switzerland are approximately 40 km and 70 km, respectively. The pipelines are mainly laid underground.

Following the decision tree in EMEP/EEA (2013), emissions reported under 1B2 a iv are estimated using a Tier 2 approach where technology-specific activity data and emission factors are available. This source category also encompasses the SO_2 emissions from Claus-units. An analogous Tier 2 method with country-specific emission factors is used to calculate the emissions.

Following the decision tree in EMEP/EEA (2013), emissions reported under 1B2 a v are estimated using a Tier 2 approach where technology-specific activity data and emission factors are available.

1B2b Fugitive emissions from natural gas

In source category 1B2b Fugitive emissions from natural gas, only NMVOC emissions are reported.

Emissions under 1B2b ii Gas production occur only between 1985 and 1994 because the only production site was closed in 1994. According to the decision tree in EMEP/EEA (2013), emissions resulting under 1B2b ii are estimated using a Tier 2 approach where technology specific activity data and specific emission factors are available.

For emission calculations from source category 1B2b iv, 1B2b v and 1B2b vi country-specific emission factors and activity data are available. Emissions are calculated with a country-specific method which first assesses the losses of natural gas in the gas network including pipelines, fittings and gas devices, as these data represent the activity data. Based on the gas losses, NMVOC emissions are calculated with country-specific emission factors which reflect the compostion of the gas lost.

Emissions from gas transmission (source category 1B2b iv) include emissions from transport pipelines including the transit pipeline and the single compressor station. Emissions comprise leakages from gas pipelines, small-scale damages, maintenance work and leakages of pipeline fittings. Gas storages are considered as components of the distribution network and the respective emissions are included in source category 1B2b v.

Source category 1B2b v Distribution covers emissions from the gas distribution pipelines and network components (e.g. control units, fittings and gas meters) as well as fugitive emissions at the end users. Emission calculations for the gas distribution network are based on the length, material and pressure of the gas pipelines. Fugitive emissions at the end users arise from on-site and indoor pipelines and the permanent leakiness of the different gas appliances in households, industry and natural gas fuelling stations. In the calculations, the number and kind of end users and connected gas appliances are considered.

This method follows a Tier 2 approach according to the decision in EMEP/EEA (2013). Emissions in source category 1B2b vi are provided by Quantis (2014) based on data from accident reports and emission reports from the gas pipeline operators. This method follows a Tier 2 approach according to the decision tree in EMEP/EEA (2013).

Losses from consumption in households and industry are already included in the losses from gas transmission reported in source category 1A.

1B2c Fugitive emissions from venting and flaring

Following the decision tree in EMEP/EEA (2013), emissions reported under 1B2c are estimated using a Tier 3 approach where plant-specific activity data are available. In Switzerland, flaring only occurs in refineries and there is no venting. One of the two refineries in Switzerland ceased its operation at the beginning of 2015.

Emission factors (1B2)

1B2a Fugitive emissions from oil

The emission factors of NMVOC for 1B2a iv are country-specific and are documented in the EMIS database (EMIS 2017/1 B 2 a iv_Raffinerie, Leckverluste)

The emission factors of NMVOC from 1B2a v are country-specific and are provided by Weyer und Partner (Schweiz) AG using a database of Swiss storage tanks and gasoline vapour recovery systems. The model is calibrated with spot checks of the gas recovery systems of gas stations. Further information is provided in the EMIS database (EMIS 2017/1B2a v Benzinumschlag Tanklager, EMIS 2017/1B2a v Benzinumschlag Tankstellen).

For emissions from Claus-units, the emission factors per tonne of crude oil are based on data from the handbook on emission factors for stationary sources (SAEFL 2000).

1B2b Fugitive emissions from natural gas

Emission factors of NMVOC for 1B2biv and v (gas transmission and distribution) as well as emissions from accidents in the gas pipeline are based on a study by Quantis (2014).

For natural gas production, NMVOC default emission factors are taken from the 2006 IPCC Guidelines (IPCC 2006) as documented in the internal emission database documentation (EMIS 2017/1B2b Gasproduktion).

Emission factors for transmission, distribution and other leakages (source category 1B2b iv 1B2b v and 1B2b vi) are calculated based on the average NMVOC concentrations of natural gas and its average lower calorific value in Switzerland as described in Quantis (2014) and in the EMIS database (EMIS 2017/1B2b Diffuse Emissionen Erdgas). Since Submission 2017, the lower calorific value of natural gas in Switzerland is evaluated annually by the Swiss Gas and Water Industry Association (SGWA).

1B2c Fugitive emissions from venting and flaring

Emission factors of 1B2c2 Venting and flaring are based on data from the refining industry as documented in the EMIS database (EMIS 2017/1B2c Raffinerie Abfackelung). Since 2005 (with the exception of 2012), the refining industry provides annual data on the CO_2 emissions from flaring under the Federal Act on the Reduction of CO_2 Emissions (Swiss Confederation 2011) based on daily measurements of CO_2 emission factors of the flared gases. From these data annual CO_2 emission factors are derived. Since 2005, the evolution of the other emission factors (NO_x, NMVOC, SO_2, CO) is assumed to be proportional to the CO_2 emission factor. Emission factors for 2015 are considered confidential and are available to reviewers on request.

Table 3-75: Emission factors in 1B2 Fugitive emissions from oil and natural gas in 2015.

1B2 Fugitive emissions from oil, natural gas and other fossil fuels	Pollutant	Fuel	Unit	Emission factor
1B2a Gasoline distribution	NMVOC	Gasoline sold	g/GJ	16
1B2a Refinery	NMVOC	Crude oil used	g/t	430
1B2a Refinery	NMVOC	Crude oil transported	g/t	66
1B2a Refinery Claus units	SO_2	Crude oil	g/t	38
1B2b Gas distribution losses, Transit	NMVOC	Natural gas	g/GJ	1'434
1B2b Gas distribution losses, Distribution	NMVOC	Natural gas	g/GJ	1'434
1B2b Gas distribution losses, Other	NMVOC	Natural gas	g/GJ	1'434
1B2c2 Venting and flaring	NO_x	Crude oil used	g/t	C
	NMVOC	Crude oil used	g/t	C
	SO_2	Crude oil used	g/t	C
	CO	Crude oil used	g/t	C

Activity data (1B2)

1B2a Fugitive emissions from oil

Activity data for 1B2a iv are based on the use and transport of crude oil. The Swiss petroleum association provides data on an annual basis (EV 2016).

The activity data for 1B2a v fugitive emissions from storage tanks and gasoline stations are gasoline sales based on the Swiss overall energy statistics (SFOE 2016), corrected for consumption of Liechtenstein, as documented in the EMIS database (EMIS 2017/1B2a v Benzinumschlag Tanklager, EMIS 2017/1B2a v Benzinumschlag Tankstellen). Activity data of the crude oil for the “Claus units” are based on data from the Swiss petroleum association (EV 2016) and the Swiss overall energy statistics (SFOE 2016).

1B2b Fugitive emissions from natural gas

For gas transmission (1B2b iv), distribution (1B2v), and other leakage (1B2b vi), the activity data have been reassessed in a recent study by Quantis (2014) and are documented in the EMIS database (EMIS 2017/1B2b Diffuse Emissionen Erdgas). The activity data represent the amount of natural gas lost from the gas network.

For source categories 1B2b iv and 1B2b v, information regarding the gas transport and distribution network from the Swiss Gas and Water Industry Association (SGWA) is used to derive the activity data (see Quantis 2014 and EMIS 2017/1B2b Diffuse Emissionen Erdgas).

For transmission pipelines a constant emission factor per pipeline length is applied accounting for losses from purging and cleaning flows, pipeline damages and leaky fittings and mountings. For the one compressor station a constant emission rate based on the physical power of the turbines is employed including emissions due to shutting down and starting of the gas turbines, leakages at regulating valves and fittings, maintenance and gasometry work.

The calculation of losses from source category 1B2b v Distribution follows a detailed country-specific approach that considers losses from the pipeline network as well as losses at the end users.

The calculated gas losses from the pipeline network depend on the length, material and pressure of the pipelines. Gas losses due to permanent leakiness, small-scale damages, network maintenance and the network components are evaluated separately. As no applicable loss rates are available for the network compounds in Switzerland (installed control units, fittings, storage systems and gas meters), a fixed percentage is applied to the permanent gas losses.

Regarding the end users, gas losses from on-site and indoor pipelines as well as gas losses due to the permanent leakiness of gas appliances are evaluated. Pipeline loss rates apply to the number of households, industrial users and gas fuelling stations separately. Regarding the gas appliances, different loss rates are assigned to the number of gas heating systems, gas cooking stoves and gas fuelling stations.

For some (earlier) years in the time series, sufficient input data are not available to calculate the gas losses. For these years, polynomial interpolations are applied to assess the activity data.

For significant emission events due to accidents the Swiss Pollutant Release and Transfer Register is considered, and emissions are attributed to source category 1B2b vi Other Leakage. So far, two events have been reported by the transit pipeline operator, one in 2010 and one in 2011.

Fugitive emissions from pipelines are the major emission source in source category 1B2b. Fugitive emissions from damages and ruptures of the pipelines, maintenance of the pipelines and the components are very small (Quantis 2014). Total CH_4 emissions from gas transmission and distribution decreased due to gradual replacement of cast-iron pipes with polyethylene pipes.

1B2c Fugitive emissions from venting and flaring

Before 2005, the amount of flared gas is assumed to be proportional to the amount of crude oil processed in the refineries. The Swiss petroleum association provides data on the use of crude oil on an annual basis (EV 2016). Since 2005, the industry provides bottom-up data on the amount of gas flared. Activity data since 2014 are considered confidential and are available to reviewers on request.

Table 3-76 Activity data of 1B2 Fugitive emissions from liquid fuels.

1B2 Fugitive emissions from oil, natural gas and other fossil fuels	Fuel	Unit	1990	1995	2000	2005
1B2a Gasoline distribution	Gasoline sold	TJ	157'335	152'575	169'331	152'955
1B2a Refinery	Residual fuel oil	t	3'127'000	4'657'000	4'649'000	4'877'000
1B2b Gas production	Natural gas	GJ	130'000	NO	NO	NO
1B2b Gas distribution losses, Transit	Natural gas	GJ	26'565	29'211	30'923	31'860
1B2b Gas distribution losses, Distribution	Natural gas	GJ	710'246	817'028	655'267	512'036
1B2b Gas distribution losses, Other	Natural gas	GJ	NO	NO	NO	NO
1B2c2 Venting and flaring	Crude oil used	t	3'127'000	4'657'000	4'649'000	4'877'000

1B2 Fugitive emissions from oil, natural gas and other fossil fuels	Fuel	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1B2a Gasoline distribution	Gasoline sold	TJ	148'256	146'832	143'620	139'726	134'723	129'506	124'969	119'280	114'466	106'074
1B2a Refinery	Residual fuel oil	t	5'563'000	4'720'000	5'133'000	4'833'000	4'546'000	4'452'000	3'455'000	4'935'000	4'975'000	2'836'000
1B2b Gas production	Natural gas	GJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B2b Gas distribution losses, Transit	Natural gas	GJ	31'949	32'786	32'906	32'921	32'930	32'904	32'681	33'309	33'338	33'338
1B2b Gas distribution losses, Distribution	Natural gas	GJ	491'785	487'066	471'734	459'198	449'419	441'858	433'733	401'313	387'785	387'785
1B2b Gas distribution losses, Other	Natural gas	GJ	NO	NO	NO	NO	35'444	28'114	NO	NO	NO	NO
1B2c2 Venting and flaring	Crude oil used	t	5'563'000	4'720'000	5'133'000	4'833'000	4'546'000	4'452'000	3'455'000	4'935'000	4'975'000	2'836'000

3.3.2.3 Category-specific recalculations for 1B2 Oil, natural gas, venting/flaring

- 1B2a: SO_2 emissions from Claus units were previously reported in source category 2H3 and are now reported in 1B2aiv.
- 1B2b: Recalculation of AD due to an update in the Swiss overall energy statistics (SFOE 2016) concerning gas production in Switzerland (1991, 1992, 1994).
- 1B2c: Emissions from flaring in gas production were missing before. Now emission factors from the EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013) are used (1990-1994).
- 1B2c: CO, NMVOC, NO_x and SO_2 emission factors of Venting and flaring in refineries changed due to increased precision in the data (less rounding) 2005-2014.

4 Industrial Processes and Product Use

4.1 Overview of Emissions

This introductory chapter gives an overview of major emissions from sector 2 Industrial processes and product use between 1990 and 2015 and comprises process emissions only. All emissions from fuel combustion in industry are reported in sector 1 Energy. Regarding main pollutants, industrial processes and product use contribute relevantly to the emissions of NMVOC and to a lesser extent to the SO_x emissions. Industrial processes and product use are also important sources for particulate matter, Pb, Cd, Hg, and PCDD/PCDF emissions.

The following source categories are reported:

- 2A Mineral products
- 2B Chemical industry
- 2C Metal production
- 2D, 2G Other solvent and product use
- 2H Other
- 2I Wood processing
- 2L – Other production, consumption, storage, transportation or handling of bulk products

4.1.1 Overview and trend for NMVOC

According to Figure 4-1 total NMVOC emissions from 2 Industrial processes and product use show a considerable decrease between 1990 and 2005 with no more significant trend afterwards. The trend until 2005 is mainly due to reductions in 2D Other solvent and product use. For the entire time series, the NMVOC emissions are dominated by the emissions from 2D. Relevant emissions stem from 2G Other product use and 2H Other as well.

In 1990, source categories 2D3d Coating applications and 2D3g Chemical products contribute for more than half of the NMVOC emissions of source category 2D whereas all the other source categories account for the rest. In 2015, the largest shares in source category 2D come from 2D3d Coating applications and 2D3a Domestic solvent use including fungicides while the shares of 2D3b Road paving with asphalt, 2D3c Asphalt roofing, 2D3e Degreasing, 2D3f Dry cleaning, 2D3g Chemical products, 2D3h Printing and 2D3i Other solvent use account for the rest.

The reduction in 2D3d Coating applications is due to changes in the paint composition, i.e. from solvent based to water based paints. Accordingly, emission factors show a significant decrease. This trend is induced and driven by the EU directive (EC 2004) on the limitation of emissions of volatile organic compounds from the solvents used in certain paints and varnishes and vehicle refinishing products. In addition, noticeable decreases in paint consumption in 2D3d Construction (1990–1998) and industrial and non-industrial paint application (2001–2004) are superposed. The latter resulted from structural changes within the industrial sector. In 1990 the NMVOC emissions from 2D3d Coating applications are dominated by the emissions from paint application in construction whereas emissions from paint application on wood, in industrial & non-industrial use and in households contributed about comparable amounts in 2015.

The NMVOC emissions from the most important single source category 2D3a Household cleaning agents increase between 1990 and 1998. They drop again until 2001 and remain roughly constant until 2010. From 2011 until 2015, the emissions are again increasing.

Factors contributing to this trend are changes in the NMVOC emission factor and population growth.

Within source category, 2D a significant reduction in emissions from 2D3g Chemical products and 2D3h Printing between 1990 and 2015 is observed. The reduction in source category 2D3h Printing as well as in industry and services in general is mainly a result of the ordinance on the VOC incentive tax (Swiss Confederation 1997) with enactment of the tax in 2000 and structural changes within the respective industry and service sectors.

Also process optimizations (production of acetic acid and PVC) and closing down of production, e.g. PVC production in 1996 (2B Chemical industry) as well as the production decrease in the iron foundries (2C Metal production) contribute to the observed decrease in NMVOC emissions. On the other hand, the NMVOC emissions from 2H Other with main contributions from source category 2H2 Bread production remain about constant over the entire time period 1990–2015. In addition, general technological improvements and post-combustion installations contribute to further emission reductions.

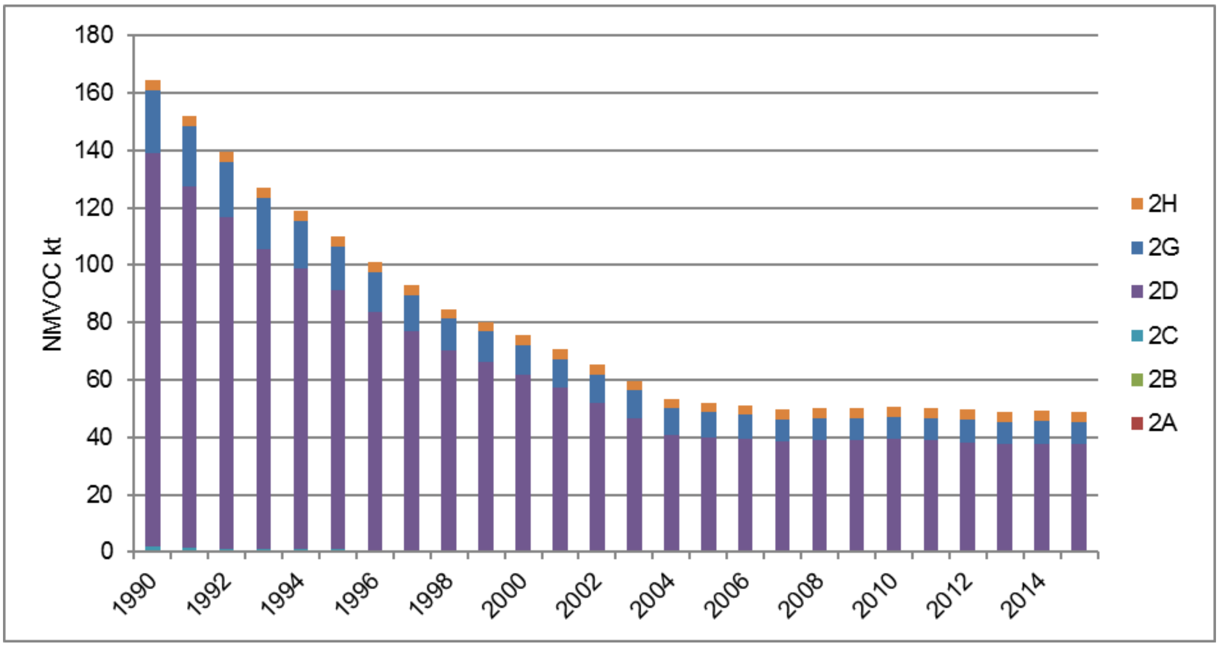

Figure 4-1: Switzerland's NMVOC emissions from industrial processes and product use by source categories 2A-2D and 2G-2H between 1990 and 2015. The corresponding data table can be found in Annex A6.3.

4.1.2 Overview and trend for SO_2

According to Figure 4-2, total SO_2 emissions from 2 Industrial processes and product use show a decrease of more than 50% in the period 1990-2015. In 1990, source category 2C Metal production shows the largest contribution to the total SO_2 emissions and other significant contributions are due to 2B Chemical industry. In 2015, the largest shares of emissions are due to 2B Chemical industry. The emissions from 2A Mineral products are negligible over the entire time period and there are no emissions from 2D. The varying and even increasing SO_2 emissions from 2B Chemical industry stem mainly from the graphite and silicon carbide production, i.e. the sulphur content of the raw materials (petroleum coke and other bituminous coal), and reflect the production volume between 1990 and 2015. In 2015, it is the largest emission source within sector 2. The SO_2 emissions from 2C Metal production originate predominately from the consumption of electrodes (anodes) in the aluminium production and follow thus the aluminium production volume in Switzerland (the only aluminium smelter was closed down in 2006). The small amount of SO_2 emissions from 2G Other product use stems from the use of fireworks.

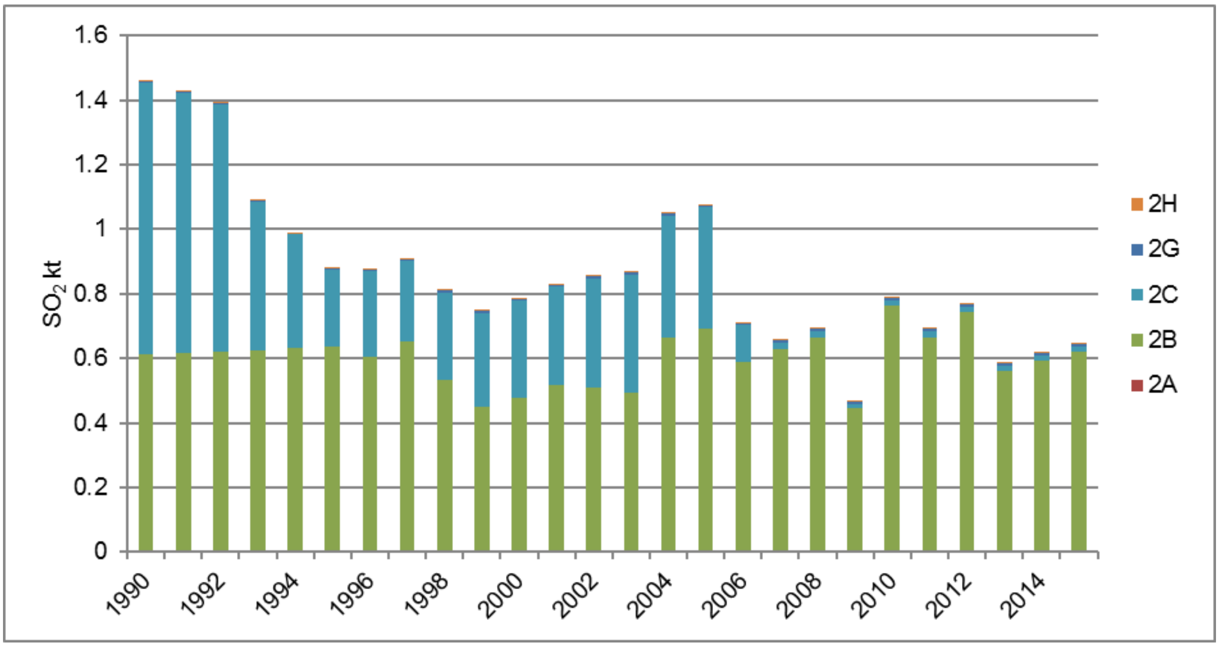

Figure 4-2: Switzerland's SO_2 emissions from industrial processes and product use by source categories 2A–2C and 2G-2H between 1990 and 2015. The corresponding data table can be found in Annex A6.3.

4.1.3 Overview and trend for PM2.5

According to Figure 4-3, total PM2.5 emissions from sector 2 Industrial processes and product use show a decrease of almost 50% in the period 1990-1999 and fluctuate only slightly since then. In 1990, the three source categories 2A Mineral products, 2C Metal production and 2H Other contribute the most to the total PM2.5 emissions. In 2015, the highest contribution to the total PM2.5 emissions is due to the source categories 2A, 2H and 2G. The other source categories are of minor importance in 2015. PM2.5 emissions from 2A Mineral products with main contributions from blasting operations in 2A1 Cement production and from 2A5a Quarrying and mining of minerals other than coal are more or less constant over the entire period 1990-2015. On the other hand, PM2.5 emissions from 2C Metal production, which is dominated by the emissions from the source category 2C1 Iron and steel production, show a strong decrease between 1990 and 2015 and are almost exclusively responsible for the total PM2.5 emission reduction in this source category. The reason for the initial emission reduction in 1995 is the closing down of two steel production sites in Switzerland, whereas the drastic drop in emission in 1998/1999 is due to the installation of new filters in the remaining two steel plants. The PM2.5 emissions from 2G Other product use increased between 1990 and 2015 and are dominated by 2G Fireworks. The emissions in 2H Other remain about constant since 1990. In this source category, the main contributions arise from 2H1 Chipboard and fibreboard production.

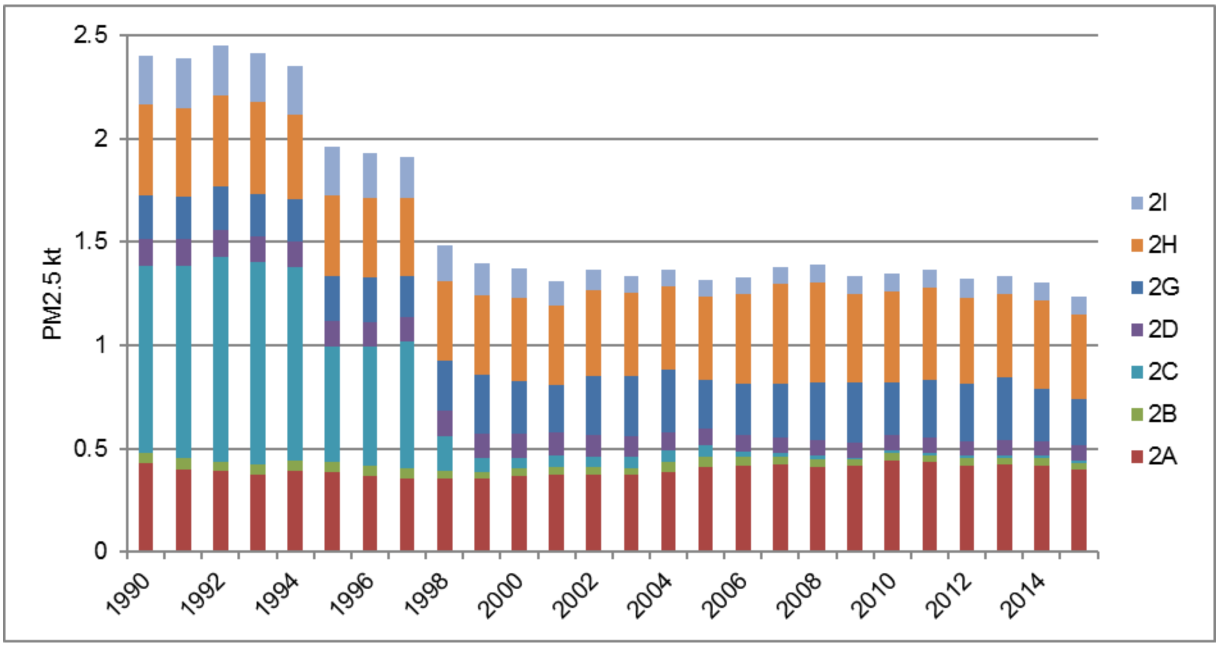

Figure 4-3: Switzerland's PM2.5 emissions from industrial processes and product use by source categories 2A-2D and 2G-2I between 1990 and 2015. The corresponding data table can be found in Annex A6.3.

4.2 Source category 2A – Mineral products

4.2.1 Source category description

Table 4-1: Specification of source category 2A Mineral products in Switzerland.

2A	Source	Specification
2A1	Cement production	Blasting operations of the cement production, Process emissions from calcination are reported in 1A2f
2A2	Lime production	Blasting operations of the lime production, Process emissions from calcination are reported in 1A2f
2A3	Glass production	Process emissions from glass production are reported in 1A2f
2A5a	Quarrying and mining of minerals other than coal	Gravel plants and blasting operations of the plaster production

Table 4-2: Key categories, level 2015 (L1) and trend 1990-2015 (T1), for source category 2A Mineral products in Switzerland

NFR	Source Category	Pollutant	Identification Criteria
2A5a	Quarrying and mining of minerals	PM10	L1
2A5a	Quarrying and mining of minerals	PM2.5	L1, T1

4.2.2 Methodological issues of 2A Mineral products

4.2.2.1 Cement production (2A1)

Methodology (2A1)

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.

According to EMEP/EEA (2013), source category 2A1 Cement production comprises all emissions from operations other than pyroprocessing (kiln). Based on the decision tree Fig. 3.1 in chapter 2A1 Cement production of EMEP/EEA (2013), the emissions resulting from blasting operations during the digging of limestone are determined by a Tier 2 method using country-specific emission factors documented in EMIS 2017/2A1. The reported emissions of non-exhaust particulate matter contain fugitive emissions of particulate matter of the production sites including storage and handling as well.

Pollutants released from the raw material during the calcination process in the kiln are reported in source category 1A2f Cement production together with the emissions from fuel combustion.

Emission factors (2A1)

Blasting: Emission factors per tonne of clinker are derived from the emission factors of civil explosives and information on the specific consumption of explosives in the quarries as documented in the Handbook on emission factors for stationary sources (SAEFL 2000) and the EMIS database. They are assumed to be constant over the entire time period. The emission factor of BC (% of PM2.5exh.) is taken from EMEP/EEA (2013).

Table 4-3: Emission factors for blasting operations of 2A1 Cement production in 2015.

2A1 Cement production	Unit	NOx	NMVOC	SO_2
Blasting operations	g/t clinker	3.3	8.6	0.14

2A1 Cement production	Unit	PM2.5 exh.	PM2.5 nonexh.	PM10 exh.	PM10 nonexh.	TSP exh.	TSP nonexh.	BC exh.	CO
Blasting operations	g/t clinker	0.51	50	0.86	77	0.86	110	0.0154	3.3

Activity data (2A1)

Since 1990, data on annual clinker production are provided by the industry association (Cemsuisse) as documented in the EMIS database (EMIS 2017/ 2A1_Zementwerke übriger Betrieb). From 2008 onwards they are based on plant-specific annual monitoring reports from the Swiss Emissions Trading Scheme (ETS).

Table 4-4: Activity data of 2A1 Cement production.

2A1 Cement production	Unit	1990	1995	2000	2005
clinker	kt	4'808	3'706	3'214	3'442

2A1 Cement production	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
clinker	kt	3'452	3'512	3'461	3'443	3'642	3'587	3'368	3'415	3'502	3'195

4.2.2.2 Lime production (2A2)

Methodology (2A2)

There is only one producer of burnt lime in Switzerland. Based on the decision tree Fig. 3.1 in chapter 2A2 Lime production of EMEP/EEA (2013), emissions from blasting operations in the quarry are determined by a Tier 2 method using country-specific emission factors (EMIS 2017/2A2). The reported emissions of non-exhaust particulate matter contain fugitive emissions of particulate matter of the production site including storage and handling as well.

Pollutants released from the raw material during the calcination process in the kiln are reported in source category 1A2f Lime production together with the emissions from fuel combustion.

Emission factors (2A2)

The emission factors (NO_x, NMVOC, SO_2, PM2.5, PM10, TSP and CO) per tonne of lime produced are confidential but available to reviewers on request. They are assumed to be constant over the entire time period. The emission factor of BC (% PM2.5) is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013).

Activity data (2A2)

Activity data on annual lime production is based on data from the only lime producer in Switzerland and is confidential but available to reviewers on request. From 2008 onwards, they are based on on plant-specific annual monitoring reports from the Swiss Emissions Trading Scheme (ETS).

4.2.2.3 Glass production (2A3)

Process emissions from glass production in Switzerland, i.e. container and tableware glass as well as glass wool are reported together with the combustion emissions in source category 1A2f according to EMEP/EEA emission inventory guidebook 2016 (EMEP/EEA 2016), since it is not straightforward to separate them. Therefore, emissions of NO_x, SO_x, PM2.5/PM10/TSP, BC, CO, Pb, Cd and Hg are reported as “included elsewhere” (IE).

4.2.2.4 Quarrying and mining of minerals other than coal (2A5a)

Methodology (2A5a)

In this source category there are two production processes occurring in Switzerland: Gravel plants and plaster production. The emissions stem mainly from blasting operations and crushing of stones either in plaster production or gravel plants.

Based on EMEP/EEA (2013), emissions from blasting operations as well as emissions of particulates from crushing and grinding work are determined by a Tier 2 method using country-specific emission factors (EMIS 2017/2A5a). Emissions from storage and handling are also accounted for.

Emission factors (2A5a)

The emission factors per tonne of gravel and rocks are country-specific. For Plaster production, emission factors are provided by SAEFL 2000.

Table 4-5: Emission factors of 2A5a Gravel plants and Plaster production in 2015.

2A5a Quarrying and mining of minerals other than coal	Unit	NOx	NMVOC	SO_2
Gravel plants	g/t gravel	NA	NA	NA
Plaster production	g/t rocks	5.6	14.4	0.24

2A5a Quarrying and mining of minerals other than coal	Unit	PM2.5 exh.	PM2.5 nonexh.	PM10 exh.	PM10 nonexh.	TSP exh.	TSP nonexh.	BC exh.	CO
Gravel plants	g/t gravel	NA	4	NA	8	NA	16	NA	NA
Plaster production	g/t rocks	0.9	150	1.44	300	1.44	450	NE	33

Activity data (2A5a)

Activity data for 2A5a Gravel plants and Plaster production is based on industry data. For plaster production plant-specific data are available for 1990, 2001 and from 2004 onwards. For the missing years in between the activity data are linearly interpolated.

Data on gravel production is provided annually by the Swiss association of gravel and concrete industry (Fachverband der Schweizerischen Kies- und Betonindustrie, FSKB). But the latest data available is always one year delayed with respect to the most current year of the submission.

Table 4-6: Activity data of 2A5a Gravel plants and Plaster production.

2A5a Quarrying and mining of minerals other than coal	Unit	1990	1995	2000	2005
Gravel plants	kt gravel	33'798	36'791	39'785	44'960
Plaster production	kt rocks	319	304	288	327

2A5a Quarrying and mining of minerals other than coal	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Gravel plants	kt gravel	47'740	47'990	46'560	48'310	50'540	51'940	49'780	53'940	53'090	52'575
Plaster production	kt rocks	323	314	295	293	335	293	271	213	166	140

4.2.3 Category-specific recalculations

Recalculations in 2A Mineral products

- 2A5a: AD of 2A5a Gravel plants have been revised for 2014 due to data from industry association.

4.3 Source category 2B – Chemical industry

4.3.1 Source category description of 2B Chemical industry

Table 4-7: Specification of source category 2B Chemical industry in Switzerland.

2B	Source	Specification
2B1	Ammonia production	Production of ammonia
2B2	Nitric acid production	Production of nitric acid
2B5	Carbide production	Production of silicon carbide and graphite
2B10a	Chemical industry: Other	Production of acetic acid, ammonium nitrate, chlorine gas, ethylene, sulfuric acid and PVC (ceased in 1996)

Table 4-8: Key categories, level 2015 (L1) and trend 1990-2015 (T1), for source category 2B Chemical industry

NFR	Source Category	Pollutant	Identification Criteria
2B5	Carbide production	SO2	L1, T1

4.3.2 Methodological Issues of 2B Chemical industry

4.3.2.1 Ammonia production (2B1)

Methodology (2B1)

In Switzerland, ammonia is produced in one single plant by catalytic reaction of nitrogen and synthetic hydrogen. Ammonia is not produced in an isolated reaction plant but is part of an integrated production chain. Starting process of this production chain is the thermal cracking of liquefied petroleum gas and light virgin naphtha yielding ethylene and a series of by-products such as e.g. synthetic hydrogen, which are used as educts in further production steps. According to the producer it is not possible to split and allocate the NMVOC emissions of the cracking process to each single product (ethylene, ammonia, cyanic acid etc.) within the integrated production chain. Therefore, the NMVOC emissions of the cracking process are allocated completely to the primary product ethylene (source category 2B10a). The only emissions reported under 2B1 Ammonia production are NH_3 emissions escaping from the flue gas scrubber.

Based on the decision tree Fig. 3.1 in chapter 2B Chemical industry in EMEP/EEA (2013), the emissions from 2B1 Ammonia production are calculated by a Tier 2 method using plant-specific emission factors documented in EMIS 2017/2B1.

Emission factors (2B1)

The NH_3 emission factor per tonne of ammonia produced is confidential but available to reviewers on request. From 1990 to 2001, a constant emission factor based on measurements is applied. In 2002, the scrubber was replaced. For 2011 and since 2013 the emission factor is determined based on measurements provided by the plant. For the years 2002 – 2010 and 2012 the average value of the years 2011 and 2012-2015 is applied.

Table 4-9: Emission factor for 2B1 Ammonia production in 2015.

2B1 Ammonia production	Unit	NMVOC	NH_3
	g/t ammonia	IE	C

Activity data (2B1)

Plant-specific activity data on annual ammonia production is provided by the single plant that exists in Switzerland for the entire time period 1990-2015. Since 2013, activity data are taken from annual monitoring reports from the Swiss Emissions Trading Scheme (ETS). Activity data are confidential and information is available to reviewers on request.

4.3.2.2 Nitric acid production (2B2)

Methodology (2B2)

In Switzerland there is one single plant producing nitric acid (HNO_3). Nitric acid is produced by catalytic oxidation of ammonia (NH_3) with air. At temperatures of 800°C nitric monoxide (NO) is formed. During cooling, nitrogen monoxide reacts with excess oxygen to form nitrogen dioxide (NO_2). The nitrogen dioxide reacts with water to form 60% nitric acid (HNO_3). Today, two types of processes are used for nitric acid production: single pressure or dual pressure plants. In Switzerland a dual pressure plant is installed.

Thus there results also some nitrogen oxide (NO_x) as an unintentional by-product. In the Swiss production plant abatement of NO_x is done by selective catalytic reduction (SCR, installed in 1988) 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). In 1990 an automatic control system for the dosing of ammonia to the SCR process was installed.

Based on the decision tree Fig. 3.1 in chapter 2B Chemical industry in EMEP/EEA (2013), NH_3 and NO_x emissions from 2B2 Nitric acid production are calculated by a Tier 2 method using plant-specific emission factors (see EMIS 2017/2B2).

Emission factors (2B2)

The emission factors for NO_x and NH_3 per tonne of nitric acid (100%) are confidential but available to reviewers upon request. The EF values for NO_x and NH_3 are mean values based on measurements on site in 2005, 2009 and 2012, and 2007, 2009 and 2012, respectively. They are assumed to be constant between 1990 and 2012 since no modifications in the production process has been made in this period.

In 2013, a new catalyst was installed in the production line along with a measurement device for NH_3 slip in order to regulate ammonia dosage in the DeNOx plant. Moreover, in 2013 the volume of the DeNOx plant was duplicated. Consequently, the NH_3 emissions could be reduced significantly. Also a slight reduction of NO_x occurred. Since 2013, emission factors are based on measurements provided by the plant.

Table 4-10: Emission factor of 2B2 Nitric acid production in 2015.

2B2 Nitric acid production	Unit	NO_x	NH_3
	g/t acid	C	C

Activity data (2B2)

Activity data on annual nitric acid (100%) production is provided for the entire time series by the single production plant in Switzerland and is therefore considered as confidential. However, this information is available to reviewers. Since 2013, activity data are taken from annual monitoring reports from the Swiss Emission Trading Scheme (ETS).

4.3.2.3 Carbide production (2B5)

Methodology (2B5)

In Switzerland, only silicon carbide is produced in one plant. This silicon carbide is used in abrasives, refractories, metallurgy and anti-skid flooring. The Swiss silicon carbide is produced in an electric furnace at temperatures above 2000ºC using the Acheson process. Based on the decision tree Fig. 3.1 in chapter 2B Chemical industry in EMEP/EEA (2013), the SO_2 and particulate matter emissions from 2B5 Silicon carbide production are calculated by a Tier 2 method using plant-specific emission factors (EMIS 2017/2B5). Included in the emissions of this source category are also the ones from the production of graphite at the same production site.

Emission factors (2B5)

The emission factors comprise the unsplit emissions from both production processes (silicon carbide and graphite). They are confidential but available to reviewers on request.

Table 4-11: Emission factor for 2B5 Carbide production in 2015.

2B5 Carbide production	Unit	SO_2	PM2.5 exh.	PM10 exh.	TSP exh.	BC exh.	CO
	g/t carbide	C	C	C	C	NE	NE

Activity data (2B5)

Activity data on annual production of silicon carbide and graphite is provided by the production plant for the years 1990 and from 1995 onwards. For 2015, no new data was provided by the industry and therefore the same activity data as in 2014 are assumed. The activity data are considered confidential. However, this information is available to reviewers on request.

4.3.2.4 Chemical industry: Other (2B10a)

Methodology (2B10a)

Source category 2B10a Chemical industry: Other comprises emissions from production of acetic acid, ammonium nitrate, chlorine gas, ethylene, PVC (ceased in 1996) as well as sulphuric acid. Based on the decision tree Fig. 3.1 in chapter 2B Chemical industry in EMEP/EEA (2013), emissions from 2B10a Chemical industry are calculated by a Tier 2 method using plant-specific emission factors (EMIS 2017/2B10a).

Acetic acid production (2B10a)

In Switzerland there is only one plant producing acetic acid (CH_3COOH) remaining in 2015 after the other one stopped its production by the end of 2012. The still existing plant emits NMVOC only whereas from the latter one also emissions of CO have occurred.

Emission factors

The emission factors for NMVOC and CO (up to 2012) from acetic acid production in Switzerland are based on measurement data from industry and expert estimates documented in EMIS 2017/2B10 Essigsäure-Produktion. From 2013 onwards, the only relevant pollutant from acetic acid production is NMVOC. Since 2013 the emission factor is confidential but available to reviewers on request.

During normal operation the process emissions in the plant, which stopped its production in the end of 2012, had been treated in a flue gas incineration. Thus, the reported emissions of NMVOC and CO only occurred in case of malfunction resulting in strongly fluctuating plant-specific emission factors. In addition, the resulting implied emission factors based on the emissions of both plants were modulated by considerable production fluctuations of one of the plants from 2000 onwards.

Table 4-12: Emission factors of 2B10a Chemical industry: Other in 2015.

2B10a Chemical industry: Other	Unit	NMVOC	SO_2	NH_3	PM2.5 nonexh.	PM10 nonexh.	TSP nonexh.	Hg
Acetic acid production	g/t acid	C	NA	NA	NA	NA	NA	NA
Ammonium nitrate production	g/t salt	NA	NA	C	C	C	C	NA
Chlorine gas production	g/t chlorine	NA	NA	NA	NA	NA	NA	C
Ethylene production	g/t ethylene	C	NA	NA	NA	NA	NA	NA
Sulfuric acid production	g/t acid	NA	C	NA	NA	NA	NA	NA

Activity data

The annual amount of produced acetic acid is based on data from industry and from the Swiss business association for the chemical, pharmaceutical and biotech industry (scienceindustries) documented in EMIS 2017/2B10 Essigsäure-Produktion. The data for acetic acid production are confidential since 2013 (only one manufacturer remaining) but available for reviewers on request.

Table 4-13: Activity data of 2B10a Chemical industry: Other.

2B10a Chemical industry: Other	Unit	1990	1995	2000	2005
Ammonium nitrate production	kt	C	C	C	C
Chlorine gas production	kt	C	C	C	C
Acetic acid production	kt	30	27	24	8
Ethylene production	kt	C	C	C	C
Sulfuric acid production	kt	C	C	C	C
PVC production	kt	43	43	NO	NO

2B10a Chemical industry: Other	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Ammonium nitrate production	kt	C	C	C	C	C	C	C	C	C	C
Chlorine gas production	kt	C	C	C	C	C	C	C	C	C	C
Acetic acid production	kt	8	9	18	28	20	18	12	C	C	C
Ethylene production	kt	C	C	C	C	C	C	C	C	C	C
Sulfuric acid production	kt	C	C	C	C	C	C	C	C	C	C
PVC production	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Ammonium nitrate production (2B10a)

In Switzerland there is only one plant producing ammonium nitrate. In the production process emissions of NH_3 and particulate matter occur.

Emission factors

The emission factors for NH_3 and for particulate matter from ammonium nitrate production in Switzerland are plant-specific and based on measurement data from industry and expert estimates documented in EMIS 2017/2B10 2B10 Ammoniumnitrat Produktion. The emission factors are confidential but available to reviewers on request.

Activity data

The annual amount of ammonium nitrate (pure NH_4NO_3) produced is based on data from industry for 1990 and from 1997 onwards as documented in EMIS 2017/2B10 Ammoniumnitrat Produktion. The activity data for ammonium nitrate production are confidential but available to reviewers on request.

Chlorine gas production (2B10a)

In Switzerland there is only one plant producing chlorine gas. Chlorine gas is produced by chlorinealkaline electrolysis in a mercury-cell process. In this process emissions of Hg occur.

Emission factors

The emission factors for Hg from chlorine gas production in Switzerland is plant-specific and based on measurement data from industry and expert estimates documented in EMIS 2017/2B10 2B10 Chlorgas-Produktion. The emission factor is confidential but available to reviewers on request.

Activity data

The annual amount of chlorine gas produced is based on data from industry and data from the Swiss business association for the chemical, pharmaceutical and biotech industry (scienceindustries) as documented in EMIS 2017/2B10 Chlorgas-Produktion. The activity data for chlorine gas production are confidential but available to reviewers on request.

Ethylene production (2B10a)

As described above in source category 2B1 Ammonia production, ethylene is produced within an integrated production chain and results as primary product of the first step, i.e. the cracking process. Since the NMVOC emissions of the cracking process cannot be split and allocated separately to the various chemical products, they are assigned completely to the production of ethylene and are reported here under source category 2B10a.

Emission factors

The emission factor for NMVOC from ethylene production in Switzerland is plant-specific and based on measurement data from industry documented in EMIS 2017/2B10 ethylene production. The emission factor is confidential but available to reviewers on request.

Activity data

The annual amount of ethylene produced is based on data from the industry as documented in EMIS 2017/2B10 ethylene production. They refer to annual monitoring reports from the Swiss Emissions Trading Scheme (ETS). The activity data for ethylene production are confidential but available to reviewers on request.

Sulphuric acid production (2B10a)

Sulphuric acid (H_2SO_4) is produced by one plant only in Switzerland. From this production process SO_2 is emitted.

Emission factors

The emission factor for SO_2 from sulphuric acid production in Switzerland is plant-specific. Since 2009, the emission factor is based on annual measurement data from industry documented in EMIS 2017/2B10 Schwefelsäure-Produktion. Between 1990 and 2008 the mean value is applied. The SO_2 emission factor is confidential but available to reviewers on request.

Activity data

The annual amount of sulphuric acid produced is based on data from industry and data from Swiss business association for the chemical, pharmaceutical and biotech industry (scienceindustries) as documented in EMIS 2017/2B10 Schwefelsäure-Produktion. The activity data for sulphuric acid production are confidential but available to reviewers on request.

PVC (2B10a)

Until 1996 PVC was produced in Switzerland. From this production process NMVOC emissions were released.

Emission factors

For PVC production the NMVOC emission factor is based on industry information and expert estimates as documented in the EMIS database (EMIS 2017/2B10 PVC-Produktion).

Activity data

The annual amount of PVC produced is based on data from industry and expert estimates documented in EMIS 2017/2B10 PVC-Produktion (see Table 4-13).

4.3.3 Category-specific recalculations

Recalculations in 2B Chemical industry

- 2B1: The emission factor of NH_3 from 2B1 Ammonia production has been revised from 2002 onwards based on plant-specific emission data from 2011 and 2013-2015.
- 2B10a: The so far reported AD in 2B10a Ammoinum nitrate production was not as assumed the amount of pure ammonium nitrate but already formulated fertilizer consisting of ammonium nitrate (75%) and shale (25%). From this submission onwards, AD and EF have changed to pure ammonium nitrate as reference figure for the entire time series resulting in minor emission changes due to rounding (1990-2014).
- 2B10a: The extrapolated values of the SO_x emission factor of 2B10a Sulphuric acid production have been revised (1990-2008).

4.4 Source category 2C – Metal production

4.4.1 Source category description of 2C Metal production

Table 4-14: Specification of source category 2C Metal production in Switzerland.

2C	Source	Specification
2C1	Iron and steel production	Secondary steel production, iron foundries
2C3	Aluminium production	Production of aluminium (ceased in 2006)
2C7a	Copper production	Non-ferrous metal foundries
2C7c	Other metal production	Battery recycling, galvanizing plants

Table 4-15: Key Categories, level 2015 (L1) and trend 1990-2015 (T1), for source category 2C Metal production

NFR	Source Category	Pollutant	Identification Criteria
2C1	Iron and steel production	PM10	T1
2C1	Iron and steel production	PM2.5	T1

4.4.2 Methodological issues of 2C Metal production

4.4.2.1 Iron and steel production (2C1)

Methodology (2C1)

In Switzerland only secondary steel production from recycled steel scrap occurs. After closing of two steel plants in 1994 another two plants remain. Both plants use electric arc furnaces (EAF) with carbon electrodes for melting the steel scrap.

Iron is processed in foundries only. There is no production of pig iron. Today, 14 iron foundries exist in Switzerland. About 75% of the iron is processed in induction furnaces and 25% in cupola furnaces.

Based on the decision tree Fig. 3.1 in chapter 2C1 in EMEP/EEA (2013), the emissions from 2C1 Iron and steel production are calculated by a Tier 2 method using country-specific emission factors (EMIS 2017/2C1).

Emission factors (2C1)

Emission factors for all pollutants emitted from steel production are based on air pollution control measurements of the steel plants. Emission factors of NO_x, NMVOC, SO_2, PM2.5/PM10/TSP, CO, Pb, Cd, PCDD/PCDF and PAH are based on air pollution control measurements at the electric arc furnaces of the two plants in 1999, 2005 and 2010 and in 1998, 2009 and 2014, respectively. There was a significant decrease in the PM2.5/PM10/TSP, Pb, Cd and Hg emission factors due to the installation of new filters in 1998/1999 at the two remaining production sites.

The emission factors from iron production in foundries are provided by the Swiss foundry association (GVS) and are assumed to be constant for the entire time period 1990–2015. NMVOC is mainly emitted in the finishing process of the cast iron. The NH_3 emission factor is taken from the Handbook on emission factors for stationary sources (SAEFL 2000).

The emission factor of BC (% PM2.5) is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013).

Table 4-16: Emission factors 2C1 Iron and steel production in 2015.

2C Metal production	Unit	NO_x	NMVOC	SO_2	NH_3	PM2.5 exh.	PM2.5 nonexh.	PM10 exh.	PM10 nonexh.	TSP exh.	TSP nonexh.	BC exh.	CO
2C1 Iron production, electric melting furnace	g/t iron	NA	33	NA	NA	7	NA	10	NA	13	NA	0.03	93
2C1 Iron production, other processes	g/t iron	10	4'000	NA	70	NA	50	NA	130	NA	150	NA	4'000
2C1 Steel production, electric melting furnace	g/t steel	140	70	14	NA	6	NA	8	NA	9	NA	0.02	700
2C1 Steel production, rolling mill	g/t steel	NA	40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

2C Metal production	Unit	Pb	Cd	Hg	PCDD/ PCDF	BaP	BbF	BkF	IcdP
2C1 Iron production, electric melting furnace	mg/t iron	320	1.3	NA	0.00013	NA	NA	NA	NA
2C1 Iron production, other processes	mg/t iron	NA	NA	NA	0.0013	NA	NA	NA	NA
2C1 Steel production, electric melting furnace	mg/t steel	200	4	40	0.00011	0.8	3.4	0.9	2.2
2C1 Steel production, rolling mill	mg/t steel	NA	NA	NA	NA	NA	NA	NA	NA

Activity data (2C1)

For the steel production, annual activity data is provided by the Swiss steel producers (1990 – 1994 four plants, since 1995 two plants). Since 2009, activity data refer to monitoring reports of the Swiss ETS.

Annual activity data on iron production is provided by the Swiss foundry association for the entire time period.

The table shows that 2C1 Steel production decreased between 1994 and 1995 significantly due to the closing of two steel production sites in Switzerland. The remarkable reduction in activity data within the metal industry in 2009 seems to be due to the effects of the financial crisis, as a recovery of the production is indicated along with the recovery of the economy in the aftermath of 2009 until 2014.

Table 4-17: Activity data for 2C1 Iron and steel production.

2C Metal production	Unit	1990	1995	2000	2005
2C1 Iron production, electric melting furnace	kt	80	70	65	35
2C1 Iron production, other processes	kt	170	130	120	67
2C1 Steel production, electric melting furnace	kt	1'108	716	1'022	1'159
2C1 Steel production, other processes	kt	1'108	716	NO	NO
2C1 Steel production, rolling mill	kt	1'108	716	1'022	1'082

2C Metal production	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2C1 Iron production, electric melting furnace	kt	36	39	41	34	40	46	34	34	33	28
2C1 Iron production, other processes	kt	67	72	78	49	53	61	46	45	43	37
2C1 Steel production, electric melting furnace	kt	1'254	1'267	1'315	935	1'218	1'322	1'252	1'231	1'315	1'296
2C1 Steel production, other processes	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C1 Steel production, rolling mill	kt	1'180	1'190	1'269	850	1'082	1'183	1'162	1'198	1'252	1'214

4.4.2.2 Aluminium production (2C3)

Methodology (2C3)

Today, there is no more aluminium production as the last production site closed in April 2006. Based on the decision tree Fig. 3.1 in chapter 2C3 of EMEP/EEA (2013), emissions from source category 2C3 are calculated by a Tier 2 method using country-specific emission factors (EMIS 2017/2C3).

Emission factors (2C3)

The emission factors are based on air pollution control measurements and data from the aluminium industry association (Aluminium – Verband Schweiz), literature and expert estimates documented in the EMIS database. Since production stopped in 2006, there are no emission factors to be reported for 2015.

Activity data (2C3)

From 1995 to 2006 data on aluminium production is based on data published regularly by the Swiss Aluminium Association (www.alu.ch). For earlier years, the data was provided directly by the aluminium industry. In April 2006, the last site of primary aluminium production (electrolysis) in Switzerland closed down.

Table 4-18: Activity data for the 2C3 Aluminium production.

2C Metal production	Unit	1990	1995	2000	2005
Aluminium production	kt	87	21	36	45

2C Metal production	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Aluminium production	kt	12	NO	NO	NO	NO	NO	NO	NO	NO	NO

4.4.2.3 Copper production (2C7a)

Methodology (2C7a)

Source category 2C7a Copper production comprises one large and several small non-ferrous metal foundries, which are organized within the Swiss foundry association (GVS). In Switzerland, only casting and no production of non-ferrous metals occur.

Based on the decision tree Fig. 3.1 in chapter 2C7a of EMEP/EEA (2013), emissions from source category 2C7a are calculated by a Tier 2 method (EMIS 2017/2C7a) using country-specific emission factors.

Emission factors (2C7a)

The emission factors from non-ferrous metal foundries are based on expert estimates and data from the industry as documented in the EMIS database. They are assumed to be constant over the entire time period.

Table 4-19: Emission factors for 2C7a Foundries of non-ferrous metals in 2015.

2C7a Copper production	Unit	NMVOC	PM2.5 exh.	PM10 exh.	TSP exh.	BC exh.	CO	Pb	Cd	PCDD/ PCDF
Foundries of non-ferrous metals	g/t metal	50	95	100	100	0.10	240	0.3	0.05	0.00003

Activity data (2C7a)

Activity data on annual non-ferrous metal production is based on data from industry (1990 and from 2006 onwards) and the Swiss foundry association (GVS, since 1996) as documented in the EMIS database.

Table 4-20: Activity data for 2C7a Foundries of non-ferrous metals.

2C7a Copper production	Unit	1990	1995	2000	2005
Foundries of non-ferrous metals	kt	55	60	70	33

2C7a Copper production	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Foundries of non-ferrous metals	kt	30	28	21	15	20	12	18	7	7	7

4.4.2.4 Other metal production (2C7c)

Methodology (2C7c)

Source category 2C7c Other metal production comprises emissions from battery recycling and galvanizing plants. In Switzerland, there is one plant recycling batteries by applying the Sumitomo-process and about a dozen of galvanizing plants. Based on chapter 2C7c of

EMEP/EEA (2013), emissions from source category 2C7c are calculated by a Tier 2 approach (EMIS 2017/2C7c) using country-specific emission factors.

Emission factors (2C7c)

The emission factors for battery recycling between 1990 and 2003 are based on measurements in 2000 (TSP, Hg) and 2003 (NO_x, SO_2, CO, Pb, Cd, PCDD/PCDF) as well as mass balances of the single recycling site. Emission factors are assumed constant between 1990 and 2002.

Emission factors of NO_x, SO_2, TSP, CO, Pb, Cd, Hg and PCDD/F since 2003 are based on air pollution control measurements from 2003 and 2012. Emission factors are assumed constant during this time period.

Emission factors of NMVOC and NH_3 are also based on air pollution control measurements from 2003 and 2012 and are reported for the first time in submission 2017. Emission factors are assumed constant for the entire time period.

The emission factors of galvanizing plants are based on data from the Swiss galvanizing association and expert estimates documented in the EMIS database. They are assumed to be constant over the entire time period.

Table 4-21: Emission factors for 2C7c Other metal production: Battery recycling and Galvanizing in 2015.

2C7c Other metal production	Unit	NO_x	NMVOC	SO_2	NH_3	PM2.5 exh.	PM2.5 nonexh.	PM10 exh.	PM10 nonexh.	TSP exh.	TSP nonexh.	BC exh.	CO
Galvanazing plants	g/t metal	NA	NA	NA	90	NA	15	NA	30	NA	37	NA	NA
Battery recycling	g/t battery	620	200	7	9	20	NA	27	NA	30	NA	NE	900

2C7c Other metal production	Unit	Pb	Cd	Hg	PCDD/ PCDF
Galvanazing plants	mg/t metal	NA	2.5	NA	0.0007
Battery recycling	mg/t battery	1600	90	1000	0.0013

Activity data (2C7c)

Annual activity data on the amount of metal processed is based on data from the only battery recycling site in Switzerland and from the Swiss galvanizing association, as documented in the EMIS database (EMIS 20177/2C7c_Batterie-Recycling, EMIS 2017/2C7c_Verzinkereien).

Table 4-22: Activity data for 2C7c Other metal production: Battery recycling and Galvanizing.

2C7c Other metal production	Unit	1990	1995	2000	2005
Galvanazing plants	kt	102	84	99	88
Battery recycling	kt	3.0	3.0	3.0	2.8

2C7c Other metal production	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Galvanazing plants	kt	101	98	92	85	93	96	92	93	93	94
Battery recycling	kt	2.4	2.4	2.5	3.4	3.3	2.4	2.4	2.3	2.6	2.5

4.4.3 Category-specific recalculations

Recalculations in 2C Metal production

- 2C1: The conversion factor used for calculation of NMVOC emissions from total carbon based on air pollution control measurements has been revised resulting in an adjusted NMVOC emission factor of 2C1 Secondary steel production, electric arc furnace from 1995 onwards.

- 2C7c: The emission factors of NMVOC and NH_3 from 2C7c Battery recycling are newly reported in the inventory based on air pollution control measurements (2003 and 2012).
- 2C7c: The emission factors of NO_x, SO_x, TSP, CO, Pb, Cd, Hg and PCDD/PCDF from 2C7c Battery recycling have been revised from 2002 onwards based on air pollution control measurements (2003 and 2012).
- 2C7c: The emission factors of PM2.5 and PM10 from 2C7c Battery recycling have been revised from 2003 onwards based on air pollution control measurements (2003 and 2012).

4.5 Source category 2D3 – Other solvent use

4.5.1 Source category description of 2D3 Other solvent use

Source category 2D3 comprises mainly NMVOC emissions from about 40 different solvent applications. From 2D3c Asphalt roofing and 2D3i Fat, edible and non-edible oil extraction (ceased in 2000) also particulate matter and CO and particulate matter, respectively, are emitted.

Table 4-23: Specification of source category 2D Other solvent use in Switzerland.

2D	Source	Specification
2D3a	Domestic solvent use including fungicides	Use of spray cans in households; domestic use of cleaning agents, solvents, cosmetics, toiletries; use of pharmaceutical products in households
2D3b	Road paving with asphalt	Road paving
2D3c	Asphalt roofing	Asphalt roofing
2D3d	Coating applications	Paint application in households, industry, construction and wood and car repairing
2D3e	Degreasing	Metal degreasing and cleaning; cleaning of electronic components; other industrial cleaning
2D3f	Dry cleaning	Dry cleaning
2D3g	Chemical products	Handling and storage of solvents; production of fine chemicals, pharmaceuticals; manufacturing of paint, inks, glues, adhesive tape (ceased in 1994); processing of rubber, PVC, polystyrene foam, polyurethane and polyester; tanning of leather
2D3h	Printing	Package printing, other printing industry
2D3i	Other solvent use	Removal of paint and lacquer; vehicles dewaxing (ceased in 2001); production of perfume/aroma and cosmetics, paper and paper board, tobacco products, textile products; scientific laboratories; not attributable solvent emissions; extraction of oil and fats (ceased in 2000);

Table 4-24: Key categories, level 2015 (L1) and trend 1990-2015 (T1), for source category 2D Other solvent use

NFR	Source Category	Pollutant	Identification Criteria
2D3a	Domestic solvent use	NMVOC	L1, T1
2D3b	Road paving with asphalt	NMVOC	L1, T1
2D3d	Coating applications	NMVOC	L1, T1
2D3e	Degreasing	NMVOC	L1
2D3g	Chemical products	NMVOC	L1, T1
2D3h	Printing	NMVOC	L1, T1
2D3i	Other Solvent Use	NMVOC	L1

4.5.2 Methodological issues of 2D Other solvent use

4.5.2.1 Domestic solvent use including fungicides (2D3a)

Methodology (2D3a)

The source category 2D3a Domestic solvent use including fungicides comprises mainly the use of cleaning agents and solvents in private households for building and furniture cleaning and cosmetics and toiletries but also the use of spray cans and pharmaceuticals. These products contain solvents, which evaporate during use or after the application. Among the numerous NMVOC emission sources, the use of household cleaning agents is the largest single source in source category 2D3.

Based on the decision tree Fig. 3.1 in chapter 2D3a in EMEP/EEA (2013), the emissions are calculated by a Tier 2 method (EMIS 2017/2D3a) using country-specific emission factors. All emissions related to domestic solvent use are calculated proportional to the Swiss population.

Emission factors (2D3a)

Household cleaning agents

The source category 2D3a Use of cleaning agents includes the use of cosmetics, toiletries, cleaning agents and care products. Its resulting emission factor bases thus on a multitude of products, their NMVOC contents, emission fractions and consumption numbers. About 80% of the NMVOC emissions stem from the use of cosmetics and toiletries whereas the rest arises from the use of cleaning agents and care products.

Available data sources consist of surveys of the use of household cleaning agents, cosmetics and toiletries in Switzerland (1990) and information from the Swiss association of cosmetics and detergents (SKW 2010) as well as surveys from Germany (1998, 2005). From 2001 until 2010 a constant EF is assumed for domestic use of cleaning agents. The value is based both on information from the Swiss association of cosmetics and detergents (SKW 2010) and from a German study on NMVOC emissions from solvent use and abatement possibilities by Theloke J. (2005). There were no significant improvements in the solvent compositions of the employed detergents.

In a study conducted in 2013/2014 in Switzerland more accurate data of household cleaning agents, cosmetics and toiletries was collected based on comprehensive surveys at retailers, producers, industry associations and experts as well as analysis of import statistics (Hubschmid 2014). As a result of this study, the emission factor of household cleaning agents was adjusted in 2013. The study indicates again an increase in the NMVOC emission factor in 2013.

Domestic use of spray cans

Emission factors of domestic use of spray cans are based on surveys in Switzerland (1990) and information from the Swiss Association for Aerosols (ASA) for years 1998, 2001, 2007 and 2010 and from a German study on NMVOC emissions from solvent use and abatement possibilities by Theloke J. (2005). In a study conducted in 2013/2014 in Switzerland more accurate data of domestic spray cans were collected based on comprehensive surveys at retailers, producers, industry associations and experts as well as analysis of import statistics (Hubschmid 2014). As a result of this study, the emission factor of spray cans was adjusted in 2013. The study indicates again an increase in the NMVOC emission factor in 2013.

Domestic use of pharmaceutical products

Emission factors of domestic use of pharmaceutical products are available from surveys in Switzerland (1990) and Germany (1998) and from the Swiss business association for the chemical, pharmaceutical and biotech industry (scienceindustries) for 2011, as documented in the EMIS database. For years with no survey data, emission factors are interpolated.

Table 4-25: Emission factors of 2D3a Domestic solvent use including fungicides in 2015

2D3a Domestic solvent use	Unit	NMVOC
Domestic use of spray cans	g/inhabitant	329
Household cleaning agents	g/inhabitant	989
Domestic use of pharmaceutical products	g/inhabitant	30

Activity data (2D3a)

As described in the methodology chapter, the activity data used for calculating the NMVOC emissions in 2D3a Domestic solvent use corresponds to the Swiss population (SFSO 2016a).

Table 4-26: Activity data of 2D3a Domestic solvent use including fungicides.

2D3a Domestic solvent use	Unit	1990	1995	2000	2005
	inhabitants	6'796'000	7'081'000	7'209'000	7'501'000

2D3a Domestic solvent use	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	inhabitants	7'558'000	7'619'000	7'711'000	7'801'000	7'878'000	7'912'000	7'997'000	8'089'000	8'189'000	8'282'000

4.5.2.2 Road paving with asphalt (2D3b)

Methodology (2D3b)

Based on the decision tree Fig. 3.1 in chapter 2D3b in EMEP/EEA (2013), the NMVOC emissions from 2D3b Road paving with asphalt are determined by a Tier 2 method based on country-specific emission factors as documented in EMIS 2017/2D3b. Other pollutants are not considered.

Emission factors (2D3b)

The emission factor for NMVOC emissions from 2D3b Road paving with asphalt comprises NMVOC emissions from the use of prime coatings and from the bitumen content in asphalt products (about 5%). The NMVOC content in the bitumen has decreased considerably between 1990 and 2010.The values are based on industry data from 1990, 1998, 2007, 2010 and 2013. All other years are interpolated and complemented with expert estimates documented in the EMIS database.

Table 4-27: Emission factors of 2D3b Road paving with asphalt in 2015.

2D3b Road paving with asphalt	Unit	NMVOC	PM2.5exh.	PM10exh.	TSP	BC
Asphalt concrete	kg/t	0.54	NE	NE	NE	NE

Activity data (2D3b)

Activity data on the amount of asphalt products (so-called mixed goods) used for road paving is based on annual data from the association of asphalt production industry (SMI) for 1990 and from 1998 onwards and expert estimates for the years in between.

Table 4-28: Activity data of 2D3b Road paving with asphalt.

2D3b Road paving with asphalt	Unit	1990	1995	2000	2005
Asphalt concrete	kt	5'500	4'800	5'170	4'780

2D3b Road paving with asphalt	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Asphalt concrete	kt	5'400	5'100	5'160	5'200	5'250	5'300	4'770	4'770	5'260	4'850

4.5.2.3 Asphalt roofing (2D3c)

Methodology (2D3c)

In Switzerland there are three main producers of asphalt roofing material. Based on the decision tree Fig. 3.1 in chapter 2D3c in EMEP/EEA (2013), the emissions of NMVOC, particulate matter and CO from Asphalt roofing are determined by a Tier 2 method based on country-specific emission factors as documented in EMIS 2017/2D3c.

Emission factors (2D3c)

The emission factors from Asphalt roofing are based on information from the industry association, literature and expert estimates as documented in the EMIS database.

Table 4-29: Emission factors of 2D3c Asphalt roofing in 2015.

2D3c Asphalt roofing	Unit	NMVOC	PM2.5 exh.	PM10 exh.	TSP exh.	BC exh.	CO
Production	kg/t sheeting	0.15	3.1	4.0	6.2	0.0003	124
Production, prime coat	kg/t solvent	30	NA	NA	NA	NA	NA
Laying	kg/t sheeting	1.8	NA	NA	NA	NA	NA
Laying, prime coat	kg/t solvent	1'000	NA	NA	NA	NA	NA

Activity data (2D3c)

Activity data is based on data from industry and expert estimates as documented in the EMIS database.

Table 4-30: Activity data of 2D3c Asphalt roofing.

2D3c Asphalt roofing	Unit	1990	1995	2000	2005
Production	kt sheeting	50	45	41	30
Production, prime coat	kt solvent	2.0	1.8	1.6	1.1
Laying	kt sheeting	59	57	56	38
Laying, prime coat	kt solvent	1.8	1.6	1.5	1.0

2D3c Asphalt roofing	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Production	kt sheeting	28	26	26	25	25	25	24	24	24	24
Production, prime coat	kt solvent	0.9	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.5
Laying	kt sheeting	32	26	26	26	26	26	26	26	26	26
Laying, prime coat	kt solvent	0.8	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.4

4.5.2.4 Coating applications (2D3d)

Methodology (2D3d)

This source category comprises emissions from paint application in construction, households, industry, wood and car repair. Based on the decision tree Fig. 3.1 in chapter 2D3d in EMEP/EEA (2013), for 2D3d Coating applications a bottom-up Tier 2 method based on the consumption of paints, lacquers, thinners and related materials and their solvent content. Country-specific emission factors are used.

In 2015, the most important emission sources are 2D3d Paint application in construction and 2D3d Paint application, wood and 2D3 Paint application industrial & non-industrial.

Emission factors (2D3d)

Emission factors for NMVOC are based on data from VSLF and retailers as documented in the EMIS database (EMIS 2017/2D3d). In recent years, values of all emission factors for coating applications declined as a result of both a reduction of the solvent content and replacing of solvent based paint by water based paint due to increasingly strict NMVOC regulations by the EU directive (EC 2004). In addition, powder coatings, which are far more efficient, replaced in this time period the conventional paint (rough estimate: 1 t of powder coating replaces 3 t of conventional paint).

For 2D3d Paint application in construction the emission factor of NMVOC is based on a case study by VSLF in 2005 and expert estimates.

Table 4-31: Emission factors of 2D3d Coating applications in 2015.

2D3d Coating applications	Unit	NMVOC
Paint application, construction	kg/t paint	55
Paint application, households	kg/t paint	86
Paint application, industrial & non-industrial	kg/t paint	345
Paint application, wood	kg/t paint	291
Paint application, car repair	kg/t paint	400

Activity data (2D3d)

The activity data correspond to the annual consumption of paints. The consumption and solvent content are estimated according to information from the Swiss association for coating and paint applications (VSLF) and in addition from relevant retailers for paint applications in households (EMIS 2017/2D3d). Between 1990 and 1998, the total consumption of paint decreased considerably and increases continuously again since 2001. This trend results from the opposing trends in the different source categories:

- 2D3d Paint application, construction: Activity data of paint application in construction show a substantial reduction compared to 1990 levels. The increasing tendency in paint application since 2000 can be explained by an increase in the construction activity in Switzerland. Since 2000, the expenditures on construction have increased and are thus contributing to an increase in paint application in construction. Before 2000, there was a decline in construction activity, which explains the decreasing tendency in paint application.
- 2D3d Paint application, industrial & non industrial: Between 1990 and 2015, the activity of industrial and non-industrial paint application decreased significantly. Due to structural changes in the industrial sectors, there is a decreasing tendency in emissions between 2000 and 2005. Slight annual fluctuations can be explained by the development of the economic situation, e.g. slight increase in 2007 and decrease in 2008.
- 2D3d Paint application, households: Activity data of paint application in households has more than doubled between 1990 and 2015 due to an increase in demand. The number of private households increased since 1990, thus leading to an increasing tendency in paint application in the household sector.

Table 4-32: Activity data of 2D3d Coating application.

2D3d Coating applications	Unit	1990	1995	2000	2005
Paint application, construction	kt	122	66	33	42
Paint application, households	kt	12	13	13	20
Paint application, industrial & non-industrial	kt	20	21	21	9
Paint application, wood	kt	6	6	7	8
Paint application, car repair	kt	2.7	2.2	2.0	1.9

2D3d Coating applications	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Paint application, construction	kt	44	45	48	51	54	56	59	61	61	61
Paint application, households	kt	20	20	23	25	28	28	28	28	28	29
Paint application, industrial & non-industrial	kt	9	9	9	9	8	8	8	8	8	8
Paint application, wood	kt	8	8	9	9	10	10	10	10	10	10
Paint application, car repair	kt	1.8	1.8	1.8	1.7	1.7	1.5	1.4	1.2	1.2	1.3

4.5.2.5 Degreasing (2D3e)

Methodology (2D3e)

Source category 2D3e comprises emissions from degreasing of electronic components, metal and other industrial cleaning. Based on the decision tree Fig. 3.1 in chapter 2D3e in EMEP/EEA (2013), the NMVOC emissions from 2D3e Degreasing are calculated by a Tier 2 method (EMIS 2017/2D3e) using country-specific emission factors.

Emission factors (2D3e)

Emission factors for NMVOC are estimated based on data from industry surveys by swissmem (including VOC balance evaluations in 2004, 2007 and 2012) and expert estimates as documented in the EMIS database.

Table 4-33: Emission factors of 2D3e Degreasing in 2015.

2D3e Degreasing	Unit	NMVOC
Cleaning of electronic components	kg/t solvent	500
Degreasing of metal	kg/t solvent	460
Other industrial cleaning	kg/t solvent	610

Activity data (2D3e)

Activity data correspond to the annual consumption of solvents for degreasing. Data are based on data from the association of Swiss mechanical and electric engineering industries (swissmem) in 2004, 2007 and 2012, VOC balances of the most important companies, import statistics and expert estimates, documented in the EMIS database (EMIS 2017/2D3e). A comparison between the surveys and the evaluations of VOC balances showed an underestimation of the survey data by about 6%. Thus, the emissions based on survey data from the industry association (swissmem) have been corrected by +10%. (EMIS 2017/2D3e).

By far, the highest activity data, i.e. consumption of solvents shows 2D3e Metal degreasing – which is the most important source of NMVOC emissions within source category 2D3e – for the entire time series.

Table 4-34: Activity data of 2D3e Degreasing.

2D3e Degreasing	Unit	1990	1995	2000	2005
Cleaning of electronic components	kt	0.9	0.6	0.4	0.6
Degreasing of metal	kt	16	10	5.9	2.6
Other industrial cleaning	kt	0.6	0.6	0.6	1.4

2D3e Degreasing	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cleaning of electronic components	kt	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7
Degreasing of metal	kt	2.5	2.4	2.3	2.2	2.1	2.0	1.9	1.9	1.9	1.9
Other industrial cleaning	kt	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

4.5.2.6 Dry cleaning (2D3f)

Methodology (2D3f)

Based on the decision tree Fig. 3.1 in chapter 2D3f in EMEP/EEA (2013), the NMVOC emissions from 2D3f Dry cleaning are calculated by a Tier 2 method (EMIS 2017/2D3f) using country-specific emission factors.

Emission factors (2D3f)

Emission factors for NMVOC are estimated based on data and information from a survey of selected dry cleaning facilities that are representative for Swiss dry cleaning factilities and import statistics as documented in the EMIS database.

Table 4-35: Emission factors of 2D3f Dry cleaning in 2015.

2D3f Dry cleaning	Unit	NMVOC
	kg/t solvent	500

Activity data (2D3f)

For dry cleaning, activity data is based on the amount of tetrachloroethylene (PER) and non-halogenated solvents imported and estimates of the share used for dry cleaning. Activity data for 2012 are based on the most recent survey at cantons and cleaning facilities as well as data from the Swiss supervising association of textile cleaning (VKTS). Activity data for 1990 are based on net imports of PER. For the years in between, data are interpolated linearly and after 2012, the activity data are assumed to remain constant.

Table 4-36: Activity data of 2D3f Dry cleaning.

2D3f Dry cleaning	Unit	1990	1995	2000	2005
solvent	kt	1.300	1.011	0.722	0.433

2D3f Dry cleaning	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
solvent	kt	0.375	0.317	0.259	0.201	0.144	0.086	0.028	0.028	0.028	0.028

4.5.2.7 Chemical products (2D3g)

Methodology (2D3g)

Based on the decision tree Fig. 3.1 in chapter 2D3g in EMEP/EEA (2013), for source category 2D3g Chemical products a Tier 2 method using country-specific emission factors is used for calculating the NMVOC emissions (EMIS 2017/2D3g).

Emission factors (2D3g)

Emission factors for NMVOC are mainly provided by industry associations, i.e. for

- fine chemicals production, pharmaceutical production and handling and storing of solvents: Swiss business association for the chemical, pharmaceutical and biotech industry (scienceindustries)
- paint and ink production: Swiss association for coating and paint applications (VSLF) and the Swiss Organisation for the Solvent Recovery of Industrial Enterprises in the Packaging Sector (SOLV)
- polyurethane processing: Swiss plastics association
- polyester processing: Swiss polyester association
- tanning of leather: Swiss leather tanning association.

For the other processes in source category 2D3g data are based on information from the industry and expert estimates as documented in the EMIS database.

Table 4-37: Emission factors of 2D3g Chemical products in 2015.

2D3g Chemical products	Unit	NMVOC
Fine chemicals production	t/production index	3.6
Glue production	kg/t glue	0.79
Handling and storing of solvents	t/production index	1.9
Ink production	kg/t ink	8.5
Paint production	kg/t paint	3.5
Pharmaceutical production	kg/t pharmaceuticals	7.7
Polyester processing	kg/t polyester	50
Polystyrene processing	kg/t polystyrene	16
Polyurethane processing	kg/t polyurethane	3.6
PVC processing	kg/t PVC	4.0
Rubber processing	kg/tyres	0.14
Tanning of leather	kg/employee	0.68

Activity data (2D3g)

The activity data are mainly production or consumption data provided by industry associations and by the Swiss Federal Office of Statistics, i.e. for

- fine chemicals production and handling and storing of solvents: Swiss Federal Office of Statistics
- pharmaceutical production: Swiss business association for the chemical, pharmaceutical and biotech industry (scienceindustries)
- paint and ink production: Swiss association for coating and paint applications (VSLF) and Swiss Organisation for the Solvent Recovery of Industrial Enterprises in the Packaging Sector (SOLV)
- polyurethane processing: Swiss plastics association
- polyester processing: Swiss polyester association
- tanning of leather: Swiss leather tanning association.

For the other processes in source category 2D3g data are based on information of from the industry and expert estimates as documented in the EMIS database. Since 1994 no production of adhesive tape is occurring in Switzerland anymore.

Table 4-38: Activity data of 2D3g Chemical products.

2D3g Chemical products	Unit	1990	1995	2000	2005
Fine chemicals production	prod. index	70	100	163	224
Glue production	kt	19	32	44	60
Handling and storing of solvents	prod. index	70	100	163	224
Ink production	kt	20	18	18	18
Paint production	kt	138	122	117	122
Pharmaceutical production	kt	16	21	20	28
Polyester processing	kt	11	7	6	7
Polystyrene processing	kt	20	19	19	24
Polyurethane processing	kt	17	35	45	54
Production of adhesive tape	kt	1.5	NO	NO	NO
PVC processing	kt	94	94	78	64
Rubber processing	tyres	120'000	119'375	103'667	67'000
Tanning of leather	employees	110	108	102	88

2D3g Chemical products	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fine chemicals production	prod. index	246	283	280	295	314	299	302	305	308	311
Glue production	kt	62	64	64	64	63	63	63	62	62	62
Handling and storing of solvents	prod. index	246	283	280	295	314	299	302	305	308	311
Ink production	kt	18	19	19	19	19	21	24	26	26	25
Paint production	kt	124	125	125	126	126	126	126	126	125	124
Pharmaceutical production	kt	28	29	29	30	30	30	30	30	30	30
Polyester processing	kt	7	8	6	5	3	4	4	4	4	4
Polystyrene processing	kt	26	26	29	31	34	36	31	32	32	33
Polyurethane processing	kt	59	70	67	52	54	40	40	38	38	37
Production of adhesive tape	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
PVC processing	kt	69	78	73	62	52	55	40	38	37	36
Rubber processing	tyres	70'000	70'000	72'500	75'000	77'500	80'000	80'000	81'000	82'000	83'000
Tanning of leather	employees	88	87	87	87	87	87	86	85	85	84

4.5.2.8 Printing (2D3h)

Methodology (2D3h)

The source category 2D3h Printing is differentiated into package printing and other printing industry. Based on the decision tree Fig. 3.1 in chapter 2D3g in EMEP/EEA (2013), a Tier 2 method using country-specific emission factors is used for calculating the NMVOC emissions from the ink applications (EMIS 2017/2D3h).

Emission factors (2D3h)

Emission factors for NMVOC are based on data from, industry associations (Swiss Organisation for the Solvent Recovery of Industrial Enterprises in the Packaging Sector (SOLV)), surveys on the VOC balances in the printing industry, German studies on NMVOC emissions from solvent use (Theloke J. 2005) and expert estimates, as documented in the EMIS database.

Table 4-39: Emission factors of 2D3h Printing in 2015.

2D3h Printing	Unit	NMVOC
Printing	kg/t ink	280
Package printing	kg/t ink	181

Activity data (2D3h)

The activity data correspond to the consumption of printing ink. These data stem from industry associations (SOLV), surveys on the VOC balances in the printing industry and expert estimates, documented in the EMIS database.

Table 4-40: Activity data of 2D3h Printing.

2D3h Printing	Unit	1990	1995	2000	2005
Printing	kt	13	13	14	5
Package printing	kt	6	6	5	9

2D3h Printing	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Printing	kt	4	3	3	2	2	2	2	2	2	2
Package printing	kt	11	13	13	13	13	13	13	13	13	13

4.5.2.9 Other solvent use (2D3i)

Methodology (2D3i)

Source category 2D3i Other solvent use consists of a number of solvent uses in various production processes and services. Based on the decision tree Fig. 3.1 in chapter 2D3i in EMEP/EEA (2013), a Tier 2 method using country-specific emission factors is applied for calculating the NMVOC emissions from the different solvent applications in source category 2D3i Other solvent use (EMIS 2017/2D3i). For the source category 2D3i Not-attributable solvent emissions, so-called direct emission data is available only.

Emission factors (2D3i)

Emission factors for NMVOC are based on data from industry and services, industry associations, German studies on NMVOC emissions from solvent use (Theloke et al. 2000 and Theloke J. 2005) and expert estimates, as documented in the EMIS database.

Table 4-41: Emission factors of 2D3i Other solvent use in 2015.

2D3i Other solvent use	Unit	NMVOC
Production of cosmetics	kg/employee	64
Production of paper and paperboard	g/t	35
Production of perfume and flavour	kg/employee	38
Production of textiles	kg/employee	8
Production of tobacoo	kg/employee	12
Removal of paint and lacquer	g/inhabitant	34
Scientific laboratories	kg/employee	15

Activity data (2D3i)

For the majority of production processes and services – such as production of perfume and flavour and production of textiles – the activity data correspond to the respective number of employees (SFSO 2016b). The quantity of NMVOC emission per employee originates from the bottom-up approach in these industrial sectors and the decentralized political structure in Switzerland. The determined NMVOC emissions of representative production sites or service institutions are referred to the number of employees in order to calculate the Swiss total.

For production of paper and paperboard and fat, edible and non-edible oil extraction, the activity data are based on production volumes. Annual production volumes of paper and paperboard are provided by the Swiss association of pulp, paper and paperboard industry (ZPK). For the removal of paint and lacquer the activity data correspond to the number of inhabitants (SFSO 2016a).

Table 4-42: Activity data of 2D3i Other solvent use.

2D3i Other solvent use	Unit	1990	1995	2000	2005
Fat, edible and non-edible oil extraction	kt	40	38	12	NO
Production of cosmetics	employees	2'200	2'200	2'267	2'100
Production of paper and paperboard	kt	1'510	1'560	1'780	1'750
Production of perfume and flavour	employees	2'200	2'325	2'567	3'200
Production of textiles	employees	25'200	26'763	24'300	17'067
Production of tobacoo	employees	3'300	2'988	2'729	2'710
Removal of paint and lacquer	inhabitants	6'796'000	7'081'000	7'209'000	7'501'000
Scientific laboratories	employees	10'194	18'604	23'217	23'000
Vehicles dewaxing	employees	200'000	166'250	72'667	NO

2D3i Other solvent use	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fat, edible and non-edible oil extraction	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Production of cosmetics	employees	2'100	2'100	2'100	2'100	2'100	2'100	2'100	2'100	2'100	2'100
Production of paper and paperboard	kt	1'690	1'734	1'700	1'540	1'540	1'380	1'390	1'400	1'410	1'420
Production of perfume and flavour	employees	3'300	3'400	3'425	3'450	3'475	3'500	3'521	3'542	3'563	3'583
Production of textiles	employees	16'733	16'400	16'200	14'200	13'800	14'800	14'789	14'778	14'767	14'756
Production of tobacoo	employees	2'705	2'700	2'825	2'950	3'075	3'200	3'200	3'200	3'200	3'200
Removal of paint and lacquer	inhabitants	7'558'000	7'619'000	7'711'000	7'801'000	7'878'000	7'912'000	7'997'000	8'089'000	8'189'000	8'282'000
Scientific laboratories	employees	23'000	23'000	23'000	23'000	23'000	23'000	23'083	23'167	23'250	23'333
Vehicles dewaxing	employees	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

4.5.3 Category-specific recalculations

Recalculations in 2D– Other solvent use

- 2D3b: The AD of 2D3b Road paving has been revised for 2014 based on corrected data from the industry association.

4.6 Source category 2G – Other product use

4.6.1 Source category description of 2G Other product use

Source category 2G Other product use includes about 20 sources releasing NMVOC. In addition, there are also emissions of NO_x, SO_x, NH_3, particulate matter, CO, Pb, Cd, Hg and PAH from use of fireworks and tobacco as well as from renovation of corrosion inhibiting coatings.

Table 4-43: Specification of source category 2G Other product use in Switzerland.

2G	Source	Specification
2G	Other product use	Use of spray cans in industry, concrete additives, cooling and other lubricants, pesticides, tobacco, fireworks; car underbody sealant; de-icing of airplanes; glass and mineral wool enduction; application of glues and adhesives; house cleaning industry/craft/services; hairdressers; cosmetic institutions; preservation of wood; medical practitioners; other health care institutions; other use of gases; renovation of corrosion inhibiting coatings

Table 4-44: Key categories, level 2015 (L1) and trend 1990-2015 (T1), for source category 2G Other product use

NFR	Source Category	Pollutant	Identification Criteria
2G	Other Product Use	NMVOC	L1, T1
2G	Other Product Use	PM2.5	L1, T1
2G	Other Product Use	PM10	L1

4.6.2 Methodological issues of 2G Other product use

4.6.2.1 Other product use (2G)

Methodology (2G)

Within source category 2G Other product use, the major NMVOC emission sources in 2015 are 2G Commercial and industrial use of cleaning agents, 2G De-icing of airplanes and 2G Health care, other.

Based on the decision tree Fig. 3.1 in chapter 2G in EMEP/EEA (2013), for source category 2G Other product use Tier 2 methods using country-specific emission factors are applied for calculating the emissions from the different product applications and the use of fireworks and tobacco (EMIS 2017/2G).

For the source categories 2G Renovation of corrosion inhibiting coatings and 2G Use of aerosol cans in commerce and industry so-called direct emission data is available only.

Emission factors (2G)

Emission factors for NMVOC are based on data from industry and services, industry associations, German studies on NMVOC emissions from solvent use (Theloke et al. 2000 and Theloke J. 2005) and expert estimates, as documented in the EMIS database.

Table 4-45: Emission factors of 2G Other product use in 2015.

2G Other product use	Unit	NMVOC
Application of glues and adhesives	kg/t solvent	732
Commercial and industrial use of cleaning agents	g/employee	454
Cosmetic institutions	kg/employee	28
De-icing of airplanes	kg/t de-icing agent	280
Glass wool enduction	g/t glass wool	190
Hairdressers	kg/employee	14
Health care, other	kg/employee	8
Medical practices	kg/employee	8
Preservation of wood	kg/t preservative	110
Rock wool enduction	g/t rock wool	380
Underseal treatment and conservation of vehicles	kg/t underseal agent	400
Use of concrete additives	g/t additive	740
Use of cooling lubricants	kg/t lubricant	6
Use of lubricants	kg/t lubricant	340
Use of pesticides	kg/t pesticide	33
Use of tobacco	kg/Mio cigarette eq.	9

Emission factors for pollutants other than NMVOC from 2G Use of fireworks and tobacco (EMIS 2017/2G) are displayed in Table 4-46. Emission factors of fireworks are documented in FOEN (2014d).

Table 4-46: Emission factors of all pollutants other than NMVOC from 2G Other product use in 2015.

2G	Unit	NO_x	SO_x	NH_3	PM2.5 exh.	PM10 exh.	TSP exh.	BC exh.	CO
Fireworks	kg/t fireworks	0.26	4	NA	90	180	180	NE	7.4
Use of tobacco	kg/Mio cigarette eq.	NE	NE	4.1	8.1	8.1	8.1	0.04	80

2G	Unit	Pb	Cd	Hg	BaP	BbF	BkF	IcdP
Fireworks	g/t fireworks	130	3.0	0.1	NE	NE	NE	NE
Use of tobacco	g/Mio cigarette eq.	NE	NE	NE	0.2	0.3	0.3	0.5

Activity data (2G)

For the production processes, such as enduction of glass and rock wool and part of the applications in services, such as preservation of wood and application of glues and adhesives the activity data are based on production volume or employed agents. For the other part of applications in services, such as house cleaning in services, commerce and industry and medical practices the activity data correspond to the respective number of employees. The quantity of NMVOC emission per employee originates from the bottom-up approach in these service sectors and the decentralized political structure in Switzerland. The determined NMVOC emissions of representative production sites or service institutions are refererenced to the number of employees in order to calculate the Swiss total.

The activity data stem from industry, services, industry associations, Swiss federal statistical office and expert estimates and are documented in the EMIS database. Activity data for annual tobacco consumption and the annual firework sales are provided by the Swiss addiction prevention foundation (“Sucht Schweiz”) and the statistics of the Swiss federal office for police (FEDPOL 2016), respectively.

Table 4-47: Activity data of 2G Other product use.

2G Other product use	Unit	1990	1995	2000	2005
Application of glues and adhesives	kt solvent	4	3	2	2
Commercial and industrial use of cleaning agents	employees	3'950'000	3'867'500	3'954'667	4'133'667
Cosmetic institutions	employees	2'600	3'100	3'533	3'800
De-icing of airplanes	kt	1	1	1	3
Fireworks	kt	1	1	2	1
Glass wool enduction	kt	24	24	31	37
Hairdressers	employees	20'553	22'826	23'530	22'200
Health care, other	employees	113'000	129'250	145'667	161'667
Medical practices	employees	27'625	42'047	50'833	55'357
Preservation of wood	kt	6	8	9	7
Rock wool enduction	kt	38	40	51	46
Underseal treatment and conservation of vehicles	kt	0.1	0.1	0.1	0.1
Use of concrete additives	kt	24	25	29	36
Use of cooling lubricants	kt	5	5	6	6
Use of lubricants	kt	1	1	1	4
Use of pesticides	kt	2	2	2	2
Use of tobacco	Mio cigarette eq.	16'192	15'774	14'751	13'369

2G Other product use	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Application of glues and adhesives	kt solvent	1	1	1	1	1	1	2	1	1	1
Commercial and industrial use of cleaning agents	employees	4'208'333	4'283'000	4'323'333	4'363'667	4'404'000	4'333'333	4'262'667	4'192'000	4'236'000	4'280'000
Cosmetic institutions	employees	4'000	4'200	4'400	4'600	4'800	5'000	5'111	5'222	5'333	5'444
De-icing of airplanes	kt	2	2	2	3	4	4	5	5	5	5
Fireworks	kt	2	2	2	2	2	2	2	2	2	2
Glass wool enduction	kt	38	44	44	33	36	41	39	33	32	31
Hairdressers	employees	22'200	22'200	23'000	23'000	23'000	23'000	23'000	23'000	23'000	23'000
Health care, other	employees	163'333	165'000	163'000	163'000	163'000	163'000	163'000	163'000	163'000	163'000
Medical practices	employees	56'471	57'586	58'700	58'700	58'700	58'700	58'700	58'700	58'700	58'700
Preservation of wood	kt	7	7	6	5	4	4	3	2	2	2
Rock wool enduction	kt	53	63	58	53	56	57	57	54	53	47
Underseal treatment and conservation of vehicles	kt	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Use of concrete additives	kt	35	34	34	34	41	44	38	38	38	38
Use of cooling lubricants	kt	6	5	4	3	4	4	4	4	4	4
Use of lubricants	kt	3	2	0.4	0.3	0.4	0.5	0.4	0.4	0.4	0.4
Use of pesticides	kt	2	2	2	2	2	2	2	2	2	2
Use of tobacco	Mio cigarette eq.	13'808	13'072	13'310	13'667	12'443	11'856	12'705	12'162	10'628	10'284

4.6.3 Category-specific recalculations

- 2G: Unfortunately, there is a double-counting in the NMVOC emissions from 2G De-icing of airplanes for the years 1990-2006. This mistake will be corrected in submission 2018.

4.7 Source categories 2H – Other and 2I – Wood processing

4.7.1 Source category description of 2H Other and 2I Wood processing

Table 4-48: Specification of source category 2H Other and 2I Wood processing in Switzerland.

2H, 2I	Source	Specification
2H1	Pulp and paper industry	Production of fibreboards, chipboards and cellulose (ceased in 2008)
2H2	Food and beverages industry	Production of beer, spirits, wine, bread, sugar, smoked and roasted meat and mills
2H3	Other industrial processes	Blasting and shooting
2I	Wood processing	Wood processing

Table 4-49: Key categories, level 2015 (L1) and trend 1990-2015 (T1), for source category 2H Other and 2I Wood processing

NFR	Source Category	Pollutant	Identification Criteria
2H1	Pulp and paper	PM2.5	L1, T1
2H2	Food and beverages industry	NMVOC	L1, T1
2H2	Food and beverages industry	PM2.5	L1
2I	Wood processing	PM10	T1

4.7.2 Methodological issues of 2H Other and 2I Wood processing

4.7.2.1 Pulp and paper industry (2H1)

Methodology (2H1)

In 2015, the production of chipboard and fibreboard are the relevant industrial processes in the source category 2H1 Pulp and paper industry. In Switzerland, chipboard and fibreboard are produced in one and two plants, respectively. The cellulose production was closed down in 2008 and is not occurring anymore in Switzerland.

Based on the decision tree Fig. 3.1 in chapter 2H1 in EMEP/EEA (2013), the emissions are calculated by a Tier 2 method using country-specific emission factors (EMIS 2017/2H1).

Emission factors (2H1)

Emission factors are based on measurements of the chipboard production plant whereas constant emission factors are assumed for the fibreboard production, documented in the EMIS database.

Table 4-50: Emission factors for 2H1 Pulp and paper industry in 2015.

2H1 Pulp and paper industry	Unit	NMVOC	PM2.5 nonexh.	PM10 nonexh.	TSP nonexh.	PCDD/PCDF
Fibreboard production	g/t fibreboard	520	430	440	500	NA
Chipboard production	g/t chipboard	584	418	434	501	0.0000005

Activity data (2H1)

Activity data on annual chipboard production has been provided by the industry since 2005 and between 1990 and 2003 annual data are based on the annual statistics on forest and wood (SFSO/BUWAL 2004) as documented in the EMIS database.

Activity data on annual fibreboard production are provided by monitoring reports of the industry since 1996 as documented in the EMIS database.

There are only two production sites for chipboard and fibreboard in Switzerland. Due to confidentiality, only the sum of the production volume of 2H1 Pulp and paper industry is provided. Detailed data can be accessed by reviewers on request.

Table 4-51: Activity data of 2H1 Pulp and paper industry.

2H1 Pulp and paper industry	Unit	1990	1995	2000	2005
Sum of chipboard, fibreboard and cellulose production	kt	604	593	641	693

2H1 Pulp and paper industry	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Sum of chipboard, fibreboard and cellulose production	kt	731	790	765	544	602	564	533	510	516	519

4.7.2.2 Food and beverages industry (2H2)

Methodology (2H2)

Based on the decision tree Fig. 3.1 in chapter 2H2 in EMEP/EEA (2013), the emissions from the source category 2H2 Food and beverages industry, are calculated by a Tier 2 method using country-specific emission factors (EMIS 2017/2H2).

Emission factors (2H2)

Emission factors are based on measurements, data from industry and expert estimates as well as data from a study on Emissions of volatile organic compounds (VOCs) from the food and drink industries of the European Community (Passant et al., 1993), documented in the EMIS database. For bread production, the emission factor is derived from the arithmetic mean of different studies and information provided by some ot the Swiss bread producers as documented in the EMIS database (EMIS 2017/2H2 Brot Produktion).

Table 4-52: Emission factors for 2H2 Food and beverages industry in 2015.

2H2 Food and beverages industry	Unit	NMVOC	NH_3
Breweries	g/m³ beer	250	NA
Spirits production	g/m³ alcohol	10'000	NA
Bread production	g/t bread	7'000	NA
Meat smokehouses	g/t meat	1'300	NA
Roasting facilities	g/t coffee	30	NA
Milling companies	g/t flour	NA	NA
Wine production	g/m³ wine	580	NA
Sugar production	g/t sugar	195	332

2H2 Food and beverages industry	Unit	PM2.5 exh.	PM2.5 nonexh.	PM10 exh.	PM10 nonexh.	TSP exh.	TSP nonexh.	BC exh.	CO	PCDD/PCDF
Breweries	g/m³ beer	NA	NA	NA	NA	NA	NA	NA	NA	NA
Spirits production	g/m³ alcohol	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bread production	g/t bread	NA	NA	NA	NA	NA	NA	NA	NA	NA
Meat smokehouses	g/t meat	350	NA	350	NA	350	NA	NE	250	0.000003
Roasting facilities	g/t coffee	NA	30	NA	60	NA	60	NA	NA	NA
Milling companies	g/t flour	NA	50	NA	100	NA	160	NA	NA	NA
Wine production	g/m³ wine	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sugar production	g/t sugar	NA	260	NA	520	NA	600	NA	NA	NA

Activity data (2H2)

Activity data on annual production have been provided by industry, the Swiss farmers' union (SBV), the Swiss Fatstock and Meat Suppliers Cooperative (Schweiz. Genossenschaft für Schlachtvieh- und Fleischversorgung (GSF)), the Swiss Federal Office for Agriculture and the Swiss Alcohol Board as documented in the EMIS database. Activity data on annual bread production are derived from the number of inhabitants (SFSO 2016) and the annual bread consumption per inhabitant provided by the Swiss bread statistics (Schwizerische Brotinformation, SBI) as documented in the EMIS database (EMIS 2017/2H2 Brot Produktion).

Table 4-53: Activity data of 2H2 Food and beverages industry.

2H2 Food and beverages industry	Unit	1990	1995	2000	2005
Breweries	m³	436'814	401'555	366'956	342'085
Spirits production	m³	4'158	3'271	2'179	2'266
Bread production	kt	340	354	360	375
Meat smokehouses	kt	66	65	60	62
Roasting facilities	kt	56	50	58	78
Milling companies	kt	1'644	1'519	1'603	1'425
Wine production	m³	120'000	111'693	123'073	108'526
Sugar production	kt	147	129	219	197

2H2 Food and beverages industry	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Breweries	m³	345'541	350'802	367'758	359'608	357'435	357'591	354'293	339'348	345'861	346'214
Spirits production	m³	1'611	1'555	1'707	1'229	1'945	1'340	1'989	1'158	1'150	1'636
Bread production	kt	378	381	386	383	388	390	394	399	404	408
Meat smokehouses	kt	63	63	65	64	67	66	65	66	67	67
Roasting facilities	kt	64	80	87	93	102	110	110	120	119	125
Milling companies	kt	1'459	1'536	1'606	1'583	1'602	1'589	1'567	1'548	1'606	1'526
Wine production	m³	104'772	109'784	109'828	104'916	108'319	102'522	98'621	108'564	99'556	99'859
Sugar production	kt	203	283	284	314	241	331	286	245	344	261

4.7.2.3 Other industrial processes (2H3)

Methodology (2H3)

Source category 2H3 Other industrial processes encompasses the emissions from blasting and shooting only. Emissions from Claus units in refineries are reported in source category

1B2a iv since submission 2017. An analogous Tier 2 method with country-specific emission factors is used to calculate the emissions.

Emission factors (2H3)

Emission factors per tonne of explosive are derived from the emission factors of civil explosives and information on the specific consumption of explosives in the quarries as documented in the Handbook on emission factors for stationary sources (SAEFL 2000) and the EMIS database. They are assumed to be constant over the entire time period.

Table 4-54: Emission factors for 2H3 Other industrial processes in 2015.

2H3 Other industrial processes	Unit	NO_x	NMVOC	SO_2	NH_3	PM2.5 exh.	PM10 exh.	TSPexh.	BC exh.	CO	Pb
Blasting and shooting	kg/t explosive	35	60	0.5	0.4	6	6	6	NE	310	0.00001

Activity data (2H3)

Activity data for blasting and shooting is taken from federal statistics on explosives (FEDPOL 2016).

Table 4-55: Activity data of 2H3 Other industrial processes.

2H3 Other industrial processes	Unit	1990	1995	2000	2005
Blasting and shooting	kt explosive	2.6	1.3	1.9	0.8

2H3 Other industrial processes	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Blasting and shooting	kt explosive	1.5	1.1	1.4	2.1	2.4	2.9	2.3	2.2	2.1	2.2

4.7.2.4 Wood processing (2I)

Methodology (2I)

Source category 2I includes particulate emissions of wood processing. Emissions from charcoal production are reported in 1A1c Manufacture of solid fuels and other energy industries. According to chapter 2I in EMEP/EEA (2013), the calculation of emissions is based on a Tier 1 method based on country-specific emission factors. Since processing of wood comprises a broad variety of manufacturing processes within the lumber industry and the amount of processed wood is not known, the population of Switzerland has been chosen as measure for the activity data (EMIS 2017/2I Holzbearbeitung).

Emission factors (2I)

Emission factors are based on an industry survey (EMPA 2004).

Table 4-56: Emission factors for 2I Wood processing in 2015.

2I Wood processing	Unit	PM2.5 nonexh.	PM10 nonexh.	TSP nonexh.
Wood processing	g/inhabitant	11	44	110

Activity data (2I)

Activity data on annual wood processing are not known and therefore the Swiss population (SFSO 2016a) is used.

Table 4-57: Activity data of 2I Wood processing.

2I Wood processing	Unit	1990	1995	2000	2005
Wood processing	Inhabitants	6'796'000	7'081'000	7'209'000	7'501'000

2I Wood processing	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Wood processing	Inhabitants	7'558'000	7'619'000	7'711'000	7'801'000	7'878'000	7'912'000	7'997'000	8'089'000	8'189'000	8'282'000

4.7.3 Category-specific recalculations

Recalculations in 2H, 2I – Other

- 2H1: AD of 2H1 Chipboard production has been revised from 2005 onwards based on a changed density value of the chipboard produced.
- 2H2: Activity data of wine production has slightly decreased in the year 2011 due to the correction in the underlying statistics provided by the Swiss Alcohol Administration.
- 2H2: Activity data of sugar production has slighty changed for the years 2011, 2012 and 2014 due to corrections in the statistics provided by the Swiss Sugar Association.
- 2H2: Activity data of meat smokehouses has slightly changed for the years 2007, 2013 and 2014 due to corrections in the statistics provided by the Swiss Federal Office for Statistics.
- 2H2: Activity data of milling companies has slightly changed for the years 2013 and 2014 due to corrections in the statistics provided by the Swiss Federal Office for Agriculture.
- 2H3: SO_2 emissions from Claus-units were previously reported in source category 2H3 and are now reported in 1B2aiv.

4.8 Source category 2L – Other production, consumption, storage, transportation or handling of bulk products

4.8.1 Source category description of 2L Other production, consumption, storage, transportation or handling of bulk products

Source category 2L Other production, consumption, storage, transportation or handling of bulk products includes NH_3 emissions from freezers.

Table 4-58: Specification of source category 2L Other production, consumption, storage, transportation or handling of bulk products in Switzerland.

2L	Source	Specification
2L	Other production, consumption, storage, transportation or handling of bulk products	Ammonia emissions from freezers (filling and storage)

Source category 2L Other production, consumption, storage, transportation or handling of bulk products is not a key category.

4.8.2 Methodological issues of 2L Other production, consumption, storage, transportation or handling of bulk products

4.8.2.1 Use of ammonia as cooling agent (2L)

Methodology (2L)

Ammonia is used as a cooling agent in various applications in the industry and services sector. The most important sources are ice rinks and cold storage facilities. Other relevant sources are breweries, nuclear power plants and chemical industries An analogous Tier 2 method with country-specific emission factors is used to calculate the emissions.

Emission factors (2L)

Emission factors are expressed as share of losses from storage and from filling and recovery. Emission factors are based on expert judgement as documented in the EMIS jdatabase (EMIS 2017/2 F_2 L_NH3 aus Kühlanlagen). Emission factors are assumed constant over the entire time period.

Table 4-59: Emission factors of 2L Other production, consumption, storage, transportation or handling of bulk products use in 2015.

2L Ammonia from freezers	Unit	NH_3
Freezers filling	kg/t	1
Freezers storage	kg/t	2

Activity data (2L)

Activity data are based on data from the industry. They are calculated by multiplying the number of plants and installations that use ammonia for cooling by an average amount of ammonia consumed by the corresponding process. This includes the number of breweries, ice rinks, nuclear power plants, cold storage facilities, chemical industries, large scale heat pumps and air conditioners. Data on average ammonia consumption of each of these processes is provided by a Swiss company for cooling devices (EMIS 2017/2 F_2 L_NH3 aus Kühlanlagen).

Table 4-60: Activity data of 2L Other production, consumption, storage, transportation or handling of bulk products.

2L Ammonia from freezers	Unit	1990	1995	2000	2005
Freezers filling	t	178	201	224	246
Freezers storage	t	1'100	1'100	1'200	1'200

2L Ammonia from freezers	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Freezers filling	t	251	255	260	264	269	273	278	283	287	292
Freezers storage	t	1'200	1'200	1'200	1'200	1'200	1'279	1'357	1'436	1'515	1'593

4.8.3 Category-specific recalculations

Recalculations in 2L – Other product use

- 2L: A new model concerning use of NH_3 as coolant has been provided. Therefore, emissions of NH_3 in commercial and industrial refrigeration due to refilling and storage of NH_3 has been introduced to the inventory.

5 Agriculture

5.1 Overview of emissions

This introductory chapter contains an overview of emissions from sector 3 Agriculture. NH_3, NO_x and PM2.5 are the selected air pollutants for this sector.

The following source categories are reported:

- 3B Manure management
- 3D Crop production and agricultural soils

Note that emissions from burning of agricultural residues is reported in sector Waste (chp. 6.4, category 5C Waste incineration and open burning of waste), since there is no in situ burning of agricultural residues as they are. Even in case of diseases the fruit trees are felled, cut up and burned on piles. This usually occurs on the field, but after chopping and stacking and not as standing trees.

5.1.1 Overview and trend for NH_3

Agriculture is the main source of NH_3 emissions in Switzerland (see Table 2-9). The trend of NH_3 emissions within agriculture is depicted in Figure 5-1. While category 3B Manure management is subject to little variation throughout the period 1990-2015, category 3D Crop production and agricultural soils shows a fluctuating and decreasing trend. A decrease of the agricultural ammonia emissions already happened in the preceding decade 1980-1990 due to declining number of animals and use of mineral fertilizers. The decrease continued until 2003, followed by an increase until 2008 and another decrease since then. This manifold trend results from a combination of changes in animal numbers, introduction of new housing systems due to developments in animal welfare regulations, increase of animal productivity and changes in production techniques.

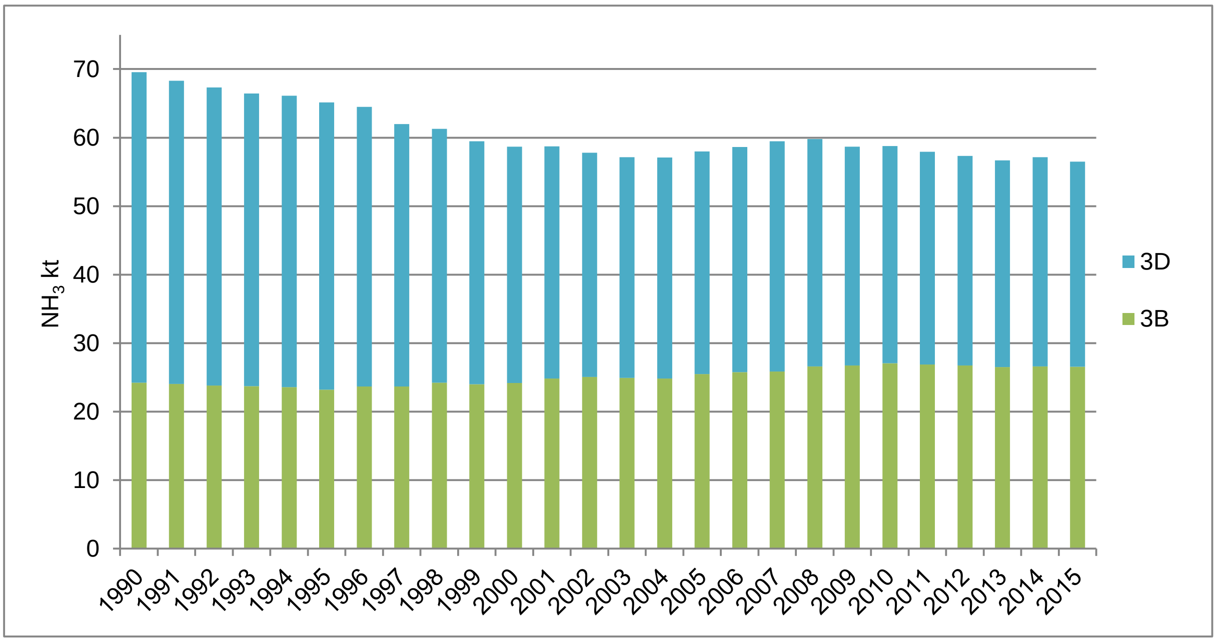

Figure 5-1 Switzerland's NH_3 emissions from agriculture by source categories 3B and 3D between 1990 and 2015. The corresponding data table can be found in Annex 6.4.4.

5.1.2 Overview and trend for PM2.5

In comparison to NH_3, PM2.5 emissions from agriculture are of minor importance compared to total PM2.5 emissions in Switzerland (see Contrary to the decreasing trends mentioned above, there is a small increasing trend in PM2.5 due to non-exhaust particulate emissions from growing activity data of mobile sources. The effect, however, is much weaker than the overall decreasing trend, and it is less pronounced for PM2.5 than for PM10 and TSP (see below in chp. 2.4.3).

Table 2-10). According to Figure 5-2, PM2.5 emissions underwent a slight decrease between 1990 and 1996 followed by a continuous increase since then, being at a slightly higher level in 2015 compared to 1990. The PM2.5 emissions in sector 3 Agriculture strongly depend on category 3B3 Swine. However, the increase since year 2000 is also due to category 3B4g Poultry.

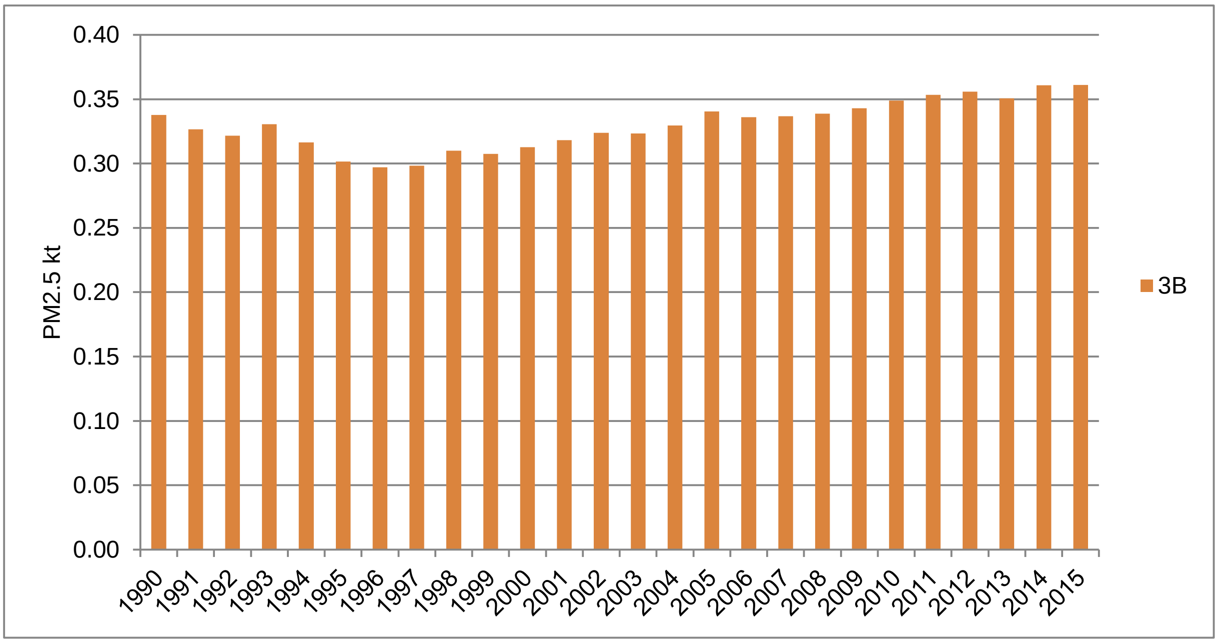

Figure 5-2 Switzerland’s PM2.5 emissions from agriculture between 1990 and 2015. The corresponding data table can be found in Annex 6.4.5.

5.1.3 Overview and trend for NO_x

Alike PM2.5, NO_x emissions from agriculture are of minor importance for the national total NO_x emissions (see Table 2-6). They show a decreasing trend over the whole period 1990-2015 (see Figure 5-3). Main source is category 3D Agricultural soils, where NO_x emissions correlate with NH_3 emissions (precursor).

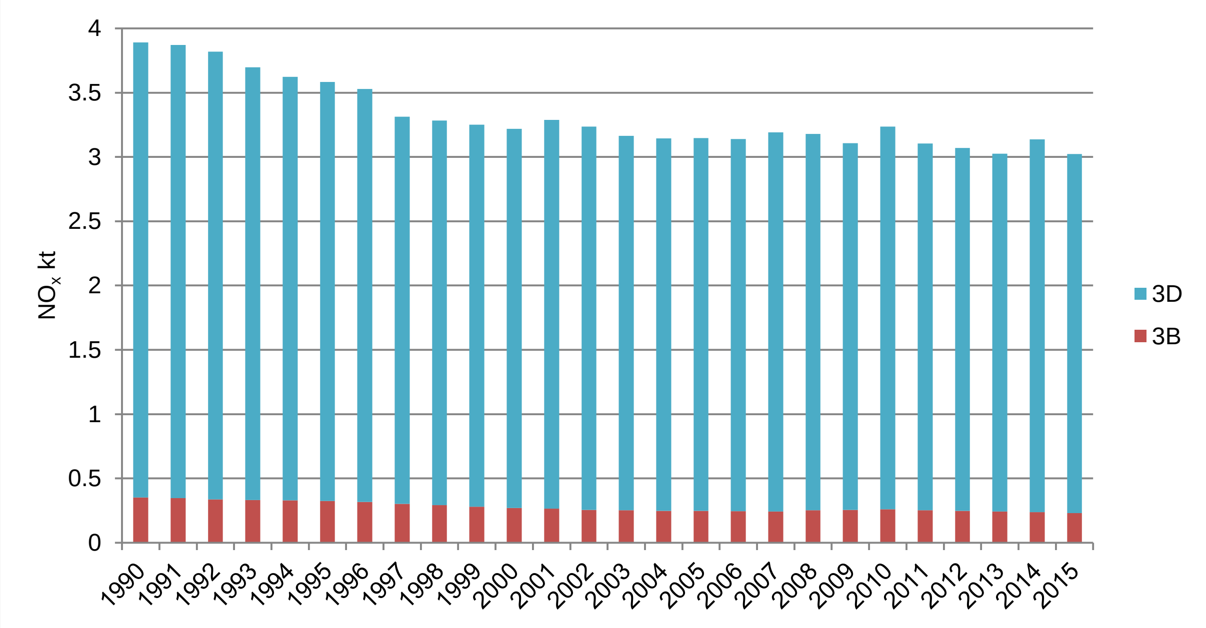

Figure 5-3 Switzerland's NO_X emissions from agriculture between 1990 and 2015. The corresponding data table can be found in Annex 6.4.1.

5.2 Source category 3B – Manure management

5.2.1 Source category description of 3B Manure management

This chapter contains emissions stemming from animal husbandry. This includes emissions from animal manure except categories 3Da2a Animal manure applied to soils and 3Da3 Urine and dung deposited by grazing animals. Emissions from physical activities of the animals (PM from abrasion and resuspension of dust) are included in 3B.

Note: As recommended by the review team, emissions of PM, PM10 and PM2.5 for categories 3B4a Buffalos and 3B4h Other animals are newly estimated and reported in the current submission.

Table 5-1: Specification of source category 3B Manure Management.

3B	Source	Specification
3B1a	Manure management - Dairy cattle	Mature dairy cattle
3B1b	Manure management - Non-dairy cattle	Other mature cattle and growing cattle: fattening calves, pre-weaned calves, breeding cattle 1st, 2nd, 3rd year, fattening cattle
3B2	Manure management - Sheep	
3B3	Manure management - Swine	
3B4a	Manure management - Buffalo	
3B4d	Manure management - Goats	
3B4e	Manure management - Horses	
3B4f	Manure management - Mules and asses	
3B4gi	Manure mangement - Laying hens	
3B4gii	Manure mangement - Broilers	
3B4giii	Manure mangement - Turkeys	
3B4giv	Manure management - Other poultry	
3B4h	Manure management - Other animals	Camels, deer, rabbits

Table 5-2: Key Categories approach 1, level 2015 (L1) and trend 1990-2015 (T1), for source category 3B Manure Management

NFR	Source Category	Pollutant	Identification Criteria
3B1a	Manure management - Dairy cattle	NH3	L1, T1
3B1b	Manure management - Non-dairy cattle	NH3	L1, T1
3B3	Swine	NH3	L1
3B3	Swine	PM10	L1
3B4gi	Layers	PM10	L1, T1
3B4gi	Layers	PM2.5	T1

5.2.2 Methodological issues of 3B Manure management

Methodology (3B)

For calculating the ammonia emissions caused by manure management a country-specific approach is used according to the Tier 3 detailed methodology described in chapter 3B Manure management of the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

An internet-based model called AGRAMMON (2013) was developed in Switzerland allowing the calculation of ammonia emissions for single farms and for regions (www.agrammon.ch). The model simulates the nitrogen flow from animal feeding to excretion (in housing systems and during grazing), to manure storage and to manure application. AGRAMMON considers important parameters on farm and manure management influencing the emissions of ammonia at the different levels of a farm. The Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences (HAFL) collected 2002, 2007, 2010 and 2015 data on farm and manure management at farm-level with a detailed questionnaire. Each survey consisted of a representative stratified random sample covering approximately 2000 to 3000 farms (in total, there are about 60’000 farms in Switzerland). The strata cover several regions of Switzerland, several classes of height above sea level, several production techniques and housing systems and specific animal categories. The data of these three surveys were used to calculate livestock category specific average national emission factors for the four respective years. The emission time series from 2002 to 2015 was established with the calculated emission factors (2002, 2007, 2010, 2015), with interpolated emission factors for the years 2003-2006, 2008-2009 and 2011-2014, and the known development of the number of animals in different livestock categories (activity data). Emission factors beyond 2015 are kept constant until new survey results (planned 2020) are available. The experience gained from the detailed surveys between 2002 and 2010 and from the extrapolation of the single farm data to the totality of farms in Switzerland was used, together with expert assumptions and available statistical data on farm management, to calculate the emissions between 1990 and 2002. The procedure is described in a detailed report accessible on the internet site of AGRAMMON (Kupper et al. 2013, http://www.agrammon.ch/documents-to-download/).

Simultaneously to AGRAMMON (2010, covering about 3000 farms), a larger survey - but less detailed with respect to ammonia relevant farm data - was carried out by the Swiss Federal Statistical Office at the national level covering a sample of about 17’000 farms. This allowed for a plausibility check of the AGRAMMON data, which showed a good compatibility of the resulting national emissions between the two surveys. The difference in overall national emissions was about 1%, although there were higher differences at the process- or farm-level, but these cancelled each other out (Kupper et al. 2013).

The calculation of nitrogen oxide (NO_x) and particulate matter (PM) emissions was conducted with a Tier 1 approach.

Emission factors (3B)

The consideration of structural and management parameters on single farms for the calculation of the ammonia emissions with the nitrogen flow model AGRAMMON results in livestock category specific emission factors reflecting the changes of such parameters over the assessed time period (AGRAMMON 2013, Kupper et al. 2013). Values from Guidebook EMEP/EEA, part Manure Management, Table 3.8 (EMEP/EEA 2013) were taken for NO_x emission factors assuming: liquid/slurry 50% N as TAN, solid storage 25% N as TAN.

The resulting NH_3 and NO_x emission factors for the livestock categories for the time period 1990 to 2010 are listed in Table 5-3 and Table 5-4. Each emission factor reflects the sum of the emissions from animal housing and manure storage. The emissions resulting from the application of manure to soils and from grazing are reported separately under category 3Da2a and 3Da3 and are not included in the emission factors listed in Table 5-3 and Table 5-4, but are given in the tables of chp. 5.3.2.

The particulate matter emission factors (PM2.5) are listed in Table 5-5.

Table 5-3: NH_3 Emission factors for livestock categories from 1990 to 2015. Note that the emissions from grazing and for the application of manure are not included in these emission factors (see chp. 5.3.2).

Emission factors		1990	1995	2000	2005
		kg NH_3 / animal			
3 B 1 a	Dairy cattle	12.88	13.79	15.61	17.30
3 B 1 b	Non-dairy cattle	13.46	14.50	14.42	15.86
3 B 1 c	Young cattle	5.52	5.80	6.09	6.33
3 B 2	Sheep	1.35	1.35	1.37	1.24
3 B 3	Swine	3.25	3.28	3.66	3.56
3 B 4 a	Buffalos	NO	5.18	5.98	6.06
3 B 4 d	Goats	2.28	2.21	2.29	2.02
3 B 4 e	Horses	9.85	9.61	8.78	8.54
3 B 4 f	Mules and asses	3.55	3.47	3.19	2.96
3 B 4 g i	Layers	0.31	0.30	0.25	0.23
3 B 4 g ii	Broilers	0.11	0.10	0.09	0.09
3 B 4 g iii	Turkey	0.37	0.36	0.32	0.32
3 B 4 g iv	Growers	0.17	0.15	0.15	0.12
3 B 4 g iv	Other poultry	0.15	0.14	0.15	0.16
3 B 4 h i	Rabbits	0.23	0.23	0.23	0.23

Emission factors		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		kg NH_3 / animal									
3 B 1 a	Dairy cattle	17.61	17.93	18.38	18.83	19.27	19.38	19.48	19.58	19.68	19.79
3 B 1 b	Non-dairy cattle	16.35	16.84	16.47	16.11	15.74	15.82	15.90	15.98	16.07	16.15
3 B 1 c	Young cattle	6.39	6.44	6.53	6.62	6.69	6.73	6.78	6.83	6.88	6.95
3 B 2	Sheep	1.20	1.18	1.21	1.30	1.35	1.35	1.37	1.38	1.37	1.56
3 B 3	Swine	3.47	3.41	3.46	3.49	3.49	3.40	3.31	3.25	3.17	3.13
3 B 4 a	Buffalos	6.07	5.66	5.71	6.22	6.51	6.73	6.50	6.53	6.46	6.49
3 B 4 d	Goats	1.95	1.85	1.97	2.14	2.24	2.25	2.25	2.23	2.22	2.54
3 B 4 e	Horses	8.56	8.57	8.35	8.14	7.91	8.08	8.26	8.45	8.63	8.83
3 B 4 f	Mules and asses	2.93	2.89	2.85	2.82	2.78	2.85	2.92	2.99	3.05	3.12
3 B 4 g i	Layers	0.22	0.22	0.22	0.22	0.22	0.21	0.21	0.20	0.19	0.18
3 B 4 g ii	Broilers	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08
3 B 4 g iii	Turkey	0.32	0.32	0.31	0.29	0.28	0.29	0.30	0.30	0.31	0.32
3 B 4 g iv	Growers	0.11	0.10	0.10	0.09	0.08	0.08	0.08	0.08	0.08	0.07
3 B 4 g iv	Other poultry	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.16	0.16
3 B 4 h i	Rabbits	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23

Table 5-4: NO_x emission factors for livestock categories from 1990 to 2015.

Emission factors		1990	1995	2000	2005
		kg NO_x / animal			
3 B 1 a	Dairy cattle	0.23	0.21	0.17	0.14
3 B 1 b	Non-dairy cattle	0.22	0.23	0.17	0.14
3 B 1 c	Young cattle	0.10	0.10	0.09	0.08
3 B 2	Sheep	0.04	0.04	0.04	0.04
3 B 3	Swine	0.00	0.00	0.00	0.00
3 B 4 a	Buffalos	NO	0.08	0.09	0.07
3 B 4 d	Goats	0.07	0.07	0.08	0.08
3 B 4 e	Horses	0.33	0.33	0.29	0.28
3 B 4 f	Mules and asses	0.12	0.12	0.11	0.10
3 B 4 g i	Layers	0.01	0.01	0.01	0.01
3 B 4 g ii	Broilers	0.00	0.00	0.00	0.00
3 B 4 g iii	Turkey	0.01	0.01	0.01	0.01
3 B 4 g iv	Growers	0.00	0.00	0.00	0.00
3 B 4 g iv	Other poultry	0.00	0.00	0.00	0.00
3 B 4 h i	Rabbits	0.01	0.01	0.01	0.01

Emission factors		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		kg NO_x / animal									
3 B 1 a	Dairy cattle	0.14	0.13	0.14	0.14	0.14	0.13	0.13	0.12	0.11	0.11
3 B 1 b	Non-dairy cattle	0.14	0.14	0.13	0.13	0.12	0.12	0.12	0.11	0.11	0.10
3 B 1 c	Young cattle	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07
3 B 2	Sheep	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05
3 B 3	Swine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 B 4 a	Buffalos	0.07	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.06	0.06
3 B 4 d	Goats	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09
3 B 4 e	Horses	0.28	0.28	0.28	0.27	0.27	0.27	0.28	0.28	0.28	0.29
3 B 4 f	Mules and asses	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
3 B 4 g i	Layers	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3 B 4 g ii	Broilers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 B 4 g iii	Turkey	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
3 B 4 g iv	Growers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 B 4 g iv	Other poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 B 4 h i	Rabbits	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 5-5: PM2.5 Emission factors for livestock categories for the year 2015. Emission factors for all poultry categories are identical. Note that the factors were taken from the former EMIS database where the data sources can no more be identified. For camels and deer, the emission factors of horses are applied.

Emission factors		g PM2.5 / animal
3 B 1 a	Dairy cattle	59
3 B 1 b	Non-dairy cattle	59
3 B 1 c	Young cattle	15
3 B 2	Sheep	6
3 B 3	Swine	109
3 B 4 a	Buffalos	59
3 B 4 d	Goats	6
3 B 4 e	Horses	6
3 B 4 f	Mules and asses	6
3 B 4 g	Poultry	13
3 B 4 h i	Rabbits	0.14

Activity data (3B)

The number of animals in the different livestock categories (SBV 2016, Agroscope/SHL 2012, SFSO 2016) for the time period 1990 to 2015 is shown in Table 5-6. The figures represent harmonized livestock numbers coming from various sources since 1990. The methodology of the harmonization is documented in HAFL (2011).

Table 5-6: Number of animals in different livestock categories from 1990 to 2015 (in thousand animals).

Activity data 3B, animal numbers		1990	2000	2005	2005
		1'000 animals			
3 B 1 a	Dairy cattle	783	669	621	621
3 B 1 b	Non-dairy cattle	12	45	78	78
3 B 1 c	Young cattle	1'060	874	856	856
3 B 2	Sheep	395	421	446	446
3 B 3	Swine	1'787	1'498	1'609	1'609
3 B 4 a	Buffalos	NO	0.26	0.37	0.37
3 B 4 d	Goats	68	62	74	74
3 B 4 e	Horses	28	50	55	55
3 B 4 f	Mules and asses	6	12	16	16
3 B 4 g i	Layers	3'083	2'150	2'189	2'189
3 B 4 g ii	Broilers	2'020	3'808	5'060	5'060
3 B 4 g iii	Turkey	95	173	132	132
3 B 4 g iv	Growers	719	832	868	868
3 B 4 g iv	Other poultry	22	21	11	11
3 B 4 h i	Rabbits	61	28	25	25

Activity data 3B, animal numbers		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		1'000 animals									
3 B 1 a	Dairy cattle	618	615	629	599	589	589	591	587	587	583
3 B 1 b	Non-dairy cattle	87	94	98	108	111	111	114	117	118	118
3 B 1 c	Young cattle	862	863	877	890	891	877	859	854	857	853
3 B 2	Sheep	448	444	446	432	434	424	417	409	403	347
3 B 3	Swine	1'635	1'573	1'540	1'557	1'589	1'579	1'544	1'485	1'498	1'496
3 B 4 a	Buffalos	0.35	0.42	0.49	0.56	0.51	0.51	0.52	0.50	0.53	0.56
3 B 4 d	Goats	76	79	81	81	83	83	85	85	85	71
3 B 4 e	Horses	56	58	59	60	62	57	58	57	57	55
3 B 4 f	Mules and asses	16	17	18	19	20	19	20	20	20	20
3 B 4 g i	Layers	2'147	2'198	2'255	2'318	2'438	2'437	2'521	2'589	2'665	2'822
3 B 4 g ii	Broilers	4'481	5'002	5'300	5'456	5'580	5'984	6'282	6'360	6'784	6'898
3 B 4 g iii	Turkey	137	112	54	52	58	58	51	55	57	49
3 B 4 g iv	Growers	888	902	919	967	926	970	1'076	1'055	1'196	1'033
3 B 4 g iv	Other poultry	16	14	15	16	23	29	25	20	22	23
3 B 4 h i	Rabbits	24	27	25	28	35	34	28	28	27	25

5.2.3 Category-specific recalculations 3B Manure management

Recalculations in 3B Manure management:

- 3B: Emission factors for NH_3 and NO_x emissions were revised due to new AGRAMMON survey results for 2015 (after the previous update 2010), which affects the interpolation of the years 2011-2014.
- 3B: Due to the findings of the Stage 3 Review 2016, emission factors (PM, PM10, PM2.5) for 3B4a Buffalo and 3B4hi Rabbit (and camels and deer) were included in the inventory for all years 1990-2014.

5.3 Source category 3D – Crop production and agricultural soils

5.3.1 Source category description of 3D Crop production and agricultural soils

This chapter contains direct and indirect emissions from agricultural soils, from all fertilizers (mineral fertilizer, sewage sludge and compost, excretion during grazing on pasture) and animal manure applied on these soils.

Note that the application of HCB as a fungicide is prohibited in Switzerland since 1972 and its application as a seed-dressing agent since 1978 (LUBW 1995).

Table 5-7: Specification of source category 3D Agricultural Soils.

3D	Source	Specification
3Da1	Inorganic N-fertilizers	
3Da2a	Animal manure applied to soils	
3Da2b	Sewage sludge applied to soils	NO after 2009
3Da2c	Other organic fertilisers applied to soils (including compost)	Also emissions from compost incl. digestate liquid and solid
3Da3	Urine and dung deposited by grazing animals	
3Db	Indirect emissions from managed soils	

Table 5-8: Key Categories approach 1, level 2015 (L1) and trend 1990-2015 (T1), for source category 3D Agricultural Soils (NFR codes as of EMEP/EEA 2013).

NFR	Source Category	Pollutant	Identification Criteria
3Da1	Inorganic N-fertilizers (includes also urea application)	NH3	T1
3Da2a	Animal manure applied to soils	NH3	L1, T1
3Da2a	Animal manure applied to soils	NOx	T1
3Da2b	Sewage sludge applied to soils	NH3	T1
3Da3	Urine and dung deposited by grazing animals	NH3	T1
3Db	Indirect Emissions from managed soils	NH3	L1
3Db	Indirect Emissions from managed soils	NMVOC	L1, T1

5.3.2 Methodological issues of 3D Crop production and agricultural soils

Methodology (3D)

The emissions are calculated by Tier 3 (3Da2a) and Tier 1 (other categories of 3D) methods based on the decision tree in Fig. 3.1 in chapter 3D Crop production and agricultural soils of the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

- 3Da1: For the application of nitrogen containing inorganic fertilizers a differentiation is made between emissions from urea-containing and other inorganic fertilizers. In 3Da1 only the agricultural use of inorganic fertilizers and urea is reported, while private use is reported under 6A3.
- 3Da2a: Emissions from the application of animal manure are calculated with animal specific emission factors multiplied by the number of animals. The emission factors are generated from stratified samples considering different regions, height above sea levels and application techniques (Tier 3).
- 3Da2b/3Da2c: NH_3 and NO_x emissions from field application of sewage sludge and compost (including solid and liquid digestate) derived from organic residues are included in this category. In Switzerland, the application of sewage sludge as fertilizer is fully prohibited nowadays.
- 3Da3: NH_3 emission from urine and dung deposited by grazing animals are determined by multiplying animal specific emission factors with the number of animals.
- 3Db: Indirect emissions from the agricultural soils resulting from the decomposition of plant material remaining on cropland and pasture are reported. They are calculated with two implied emission factors differentiating between agricultural and alpine area.

Emission factors

Table 5-9 shows emission factors for nitrogen containing fertilizers, sewage sludge and compost applied to soils. NH_3 emission factors are taken from Vanderweerden and Jarvis (1997), NO_x emission factors from Stehfest and Bouwman (2006). A fertiliser-induced emission (FIE) value of 0.55% from Stehfest and Bouwman (2006) is used for NO_x emission factors.

Table 5-9: NH_3 and NO_x emission factors 2015 for nitrogen containing fertilizers.

Emission factors		kg NH_3 / tN	kg NO_x / tN
3 D a 1	Urea containing fertiliser	182	18
3 D a 1	other synthetic N-fertiliser	24	18
3 D a 2 b	Sewage sludge	316.6	18
3 D a 2 c	Organic compost	145.9	18

Emission factors for the application of animal manure are displayed in Table 5-10 and Table 5-11.

Table 5-10: Time series of NH_3 emission factors for the application of animal manure to soils from 1990 to 2015.

Emission factors		1990	1995	2000	2005
		kg NH_3 / animal			
3 D a 2 a 1 a	Dairy cattle	27.61	27.86	24.95	24.61
3 D a 2 a 1 b	Non-dairy cattle	15.84	15.39	12.32	13.09
3 D a 2 a 1 c	Young cattle	7.80	7.84	6.42	6.17
3 D a 2 a 2	Sheep	0.43	0.47	0.48	0.52
3 D a 2 a 3	Swine	2.97	2.74	1.88	1.60
2 D a 2 a 4 a	Buffalos	NO	8.08	7.19	6.44
3 D a 2 a 4 d	Goats	0.78	0.82	0.77	1.06
3 D a 2 a 4 e i	Horses	3.61	3.85	2.97	3.00
3 D a 2 a 4 f i	Mules and asses	1.30	1.39	1.02	1.01
3 D a 2 a 4 g i	Layers	0.08	0.08	0.10	0.10
3 D a 2 a 4 g ii	Broilers	0.05	0.06	0.06	0.05
3 D a 2 a 4 g iii	Turkey	0.18	0.20	0.18	0.21
3 D a 2 a 4 g iv	Growers	0.03	0.04	0.03	0.03
3 D a 2 a 4 g iv	Other poultry	0.07	0.08	0.07	0.06
3 D a 2 a 4 h i	Rabbits	0.09	0.09	0.08	0.08

Emission factors		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		kg NH_3 / animal									
3 D a 2 a 1 a	Dairy cattle	24.91	25.22	24.62	24.03	23.43	23.15	22.88	22.60	22.32	22.04
3 D a 2 a 1 b	Non-dairy cattle	13.76	14.43	13.97	13.50	13.04	12.97	12.89	12.82	12.75	12.68
3 D a 2 a 1 c	Young cattle	6.31	6.43	6.37	6.33	6.27	6.18	6.09	6.01	5.93	5.87
3 D a 2 a 2	Sheep	0.53	0.55	0.55	0.58	0.59	0.58	0.58	0.58	0.57	0.64
3 D a 2 a 3	Swine	1.58	1.58	1.55	1.51	1.46	1.45	1.43	1.43	1.41	1.42
2 D a 2 a 4 a	Buffalos	6.43	5.99	5.80	6.05	6.07	6.17	5.86	5.78	5.63	5.55
3 D a 2 a 4 d	Goats	1.18	1.28	1.12	0.98	0.81	0.85	0.87	0.90	0.92	1.09
3 D a 2 a 4 e i	Horses	3.12	3.24	3.17	3.11	3.04	3.13	3.22	3.33	3.43	3.55
3 D a 2 a 4 f i	Mules and asses	1.06	1.10	1.22	1.33	1.45	1.40	1.34	1.29	1.24	1.19
3 D a 2 a 4 g i	Layers	0.10	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.11
3 D a 2 a 4 g ii	Broilers	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.06	0.06
3 D a 2 a 4 g iii	Turkey	0.23	0.24	0.22	0.19	0.17	0.17	0.17	0.17	0.17	0.17
3 D a 2 a 4 g iv	Growers	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04
3 D a 2 a 4 g iv	Other poultry	0.06	0.06	0.07	0.09	0.10	0.09	0.09	0.08	0.07	0.06
3 D a 2 a 4 h i	Rabbits	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08

Table 5-11: Time series of NO_x emission factors for the application of anial manure to soils from 1990 to 2015.

Emission factors		1990	1995	2000	2005
		g NO_x / animal			
3 D a 2 a 1 a	Dairy cattle	1397	1404	1324	1320
3 D a 2 a 1 b	Non-dairy cattle	862	847	716	730
3 D a 2 a 1 c	Young cattle	420	419	367	347
3 D a 2 a 2	Sheep	73	74	77	73
3 D a 2 a 3	Swine	193	182	136	116
2 D a 2 a 4 a	Buffalos	NO	421	394	347
3 D a 2 a 4 d	Goats	128	128	131	140
3 D a 2 a 4 e i	Horses	581	583	501	482
3 D a 2 a 4 f i	Mules and asses	209	211	182	170
3 D a 2 a 4 g i	Layers	8.14	8.29	9.68	10.13
3 D a 2 a 4 g ii	Broilers	5.61	5.70	6.41	6.69
3 D a 2 a 4 g iii	Turkey	19.63	19.74	19.84	19.74
3 D a 2 a 4 g iv	Growers	3.63	3.83	3.55	3.76
3 D a 2 a 4 g iv	Other poultry	7.85	7.93	7.65	7.45
3 D a 2 a 4 h i	Rabbits	13.8	13.8	13.8	13.8

Emission factors		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		g NO_x / animal									
3 D a 2 a 1 a	Dairy cattle	1330	1340	1338	1336	1334	1338	1341	1344	1348	1351
3 D a 2 a 1 b	Non-dairy cattle	752	774	762	751	740	742	744	746	748	750
3 D a 2 a 1 c	Young cattle	349	351	355	359	362	361	360	359	358	357
3 D a 2 a 2	Sheep	72	72	74	78	80	80	81	81	80	91
3 D a 2 a 3	Swine	113	112	113	114	114	114	113	113	113	114
2 D a 2 a 4 a	Buffalos	342	314	312	335	345	354	339	338	333	331
3 D a 2 a 4 d	Goats	145	146	143	142	137	139	139	140	140	161
3 D a 2 a 4 e i	Horses	485	488	481	473	466	471	478	485	492	501
3 D a 2 a 4 f i	Mules and asses	169	169	173	178	182	180	178	176	174	172
3 D a 2 a 4 g i	Layers	10.08	10.04	10.11	10.18	10.26	10.34	10.42	10.50	10.59	10.67
3 D a 2 a 4 g ii	Broilers	6.68	6.68	6.75	6.81	6.88	6.89	6.89	6.90	6.91	6.91
3 D a 2 a 4 g iii	Turkey	19.69	19.64	19.94	20.25	20.55	20.38	20.20	20.03	19.85	19.68
3 D a 2 a 4 g iv	Growers	3.87	3.97	4.08	4.18	4.28	4.31	4.34	4.38	4.41	4.45
3 D a 2 a 4 g iv	Other poultry	7.42	7.39	7.53	7.66	7.79	7.73	7.66	7.59	7.52	7.46
4 D a 2 a 4 h i	Rabbits	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8

The following tables list the emission factors for NH_3 and NO_x for N excretion on pasture and paddock due to grazing. Note that emission factors can be zero, if grazing was not occurring (e.g. for swine 1990–1995).

Table 5-12: Time series of NH_3 emission factors for N excretion on pasture and paddock of livestock categories from 1990 to 2015.

Emission factors		1990	1995	2000	2005
		g NH_3 / animal			
3 D a 3 1 a	Dairy cattle	476	564	940	1110
3 D a 3 1 b	Non-dairy cattle	1272	1270	1714	1598
3 D a 3 1 c	Young cattle	316	320	494	520
3 D a 3 2	Sheep	136	139	158	182
3 D a 3 3	Swine	0.00	0.00	1.58	12.21
2 D a 3 4 a	Buffalos	NO	577	863	872
3 D a 3 4 d	Goats	87	86	81	58
3 D a 3 4 e i	Horses	181	181	508	590
3 D a 3 4 f i	Mules and asses	65	65	176	230
3 D a 3 4 g i	Layers	0.00	2.13	15.16	26.28
3 D a 3 4 g ii	Broilers	0.00	0.80	1.24	2.16
3 D a 3 4 g iii	Turkey	0.00	2.80	16.42	21.89
3 D a 3 4 g iv	Growers	0.00	1.02	0.50	1.51
3 D a 3 4 g iv	Other poultry	0.00	0.00	6.26	8.76
3 D a 3 4 h i	Rabbits	0.00	0.00	0.00	0.00

Emission factors		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		g NH_3 / animal									
3 D a 3 1 a	Dairy cattle	1114	1118	1101	1084	1068	1060	1052	1043	1035	1027
3 D a 3 1 b	Non-dairy cattle	1500	1402	1458	1514	1569	1559	1549	1538	1528	1517
3 D a 3 1 c	Young cattle	514	507	494	486	472	470	468	471	473	480
3 D a 3 2	Sheep	189	197	186	182	173	173	174	175	174	197
3 D a 3 3	Swine	15.09	18.20	13.02	7.57	1.98	1.63	1.29	0.97	0.64	0.32
2 D a 3 4 a	Buffalos	849	770	744	774	774	799	771	773	765	766
3 D a 3 4 d	Goats	52	45	51	59	64	67	70	72	75	89
3 D a 3 4 e i	Horses	578	566	604	641	680	652	621	588	556	519
3 D a 3 4 f i	Mules and asses	233	236	223	210	197	201	204	207	211	214
3 D a 3 4 g i	Layers	28.04	29.81	28.15	26.49	24.83	25.61	26.39	27.16	27.94	28.72
3 D a 3 4 g ii	Broilers	2.41	2.65	1.97	1.29	0.60	0.60	0.59	0.58	0.57	0.56
3 D a 3 4 g iii	Turkey	21.90	21.91	19.15	16.39	13.63	15.29	16.94	18.60	20.25	21.91
3 D a 3 4 g iv	Growers	1.91	2.31	2.18	2.04	1.90	1.64	1.37	1.11	0.84	0.58
3 D a 3 4 g iv	Other poultry	8.76	8.76	6.98	5.19	3.41	4.11	4.82	5.53	6.23	6.94
3 D a 3 4 h i	Rabbits	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5-13: NO_x emission factors for N excretion on pasture and paddock of livestock categories from 1990 to 2015.

Emission factors		1990	1995	2000	2005
		g NO_x / animal			
3 D a 3 1 a	Dairy Cattle	143	170	287	342
3 D a 3 1 b	Non dairy Cattle	380	379	512	478
3 D a 3 1 b	Young Cattle	94	96	148	155
3 D a 3 2	Sheep	41	41	47	54
3 D a 3 3	Swine	0.00	0.00	0.17	1.30
2 D a 3 4 a	Buffalos	NO	172	258	261
3 D a 3 4 d	Goats	26	26	24	17
3 D a 3 4 e i	Horses	54	54	151	176
3 D a 3 4 f i	Mules and Asses	19	19	52	68
3 D a 3 4 g i	Layers	0.00	0.08	0.54	0.93
3 D a 3 4 g ii	Broilers	0.00	0.03	0.04	0.08
3 D a 3 4 g iii	Turkey	0.00	0.10	0.58	0.78
3 D a 3 4 g iv	Growers	0.00	0.04	0.02	0.05
3 D a 3 4 g iv	other Poultry	0.00	0.00	0.22	0.31
3 D a 3 4 h i	Rabbits	0.00	0.00	0.00	0.00

Emission factors		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		g NO_x / animal									
3 D a 3 1 a	Dairy Cattle	344	346	341	336	331	329	326	324	321	319
3 D a 3 1 b	Non dairy Cattle	448	419	436	452	469	466	463	460	457	453
3 D a 3 1 b	Young Cattle	154	151	148	145	141	141	140	141	141	143
3 D a 3 2	Sheep	56	59	56	54	52	51	52	52	52	59
3 D a 3 3	Swine	1.60	1.93	1.38	0.80	0.21	0.17	0.14	0.10	0.07	0.03
2 D a 3 4 a	Buffalos	254	230	222	231	231	239	230	231	229	229
3 D a 3 4 d	Goats	16	14	15	17	19	20	21	22	22	26
3 D a 3 4 e i	Horses	172	168	180	191	202	194	185	175	165	155
3 D a 3 4 f i	Mules and Asses	69	70	66	63	59	60	61	62	63	64
3 D a 3 4 g i	Layers	0.99	1.06	1.00	0.94	0.88	0.91	0.93	0.96	0.99	1.02
3 D a 3 4 g ii	Broilers	0.09	0.09	0.07	0.05	0.02	0.02	0.02	0.02	0.02	0.02
3 D a 3 4 g iii	Turkey	0.78	0.78	0.68	0.58	0.48	0.54	0.60	0.66	0.72	0.78
3 D a 3 4 g iv	Growers	0.07	0.08	0.08	0.07	0.07	0.06	0.05	0.04	0.03	0.02
3 D a 3 4 g iv	other Poultry	0.31	0.31	0.25	0.18	0.12	0.15	0.17	0.20	0.22	0.25
3 D a 3 4 h i	Rabbits	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NH_3 Emission factors for indirect emissions from soils: the emission factor used to calculate the emissions resulting from decomposition of plant material remaining on the agricultural field are taken from Schjoerring and Mattsson (2001) for the agricultural area and those for Alpine area from statistical data (SFSO 2014b). See Table 5-14.

Table 5-14: NH_3 and NMVOC emission factors 2015 for indirect emissions from soils.

Emission factors		kg NH_3 / ha	kg NMVOC / ha
3 D b	Agricultural area	2.4	3.72
3 D b	Alpine area	0.6	---

Activity data (3D)

The nitrogen amount applied with urea-containing and other synthetic fertilizers (SBV 2016, Agricura 2015, AGRAMMON 2013) as well as the amount applied with sewage sludge and compost derived from organic residues are shown in Table 5-15. Included in the table are the areas of agricultural soils relevant for emissions from plant decomposition, too.

Activity data for emissions from N excretion resulting from the application of animal manure to soils and from grazing are the livestock numbers for source category 3B Manure management given in Table 5-6. The application of sewage to soils has been prohibited (heavy metal content), therefore the activity data drops to zero from 2010 onwards.

Table 5-15: Nitrogen amount applied with synthetic N-fertilizers (urea-containing and other N-containing synthetic fertilizers), with sewage sludge and compost derived from organic residues (in t N) and agricultural area for calculation of emissions from plant decomposition (in ha).

Activity data of agricultural soils			1990	1995	2000	2005
3 D a 1	Urea containing fertiliser	tN	17'000	11'185	7'978	6'910
3 D a 1	other synthetic N-fertiliser	tN	49'912	47'375	42'902	43'394
3 D a 2 b	Sewage sludge	tN	4'815	4'942	3'356	1'248
3 D a 2 c	Organic compost	tN	824	1'380	1'569	2'525
3 D b	Agricultural area	ha	1'066'981	1'080'226	1'072'492	1'065'118
3 D b	Alpine area	ha	538'676	499'774	496'667	487'956

Activity data of agricultural soils			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
3 D a 1	Urea containing fertiliser	tN	6'254	8'680	6'905	5'551	7'424	6'788	5'589	6'015	8'245	7'232
3 D a 1	other synthetic N-fertiliser	tN	43'090	43'064	41'863	40'433	45'856	40'156	39'723	37'857	41'260	36'703
3 D a 2 b	Sewage sludge	tN	1'054	859	573	286	NO	NO	NO	NO	NO	NO
3 D a 2 c	Organic compost	tN	2'789	3'096	3'503	3'888	4'326	4'369	4'472	4'588	4'701	4'811
3 D b	Agricultural area	ha	1'065'199	1'060'242	1'058'100	1'055'648	1'051'748	1'051'866	1'051'063	1'049'923	1'051'183	1'049'478
3 D b	Alpine area	ha	484'816	486'686	485'812	485'330	486'383	483'414	481'379	479'745	475'773	474'821

5.3.3 Category-specific recalculations for 3D Crop production and agricultural soils

Recalculations in 3D Crop production and agricultural soils:

- 3D: Emission factors for NH_3 and NO_x emissions were revised due to new AGRAMMON survey results for 2015 (after the previous update 2010), which affects the interpolation of the years 2011-2014.
- 3D: There are rounding differences concerning NH_3 emissions for all poultry categories in all the years.

6 Waste

6.1 Overview of emissions

In this introductory chapter, an overview of emissions separated by most relevant pollutants are presented. Likewise, surfacing trends and changes are analysed and discussed for individual source categories in the period between 1990 and 2015. Among the main contributors to air pollution in the waste sector are NMVOC and to a lesser extent PM2.5, NH_3, NO_x.

The following source categories are reported:

- 5A Biological treatment of waste - Solid waste disposal on land
- 5B Biological treatment of waste - Composting and anaerobic digestion
- 5C Waste incineration and open burning of waste
- 5D Wastewater handling
- 5E Other waste

Please note that according to IPCC Guidelines (IPCC 2006) and EMEP/EEA Guidebook 2013 (EMEP/EEA 2013) **all emissions from waste-to-energy, where waste material is used directly as fuel or converted into a fuel, are reported under the sector 1A Fuel combustion**. Therefore, the largest share of waste-related emissions in Switzerland is not reported under sector 5 Waste but in sector 1 Energy.

6.1.1 Overview and trend for NMVOC

Figure 6-1 depicts the NMVOC emissions in the waste related sectors since 1990. A clear and continuous increasing trend of total NMVOC emissions from 1990 to 2015 can be observed.

The main sources of NMVOC emissions are 5B Biological treatment of solid waste and 5C Incineration and open burning of waste. Nowadays the bulk emissions in this sector stem from 5B Biological treatment of solid waste. The reason for this development is a continuous increase of industrial and commercial composting activities and digesting of organic waste. Digestion has become economical more attractive due to cost covering feed-in tariffs and due to additional revenues as CO_2 compensation projects. The increase of treated quantities is also linked to population growth.

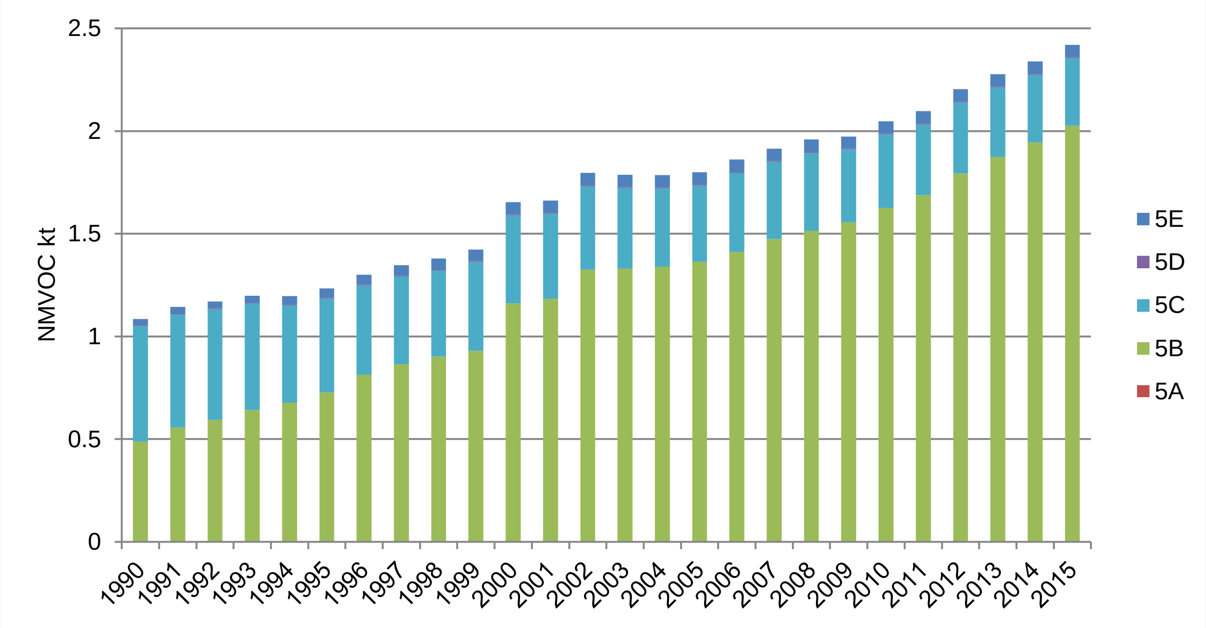

Figure 6-1: Switzerland's NMVOC emissions from the waste sector by source categories 5A-5E between 1990-2015. The corresponding data table can be found in Annex 6.5.

6.1.2 Overview and trend for PM2.5

Figure 6-2 depicts the PM2.5 emissions in the waste related sectors since 1990. 5C Incineration and open burning of waste contributes most to total PM2.5 emissions from the waste sector over the whole reporting period.

Between 1990 and 2015 a continuous decrease of total PM2.5 emissions occurred that largely can be affiliated with the reductions achieved in 5C Waste incineration. This is mainly because of the reduction of the emissions from sewage sludge incineration, refurbishment of crematoriums and the cessation of burning cable insulation in 1995.

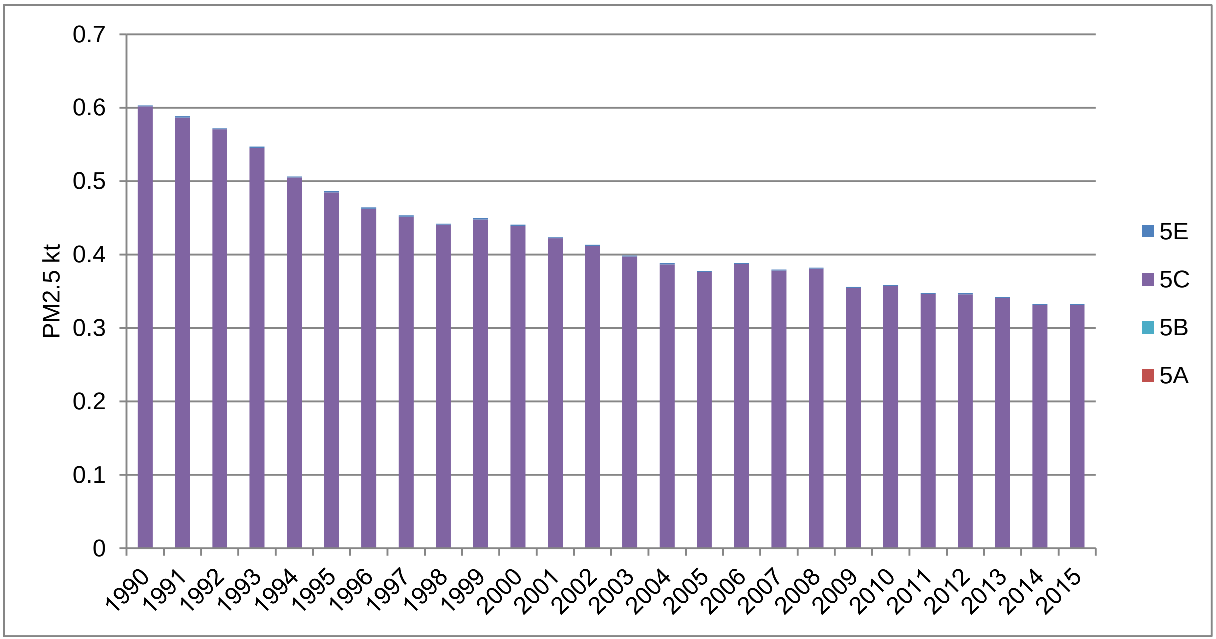

Figure 6-2: Switzerland's PM2.5 emissions from the waste sector by source categories 5A–5E between 1990 – 2015. Note that PM2.5 emissions from 5D are not occurring. The corresponding data table can be found in Annex 6.5.

6.2 Source category 5A – Biological treatment of waste - Solid waste disposal on land

6.2.1 Source category description of 5A - Biological treatment of waste - Solid waste disposal on land

The source category 5A Biological treatment of waste - Solid waste disposal on land comprises all emissions from handling of solid waste on landfill sites. Since 1987 all deposited waste in Switzerland has been deposited on managed landfill sites.

In Switzerland, managed biogenic active landfills are equipped to recover landfill gas (SFOE 2016a). The landfill gas is generally used in combined heat and power plants to produce electricity and heat (reported under 1A Fuel combustion). Some landfill gas is used to generate heat only. A very small portion of the landfill gas is flared (to be reported under 5A).

In the year 2015 the First Order Decay (FOD) model that is used to calculate methane emissions has been completely revised and is now compliant with IPCC 2006 (see below). In the course of this revision activity data for open burning on solid waste disposal sites has been assessed. It is assumed that open burning did not take place after 1990 anymore, which is more plausible than the former assumption of open burning taking place until today (Consaba 2016).

Table 6-1: Specification of source category 5A Biological treatment of waste - Solid waste disposal on land.

5A	Source	Specification
5A	Biological treatment of waste - Solid waste disposal on land	Emissions from handling of solid waste on landfill sites

Source category 5A Biological treatment of waste - Solid waste disposal on land is not a key category.

6.2.2 Methodological issues of 5A - Biological treatment of waste - Solid waste disposal on land

Methodology (5A)

The emission modelling corresponds to a Tier 2 approach (although the use of Tier 2 is not officially recommended for this source). See decision tree in chapter 5A Biological treatment of waste – Solid waste disposal on land of the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

The main pollutant from landfills is CH_4, which is not relevant for the CLRTAP Inventory. However, methane is used for combined heat and power generation or flaring. Thereby other pollutants are produced and emitted. They are reported in the CLRTAP Inventory. Emissions from combined heat and power generation are reported in the energy sector, emissions from flaring in the waste sector.

The emissions of CH_4 are calculated in several steps, the details are described in Switzerland’s National Inventory Report (FOEN 2017):

1. CH_4 emissions are modelled with the FOD model according to IPCC (IPCC 2006).
2. The amount of CH_4 that is recovered and used as fuel for combined heat and power generation as well as for flaring is subtracted from the total CH_4 generated in landfills.
3. Emissions of air pollutants from burning methane in engines and torches are calculated. They are proportional to the CH_4 burnt.

Emission factors (5A)

Emission factors are country-specific based on measurements and expert estimates, documented in EMIS (EMIS 2017/1A1a & 5A), see the following table. Emission factors for open burning of waste are not shown because open burning on solid waste disposal sites is assumed not to occur anymore in Switzerland since 1990.

Table 6-2: Emission factors 2015 for 5A Biological treatment of waste - Solid waste disposal on land.

5A1 Solid waste disposal on land	Pollutant	Unit	Emission factors
Flaring	NOx	kg/t CH4 produced	1.0
	CO	kg/t CH4 produced	17.0
	PM10 exhaust	kg/t CH4 produced	0.40
	TSP exhaust	kg/t CH4 produced	0.40
Direct emission	NH3	kg/t CH4	20.0

Activity data (5A)

One set of activity data for 5A Biological treatment of waste - Solid waste disposal on land are the waste quantities disposed on landfills. Activity data are taken from EMIS 2017/1A1a & 5A. Table 6-3 documents the decrease of municipal solid waste, construction waste and sewage sludge disposed in landfill sites in the reporting period.

Table 6-3: Activity data for 5A Biological treatment of waste - Solid waste disposal on land from 1990 to 2015 (source EMIS 2017/1A1a & 5A).

5A1 Solid waste disposal on land	Unit	1990	1995	2000	2005
Municipal solid waste (MSW)	kt	650.0	540.0	291.7	13.7
Construction waste (CW)	kt	150.0	60.0	53.9	1.4
Sewage sludge (SS)	kt (dry)	60.0	28.1	4.2	1.0
Open burned waste	kt	NO	NO	NO	NO
Total waste quantity	kt	860.0	628.1	349.7	16.1

5A1 Solid waste disposal on land	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Municipal solid waste (MSW)	kt	3.6	1.5	1.2	NO	NO	NO	NO	NO	NO	NO
Construction waste (CW)	kt	0.8	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sewage sludge (SS)	kt (dry)	0.3	NO	NO	NO	NO	NO	NO	NO	NO	NO
Open burned waste	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total waste quantity	kt	4.7	1.5	1.2	NO	NO	NO	NO	NO	NO	NO

The other set of activity data for 5A Biological treatment of waste - Solid waste disposal on land is CH_4 flared. The quantity of CH_4 flared on Swiss landfill sites was assessed in 2015 and is documented in a separate report (Consaba 2016).

Table 6-4: Activity data of 5A Biological treatment of waste - Solid waste disposal on land (data source: Consaba 2016).

5A1 Solid waste disposal on land	Unit	1990	1995	2000	2005
CH_4 flared	kt	1.8	5.2	5.6	3.4

5A1 Solid waste disposal on land	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CH_4 flared	kt	3.2	2.9	2.6	2.4	2.4	2.1	1.8	1.6	1.4	1.4

6.2.3 Category-specific recalculations in 5A - Biological treatment of waste - Solid waste disposal on land

- There were no recalculations carried out in source category 5A.

6.3 Source category 5B - Biological treatment of waste - Composting and anaerobic digestion at biogas facilities

6.3.1 Source category description of 5B - Biological treatment of waste - Composting and anaerobic digestion at biogas facilities

The source category 5B Biological treatment of waste comprises the emissions from 5B1 Composting and from 5B2 Anaerobic digestion at biogas facilities. Note that emissions from combined heat and power generation that use biogas from digestion are reported under 1A1a Energy industries.

Within the composting activity four kinds of composting are distinguished, i.e. i) hall composting, ii) field edge composting, iii) box composting and iv) windrow composting. Composting covers the emissions from centralized composting plants with a capacity of more than 100 tonnes of organic matter per year. Backyard composting is also common practice in Switzerland. However, there are only estimates concerning these respective quantities.

The digestion of organic waste takes place under anaerobic conditions. The digestate (solid and liquid output after completion of a process of anaerobic microbial degradation of organic matter) is composted or used as fertilizer, respectively. The biogas generated during the digestion process is used for combined heat and power generation or upgraded and used as fuel for cars or fed into the natural gas grid.

Table 6-5: Specification of source category 5B Biological treatment of waste - Composting and anaerobic digestion at biogas facilities.

5B	Source	Specification
5B1	Biological treatment of waste - Composting	Emissions from composting activities
5B2	Biological treatment of waste - Anaerobic digestion at biogas facilities	Emissions from digesting of organic waste at biogas facilities

Source category 5B Biological treatment of waste - Composting and anaerobic digestion at biogas facilities is not a key category.

6.3.2 Methodological issues of 5B - Biological treatment of waste - Composting and anaerobic digestion at biogas facilities

Methodology (5B)

For the emissions from composting a Tier 2 method is used (see decision tree in chapter 5B1 Biological treatment of waste – Composting of the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

For the emissions from digestion a Tier 2 method is used (see decision tree in chapter 5B2 Biological treatment of waste – Anaerobic digestion at biogas facilities of the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013). Digestion plants lead to emissions from (i) the storage of digestible waste, (ii) the storage of digested waste, (iii) composting of residues, (iv) biogas engines and boilers, and (v) flaring.

Emission factors (5B)

Emission factors for composting and digestion are country-specific based on measurements and expert estimates, documented in comments of the database (EMIS 2017/5B1 Kompostierung, EMIS 2017/1A1a and 5B2 Vergärung IG and EMIS 2017/1A1a and 5B2 Vergärung LW). For all years emission factors are considered to remain constant. The data used for digestion comprises information from Edelmann and Schleiss (2001). The following table presents the emission factors used in 5B.

Table 6-6: Emission factors of 5B Biological treatment of waste - Composting and anaerobic digestion at biogas facilities in 2015.

5B Composting and anaerobic digestion at biogas facilities	Pollutant	Unit	Emission factors
Composting (industrial)	NMVOC	g/t composted waste	1'700
	NH3	g/t composted waste	100
Composting (backyard)	NH3	g/t composted waste	320
Digestion (ind., digestable waste / storage)	NMVOC	g/t digestable waste	70
	NH3	g/t digestable waste	6
Digestion (ind., digested waste liquid / storage)	NMVOC	g/t digested waste (liquid)	400
	NH3	g/t digested waste (liquid)	80
Digestion (ind., digested waste solid / rotting)	NMVOC	g/t digested waste (solid)	230
	NH3	g/t digested waste (solid)	104
Digestion (ind., flaring, CH_4)	NOx	g/t CH4	4'066
	NMVOC	g/t CH4	82
	SO2	g/t CH4	616
	PM2.5 exhaust	g/t CH4	37
	PM10 exhaust	g/t CH4	37
	TSP exhaust	g/t CH4	37
	CO	g/t CH4	2'054
Digestion (agr., digested waste liquid / process water)	NMVOC	g/t digested waste (liquid)	400
	NH3	g/t digested waste (liquid)	80
Digestion (agr., digested waste solid / rotting)	NMVOC	g/t digested waste (solid)	230
	NH3	g/t digested waste (solid)	104
Digestion (agr., flaring, CH_4)	NOx	g/t CH4	4'066
	NMVOC	g/t CH4	82
	SO2	g/t CH4	616
	PM2.5 exhaust	g/t CH4	37
	PM10 exhaust	g/t CH4	37
	TSP exhaust	g/t CH4	37
	CO	g/t CH4	2'054

Activity data (5B)

Activity data for 5B Biological treatment of waste are extracted from EMIS 2017/5B1 Kompostierung, EMIS 2017/1A1a and 5B2 Vergärung IG and EMIS 2017/1A1a and 5B2 Vergärung LW). Activity data for composting and digestion are generally based on reliable statistical data from the statistics of renewable energies (SFOE 2016a).

The activity data for industrial composting from 1990 to 2002 and for 2007 are based on waste statstics. The quantities in between, i.e. from 2003 to 2006 as well as from 2008 to the projection value in 2020 are interpolated. The quantities for backyard composting are estimated as 10% of the amount of waste from industrial composting plants.

Table 6-7: Activity data of 5B Biological treatment of waste, 1990–2015.

5B Composting and anaerobic digestion at biogas facilities	Unit	1990	1995	2000	2005
Composting (industrial)	kt wet	260	400	640	735
Composting (backyard)	kt wet	9	47	84	78
Digestion (ind., digestable waste / storage)	kt wet	NO	27	60	107
Digestion (ind., digested waste liquid / storage)	kt wet	NO	15	33	60
Digestion (ind., digested waste solid / rotting)	kt wet	NO	9	20	37
Digestion (ind., flaring, CH_4)	kt	NO	0.03	0.10	0.17
Digestion (agr., digested waste liquid / process water)	kt wet	113	94	125	181
Digestion (agr., digested waste solid / rotting)	kt wet	6	5	7	10
Digestion (agr., flaring, CH_4)	kt	NO	NO	NO	NO

5B Composting and anaerobic digestion at biogas facilities	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Composting (industrial)	kt wet	737	739	747	755	763	771	779	787	795	803
Composting (backyard)	kt wet	77	75	76	77	78	79	79	80	81	82
Digestion (ind., digestable waste / storage)	kt wet	137	163	176	224	288	371	507	560	589	649
Digestion (ind., digested waste liquid / storage)	kt wet	76	91	98	125	161	207	283	312	328	362
Digestion (ind., digested waste solid / rotting)	kt wet	47	56	60	77	98	127	173	191	201	222
Digestion (ind., flaring, CH_4)	kt	0.23	0.27	0.30	0.39	0.48	0.60	0.80	0.86	0.85	0.90
Digestion (agr., digested waste liquid / process water)	kt wet	261	383	436	463	541	583	686	799	913	1023
Digestion (agr., digested waste solid / rotting)	kt wet	14	20	23	24	29	31	36	42	48	54
Digestion (agr., flaring, CH_4)	kt	NO	NO	NO	NO	0.12	0.13	0.16	0.20	0.22	0.25

Planned Improvements

Activity data for backyard composting is assumed to be approx. 10% of the amount of waste composted in industrial plants in the year 2007 and later. This share is not constant over time, but assumed to be approx. 3% in 1990 and 13% in 2000. These values are based on expert judgements. It is planned for a subsequent submission to assess and verify the activity data. In the same course emission factors will be verified and completed if necessary.

6.3.3 Category-specific recalculations in 5B - Biological treatment of waste - Anaerobic digestion at biogas facilities

- NH_3 and NMVOC: Activity data for liquid and solid digestate has slightly changed in the year 2014 due to a correction of the fraction of manure and co-substrate.

6.4 Source category 5C – Waste incineration and open burning of waste

6.4.1 Source category description of 5C - Waste incineration and open burning of waste

There is a long tradition in Switzerland for waste to be incinerated. It is a requirement that waste heat generated during the incineration has to be recovered if technically and economically feasible. In accordance with the IPCC provisions (IPCC 2006), emissions from the combustion of waste-to-energy activities are reported within 1A Fuel combustion activities. The sources included in source category 5C are given in subsequent Table 6-8.

Table 6-8: Specification of source category 5C Waste incineration and open bruning of waste.

5C	Source	Specification
5C1a	Illegale waste incineration	Emissions from illegal incineration of municipal solid wastes at home Emissions from waste incineration at construction sites (open burning)
5C1b i	Cable insulation materials	Emissions from incinerating cable insulation materials
5C1b iii	Clinical waste incineration	Emissions from incinerating hospital waste in hospital incinerators
5C1b iv	Sewage sludge incineration	Emissions from sewage sludge incineration plants
5C1b v	Cremation	Emissions from the burning of dead bodies
5C2	Open burning of waste	Emissions from field burning of agricultural waste. Burning of gardening residues from private households is also integrated (small contribution compared to agriculture).

The following table gives an overview of other waste incineration sources in Switzerland and the source category, where respective emissions are reported in the national inventory.

Table 6-9: 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 Public electricity and heat production
Waste in cement plants	Emissions from waste incineration as alternative fuels in cement kilns	1A2fi Non-metallic minerals
Special waste	Emissions from incinerating industrial and hazardous wastes	1A1a Public electricity and heat production

Table 6-10: Key Categories, level 2015 (L1) and trend 1990-2015 (T1), for source category 5C Waste incineration and open burning of waste (NFR code as of EMEP/EEA 2013).

NFR	Source Category	Pollutant	Identification Criteria
5C1a	5 C 1 a - Municipal Waste Incineration	PM2.5	L1

6.4.2 Methodological issues of 5C - Waste incineration and open burning of waste

Methodology (5C)

For the calculation of the emissions from municipal waste incineration (illegal waste incineration) a Tier 2 method is used (see decision tree in chapter 5C1a Municipal waste incineration EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

For the calculation of the emissions from the incineration of insulation materials from cables a Tier 2 method is used (see decision tree in chapter 5C1b iv Industrial waste incineration including hazardous waste and sewage sludge EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

For the calculation of the emissions from clinical waste incineration a Tier 2 method is used (see decision tree in chapter 5C1b iii Clinical waste incineration EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

For the calculation of the emissions from sewage sludge incineration plants a Tier 2 method is used (see decision tree in chapter 5C1b iv Industrial waste incineration including hazardous waste and sewage sludge EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

For the calculation of the emissions from cremation a Tier 2 method is used (see decision tree in chapter 5C1b v Cremation EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

For the calculation of the emissions from burning of agricultural waste a country-specific Tier 2 method is used (see decision tree in chapter 5C2 Open burning of waste EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

Emission factors (5C)

Emission factors are country-specific based on measurements and expert estimates as documented in the EMIS database (EMIS 2017/5C1 Abfallverbrennung illegal, EMIS 2017/5C1 Kabelbrand, EMIS 2017/5C1 Spitalabfallverbrennung, EMIS 2017/5C1 Krematorien, EMIS 2017/5C1 Klärschlammverbrennung, EMIS 2017/5C2 Abfallverbrennung Land- und Forstwirtschaft).

The emission factor of dioxine for 5C1 Illegal waste incineration in particular is defined based on Wevers (2004) and Lemieux (2003). Emission factors for 5C2 Open burning of waste were taken from EMEP/EEA (2013) for main air pollutants, particulate matter and PAH.

The emission factors for 5C1b Sewage sludge incineration for the year 1990 are taken from SAEFL (2000). The emission factors for the year 2002 are based on emission declarations form plants in the region of Basel (accounting for about 1/3 of the national total quantities). From then onwards the emission factors are assumed to be constant.

The following Table 6-11 depicts the emission factors used in 5C.

Table 6-11: Emission factors for 5C Waste incineration and open burning of waste in 2015.

5C Incineration and open burning of waste	Unit	NOx	NMVOC	SO2	NH3	PM2.5 exhaust	PM10 exhaust	TSP exhaust	CO
Clinical waste incineration	g/t waste	1'500	300	1'300	NA	1'100	1'600	2'200	1'400
Illegal waste incineration	g/t waste	2'500	16'000	750	NA	14'400	16'000	20'000	50'000
Insulation material from cables	g/t cable	1'300	500	6'000	NA	62	410	510	2'500
Sewage sludge incineration	g/t sludge	700	5.0	470	100	28	40	40	190
Open burning of natural residues in agriculture	g/t wood	1'380	1'470	30	800	3'760	4'130	4'310	48'790
Open burning of natural residues in private households	g/t wood	1'380	1'470	30	800	3'760	4'130	4'310	48'790
Cremation	g/cremation	210	7.0	NA	NA	19	19	21	57

5C Incineration and open burning of waste	Unit	Pb	Hg	Cd	PCDD/PCDF	BaP	BbF	BkF	IcdP
Clinical waste incineration	mg/t waste	25	16	1.10	0.46	NE	NE	NE	NE
Illegal waste incineration	mg/t waste	100	0.10	0.20	0.16	0.34	0.20	0.27	0.10
Insulation material from cables	mg/t cable	80	1.9	0.20	0.02	NE	NE	NE	NE
Sewage sludge incineration	mg/t sludge	0.90	0.10	0.10	0.005	NE	NE	NE	NE
Open burning of natural residues in agriculture	mg/t wood	NA	0.06	NA	0.01	3'150	6'450	5'150	1'700
Open burning of natural residues in private households	mg/t wood	NA	0.06	NA	0.01	3'150	6'450	5'150	1'700
Cremation	mg/cremation	0.06	0.20	NA	0.001	NE	NE	NE	NE

Activity data (5C)

The clinical waste incineration quantities are based on rough expert estimates (EMIS 2017/5C1 Spitalabfallverbrennung).

Emissions from illegal waste incineration are based on the amount of municipal solid waste and waste from construction work burned in Switzerland. Due to the lack of reliable data it is estimated that in 1990 1% and in 2035 0.25% of this amount is burned illegally (expert judgment). The shares for the years in between are interpolated. In order to get the illegal waste quantity the percentage quotation is multiplied by the total amount of municipal solid waste and waste from construction work (EMIS 2017/5C1 Abfallverbrennung illegal).

The sewage sludge quantity for 1990 is taken from the waste statistics report (FOEN 2009j). The quantities until 2006 are based on reliable statistical data for every second year. From then onwards the sewage sludge quantities incinerated in sewage sludge incineration plants are taken from the yearly waste statistics (FOEN 2016a) (sewage sludge generated minus the sewage sludge quantities burnt in municipal solid waste incineration plants and sewage sludge used as alternative fuel in cement plants).

The activity data for burning of agricultural waste is about to decrease since legal burning is more strongly restricted since the last revision of the corresponding article in the Swiss Federal Ordinance on Air Pollution Control (Swiss Confederation 1985 as at 1 January 2009) (EMIS 2017/5C2 Abfallverbrennung Land- und Forstwirtschaft). As a consequence of the greenhouse gas inventory UNFCC in-country review 2016 greenhouse gas emissions from open burning of natural residues in forestry (5C2 ii) were moved to sector 4 V in the greenhouse gas inventory. The corresponding air pollutant emissions have been moved to 11 B within the informative inventory report (Natural sources, natural and man induced forest fires).

Table 6-12: Activity data for the various emission sources within source category 5C Waste incineration and open burning of waste 1990-2015.

5C Incineration and open burning of waste	Unit	1990	1995	2000	2005
Clinical waste incineration	kt	30.0	17.5	5.0	NO
Illegal waste incineration	kt	32.3	26.2	24.9	21.7
Insulation material from cables	kt	7.5	NO	NO	NO
Sewage sludge incineration	kt dry	57.0	50.2	64.3	94.9
Open burning of natural residues in agriculture	kt	16.5	15.2	14.0	12.8
Open burning of natural residues in private households	kt	6.1	4.9	3.6	2.4
Total	kt	149.3	114.0	111.8	131.7
Cremation	Numb.	37'513	40'968	44'821	48'169

5C Incineration and open burning of waste	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Clinical waste incineration	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Illegal waste incineration	kt	22.6	22.1	22.4	20.7	21.0	20.3	20.3	19.9	19.3	19.3
Insulation material from cables	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sewage sludge incineration	kt dry	92.7	95.2	97.7	100.1	102.6	102.4	100.8	120.9	121.0	127.6
Open burning of natural residues in agriculture	kt	12.5	12.3	12.0	11.8	11.5	11.5	11.6	11.6	11.6	11.6
Open burning of natural residues in private households	kt	2.2	1.9	1.7	1.5	1.2	1.2	1.2	1.3	1.3	1.3
Total	kt	130.0	131.5	133.8	134.1	136.4	135.5	133.9	153.6	153.2	159.8
Cremation	Numb.	48'083	49'413	51'116	52'402	52'813	52'530	50'567	53'205	55'616	59'664

Note that since 2002, all special clinical waste incinerator plants have ceased operation and all hospital waste is incinerated in municipal solid waste incineration plants (accounted for in 1A1 Energy industry). Also note that since 1995, all burning of insulation material (industrial waste incineration in the table above) cables ceased.

6.4.3 Category-specific recalculations in 5C – Waste incineration and open burning of waste

- Activity data for illegal waste incineration for the year 2013 has slightly increased due to the correction of an error in waste statistics.
- Activity data for sewage sludge incineration for the year 2013 has slightly increased due to the correction of an error in waste statistics.
- Emission factors for cremations have slighly changed for the year 1996 and onwards due to corrections in the calculation of weighted emission factors according to the share of cremations in retroffited / non-retrofitted installations.
- As a consequence of the greenhouse gas inventory UNFCC incountry review 2016 greenhouse gas emissions from open burning of natural residues in forestry (5C2 ii) had to be moved to sector 4 V. The corresponding air pollutant emissions have been moved to 11 B (Natural sources, natural and man induced forest fires). Emissions in 5C2 have therefore decreased.

6.5 Source category 5D – Wastewater handling

6.5.1 Source category description of 5D - Wastewater handling

Source category 5D1 Domestic wastewater handling comprises all emissions from liquid waste handling and sludge from housing and commercial sources (including grey water and night soil). In Switzerland, municipal wastewater treatment (WWTP) plants treat wastewater from single cities or several cities and municipalities together. Wastewater in general is treated in three steps: 1. Mechanical treatment, 2. Biological treatment, and 3. Chemical treatment. The treated wastewater flows into a receiving system (lake, river or stream). Switzerland's wastewater management infrastructure is now practically complete (FOEN 2012g). The vast majority of WWT plants apply an anaerobic sludge treatment with sewage gas recovery and use the sewage gas for combined power and heat production.

The source category 5D2 Industrial wastewater handling comprises all emissions from liquid wastes and sludge from industrial processes such as food processing, textiles, car-washing places and electroplating plants as well as pulp and paper production. These processes may result in effluents with a high load of organics. Depending on the contaminants, an on-site pre-treatment is necessary in order to reduce the load of pollutants in the wastewater, to meet the regulatory standards (which are in place to preclude disruptions of the municipal WWTP), and to reduce discharge fees. The on-site pre-treatment is generally anaerobic, in order to use the sewage gas as source for combined heat and power production. The pre-treated wastewater is discharged to the domestic sewage systems, where the industrial wastewater is further treated, together with domestic wastewater in municipal WWTP.

Table 6-13: Specification of source category 5D Wastewater handling.

5D	Source	Specification
5D1	Domestic wastewater handling	Emissions from liquid waste handling and sludge from housing and commercial sources
5D2	Industrial wastewater handling	Emissions from handling of liquid wastes and sludge from industrial processes

Source category 5D Wastewater handling is not a key category.

The emissions related to wastewater treatment fall under various categories as laid out in Figure 6-3 below. The system boundaries of category 5D contain all emissions from direct wastewater handling, some emissions from sewage sludge drying and no emissions from sewage sludge use or disposal. The discharge of sewage sludge on agricultural soils has been phased out since 2003 and is generally forbidden since 2008, therefore this process is crossed out in the figure below. The same applies to solid waste disposal on land (5A). All sewage sludge is incinerated either in MSW incineration plants (1A1a), Sewage sludge incineration plants (5C) or used as alternative fuel in the cement industry (1A2f).

The emissions from combined heat and power generation as well as from boilers are reported within this source category since the energy is (mostly) used for the operation of the waste water treatment plants.

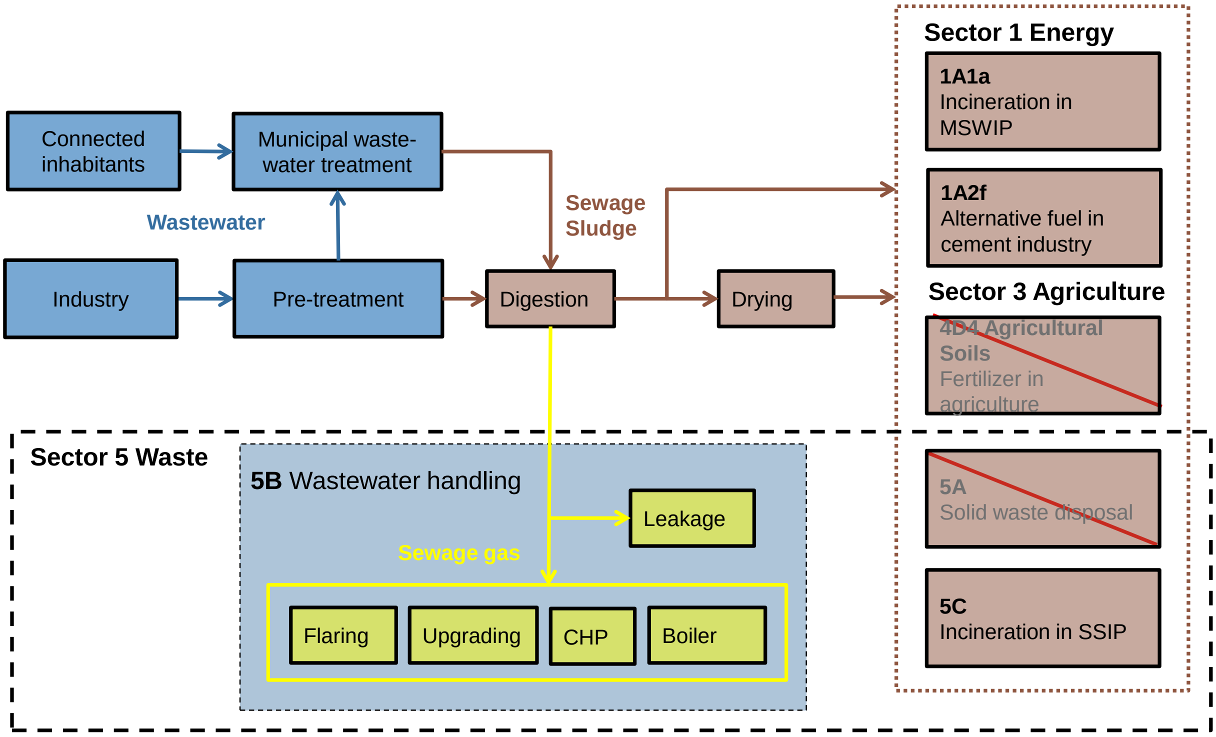

Figure 6-3: System boundaries of emissions related to wastewater handling. Abbreviations: CHP Combined Heat and Power Generation, MSWIP municipal solid waste incinearion plant, SSIP sewage sludge incineration plant.

6.5.2 Methodological issues of 5D Wastewater handling

Methodology (5D)

For 5D1 Domestic wastewater handling and 5D2 Industrial wastewater handling, a Tier 2 method is used (see decision tree in chapter 5D Wastewater handling EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

For 5D1 Domestic wastewater handling the emission factors are calculated on the basis of the total emissions divided by the number of inhabitants (Swiss population). This number is not equivalent to the number of inhabitants connected to the system.

Emission factors (5D)

Emission factors are country-specific based on measurements and expert estimates, documented in the EMIS database (EMIS 2017/5D1, EMIS 2017/5D2), see the following table.

Table 6-14: Emission factors for 5D Wastewater handling in 2015.

5D Wastewater handling	**NO_x**	**NMVOC**	**SO_x**	**NH_3**	**CO**
	g/person				
5D1 Domestic wastewater handling	22	0.5	2.4	15	38
5D2 Industrial wastewater handling	2.9	0.07	0.3	NA	4.7

Activity data (5D)

Activity data for 5D1 Domestic wastewater handling and 5D2 Industrial wastewater handling are the total number of inhabitants extracted from SFSO (2016a). The number of persons connected to the system (ICS) is the product of the number of inhabitants and the service level. The fraction and number of persons connected to waste water systems is indicated below for informational reason.

Table 6-15: Activity data in 5D Wastewater handling: Population and fraction connected to waste water treatment plants.

5D Wastewater handling	**Unit**	**1990**	**1995**	**2000**	**2005**
Inhabitants	persons in 1000	6'796	7'081	7'209	7'501
Fraction connected to waste water treatment plants	%	90	94	95	97
Inhabitants connected	persons in 1000	6'116	6'621	6'877	7'261

5D Wastewater handling	**Unit**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Inhabitants	persons in 1000	7'558	7'619	7'711	7'801	7'878	7'912	7'997	8'089	8'189	8'282
Fraction connected to waste water treatment plants	%	97	97	97	97	97	97	97	97	97	97
Inhabitants connected	persons in 1000	7'331	7'390	7'480	7'567	7'642	7'675	7'757	7'846	7'943	8'034

6.5.3 Category-specific recalculations in 5D - Wastewater handling

- Activity data of energy produced in combined heat and power generation engines (CHP) has been recalculated for 2011-2014 in the Swiss Statistics for Renewable Energies (SFOE 2016a). This leads to changed emission factors (emissions per capita).

6.6 Source category 5E – Other waste, car shredding

6.6.1 Source category description of 5E - Other waste, car shredding

In source category 5E only car shredding is considered.

Table 6-16: Specification of source category 5E Other waste, car shredding

5E	**Source**	**Specification**
5E	Car shredding	Emissions from car shredding plants

Source category 5E Other waste, car shredding is not a key category.

6.6.2 Methodological Issues of 5E - Other waste, car shredding

Methodology (5E)

For the emissions from car shredding a country specifc method is used. Emissions are calculated by multiplying the quantity of scrap by respective emission factors.

Emission factors (5E)

For the emissions from car shredding country-specific emission factors are used (SAEFL 2000 and EMIS 2017/5E Shredder Anlagen. For all years emission factors are considered to remain constant.

Table 6-17: Emission factors for 5E Other waste, car shredding in 2015.

5E Other waste	Pollutant	Unit	Emission factors
Shredding	NMVOC	g/t scrap	200
	PM2.5 nonexhaust	g/t scrap	5
	PM10 nonexhaust	g/t scrap	10
	TSP nonexhaust	g/t scrap	12
	CO	g/t scrap	5
	Pb	g/t scrap	0.0220
	Cd	g/t scrap	0.0025
	PCDD/PCDF	mg/t scrap	0.0004

Activity data (5E)

The waste quantities from 1990 are data provided by the Swiss shredder association. The data from 2003 and 2007 are taken from Swiss waste statstics. In between years are interpolated. From 2007 onwards the quantites are assumed to remain constant due to the lack of data (EMIS 2017/5E Shredder Anlagen).

Table 6-18: Activity data for car shredding 1990-2015 (source EMIS 2017/5E Shredder Anlagen)

5E Other waste	Unit	1990	1995	2000	2005
Shredding	kt	280	300	300	300

5E Other waste	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Shredding	kt	300	300	300	300	300	300	300	300	300	300

6.6.3 Category-specific recalculations in 5E - Other waste, car shredding

No recalculations were carried out for source category 5E.

7 Other and natural emissions

7.1 Overview of emissions

In this introductory chapter, an overview of emissions separated by the most relevant pollutants is presented. Likewise, surfacing trends and changes are analysed and discussed for individual source categories in the period between 1990 and 2015. In sector 6 Other and natural emissions NH_3, NO_x and PM2.5 are the most relevant contributors to air pollution.

The following source categories are reported:

- 6Aa Humans
- 6Ab Pets
- 6Ac Fertilizers
- 6Ad Fire damages estates and motor vehicles

7.1.1 Overview and trend for NH_3

Figure 7-1 depicts the trend of NH_3 emissions in sector 6 Other and natural emissions since 1990. Total emissions fluctuate and have slightly increased within the reporting period. Source category 6Ab Pets emissions contributes the largest share to total emissions. Emissions from the other two source categories 6Aa Humans and 6Ac Fertilizers remain considerably stable in total during past years, although 6Aa shows a very slight increase with population.

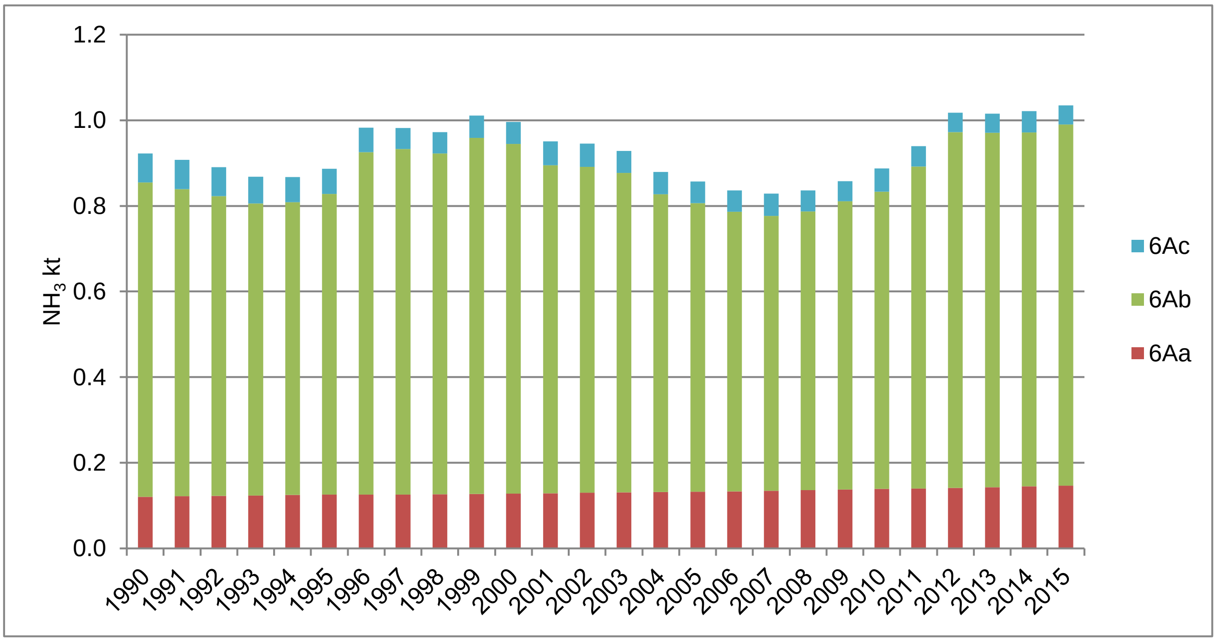

Figure 7-1: Switzerland's NH_3 emissions from the sector 6 Other and natural emissions by source categories 6Aa-6Ac between 1990–2015. The corresponding data table can be found in Annex 6.6.

7.1.2 Overview and trend for NO_x

NO_x emissions from the source categories 6Ab Pets, 6Ac Fertilizers and 6Ad Other waste - fire damages estates and motor vehicles between 1990 and 2015 are summarised in Figure 7-2. The overall emissions fluctuate but remain at about the same level within the reporting period. For all years, 6Ac Fertilizers contributes the bulk to total emissions. While emissions from 6Ad Other waste - fire damages estates and motor vehicles and 6Ab Pets remained very stable, those from 6Ac Fertilizers decreased continuously.

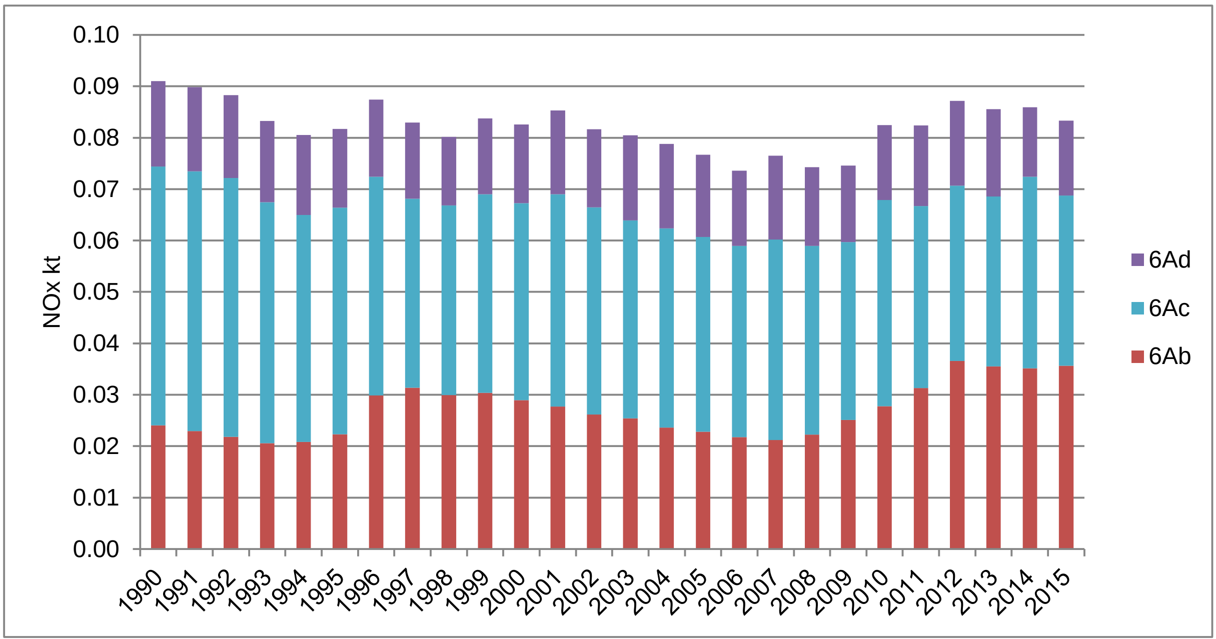

Figure 7-2: Switzerland's NO_x emissions from the sector 6 Other and natural emissions by source categories 6Ab-6Ad between 1990–2015. The corresponding data table can be found in Annex 6.6.

7.1.3 Overview and trend for PM2.5

PM2.5 emissions in the sector 6 Other and natural emissions stem predominantly from 6Ad Other waste - fire damages estates and motor vehicles. Total emissions increased in the reporting period. Emissions from 6Ab Pets are the other relevant source category.

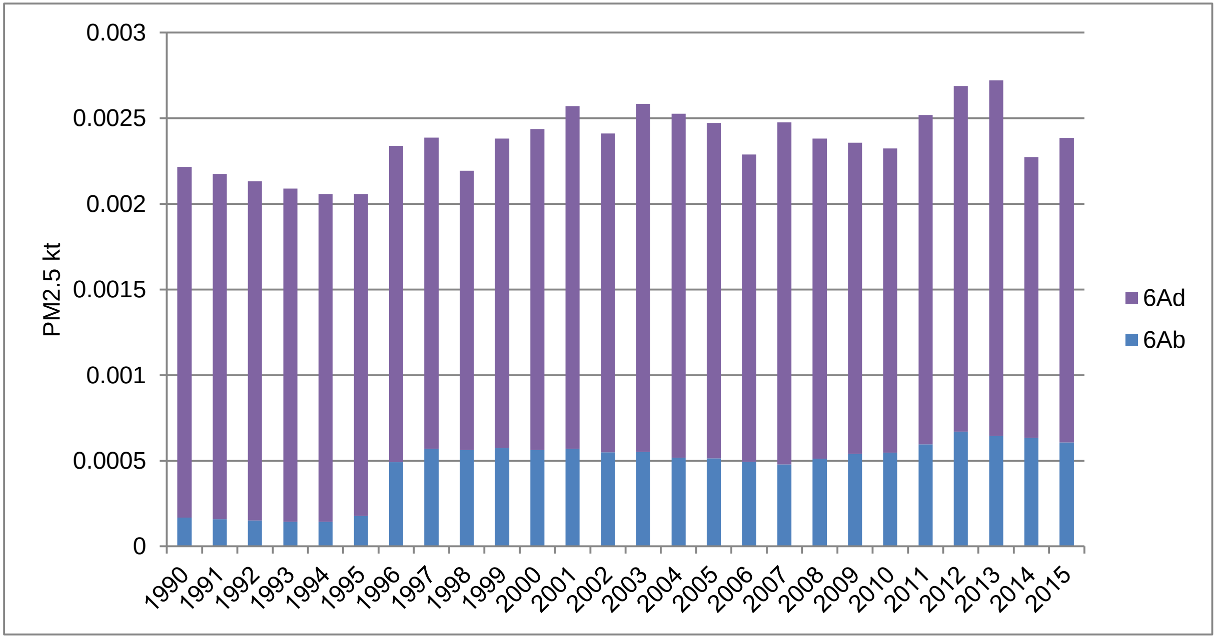

Figure 7-3: Switzerland's PM2.5 emissions from the sector 6 Other and natural emissions between 1990–2015. Please consider the logarithmic scale. The corresponding data table can be found in Annex 6.6.

7.2 Source category 6 - Other and natural emissions

7.2.1 Source category description of 6 - Other and natural emissions

Within the sector 6 Other and natural emissions, emissions from the sources as shown in Table 7-1 are considered.

Table 7-1: Specification of sector 6 Other and natural emissions.

6A	Source	Specification
6Aa	Human emissions	Ammonia emissions from respiration and transpiration and diapers
6Ab	Pet emissions	Ammonia, PM2.5 and PM10 emissions of domestic and zoo animals
6Ac	Private application of synthetic fertilizer and urea	N_2O, NH_3 and NOx emissions
6Ad	Fire damage estates and motor vehicles	Emissions from fires in buildings and emissions from fires and fire damage in motor vehicles.

Source category 6 Other and natural emissions is not a key category.

7.2.2 Methodological issues of 6 - Other and natural emissions

Methodology (6A)

Human emissions (6Aa)

Ammonia emissions of human respiration and transpiration and of diapers are considered.

Pet emissions (6Ab)

Ammonia emissions of domestic animals such as cats, dogs and animals outside agriculture (such as mules, horses, asses) as well as zoo animals are considered.

PM2.5 and PM10 emissions from manure management from domestic animal keeping (e.g. horse and other animal farms outside agriculture) like horses, sheep, goats and donkeys are considered.

Emissions from private fertilizer use (6Ac)

Emissions for the use of mineral fertilizers are calculated by multiplying activity data of Table 7-4 by the emission factor of Table 7-2. The methodology is the same as for fertilizers used and reported in the agricultural sector (see chp. 5.3.2).

Emissions from fire damage estates and motor vehicles (6Ad)

The fire insurance association of the cantons (Vereinigung kantonaler Feuerversicherungen, VKF) publishes the number of fire incidents in buildings each year and the total sum of monetary damage. Data from 1992 to 2001 show that the average damage sum per fire incident in buildings amounts to approx. CHF 20'000. It is assumed that this corresponds to 780 kg of flammable material per case. It is further assumed that in average only 50% of the material actually burns down during an incident because of the interference of the fire brigade. Thus, an amount of 400 kg of burnt material per fire case is estimated. With these assumptions, the amount of burnt material for each year can be calculated from the total sum of monetary damage published by VKF (EMIS 2017/6A).

Based on data from a Swiss insurance company with 25% market share in 2002, the number of reported cases of fire damage to vehicles was extrapolated to the total vehicle number in Switzerland. It was estimated that one fire case per 790 vehicles occurs per year, remaining constant within the reporting period. Applying this ratio to the actual vehicle number which is published by the Swiss Federal Statistical Office, the total number of fire incidents with vehicles in Switzerland is obtained for each year (EMIS 2017/6A). During a car fire incident, a car burns down only partially. It is assumed that approx. 100 kg of material burns down during a car fire. With these assumptions, the total number of material burnt can be calculated from the total number of cars in Switzerland.

Emission factors (6A)

The emission factors of source categories reported under 6Aa-6Ac are depicted in Table 7-2. Emission factors for fertilizer see also Table 5-9.

Ammonia emissions (6Aa-6Ac)

Emission factors for human ammonia emissions are extracted from Sutton et al (2000). Emission factors for pet ammonia emissions are retrieved from Reidy and Menzi (2005).

PM2.5 and PM10 nonexhaust (6Ab)

For detailed information about emission factors for PM2.5 and PM10 please refer to source category 3B – Manure management.

Table 7-2: Emission factors for the year 2015 in sector 6 Other and natural emissions (source EMIS 2017/6A).

EMIS nomenclature	Source	Pollutant	Unit	Emission factor
6 A a	Human respiration	NH3	g/person	3
6 A a	Human transpiration	NH3	g/person	14
6 A a	Children <1y	NH3	g/person	12
6 A a	Children 1-3y	NH3	g/person	15
6 A a	Aged inhabitants	NH3	g/person	42
6 A b	Livestock outside agriculture	NOx	g/numb.	352
6 A b	Livestock outside agriculture	NH3	g/numb.	4'557
6 A b	Livestock outside agriculture	PM10 nonexhaust	g/numb.	39
6 A b	Livestock outside agriculture	PM2.5 nonexhaust	g/numb.	6
6 A b	Cats	NH3	g/numb.	90
6 A b	Dogs	NH3	g/numb.	436
6 A b	Zoo animals	NH3	g/t	41
6 A c	Fertilizer, NOx emissions	NOx	kg/t	18
6 A c	Fertilizer, NH3 emissions	NH3	kg/t	24

Fire damages (6Ad)

Emission factors for CO_2, CO, NO_x and SO_2 are country-specific based on measurements and expert estimates originally done for illegal waste incineration. It is assumed that emissions are similar in fire damage in estates (EMIS 2017/6A “Brand- und Feuerschäden Immobilien”). The emission factors of Pb, Cd, and Hg are country-specific based on measurements of a study about a cable recycling company in Switzerland (Graf 1990). It is assumed that the PCDD emission factor is the same as for illegal waste incineration. The emission factor for B(a)P is taken from US-EPA (1998a).

Emission factors for CO_2, CO, NO_x and SO_2 are country-specific based on measurements and expert estimates originally done for wire burn off, documented in EMIS 2017/6A Brand- und Feuerschäden Motorfahrzeuge”.

Table 7-3 presents the emission factors used. Please note the different units for the upper and lower table. The emission factors of Pb, Cd, Hg, and B(a)P are the same as the emission factors of fire damge estates. The PCDD emission factors of fire damage of motor vehicles are determined by two studies (US-EPA 1998a, 1998b). It is assumed that the emission factor for B(a)P is slightly higher than the study-based EF for B(a)P of car scrap due to higher B(a)P EF values of car tires.

Table 7-3: Emission factors for fires reported under 6Ad Fire damages estates and motor vehicles in 2015 as kg/t burned good and g/t burned good, respectively.

6 A d Fire damages	Unit	NO_x	NMVOC	SO_2	PM10	TSP	CO
Fire damage estates	kg / t burned good	2	16	1	25	30	100
Fire damage motor vehicles	kg / t burned good	1.3	2	5	1	5	2

6 A d Fire damages	Unit	Pb	Cd	Hg	Zn	PCDD/F	BaP	BbF	BkF	IcdP
Fire damage estates	g / t burned good	800	20	10	350	0.0003	0.34	0.2	0.27	0.1
Fire damage motor vehicles	g / t burned good	800	20	0.05	350	0.0003	50	30	40	15

Activity data (6A)

Human emissions (6Aa)

Activity data for human ammonia emissions is retrieved from the Swiss Federal Statistical Office and consists in the number of inhabitants for the processes respiration and transpiration, whereas for the emissions from diapers the number of children younger than 1 year and 3 years respectively, are taken into account as well as the number of residents in nursing homes.

Pet emissions (6Ab)

Activity data for pet ammonia as well as PM2.5 and PM10 (for livestock outside agriculture) emissions are the number of domestic animals and the total live weight of zoo animals, respectively. For domestic animals different publications are used as a source. The number of the most important category of dogs and cats is provided by the Swiss Association for pet food[7].

Emissions from private fertilizer use (6Ac)

For 6Ac only mineral fertilizers (no urea based fertilizers) are used for private applications.

Table 7-4: Activity data causing N emissions in sector 6 Other and natural emissions from 1990-2015.

EMIS nomenclature	Source	Unit	1990	1995	2000	2005
6 A a	Human respiration	person	6'796'000	7'081'000	7'209'000	7'501'000
6 A a	Human transpiration	person	6'796'000	7'081'000	7'209'000	7'501'000
6 A a	Children <1y	person	83'939	81'199	78'458	75'627
6 A a	Children 1-3y	person	236'991	237'415	237'839	226'243
6 A a	Aged inhabitants	person	9'000	9'752	10'504	11'029
6 A b	Livestock outside agriculture	numb.	27'876	29'597	93'829	85'694
6 A b	Cats	numb.	1'164'786	1'205'000	1'379'000	1'417'000
6 A b	Dogs	numb.	456'015	438'000	513'000	487'000
6 A b	Zoo animals	t	140'000	140'000	140'000	140'000
6 A c	Fertilizer, NH_3 emissions	t	2'788	2'440	2'120	2'096
6 A c	Fertilizer, NO_x emissions	t	2'788	2'440	2'120	2'096

EMIS nomenclature	Source	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
6 A a	Human respiration	person	7'558'000	7'619'000	7'711'000	7'801'000	7'878'000	7'912'000	7'997'000	8'089'000	8'189'000	8'282'000
6 A a	Human transpiration	person	7'558'000	7'619'000	7'711'000	7'801'000	7'878'000	7'912'000	7'997'000	8'089'000	8'189'000	8'282'000
6 A a	Children <1y	person	75'060	74'494	76'691	78'286	80'290	80'808	82'164	82'731	85'287	86'559
6 A a	Children 1-3y	person	223'924	221'605	224'819	224'556	229'471	235'267	239'384	243'262	245'703	250'182
6 A a	Aged inhabitants	person	11'134	11'239	11'338	17'080	17'357	17'393	17'972	18'389	18'679	18'891
6 A b	Livestock outside agriculture	numb.	82'385	79'759	85'504	90'019	91'367	99'185	111'750	107'347	105'572	101'172
6 A b	Cats	numb.	1'488'000	1'477'000	1'392'000	1'449'500	1'507'000	1'497'000	1'487'000	1'572'537	1'590'955	1'655'951
6 A b	Dogs	numb.	477'000	491'000	508'000	476'500	445'000	475'500	506'000	509'146	511'573	521'891
6 A b	Zoo animals	t	140'000	140'000	140'000	140'000	140'000	140'000	140'000	140'000	140'000	140'000
6 A c	Fertilizer, NH_3 emissions	t	2'056	2'156	2'032	1'916	2'220	1'956	1'888	1'828	2'063	1'831
6 A c	Fertilizer, NO_x emissions	t	2'056	2'156	2'032	1'916	2'220	1'956	1'888	1'828	2'063	1'831

Fire damages (6Ad)

Activity data for source category fire damages (6Ad) are given in Table 7-5.

Table 7-5: Activity data in source category 6Ad Fire damages: Burnt goods from 1990 to 2015 (source EMIS 2017/6A).

6 A d Fire damages	Unit	1990	1995	2000	2005
Fire damage estates	kt	8.0	7.3	7.3	7.6
Fire damage motor vehicles	kt	0.5	0.5	0.6	0.6

6 A d Fire damages	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fire damage estates	kt	6.9	7.7	7.2	7.0	6.8	7.4	7.8	8.0	6.3	6.8
Fire damage motor vehicles	kt	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8

7 http://www.vhn.ch/

7.2.3 Recalculations in 6 - Other and natural emissions

- NH_3: Activity data for 2014 for nappies used in nursery homes has very slightly changed due to a recalculation in the statistics for elderly persons in nursery homes provided by the SFSO
- NH_3: Activity data for 2013 and 2014 for cat population has slightly increased due to a correction in the model (AD had to be interpolated between 2012 and 2015 because of lack of data for the two years in between).
- NH_3: Activity data for 2013 and 2014 for dog population has slightly increased due to a correction in the model (AD had to be interpolated between 2012 and 2015 because of lack of data for the two years in between).
- Activity data for fire damages motor vehicles has changed for the years 2003-2014 because the model has been updated with vehicle data provided by the SFSO.
- Activity data for fire damages estates has changed for the years 1996-2014 because the model has been updated with damage sums provided by the fire insurance association of the cantons.

7.3 Source category 11B - Natural emissions

7.3.1 Source category description of 11B - Natural emissions

Within 11B Forest fires following source categories are reported:

- Emissions from forest fires occurring naturally or caused by humans.
- Emissions from open burning of natural residues in forestry.

Note that emissions are reported under Natural emissions (11B) but are not accounted for in the national totals and are reported as memo item only.

As a consequence of the greenhouse gas inventory UNFCC incountry review 2016 greenhouse gas emissions from open burning of natural residues in forestry (5C2 ii) was moved from sector 5C to sector 4VA1. The corresponding air pollutant emissions are reported here.

7.3.2 Methodology of 11B - Natural emissions

For calculating the emissions of forest fires a country-specific Tier 2 method is used (see decision tree in chapter 11B Forest fires in MEP/EEA Guidebook 2013 (EMEP/EEA 2013). Emissions of forest fires are calculated by multiplying the area of forest burnt yearly by an emission factor.

For the calculation of the emissions from burning of silvicultural waste a country-specific Tier 2 method is used (see decision tree in chapter 5C2 Open burning of waste EMEP/EEA Guidebook 2013 (EMEP/EEA 2013).

Emission factors (11B)

Emission factors for Forest fires are specified in the EMIS database (see old com "Waldbrände").

Emission factors for open burning of natural residues in forestry are country-specific based on measurements and expert estimates as documented in the EMIS 2017/5C2 Abfallverbrennung Land- und Forstwirtschaft.

Table 7-6: Emission factors 2015 of 11B Forest fires.

11B Forest fires	Unit	NO_x	NMVOC	SO_2	NH3	PM10	PM2.5	TSP	CO
Forest fires	kg/ha	80	550	40	NA	500	400	1'000	1'600
Open burning of natural residues in forestry	g/t	1'380	1'470	30	800	4'130	3'760	4'310	48'790

11B Forest fires	Unit	Hg	PCDD/F	BaP	BbF	BkF	IcdP
Forest fires	kg/ha	0.001	NA	0.30	0.60	0.60	0.80
Open burning of natural residues in forestry	g/t	0.060	0.00001	3.15	6.45	5.15	1.70

Activity data (11B)

The area of forests burnt is based on a statistic of forest fires managed by FOEN and documented in the EMIS database (see old com "Waldbrände").

The activity data for burning of silvicultural waste is about to decrease since legal burning is more strongly restricted since the last revision of the corresponding article in the Swiss Federal Ordinance on Air Pollution Control (Swiss Confederation 1985 as at 1 January 2009). Activity data are documented in EMIS 2017/5C2 Abfallverbrennung Land- und Forstwirtschaft.

Table 7-7: Activity data 2015 of 11B Forest Fires.

11B Forest fires	Unit	1990	1995	2000	2005
Forest fires	ha	1'698	445	69	43
Open burning of natural residues in forestry	kt	28.8	24.5	20.2	15.9

11B Forest fires	Unit	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Forest fires	ha	117	322	67	51	27	224	28	28	45	65
Open burning of natural residues in forestry	kt	15.0	14.1	13.3	12.4	11.5	11.6	11.6	11.7	11.7	11.8

7.3.3 Recalculations in 11B - Natural emissions

- Emission from open burning of natural residues in forestry were formerly reported in source category 5C. Based on the NIR in country review 2016 this source category has been moved to this chapter.

8 Recalculations and Improvements

8.1 Explanations and Justifications for Recalculation

Several recalculations had to be carried out due to improvements in several sectors. They are listed sorted by sector in the following enumerations.

8.1.1 1 Energy

8.1.1.1 Category-specific recalculations 1A

- 1A: Small recalculations due to rounding in SFOE 2016 (Swiss overall energy statistics) concerning other bituminous coal and natural gas (2013, 2014).
- 1A: In 1A1a, 1A2gviii, 1A4ai, 1A4bi and 1A4ci Wood combustion AD of automatic boilers and stoves have been revised for 1990-2014 and 2011-2014, respectively due to minor recalculations in Swiss wood energy statistics (SFOE 2016b) (1990-2014).

8.1.1.2 Category specific recalculations for 1A1 (stationary)

- 1A1a: The time series value of waste generation rate for 2013 has slightly changed due to the correction of an error in waste statistics.
- 1A1a: Emission factors for PM for municipal waste incineration plants have slightly changed for the year 2014. EF for the year 2013 are based on measurements and are assumed to be constant for the years 2014 and onwards.
- 1A1a: EF for all air pollutants have changed for special waste incineration plants for the years 1991 - 2012. EF from 2013 have been adopted for the year 2003 because they are based on measurements and seem more plausible than the original values that have been taken over from municipal waste incineration.
- 1A1a: Recalculation in residual fuel oil boilers due to mistake in calculations in the energy model (1990-2014).

8.1.1.3 Category-specific recalculations for 1A2 (stationary)

- 1A2: Recalculations due to new available statistical data (Energy consumption statistics in the industry and services sectors SFOE 2016d) (2013, 2014).
- 1A2: Amount of used gas oil in households, industry and commercial sector in Liechtenstein has been redistributed. Therefore, the amount of used gas oil in boilers in households, industry and in the commercial sector has changed for Switzerland too (1990-2014).
- 1A2a: The so far missing Hg emission factor of 1A2a Iron foundries, cupola furnaces is now included in the inventory for the entire time series based on the default value for other bituminous coal of the EMEP/EEA Guidebook 2013.
- 1A2f: AD of 1A2f Production of mixed goods has been revised for 2014 based on corrected data from industry association.
- 1A2f: The emission factors of BaP, BbF, BkF and IcdP of 1A2f Production of mixed goods have been revised for the entire time series based on air pollution control measurements (2001-2015).
- 1A2f: The emission factors of NO_x, NMVOC, PM2.5, PM10, TSP, BC, CO and Cd of 1A2f Production of mixed goods have been revised from 1991 onwards based on air pollution control measurements (2001-2015).

- 1A2f: Revised interpolated emission factors for CO, Pb and Cd of 1A2f Rockwool production in 2014 due to new plant-specific data for 2015.
- 1A2f: The emission factors of NMVOC, SO_x, Pb, Cd and Hg as well as CO from 1A2f Glass production (specialty tableware) have been revised from 1991 and 1996, respectively, onwards.
- 1A2f: AD of 1A2f Container glass have been revised for 2003-2006 based on monitoring reports of the Swiss emissions trading scheme.
- 1A2f: The conversion factor used for calculation of NMVOC emissions from total carbon based on air pollution control measurements has been revised resulting in adjusted NMVOC emission factors of 1A2f Brick and tile production and 1A2f Fine ceramics production for the entire time series.
- 1A2g: Recalculations in AD (1990-2008: gas oil, residual oil, 1990-1994: petroleum coke, other bituminous coal) of 1A2gviii Industrial boilers due to revised fuel mix and consumption in 1A2f Lime production.

8.1.1.4 Category-specific recalculations for 1A4 (stationary)

- 1A4: In 1A4ai, 1A4bi and 1A4ci Wood combustion AD of automatic boilers and stoves have been revised for 1990-2014 and 2011-2014, respectively due to minor recalculations in Swiss wood energy statistics (SFOE 2016b) (1990-2014).
- 1A4ci: The missing emission factors in last year's submission of all air pollutants for 1A4ci Plants for renewable waste from wood products in 2014 are now included in the inventory.1A4ci: The emission factors of NMVOC as well as NO_x, PM2.5, PM10, TSP, BC and CO from 1A4ci Drying of grass have been revised from 1990 and 1991, respectively, onwards based on air pollution control measurements (2005-2015).

8.1.1.5 Category-specific recalculations for 1A2 Mobile combustion in manufacturing industry and construction (mobile)

- No recalculations were carried out for source category 1A2g vii.

8.1.1.6 Category-specific recalculations for 1A3 Transport

- 1A3a: Particulate matter emissions estimations have been updated. New and considerably lower emission factors for non-exhaust emissions have been used for a recalculation of the the years 1990-2014.
- 1A3a: As recommended by the ERT during the stage 3 review (UNECE 2016a) there are no more CH_4 emissions for cruise activities. This implies that the NMVOC emissions for cruise activities are increasing correspondingly.
- 1A3b/1A3d: Small recalculation due to a change in the NCV of diesel used in international navigation to equalise with other diesel processes. Therefore, small changes occurred 1990-2014 in fuel tourism and statistical difference for diesel which is integrated in 1A3biii.

8.1.1.7 Category-specific recalculations for 1A4 Non-road mobile sources and machinery

- No recalculations were carried out for source category 1A4a ii, 1A4b ii, 1A4c ii (mobile).

8.1.1.8 Category-specific recalculations for 1A5b Other, mobile (Military)

- No recalculations were carried out for source category 1A5b Other, mobile (Military).

8.1.1.9 Category-specific recalculations for 1B1 Fugitive emissions from solid fuels

- The emission factors are taken from the in EMEP/EEA Guidebook (EMEP/EEA 2013).

8.1.1.10 Category-specific recalculations for 1B2 Oil, natural gas, venting/flaring

- 1B2a: SO_2 emissions from Claus units were previously reported in source category 2H3 and are now reported in 1B2aiv..
- 1B2b: Recalculation of AD due to an update in the Swiss overall energy statistics (SFOE 2016) concerning gas production in Switzerland (1991, 1992, 1994).
- 1B2c: Emissions from flaring in gas production were missing before. Now emission factors from the EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013) are used (1990-1994).
- 1B2c: CO, NMVOC, NO_x and SO_2 emission factors of Venting and flaring in refineries changed due to increased precision in the data (less rounding) 2005-2014.

8.1.2 2 Industrial processes and product use

8.1.2.1 Category-specific recalculations in 2A Mineral products

- 2A5a: AD of 2A5a Gravel plants have been revised for 2014 due to data from industry association.

8.1.2.2 Category-specific recalculations in 2B Chemical industry

- 2B1: The emission factor of NH_3 from 2B1 Ammonia production has been revised from 2002 onwards based on plant-specific emission data from 2011 and 2013-2015.
- 2B10: The so far reported AD in 2B10a Ammoinum nitrate production was not as assumed the amount of pure ammonium nitrate but already formulated fertilizer consisting of ammonium nitrate (75%) and shale (25%). From this submission onwards, AD and EF have changed to pure ammonium nitrate as reference figure for the entire time series resulting in minor emission changes due to rounding (1990-2014).
- 2B10: The extrapolated values of the SO_x emission factor of 2B10a Sulphuric acid production have been revised (1990-2008).

8.1.2.3 Category-specific recalculations in 2C Metal production

- 2C1: The conversion factor used for calculation of NMVOC emissions from total carbon based on air pollution control measurements has been revised resulting in an adjusted NMVOC emission factor of 2C1 Secondary steel production, electric arc furnace from 1995 onwards.
- 2C7c: The emission factors of NMVOC and NH_3 from 2C7c Battery recycling are newly reported in the inventory based on air pollution control measurements (2003 and 2012).

- 2C7c: The emission factors of NO_x, SO_x, TSP, CO, Pb, Cd, Hg and PCDD/PCDF from 2C7c Battery recycling have been revised from 2002 onwards based on air pollution control measurements (2003 and 2012).
- 2C7c: The emission factors of PM2.5 and PM10 from 2C7c Battery recycling have been revised from 2003 onwards based on air pollution control measurements (2003 and 2012).

8.1.2.4 Category-specific recalculations in 2D Other solvent use

- 2D3b: The AD of 2D3b Road paving has been revised for 2014 based on corrected data from the industry association.

8.1.2.5 Category-specific recalculations in 2G Other product use

- 2G: Unfortunately, there is a double-counting in the NMVOC emissions from 2G De-icing of airplanes for the years 1990-2006. This mistake will be corrected in submission 2018.

8.1.2.6 Category-specific recalculations in 2H, 2I Other

- 2H1: AD of 2H1 Chipboard production has been revised from 2005 onwards based on a changed density value of the chipboard produced.
- 2H2: Activity data of wine production has slightly decreased in the year 2011 due to the correction in the underlying statistics provided by the Swiss Alcohol Administration.
- 2H2: Activity data of sugar production has slighty changed for the years 2011, 2012 and 2014 due to corrections in the statistics provided by the Swiss Sugar Association.
- 2H2: Activity data of meat smokehouses has slightly changed for the years 2007, 2013 and 2014 due to corrections in the statistics provided by the Swiss Federal Office for Statistics.
- 2H2: Activity data of milling companies has slightly changed for the years 2013 and 2014 due to corrections in the statistics provided by the Swiss Federal Office for Agriculture.
- 2H3: SO_2 emissions from Claus units were previously reported in source category 2H3 and are now reported in 1B2aiv.

8.1.2.7 Category-specific recalculations in 2L Other production, consumption, storage, transportation or handling of bulk products

- 2L: A new model concerning use of NH_3 as coolant has been provided. Therefore, emissions of NH_3 in commercial and industrial refrigeration due to refilling and storage of NH_3 has been introduced to the inventory.

8.1.3 3 Agriculture

8.1.3.1 Category-specific recalculations in 3B Manure management

- 3B: Emission factors for NH_3 and NO_x emissions were revised due to new AGRAMMON survey results for 2015 (after the previous update 2010), which affects the interpolation of the years 2011-2014.

- 3B: Due to the findings of the Stage 3 Review 2016, emission factors (PM, PM10, PM2.5) for 3B4a Buffalo and 3B4hi Rabbit (and camels and deer) were included in the inventory for all years 1990-2014.

8.1.3.2 Category-specific recalculations in 3D Crop production and agricultural soils

- 3D: Emission factors for NH_3 and NO_x emissions were revised due to new AGRAMMON survey results for 2015 (after the previous update 2010), which affects the interpolation of the years 2011-2014.
- 3D: There are rounding differences concerning NH_3 emissions for all poultry categories in all the years.

8.1.4 5 Waste

8.1.4.1 Category-specific recalculations in 5A Biological treatment of waste - Solid waste disposal on land

- There were no recalculations carried out in source category 5A.

8.1.4.2 Category-specific recalculations in 5B Anaerobic digestion at biogas facilities

- NH_3 and NMVOC: Activity data for liquid and solid digestate has slightly changed in the year 2014 due to a correction of the fraction of manure and co-substrate.

8.1.4.3 Category-specific recalculations in 5C Waste incineration

- Activity data for illegal waste incineration for the year 2013 has slightly increased due to the correction of an error in waste statistics.
- Activity data for sewage sludge incineration for the year 2013 has slightly increased due to the correction of an error in waste statistics.
- Emission factors for cremations have slighly changed for the year 1996 and onwards due to corrections in the calculation of weighted emission factors according to the share of cremations in retroffited / non-retrofitted installations.
- As a consequence of the greenhouse gas inventory UNFCC incountry review 2016 greenhouse gas emissions from open burning of natural residues in forestry (5C2 ii) had to be moved to sector 4V. The corresponding air pollutant emissions have been moved to 11 B (Natural sources, natural and man induced forest fires). Emissions in 5C2 have therefore decreased.

8.1.4.4 Category-specific recalculations in 5D Wastewater handling

- Activity data of energy produced in combined heat and power generation engines (CHP) has been recalculated for 2011-2014 in the Swiss Statistics for Renewable Energies (SFOE 2016a). This leads to changed emission factors (emissions per capita).

8.1.4.5 Category-specific recalculations in 5E Other waste, car shredding

- NH_3: Activity data for 2014 for nappies used in nursery homes has very slightly changed due to a recalculation in the statistics for elderly persons in nursery homes provided by the SFSO.
- NH_3: Activity data for 2013 and 2014 for cat population has slightly increased due to a correction in the model (AD had to be interpolated between 2012 and 2015 because of lack of data for the two years in between).
- NH_3: Activity data for 2013 and 2014 for dog population has slightly increased due to a correction in the model (AD had to be interpolated between 2012 and 2015 because of lack of data for the two years in between).
- Activity data for fire damages motor vehicles has changed for the years 2003-2014 because the model has been updated with vehicle data provided by the SFSO.
- Activity data for fire damages estates has changed for the years 1996-2014 because the model has been updated with damage sums provided by the Swiss Building Insurance Association.

8.1.5 6 Other

8.1.5.1 Recalculations in 6 Other and natural emissions

- NH_3: Activity data for 2014 for nappies used in nursery homes has very slightly changed due to a recalculation in the statistics for elderly persons in nursery homes provided by the SFSO.
- NH_3: Activity data for 2013 and 2014 for cat population has slightly increased due to a correction in the model (AD had to be interpolated between 2012 and 2015 because of lack of data for the two years in between).
- NH_3: Activity data for 2013 and 2014 for dog population has slightly increased due to a correction in the model (AD had to be interpolated between 2012 and 2015 because of lack of data for the two years in between).
- Activity data for fire damages motor vehicles has changed for the years 2003-2014 because the model has been updated with vehicle data provided by the SFSO.
- Activity data for fire damages estates has changed for the years 1996-2014 because the model has been updated with damage sums provided by the Swiss Building Insurance Association.

8.1.5.2 Recalculations in 11B natural emissions

- Emission from open burning of natural residues in forestry were formerly reported in source category 5C. Based on the NIR in country review 2016 this source category has been moved to this chapter.

8.1.6 Implications of Recalculation for Emission Levels

Table 8-1 shows the effect of recalculations on the emission levels 2014 and 1990, based on the previous (2016) and latest (2017) NFR submission. In 2014, recalculations cause a lower emission level by at least 1% for NH_3, Pb. Cd, Hg, PCDD/PCDF and total PAH emissions. An increase due to recalculations is observed for NMVOC, PM2.5 and BC but the recalculation does not exceed 1%. In 1990, recalculations cause only for PAH a decrease of more than 1%.

Table 8-1: Recalculations: Implications for the emission levels 2014 and 1990. The values refer to the NFR submission 2016 (previous) and 2017 (latest). Differences in absolute and relative numbers for all pollutants. Differences are consequently rounded up to two significant digits.

Pollutant	Units	2014			
		previous subm. 2016	latest subm. 2017	difference (abs.)	difference (rel.) previous = 100%
NO_x	kt	62.00	61.98	-0.02	0.0%
NMVOC	kt	79.05	79.48	0.43	0.5%
SO_x	kt	7.94	7.90	-0.04	-0.6%
NH_3	kt	62.56	61.47	-1.09	-1.7%
PM2.5	kt	7.28	7.30	0.01	0.2%
PM10	kt	17.59	17.51	-0.08	-0.4%
TSP	kt	21.76	21.64	-0.12	-0.5%
BC	kt	1.56	1.57	0.01	0.6%
CO	kt	189.54	188.41	-1.14	-0.6%
Pb	t	17.43	15.02	-2.41	-13.8%
Cd	t	1.43	0.99	-0.44	-31.1%
Hg	t	0.67	0.66	-0.01	-2.2%
PCDD/PCDF	g I-TEQ	20.87	20.14	-0.73	-3.5%
PAH (total)	t	3.03	2.83	-0.20	-6.7%
HCB	kg	0.33	0.33	0.00	-0.2%

Pollutant	Units	1990			
		previous subm. 2016	latest subm. 2017	difference (abs.)	difference (rel.) previous = 100%
NO_x	kt	138.00	137.93	-0.07	-0.1%
NMVOC	kt	287.50	288.34	0.84	0.3%
SO_x	kt	39.64	39.62	-0.02	0.0%
NH_3	kt	73.22	73.20	-0.02	0.0%
PM2.5	kt	15.65	15.52	-0.12	-0.8%
PM10	kt	26.77	26.58	-0.18	-0.7%
TSP	kt	35.92	35.71	-0.22	-0.6%
BC	kt	5.02	5.01	-0.01	-0.2%
CO	kt	735.31	733.87	-1.43	-0.2%
Pb	t	346.31	346.29	-0.02	0.0%
Cd	t	3.58	3.58	0.00	0.0%
Hg	t	6.57	6.58	0.00	0.0%
PCDD/PCDF	g I-TEQ	202.85	202.55	-0.30	-0.1%
PAH (total)	t	12.49	12.01	-0.47	-3.8%
HCB	kg	172.33	172.33	0.00	0.0%

The source categories with the most important recalculations implemented for main pollutants and PM2.5 in submission 2017 in terms of absolute emissions are listed in Table 8-2 for 2014 and Table 8-3 for 1990. The two most important recalculations for each year and each pollutant are the following:

NO_x

- In 2014, the most important recalculation is in source category 1A4ci due to the recalculation of the NO_x emission factor of 1A4ci Grass drying based on air pollution control measurements and the introduction of the so far missing NO_x emission factor 1A4ci Plants for renewable waste from wood products. Furthermore, recalculations due to new available statistical data (Energy consumption statistics in the industry and services sectors SFOE 2016d) result in a decrease in emissions from 1A2c.

- In 1990, the most important recalculation is in 5C2 Open burning of waste. As a consequence of the greenhouse gas inventory UNFCC incountry review 2016 greenhouse gas emissions from open burning of natural residues in forestry (5C2ii) was moved to sector 4V. The corresponding air pollutant emissions have been moved to 11B (Natural sources, natural and man induced forest fires). Emissions in 5C2 have therefore decreased. The second most important recalculation in 1990 are the recalculations of AD of 1A2gviii Industrial boilers (gas oil, residual oil, petroleum coke and other bituminous coal) due to revised fuel mix and consumption in 1A2f Lime production and of 1A2gviii Automatic wood boilers.

NMVOC

- In 2014, the AD of 2D3b Road paving has been revised based on corrected data from the industry association. This is the most important recalculation in 2014. Additionally, several recalculations (AD, EF) in source category 1A2f have an important impact (see 3.2.3.3).
- In 1990, there is by mistake a double counting in the NMVOC emissions from 2G De-icing of airplanes for the years 1990-2006. This mistake will be corrected in submission 2018. The most important recalculation in 1990 is due to the recalculation of the NMVOC emission factor of 1A4ci Grass drying based on air pollution control measurements.

SO_x

- In 2014 and 1990, emissions from Claus units that were previously reported under 2H3 and are now reported under 1B2aiv. This leads to a recalculation at the level of these sources categories for the entire time series, but does not affect total emissions.

NH_3

- In 2014, the most important recalculations result from the implementation of new AGRAMMON survey results for 2015, which affect the interpolated data in 2014.
- In 1990, the most important recalculation is in 5C2 Open burning of waste. As a consequence of the greenhouse gas inventory UNFCC incountry review 2016 greenhouse gas emissions from open burning of natural residues in forestry (5C2ii) had to be moved to sector 4V. The corresponding air pollutant emissions have been moved to 11B (Natural sources, natural and man induced forest fires). Emissions in 5C2 have therefore decreased. The impact of all other recalculations is comparatively small.

PM2.5

- The most important recalculation in 2014 is due to the recalculation of the PM2.5 emission factor of 1A4ci Grass drying based on air pollution control measurements. In 2014, one of the most important recalculations is in 5C2 Open burning of waste. As a consequence of the greenhouse gas inventory UNFCC in-country review 2016 greenhouse gas emissions from open burning of natural residues in forestry (5C2ii) had to be moved to sector 4V. The corresponding air pollutant emissions have been moved to 11B (Natural sources, natural and man induced forest fires). Emissions in 5C2 have therefore decreased.
- In 1990, the most important recalculation is also in 5C2 Open burning of waste. As a consequence of the greenhouse gas inventory UNFCC incountry review 2016 greenhouse gas emissions from open burning of natural residues in forestry (5C2ii) had to be moved to sector 4V. The corresponding air pollutant emissions have been moved to 11B (Natural sources, natural and man induced forest fires). Emissions in 5C2 have therefore decreased. The second most important recalculation in 1990 are the recalculations of AD of 1A2gviii Industrial boilers (gas oil, residual oil, petroleum coke and other bituminous coal) due to revised fuel mix and consumption in 1A2f Lime production and of 1A2gviii Automatic wood boilers.

Table 8-2: NFR categories with most important implications of recalculations on emission levels in 2014 in terms of absolute differences for the main pollutants and PM2.5. The values refer to the NFR submission 2016 and 2017. The list is ranked for each pollutant in terms of the absolute difference in emission levels due to recalculations.

NOx		NMVOC		SOx		NH_3		$PM_{2.5}$	
	kt		kt		kt		kt		kt
1A4ci Agriculture/Forestry/Fishing : Stationary	0.030	2D3b Road paving with asphalt	0.275	2H3 Other industrial processes	-0.189	3Da2a Animal manure applied to soils	-1.037	1A4ci Agriculture/Forestry /Fishing: Stationary	0.046
1A2c Stationary combustion in manufacturing industries and construction: Chemicals	-0.029	1A2f Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.107	1B2aiv Fugitive emissions oil: Refining / storage	0.189	3B3 Manure management - Swine	-0.472	5C2 Open burning of waste	-0.044
1A2gviii Stationary combustion in manufacturing industries and construction: Other	0.024	1A4ci Agriculture/Forestry /Fishing: Stationary	0.042	1A2gviii Stationary combustion in manufacturing industries and construction: Other	-0.031	3B1a Manure management - Dairy cattle	0.242	2H2 Food and beverages industry	0.026
1A2e Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	0.017	6A Other	-0.027	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	-0.010	3B1b Manure management - Non-dairy cattle	0.187	2H1 Pulp and paper industry	0.012
1A2d Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	-0.017	2C1 Iron and steel production	0.026	1A2f Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.008	3B4gi Manure mangement - Laying hens	-0.079	1A4bi Residential: Stationary	-0.011

Table 8-3: NFR categories with most important implications of recalculations on emission levels in 1990 in terms of absolute differences for the main pollutants and PM2.5. The values refer to the NFR submission 2016 and 2017. The list is ranked for each pollutant in terms of the absolute difference in emission levels due to recalculations.

NOx		NMVOC		SOx		NH_3		$PM_{2.5}$	
	kt		kt		kt		kt		kt
5C2 Open burning of waste	-0.040	2G Other product use	0.598	2H3 Other industrial processes	-0.419	5C2 Open burning of waste	-0.02306	5C2 Open burning of waste	-0.1084
1A42gviii Stationary combustion in manufacturing industries and construction: Other	-0.025	1A4ci Agriculture/Forestry /Fishing: Stationary	0.114	1B2aiv Fugitive emissions oil: Refining / storage	0.419	2B10a Chemical industry: Other	-0.00011	1A2gviii Stationary combustion in manufacturing industries and construction: Other	-0.0070
1A1a Public electricity and heat production	-0.003	1B2av Distribution of oil products	0.090	1A2gviii Stationary combustion in manufacturing industries and construction: Other	-0.019	2C7c Other metal production	0.00003	1A3ai(i) International aviation LTO (civil)	-0.0069
1A4bi Residential: Stationary	-0.002	1A2f Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.057	1A1a Public electricity and heat production	-0.009	1A4ai Commercial/institut ional: Stationary	0.00002	1A3aii(i) Domestic aviation LTO (civil)	-0.0018
1A4ai Commercial/institutional: Stationary	0.001	1B2b Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	0.050	1A2f Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.006	3Db Indirect emissions from managed soils	-0.00001	1B1a Fugitive emission from solid fuels: Coal mining and handling	-0.0004

8.1.7 Implications of Recalculation for Emission Trends of Main Pollutants and PM2.5

The emission trends 1990–2014 are affected by less than one percent for the main pollutants except for NH_3, where the difference adds up to -1.5% (i.e. a stronger decreasing trend). The small change is positive (i.e. a slightly weaker decreasing trend) for NO_x, NMVOC and PM2.5 and negative (i.e. a slightly stronger decreasing trend) for SO_x.

Table 8-4: Recalculations: Implications for the emission trends between 1990 and 2014 for the main pollutants. The values refer to the NFR submission 2016 and 2017.

Pollutant	Trend 1990-2014 (1990 = 100%)	
	previous subm. 2016	latest subm. 2017
	%	%
NO_x	44.9	44.9
NMVOC	27.5	27.6
SO_x	20.0	19.9
NH_3	85.4	84.0
PM2.5	46.5	47.0

8.2 Planned Improvements

The following improvements are planned for the submission of 2017:

General

- A comprehensive study to asses the so-far missing PCB emissions in Switzerland is on going. The study is based on a mass balance model that tracks PCB used in transformers, capacitors, joint sealants and anti-corrosive paints through their lifecycle of import, usage and disposal. A still open point that has to be resolved by TFEIP is whether the dioxin-like, the so-called indicator or all PCB have to be reported.
- Possibilities of adding an Approach 2 uncertainty analysis and an Approach 2 KCA in subsequent submissions are currently assessed.

Energy (mobile)

- 1A2g vii: See below.
- 1A3b An error in the implied emission factors for gas-driven light duty vehicles was detected and will be corrected for the next submission.
- 1A3b The emission factors for PCDD/PCDF shall be updated to the latest version of the EMEP Guidebook.
- 1A3b A general update of 1A3b Road transportation is ongoing. The new results are expected for 2017 and are supposed to be integrated in the EMIS inventory for submission 2018 including also cadmium and mercury emissions.
- 1A2g vii, 1A3c, 1A3d, 1A4 aii/bii/cii, 1A5b: Emission factors for PAH of the latest EMEP Guidebook shall be adopted and applied for gasoline driven vehicles and machinery. The emission factors for PAH/diesel oil used so far shall be reviewed with those of EMEP Guidebook’s latest version and shall be adopted for non-road vehicles if needed. In addition, emission PCDD/PCDF shall be estimated by means of the corresponding emission factors of latest EMEP Guidebook version.

Agriculture

- 3B /3D: NMVOC emission factors will be revised in submission 2018 as recommended in the Stage 3 review. In the current submission 2017, emissions from NMVOC under 3B are set to NE instead of IE.
- 3B: NO_x emission factors in category 3B Manure management will be checked and the method will be modified appropriately in a subsequent submission as recommended in Stage 3 Review 2016.
- 3B /3D: TSP, PM2.5 and PM10 emission factors will be revised in submission 2018. A study for obtaining country-specific EFs is carried out. Either the study results or the Tier 1 EFs from the Guidebook 2013 will be used.
- 3B /3D: Update of AGRAMMON introducing other N species (N_2O, N_2, NO_x) to the N flux model and considering newest scientific findings.
- 3D: NH_3 emission factors for mineral fertilisers will be reassessed for submission 2018, and either the study results or the default EFs from Guidebook 2013 (EMEP/EEA 2013) will be implemented.

Waste

- 5B: Activity data for backyard composting is assumed to be approx. 10% of the amount of waste composted in industrial plants in the year 2007 and later. This share is not constant over time, but assumed to be approx. 3% in 1990 and 13% in 2000. These values are based on an expert judgement. It is planned for a subsequent submission to assess and verify the activity data. In the same course emission factors will be verified and completed if necessary.

9 Emission projections 2015–2030

9.1 Comments on projections

Two scenarios are presented in this chapter, "With Measures (WM)" and "With Additional Measures (WAM)". Both are based on the energy consumption of the Energy Perspectives 2050 (Prognos 2012a) and on further assumptions for the activity data. The emission projections of air pollutants in Switzerland have been fully revised in the course of submission 2014. The data for the energy sector are in accordance with the scenarios of the Energy Perspectives 2050 (Prognos 2012a) from 2020 onwards. For the sectors IPPU and Waste the latest perspectives for Switzerland's inhabitants are integrated (SFSO 2015c), and for the agricultural sector, independent scenarios were developed (FOAG 2011).

Note that all emission data for the projections refer to the "national total for compliance assessment (fuel used principle)", which deviate from the "national total for the entire territory based on fuel sold". The submitted emission projections templates 2A and 2B therefore base on the fuel sold principle, which is not congruent with the Swiss "national total for compliance".

In the IIR on hand the air pollutant emissions in chps. 9.3 to 9.6 are shown for the "With Measures (WM)" scenario only.

9.2 Assumptions for projections for two scenarios (WM and WAM)

9.2.1 Emission factors

Overall, the emission factors are determined independently from the WM and WAM scenario and thus are the same in both.

Emission factors for the sectors 1 Energy and 2 Industrial processes and product use are mainly based on available emission measurements and assumptions about their future development. Where no such assumptions can be made, the emission factors are kept constant.

Emission factors for the sector 1 Energy are taken from the following reports:

- Fuel combustion / heating systems: Internal emission database EMIS (2016, 2017)
- Road transportation: TUG (2009), FOEN (2010i), INFRAS (2010)
- Domestic aviation: EMEP/EEA (2013), FOCA (2006, 2006a, 2007a, 2008-2016)
- Non-road vehicles: FOEN (2015j), INFRAS (2015a)

Emission factors for the sector 3 Agriculture are derived from the AGRAMMON model (Agrammon 2013).

Emission factors for sector 5 Waste and sector 6 Other are taken from further various literature sources. Details about respective data sources are provided in sector chapters 9.3-9.6.

9.2.2 Activity data

9.2.2.1 Two scenarios WM and WAM

The projections of emissions of air pollutants in Switzerland have been fully revised in the course of submission 2014. In order to provide consistent scenarios for shaping future energy and climate policies, the energy scenarios of Energy Perspectives 2050 (Prognos 2012a) are used as framework for the projections presented here. Independent scenarios were developed for the agriculture sector.

For the projections of the CLRTAP Inventory requiring a scenario “With Measures (WM)” (ECE 2014a) the scenario “Politische Massnahmen (POM)” - “Political Measures” - from the Energy Perspectives 2050 (Prognos 2012a) is used. It is based on the effects of a package of measures which is currently in the political process of the Parliament. A second scenario “With Additional Measures” (WAM) is required by CLRTAP (ECE 2014a). For this purpose, the scenario “Neue Energiepolitik (NEP)” - “New Energy Policy” (NEP)” – from Prognos (2012a) is used. It accounts for the effects of additional measures compared to the “with measures (WM)” scenario.

The energy scenarios of Prognos (2012a) are all based on energy consumption data from 2010 onwards. That means that for the period 2011-2015, statistical and projected data exist. The statistical data available between 2010 and 2015 (Swiss overall energy statistics) are used to calculate the emissions as reported in the preceeding sectoral chapters. Projected data 2011-2015 in the “With Measures (WM)” scenario deviate slightly from the statistical data 2011-2015 and are not used. Data from 2016 to 2019 is linearly interpolated between statistical data 2015 and projected data 2020, and from 2020 onwards, the original projections of Prognos (2012a) are used.

Table 9-1 provides an overview of the respective sectoral background scenarios used for WM and WAM scenarios. The underlying assumptions are discussed hereinafter.

Table 9-1: Overview of sectoral underlying detailed scenarios in the WM and WAM scenario.

Sector	Scenario	Sectoral scenario	Reference
1 Energy	WM	Energy scenario "political measures", electricity generation option C&E from Energy Perspectives	Prognos (2012a)
	WAM	Energy scenario "new energy policy", electricity generation option E from Energy Perspectives	Prognos (2012a)
2 IPPU	WM = WAM	Scenario based on key parameters of the Energy Perspectives but updated with new national reference scenario for popoulation ("A-00-2015")	Prognos (2012a) SFSO (2015c)
3 Agriculture	WM	Agricultural policy 2014-2017	Swiss Confederation (2013)
	WAM	Climate strategy for agriculture	FOAG (2011)
5 Waste	WM	Scenario based on key parameters of the Energy Perspectives but updated with new national reference scenario for popoulation ("A-00-2015")	Prognos (2012a) SFSO (2015c)
	WAM	Individual scenario based on assumptions regarding use/replacement of HFCs and SF6	Prognos (2012a) SFSO (2015c)

9.2.2.2 WM Scenario

A detailed description of the WM scenario can be found in Switzerland’s 6th National Communication under the UNFCCC - therein named as “With Existing Measures (WEM)” (FOEN 2014a). The projection parameters have all been adjusted in comparison to the 5th National Communication. Table 9-2 lists the key factors underlying the WM scenario and their assumed development between 2010 and 2030. All effects of enforced and already implemented measures to improve energy efficiency and to reduce energy consumption are accounted for in this scenario. A relevant assumption used for the projections under the WM scenario is that population increases further by 12% between 2010 and 2030. This is one of the factors leading to increases in energy reference area and transport. GDP is also assumed to increase considerably over the coming decades. Finally, also oil and gas prices are expected to increase by 28% and 95% respectively until 2030.

Table 9-2: Trend of underlying key factors of the WM (WEM) scenario between 2010 and 2030 (Prognos 2012a).

Indicator	**2010**	**2020**	**2025**	**2030**	**2010-2030**
Population (million)	7.82	8.38	8.58	8.73	12%
GDP (prices 2010, billion CHF)	547	618	646	671	23%
Oil price (prices 2010, CHF/barrel)	79.3	98.3	101.3	101.7	28%
Gas price (prices 2010, CHF/tonne)	321	561	598	627	95%
Heating degree days	3585	3244	3154	3064	-15%
Cooling degree days	153	186	203	219	43%
Energy reference area (million m2)	709	799	836	863	22%
Passenger transport (billion passenger km)	114	131	137	141	24%
Passenger transport road/rail split (%)	82/18	80/20	-	78/22	-
Freigth transport (billion tonne km)	26.9	34.2	37	39.1	45%
Freigth transport road/rail split (%)	63/37	58/42	-	56/44	-

Please note that the population data for the WM (WEM) scenario do not match the official statistics which are generally used within the air pollutant (and greenhouse gas) inventory since the Energy Perspectives 2050 (Prognos 2012a) are based on a specific population growth scenario defined by the Federal Statistical Office. These specific numbers are only used for the emission projections 2015-2030 and are very similar to the official statistics. For further details, see Prognos (2012a).

For each sector further specific methods and respective assumptions apply that are described below in more detail:

Sector 1 Energy

Energy consumption in the WEM scenario is based on the scenario “political measures”, option C&E (central fossil “C” and renewable “E” electricity generation to replace nuclear power generation) of the most recent energy scenarios (Prognos 2012a). The energy scenarios are based on an aggregation of various bottom-up models. Energy demand is determined using separate models for private households, industry, transportation, services/agriculture and electricity supply (Prognos 2012a). Figure 9-1 depicts the total energy demand in recent years and as projected in the WEM scenario up to 2030 for each source category in the energy sector.

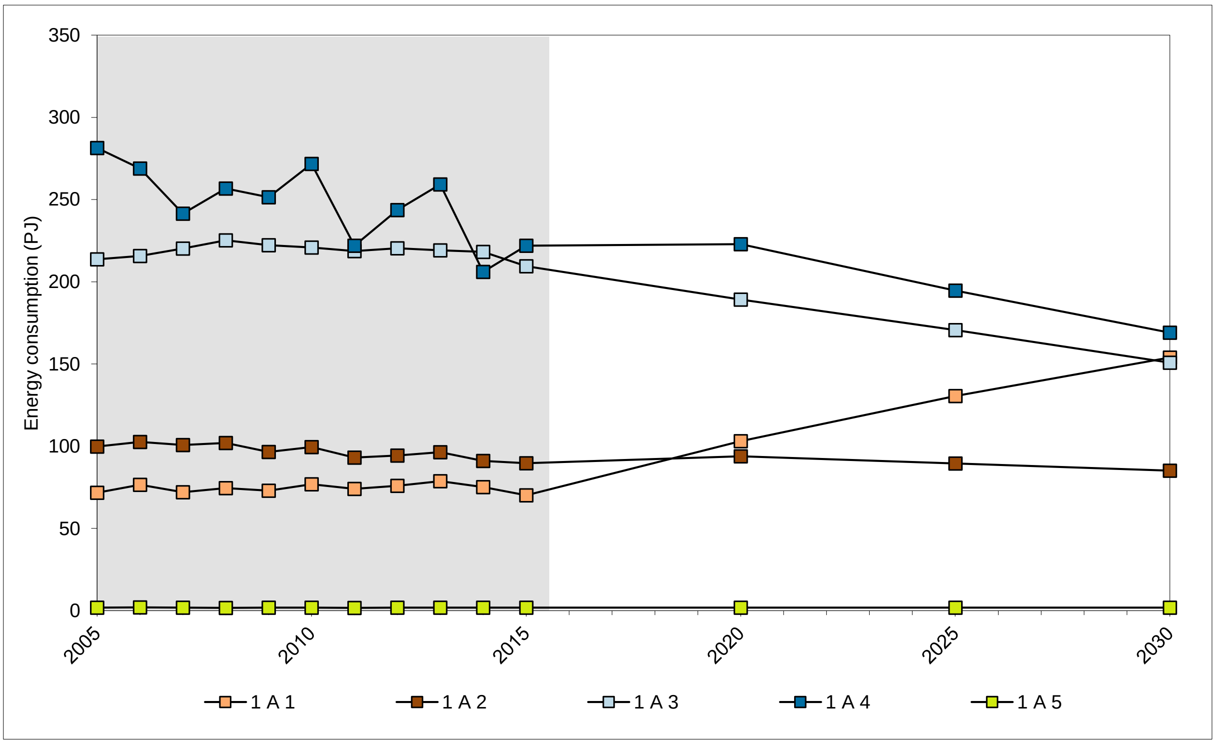

Figure 9-1: Energy demand in Switzerland as projected in the WM (WEM) scenario for 2016–2030 in the source categories 1A1 – 1A5 of the sector 1 Energy.

Energy demand in households is modelled based on energy use for heating, hot water, household appliances, lighting and other electrical equipment. The model consists of a dynamic building stock in various classes. The projection is then based on population growth, average floor space per person, average household size as well as technological developments of old and new buildings. Energy demand in industry is based on 164 industrial production processes and 64 building and facility management processes, 12 energy sources and 12 industry branches. Energy use is then projected based on activity data for the branches and specific energy use per process. For the transport sector parameters such as tonne-kilometers, passenger-kilometers, vehicle-kilometers, specific energy use, and substitution effects were determined on the basis of model estimations. Energy demand from sector 3 Agriculture is based on energy use of heating, hot water, air conditioning, lighting, office appliances, engines and other uses, split for 9 different energy sources and 7 different trades and services. Projections are then driven by gross value-creating activity, number of employees, energy reference area and technical standards. Finally, the electricity production of the existing power plant park is projected with a bottom-up approach, taking into account the life-time of the power plants.

The use of these bottom-up models allows to reproduce past developments and to derive the key drivers for particular segments of energy demand. Future energy demand is projected based on assumptions on the evolution of the key drivers. The energy demand is then assigned to the relevant categories.

The main measures and underlying assumptions in the energy scenario are:

- Building renovation program: continuation and intensification of the current program (Annual funds CHF 300 million in 2014, CHF 600 million from 2015)
- Building codes: continuously rising building standards, along with technological progress. Energy consumption for new buildings nearing zero by 2020
- CO_2 levy on fossil combustible fuels, such as gas oil and natural gas: e.g. gas oil 2016: 84 CHF/tonne.

- Overall substitution of fuel oil by natural gas continues and gasoline will also partly be substituted by diesel oil.
- CO_2 emission standards for new vehicles: 2015: 130 g/km; 2020: 95 g/km; further reduction towards 35 g/km in 2050.
- Competitive call for tender for energy efficiency measures (in particular electricity) in industry, trades and services with an annual budget of CHF 100 million from 2015.
- Continuation of the program SwissEnergy (provision of incentives for energy saving measures) with moderately increasing funds.
- Feed-in remuneration at cost for electricity production from renewable energy sources.

Source category 1A3 Transport

Activity data from transport activities are based on the same model as the one used to derive energy demand for the energy scenarios (see above). The main measures and underlying assumptions are:

- Implementation of measures such as efficiency targets set for light goods vehicles, energy efficiency labelling, as well as economic incentives for low-emission vehicles.
- Road transportation: Projections of the mileage by vehicle categories are given by the Swiss Federal Office of Statistics are represented in FOEN (2010i) and updated with projections by Prognos (2012a). The projections of the fuel consumption factors are based on the expected development of the vehicle fleets (INFRAS 2010).
- Non-road vehicles: Projections of vehicle fleets, operating hours and expected fuel consumption (see Annex A2.1.2) serve as input for projecting the fuel consumption of non-road vehicles (FOEN 2015j, INFRAS 2015a).

Sector 2 Industrial processes and product use

Activity data of sector 2 Industrial processes and product use are inferred from the sectoral production data that were used in the Energy Perspectives 2050 (Prognos 2012a). In particular, sectoral indices of production volumes of cement (2A1 Cement production, 2A2 Lime production and 2A4 Other - plaster production), food (all 2H2 source categories except 2H2 Bread production), metals (2C1 Iron and steel production and 2C5e Non-ferrous metal foundries) and so-called other (2H1 Chipboard and fibreboard production) have been used. For other processes, such as production of basic chemicals of source category 2B Chemical industry, the provided increasing production index scenario is not consistent with the more or less stable production volumes of the past twenty years. Therefore, constant activity data at the level of the recent years have been assumed for these source categories. Furthermore, a few activity data are only scaled with population growth or production volume indices (Prognos 2012a). However, the Energy Perspectives 2050 provide no appropriate key parameters or measures for the majority of source categories and therefore, the estimates based on information from industry, industry associations or expert judgement are continuously applied.

The main measure is:

- All indices of production volume applied in sector 2 Industrial processes and product use will decrease by about 10% to 50% between 2010 and 2050, based on the assumptions for industrial production used in the energy perspectives 2050 (Prognos 2012a). For the indices of metal and food industry still a slight increase is projected until 2020. Afterwards they decline.

Sector 3 Agriculture

The WM (WEM) scenario is based on the latest decision of the Federal Parliament on the agricultural policy 2014-2017 (Swiss Confederation 2013). Models for the sector provide projected activity data, e.g. livestock numbers, crop production parameters and fertilizer use. Most production parameters and emission factors are kept constant as in 2015. Particularly crop yield data can show considerable year-to-year variability and consequently a single year reference value for the projections (e.g. 2011) would lead to rather unrealistic developments. The main measures and underlying assumptions are:

- Livestock populations: Direct payments will be decoupled to a certain degree from cropping area and particularly from the quantity of animals living on the farms reducing incentives for intensification that would lead to negative environmental impacts (Swiss Confederation 2009). Consequently, the animal population numbers are more directly dependent on price levels and are projected to decline. Beyond 2020 (the time horizon of Zimmermann et al. 2011) constant population numbers have been assumed for all animal categories due to the lack of further projections.
- Manure management: the shares of manure excreted on pasture, range and paddock as well as the shares of the individual manure management systems cannot be predicted satisfactorily and are thus left constant as in 2015.
- Crop cultures: Important aspects of the further development of direct payments that influence the development of the crop cultures are an improved targeting of direct payments, particularly for the promotion of common goods and the securing of a socially acceptable development (Swiss Confederation 2009, FOAG 2011). Overall, agricultural area is projected to slightly decrease while arable land is slightly increasing. Beyond 2020, constant yields and areas have been assumed due to the lack of further projections.
- Fertilizers and fertilizer management: Use of commercial fertilizers is projected to further decrease until 2020 according to Zimmermann et al. (2011). Beyond 2020, constant fertilizer use has been assumed due to the lack of further projections.

Sector 5 Waste

Waste generation is assumed to remain at the current levels per capita. However, in agreement with the energy scenarios, digestion of organic waste is increasing according to the use of biogas and sewage gas in the energy scenarios. Landfilling of combustible waste is prohibited in Switzerland, and it is assumed that this will also be the case in the future.

9.2.2.3 WAM Scenario

Beside the WM (WEM) scenario an additional scenario called “with additional measures” (WAM) was developed in the energy scenarios by Prognos (2012a). The scenario is a long-term target scenario that follows the strategic orientation in key policy areas (FOEN 2014a, FOAG 2011). However, the scenario is not based on concrete policies and measures but rather assumes that policies and measures are developed and implemented in due time in order to reach the strategic goals.

The following assumptions are made in the WAM scenario:

- Energy consumption for the WAM scenario is based on the scenario “New Energy Policy”, option E of the latest energy scenarios (Prognos 2012a). This scenario assumes that efforts are made to curb GHG emissions (1-1.5 t CO_2 per capita in 2050) and thus also air pollutant emissions are affected. Overall, the scenario relies on substantial energy efficiency gains in all sectors. When compared to the WM (WEM) scenario, differences in the WAM scenario mainly occur due to efficiency improvements. Figure 9-2 depicts the total energy demand in recent years and as projected in the WAM scenario up to 2030 for each source category in the energy sector.

- Transport requirements are projected to increase more moderately compared to the WM (WEM) scenario, reaching just over 125 billion passenger kilometres in 2020 and approximately 135 billion passenger kilometres in 2030 (Prognos 2012a).
- Assumptions for emissions from sector 2 Industrial processes and product use are the same as in the WM (WEM) scenario.
- The WAM scenario in sector 3 Agriculture is consistent with the long-term target in this sector as stated in the Climate Strategy (FOAG 2011). Up to 2020, emissions follow the same course as in the WM (WEM) scenario. After 2020, it is assumed that the activity data will be more strongly reduced as in the WM (WEM) scenario. The same projections for most parameters are used as in the WM (WEM) scenario, except for livestock populations where a clear decrease after 2020 is expected to halve the stocks by 2050 compared to 1990.
- Finally, the projections in the waste sector for the WAM scenario are the same as for the WM (WEM) scenario. No specific additional policies and measures are currently under consideration.

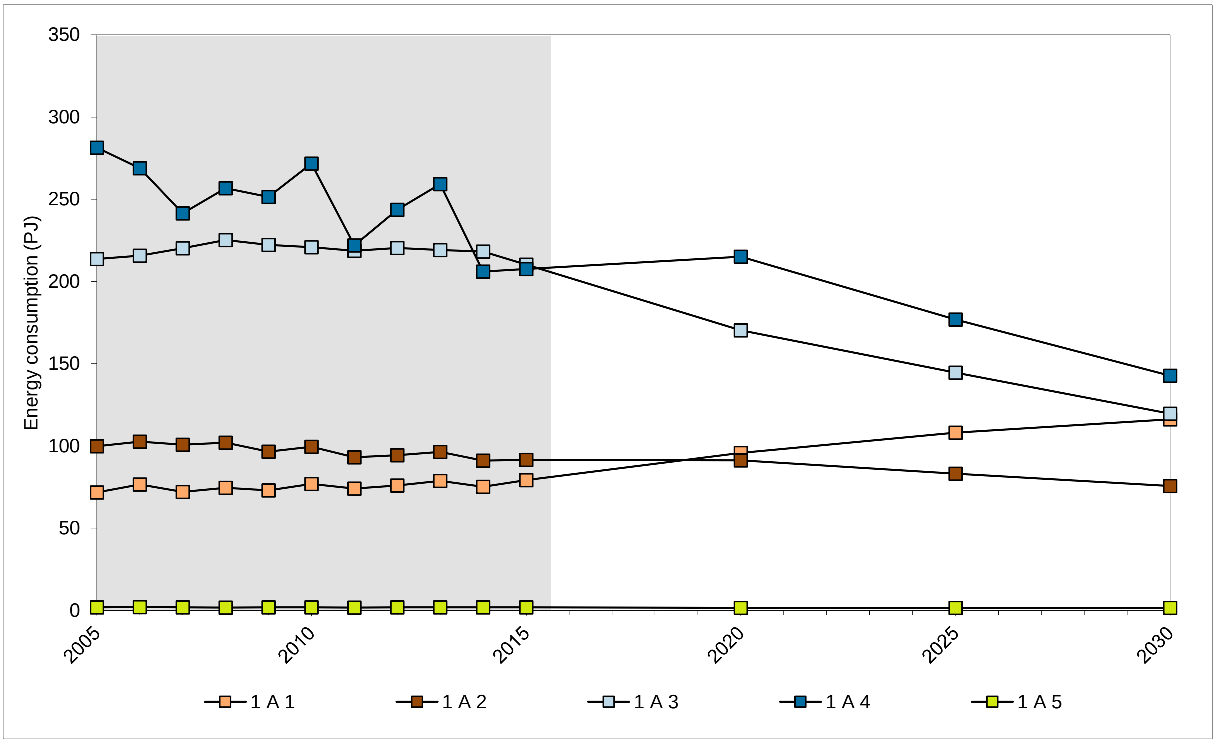

Figure 9-2: Energy demand in Switzerland as projected in the WAM scenario for 2016–2030 in source categories 1A1 – 1A5 of sector 1 Energy.

9.3 Main pollutants and CO for the WM scenario

Overall projections of the emissions for NO_x, SO_x and CO indicate a continuous decline until 2030 (Figure 9-3). However, the reduction of these emissions is expected to become less pronounced after the year 2020, as possible additional abatement measures are not yet identified. The projection for SO_x is rather uncertain because it is sensitively dependent on the consumption of coal, which might increase with rising fuel prices for gas oil and natural gas. The decline in NMVOC emissions is less pronounced than for NO_x, SO_x and CO. In contrast to the other main pollutants, NH_3 emissions have only slightly decreased since 2005 and within the WM (WEM) scenario, no further relevant decline is expected up to 2030.

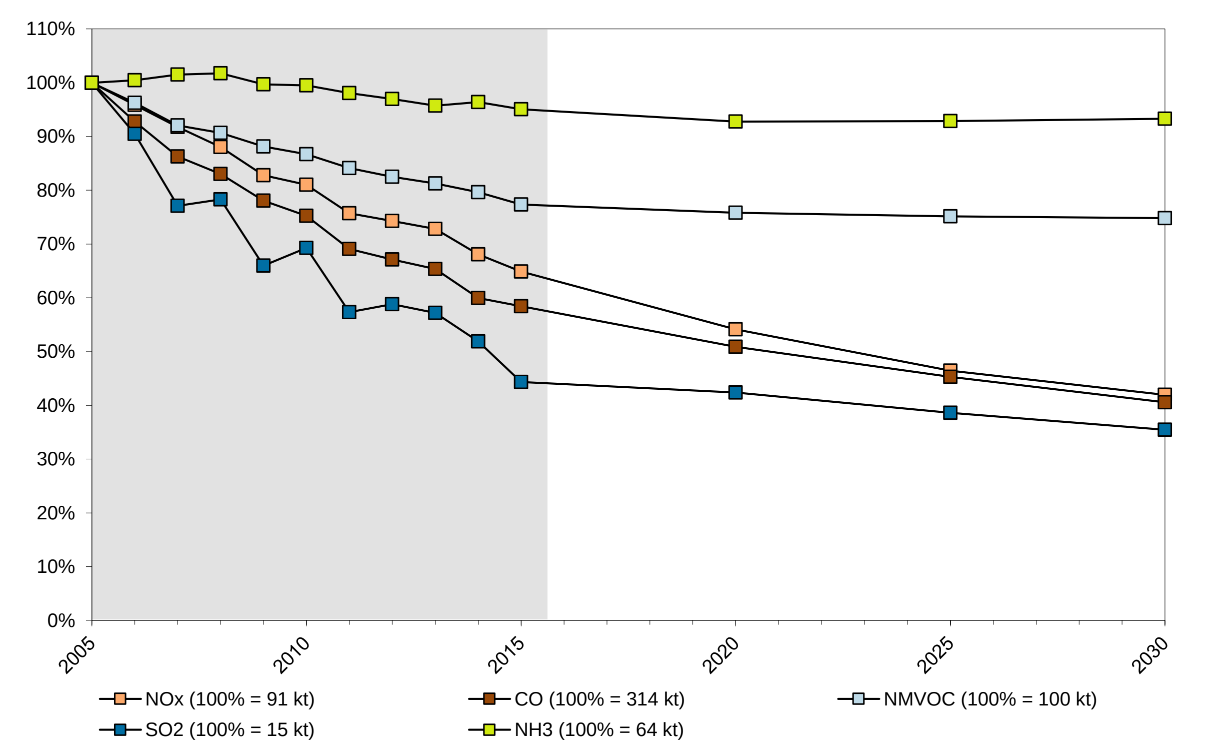

Figure 9-3: Relative trends for the total emissions of main air pollutants in Switzerland as projected in the WM (WEM) scenario for 2016–2030. 100% corresponds to the 2005 levels (base year).

Table 9-3: Main air pollutants: Total emissions of the WM (WEM) projections until 2030 in kt.

Year	NO_x	NMVOC	SO_2	NH_3	CO
	kt	kt	kt	kt	kt
2005	91.05	99.79	15.21	63.77	314.13
2010	73.77	86.51	10.54	63.44	236.31
2011	68.95	83.95	8.72	62.53	217.05
2012	67.62	82.34	8.95	61.83	210.92
2013	66.29	81.08	8.70	61.04	205.23
2014	61.98	79.47	7.90	61.47	188.41
2015	59.06	77.17	6.75	60.63	183.56
2016	57.20	76.85	6.70	59.93	178.77
2017	55.30	76.54	6.64	59.73	174.00
2018	53.34	76.23	6.58	59.42	169.26
2019	51.33	75.93	6.51	59.49	164.55
2020	49.27	75.64	6.44	59.15	159.85
2025	42.30	74.98	5.87	59.22	142.28
2030	38.18	74.64	5.39	59.48	127.38
2015 to 2030 (%)	-35%	-3%	-20%	-2%	-31%

9.3.1 Projections for NO_x

The decreasing trend for NO_x emissions attributed to the WM (WEM) scenario is expected to continue until 2030 (see Table 9-4). While in most sectors, only a modest decrease is projected, significant reductions happen in sector 1A Fuel combustion. These reductions are expected to be achieved by improved emission abatement technology and by improved in-use compliance under real driving conditions for road vehicles (triggered by the Euro 6/VI standards) as well as by measures related to domestic and commercial heating such as better insulation of buildings, higher share of solar heating and heat pumps or increased use of eco-friendly (low-emission) fuel oil. Emissions in sector 2 Industrial processes and product use peaks in the period 2015-2020 and are then projected to slightly increase until 2030 compared to the base year. Emissions in sector 3 Agriculture are expected to decrease until 2020. A continuous increase in emissions is expected in sector 5 Waste compared to 2005. However, in absolute terms these trends have minimal impact on total emissions. For sector 6 Other only a slight emission decrease is expected.

Table 9-4: WM (WEM) projections: Relative trends of NO_x emissions per sector (2005 represents 100%).

NO_x emissions	2005	2015	2020	2025	2030
	kt	%			
1 Energy	87.20	63%	52%	44%	39%
1A Fuel combustion	87.02	63%	52%	44%	40%
1A1 Energy industries	3.00	89%	164%	201%	224%
1A2 Manufacturing industries and constr.	14.83	66%	50%	44%	41%
1A3 Transport	52.43	60%	44%	33%	28%
1A4 Other sectors	16.32	66%	59%	50%	43%
1A5 Other (Military)	0.44	75%	65%	60%	57%
1B Fugitive emissions from fuels	0.18	17%	26%	24%	20%
2 IPPU	0.28	109%	119%	115%	110%
3 Agriculture	3.15	96%	94%	93%	93%
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.35	109%	112%	117%	122%
6 Other	0.08	109%	107%	108%	108%
National total	91.05	65%	54%	46%	42%

9.3.2 Projections for NMVOC

The decreasing trend of NMVOC emissions is expected to continue for the next years (see Table 9-5), the bulk of emission reductions have been achieved until 2015 and further, minor reductions are expected between 2015 and 2030. Overall, NMVOC emission reductions mainly occur in 1A Fuel combustion (1A3 Transport and 1A4 Other sectors). These will be accomplished by improved emission abatement technology for road vehicles. Furthermore, some NMVOC emission reductions in sector 2 IPPU can be attributed to additional requirements of the ordinance on the VOC incentive tax (Swiss Confederation 1997). On the other hand, the population growth leads to increasing NMVOC emissions and therefore the projections remain roughly at the same level as in 2015.

Table 9-5: WM (WEM) projections: Relative trends of NMVOC emissions per sector (2005 represents 100%).

NMVOC emissions	**2005**	**2015**	**2020**	**2025**	**2030**
	kt	%			
1 Energy	41.85	53%	47%	41%	35%
1A Fuel combustion	35.82	51%	43%	37%	32%
1A1 Energy industries	0.24	70%	99%	111%	118%
1A2 Manufacturing industries and constr.	1.99	52%	43%	39%	36%
1A3 Transport	23.79	51%	42%	36%	31%
1A4 Other sectors	9.68	49%	45%	38%	33%
1A5 Other (Military)	0.11	66%	62%	60%	58%
1B Fugitive emissions from fuels	6.03	62%	70%	62%	55%
2 IPPU	52.05	94%	93%	94%	94%
3 Agriculture	3.96	98%	97%	97%	97%
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	1.80	134%	198%	290%	382%
6 Other	0.12	90%	90%	90%	90%
National total	99.79	77%	76%	75%	75%

9.3.3 Projections for SO_x

The projection of SO_x emissions is rather uncertain because it is sensitively dependent on the consumption of coal, which might increase with rising fuel prices for gasoil or natural gas. At the moment, the decreasing trend of SO_x emissions is expected to continue for the next years (see Table 9-6). This is mainly due to the rather distinctive reduction in 1A Fuel combustion (particularly small combustion in sector 1A4). This is a result of increased use of eco fuel oil with lower sulphur contents. Finally, reductions might occur along with the provisions of the new CO_2 law and respective regulations. Only marginal emission reductions or stable levels are projected for all source categories.

Table 9-6: WM (WEM) projections: Relative trends of SO_x emissions per sector (2005 represents 100%).

SO_x emissions	**2005**	**2015**	**2020**	**2025**	**2030**
	kt	%			
1 Energy	14.05	43%	41%	36%	33%
1A Fuel combustion	13.60	43%	40%	36%	33%
1A1 Energy industries	1.82	46%	96%	102%	104%
1A2 Manufacturing industries and constr.	4.33	51%	46%	40%	35%
1A3 Transport	0.21	112%	108%	109%	110%
1A4 Other sectors	7.21	35%	20%	15%	11%
1A5 Other (Military)	0.04	96%	96%	96%	95%
1B Fugitive emissions from fuels	0.45	34%	53%	47%	41%
2 IPPU	1.07	60%	59%	59%	59%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.08	120%	112%	117%	122%
6 Other	0.01	98%	98%	98%	98%
National total	15.21	44%	42%	39%	35%

9.3.4 Projections for NH_3

The emission projections for the sector 3 Agriculture up to 2030 are based on Swiss modelling studies covering the expected development of livestock numbers under specified economic and regulatory conditions (Peter at al. 2010, Zimmermann et al. 2011). Projections are calculated with unchanged emission factors (except for dairy cattle, see chapter 9.2) resulting for different livestock categories on the basis of the detailed farm survey carried out in 2010 (see chapter 5.2.2). This is a conservative approach that does not include any further changes in housing systems and manure management techniques. Emission factors on the aggregated reporting level may change slightly due to changes in the projected animal numbers on lower disaggregated levels, as for example in the source category "3B3 Swine" consisting of animal categories piglets, fattening pig, dry sows, nursing sows, boars with constant emission factors each. Nonetheless, changes are expected to occur due to the further application of existing programs with incentives to introduce low-emission techniques. A small decrease in emissions is also expected due to decreasing livestock numbers. A high share of emission reductions are expected to be accomplished in the near future, for instance under the agricultural policy 2014-2017 (Swiss Confederation 2013), whereas reductions after that will not be as high. Ammonia emissions from non-agricultural sectors show decreasing trends for sectors 1 Energy (due to new low emission vehicles and machinery), 2 Industrial processes and product use and 6 Other. An increase compared to 2005 level is expected to occur in sector 5 Waste due to a growing population.

Table 9-7: WM (WEM) projections: Relative trends of NH_3 emissions per sector (2005 represents 100%).

NH_3 emissions	**2005**	**2015**	**2020**	**2025**	**2030**
	kt	%			
1 Energy	3.89	59%	51%	49%	48%
1A Fuel combustion	3.89	59%	51%	49%	48%
1A1 Energy industries	0.03	150%	383%	530%	617%
1A2 Manufacturing industries and constr.	0.19	123%	81%	75%	68%
1A3 Transport	3.56	53%	45%	42%	41%
1A4 Other sectors	0.12	101%	103%	102%	99%
1A5 Other (Military)	0.00	106%	104%	103%	103%
1B Fugitive emissions from fuels	NA	NA	NA	NA	NA
2 IPPU	0.35	47%	51%	44%	37%
3 Agriculture	57.99	97%	95%	95%	95%
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.68	100%	127%	173%	222%
6 Other	0.86	121%	119%	122%	123%
National total	63.77	95%	93%	93%	93%

9.3.5 Projections for CO

For the next years, a continuous decreasing trend for total CO emissions is projected (see Figure 9-4 and Table 9-8). Similar to NO_x emissions, this reduction should be achieved by improved emission abatement technology for road vehicles (triggered by the Euro 6/VI standards) and for domestic and commercial heating such as better insulation of buildings, higher share of solar heating and heat pumps or increased use of eco-friendly fuel oil. Accordingly, the bulk of emission reductions occur in 1A Fuel combustion, particularly in 1A3 Transport as well as in in source category 1A4 Small combustion. An increase in emissions can be observed in 1A1 Energy industries. In all other sectors slight reductions occur.

Table 9-8: WM (WEM) projections: Relative trends of CO emissions per sector (2005 represents 100%).

CO emissions	**2005**	**2015**	**2020**	**2025**	**2030**
	kt	%			
1 Energy	303.50	58%	50%	44%	39%
1A Fuel combustion	303.46	58%	50%	44%	39%
1A1 Energy industries	1.20	84%	217%	288%	327%
1A2 Manufacturing industries and constr.	20.73	73%	56%	50%	45%
1A3 Transport	179.19	53%	43%	37%	33%
1A4 Other sectors	100.71	62%	59%	52%	46%
1A5 Other (Military)	1.63	92%	91%	90%	89%
1B Fugitive emissions from fuels	0.04	17%	27%	25%	22%
2 IPPU	7.64	73%	73%	72%	70%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	2.24	89%	85%	83%	80%
6 Other	0.76	90%	90%	90%	90%
National total	314.13	58%	51%	45%	41%

9.4 Suspended particulate matter

Projected trends for suspended particulate matter PM2.5, PM10, TSP and BC show a decline between 2015 and 2030 (see Figure 9-4 and Table 9-9). The decline can be explained by two main measures. On one hand, the tightening of emission standards for diesel engine vehicles that will prescribe lower limit values. On the other hand, emission limit values for particle emissions of (wood) combustion installations are tightened as well, so that emissions of fuel combustion particles will decrease. A considerable amount of particle emissions stems from road traffic abrasion and re-suspension processes. They are not subject to reduction and are expected to increase with increasing activity.

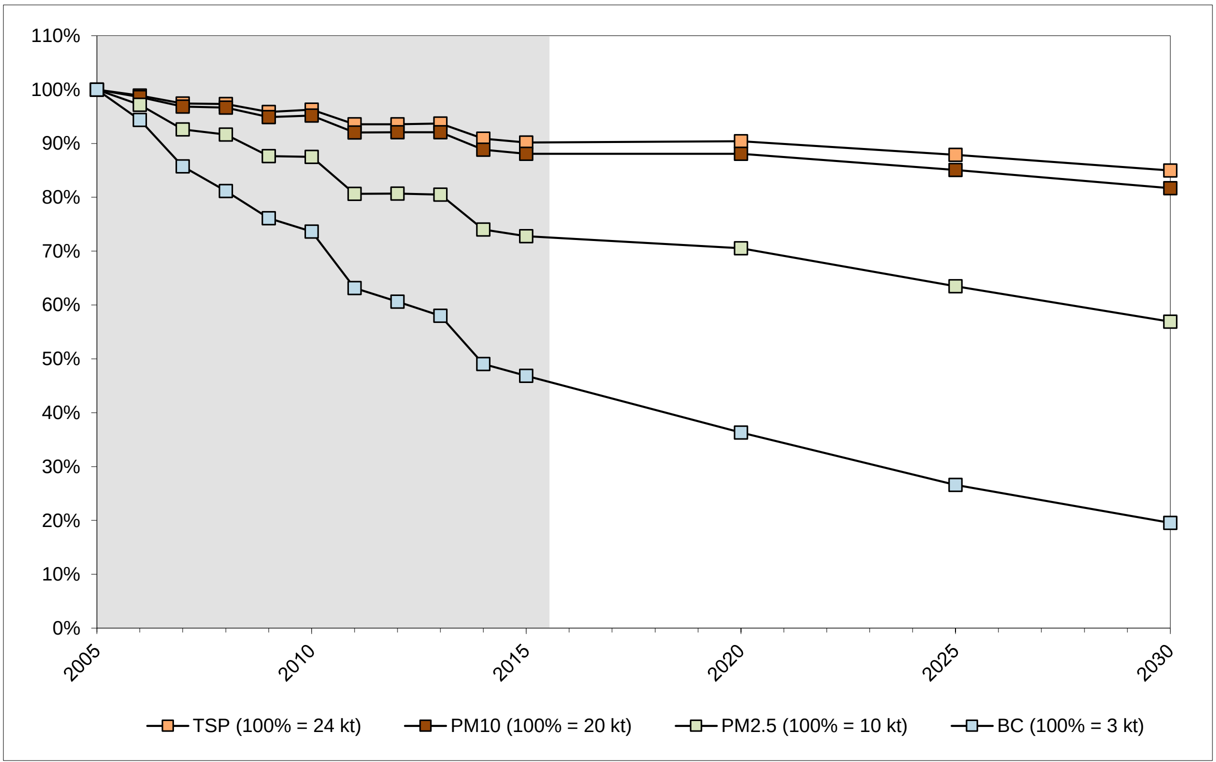

Figure 9-4: Projection of total emissions of suspended particulate matter TSP, PM10, PM2.5 and BC in Switzerland 2016-2030 of the WM (WEM) scenario (in percentage of 2005). The figure shows the sum of exhaust and non-exhaust particles.

Table 9-9: Projected total emissions of the WEM scenario concerning particulate matter 2005–2030 in kt.

Year	PM2.5	PM10	TSP	BC
	kt	kt	kt	kt
2005	9.86	19.72	23.81	3.20
2010	8.63	18.76	22.92	2.36
2011	7.95	18.14	22.27	2.02
2012	7.95	18.15	22.27	1.94
2013	7.93	18.15	22.30	1.86
2014	7.30	17.51	21.64	1.57
2015	7.17	17.36	21.46	1.50
2016	7.13	17.33	21.44	1.43
2017	7.10	17.36	21.48	1.36
2018	7.05	17.34	21.48	1.29
2019	7.01	17.39	21.54	1.23
2020	6.95	17.37	21.53	1.16
2025	6.25	16.77	20.92	0.85
2030	5.61	16.10	20.22	0.63
2015 to 2030 (%)	-22%	-7%	-6%	-58%

9.4.1 Projections for PM2.5

The decreasing trend of emissions from PM2.5 is expected to continue (see Figure 9-4 and Table 9-10). The largest reductions are expected to occur in 1A Fuel combustion, particularly in 1A3 Transport and in small combustions in source category 1A4. There are two main arguments that can back these expectations: The Euro VI standard and a limit value for particle number emissions for construction machinery will diminish future emissions, and wood-fired installations must comply with stricter air pollution control requirements from 2007 onwards.

Table 9-10: WM (WEM) projections: Relative trends of PM2.5 emissions per sector (2005 represents 100%).

PM2.5 emissions	2005	2015	2020	2025	2030
	kt	%			
1 Energy	7.82	67%	63%	55%	47%
1A Fuel combustion	7.82	67%	63%	55%	47%
1A1 Energy industries	0.14	82%	186%	221%	230%
1A2 Manufacturing industries and constr.	1.44	59%	55%	49%	44%
1A3 Transport	2.19	60%	48%	40%	37%
1A4 Other sectors	3.99	73%	69%	58%	47%
1A5 Other (Military)	0.06	82%	78%	78%	78%
1B Fugitive emissions from fuels	0.0001	95%	100%	89%	80%
2 IPPU	1.32	94%	104%	102%	99%
3 Agriculture	0.34	106%	106%	109%	109%
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.38	88%	78%	72%	67%
6 Other	0.00	97%	96%	97%	97%
National total	9.86	73%	71%	63%	57%

9.4.3 Projections for TSP

The decreasing trend of emissions from TSP is expected to continue (see Figure 9-4 and Table 9-11). The largest reductions are expected to occur in 1A Fuel combustion particularly in 1A3 and 1A4. The decline can be explained by two main measures. On one hand, the tightening of emission standards for diesel engine vehicles that will prescribe lower limit values. On the other hand, emission limit values for particle emissions of (wood) combustion installations are tightened as well, so that emissions of fuel combustion particles will decrease.

Table 9-11: WM (WEM) projections: Relative trends of TSP emissions per sector (2005 represents 100%).

TSP emissions	**2005**	**2015**	**2020**	**2025**	**2030**
	kt	%			
1 Energy	17.31	86%	85%	82%	78%
1A Fuel combustion	17.31	86%	85%	82%	78%
1A1 Energy industries	0.16	80%	184%	216%	223%
1A2 Manufacturing industries and constr.	4.37	90%	91%	91%	90%
1A3 Transport	5.62	90%	88%	86%	84%
1A4 Other sectors	6.75	80%	76%	68%	60%
1A5 Other (Military)	0.40	101%	100%	100%	100%
1B Fugitive emissions from fuels	0.0017	95%	100%	89%	80%
2 IPPU	3.49	100%	108%	108%	106%
3 Agriculture	2.26	106%	106%	109%	109%
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.51	88%	78%	72%	66%
6 Other	0.23	91%	91%	91%	91%
National total	23.81	90%	90%	88%	85%

9.4.4 Projections for BC

The decreasing trend of emissions from PM2.5 is also reflected in the trends of BC emissions and is even more pronounced since the reduction measure mainly focus on combustion particles which largely consists of BC (see Figure 9-4 and Table 9-12). The largest reductions are expected to occur in 1A Fuel combustion, and particularly in 1A3 Transport and in small combustions in source category 1A4. There are the same arguments that can back these expectations as for PM2.5: The Euro VI standard will diminish future emissions, and wood-fired installations must comply with stricter air pollution control requirements from 2007 onwards.

Table 9-12: WM (WEM) projections: Relative trends of BC emissions per sector (2005 represents 100%).

BC emissions	2005	2015	2020	2025	2030
	kt		%		
1 Energy	3.17	46%	36%	26%	19%
1A Fuel combustion	3.17	46%	36%	26%	19%
1A1 Energy industries	0.01	72%	162%	181%	183%
1A2 Manufacturing industries and constr.	0.27	25%	18%	12%	9%
1A3 Transport	1.13	36%	17%	10%	8%
1A4 Other sectors	1.76	57%	51%	38%	27%
1A5 Other (Military)	0.01	33%	24%	23%	23%
1B Fugitive emissions from fuels	0.0000	95%	100%	89%	80%
2 IPPU	0.002	31%	31%	30%	29%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.03	88%	78%	73%	67%
6 Other	0.0001	91%	91%	91%	91%
National total	3.20	47%	36%	27%	20%

9.5 Priority heavy metals

Projected emission trends for priority heavy metals Pb, Cd and Hg are shown in Figure 9-5 and Table 9-13. While Pb and Hg are projected to further decrease between 2015 and 2030, Cd is considered to increase in this period.

The increase of Cd emissions is related to a huge predicted increase of wood consumption mainly for electricity production.

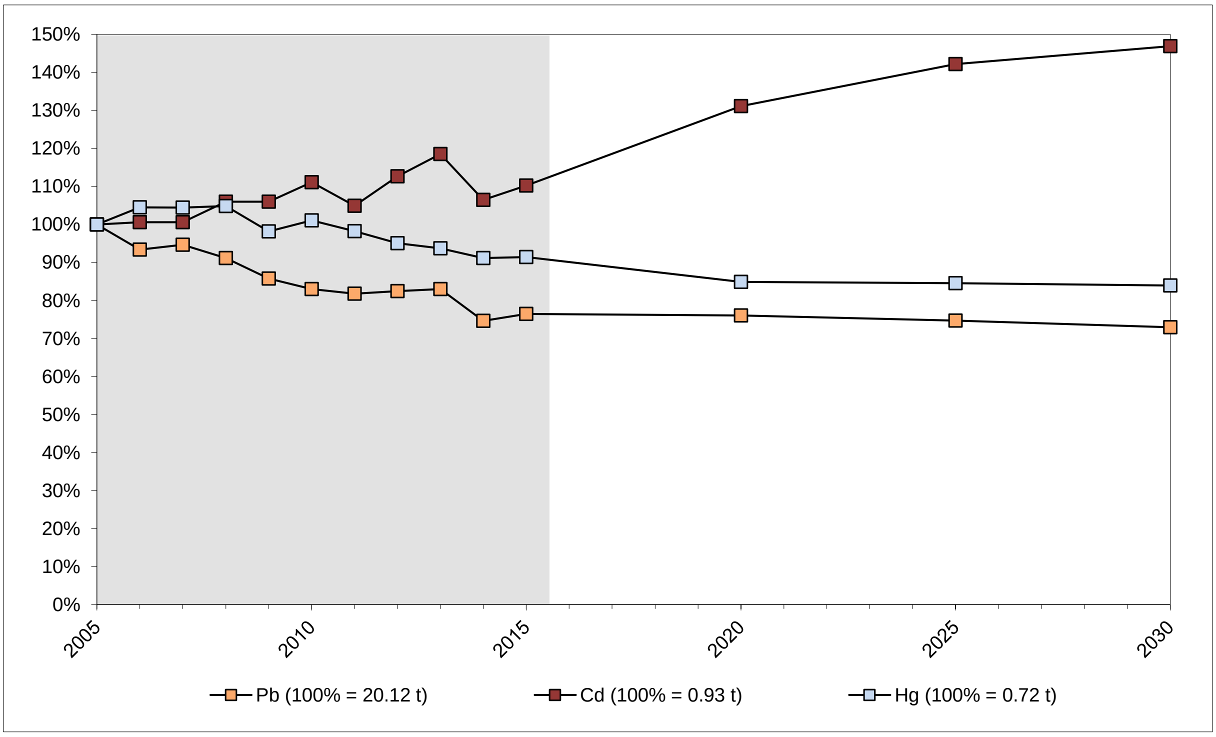

Figure 9-5: Projected emissions of priority heavy metals in Switzerland 2016-2030 of the WM (WEM) scenario (in percentage of 2005 level).

Table 9-13: WM (WEM) projected total emissions of priority heavy metal 2005-2030 in tonnes.

Year	Pb	Cd	Hg
	t	t	t
2005	20.12	0.93	0.72
2010	16.70	1.03	0.73
2011	16.45	0.97	0.71
2012	16.60	1.05	0.69
2013	16.71	1.10	0.68
2014	15.02	0.99	0.66
2015	15.38	1.02	0.66
2016	15.36	1.06	0.65
2017	15.35	1.10	0.64
2018	15.33	1.14	0.63
2019	15.32	1.18	0.62
2020	15.31	1.22	0.61
2025	15.04	1.32	0.61
2030	14.69	1.36	0.61
2015 to 2030 (%)	-5%	33%	-8%

9.5.1 Projections for lead (Pb)

The annual national total of lead emissions will presumably decrease until 2030 (see Table 9-14 and Figure 9-5). In absolute terms, only one minor increase might occur in source category 1A1 Energy industries, while some distinctive emissions reductions can be expected in sectors 1A Fuel combustion, 2 Industrial processes and product use and 5 Waste. The projection for the major source 6A4 Fire damage estates and motor vehicles assumes that emission factor and activity data remain constant until 2030.

Table 9-14: WM (WEM) projections: Relative trends of Pb emissions 2005-2030 sorted by sectors.

Pb emissions	2005	2015	2020	2025	2030
	t	%			
1 Energy	9.18	72%	74%	72%	70%
1A Fuel combustion	9.18	72%	74%	72%	70%
1A1 Energy industries	1.68	83%	106%	121%	130%
1A2 Manufacturing industries and constr.	2.06	40%	44%	43%	41%
1A3 Transport	4.38	75%	69%	62%	55%
1A4 Other sectors	1.05	102%	100%	97%	93%
1A5 Other (Military)	0.00	100%	100%	100%	100%
1B Fugitive emissions from fuels	NO	NO	NO	NO	NO
2 IPPU	2.10	33%	35%	34%	34%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	2.28	90%	78%	72%	65%
6 Other	6.57	92%	92%	92%	92%
National total	20.12	76%	76%	75%	73%

9.5.2 Projections for cadmium (Cd)

Cadmium emissions are expected to increase (see Table 9-15 and Figure 9-5). Responsible for the large increase in cadmium emissions are the predicted increase of wood consumption mainly for electricity production (1A1) (Prognos 2012a).

Table 9-15: WM (WEM) projections: Relative trends of Cd emissions 2005-2030 sorted by sectors.

Cd emissions	2005	2015	2020	2025	2030
	t		%		
1 Energy	0.73	114%	140%	155%	161%
1A Fuel combustion	0.73	114%	140%	155%	161%
1A1 Energy industries	0.18	129%	219%	275%	308%
1A2 Manufacturing industries and constr.	0.14	109%	111%	112%	112%
1A3 Transport	0.08	109%	115%	118%	118%
1A4 Other sectors	0.32	108%	115%	114%	108%
1A5 Other (Military)	NA	NA	NA	NA	NA
1B Fugitive emissions from fuels	NA	NA	NA	NA	NA
2 IPPU	0.02	127%	135%	133%	132%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.01	119%	104%	106%	107%
6 Other	0.16	92%	92%	92%	92%
National total	0.93	110%	131%	142%	147%

9.5.3 Projections for mercury (Hg)

Overall, the annual national total of mercury emissions is expected to be reduced until 2030 (see Table 9-16 and Figure 9-5). Emissions from sector 1 Energy and sector 2 Industrial processes and product use are expected to reach a maximum around 2020 and will then start to decrease slightly. An exception is category 1A1, the main source for Hg emissions, which is increasing at a constant rate due to an expected increase in the amount of waste incinerated. Sectors 5 Waste and 6 Other are on low levels, waste decreasing significantly, while Others (Fire damages) are expected to remain constant.

Table 9-16: WM (WEM) projections: Relative trends of Hg emissions 2005-2030 sorted by sectors.

Hg emissions	2005	2015	2020	2025	2030
	t		%		
1 Energy	0.51	94%	89%	90%	89%
1A Fuel combustion	0.51	94%	89%	90%	89%
1A1 Energy industries	0.34	84%	89%	94%	98%
1A2 Manufacturing industries and constr.	0.12	130%	93%	85%	77%
1A3 Transport	0.00	71%	71%	71%	71%
1A4 Other sectors	0.05	87%	80%	71%	63%
1A5 Other (Military)	NA	NA	NA	NA	NA
1B Fugitive emissions from fuels	NA	NA	NA	NA	NA
2 IPPU	0.07	125%	106%	102%	98%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.07	39%	27%	26%	25%
6 Other	0.08	90%	90%	90%	90%
National total	0.72	91%	85%	85%	84%

9.6 Persistent organic pollutants (POPs)

Figure 9-6 shows projected emission trends for persistent organic pollutants (POP). More detailed figures on projections are given in Table 9-17. PCDD/PCDF, PAH and HCB emissions are expected to decrease until 2030.

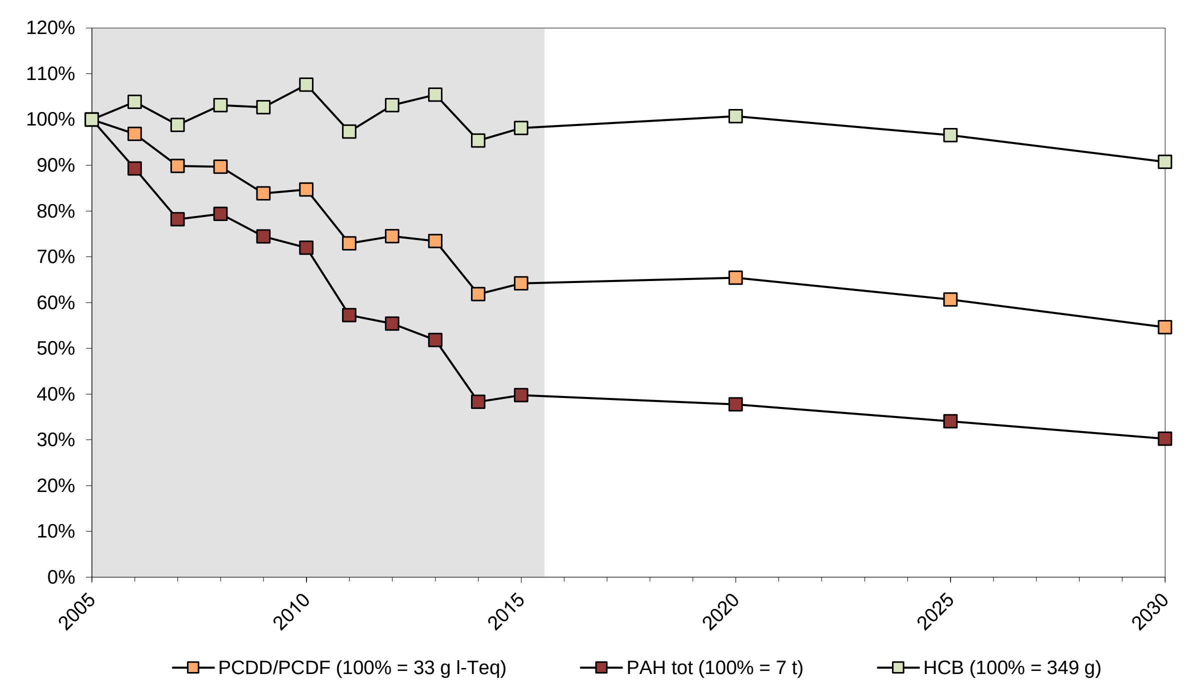

Figure 9-6: Emissions of POPs: PCDD/PCDF, PAH as the sum of benzo(a)pyrene), benzo(b)fluoranthene, benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, furthermore HCB in Switzerland 2005-2030 of the WM (WEM) scenario (in percent of 2005).

Table 9-17: Projected total emissions of POPs 2005–2030. Please take note of different units.

Year	PCDD/PCDF	BaP	BbF	BkF	IcdP	PAH tot	HCB
	g I-Teq	t	t	t	t	t	kg
2005	32.6	2.34	2.39	1.28	1.38	7.38	0.35
2010	27.6	1.72	1.69	0.90	1.01	5.31	0.38
2011	23.8	1.35	1.34	0.74	0.80	4.23	0.34
2012	24.3	1.29	1.29	0.74	0.77	4.09	0.36
2013	23.9	1.19	1.20	0.72	0.71	3.83	0.37
2014	20.1	0.85	0.89	0.57	0.51	2.83	0.33
2015	20.9	0.89	0.92	0.60	0.53	2.94	0.34
2016	21.0	0.88	0.91	0.60	0.53	2.91	0.35
2017	21.1	0.86	0.90	0.59	0.53	2.88	0.35
2018	21.2	0.85	0.89	0.59	0.52	2.85	0.35
2019	21.3	0.83	0.87	0.59	0.52	2.82	0.35
2020	21.3	0.82	0.86	0.59	0.52	2.79	0.35
2025	19.8	0.73	0.77	0.54	0.47	2.52	0.34
2030	17.8	0.64	0.68	0.49	0.42	2.23	0.32
2015 to 2030 (%)	-15%	-28%	-26%	-17%	-21%	-24%	-8%

9.6.1 Projections for PCDD/PCDF

PCDD/PCDF emissions are expected to decrease until 2030 in all sectors (see Table 9-18 and Figure 9-6). The major part of this reduction is expected in source category 1A Fuel combustion, in particular in 1A1 Energy industries (mainly from waste incineration plants) and small combustion in source category 1A4 as well as in sector 5 Waste.

Table 9-18: WM (WEM) projections: Relative trends of PCDD/PCDF emissions 2005-2030 by sectors.

PCDD/PCDF emissions	2005	2015	2020	2025	2030
	g I-Teq		%		
1 Energy	23.48	59%	61%	56%	49%
1A Fuel combustion	23.48	59%	61%	56%	49%
1A1 Energy industries	5.16	37%	49%	54%	55%
1A2 Manufacturing industries and constr.	2.25	43%	41%	36%	30%
1A3 Transport	0.21	86%	82%	76%	68%
1A4 Other sectors	15.86	68%	68%	59%	49%
1A5 Other (Military)	NA	NA	NA	NA	NA
1B Fugitive emissions from fuels	NA	NA	NA	NA	NA
2 IPPU	2.11	38%	57%	55%	52%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	4.53	88%	77%	72%	67%
6 Other	2.46	92%	92%	92%	92%
National total	32.58	64%	65%	61%	55%

9.6.2 Projections for polycyclic aromatic hydrocarbons (PAH)

Overall, the annual national total of PAH emissions is expected to decrease from 2015 onwards (see Table 9-19 and Figure 9-6). The main relevant source of PAH remaining in the future are small combustion installations of source category 1A4. Reductions are projected for 1A2 Manufacturing industries and construction and similarly for sector 5 Waste. An important decline in emissions from 1A4 is expected between 2005 and 2030 while for 1A1 Energy industries a strong continuous increase – but on low level – is projected until 2030.

Table 9-19: WM (WEM) projections: Relative trends of PAHs emissions 2005-2030 by sectors.

PAHs emissions	2005	2015	2020	2025	2030
	t		%		
1 Energy	6.53	40%	37%	33%	29%
1A Fuel combustion	6.53	40%	37%	33%	29%
1A1 Energy industries	0.11	11%	48%	62%	62%
1A2 Manufacturing industries and constr.	0.87	10%	18%	17%	16%
1A3 Transport	0.16	116%	124%	127%	124%
1A4 Other sectors	5.39	43%	38%	33%	28%
1A5 Other (Military)	0.00	101%	95%	94%	93%
1B Fugitive emissions from fuels	NA	NA	NA	NA	NA
2 IPPU	0.51	5%	5%	4%	4%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.25	85%	86%	86%	86%
6 Other	0.09	115%	115%	115%	115%
National total	7.38	40%	38%	34%	30%

9.6.3 Projections for hexachlorobenzene (HCB)

HCB emissions on national level are projected to slightly decrease 2030 when compared to 2005 levels (see Table 9-20 and Figure 9-6). The only source categories causing HCB emissions are 1A1 Energy industries, 1A2 Manufacturing industries and construction and small combustions in source category 1A4. While a decrease is projected for 1A2 and 1A4, striking increase can be observed in 1A1 Energy industries because of intensified utilization used of wood in this category for district heating and CHP (combined heat and power production).

Table 9-20 WM (WEM) projections: Relative trends of HCB emissions 2005-2030 by sectors.

HCB emissions	**2005**	**2015**	**2020**	**2025**	**2030**
	kg		%		
1 Energy	0.35	98%	101%	97%	91%
1A Fuel combustion	0.35	98%	101%	97%	91%
1A1 Energy industries	0.15	118%	129%	136%	140%
1A2 Manufacturing industries and constr.	0.04	81%	69%	60%	50%
1A3 Transport	NA	NA	NA	NA	NA
1A4 Other sectors	0.16	84%	81%	68%	53%
1A5 Other (Military)	NA	NA	NA	NA	NA
1B Fugitive emissions from fuels	NA	NA	NA	NA	NA
2 IPPU	NA	NA	NA	NA	NA
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	NA	NA	NA	NA	NA
6 Other	NA	NA	NA	NA	NA
National total	0.35	98%	101%	97%	91%

10 Reporting of gridded emissions and LPS

Paragraph 28 of the “Guidelines for Reporting Emissions and Projections Data under the CLRTAP” requires that “Emission data calculated by Parties within the geographic scope of EMEP shall be spatially allocated in the EMEP grid as defined in paragraph 14 of these Guidelines (ECE 2014). This chapter describes how Switzerland implemented these requirements.

10.1 EMEP grid

Definition of the EMEP grid

The EMEP grid is based on a latitude-longitude coordinate system: 0.1°×0.1° latitude-longitude projection in the geographic coordinate World Geodetic System latest revision, WGS 84. The domain is therefore described in degrees and not in km^2. It extends in south-north direction from 30°N-82°N latitude and in west-east direction from 30°W-90°E longitude.

The grid fulfils the following requirements:

- It allows assessing globally dispersed pollutants on a hemispheric/global scale (Assessment Report, HTAP 2010).
- It allows to consider wider spatial scales in order to deal with tasks related to climate change and its effect on air pollution.
- Pollution levels can be assessed at a finer spatial resolution in order to provide more detailed information on pollution levels within territories of parties of the convention.

Figure 10-1 shows the new EMEP grid domain in comparison with the domain of the old (1999-2013) EMEP grid.

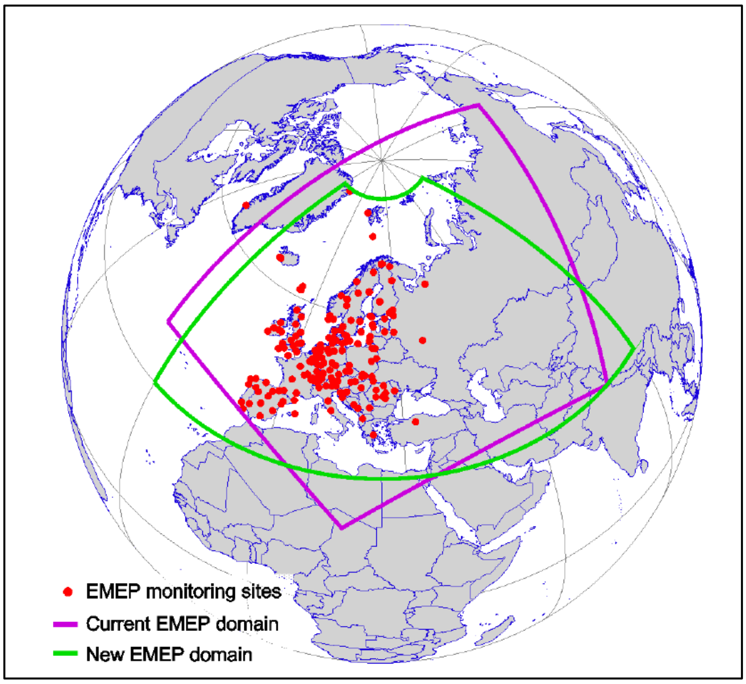

Figure 10-1 : Current and new EMEP domains. Magenta line: current EMEP domain in the polar-stereographic projection; green line: new EMEP domain in the latitude-longitude projection (30°N-82°N, 30°W-90°E); red dots: EMEP monitoring sites (EMEP 2012a). The new EMEP domain is now in place.

The EMEP domain on regional-scale

In accordance with the requirements described above, grid resolution for standard EMEP regional simulations can be chosen in the range of 0.5° x 0.5° to 0.2° x 0.2° (EMEP 2012a). This means, for instance, that in a 0.2°-based EMEP grid the cell size at 40°N (Italy) is 17 x 22 km^2 whereas at 60°N (Scandinavia) the cell size is 11 x 22 km^2. In total, a 0.2° x 0.2° resolution results in 156’000 grid cells.

EMEP domain on local-scale

For a more detailed assessment of air pollution levels, spatial resolution needs to be further refined. Several studies have shown that the EMEP modelling centres can provide more accurate results if refined resolution with more detailed input data is applied (EMEP 2012a). Therefore, a spatial resolution for national/local levels is defined at 0.1° x 0.1°. This results in a spatial resolution at 40°N (Italy) of 9 x 11 km^2 and 6 x 11 km^2 at 60°N (Scandinavia). Figure 10-2 illustrates the new EMEP grid resolution for Europe as used on local scales. In total approximately 624’000 grid cells exist within the new local EMEP domain.

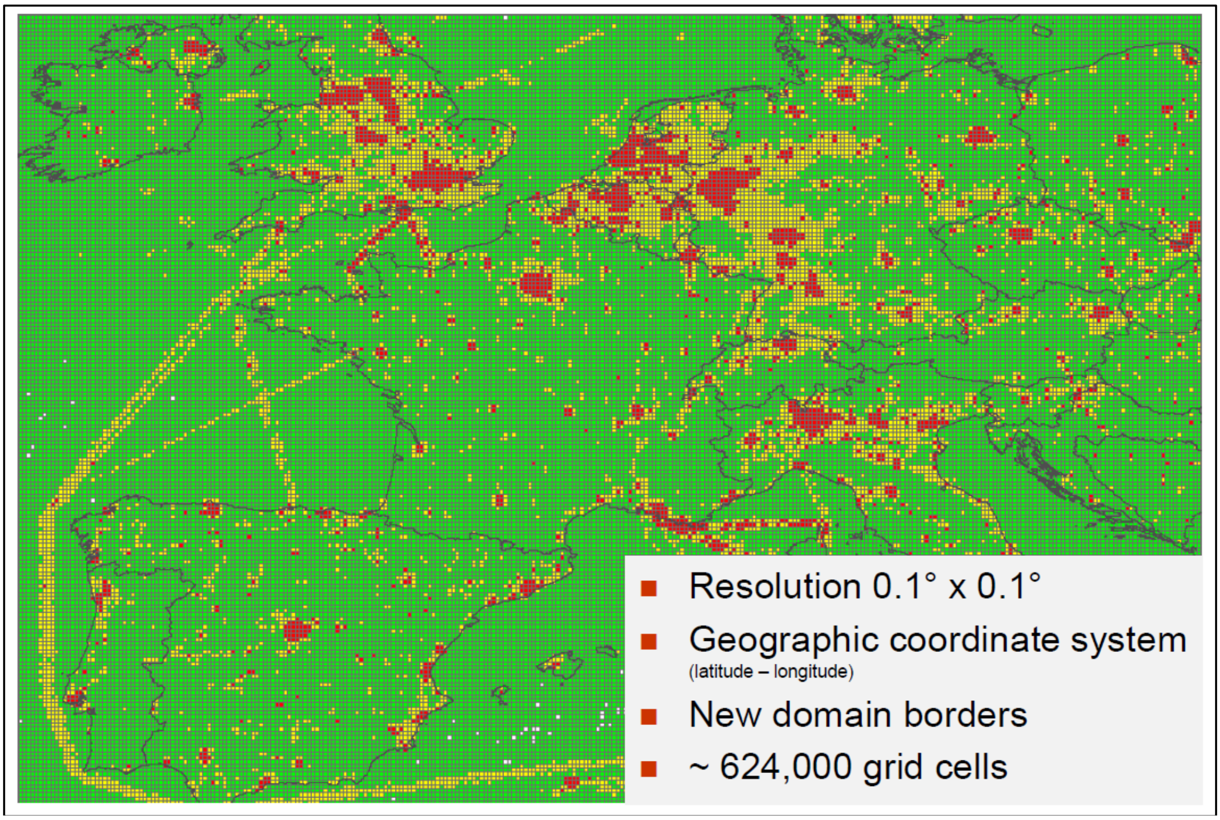

Figure 10-2: Resolution of the new EMEP grid for Europe (EMEP 2012b).

Switzerland started reporting with the new grid in its submission 2014. Hence, in Switzerland's air pollution inventory of current submission 2017, the new EMEP grid on local scale (0.1° x 0.1°) is applied for the fourth time (see chapter 10.3) and contains 580 different grid cells. This includes also cells covering Lake of Constance. For grid cells outside Swiss borders no emissions are reported (see Figure 10-3).

The challenge in modelling on local scale (0.1° x 0.1°) is the accurate allocation of emissions from the national total of emissions. Accordingly, emissions form national total should be processed to a resolution that is at least as fine as the resolution of the new local-based EMEP grid. To achieve that a separate study has been carried out which provides the allocation of the emissions sources within the new local-scale EMEP grid (see Meteotest 2013, Meteotest 2013a).

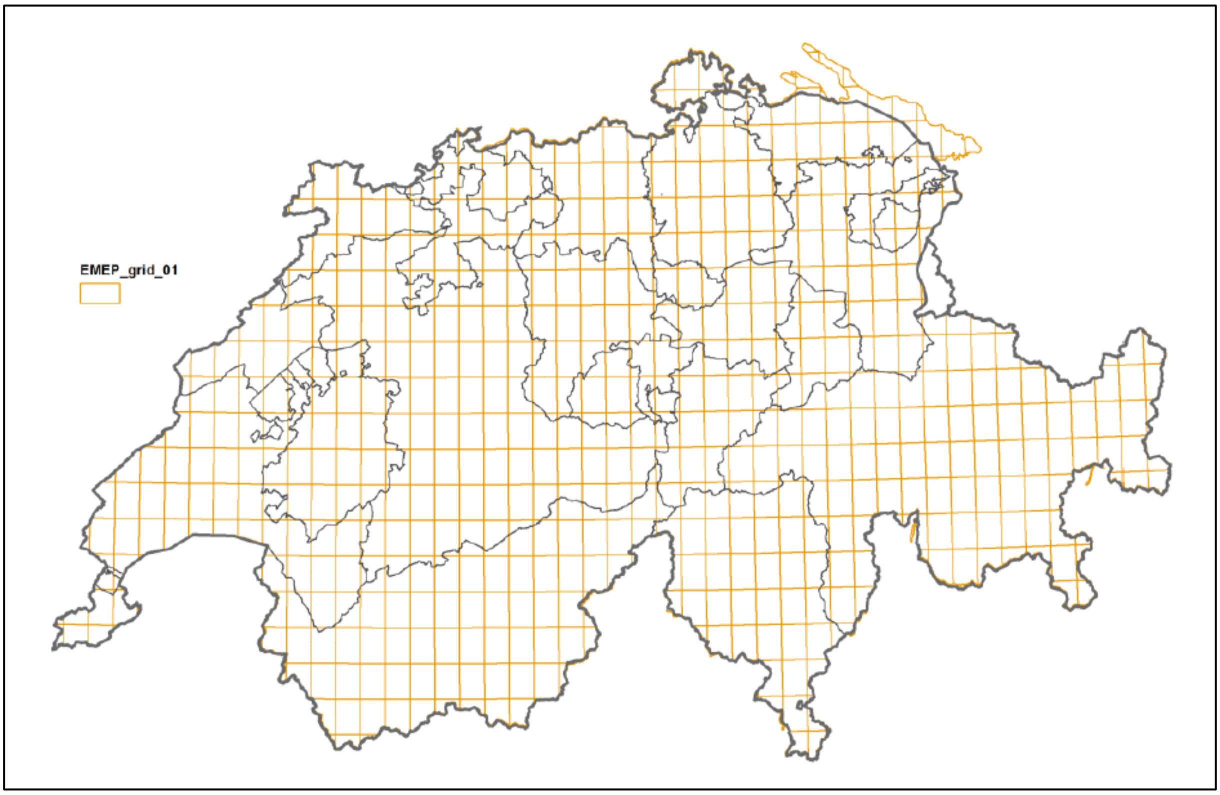

Figure 10-3 : Official EMEP grid of Switzerland with 0.1° x 0.1° spatial resolution (from Meteotest 2013 and Meteotest 2013a according to EMEP 2013).

10.2 Gridding of emissions

10.2.1 Switzerland's emissions according to the GNFR-Code

As described above, the emissions of the Swiss national inventory have to be allocated to the EMEP grid. Therefore, the source categories according to the NFR (Nomenclature for Reporting) code need to be aggregated to the GNFR categories (NFR Aggregation for Gridding according to annexes V (GNFR) of ECE 2014a). Table 10-1 shows the relative shares of the GNFR categories of Switzerland's total emissions (national total) in 2015 for all main air pollutants including PM2.5.

Table 10-1: GNFR categories and their part (%) of total emissions in 2015 (national total) for the main air pollutants including PM2.5.

GNFR aggregated sectors	NO_x	NMVOC	SO_x	NH_3	PM2.5
A_PublicPower	3.44%	0.19%	3.84%	0.07%	0.95%
B_Industry	11.27%	9.93%	50.62%	0.55%	20.18%
C_OtherStatComb	12.61%	3.82%	37.28%	0.20%	33.04%
D_Fugitive	0.05%	4.83%	2.25%	0.00%	0.00%
E_Solvents	0.00%	53.80%	0.10%	0.10%	3.11%
F_RoadTransport	52.06%	15.25%	1.23%	3.16%	16.87%
G_Shipping	1.73%	0.58%	0.04%	0.00%	0.53%
H_Aviation	3.04%	0.32%	2.33%	0.00%	0.32%
I_Offroad	10.39%	2.96%	0.70%	0.01%	15.53%
J_Waste	0.59%	3.12%	1.45%	1.11%	4.52%
K_AgriLivestock	0.36%	0.00%	0.00%	43.74%	4.91%
L_AgriOther	4.33%	5.03%	0.00%	49.37%	0.00%
M_Other	0.13%	0.14%	0.16%	1.71%	0.03%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

10.2.2 Data availability for emission allocation

In order to allocate the emissions of each GNFR category, an adequate allocation key has to be determined. This work has been done by Meteotest under mandate of the FOEN. Numerous GNFR categories overlap with various source categories thus is not possible to apply a single approach. Depending on the properties of each GNFR category, evaluation and identification of an appropriate allocation key is required. This ensures the adequate allocation of total emissions in the EMEP grid. For allocation purposes only relative shares of the national total emissions are relevant.

For the current submission, Switzerland calculated gridded emissions for the entire time series 1980-2015. For the allocation process of the emissions various data sources were applied for the time intervals 1980-1989, 1990-1999, 2000-2010 and >2010. Table 10-2 illustrates the data source applied for each time interval.

Table 10-2: Applied data sources for gridded emission time series 1980-1989, 1990-1999, 2000-2010 and >2010 (Meteotest 2015).

Data source	Available years	Applied data source for gridded emission time series			
		1980-1989	1990-1999	2000-2010	> 2010
Population data	1990, 2000, 2010	1990	1990	2000	2010
Census of enterprises sector 1	1996, 2000, 2005, 2008	1996	1996	2005	2008
Census of enterprises sector 2+3	1995, 1998, 2001, 2005, 2008	1995	1995	2005	2008
Land use statistics	1979/85, 1992/97, 2004/09	1979/85	1992/97	2004/09	2004/09
NO_x emission maps	1990, 2000, 2005, 2010	2005	2005	2005	2005
PM10 emission maps	2005, 2010	2005	2005	2005	2005
NH_3 emission maps	1990, 2000, 2007, 2010	1990	2000	2007	2010

Population Density

At first sight, most emissions originate where people live and occur proportional to population density in an area. Therefore, population density is one of the main factors to allocate emissions in the EMEP grid. Geo-referenced population data is available annually by the Federal Statistical Office. The most populated area in Switzerland is the Swiss Plateau and the largest cities with their agglomerations in particular (Figure 10-4).

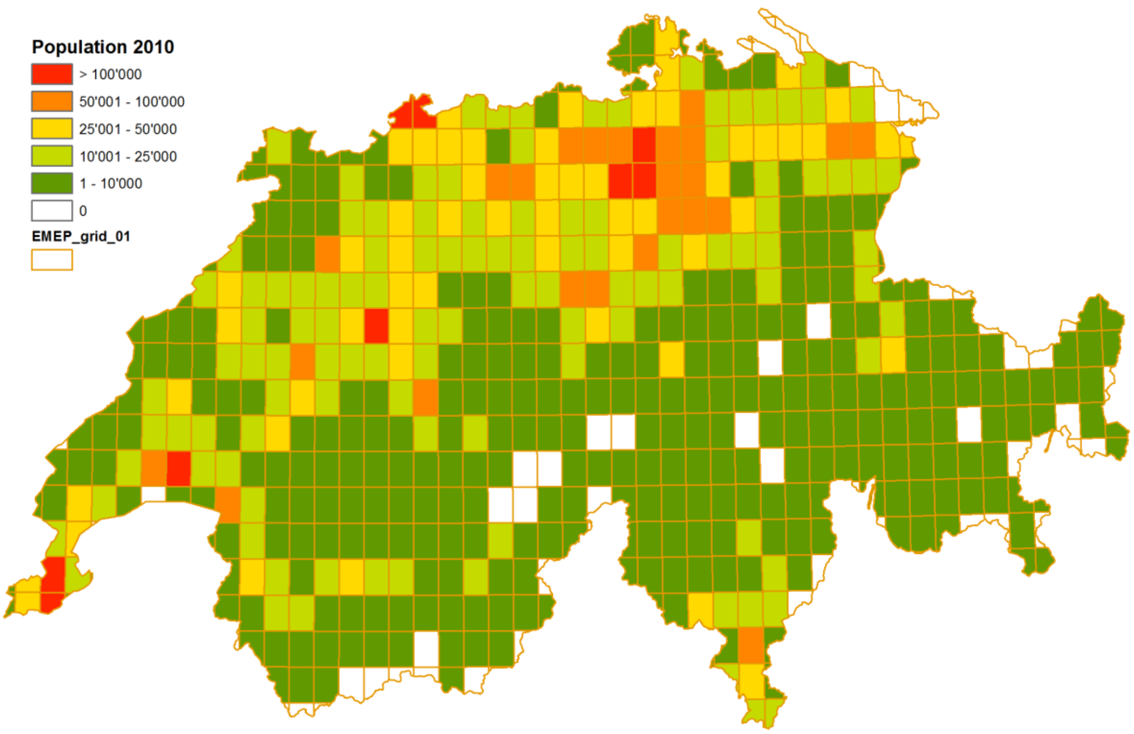

Figure 10-4 : Population number per EMEP grid cell in Switzerland in 2010 (SFSO 2011a, Meteotest).

Census of enterprises/number of employee by economic sectors

Statistical surveys exist for enterprises, from which information about the specific economic use per hectare (100 x100 m^2) is derived. This data is provided by the Federal Statistical Office and the most recent publication is based on data from 2008 (SFSO 2009). For several GNFR categories covering industrial production, the number of employee per economic branch and per hectare combined with the information on the economic use per hectare is used for the allocation of the emissions in the EMEP grid.

Land Use Statistics

Switzerland's Land Use Statistics allows determining specific land use characteristics on a hectare-scale (100 x100 m^2). According to the Land Use Statistics (SFSO 2007) 74 categories are available. They are aggregated to 9 main land use categories to apply them to the EMEP grid (Meteotest 2013, Meteotest 2013a). The 9 main land use categories are:

- Wooded areas
- Industrial buildings
- Industrial grounds
- Residential buildings
- Surroundings of residential buildings
- Agricultural buildings
- Agricultural areas
- Unspecified buildings

- Waste water treatment plants

Air pollution modeling data

As additional data for allocation purposes specific emission models are used. Based on these models maps of selected emissions can be applied for allocation. For the following air pollutants and source categories, appropriate emission maps are available:

- NO_x: Emissions of road traffic (FOEN 2011a)
- NO_x: Emissions of navigation (FOEN 2011a)
- NO_x: Emissions of construction machinery (FOEN 2011a)
- NO_x: Emissions of industrial vehicles (FOEN 2011a)
- PM10: Emissions of rail traffic (FOEN 2013d)
- NH_3 Emissions of manure management - farming of animals without pasture (Kupper et al. 2013)

10.2.3 Switzerland’s allocation of emissions for the EMEP grid

Method

The data sets described in 10.2.2 are available for the allocation of total emissions to the new EMEP grid. The application of those data sets results in various spatial patterns of national emissions in each GNFR category. The attribution of GNFR categories to the patterns is given in the Table 10-3. This allocation method is applied for every pollutant (Meteotest 2013, Meteotest 2013a).

Example of a GNFR category allocation in the EMEP grid in a case where the emission is attributed to the pattern “population” that means that the emission per hectare is proportional to its population:

$$Emission_{gs} = \frac{Population_g}{Total\ population\ of\ Switzerland} \times Emission_{tot_s}$$

$Emission_{gs}$: Emission of air pollutant (s) of a GNFR category in EMEP grid cell (g)

$Population_g$: Population of grid cell (g)

$Emission_{tots}$: Total emission of Switzerland of air pollutant (s) within the GNFR category with:

$\sum_{g=0}^{n_g} Emisson_{g_s} = Emission_{tot_s}$

GNFR categories include by definition also Large Point Sources (LPS). The LPS for 2010 are described under 10.4 and illustrated in Figure 10-10.

Allocation rules and emission shares

The GNFR categories including their shares of emissions (main air pollutants, PM10 and PM2.5) and their allocation rules are presented in Meteotest (2013) and Meteotest (2015).

Table 10-3: GNFR categories and their allocation indicators.

GFNR category	Allocation indicators
A_PublicPower	proportional to the population density and employees in economic sector 2
B_Industry	proportional to the number of employees in economic sector 2
C_OtherStatComb	proportional to the number of employees in sector 3 (1A4ai), sector 1 (1A4ci) and the population density (1A4bi)
D_Fugitive	proportional to the number of employees in sector 2 and restricted to land use category industrial buildings, industrial grounds, residential buildings and unspecified buildings
E_Solvents	proportional to the number of employees in sector 2, to the population density and the land use categories industrial buildings, industrial grounds, residential buildings and unspecified buildings
F_RoadTransport	based on specific air pollution modelling data (NOx emission map for road transport)
G_Shipping	based on specific air pollution modelling data (NOx emission map of navigation)
H_Aviation	based on the annual statistics of flight passengers of the six largest airports in Switzerland (excluding Basel since it lies on French territory)
I_OffRoad	based on selected land use categories, proportional to the number of employees in economic sector 2 and specific air pollution modelling data (NO_x emission map of construction machinery and industrial vehicles, PM10 emission map of rail transport). Emissions from military activities were uniformly distributed on areas below 1500 meters above sea level.
J_Waste	proportional to the population density, the land use categories industrial buildings, industrial grounds, residential buildings and unspecified buildings, to the number of employees in sector 2 and to the waste water treatment plants
K_AgriLivestock	based on specific air pollution modelling data (NH_3 emission map of manure management – farming of animals without pasture)
L_AgriOther	based on the land use categories agricultural areas
M_Other	proportional to the population density

Emissions not included in national total emissions

The following GNFR categories are not part of the national total emissions for the EMEP grid domain. These emissions are, therefore, not allocated to the EMEP grid cells.

Table 10-4: GNFR categories not included in the EMEP grid domain (according to Meteotest 2013, Meteotest 2013a).

GNFR	NFR Code	Longname
K_CivilAviCruise	1 A 3 a ii (ii)	1 A 3 a ii (ii) Civil Aviation (Domestic Cruise)
T_IntAviCruise	1 A 3 a i (ii)	1 A 3 a i (ii) Civil Aviation (International Cruise)
z_memo	1 A 3 d i (i)	1 A 3 d i (i) International maritime Navigation
	1 A 3	Transport (fuel used)
	7 B	Other (not included in National Total for Entire Territory)
S_Natural	11 A	11 (11 08 Volcanoes)
	11 B	Forest fires
	11 C	Other natural emissions

10.3 EMEP grid results (visualizations)

10.3.1 Spatial distribution of Switzerland's NO_x emissions 2015

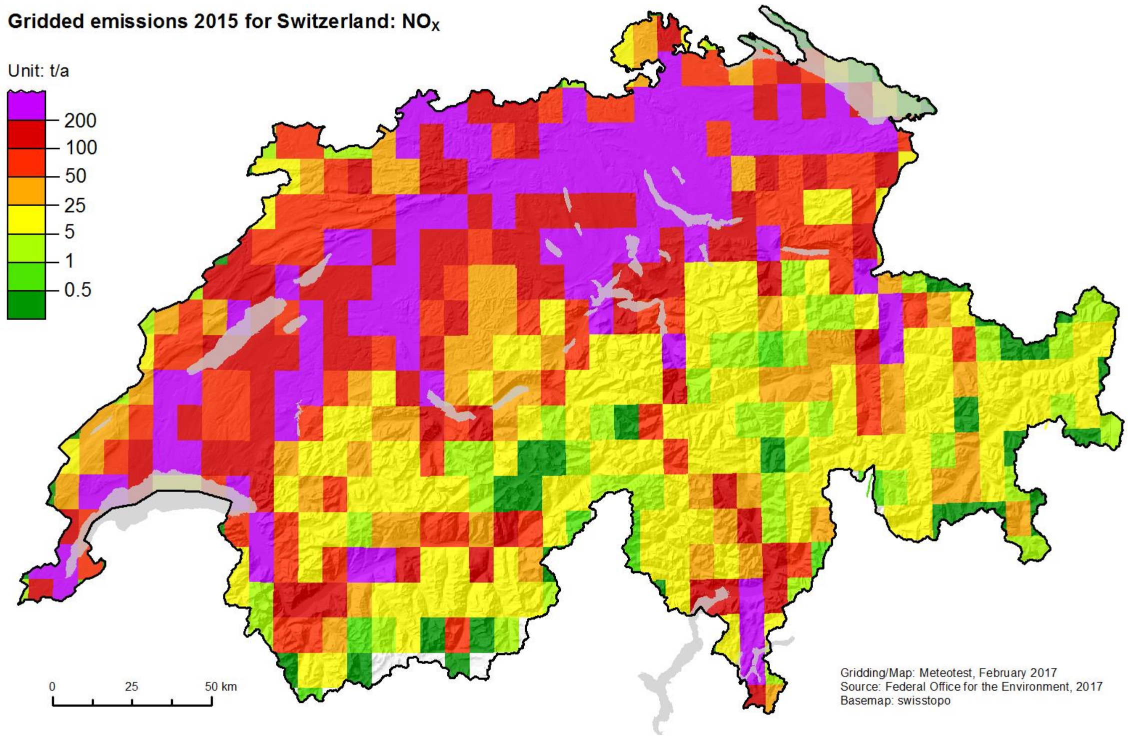

Figure 10-5: Spatial distribution of the NO_x emissions in Switzerland 2015.

10.3.2 Spatial distribution of Switzerland's NMVOC emissions 2015

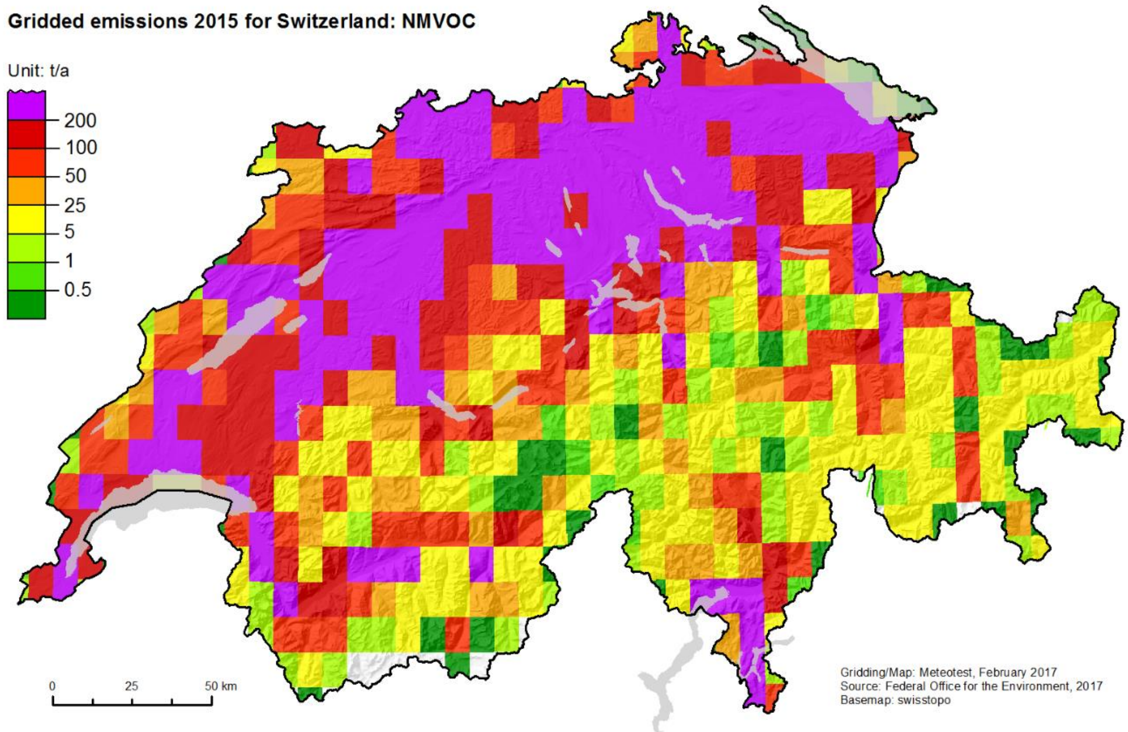

Figure 10-6: Spatial distribution of the NMVOC emissions in Switzerland 2015.

10.3.3 Spatial distribution of Switzerland's SO_x emissions 2015

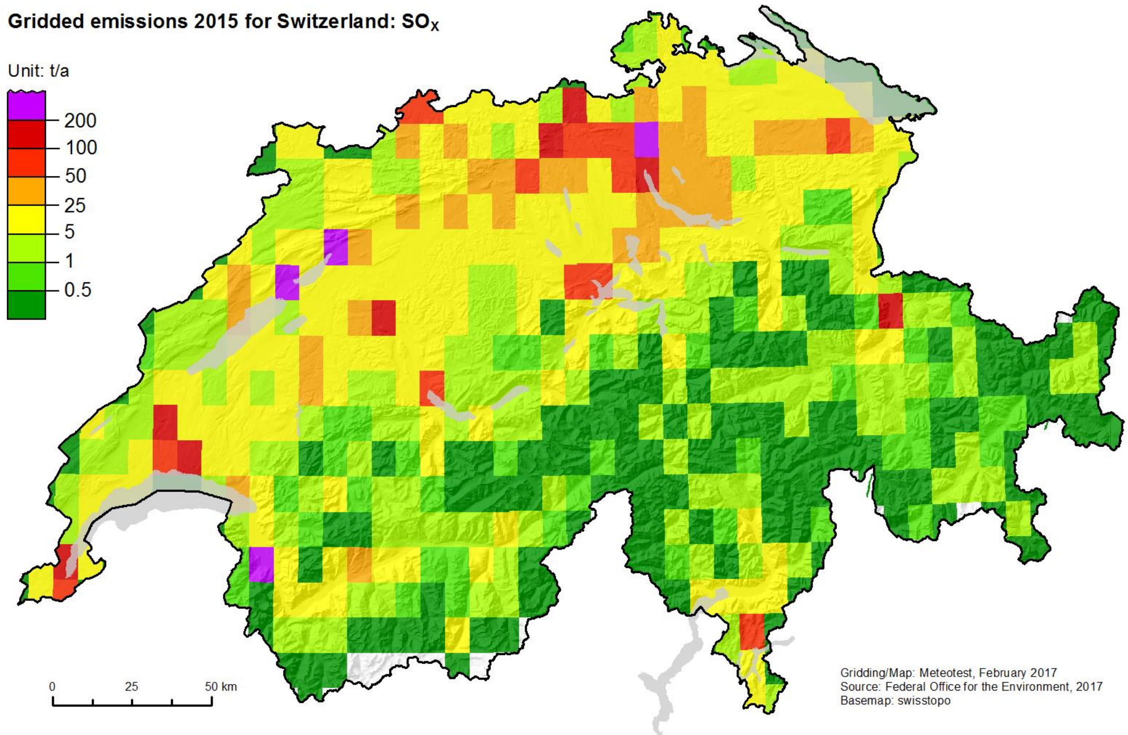

Figure 10-7: Spatial distribution of the SO_x emissions in Switzerland 2015.

10.3.4 Spatial distribution of Switzerland's NH_3 emissions 2015

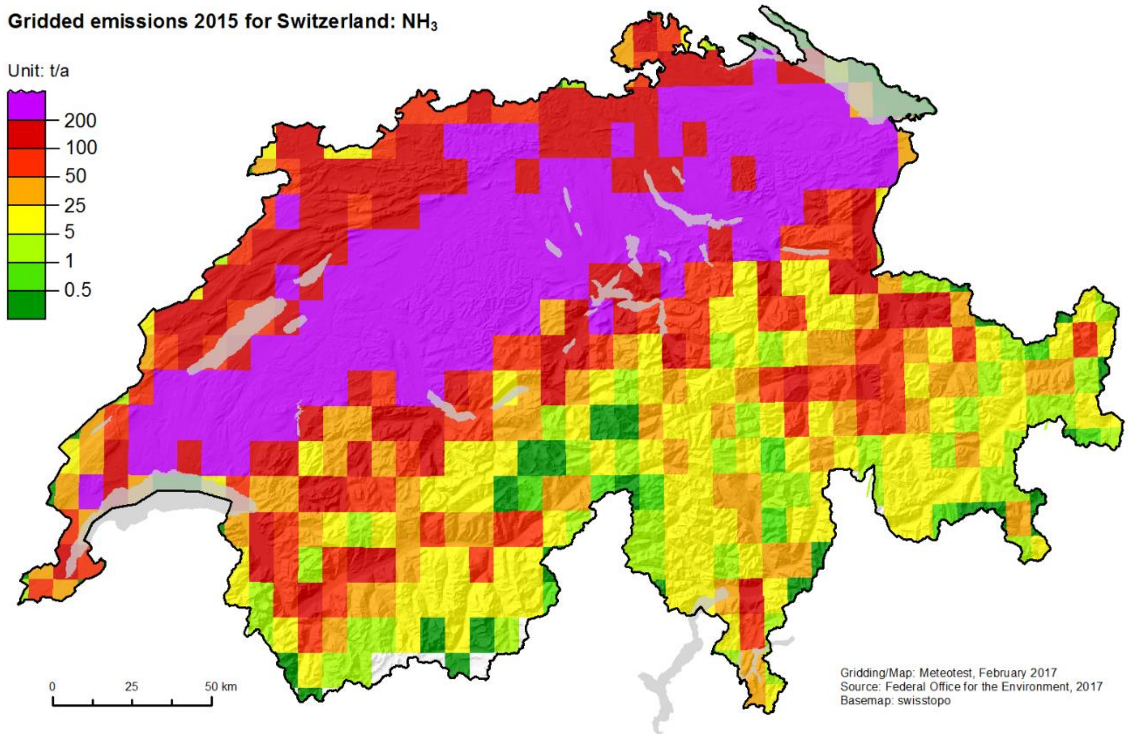

Figure 10-8: Spatial distribution of the NH_3 emissions in Switzerland 2015.

10.3.5 Spatial distribution of Switzerland's PM2.5 emissions 2015

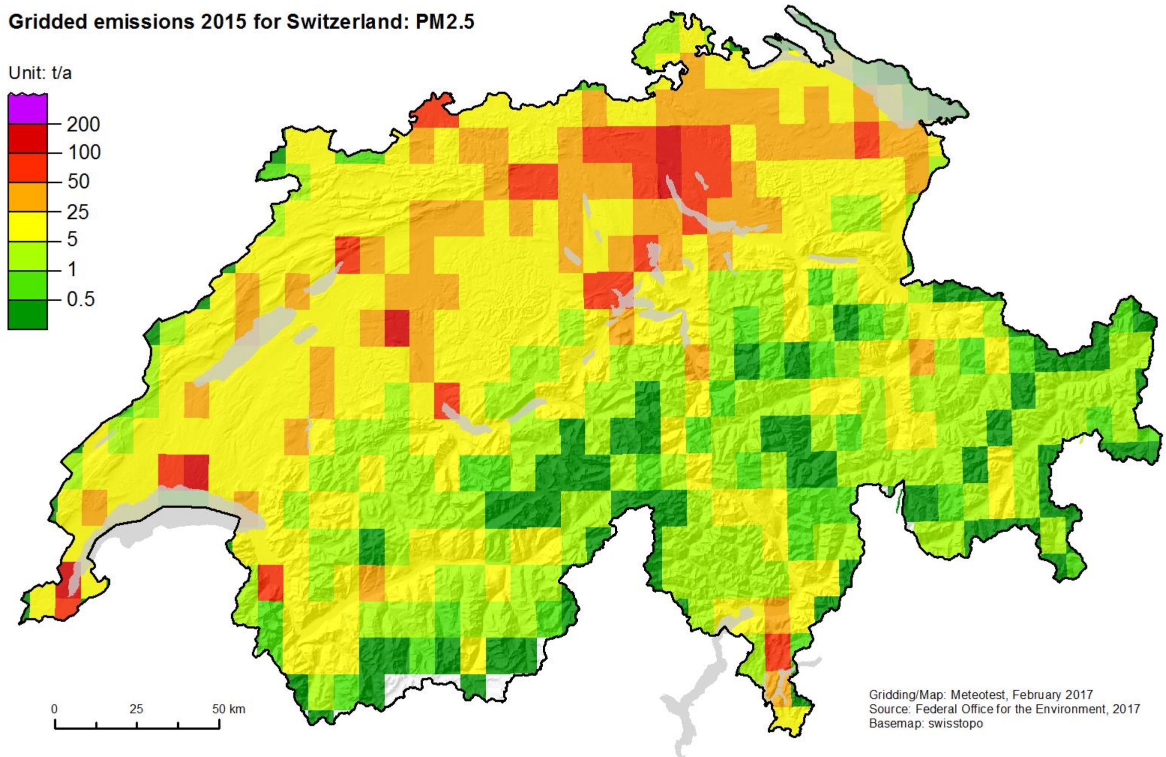

Figure 10-9: Spatial distribution of the PM2.5 emissions in Switzerland 2015.

10.4 Large point sources (LPS)

Large Point Sources (LPS) are reported according to the definitions of the ECE Guidelines (ECE 2014). LPS are defined as facilities or installations whose emissions of at least one of 14 pollutants exceed the threshold value given in Table 1 of the ECE Guidelines (ECE 2014).

Facility designations, locations and emissions of Switzerland’s LPS of the year 2013 are reported based on the most recent data of the Swiss Pollution Release and Transfer Register (PRTR). Data concerning air pollution release are reported annually by the facility operators and may be calculated based on periodic measurements, fuel consumption or other methods.

In 2014, the list of Switzerland’s LPS includes 29 facilities, in particular of the industrial and waste sectors. This represents the lowest number of LPS since the implementation of the Swiss-PRTR in the year 2007. As in previous years, most significant LPS are cement production plants and installations for incineration of municipal waste, followed by different facilities of the manufacturing industry such as steel production and chemicals (see Figure 10-10).

Information concerning the physical height of stack is reported as stack height class and the locations of the LPS are given in WGS 84 decimal coordinates, recalculated from Swiss grid coordinates (CH1903) as given in the Swiss PRTR.

The reported E-PRTR facility IDs correspond to the BER-Code (Business and Enterprise Register) of the Swiss Federal Statistical Office.

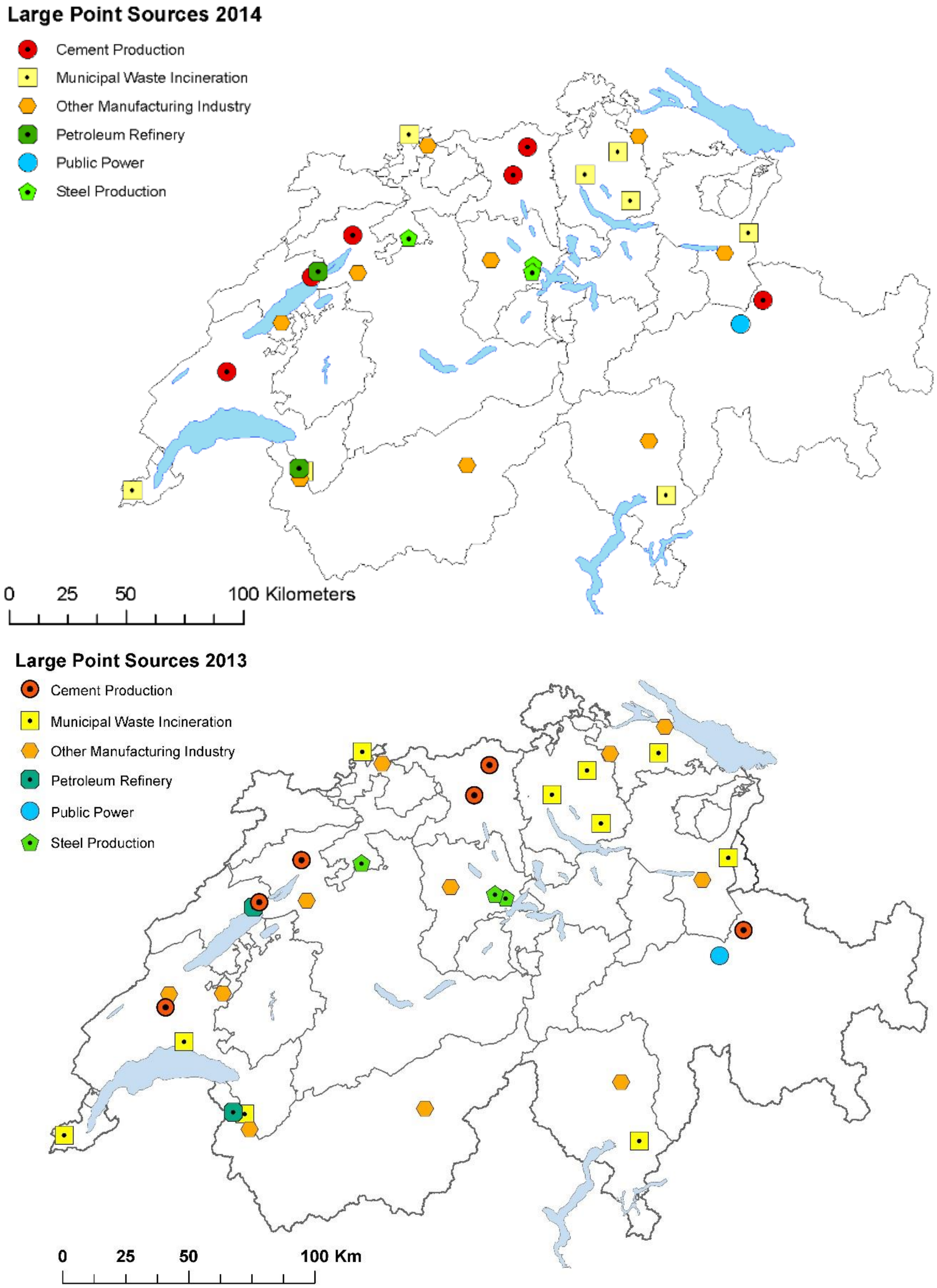

Figure 10-10: Spatial distribution of Switzerland's LPS in 2014.

11 Adjustments

There are no adjustments in Switzerland's air pollutant emission inventory.

12 References and Assignments to EMIS Categories

12.1 References

AGRAMMON 2013: The Swiss agricultural ammonia emission calculation model, developed by the Swiss College of Agriculture in cooperation with Bonjour Engineering GmbH and Oetiker + Partner AG on behalf of the Federal Office for the Environment FOEN. Internet version 4.0 in German, French and English: http://www.agrammon.ch/documents-to-download/ [03.02.2017]; Technical description for download (updated periodically): http://www.agrammon.ch/technical-description [03.02.2017]

Agricura 2015: Geschäftsbericht 2014/2015. Agricura, Bern [confidential/internal].

ARE 2010: Nationales Personenverkehrsmodell – Basismodell 2005, Bern. https://www.are.admin.ch/are/de/home/medien-und-publikationen/publikationen/verkehr/nationales-personenverkehrsmodell-des-uvek-basismodell-2005.html [08.02.2017]

ARE 2012: Ergänzungen zu den schweizerischen Verkehrsperspektiven bis 2030. Bundesamt für Raumentwicklung (ARE), Bern. https://www.are.admin.ch/are/de/home/medien-und-publikationen/publikationen/verkehr/ergaenzungen-zu-den-schweizerischen-verkehrsperspektiven-bis-203.html [08.02.2017]

ARE/SFSO 2005: Mobilität in der Schweiz. Ergebnisse des Mikrozensus 2005 zum Verkehrsverhalten. Federal Office for Spatial Development, Bern and Swiss Federal Statistical Office, Neuchâtel.

Agroscope/SHL 2012: Categorization of livestock animals in Switzerland. D. Bretscher and T. Kupper. Agroscope Research Station Zürich (ART), Schweizerische Hochschule für Landwirtschaft Zollikofen (SHL). March 2012.

Carbura 2016: Geschäftsbericht 2015 http://www.carbura.ch/fileadmin/user_upload/editors/web_dokumente/pdf_dokumente/Geschaeftsberichte/__Def_059839_Carbura_JB_2015_DE_fuer_website.pdf [09.02.2017]

Cemsuisse 2016: Jahresbericht 2015. [Rapport annuel 2015]. Association of the Swiss Cement Industry, Bern. http://www.cemsuisse.ch/php/modules/mediamanager/sendobject.php?lang=de&download=NHzLpZeg7t,lnJ6lzdeIp96km56VlW1ol5dOqdayYLGH4tjTy4am06iDf76Af4SN0NTY0oau3aWWpl3Iy5Wn6A-- [German and French] [01.02.2017]

Cemsuisse 2010a: Bestimmung der Emissionsfaktoren an Mischproben, Interner Bericht von Wessling im Auftrag von cemsuisse, 2010

Citepa 2012: Inventaire des emissions de polluants atmospheriques en France au titre de la Convention sur la Pollution Atmospherique Transfrontaliere a longue Distance et de la Directive Europeenne relative aux plafonds d'emissions nationaux (NEC). Ministère de l'Ecologie, du Développement Durable, des Transport et du Logement. CITEPA, Mars 2012. http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2012_submissions [17.02.2017]

Consaba 2016: Erhebung Verwertung Deponiegas über Fackelanlagen in der Schweiz 1990 bis 2014. Entwurf 6. Consaba GmbH, 25.01.2016 [confidential/internal].

DDPS 2014a: List of military non-road machinery (stocks, engine-power, annual operating hours). E-Mail C. Stucki (Federal Department of Defence, Civil Protection and Sport) to B. Notter (INFRAS) 27.05.2014 [confidential/internal].

DDPS 2016: Consumption of aviation fuel and jet kerosene of Swiss military aircraft 1990–2014. Didier Castella (Federal Department of Defence, Civil Protection and Sport) to Anouk-Aimée Bass (FOEN, Bern) [confidential/internal]

EC 2004: Directive 2004/42/CE of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC. Official Journal of the European Union. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004L0042&qid=1455622565462&from=EN [06.02.2017]

ECE 2014: Guidelines for Reporting Emissions and Projections data under the Convention on Long-range Transboundary Air Pollution. ECE/EB.AIR/125. 13 March 2014. http://www.ceip.at/fileadmin/inhalte/emep/2014_Guidelines/ece.eb.air.125_ADVANCE_VERSION_reporting_guidelines_2013.pdf [26.01.2017]

ECE 2014a: Annexes for the revised 2014 reporting guideline: Annex II Recommended Structure for Informative Inventory Report for Report, Annex V Gridding NFR sectors, Annex VI LPS data http://www.ceip.at/fileadmin/inhalte/emep/2014_Guidelines/Annexes_revised_150708.zip [09.03.2017]

Edelmann, W., Schleiss, K. 2001: Ökologischer, energetischer und ökonomischer Vergleich von Vergärung, Kompostierung und Verbrennung fester biogener Abfallstoffe. On behalf of the Swiss Federal Office of Energy, Bern and the Swiss Agency for the Environment, Forests and Landscape, Bern. http://www.bfe.admin.ch/forschungbiomasse/02390/02720/03176/index.html?lang=dehttp://www.bfe.admin.ch/forschungbiomasse/02390/02720/03176/index.html?dossier_id=03405&lang=d [08.03.2017]

EMEP 2012a: Considerations of Changing the EMEP Grid. 36th Session of the EMEP Steering Body, 17 to 19 September 2012, Geneva, Switzerland. http://www.unece.org/index.php?id=30313 [17.02.2017]

EMEP 2012b: The new EMEP grid – An overview of the upcoming changes. http://www.ceip.at/fileadmin/inhalte/emep/pdf/CEIP_new_EMEP_grid.pdf [17.02.2017]

EMEP 2013: The new EMEP grid – Official site. http://www.ceip.at/the-new-emep-grid/ [17.02.2017]

EMEP/EEA 2013: Air pollutant emission inventory guidebook 2013. Technical report No 12/2013. Published by EEA (European Environment Agency). 29 Aug 2013 http://www.eea.europa.eu/publications/emep-eea-guidebook-2013 [31.01.2017]

EMIS 2017/(NFR-Code): Comments to EMIS database. Internal documents. Federal Office for the Environment, Bern. To find the EMIS comment that belongs to the specified NFR Code, see Table 12-1 on page 272 [available in German only]. If not further specified in the reference and more than one comment appear under the same NFR Code, all comments are relevant.

EMPA 1999: Written communication from Dr. H.W. Jäckl (EMPA, Dübendorf) to Andreas Liechti (FOEN, Bern), 09.03.1999. www.bafu.admin.ch/ghginv-ref [01.02.2017]

EMPA 2004: PM10-Emissionen bei Anlagen der Holzbearbeitung, Bericht zur Hauptstudie, März 2004.

EMPA/PSI 2009: PM10 emission factors of abrasion particles from road traffic (APART). EMPA/PSI, Forschungsauftrag ASTRA 2005/007 auf Antrag des Bundesamtes für Strassen (ASTRA). http://www.transport-research.info/sites/default/files/project/documents/20150710_141622_66365_priloha_radek_1052.pdf [8.02.2017]

EPA 2010: Exhaust and Crankcase Emission Factors for Nonroad Engine Modelling - Compression Ignition. EPA-420-R-10-018 / NR-009d. Assessment and Standards Division Office of Transportation and Air Quality U.S. Environmental Protection Agency. July 2010. http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2010/420r10018.pdf [09.03.2017]

EV 2014: Jahresbericht 2014. Erdöl-Vereinigung [Rapports annuel 2013. L'Union Pétrolière]. Zürich.
https://www.erdoel.ch/de/brennstoffe-und-waermemarkt/publikationen/jahresbericht/2013
in German [31.01.2017]

EV 2016: Jahresbericht 2015. Erdöl-Vereinigung [Rapports annuel 2015. L'Union Pétrolière]. Zürich.
https://erdoel.ch/de/42-treibstoffe-und-mobilitaet/publikationen/jahresbericht/50-jahresbericht-2015
in German [31.01.2017]

FCA 2015a: Bunkers of diesel oil 1990-2014. Written communication Wolfgang Kobler, Federal Customs Administration (FCA) to Anouk Bass (FOEN), 21.09.2016.

FCA 2015c: Import- und Exportstatistik Swiss-Impex. Tarifnummer 87 Automobile etc. (tarif no. 87 motorised vehicles) https://www.swiss-impex.admin.ch [8.02.2017]

FEDPOL 2016: Bundesamt für Polizei fedpol, Statistik Pyrotechnikumsatz in der Schweiz. https://www.fedpol.admin.ch/fedpol/de/home/sicherheit/sprengstoff_pyrotechnik/pyrotechnische_gegenstaende/pyrotechnikumsatz.html [02.02.2017]

FEDRO 2010: Swiss Automatic Road Traffic Counts (SARTC). Federal Roads Office, Bern. https://www.astra.admin.ch/astra/en/home/documentation/traffic-data/data-and-publication/swiss-automatic-road-traffic-counts--sartc-.html [08.02.2017]
Numbers for 2009:
https://www.astra.admin.ch/dam/astra/en/dokumente/verkehrsdaten/jahresergebnisse2009.xls.download.xls/annual_results_2009.xls [08.02.2017]

FEDRO 2013: Extract 2AA of MOFIS database (reference date 30.09.2013) of the Federal Roads Office (FEDRO) containing vehicle stock numbers. E-mail from A. Lehmann (FEDRO) to P. Wüthrich, INFRAS on 14.11.2013

Fial 2013: Die Schweizer Nahrungsmittel-Industrie im Jahr 2012. http://fial.ch/de/statistics/fial_Statistik%202012_de.pdf [09.03.2017]

FOAG 2011: Klimastrategie Landwirtschaft: Klimaschutz und Anpassung an den Klimawandel für eine nachhaltige Schweizer Land- und Ernährungswirtschaft. Federal Office for Agriculture, Bern.
https://www.blw.admin.ch/blw/de/home/nachhaltige-produktion/umwelt/klima.html
[07.02.2017], [in German]

FOCA 1991: Crossair confidential data 1991. Federal Office of Civil Aviation, Bern.

FOCA 1991a: L'aviation civile Suisse en 1990. Federal Office of Civil Aviation, Bern. https://www.bafu.admin.ch/bafu/en/home/topics/climate/state/data/climate-reporting/references.html [07.02.2017]

FOCA 2004: Unternehmensstatistik der Schweizerischen Helikopterunternehmungen. Federal Office of Civil Aviation, Bern.
https://www.bafu.admin.ch/bafu/en/home/topics/climate/state/data/climate-reporting/references.html [07.02.2017]

FOCA 2006: GHG emissions of Swiss civil aircraft in 1990 and 2004: data, proceeding and description of the calculations. Written communication from Theo Rindlisbacher and Paul Stulz (FOCA, Bern) to Andreas Liechti (FOEN, Bern), 20./22.02.2006.

FOCA 2006a: GHG emissions of Swiss civil aircraft in 1990, 1995, 2000, 2002, 2004 and 2005: data, proceeding and description of the calculations. Written communication from Theo Rindlisbacher (FOCA, Bern) to Paul Filliger (FOEN, Bern), 17.11.2006. https://www.bafu.admin.ch/bafu/en/home/topics/climate/state/data/climate-reporting/references.html [07.02.2017]

FOCA 2007a: Aircraft Piston Engine Emissions. Summary Report. Federal Office of Civil Aviation. Report Ref. 0 / 3/33/33-05-003 ECERT. Bern. https://www.bafu.admin.ch/bafu/en/home/topics/climate/state/data/climate-reporting/references.html [07.02.2017]

FOCA 2008: GHG emissions of Swiss civil aircraft in 2007. Written communication from Theo Rindlisbacher (FOCA, Bern) to Beat Müller (FOEN, Bern), 01.12.2008. https://www.bafu.admin.ch/bafu/en/home/topics/climate/state/data/climate-reporting/references.html [07.02.2017]

FOCA 2009: GHG emissions of Swiss civil aircraft in 2008. Written communication from Theo Rindlisbacher (FOCA, Bern) to Beat Müller (FOEN, Bern), 16.2.2010. https://www.bafu.admin.ch/bafu/en/home/topics/climate/state/data/climate-reporting/references.html [07.02.2017]

FOCA 2010: GHG emissions of Swiss civil aircraft in 2009. Written communication from Theo Rindlisbacher (FOCA, Bern) to Sophie Hoehn (FOEN, Bern), 18.11.2010. https://www.bafu.admin.ch/bafu/en/home/topics/climate/state/data/climate-reporting/references.html [07.02.2017]

FOCA 2011: GHG emissions of Swiss civil aircraft in 2010. Written communication from Theo Rindlisbacher (FOCA, Bern) to Sophie Hoehn (FOEN, Bern), 09.11.2011. https://www.bafu.admin.ch/bafu/en/home/topics/climate/state/data/climate-reporting/references.html [07.02.2017]

FOCA 2012: GHG emissions of Swiss civil aircraft in 2011. Written communication from Theo Rindlisbacher (FOCA, Bern) to Anouk Bass (FOEN, Bern), 07.09.2012. https://www.bafu.admin.ch/bafu/en/home/topics/climate/state/data/climate-reporting/references.html [07.02.2017]

FOCA 2013: GHG emissions of Swiss civil aircraft in 2012. Written communication from Theo Rindlisbacher (FOCA, Bern) to Anouk Bass (FOEN, Bern), 07.11.2013. https://www.bafu.admin.ch/bafu/en/home/topics/climate/state/data/climate-reporting/references.html [07.02.2017]

FOCA 2014: GHG emissions of Swiss civil aircraft in 2013 and corrections for the year 2011. Written communication from Theo Rindlisbacher (FOCA, Bern) to Anouk-Aimée Bass (FOEN, Bern), 30.10.2014 [confidential/internal].

FOCA 2015: GHG emissions of Swiss civil aircraft in 2014. Written communication from Theo Rindlisbacher (FOCA, Bern) to Anouk-Aimée Bass (FOEN, Bern), 29.10.2015 [confidential/internal].

FOCA 2016: GHG emissions of Swiss civil aircraft in 2015. Written communication from Theo Rindlisbacher (FOCA, Bern) to Anouk-Aimée Bass (FOEN, Bern), 6.12.2016 [confidential/internal].

FOCA 2016a: Abschätzung voin PM Emissionen aus dem Luftverkehr mittel genereischer Faktoren. Aktennotiz. Bundesamt für Zivilluftfahrt BAZL. 26. Sept. 2016. Uster.

FOEN 2006: Prozess EMIS (Emissions-Informationssytem Schweiz). Beschrieb des Prozesses (= Handbuch zur EMIS-Datenbank (Entwurf)). Internes Dokument. [Manual to EMIS database]. Federal Office for the Environment. 23. Mai 2006. Bern.

FOEN 2008: Switzerland's Informative Inventory Report 2008 (IIR). Submission under the UNECE Convention on Long-range Transboundary Air Pollution. Submission of March 2008 to the United Nations ECE Secretariat.

FOEN 2009j: Waste Statistics for 2008. Federal Office for the Environment, Bern. (selected data). See also: Abfallwirtschaftsbericht 2008, Zahlen und Entwicklungen der schweizerischen Abfallwirtschaft 2005-2008 [German] https://www.bafu.admin.ch/bafu/de/home/themen/abfall/zustand/daten.html [08.03.2017]

FOEN 2010i: Pollutant Emissions from Road Transport, 1990 to 2035. Updated in 2010. Environmental studies no. 1021. Federal Office for the Environment, Bern. https://www.bafu.admin.ch/bafu/en/home/topics/air/publications-studies/publications/pollutant-emissions-from-road-transport-1990-to-2035.html [08.02.2017]

FOEN 2011a: NO_2 ambient concentrations in Switzerland. Modelling results for 2005, 2010, 2015. Federal Office for the Environment, Bern. Environmental studies no. 1123. INFRAS/Meteotest, Zürich, Bern.

FOEN 2012g: Adressliste der Schweizer Kläranlagen mit Angaben zur Ausbaugrösse. Federal Office for the Environment, Bern, 27.11.2012j. https://www.bafu.admin.ch/bafu/de/home/themen/wasser/fachinformationen/massnahmen-zum-schutz-der-gewaesser/abwasserreinigung/kommunale-abwasserreinigung.html [08.03.2017]

FOEN 2013d: PM10 and PM2.5 ambient concentrations in Switzerland. Modelling results for 2005, 2010, 2020. Federal Office for the Environment, Bern. Environmental studies no. 1301. INFRAS/Meteotest, Zürich, Bern.

FOEN 2014a: Switzerland's 6th National Communication under the UNFCCC. Third National Communication under the Kyoto Protocol to the UNFCCC. Federal Office for the Environment, Bern. https://www.bafu.admin.ch/dam/bafu/en/dokumente/klima/klima-climatereporting/6th_national_communicationand1stbiennialreport2014.pdf.download.pdf/6th_national_communicationand1stbiennialreport2014.pdf [09.02.2017]

FOEN 2014d: Von Arx U.: Feuerwerkskörper. Umweltauswirkungen und Sicherheitsaspekte. Bundesamt für Umwelt, Bern. Umwelt-Wissen Nr.1423

FOEN 2015j: Non-road energy consumption and pollutant emissions. Study for the period from 1980 to 2050 (Original in German: Energieverbrauch und Schadstoffemissionen des Nonroad-Sektors. Studie für die Jahre 1980-2050. Schlussbericht). INFRAS. Ed. by the Federal Office for the Environment. https://www.bafu.admin.ch/bafu/en/home/topics/air/publications-studies/publications/non-road-energy-consumption-and-pollutant-emissions.html [7.02.2017]

FOEN 2016a: Waste Statistics for 2015. Federal Office for the Environment, Bern. https://www.bafu.admin.ch/bafu/de/home/themen/abfall/zustand/daten/Abfallstatistiken_2015.html [09.02.2017] selected data.

FOEN 2016b: Switzerland's Informative Inventory Report 2016 (IIR), Submission under the UNECE Convention on Long-range Transboundary Air Pollution, Submission of March 2016 to the United Nations ECE Secretariat. Federal Office for the Environment, Bern. http://webdab1.umweltbundesamt.at/download/submissions2016/CH_IIR2016.zip?cgiproxy_skip=1 [13.02.2017]

FOEN 2016h: CO_2-Emissionsfaktor Erdgas, Zeitreihe für das Treibhausgasinventar der Schweiz, internal documentation, Federal Office for the Environment, Bern.

FOEN 2017: Switzerland's Greenhouse Gas Inventory 1990–2015, National Inventory Report 2017 and CRF tables 1990–2015. Submission 2017 to the United Nations Framework Convention on Climate Change. Federal Office for the Environment, Bern. [forthcoming].

FOEN 2017a: «Umsetzung IIR Review 2016.xlsx». Fle to develop Switzerland's air pollutant inventory. Internal document. Federal Office for the Environment, Bern.

Graf 1990: Schmoll AG Basel Kabelzerlegungsanlage, Konzept Rauchgasreinigung.

HAFL 2011: Bestimmung Tiere der Rindviehkategorien ab 2009 für die Berechnung des Ammoniakinventars. Hochschule für Agrar-, Forst- und Lebensmittelwissenschaften. Zollikofen. 2011.

HTAP 2010: Task Force on Hemispheric Transport of Air Pollution – Advice on Future O3 Boundary Conditions for Europe. Assessment Report, October 2012. http://www.htap.org/publications/assessment_reports.htm [17.02.2017]

Hubschmid 2014: VOC-Emissionen aus lösungsmittelhaltigen Haushaltsprodukten, Master-Arbeit Silvia Hubschmid, FHNW 2014

IFEU 2010: Aktualisierung des Modells TREMOD - Mobile Machinery (TRE-MOD-MM). Endbericht im Auftrag des Umweltbundesamtes. UBA Texte 28/2010. Institut für Energie- und Umweltforschung (IFEU), Heidelberg. https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3944.pdf [8.02.2017]

IFEU/INFRAS 2009: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland, Endbericht. IFEU und INFRAS im Auftrag des Umweltbundesamts Dessau/Deutschland, FKZ 360 16 023. Heidelberg/Zürich/Bern. 31. Oktober 2009.

INFRAS 2007: PM10-Emissionen des Verkehrs, Teil Schienenverkehr. INFRAS commissioned by FOEN. Internal report. 10.01.2007

INFRAS 2010: The Handbook Emission Factors for Road Transport (HBEFA), version 3.1 (MS AccessXP runtime application and report). INFRAS in cooperation with further editors: FOEN/Switzerland; Umweltbundesamt Dessau/Germany; Umweltbundesamt Wien/Austria; Swedish Road Administration, ADEME/France; SFT/Norway. Bern. 30.01.2010.
http://www.hbefa.net/e/index.html [07.02.2017]

INFRAS 2011a: Bunker fuels Bodensee/Genfersee, Datenverfügbarkeit und Berechnung der Bunker Fuels. Internal document. Federal Office fort he Environment. September 2011.

INFRAS 2015a: Online database of emission factors, activity data and emissions of non-road vehicles (corresponding report is FOEN 2015j)
https://www.bafu.admin.ch/bafu/en/home/topics/air/state/non-road-datenbank.html [07.02.2017]

INFRAS 2015b: Ammoniakemissionen aus der Landwirtschaft. Unsicherheitsanalyse. Schlussbericht. Zürich, 26. Juni 2015 (Uncertainties of agricultural ammonia emissions). INFRAS mandated by the Federal Office for the Environment FOEN. Internal report, 26th June 2015 Zürich.

INFRAS 2017: Ammoniakemissionen aus der Landwirtschaft. Unsicherheitsanalyse Teil II. Schlussbericht. (Uncertainties of agricultural ammonia emissions – part II; Report in German only). INFRAS mandated by the Federal Office for the Environment FOEN. Internal report, January 2017 Zürich.

Integer 2013: Emissions Control in Non-Road Mobile Machinery (NRMM) Markets: 2013 Edition. Integer Research Limited, London.
https://www.integer-research.com/wp-content/uploads/2014/07/NRMM-markets-2013-Brochure-amended.pdf [8.02.2017]

IPCC 2006: IPCC 2006: IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change.
http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm [27.01.2017]

Jardin Suisse 2012: Zahlen zum Schweizerischen Gartenbau. Unternehmerverband Gärtner Schweiz. Internal document FOEN.

Kaufmann 2015: Energieverbrauch stationäre Motoren und Gasturbinen ab 1990. Excel data file for internal use on behalf of the Federal Office for the Environment, Bern. Eicher + Pauli, Liestal, 13.10.2015.

Kupper 2012: Expet judgementon uncertainty estimates of emission factors of the AGRAMMON model, oral communication to S. Liechti and B. Achermann (FOEN), 13 March 2012

Kupper, T., Bonjour, C., Achermann, B., Zaucker, F., Rihm, B., Menzi, H., 2013: Ammoniakemissionen in der Schweiz 1990-2010 und Prognose bis 2020. Berner Fachhochschule. Hochschule für Agrar-, Forst- und Lebensmittelwissenschaften. http://agrammon.ch [03.02.2017]

KWF 2012: P. Harbauer: Forstmaschinenstatistik zeigt deutliche Stabilisierung des Marktes. 17. KWF-Tagung. http://www.kwf-tagung.org/fr/aktuelles/news-detailanzeige/eintrag/39.html [8.02.2017]

LUBW 1995: Stoffbericht Hexachlorbenzol (HCB). Texte und Bericht zur Altlastenbearbeitung 18/95. Landesanstalt für Umweltschutz, Baden-Württemberg, Karlsruhe. Germany. http://www4.lubw.baden-wuerttemberg.de/servlet/is/16795/stoffbericht_hcb.pdf?command=downloadContent&filename=stoffbericht_hcb.pdf [14.02.2017]

Lemieux, P., et al. 2003: Variables affecting emissions of PCDD/Fs from uncontrolled combustion of household waste in barrels. Air & Waste Management Association. 53: 523–531. USA.

Leupro 2012: Entwicklung und Prognose der Emissionsfaktoren Feuerungen für den Zeitraum 1990 – 2035. Leupro im Auftrag des Bundesamtes für Umwelt (BAFU), 2012.

Mejía-Centeno 2007: Effect of low-sulfur fuels upon NH_3 and N_2O emission during operation of commercial three-way catalytic converters. Topics in Catalysis. Volume 42-43, Numbers 1-4.

Meteotest 2013: Rasterung der Emissionsdaten der Schweiz auf 0.1°-Gitter – Mehtodik (Vorstudie). Meteotest im Auftrag des Bundesamtes für Umwelt (BAFU), 2013.

Meteotest 2013a: Rasterung der Emissionsdaten der Schweiz auf 0.1°-Gitter. Dokumentation von Methodik und Exceltool. Meteotest im Auftrag des Bundesamtes für Umwelt (BAFU), 2013.

Meteotest 2015: Datengrundlagen/Verteilschlüssel für GNFR-Tool im MESAP: Anpassungen für die Submission 2015. Aktennotiz zu den GNFR-Anpassungen. Meteotest im Auftrag des Bundesamtes für Umwelt (BAFU), 2015.

Nielsen et al. 2013. Nielsen, O.-K., Plejdrup, M.S., Winther, M., Nielsen, M., Fauser, P., Mikkelsen, M.H., Albrektsen, R., Hjelgaard, K., Hoffmann, L., Thomsen, M., Bruun, H.G.; Danish emission inventory for hexachlorobenzene and polychlorinated biphenyls. Aarhus University, DCE – Danish Centre for Environment and Energy, 65 pp. Scientific Report from DCE – Danish Centre for Environment and Energy No. 103 http://www.dce2.au.dk/pub/SR103.pdf [09.03.2017]

Nussbaumer, T., Hälg, L. 2015: Emissionsfaktoren von Holzfeuerungen – Aktualisierung und Ergänzung 2014. Verenum im Auftrag des Bundesamtes für Umwelt (BAFU) 2015, inkl. Excelfile. (draft)

Off-Highway Research 2005: The Market for Construction Equipment and Agricultural Tractors in Switzerland. Internal document INFRAS Bern. September 2005 [confidential/hardcopy].

Off-Highway Research 2008: The Market for Construction Equipment and Agricultural Tractors in Switzerland. Internal document FOEN. November 2008 [confidential/internal]

Off-Highway Research 2012: The Market for Construction Equipment and Agricultural Tractors in Switzerland. Internal document FOEN. April 2012 [confidential/internal].

OS 2016: Liechtenstein's energy statistics 2015. Office of statistics Liechtenstein. http://www.llv.li/files/as/energiestatistik-2015.pdf [09.02.2017]

Passant et al. 1993: Emissions of volatile organic compounds (VOCs) from the food and drink industries of the European Community, Atmospheric Environment Vol. 27A, No. 16, 1993

Peter, S., Lehmann, B., Valsangiacomo, A. 2010: "Stickstoff 2020" – Möglichkeiten und Einschränkungen zur Vermeidung landwirtschaftlicher Stickstoffemissionen in der Schweiz. Zürich, Switzerland: ETH Zürich, Gruppe Agrar-, Lebensmittel- und Umweltökonomie (AFEE), Institut für Umweltentscheidungen (IED).

Prognos 2012a: Die Energieperspektiven für die Schweiz bis 2050 – Energienachfrage und Elektrizitätsangebot in der Schweiz 2000–2050. Prognos AG im Auftrag des Bundesamtes für Energie, Basel. http://www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=de&name=de_564869151.pdf&endung=Die Energieperspektiven für die Schweiz bis 2050 [08.02.2017]

Prognos 2013: CO_2-Emissionen 1990-2012 von Industrie- und Dienstleistungen, Endbericht / Kurzdokumentation zuhanden Bundesamt für Umwelt, Bern. Prognos, Basel. http://www.bafu.admin.ch/ghginv-ref [08.02.2017]

Quantis 2014: Methanemissionen der Schweizer Gaswirtschaft. Zeitreihe 1990 bis 2012. Schlussbericht. Quantis im Auftrag des Schweizerischen Vereins des Gas- und Wasserfaches SVGW und des Bundesamts für Umwelt BAFU. http://www.bafu.admin.ch/ghginv-ref [08.02.2017]

Reidy, B. and Menzi H. 2005: Ammoniakemissionen in der Schweiz: Neues Emissionsinventar 1990 bis 2000 mit Hochrechnungen bis 2003. Technischer Schlussbericht, HAFL Zollikofen, Bern.

SAEFL 1996: Schadstoffemissionen und Treibstoffverbrauch des Offroad Sektors, Umwelt-Materialien Nr. 49. Elektrowatt Ingenieurunternehmung AG, Zürich; Technik Thermische Maschinen, Niederrohrdorf; Swiss Agency for the Environment, Forests and Landscape, Bern.

SAEFL 2000: Handbuch Emissionsfaktoren für stationäre Quellen. Bundesamt für Umwelt, Wald und Landschaft (BUWAL). Reihe Vollzug Umwelt. Bern.

SBB 2005: PM10-Emissionen des Schienenverkehrs. Schlussbericht Teil SBB, Umwelt-Center der Schweiz. Bundesbahnen. FOEN-internal document. 25. August 2005.

SBV 2013: Betriebsinterne Verrechnungsansätze und Inventar-Grunddaten (BIV) 2013. Schweizerischer Baumeisterverband. Verlag SBV [confidential/internal].

SBV 2016: Statistiques et évaluations concernant l'agriculture et l'alimentation, 2015. [Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung, 2015]. Swiss Farmers Union, Brugg. [available in German and French, partly online, partly hardcopy] http://www.sbv-usp.ch/de/statistik [16.02.2017]

Schjoerring, J.K., Mattsson, M. 2001: Quantification of ammonia exchange between agricultural cropland and the atmosphere: measurements over two complete growth cycles of oilseed rape, wheat, barley and pea. Plant and Soil 228(1), 105-115.

Schwager, S. 2005: Personal communication from Stefan Schwager (FOEN, Bern) to Andreas Liechti (FOEN, Bern), 23.12.2005. http://www.bafu.admin.ch/ghginv-ref [17.02.2017]

SEPA 2010: Sweden's Informative Inventory Report 2010, Submitted under the Convention on Long-Range Transboundary Air Pollution. Swedish Environmental, Protection Agency. http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2010_submissions/ [17.02.2017]

SFOE 1991: Schweizerische Gesamtenergiestatistik 1990. Statistique globale suisse de l'énergie 1990. Swiss Federal Office of Energy, Bern.

SFOE 2015d: Energieverbrauch in der Industrie und im Dienstleistungssektor. Resultate 2014 (German/French). Swiss Federal Office of Energy, Bern. http://www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=de&name=de_567447663.pdf [31.01.2017]

SFOE 2016: Schweizerische Gesamtenergiestatistik 2015. Statistique globale suisse de l'énergie 2015. Swiss Federal Office of Energy, Bern. In German and French. http://www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=de&name=de_83041321.pdf&endung=Schweizerische Gesamtenergiestatistik 2015 [31.01.2017]

SFOE 2016a: Schweizerische Statistik der erneuerbaren Energien (Swiss renewable energy statistics). Ausgabe 2015. Swiss Federal Office of Energy, Bern. http://www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=de&name=de_818961010.pdf&endung=Schweizerische%20Statistik%20der%20erneuerbaren%20Energien [31.01.2017]

SFOE 2016b: Schweizerische Holzenergiestatistik. Erhebung für das Jahr 2015. Swiss Federal Office of Energy, Bern. http://www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=de&name=de_373702251.pdf&endung=Schweizerische%20Holzenergiestatistik [31.01.2017]

SFOE 2016c: Thermische Stromproduktion inklusive Wärmekraftkopplung (WKK) in der Schweiz. Ausgabe 2015. Swiss Federal Office of Energy, Bern. http://www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=de&name=de_481124506.pdf. [31.01.2017]

SFOE 2016d: Energieverbrauch in der Industrie und im Dienstleistungssektor. Resultate 2015 (German/French). Swiss Federal Office of Energy, Bern. http://www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=de&name=de_14044384.pdf [31.01.2017]

SFOE/FOEN 2014: Messung von Heizwerten und CO_2-Emissionsfaktoren von Erdölprodukten 2013. Statistische Analyse der Messresultate, Bern.

SFSO 2007: Federal Statistical Office – Land Use statistics (GEOSTAT) according to 1992 nomeclature.

SFSO 2009: Federal Statistical Office – Census of enterprises (GEOSTST).

SFSO 2009c: Actualités OFS: Prestations du transport privé de personnes par la route, Séries chronologiques actualisées jusqu'en 2008. Swiss Federal Statistical Office (SFSO). Neuchâtel 2010.

SFSO 2010c: Fahrzeugbewegungen und Fahrleistungen im Güterverkehr bis 2014, Neuchâtel 2010. Swiss Federal Statistical Office (SFSO).

SFSO 2011a: Swiss Federal Statistical Office – Statistics of population and households (STATPOP) 2010.

SFSO 2013a: Landwirtschaftliche Betriebszählung – Zusatzerhebung. Swiss Federal Statistical Office (SFSO), Neuchâtel. Internal/confidential.

SFSO 2014b: Background data of the Gross Nutrient Balance of the Swiss Federal Statistical Office (F. Kohler).

SFSO 2015c: Szenarien zur Bevölkerungsentwicklung der Schweiz 2015-2045 (Scenarios of the development of Switzerland's inhabitant 2015-2045); Swiss Federal Office for Statistics, Neuchâtel, Juni 2015 https://www.bfs.admin.ch/bfs/de/home/statistiken/bevoelkerung.gnpdetail.2015-0701.html [16.02.2017]

SFSO 2016: STAT-TAB: Die interaktive Statistikdatenbank; Datenwürfel für Thema 07.2 – Landwirtschaft. Swiss Federal Statistical Office, Neuchâtel. https://www.pxweb.bfs.admin.ch/Default.aspx?px_language=de [queries from database].

SFSO 2016a: Die Bevölkerung der Schweiz 2015. Swiss Federal Statistical Office. Neuchâtel. https://www.bfs.admin.ch/bfsstatic/dam/assets/1401562/master [09.03.2017]

SFSO 2016b: Die Beschäftigungsstatistik der Schweiz 2015. Swiss Federal Office. Neuchâtel. http://www.bfs.admin.ch/bfs/portal/de/index/themen/06/02/blank/data.html [07.02.2017]

SFSO 2016c: vehicle stock numbers are published by the Swiss Federal Statistical Office: https://www.bfs.admin.ch/bfs/en/home/statistics/mobility-transport.html [08.02.2017]

SFSO/BUWAL 2004: Wald und Holz in der Schweiz Jahrbuch 2004. Bundesamt für Statistik (SFSO) und Bundesamt für Umwelt, Wald und Landschaft (BUWAL). Bern.

SKW 2010: Annual reports of the Swiss Cosmetic and Detergent Association. Zurich. http://www.skw-cds.ch/fileadmin/skwcdsch/02_Kosmetik/JB2012E.pdf [07.02.2017]

Stehfest, E., Bouwman, L. 2006: N_2O and NO emission from agricultural fields and soils under natural vegetation: summarizing available measurement data and modeling of global annual emissions. Nutrient Cycling in Agroecosystems 74 (3): 207-228. http://link.springer.com/article/10.1007%2Fs10705-006-9000-7 [03.02.2017]

Sutton, M. A., U. Dragosits, Y. S. Tang, and D. Fowler. 2000: "Ammonia Emissions From Non-Agricultural Sources in the UK." Atmospheric Environment 34(6): 855-869

Swiss Confederation 1983: Loi fédérale du 7 octobre 1983 sur la protection de l'environnement (Loi sur la protection de l'environnement, LPE). As at 1 August 2008. http://www.admin.ch/ch/f/rs/c814_01.html [official text in German, French and Italian] [03.02.2017]

Swiss Confederation 1985: Ordonnance du 16 décembre 1985 sur la protection de l'air (OPair). [Swiss Federal Ordinance on Air Pollution Control]. As at 1 January 2009: Annex. http://www.admin.ch/ch/f/rs/c814_318_142_1.html [official text in German, French and Italian] [27.01.2017]
https://www.admin.ch/opc/en/classified-compilation/19850321/index.html [27.01.2017; English; as at 28 March 2000]

Swiss Confederation 1993: Verordnung über die Abgasemissionen von Schiffsmotoren auf schweizerischen Gewässern. As at 1 June 2007. https://www.admin.ch/opc/de/classified-compilation/19930362/index.html [official text in German/French/Italian] [09.02.2017]

Swiss Confederation 1995: Ordinance of 19 June 1995 on the Technical Standards for Motor Vehicles and Their Trailors (TAFV1). As at 1 July 2008. http://www.admin.ch/ch/d/sr/c741_412.html [official text in German/French/Italian] [03.02.2017]

Swiss Confederation 1997: Ordonnance du 12 novembre 1997 sur la taxe d'incitation sur les composés organiques volatils (OCOV). As at 1 January 2009. http://www.admin.ch/ch/f/rs/c814_018.html [official text in German/French/Italian] [03.02.2017]

Swiss Confederation 1999a: Federal Law of 8 October 1999 on the reduction of the CO_2 emissions (CO_2G). As at 1 May 2007. 641.71. http://www.admin.ch/ch/d/sr/c641_71.html [official text in German, French and Italian] [03.02.2017]

Swiss Confederation 2004: Botschaft zur Ratifikation des Protokolls vom 30. November 1999 zum Übereinkommen von 1979 über weiträumige grenzüberschreitende Luftverunreinigung, betreffend die Verringerung von Versauerung, Eutrophierung und bodennahem Ozon. http://www.admin.ch/ch/d/ff/2004/3013.pdf [03.02.2017]

Swiss Confederation 2009: Bericht zum Konzept betreffend Lufthygienischen Massnahmen des Bundes (LRK) vom 11. September 2009. http://www.admin.ch/ch/d/ff/2009/6585.pdf [03.02.2017]

Swiss Confederation 2011: Ordonnance sur le traitement des déchets (OTD). As at 1 July 2011 [official text in German/French/Italian http://www.admin.ch/opc/fr/classified-compilation/19900325/index.html [08.03.2017]

Swiss Confederation 2012: Verordnung über die Reduktion der CO_2-Emissionen (CO_2-Verordnung). As of 12.2.2013.

http://www.admin.ch/ch/d/sr/c641_711.html [31.01.2017]

Swiss Confederation 2013: Verordnungspaket zur Agrarpolitik 2014-2017. Schweizerischer Bundesrat.Bern. https://www.blw.admin.ch/blw/de/home/politik/agrarpolitik/ap-14-17/verordnungspaket-ap-14-17.html [17.02.2017]

Swiss TS 2013: Quality Management according to ISO 9001:2008 Certificate. Certified area: National Inventory System and Reporting under the UNFCCC and the Kyoto Protocol. Registration number: 13-299-113. Issued 25.11.2013.

TBF 2015: Neubearbeitung des Projektes "LEA - Emissionsfaktoren aus der Abfallverbrennung". Schlussbericht. Zürich, 22. September 2015.

Theloke et al. 2000: Ermittlung der Lösemittelemissionen 1994 in Deutschland und Methoden zur Fortschreibung. Institut für Energiewirtschaft und Rationelle Energieanwendung (IER) der Universität Stuttgart.Forschungsbericht 295 42 628. Im Auftrag des Umweltbundesamtes. https://www.umweltbundesamt.de/publikationen/ermittlung-loesemittelemissionen-1994-in [16.02.2017]

Theloke, J. 2005: NMVOC-Emissionen aus der Lösemittelanwendung und Möglichkeiten zu ihrer Minderung. Fortschritt-Berichte VDI Reihe 15 Nr. 252. Düsseldorf: VDI-Verlag. http://elib.uni-stuttgart.de/opus/volltexte/2005/2339/ [16.02.2017]

TUG 2009: Emission Factors from the Model PHEM for the HBEFA Version 3, Institute for Internal Combustion Engines and Thermodynamics. Report Nr. I-20/2009 Haus-Em 33/08/679 from 07.12.2009. Graz. http://www.hbefa.net/e/documents/HBEFA_31_Docu_hot_emissionfactors_PC_LCV_HDV.pdf [07.02.2017]

UNECE 2010: Report for the Stage 3 in-depth review of emission inventories submitted under the UNECE LRTAP Convention and EU National Emissions Ceilings, CEIP/S3.RR/2010/SWITZERLAND, 24.11.2010

UNECE 2016: Stage 1 review report and Stage 2 review data from the Annual Synthesis & Assessment CLRTAP Inventory review http://www.ceip.at/ms/ceip_home1/ceip_home/review_results/review_results_2016/ [27.01.2017]

UNECE 2016a: Report for the Stage 3 in-depth review of emission inventories submitted under the UNECE LRTAP Convention and EU National Emissions Ceilings, CEIP/S3.RR/2016/SWITZERLAND, 26.09.2016

UNFCCC 2014a: Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention. Decision 24/CP.19 (FCCC/CP/2013/10/Add.3)
http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf [07.02.2017]

US-EPA 1995: Compilation of air pollutant emission factors, Chapter 10.7 Charcoal. https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emission-factors [09.03.2017]

US-EPA 1998a: Miscellaneous open burning", Table 4.10.5-1 (Open burning of Municipal Refuse), Locating and Estimating Air Emissions from Sources of Polycyclic Organic Matter.

US-EPA 1998b: Open burning of scrap tires", Table 4.10.2, Locating and Estimating Air Emissions from Sources of Polycyclic Organic Matter.

Vanderweerden, T. J. and Jarvis, S. C. 1997: Ammonia Emission Factors for N Fertilizers Applied to Two Contrasting Grassland Soils. Environmental Pollution. Volume 95, Issue 2, 1997, Pages 205–211
http://www.sciencedirect.com/science/article/pii/S0269749196000991 [03.02.2017]

VSG 2016: Jahresbericht VSG 2015. Swiss gas industry association – annual report. http://www.erdgas.ch/fileadmin/customer/erdgasch/Data/Broschueren/JB_VSG/erdgas_JB_2015_d.pdf [09.02.2017]

Wevers 2004: M.Wevers et al., Effect of backyard burning on dioxin deposition and air concetrations. Chemosphere 54, pp. 1351-1356.

Zimmermann, A., Möhring, A., Mack, G., Mann, S., Ferjani, A., Gennai, M.-P. 2011: Die Auswirkungen eines weiterentwickelten Direktzahlungssystems. Modellberechnungen mit SILAS und SWISSland. ART Bericht Nr. 744.

12.2 Assignment of EMIS Categories to NFR Code

Table 12-1: Assignements of NFR Code to titles of EMIS database comments. For the CLRTAP Inventory the Code in [violet] are relevant. Green cell: new comment.

NFR Code CRF [UNECE]	EMIS Title	NFR Code CRF [UNECE]	EMIS Title
1 A 1 a & 2 A 4 d	Kehrichtverbrennungsanlagen	2 D 3 a [2 D 3 g]	Klebstoff-Produktion
1 A 1 a	Sondermüllverbrennungsanlagen	2 D 3 a [2 D 3 g]	Lösungsmittel-Umschlag und -Lager
1 A 1 a & 5 A	Kehrichtdeponien	2 D 3 a [2 D 3 g]	Pharmazeutische Produktion**
1 A 1 a & 5 B 2	Vergärung IG (industriell-gewerblich)	2 D 3 a [2 D 3 g]	Polyester-Verarbeitung
1 A 1 a & 5 B 2	Vergärung LW (landwirtschaftlich)	2 D 3 a [2 D 3 g]	Polystyrol-Verarbeitung
1 A 1 c	Holzkohle Produktion	2 D 3 a [2 D 3 g]	Polyurethan-Verarbeitung
1 A 2 a & 2 A 4 d	Eisengiessereien Kupolöfen	2 D 3 a [2 D 3 g]	PVC-Verarbeitung
1 A 2 a	Stahl-Produktion Wärmeöfen**	2 D 3 a [2 D 3 g]	Gerben von Ledermaterialien
1 A 2 b	Buntmetallgiessereien übriger Betrieb**	2 D 3 b	Strassenbelagsarbeiten**
1 A 2 b & 2 C 3	Aluminium Produktion	2 D 3 c	Dachpappen Produktion Emissionen aus Bitumen
1 A 2 c & 2 B 8 b [2 B 10 a]	Ethen-Produktion*	2 D 3 c	Dachpappen Produktion Voranstrich
1 A 2 d & 2 A 4 d	Zellulose-Produktion Feuerung*	2 D 3 c	Dachpappen Verlegung Bitumen
1 A 2 f	Kalkproduktion, Feuerung*	2 D 3 c	Dachpappen Verlegung Voranstrich
1 A 2 f	Mischgut Produktion	2 D 3 d	Urea (AdBlue) Einsatz Strassenverkehr
1 A 2 f	Zementwerke Feuerung	2 G 3 a	Lachgasanwendung Spitäler**
1 A 2 f & 2 A 3	Glas übrige Produktion*	2 G 3 b	Lachgasanwendung Haushalt**
1 A 2 f & 2 A 3	Glaswolle Produktion Rohprodukt*	2 G 4 [2 D 3 a]	Pharma-Produkte im Haushalt
1 A 2 f & 2 A 3	Hohlglas Produktion*	2 G 4 [2 D 3 a]	Reinigungs- und Lösemittel; Haushalte
1 A 2 f & 2 A 4 a	Feinkeramik Produktion*	2 G 4 [2 D 3 a]	Spraydosen Haushalte**
1 A 2 f & 2 A 4 a	Ziegeleien**	2 G 4 [2 D 3 h]	Verpackungsdruckereien**
1 A 2 f & 2 A 4 d	Steinwolle Produktion*	2 G 4 [2 D 3 h]	Druckereien uebrige
1 A 2 g iv	Faserplatten Produktion**	2 G 4 [2 D 3 i]	Entfernung von Farben und Lacken
1 A 3 a & 1 A 5	Flugverkehr	2 G 4 [2 D 3 i]	Entwachsung von Fahrzeugen
1 A 3 b i-viii	Strassenverkehr	2 G 4 [2 D 3 i]	Kosmetika-Produktion**
1 A 3 c	Schienenverkehr	2 G 4 [2 D 3 i]	Lösungsmittel-Emissionen IG nicht zugeordnet
1 A 3 e	Gastransport Kompressorstation	2 G 4 [2 D 3 i]	Öl- und Fettgewinnung
1 A 4 b i	Holzkohle-Verbrauch	2 G 4 [2 D 3 i]	Papier- und Karton-Produktion**
1 A 4 b i	Lagerfeuer	2 G 4 [2 D 3 i]	Parfum- und Aromen-Produktion**
1 A 4 c i	Grastrocknung**	2 G 4 [2 D 3 i]	Tabakwaren Produktion**
1 B 2 a iv	Raffinerie, Leckverluste	2 G 4 [2 D 3 i]	Textilien-Produktion
1 B 2 a v	Benzinumschlag Tanklager	2 G 4 [2 D 3 i]	Wissenschaftliche Laboratorien
1 B 2 a v	Benzinumschlag Tankstellen	2 G 4 [2 G]	Korrosionsschutz im Freien
1 B 2 b ii	Gasproduktion	2 G 4 [2 G]	Betonzusatzmittel-Anwendung
1 B 2 b iv-vi	Netzverluste Erdgas	2 G 4 [2 G]	Coiffeursalons
1 B 2 c	Raffinerie, Abfackelung	2 G 4 [2 G]	Fahrzeug-Unterbodenschutz**
1 Energy Model***	Energie New	2 G 4 [2 G]	Feuerwerke
1A	Holzfeuerungen	2 G 4 [2 G]	Flugzeug-Enteisung
1A2g vii, 1A3c, 1A3e, 1A5b (	Off-Road	2 G 4 [2 G]	Gas-Anwendung
2 A 1	Zementwerke Rohmaterial	2 G 4 [2 G]	Gesundheitswesen, übrige**
2 A 1	Zementwerke übriger Betrieb	2 G 4 [2 G]	Glaswolle Imprägnierung*
2 A 2	Kalkproduktion, Rohmaterial*	2 G 4 [2 G]	Holzschutzmittel-Anwendung
2 A 2	Kalkproduktion, übriger Betrieb*	2 G 4 [2 G]	Klebstoff-Anwendung
2 A 4 d	Karbonatanwendung weitere	2 G 4 [2 G]	Kosmetik-Institute
2 A 5 a	Gips-Produktion übriger Betrieb**	2 G 4 [2 G]	Kühlschmiermittel-Verwendung
2 A 5 a	Kieswerke	2 G 4 [2 G]	Medizinische Praxen**
2 B 1	Ammoniak-Produktion*	2 G 4 [2 G]	Pflanzenschutzmittel-Verwendung
2 B 10 [2 B 10 a]	Ammoniumnitrat-Produktion*	2 G 4 [2 G]	Reinigung Gebäude IGD**
2 B 10 [2 B 10 a]	Chlorgas-Produktion*	2 G 4 [2 G]	Schmierstoff-Verwendung
2 B 10 [2 B 10 a]	Essigsäure-Produktion*	2 G 4 [2 G]	Spraydosen IndustrieGewerbe
2 B 10 [2 B 10 a]	*Formaldehyd-Produktion*	2 G 4 [2 G]	Tabakwaren Konsum
2 B 10 [2 B 10 a]	PVC-Produktion	2 G 4 [2 G]	Steinwolle-Imprägnierung*
2 B 10 [2 B 10 a]	*Salzsäure-Produktion**	2 H 1	Faserplatten Produktion**
2 B 10 [2 B 10 a]	Schwefelsäure-Produktion*	2 H 1	Zellulose Produktion übriger Betrieb*
2 B 10	Kalksteingrube*	2 H 1	Spanplatten Produktion*
2 B 10	Niacin-Produktion*	2 H 2	Bierbrauereien
2 B 2	Salpetersäure Produktion*	2 H 2	Branntwein Produktion
2 B 5	Graphit und Siliziumkarbid Produktion*	2 H 2	Brot Produktion
2 C - 2 G	Synthetische Gase	2 H 2	Fleischräuchereien
2 C 1	Eisengiessereien Elektroschmelzöfen	2 H 2	Kaffeeröstereien
2 C 1	Eisengiessereien übriger Betrieb	2 H 2	Müllereien
2 C 1	Stahl-Produktion Elektroschmelzöfen**	2 H 2	Wein Produktion
2 C 1	Stahl-Produktion übriger Betrieb**	2 H 2	Zucker Produktion
2 C 1	Stahl-Produktion Walzwerke**	2 H 3	Sprengen und Schiessen
2 C 7 a	Buntmetallgiessereien Elektroöfen**	2 I	Holzbearbeitung
2 C 7 c	Verzinkereien	2 L	NH3 aus Kühlanlagen
2 C 7 c	Batterie-Recycling*	3	Landwirtschaft
2 D 1	Schmiermittel-Anwendung	3 C	Reisanbau
2 D 2	Paraffinwachs-Anwendung	5 B 1	Kompostierung Industrie
2 D 3 a [2 D 3 d]	Farben-Anwendung Bau	5 B 1	Kompostierung, Verbreitung als Dünger im Haushalt
2 D 3 a [2 D 3 d]	Farben-Anwendung andere	5 B 2	Biogasaufbereitung (Methanverlust)
2 D 3 a [2 D 3 d]	Farben-Anwendung Haushalte**	5 C 1 [5 C 1 a]	Abfallverbrennung illegal
2 D 3 a [2 D 3 d]	Farben-Anwendung Holz	5 C 1 [5 C 1 b i]	Kabelabbrand
2 D 3 a [2 D 3 d]	Farben-Anwendung Autoreparatur	5 C 1 [5 C 1 b iii]	Spitalabfallverbrennung
2 D 3 a [2 D 3 e]	Elektronik-Reinigung	5 C 1 [5 C 1 b iv]	Klärschlammverbrennung
2 D 3 a [2 D 3 e]	Metallreinigung	5 C 1 [5 C 1 b v]	Krematorien
2 D 3 a [2 D 3 e]	Reinigung Industrie übrige	5 C 2	Abfallverbrennung Land- und Forstwirtschaft
2 D 3 a [2 D 3 f]	Chemische Reinigung**	5 D 1 [5 D]	Kläranlagen kommunal (Luftschadstoffe)
2 D 3 a [2 D 3 g]	Druckfarben Produktion	5 D 2 [5 D]	Kläranlagen industriell (Luftschadstoffe)
2 D 3 a [2 D 3 g]	Farben-Produktion	5 D 1 / 5 D 2 [5 D]	Kläranlagen GHG
2 D 3 a [2 D 3 g]	Feinchemikalien-Produktion**	5 E	Shredder Anlagen
2 D 3 a [2 D 3 g]	Gummi-Verarbeitung**	6 A d	Brand- und Feuerschäden Immobilien
2 D 3 a [2 D 3 g]	Klebband-Produktion	6 A d	Brand- und Feuerschäden Motorfahrzeuge

* confidential process
** confidential EMIS comment
*** work in progress
Prozess nicht relevant für Inventar ab 1990
Neue Kommentare

Annexes

Annex 1: Key Category Analysis (KCA)

The following table shows a summary of the key categories.

Table A - 1: Summary of Switzerland's Approach 1 level key categories 2015.

NFR	Source Category	Pollutant	Identification Criteria
1A1a	Public Electricity and Heat Production	NOx	L1
1A1a	Public Electricity and Heat Production	PM10	T1
1A1a	Public Electricity and Heat Production	PM2.5	T1
1A1a	Public Electricity and Heat Production	SO2	T1
1A1b	Petroleum Refining	SO2	L1, T1
1A2d	Pulp Paper and Print	SO2	T1
1A2e	Food Processing Beverages and Tobacco	SO2	T1
1A2f	Non Metallic Minerals	NOx	L1, T1
1A2f	Non Metallic Minerals	PM10	T1
1A2f	Non Metallic Minerals	PM2.5	T1
1A2f	Non Metallic Minerals	SO2	L1, T1
1A2gvii	Off Road Vehicles and Other Machinery	NOx	L1
1A2gvii	Off Road Vehicles and Other Machinery	PM10	L1, T1
1A2gvii	Off Road Vehicles and Other Machinery	PM2.5	L1
1A2gviii	Other Boilers and Engines Industry	NOx	T1
1A2gviii	Other Boilers and Engines Industry	PM10	L1
1A2gviii	Other Boilers and Engines Industry	PM2.5	L1, T1
1A2gviii	Other Boilers and Engines Industry	SO2	L1
1A3ai(i)	International Aviation	NOx	T1
1A3ai(i)	International Aviation	SO2	T1
1A3bi	Passenger Cars	NH3	T1
1A3bi	Passenger Cars	NMVOC	L1, T1
1A3bi	Passenger Cars	NOx	L1, T1
1A3bi	Passenger Cars	PM10	L1
1A3bi	Passenger Cars	PM2.5	L1
1A3bi	Passenger Cars	SO2	T1
1A3bii	Light Duty Trucks	NOx	L1, T1
1A3biii	Heavy Duty Trucks and Busses	NOx	L1, T1
1A3biii	Heavy Duty Trucks and Busses	PM10	T1
1A3biii	Heavy Duty Trucks and Busses	PM2.5	L1, T1
1A3biii	Heavy Duty Trucks and Busses	SO2	T1
1A3bv	Other and Evaporation	NMVOC	T1
1A3bvi	Tyre and Brake Wear	PM10	L1, T1
1A3bvi	Tyre and Brake Wear	PM2.5	L1, T1
1A3c	Railways	PM10	L1, T1
1A3c	Railways	PM2.5	L1, T1
1A3d	Domestic Navigation	NOx	T1

Continued: Table A - 1: Summary of Switzerland's Approach 1 level key categories 2015.

NFR	Source Category	Pollutant	Identification Criteria
1A4ai	Stationary Combustion	NOx	L1
1A4ai	Stationary Combustion	PM10	L1, T1
1A4ai	Stationary Combustion	PM2.5	L1, T1
1A4ai	Stationary Combustion	SO2	L1
1A4bi	Stationary Combustion	NMVOC	L1
1A4bi	Stationary Combustion	NOx	L1
1A4bi	Stationary Combustion	PM10	L1, T1
1A4bi	Stationary Combustion	PM2.5	L1, T1
1A4bi	Stationary Combustion	SO2	L1
1A4ci	Stationary Combustion	PM2.5	T1
1A4cii	Off Road Machinery	NOx	L1, T1
1A4cii	Off Road Machinery	PM10	L1, T1
1A4cii	Off Road Machinery	PM2.5	L1, T1
1B2aiv	Refining and Storage	SO2	
1B2av	Distribution of Oil Products	NMVOC	T1
2A5a	Quarrying and mining of minerals	PM10	L1
2A5a	Quarrying and mining of minerals	PM2.5	L1, T1
2B5	Carbide production	SO2	L1, T1
2C1	Iron and steel production	PM10	T1
2C1	Iron and steel production	PM2.5	T1
2D3a	Domestic solvent use	NMVOC	L1, T1
2D3b	Road paving with asphalt	NMVOC	L1, T1
2D3d	Coating applications	NMVOC	L1, T1
2D3e	Degreasing	NMVOC	L1
2D3g	Chemical products	NMVOC	L1, T1
2D3h	Printing	NMVOC	L1, T1
2D3i	Other Solvent Use	NMVOC	L1
2G	Other Product Use	NMVOC	L1, T1
2G	Other Product Use	PM2.5	L1, T1
2G	Other Product Use	PM10	L1
2H1	Pulp and paper	PM2.5	L1, T1
2H2	Food and beverages industry	NMVOC	L1, T1
2H2	Food and beverages industry	PM2.5	L1
2I	Wood processing	PM10	T1
3B1a	Manure management - Dairy cattle	NH3	L1, T1
3B1b	Manure management - Non-dairy cattle	NH3	L1, T1
3B3	Swine	NH3	L1
3B3	Swine	PM10	L1
3B4gi	Layers	PM10	L1, T1
3B4gi	Layers	PM2.5	T1
3Da1	Inorganic N-fertilizers (includes also urea application)	NH3	T1
3Da2a	Animal manure applied to soils	NH3	L1, T1
3Da2a	Animal manure applied to soils	NOx	T1
3Da2b	Sewage sludge applied to soils	NH3	T1
3Da3	Urine and dung deposited by grazing animals	NH3	T1
3Db	Indirect Emissions from managed soils	NH3	L1
3Db	Indirect Emissions from managed soils	NMVOC	L1, T1
5C1a	5 C 1 a - Municipal Waste Incineration	PM2.5	L1

Annex 2: Other Detailed Methodological Descriptions for Individual Source Categories

A2.1 Sector Energy: non-road vehicles

A2.1.1 Emission and fuel consumption factors for non-road vehicles

As mentioned in chp. 3.2.1.1.1 (non-road transportation model), emission factors and activity data can be downloaded by query from the non-road database INFRAS (2015a[8]), which is the data pool of FOEN (2015j). They can be queried by year, non-road family, machine type, engine type (diesel, gasoline), engine capacity (power class) and emission concept (standard), pollutant either at aggregated or disaggregated levels. The following table illustrates a query for construction machinery.

Table A - 2: Excerpt of the non-road database INFRAS (2015a).

Construction machinery, 2010								
Machine type	Engine type	Engine capacity	Emission concept	Poll.	Op. hrs. (h/a)	EF (kg/h)	EF [w/o PF] (kg/h)	EF [100% PF] (kg/h)
Road finishing machines	diesel	18-37 kW	Nonr D PreEUB	PM	112.7	0.0074	0.0074	0.0007
Road finishing machines	diesel	18-37 kW	Nonr D EU2	PM	259.9	0.0045	0.0045	0.0005
Road finishing machines	diesel	18-37 kW	Nonr D EU3A	PM	305.8	0.0006	0.0046	0.0005
Road finishing machines	diesel	37-75 kW	Nonr D PreEUB	PM	130.1	0.0133	0.0133	0.0013
Road finishing machines	diesel	37-75 kW	Nonr D EU1	PM	248.6	0.0073	0.0073	0.0007
Road finishing machines	diesel	37-75 kW	Nonr D EU2	PM	327.8	0.0014	0.0047	0.0005
Road finishing machines	diesel	37-75 kW	Nonr D EU3A	PM	357.7	0.0005	0.0053	0.0005
Road finishing machines	diesel	75-130 kW	Nonr D PreEUB	PM	138.8	0.0129	0.0129	0.0013
Road finishing machines	diesel	75-130 kW	Nonr D EU1	PM	239.4	0.0096	0.0096	0.001
Road finishing machines	diesel	75-130 kW	Nonr D EU2	PM	332.7	0.0031	0.0062	0.0006
Road finishing machines	diesel	75-130 kW	Nonr D EU3A	PM	376.4	0.0007	0.007	0.0007
Hydraulic rammers of all types	diesel	75-130 kW	Nonr D PreEUB	PM	131.7	0.0104	0.0104	0.001
Hydraulic rammers of all types	diesel	75-130 kW	Nonr D EU1	PM	227.2	0.0077	0.0077	0.0008
Hydraulic rammers of all types	diesel	75-130 kW	Nonr D EU2	PM	315.7	0.0025	0.005	0.0005
Hydraulic rammers of all types	diesel	75-130 kW	Nonr D EU3A	PM	357.2	0.0005	0.0048	0.0005
Rolling mill engines of all types	diesel	<18 kW	Nonr D PreEUB	PM	130.9	0.005	0.005	0.0005
Rolling mill engines of all types	diesel	<18 kW	Nonr D EU1	PM	250.1	0.0042	0.0042	0.0004
Rolling mill engines of all types	diesel	<18 kW	Nonr D EU2	PM	329.7	0.0032	0.0032	0.0003
Rolling mill engines of all types	diesel	<18 kW	Nonr D EU3A	PM	359.8	0.0029	0.0032	0.0003
Rolling mill engines of all types	diesel	18-37 kW	Nonr D PreEUB	PM	148.3	0.0077	0.0077	0.0008
Rolling mill engines of all types	diesel	18-37 kW	Nonr D EU2	PM	341.8	0.0046	0.0046	0.0005
Rolling mill engines of all types	diesel	18-37 kW	Nonr D EU3A	PM	402.3	0.0006	0.0047	0.0005
Rolling mill engines of all types	diesel	37-75 kW	Nonr D PreEUB	PM	168.8	0.0138	0.0138	0.0014
Rolling mill engines of all types	diesel	37-75 kW	Nonr D EU1	PM	322.6	0.0076	0.0076	0.0008
Rolling mill engines of all types	diesel	37-75 kW	Nonr D EU2	PM	425.3	0.0014	0.0048	0.0005
Rolling mill engines of all types	diesel	37-75 kW	Nonr D EU3A	PM	464.1	0.0005	0.0054	0.0005
Rolling mill engines of all types	diesel	75-130 kW	Nonr D PreEUB	PM	174.5	0.0133	0.0133	0.0013
Rolling mill engines of all types	diesel	75-130 kW	Nonr D EU1	PM	301	0.0099	0.0099	0.001
Rolling mill engines of all types	diesel	75-130 kW	Nonr D EU2	PM	418.3	0.0032	0.0064	0.0006
Rolling mill engines of all types	diesel	75-130 kW	Nonr D EU3A	PM	473.2	0.0007	0.0071	0.0007
Rolling mill engines of all types	diesel	130-300 kW	Nonr D PreEUB	PM	174.5	0.0279	0.0279	0.0028
Rolling mill engines of all types	diesel	130-300 kW	Nonr D EU2	PM	387.1	0.0068	0.0094	0.0009
Rolling mill engines of all types	diesel	130-300 kW	Nonr D EU3A	PM	467.7	0.001	0.0104	0.001
Mechanical vibrators	diesel	18-37 kW	Nonr D PreEUB	PM	100.6	0.0059	0.0059	0.0006
Mechanical vibrators	diesel	18-37 kW	Nonr D EU2	PM	232	0.0036	0.0036	0.0004
Mechanical vibrators	diesel	18-37 kW	Nonr D EU3A	PM	273	0.0004	0.0031	0.0003
Mechanical vibrators	diesel	37-75 kW	Nonr D PreEUB	PM	131.3	0.0108	0.0108	0.0011
Mechanical vibrators	diesel	37-75 kW	Nonr D EU1	PM	250.9	0.0059	0.0059	0.0006
Mechanical vibrators	diesel	37-75 kW	Nonr D EU2	PM	330.7	0.0011	0.0038	0.0004
Mechanical vibrators	diesel	37-75 kW	Nonr D EU3A	PM	361	0.0004	0.0036	0.0004
Mechanical vibrators	diesel	75-130 kW	Nonr D PreEUB	PM	140	0.0105	0.0105	0.0011
Mechanical vibrators	diesel	75-130 kW	Nonr D EU1	PM	241.6	0.0078	0.0078	0.0008
Mechanical vibrators	diesel	75-130 kW	Nonr D EU2	PM	335.8	0.0025	0.0051	0.0005
Mechanical vibrators	diesel	75-130 kW	Nonr D EU3A	PM	379.8	0.0005	0.0048	0.0005

[8] https://www.bafu.admin.ch/bafu/en/home/topics/air/state/non-road-datenbank.html [07.02.2017]

A2.1.2 Activity data non-road vehicles

The following table gives an overview on the stock and the operating hours of non-road vehicles (FOEN 2015j).

Table A - 3: Number of vehicles, specific operating hours per year and total operating hours per year for all non-road families (FOEN 2015j).

Category	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**
	number of vehicles					
Construction machinery	63'364	58'816	52'729	57'102	60'384	62,726
Industrial machinery	26'714	43'244	70'671	69'786	69'757	70,083
Agricultural machinery	292'773	324'567	337'869	318'876	309'825	305,235
Forestry machinery	11'815	13'844	13'055	11'857	10'831	10,170
Garden-care / hobby appliances	1'198'841	1'539'624	1'944'373	2'322'737	2'464'323	2,499,627
Navigation machinery	94'866	103'383	93'912	95'055	97'522	99,104
Railway machinery	529	1'300	1'255	697	640	640
Military machinery	13'092	13'373	14'272	13'083	12'853	12,856

Category	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**
	Specific operating hours per year					
Construction machinery	247	322	406	417	424	429
Industrial machinery	666	670	684	680	675	671
Agricultural machinery	136	119	112	103	99	95
Forestry machinery	203	199	203	193	188	182
Garden-care / hobby appliances	12	17	20	64	77	81
Navigation machinery	39	38	38	36	35	35
Railway machinery	877	613	617	783	719	719

Category	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**
	million operating hours per year					
Construction machinery	15.7	19.0	21.4	23.8	25.6	26.9
Industrial machinery	17.8	29.0	48.4	47.5	47.1	47.0
Agricultural machinery	39.9	38.8	37.7	33.0	30.6	29.0
Forestry machinery	2.4	2.8	2.6	2.3	2.0	1.9
Garden-care / hobby appliances	14.6	25.7	39.3	149.7	190.8	201.3
Navigation machinery	3.7	3.9	3.5	3.4	3.4	3.4
Railway machinery	0.5	0.8	0.8	0.5	0.5	0.5
Military machinery	0.8	0.9	0.9	0.9	0.9	0.9
Total	**95**	**121**	**155**	**261**	**301**	**311**

Annex 3: Further Elaboration of Completeness Use of IE and (Potential) Sources of Air Pollutant Emissions Excluded

Table A - 4: Explanation of the NE Notation key from NFR table 2 Add Info from Submission 2017.

NFR code	Substance(s)	Reason for not estimation
all	PCB	Lack of data. Emissions will be considered when ongoing study on application of PCB in Switzerland is available.
all	As, Cr, Cu, Ni, Se, Zn	Lack of data
2 A 5 a	BC	no EF available
2 B 5	BC, CO	no EF available
2 C 7 c	BC	no EF available
2 H 2	BC	no EF available
2 H 3	BC	no EF available
3 B	NMVOC	Lack of data. Emissions will be considered when ongoing study is available.
3 D c	PM2.5, PM10, TSP	Lack of data. Emissions will be considered when ongoing study is available.

NFR code	Substance(s)	Reason for not estimation
all	PCB	Lack of data. Emissions will be considered when ongoing study on application of PCB in Switzerland is available.
all	As, Cr, Cu, Ni, Se, Zn	Lack of data
2 A 5 a	BC	no EF available
2 B 5	BC, CO	no EF available
2 C 7 c	BC	no EF available
2 H 2	BC	no EF available
2 H 3	BC	no EF available
3 B	NMVOC	Lack of data. Emissions will be considered when ongoing study is available.
3 D c	PM2.5, PM10, TSP	Lack of data. Emissions will be considered when ongoing study is available.

Table A - 5: Explanation of the IE Notation key from NFR table 2 Add Info from Submission 2017.

NFR code	Substance(s)	Included in NFR code
1 A 3 b vii	Biomass	1 A 3 b i, 1A3biii
1 A 3 b vii	PM2.5	1 A 3 b vi
1 A 3 b vii	PM10	1 A 3 b vi
1 A 3 b vii	TSP	1 A 3 b vi
1 A 3 b vii	BC	1 A 3 b vi
1 A 3 b vii	Cd	1 A 3 b vi
1 A 4 c iii	All	1 A 4 c ii
2 A 3	NOx, SOx, PM2.5, PM10, TSP, BC, CO, Pb, Cd, Hg	1 A 2 f
2 B 1	NMVOC	2 B 10 a
2 D 3 b	PM2.5, PM10, TSP, BC	1 A 2 f
2 D 3 c	NMVOC	2 D 3 i (1980-1989)
2 D 3 e	NMVOC	2 D 3 i (1980-1989)
2 D 3 f	NMVOC	2 D 3 i (1980-1989)
2 D 3 g	NMVOC	2 D 3 i (1980-1989)
2 D 3 h	NMVOC	2 D 3 i (1980-1989)
3B4gii	PM2.5, PM10, TSP	3B4gi
3B4giii	PM2.5, PM10, TSP	3B4gi
3B4giv	PM2.5, PM10, TSP	3B4gi
3B4f	NOx, NH3, PM2.5, PM10, TS	3B4e (for the years 1980-1989)
3Da2a	NH3	3B1-3B4 (for the years 1980-1989)
3Da2c	NOx, NH3	3Da1 (for the years 1980-1989)
3Da3	NOx, NH3	3B1-3B4 (for the years 1980-1989)
3Db	NMVOC, NH3	3Da1 (for the years 1980-1989)

NFR code	Substance(s)	Included in NFR code
1 A 3 b vii	Biomass	1 A 3 b i, 1A3biii
1 A 3 b vii	PM2.5	1 A 3 b vi
1 A 3 b vii	PM10	1 A 3 b vi
1 A 3 b vii	TSP	1 A 3 b vi
1 A 3 b vii	BC	1 A 3 b vi
1 A 3 b vii	Cd	1 A 3 b vi
1 A 4 c iii	All	1 A 4 c ii
2 A 3	NOx, SOx, PM2.5, PM10, TSP, BC, CO, Pb, Cd, Hg	1 A 2 f
2 B 1	NMVOC	2 B 10 a
2 D 3 b	PM2.5, PM10, TSP, BC	1 A 2 f
2 D 3 c	NMVOC	2 D 3 i (1980-1989)
2 D 3 e	NMVOC	2 D 3 i (1980-1989)
2 D 3 f	NMVOC	2 D 3 i (1980-1989)
2 D 3 g	NMVOC	2 D 3 i (1980-1989)
2 D 3 h	NMVOC	2 D 3 i (1980-1989)
3B4gii	PM2.5, PM10, TSP	3B4gi
3B4giii	PM2.5, PM10, TSP	3B4gi
3B4giv	PM2.5, PM10, TSP	3B4gi
3B4f	NOx, NH3, PM2.5, PM10, T	3B4e (for the years 1980-1989)
3Da2a	NH3	3B1-3B4 (for the years 1980-1989)
3Da2c	NOx, NH3	3Da1 (for the years 1980-1989)
3Da3	NOx, NH3	3B1-3B4 (for the years 1980-1989)
3Db	NMVOC, NH3	3Da1 (for the years 1980-1989)

Table A - 6: List of sub-sources accounted for in reporting codes "other" in inventory 2015 of submission 2017.

NFR code	Substance(s) reported	Sub-source description
1A2gviii	NOx, NMVOC, SOx, NH3, PM2.5, PM10, TSP, BC, CO, Pb, Cd, Hg, PCDD/PCDF, PAH, HCB	industrial combustion of wood and wood waste, other boilers and engines in industry, fibreboard production
1A3eii	-	NO
1A5a	-	NO
1A5b	NOx, NMVOC, SOx, NH3, PM2.5, PM10, TSP, CO, Pb, PCDD/PCDF, PAH	Military mobile only (aviation and off-roads)
1B1c	-	NO
1B2d	-	NO
2 B 10 a	NMVOC, SOx, NH3, PM2.5, PM10, TSP, CO, Hg	Acetic acid, ammonium nitrate, chlorine gas, ehtylene, formaldehyde (until 1989), PVC (until 1996) and sulphuric acid
2 C 7 c	NOx, NMVOC, SOx, NH3, PM2.5, PM10, TSP, CO, Pb, Cd, Hg, PCDD/PCDF	Battery recycling, galvanizing plants, silicium production (until 1988)
2 D 3 i	NMVOC, PM2.5, PM10, TSP	Removal of paint and lacquer, vehicles dewaxing (until 2001), production of perfume/arome, cosmetics, paper/paper board, tobacco products and textiles, extraction of oil and fat (until 2000) and scientific laboratories, unspecified commercial and industrial solvent emissions
2 G	NOx, NMVOC, SOx, NH3, PM2.5, PM10, TSP, BC, CO, Pb, Cd, Hg, PAHs	Application of glues and adhesives, commercial and industrial use of cleaning agents, cosmetic institutions, de-icing of airplanes, glass wool enduction, hairdressers, health care other, medical practices, preservation of wood, renovation of anti-corrosive coatings, rock wool enduction, underseal treatment and conservation of vehicles and use of concrete additives, cooling lubricants, fireworks, lubricants and pesticides
2 H 3	NOx, NMVOC, SOx, NH3, PM2.5, PM10, TSP, CO, Pb	Blasting and shooting
3B4h	NOx, NH3, TSP, PM10, PM2	Camels and Llamas (3B4b), Deer (3B4c), Rabbits (3B4hi)
5 E	NMVOC, PM2.5, PM10, TSP, CO, Pb, Cd, PCDD/F	Car shredding
6 A	NOx, NMVOC, SOx, NH3, PM2.5, PM10, TSP, BC, CO, Pb, Cd, Hg, PCDD/F, PAH	Human ammonia emissions (breath, transpiration, napkin), pet ammonia emissions, pet PM emissions (keeping of horses, sheep, goats and donkeys outside agriculture), domestic use of fertilizers, fire damages estates and motor vehicles

Table A - 7: Basis for estimating emissions from mobile sources.

NFR code	Description	Fuel sold	Fuel used	Comment
1 A 3 a i (i)	International Aviation (LTO)	X		
1 A 3 a i (ii)	International Aviation (Cruise)	X		
1 A 3 a ii (i)	1 A 3 a ii Civil Aviation (Domestic, LTO)	X		
1 A 3 a ii (ii)	1 A 3 a ii Civil Aviation	X		
1A3b	**Road transport**	**(X)**	**X**	**National Totoal reported as "fuel sold", NT for Compliance "fuel used"**
1A3c	Railways		X	
1A3di (i)	International maritime Navigation	X		
1A3di (ii)	International inland waterways			**NO**
1A3dii	National Navigation	X		
1A4ci	Agriculture; stationary		X	
1A4cii	Off-road Vehicles and Other Machinery		X	
1A4ciii	National Fishing			**IE**
1 A 5 b	Other, Mobile (Including military)		X	

Annex 4: National Energy Balance

Swiss Energy Flow

The diagrams show a summary of the Swiss energy flow 2015 and 1990 in TJ as published by the Swiss Federal Office of Energy (SFOE 2016) in German and French.

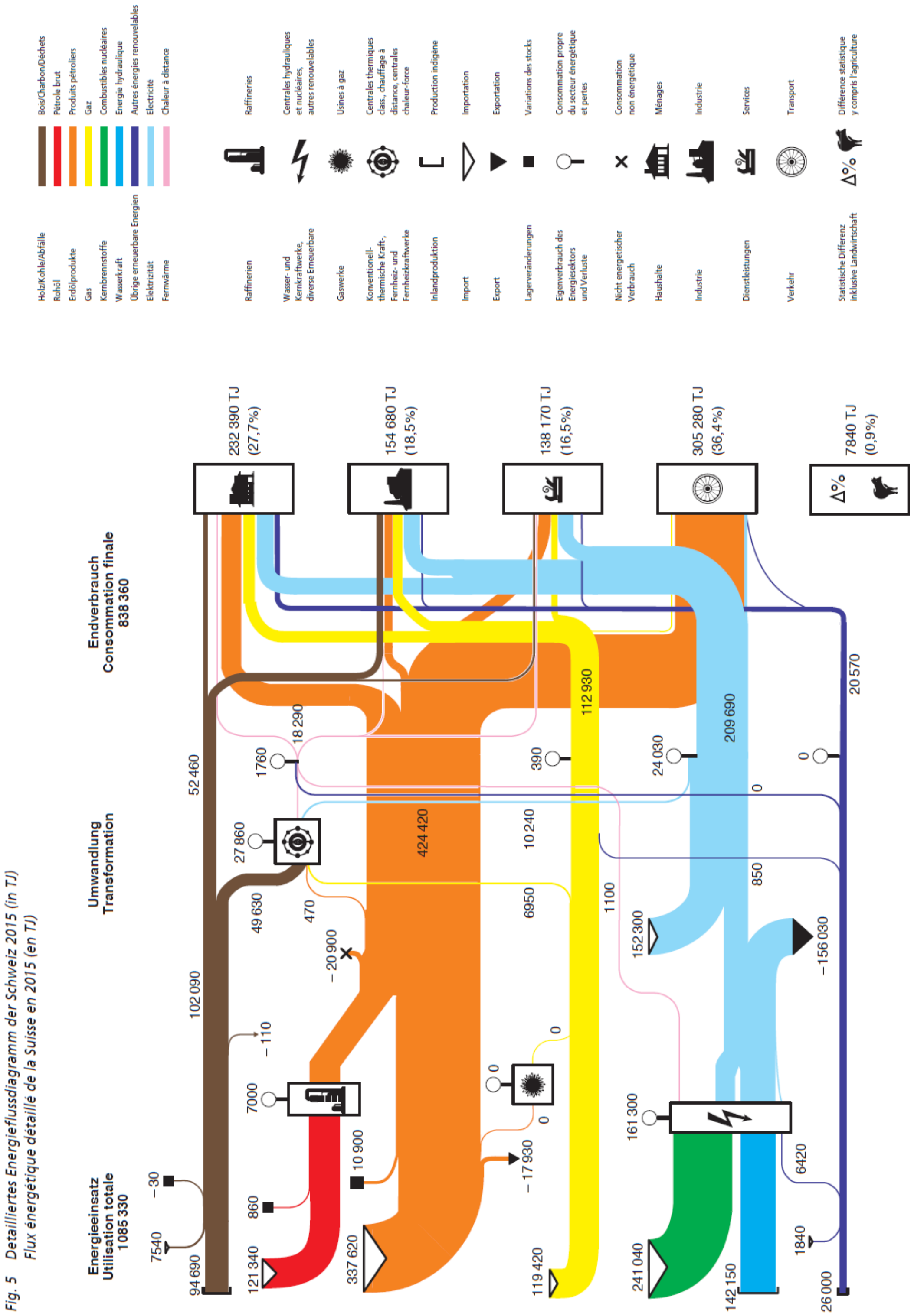

Figure A - 1: Energy flow in Switzerland 2015 (SFOE 2016). Depicted values are in TJ.

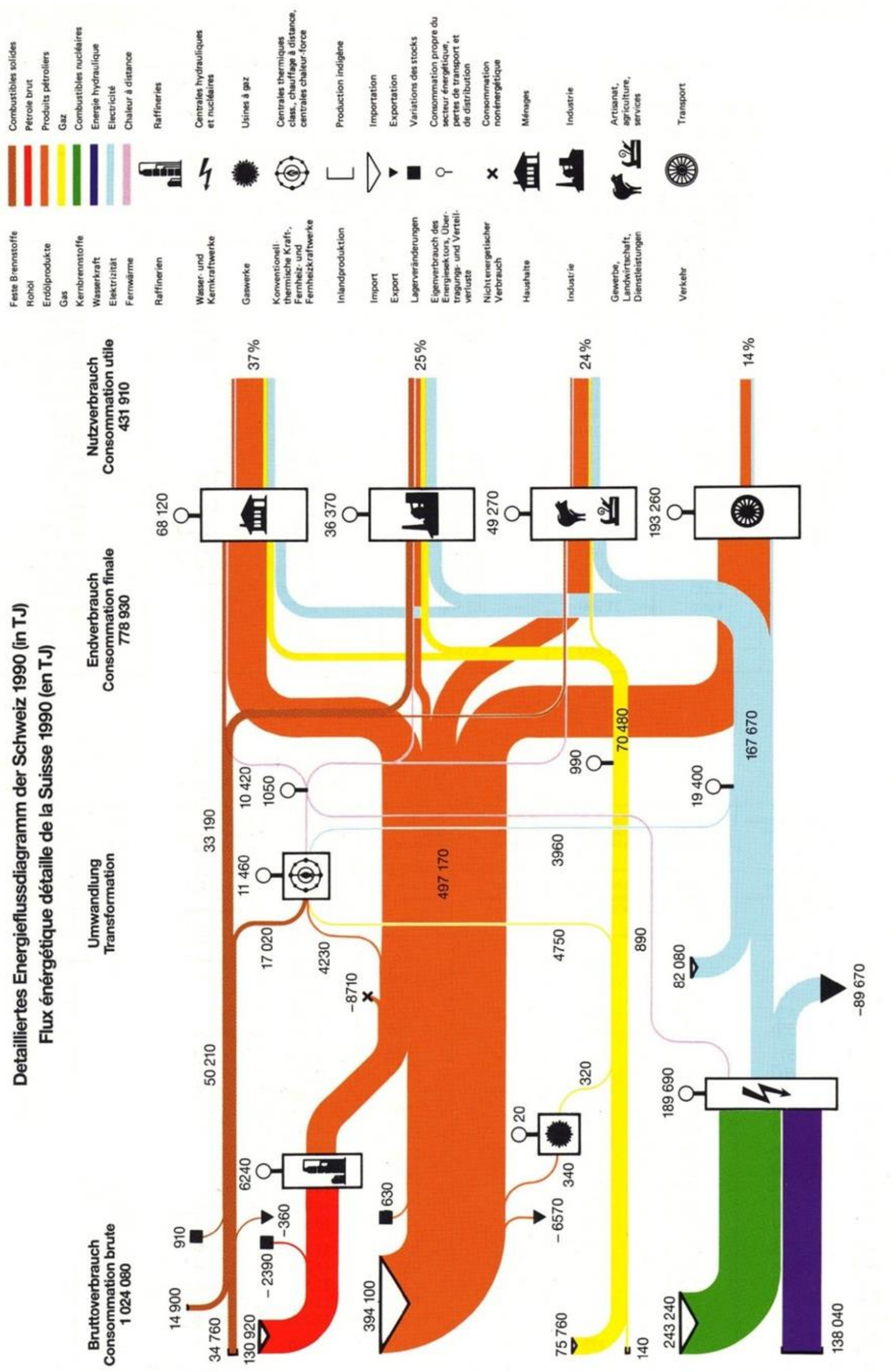

Figure A - 2: Energy flow in Switzerland 1990 (SFOE 1991). Depicted values are in TJ.

Table A - 8: Energy balance for Switzerland 2015 (table 4 in the Swiss overall energy statistics, SFOE 2016) in TJ.[9].

Energiebilanz der Schweiz für das Jahr 2015 (in TJ)
Bilan énergétique de la Suisse pour 2015 (en TJ)

Tabelle 4
Tableau 4

			Holzenergie	Kohle	Müll und Industrie-abfälle	Rohöl	Erdöl-produkte	Gas	Wasserkraft	Kern-brennstoffe	Übrige erneuerbare Energien	Elektrizität	Fernwärme	Total
			Energie du bois	Charbon	Ord. mén. et déchets ind.	Pétrole brut	Produits pétroliers	Gaz	Energie hydraulique	Combustibles nucléaires	Autres énergies renou-velables	Electricité	Chaleur à distance	Total
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Inlandproduktion	Production indigène	(a)	38 060	–	56 630	–	–	0	142 150	–	26 000	–	–	262 840
+ Import	Importation	(b)	2 100	5 440	–	121 340	337 620	119 420	–	241 040	1 840	152 300	–	981 100
+ Export	Exportation	(c)	– 110	0	–	–	– 17 930	–	–	–	–	–156 030	–	–174 070
+ Lagerveränderung[1]	Variation de stock[1]	(d)	–	– 30	–	860	10 900	–	–	–	–	–	–	11 730
= Bruttoverbrauch	Consommation brute	(e)	40 050	5 410	56 630	122 200	330 590	119 420	142 150	241 040	27 840	– 3 730	0	1 081 600
+ Energieumwandlung:	Transformation d'énergie:													
• Wasserkraftwerke	• Centrales hydrauliques	(f)	–	–	–	–	–	–	– 142 150	–	–	142 150	–	0
• Kernkraftwerke	• Centrales nucléaires	(g)	–	–	–	–	–	–	–	–241 040	–	79 540	1 100	–160 400
• konventionell-thermische Kraft-, Fernheiz- und Fernheizkraftwerke	• Centrales thermiques class., chauffage à distance, centrales chaleur-force	(h)	– 2 190	–	– 46 430	–	– 470	– 6 950	–	–	–	9 580	18 950	–27 510
• Gaswerke	• Usines à gaz	(i)	–	–	–	–	–	0	–	–	–	–	–	0
• Raffinerien	• Raffineries	(j)	–	–	–	– 122 200	122 240	–	–	–	–	–	–	40
• Diverse Erneuerbare	• Renouvelables div.	(k)	– 1 010	–	–	–	–	850	–	–	– 7 270	6 180	0	–1 250
+ Eigenverbrauch des Energiesektors, Netzverluste, Verbrauch der Speicherungen	Consommation propre du secteur énergétique, pertes de réseau, pompage d'accumulation	(l)	–	–	–	–	–7 040	– 390	–	–	–	– 24 030	– 1 760	–33 220
+ Nichtenergetischer Verbrauch	Consommation non énergétique	(m)	–	–	–	–	–20 900	–	–	–	–	–	–	–20 900
= Endverbrauch	Consommation finale	(n)	36 850	5 410	10 200	0	424 420	112 930	0	0	20 570	209 690	18 290	838 360
Haushalte	Ménages	(o)	17 970	400	–	–	79 520	46 260	–	–	13 500	67 540	7 200	232 390
Industrie	Industrie	(p)	10 430	5 010	10 200	–	16 270	39 370	–	–	1 560	64 760	7 080	154 680
Dienstleistungen	Services	(q)	7 860	0	–	–	35 030	25 530	–	–	3 190	62 550	4 010	138 170
Verkehr	Transport	(r)	–	–	–	–	290 530	1 390	–	–	2 070	11 290	–	305 280
Statistische Differenz inkl. Landwirtschaft	Différence statistique, y compris l'agriculture	(s)	590	0	–	–	3 070	380	–	–	250	3 550	0	7 840

[1] + Lagerabnahme
– Lagerzunahme

[1] + diminution de stock
– augmentation de stock

[9] Note that Liechtenstein's consumption of liquid fuels is included in these numbers (see chp. 3.1.6.4).

Annex 5: Additional Information to be Considered Part of the IIR Submission Concerning Uncertainties

The following tables provide information about the level and trend uncertainty analysis of all relevant air pollutant emissions in 1990 and 2015.

Table A - 9: Uncertainty analysis of NO_x emissions 1990 and 2015.

A	B	C	D	E	F	G	H	I	J	K	L	M
NFR	Pollutant	Emissions 1990	Emissions 2015	AD uncertainty 2015	EF uncertainty 2015	Combined uncertainty 2015	Combined uncertainty as % of total national 2015	Type A sensitivity	Type B sensitivity	Uncertainty in trend introduced by emission factor uncertainty	Uncertainty in trend introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		t	t	%	%	%	%	%	%	%	%	%
1A1a	NOx	6'316.6	2'219.5	10%	19%	21%	0.739%	-0.427%	1.544%	-0.081%	0.218%	0.233%
1A1b	NOx	494.2	457.7	1%	20%	20%	0.142%	0.164%	0.318%	0.033%	0.006%	0.033%
1A1c	NOx	0.0	0.0	0%	20%	20%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A2a	NOx	308.1	147.4	2%	27%	27%	0.062%	0.006%	0.103%	0.002%	0.003%	0.003%
1A2b	NOx	126.9	38.7	2%	20%	20%	0.012%	-0.013%	0.027%	-0.003%	0.001%	0.003%
1A2c	NOx	1'046.7	304.8	2%	10%	10%	0.048%	-0.115%	0.212%	-0.011%	0.006%	0.013%
1A2d	NOx	1'260.7	74.1	2%	10%	10%	0.012%	-0.342%	0.052%	-0.034%	0.001%	0.034%
1A2e	NOx	743.3	249.5	2%	10%	10%	0.039%	-0.058%	0.174%	-0.006%	0.005%	0.008%
1A2f	NOx	10'534.5	3'722.8	2%	17%	17%	0.988%	-0.698%	2.590%	-0.119%	0.073%	0.139%
1A2gvii	NOx	6'333.9	3'210.4	1%	13%	13%	0.650%	0.256%	2.233%	0.033%	0.041%	0.053%
1A2gviii	NOx	2'502.3	1'972.1	2%	17%	17%	0.524%	0.591%	1.372%	0.100%	0.040%	0.108%
1A3ai(i)	NOx	1'214.3	1'888.5	1%	20%	20%	0.587%	0.935%	1.314%	0.187%	0.024%	0.188%
1A3aii(i)	NOx	153.8	74.9	1%	20%	20%	0.023%	0.004%	0.052%	0.001%	0.001%	0.001%
1A3bi	NOx	52'159.7	14'592.7	1%	38%	38%	8.654%	-6.105%	10.152%	-2.334%	0.185%	2.341%
1A3bii	NOx	5'746.6	3'361.3	1%	32%	32%	1.680%	0.545%	2.338%	0.175%	0.043%	0.180%
1A3biii	NOx	25'992.9	15'183.2	1%	18%	18%	4.249%	2.446%	10.563%	0.440%	0.192%	0.480%
1A3biv	NOx	297.2	434.6	1%	36%	36%	0.243%	0.210%	0.302%	0.075%	0.006%	0.076%
1A3c	NOx	595.5	397.3	1%	13%	13%	0.080%	0.091%	0.276%	0.012%	0.005%	0.013%
1A3dii	NOx	1'054.7	1'112.8	1%	13%	13%	0.225%	0.445%	0.774%	0.058%	0.014%	0.060%
1A3ei	NOx	145.6	45.6	2%	50%	50%	0.035%	-0.014%	0.032%	-0.007%	0.001%	0.007%
1A4ai	NOx	5'056.9	2'730.9	2%	16%	16%	0.681%	0.321%	1.900%	0.051%	0.042%	0.067%
1A4aii	NOx	16.3	46.7	1%	13%	13%	0.009%	0.027%	0.032%	0.004%	0.001%	0.004%
1A4bi	NOx	11'552.4	5'296.0	4%	13%	14%	1.110%	0.079%	3.684%	0.010%	0.194%	0.194%
1A4bii	NOx	18.8	24.9	1%	30%	30%	0.012%	0.011%	0.017%	0.003%	0.000%	0.003%
1A4ci	NOx	119.6	104.0	21%	30%	37%	0.059%	0.035%	0.072%	0.011%	0.022%	0.024%
1A4cii	NOx	4'357.5	2'648.1	1%	13%	13%	0.536%	0.482%	1.842%	0.063%	0.034%	0.071%
1A5b	NOx	584.2	330.0	1%	13%	13%	0.067%	0.047%	0.230%	0.006%	0.004%	0.007%
1B2c	NOx	134.5	30.9	22%	30%	37%	0.018%	-0.020%	0.022%	-0.006%	0.007%	0.009%
2A1	NOx	15.9	10.5	2%	30%	30%	0.005%	0.002%	0.007%	0.001%	0.000%	0.001%
2A2	NOx	0.3	0.2	2%	30%	30%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2A5a	NOx	1.8	0.8	5%	20%	21%	0.000%	0.000%	0.001%	0.000%	0.000%	0.000%
2B2	NOx	82.8	30.5	2%	20%	20%	0.010%	-0.005%	0.021%	-0.001%	0.001%	0.001%
2C1	NOx	245.5	181.8	2%	40%	40%	0.113%	0.050%	0.126%	0.020%	0.004%	0.020%
2C3	NOx	17.4	-	5%	30%	30%	0.000%	-0.005%	0.000%	-0.002%	0.000%	0.002%
2C7c	NOx	2.6	1.5	5%	10%	11%	0.000%	0.000%	0.001%	0.000%	0.000%	0.000%
2G	NOx	0.2	0.4	25%	30%	39%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2H3	NOx	91.0	77.7	3%	0%	3%	0.004%	0.026%	0.054%	0.000%	0.002%	0.002%
3B1a	NOx	178.4	63.2	6%	50%	50%	0.049%	-0.012%	0.044%	-0.006%	0.004%	0.007%
3B1b	NOx	109.8	75.9	6%	50%	50%	0.059%	0.019%	0.053%	0.009%	0.005%	0.010%
3B2	NOx	16.9	18.2	6%	50%	50%	0.014%	0.007%	0.013%	0.004%	0.001%	0.004%
3B3	NOx	3.9	2.2	6%	50%	50%	0.002%	0.000%	0.002%	0.000%	0.000%	0.000%
3B4a	NOx	NA	0.0	6%	50%	50%	0.000%	NA	NA	NA	NA	NA
3B4d	NOx	5.1	6.5	6%	50%	50%	0.005%	0.003%	0.005%	0.001%	0.000%	0.002%
3B4e	NOx	9.4	16.1	6%	50%	50%	0.013%	0.008%	0.011%	0.004%	0.001%	0.004%
3B4f	NOx	0.7	2.0	6%	50%	50%	0.002%	0.001%	0.001%	0.001%	0.000%	0.001%
3B4gi	NOx	18.0	17.2	6%	50%	50%	0.013%	0.006%	0.012%	0.003%	0.001%	0.003%
3B4gii	NOx	6.6	25.4	6%	50%	50%	0.020%	0.016%	0.018%	0.008%	0.002%	0.008%
3B4giii	NOx	1.1	0.5	6%	50%	50%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
3B4giv	NOx	2.1	2.7	6%	50%	50%	0.002%	0.001%	0.002%	0.001%	0.000%	0.001%
3B4h	NOx	0.5	1.4	6%	50%	50%	0.001%	0.001%	0.001%	0.000%	0.000%	0.000%
3Da1	NOx	1'209.2	794.0	25%	100%	103%	1.269%	0.175%	0.552%	0.175%	0.195%	0.262%
3Da2a	NOx	1'991.8	1'513.0	6%	50%	50%	1.181%	0.431%	1.053%	0.215%	0.089%	0.233%
3Da2b	NOx	87.0	-	6%	100%	100%	0.000%	-0.027%	0.000%	-0.027%	0.000%	0.027%
3Da2c	NOx	14.9	86.9	6%	100%	100%	0.135%	0.056%	0.060%	0.056%	0.006%	0.056%
3Da3	NOx	236.3	398.3	6%	100%	100%	0.619%	0.203%	0.277%	0.203%	0.025%	0.205%
5A	NOx	1.8	1.4	10%	50%	51%	0.001%	0.000%	0.001%	0.000%	0.000%	0.000%
5B2	NOx	NA	4.7	20%	100%	102%	0.007%	NA	NA	NA	NA	NA
5C1a	NOx	80.8	48.3	50%	40%	64%	0.048%	0.008%	0.034%	0.003%	0.024%	0.024%
5C1bi	NOx	9.8	-	30%	30%	42%	0.000%	-0.003%	0.000%	-0.001%	0.000%	0.001%
5C1biii	NOx	45.0	-	30%	30%	42%	0.000%	-0.014%	0.000%	-0.004%	0.000%	0.004%
5C1biv	NOx	114.0	89.3	20%	50%	54%	0.075%	0.027%	0.062%	0.013%	0.018%	0.022%
5C1bv	NOx	11.3	12.5	5%	30%	30%	0.006%	0.005%	0.009%	0.002%	0.001%	0.002%
5C2	NOx	31.1	17.8	48%	133%	141%	0.039%	0.003%	0.012%	0.004%	0.008%	0.009%
5D1	NOx	137.6	179.9	1%	10%	10%	0.028%	0.082%	0.125%	0.008%	0.002%	0.009%
5D2	NOx	2.4	23.7	10%	10%	14%	0.005%	0.016%	0.017%	0.002%	0.002%	0.003%
6A	NOx	91.0	83.3	30%	50%	58%	0.075%	0.030%	0.058%	0.015%	0.025%	0.029%
Total		**143'741**	**64'487**	**Level uncertainty:**			**10.2%**	**Trend uncertainty:**				**2.469%**

Table A - 10: Uncertainty analysis of NMVOC emissions 1990 and 2015.

A	B	C	D	E	F	G	H	I	J	K	L	M
NFR	Pollutant	Emissions 1990	Emissions 2015	AD uncertainty 2015	EF uncertainty 2015	Combined uncertainty 2015	Combined uncertainty as % of total national 2015	Type A sensitivity	Type B sensitivity	Uncertainty in trend introduced by emission factor uncertainty	Uncertainty in trend introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		t	t	%	%	%	%	%	%	%	%	%
1A1a	NMVOC	295.2	149.5	10%	32%	34%	0.065%	0.024%	0.050%	0.008%	0.007%	0.011%
1A1b	NMVOC	6.9	17.4	1%	20%	20%	0.004%	0.005%	0.006%	0.001%	0.000%	0.001%
1A1c	NMVOC	2.1	5.6	0%	20%	20%	0.001%	0.002%	0.002%	0.000%	0.000%	0.000%
1A2a	NMVOC	10.1	9.0	2%	18%	18%	0.002%	0.002%	0.003%	0.000%	0.000%	0.000%
1A2b	NMVOC	51.7	6.5	2%	19%	19%	0.002%	-0.002%	0.002%	0.000%	0.000%	0.000%
1A2c	NMVOC	34.1	27.8	2%	10%	10%	0.004%	0.006%	0.009%	0.001%	0.000%	0.001%
1A2d	NMVOC	29.9	7.2	2%	10%	10%	0.001%	0.000%	0.002%	0.000%	0.000%	0.000%
1A2e	NMVOC	22.0	23.2	2%	10%	10%	0.003%	0.006%	0.008%	0.001%	0.000%	0.001%
1A2f	NMVOC	596.6	454.0	2%	30%	30%	0.176%	0.100%	0.152%	0.030%	0.004%	0.030%
1A2gvii	NMVOC	1'361.0	404.1	1%	34%	34%	0.177%	0.017%	0.135%	0.006%	0.002%	0.006%
1A2gviii	NMVOC	231.5	104.4	2%	30%	30%	0.041%	0.015%	0.035%	0.004%	0.001%	0.005%
1A3ai(i)	NMVOC	247.5	201.5	1%	50%	50%	0.130%	0.046%	0.068%	0.023%	0.001%	0.023%
1A3aii(i)	NMVOC	58.8	47.0	1%	50%	50%	0.030%	0.011%	0.016%	0.005%	0.000%	0.005%
1A3bi	NMVOC	61'831.8	8'672.4	1%	52%	52%	5.845%	-2.474%	2.908%	-1.292%	0.053%	1.293%
1A3bii	NMVOC	4'241.7	405.3	1%	46%	46%	0.239%	-0.234%	0.136%	-0.107%	0.002%	0.107%
1A3biii	NMVOC	2'043.6	412.3	1%	22%	22%	0.117%	-0.040%	0.138%	-0.009%	0.003%	0.009%
1A3biv	NMVOC	6'750.7	1'572.0	1%	400%	400%	8.114%	-0.061%	0.527%	-0.244%	0.010%	0.244%
1A3bv	NMVOC	13'602.1	759.4	1%	40%	40%	0.392%	-0.930%	0.255%	-0.372%	0.005%	0.372%
1A3c	NMVOC	83.8	45.9	1%	34%	34%	0.020%	0.008%	0.015%	0.003%	0.000%	0.003%
1A3dii	NMVOC	1'640.6	450.2	1%	34%	34%	0.198%	0.008%	0.151%	0.003%	0.003%	0.004%
1A3ei	NMVOC	0.1	0.1	2%	50%	50%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A4ai	NMVOC	1'050.3	545.2	2%	56%	56%	0.394%	0.091%	0.183%	0.051%	0.004%	0.051%
1A4aii	NMVOC	1'126.5	377.8	1%	75%	75%	0.366%	0.029%	0.127%	0.021%	0.002%	0.022%
1A4bi	NMVOC	7'976.7	2'363.7	4%	68%	68%	2.077%	0.098%	0.793%	0.066%	0.042%	0.078%
1A4bii	NMVOC	427.5	163.1	1%	75%	75%	0.158%	0.017%	0.055%	0.013%	0.001%	0.013%
1A4ci	NMVOC	234.6	53.4	21%	75%	78%	0.054%	-0.003%	0.018%	-0.002%	0.005%	0.006%
1A4cii	NMVOC	4'569.4	1'231.1	1%	75%	75%	1.192%	0.015%	0.413%	0.011%	0.008%	0.013%
1A5b	NMVOC	141.3	73.9	1%	34%	34%	0.032%	0.012%	0.025%	0.004%	0.000%	0.004%
1B2ai	NMVOC	205.9	186.8	30%	50%	58%	0.141%	0.045%	0.063%	0.022%	0.027%	0.035%
1B2aiv	NMVOC	1'344.6	1'219.5	30%	47%	56%	0.877%	0.292%	0.409%	0.137%	0.173%	0.221%
1B2av	NMVOC	17'279.0	1'731.0	1%	26%	26%	0.581%	-0.924%	0.580%	-0.240%	0.011%	0.241%
1B2b	NMVOC	1'052.5	603.9	22%	50%	55%	0.426%	0.111%	0.202%	0.055%	0.063%	0.084%
1B2c	NMVOC	10.9	2.5	22%	51%	56%	0.002%	0.000%	0.001%	0.000%	0.000%	0.000%
2A1	NMVOC	41.3	27.4	2%	30%	30%	0.011%	0.006%	0.009%	0.002%	0.000%	0.002%
2A2	NMVOC	0.7	0.6	2%	30%	30%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2A5a	NMVOC	4.6	2.0	5%	14%	15%	0.000%	0.000%	0.001%	0.000%	0.000%	0.000%
2B10a	NMVOC	608.6	20.5	2%	20%	20%	0.005%	-0.046%	0.007%	-0.009%	0.000%	0.009%
2C1	NMVOC	1'053.6	287.8	2%	40%	40%	0.149%	0.005%	0.097%	0.002%	0.003%	0.003%
2C3	NMVOC	56.6	-	5%	31%	31%	0.000%	-0.005%	0.000%	-0.002%	0.000%	0.002%
2C7a	NMVOC	2.8	0.3	5%	20%	21%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2C7c	NMVOC	0.6	0.5	5%	0%	5%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2D3a	NMVOC	9'310.5	11'157.0	1%	50%	50%	7.200%	2.929%	3.741%	1.464%	0.053%	1.465%
2D3b	NMVOC	4'895.0	2'619.0	5%	30%	30%	1.028%	0.452%	0.878%	0.135%	0.062%	0.149%
2D3c	NMVOC	2'516.6	503.6	20%	50%	54%	0.350%	-0.050%	0.169%	-0.025%	0.048%	0.054%
2D3d	NMVOC	54'168.0	11'992.7	30%	30%	42%	6.565%	-0.697%	4.021%	-0.209%	1.706%	1.719%
2D3e	NMVOC	11'218.0	1'976.8	40%	40%	57%	1.443%	-0.314%	0.663%	-0.126%	0.375%	0.395%
2D3f	NMVOC	910.0	14.0	20%	20%	28%	0.005%	-0.075%	0.005%	-0.015%	0.001%	0.015%
2D3g	NMVOC	28'313.8	3'614.3	30%	20%	36%	1.682%	-1.254%	1.212%	-0.251%	0.514%	0.572%
2D3h	NMVOC	20'353.8	2'955.6	15%	20%	25%	0.953%	-0.782%	0.991%	-0.156%	0.210%	0.262%
2D3i	NMVOC	5'384.8	2'366.9	30%	20%	36%	1.101%	0.324%	0.794%	0.065%	0.337%	0.343%
2G	NMVOC	22'146.2	7'619.3	25%	25%	35%	3.476%	0.625%	2.555%	0.156%	0.903%	0.917%
2H1	NMVOC	555.0	287.5	30%	19%	36%	0.132%	0.048%	0.096%	0.009%	0.041%	0.042%
2H2	NMVOC	2'826.5	3'160.3	10%	30%	32%	1.290%	0.813%	1.060%	0.244%	0.150%	0.286%
2H3	NMVOC	156.0	133.2	3%	28%	28%	0.048%	0.031%	0.045%	0.009%	0.002%	0.009%
3Db	NMVOC	3'953.8	3'899.4	6%	75%	75%	3.788%	0.963%	1.307%	0.722%	0.119%	0.732%
5B1	NMVOC	442.0	1'365.4	30%	30%	42%	0.747%	0.419%	0.458%	0.126%	0.194%	0.231%
5B2	NMVOC	46.4	662.6	20%	30%	36%	0.308%	0.218%	0.222%	0.065%	0.063%	0.091%
5C1a	NMVOC	516.8	308.8	50%	50%	71%	0.282%	0.059%	0.104%	0.029%	0.073%	0.079%
5C1bi	NMVOC	3.8	-	30%	30%	42%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
5C1biii	NMVOC	9.0	-	30%	30%	42%	0.000%	-0.001%	0.000%	0.000%	0.000%	0.000%
5C1biv	NMVOC	0.5	0.6	20%	20%	28%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
5C1bv	NMVOC	1.2	0.4	5%	30%	30%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
5C2	NMVOC	33.1	19.0	48%	133%	141%	0.035%	0.003%	0.006%	0.005%	0.004%	0.006%
5D1	NMVOC	3.4	4.1	1%	27%	27%	0.001%	0.001%	0.001%	0.000%	0.000%	0.000%
5D2	NMVOC	0.1	0.6	10%	20%	22%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
5E	NMVOC	28.0	60.0	20%	24%	31%	0.024%	0.018%	0.020%	0.004%	0.006%	0.007%
6A	NMVOC	129.0	110.6	30%	50%	58%	0.083%	0.026%	0.037%	0.013%	0.016%	0.020%
Total		**298'251**	**77'497**	**Level uncertainty:**			**15.5%**	**Trend uncertainty:**				**3.055%**

Table A - 11: Uncertainty analysis of SO_x emissions 1990 and 2015.

A	B	C	D	E	F	G	H	I	J	K	L	M
NFR	Pollutant	Emissions 1990	Emissions 2015	AD uncertainty 2015	EF uncertainty 2015	Combined uncertainty 2015	Combined uncertainty as % of total national 2015	Type A sensitivity	Type B sensitivity	Uncertainty in trend introduced by emission factor uncertainty	Uncertainty in trend introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		t	t	%	%	%	%	%	%	%	%	%
1A1a	SOx	3'690.3	259.2	10%	22%	24%	0.927%	-0.926%	0.652%	-0.204%	0.092%	0.224%
1A1b	SOx	660.4	573.7	1%	20%	20%	1.701%	1.161%	1.443%	0.232%	0.026%	0.234%
1A2a	SOx	364.3	19.8	2%	15%	15%	0.044%	-0.106%	0.050%	-0.016%	0.001%	0.016%
1A2b	SOx	68.6	14.9	2%	10%	10%	0.022%	0.008%	0.037%	0.001%	0.001%	0.001%
1A2c	SOx	1'212.0	110.4	2%	11%	11%	0.183%	-0.241%	0.278%	-0.026%	0.008%	0.028%
1A2d	SOx	3'278.6	13.7	2%	14%	14%	0.029%	-1.367%	0.034%	-0.191%	0.001%	0.191%
1A2e	SOx	1'106.0	46.9	2%	12%	12%	0.085%	-0.355%	0.118%	-0.043%	0.003%	0.043%
1A2f	SOx	3'530.3	1'371.6	2%	19%	19%	3.877%	1.939%	3.451%	0.368%	0.098%	0.381%
1A2gvii	SOx	355.6	4.4	1%	10%	10%	0.007%	-0.141%	0.011%	-0.014%	0.000%	0.014%
1A2gviii	SOx	3'611.8	630.9	2%	19%	19%	1.784%	0.042%	1.588%	0.008%	0.046%	0.047%
1A3ai(i)	SOx	99.7	149.8	1%	10%	10%	0.223%	0.334%	0.377%	0.033%	0.007%	0.034%
1A3aii(i)	SOx	24.9	8.0	1%	10%	10%	0.012%	0.010%	0.020%	0.001%	0.000%	0.001%
1A3bi	SOx	1'863.1	54.2	1%	10%	10%	0.081%	-0.661%	0.136%	-0.066%	0.002%	0.066%
1A3bii	SOx	256.3	5.2	1%	10%	10%	0.008%	-0.097%	0.013%	-0.010%	0.000%	0.010%
1A3biii	SOx	1'645.6	22.8	1%	10%	10%	0.034%	-0.646%	0.057%	-0.065%	0.001%	0.065%
1A3biv	SOx	21.2	1.2	1%	10%	10%	0.002%	-0.006%	0.003%	-0.001%	0.000%	0.001%
1A3c	SOx	25.5	0.2	1%	10%	10%	0.000%	-0.010%	0.000%	-0.001%	0.000%	0.001%
1A3dii	SOx	64.8	2.6	1%	10%	10%	0.004%	-0.021%	0.007%	-0.002%	0.000%	0.002%
1A3ei	SOx	0.3	0.4	2%	10%	10%	0.001%	0.001%	0.001%	0.000%	0.000%	0.000%
1A4ai	SOx	4'367.0	736.4	2%	10%	10%	1.103%	-0.016%	1.853%	-0.002%	0.041%	0.041%
1A4aii	SOx	8.6	1.3	1%	10%	10%	0.002%	0.000%	0.003%	0.000%	0.000%	0.000%
1A4bi	SOx	10'735.8	1'742.6	4%	10%	11%	2.751%	-0.208%	4.385%	-0.021%	0.231%	0.231%
1A4bii	SOx	3.2	0.3	1%	10%	10%	0.000%	-0.001%	0.001%	0.000%	0.000%	0.000%
1A4ci	SOx	83.1	40.3	21%	18%	28%	0.166%	0.066%	0.101%	0.012%	0.030%	0.033%
1A4cii	SOx	309.2	4.3	1%	10%	10%	0.006%	-0.121%	0.011%	-0.012%	0.000%	0.012%
1A5b	SOx	78.3	36.6	1%	10%	10%	0.055%	0.059%	0.092%	0.006%	0.002%	0.006%
1B2aiv	SOx	419.0	107.8	30%	47%	56%	0.889%	0.092%	0.271%	0.043%	0.115%	0.123%
1B2c	SOx	193.9	44.5	22%	31%	38%	0.250%	0.029%	0.112%	0.009%	0.035%	0.036%
2A1	SOx	0.7	0.5	2%	30%	30%	0.002%	0.001%	0.001%	0.000%	0.000%	0.000%
2A2	SOx	0.0	0.0	2%	30%	30%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2A5a	SOx	0.1	0.0	5%	21%	22%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2B5	SOx	444.8	510.4	2%	20%	20%	1.518%	1.094%	1.284%	0.219%	0.036%	0.222%
2B10a	SOx	168.0	109.0	2%	20%	20%	0.324%	0.202%	0.274%	0.040%	0.008%	0.041%
2C1	SOx	144.0	18.1	2%	40%	40%	0.108%	-0.016%	0.046%	-0.006%	0.001%	0.007%
2C3	SOx	696.3	-	5%	20%	21%	0.000%	-0.298%	0.000%	-0.060%	0.000%	0.060%
2C7c	SOx	0.0	0.0	5%	40%	40%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2G	SOx	3.4	6.6	25%	17%	30%	0.030%	0.015%	0.017%	0.003%	0.006%	0.006%
2H3	SOx	1.3	1.1	3%	50%	50%	0.008%	0.002%	0.003%	0.001%	0.000%	0.001%
5B2	SOx	NA	0.7	20%	100%	102%	0.011%	NA	NA	NA	NA	NA
5C1a	SOx	24.2	14.5	50%	40%	64%	0.137%	0.026%	0.036%	0.010%	0.026%	0.028%
5C1bi	SOx	45.0	-	30%	30%	42%	0.000%	-0.019%	0.000%	-0.006%	0.000%	0.006%
5C1biii	SOx	39.0	-	30%	30%	42%	0.000%	-0.017%	0.000%	-0.005%	0.000%	0.005%
5C1biv	SOx	74.1	60.0	20%	30%	36%	0.320%	0.119%	0.151%	0.036%	0.043%	0.056%
5C2	SOx	0.7	0.4	48%	117%	126%	0.007%	0.001%	0.001%	0.001%	0.001%	0.001%
5D1	SOx	12.2	19.9	1%	37%	37%	0.109%	0.045%	0.050%	0.017%	0.001%	0.017%
5D2	SOx	0.2	2.5	10%	20%	22%	0.008%	0.006%	0.006%	0.001%	0.001%	0.002%
6A	SOx	10.4	10.6	30%	50%	58%	0.091%	0.022%	0.027%	0.011%	0.011%	0.016%
Total		**39'742**	**6'758**	**Level uncertainty:**			**5.9%**	**Trend uncertainty:**				**0.658%**

Table A - 12: Uncertainty analysis of NH_3 emissions 1990 and 2015.

A	B	C	D	E	F	G	H	I	J	K	L	M
NFR	Pollutant	Emissions 1990	Emissions 2015	AD uncertainty 2015	EF uncertainty 2015	Combined uncertainty 2015	Combined uncertainty as % of total national 2015	Type A sensitivity	Type B sensitivity	Uncertainty in trend introduced by emission factor uncertainty	Uncertainty in trend introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		t	t	%	%	%	%	%	%	%	%	%
1A1a	NH3	4.6	39.5	10%	20%	22%	0.015%	0.049%	0.054%	0.010%	0.008%	0.012%
1A1b	NH3	0.0	0.0	1%	10%	10%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A2a	NH3	0.0	0.0	2%	10%	10%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A2b	NH3	0.1	0.0	2%	10%	10%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A2c	NH3	0.0	0.0	2%	10%	10%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A2d	NH3	0.0	0.0	2%	10%	10%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A2e	NH3	0.0	0.0	2%	10%	10%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A2f	NH3	147.0	193.1	2%	9%	9%	0.029%	0.098%	0.263%	0.009%	0.007%	0.012%
1A2gvii	NH3	2.1	2.1	1%	50%	50%	0.002%	0.001%	0.003%	0.000%	0.000%	0.000%
1A2gviii	NH3	9.3	34.0	2%	9%	9%	0.005%	0.036%	0.046%	0.003%	0.001%	0.003%
1A3bi	NH3	1'431.5	1'857.5	1%	50%	50%	1.532%	0.918%	2.532%	0.459%	0.046%	0.461%
1A3bii	NH3	8.9	38.9	1%	50%	50%	0.032%	0.043%	0.053%	0.021%	0.001%	0.021%
1A3biii	NH3	6.6	15.7	1%	50%	50%	0.013%	0.014%	0.021%	0.007%	0.000%	0.007%
1A3biv	NH3	3.1	4.7	1%	50%	50%	0.004%	0.003%	0.006%	0.001%	0.000%	0.001%
1A3c	NH3	0.1	0.1	1%	50%	50%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A3dii	NH3	0.2	0.2	1%	50%	50%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A3ei	NH3	NA	0.5	2%	50%	50%	0.000%	NA	NA	NA	NA	NA
1A4ai	NH3	11.7	22.4	2%	10%	10%	0.004%	0.017%	0.031%	0.002%	0.001%	0.002%
1A4aii	NH3	0.0	0.0	1%	10%	10%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A4bi	NH3	126.5	96.6	4%	10%	11%	0.017%	-0.011%	0.132%	-0.001%	0.007%	0.007%
1A4bii	NH3	0.0	0.0	1%	10%	10%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A4ci	NH3	1.2	2.2	21%	10%	23%	0.001%	0.002%	0.003%	0.000%	0.001%	0.001%
1A4cii	NH3	0.8	0.9	1%	50%	50%	0.001%	0.000%	0.001%	0.000%	0.000%	0.000%
1A5b	NH3	0.0	0.0	1%	50%	50%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2B1	NH3	0.1	0.2	2%	10%	10%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2B2	NH3	0.7	0.0	2%	50%	50%	0.000%	-0.001%	0.000%	0.000%	0.000%	0.000%
2B10a	NH3	7.7	3.2	2%	5%	5%	0.000%	-0.004%	0.004%	0.000%	0.000%	0.000%
2C1	NH3	11.9	2.6	2%	50%	50%	0.002%	-0.010%	0.004%	-0.005%	0.000%	0.005%
2C7c	NH3	9.2	8.4	5%	40%	40%	0.006%	0.001%	0.012%	0.000%	0.001%	0.001%
2G	NH3	202.3	59.7	25%	60%	65%	0.064%	-0.147%	0.081%	-0.088%	0.029%	0.093%
2H2	NH3	132.3	86.7	10%	90%	91%	0.129%	-0.031%	0.118%	-0.028%	0.017%	0.032%
2H3	NH3	1.0	0.9	3%	50%	50%	0.001%	0.000%	0.001%	0.000%	0.000%	0.000%
2L	NH3	2.4	3.5	0%	0%	0%	0.000%	0.002%	0.005%	0.000%	0.000%	0.000%
3B1a	NH3	10'085.8	11'542.0	6%	38%	39%	7.381%	4.359%	15.732%	1.668%	1.433%	2.199%
3B1b	NH3	6'012.1	7'829.5	6%	25%	26%	3.311%	3.893%	10.672%	0.967%	0.972%	1.371%
3B2	NH3	534.5	541.7	6%	54%	54%	0.483%	0.136%	0.738%	0.073%	0.067%	0.099%
3B3	NH3	5'798.9	4'687.5	6%	36%	37%	2.831%	-0.146%	6.389%	-0.053%	0.582%	0.584%
3B4a	NH3	NA	3.6	6%	50%	50%	0.003%	NA	NA	NA	NA	NA
3B4d	NH3	155.4	180.7	6%	57%	58%	0.172%	0.071%	0.246%	0.041%	0.022%	0.047%
3B4e	NH3	277.3	490.0	6%	34%	35%	0.281%	0.355%	0.668%	0.122%	0.061%	0.136%
3B4f	NH3	20.9	61.4	6%	47%	48%	0.048%	0.060%	0.084%	0.028%	0.008%	0.029%
3B4gi	NH3	961.9	516.1	6%	83%	83%	0.709%	-0.381%	0.703%	-0.316%	0.064%	0.323%
3B4gii	NH3	216.3	542.0	6%	69%	69%	0.621%	0.495%	0.739%	0.342%	0.067%	0.349%
3B4giii	NH3	35.5	15.8	6%	78%	78%	0.020%	-0.019%	0.021%	-0.014%	0.002%	0.015%
3B4giv	NH3	123.9	81.0	6%	55%	56%	0.074%	-0.029%	0.110%	-0.016%	0.009%	0.019%
3B4h	NH3	14.6	41.5	6%	50%	50%	0.034%	0.040%	0.057%	0.020%	0.005%	0.021%
3Da1	NH3	4'308.6	2'208.6	25%	50%	56%	2.035%	-1.844%	3.010%	-0.922%	1.064%	1.408%
3Da2a	NH3	36'101.8	22'814.7	6%	22%	23%	8.666%	-9.544%	31.097%	-2.123%	2.639%	3.387%
3Da2b	NH3	1'169.4	-	6%	50%	50%	0.000%	-1.318%	0.000%	-0.659%	0.000%	0.659%
3Da2c	NH3	34.3	701.8	6%	50%	50%	0.583%	0.918%	0.957%	0.459%	0.087%	0.467%
3Da3	NH3	788.3	1'386.7	6%	38%	38%	0.870%	1.002%	1.890%	0.376%	0.172%	0.413%
3Db	NH3	2'918.3	2'837.0	6%	50%	50%	2.358%	0.578%	3.867%	0.289%	0.352%	0.455%
5A	NH3	610.7	280.7	10%	50%	51%	0.236%	-0.306%	0.383%	-0.153%	0.054%	0.162%
5B1	NH3	28.9	106.5	30%	20%	36%	0.063%	0.113%	0.145%	0.023%	0.062%	0.066%
5B2	NH3	9.6	143.0	20%	75%	78%	0.183%	0.184%	0.195%	0.138%	0.055%	0.149%
5C1biv	NH3	5.7	12.8	20%	50%	54%	0.011%	0.011%	0.017%	0.005%	0.005%	0.007%
5C2	NH3	18.0	10.3	48%	25%	54%	0.009%	-0.006%	0.014%	-0.002%	0.010%	0.010%
5D1	NH3	91.7	120.5	1%	50%	50%	0.099%	0.061%	0.164%	0.030%	0.003%	0.031%
6A	NH3	922.1	1'034.9	30%	0%	30%	0.512%	0.371%	1.411%	0.000%	0.598%	0.598%
Total		**73'366**	**60'664**	**Level uncertainty:**			**12.8%**	**Trend uncertainty:**				**4.736%**

Table A - 13: Uncertainty analysis of PM2.5 emissions 1990 and 2015.

A	B	C	D	E	F	G	H	I	J	K	L	M
NFR	Pollutant	Emissions 1990	Emissions 2015	AD uncertainty 2015	EF uncertainty 2015	Combined uncertainty 2015	Combined uncertainty as % of total national 2015	Type A sensitivity	Type B sensitivity	Uncertainty in trend introduced by emission factor uncertainty	Uncertainty in trend introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		t	t	%	%	%	%	%	%	%	%	%
1A1a	PM2.5	749.7	69.6	10%	71%	72%	0.679%	-1.828%	0.447%	-1.298%	0.063%	1.299%
1A1b	PM2.5	47.7	32.4	1%	20%	20%	0.088%	0.064%	0.208%	0.013%	0.004%	0.013%
1A1c	PM2.5	4.6	12.2	0%	0%	0%	0.000%	0.064%	0.079%	0.000%	0.000%	0.000%
1A2a	PM2.5	14.9	3.5	2%	28%	28%	0.014%	-0.023%	0.023%	-0.006%	0.001%	0.006%
1A2b	PM2.5	9.3	2.1	2%	30%	30%	0.009%	-0.015%	0.014%	-0.004%	0.000%	0.004%
1A2c	PM2.5	40.8	6.7	2%	10%	10%	0.009%	-0.081%	0.043%	-0.008%	0.001%	0.008%
1A2d	PM2.5	149.6	0.8	2%	33%	33%	0.003%	-0.449%	0.005%	-0.148%	0.000%	0.148%
1A2e	PM2.5	25.7	1.4	2%	10%	10%	0.002%	-0.069%	0.009%	-0.007%	0.000%	0.007%
1A2f	PM2.5	437.6	43.2	2%	65%	65%	0.382%	-1.051%	0.277%	-0.683%	0.008%	0.683%
1A2gvii	PM2.5	728.9	412.2	1%	50%	50%	2.803%	0.435%	2.648%	0.218%	0.048%	0.223%
1A2gviii	PM2.5	512.9	371.9	2%	65%	65%	3.288%	0.832%	2.389%	0.541%	0.069%	0.545%
1A3ai(i)	PM2.5	92.4	20.5	1%	30%	30%	0.084%	-0.149%	0.132%	-0.045%	0.002%	0.045%
1A3aii(i)	PM2.5	22.7	3.3	1%	30%	30%	0.014%	-0.047%	0.021%	-0.014%	0.000%	0.014%
1A3bi	PM2.5	717.7	385.9	1%	57%	57%	3.009%	0.300%	2.479%	0.172%	0.045%	0.178%
1A3bii	PM2.5	332.6	141.1	1%	48%	48%	0.927%	-0.103%	0.907%	-0.050%	0.017%	0.052%
1A3biii	PM2.5	1'072.9	263.0	1%	27%	27%	0.967%	-1.566%	1.690%	-0.423%	0.031%	0.424%
1A3bvi	PM2.5	343.3	450.8	1%	50%	50%	3.066%	1.854%	2.897%	0.927%	0.053%	0.928%
1A3c	PM2.5	172.7	195.1	1%	50%	50%	1.327%	0.729%	1.254%	0.365%	0.023%	0.365%
1A3dii	PM2.5	59.1	39.0	1%	50%	50%	0.265%	0.071%	0.251%	0.036%	0.005%	0.036%
1A3ei	PM2.5	0.1	0.2	2%	27%	27%	0.001%	0.001%	0.001%	0.000%	0.000%	0.000%
1A4ai	PM2.5	427.5	515.6	2%	78%	78%	5.470%	2.014%	3.313%	1.571%	0.074%	1.573%
1A4bi	PM2.5	4'915.4	1'776.7	4%	76%	76%	18.383%	-3.497%	11.415%	-2.657%	0.600%	2.724%
1A4ci	PM2.5	528.3	137.5	21%	39%	44%	0.830%	-0.720%	0.883%	-0.281%	0.265%	0.386%
1A4cii	PM2.5	733.8	488.0	1%	80%	80%	5.310%	0.907%	3.136%	0.726%	0.057%	0.728%
1A5b	PM2.5	77.9	46.8	1%	50%	50%	0.319%	0.064%	0.301%	0.032%	0.005%	0.033%
1B1a	PM2.5	0.2	0.1	30%	40%	50%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2A1	PM2.5	240.5	159.8	2%	30%	30%	0.653%	0.296%	1.027%	0.089%	0.029%	0.094%
2A2	PM2.5	7.2	5.9	2%	50%	50%	0.040%	0.016%	0.038%	0.008%	0.001%	0.008%
2A5a	PM2.5	183.3	231.4	5%	20%	21%	0.649%	0.930%	1.487%	0.186%	0.105%	0.214%
2B5	PM2.5	43.7	32.4	2%	10%	10%	0.045%	0.075%	0.208%	0.008%	0.006%	0.010%
2B10a	PM2.5	7.9	0.6	2%	50%	50%	0.004%	-0.020%	0.004%	-0.010%	0.000%	0.010%
2C1	PM2.5	817.9	9.8	2%	57%	57%	0.076%	-2.419%	0.063%	-1.379%	0.002%	1.379%
2C3	PM2.5	78.3	-	5%	23%	24%	0.000%	-0.238%	0.000%	-0.055%	0.000%	0.055%
2C7a	PM2.5	5.2	0.6	5%	30%	30%	0.003%	-0.012%	0.004%	-0.004%	0.000%	0.004%
2C7c	PM2.5	1.7	1.5	5%	80%	80%	0.016%	0.004%	0.009%	0.003%	0.001%	0.003%
2D3c	PM2.5	120.0	72.4	20%	100%	102%	1.005%	0.101%	0.465%	0.101%	0.132%	0.166%
2D3i	PM2.5	12.0	-	30%	0%	30%	0.000%	-0.036%	0.000%	0.000%	0.000%	0.000%
2G	PM2.5	206.8	228.7	25%	30%	39%	1.215%	0.842%	1.470%	0.253%	0.520%	0.578%
2H1	PM2.5	235.8	219.7	30%	40%	50%	1.494%	0.696%	1.412%	0.278%	0.599%	0.660%
2H2	PM2.5	188.8	171.3	10%	41%	42%	0.983%	0.527%	1.100%	0.216%	0.156%	0.266%
2H3	PM2.5	15.6	13.3	3%	0%	3%	0.005%	0.038%	0.086%	0.000%	0.004%	0.004%
2I	PM2.5	237.9	91.1	1%	30%	30%	0.372%	-0.137%	0.585%	-0.041%	0.008%	0.042%
3B1a	PM2.5	46.2	34.4	6%	50%	50%	0.236%	0.081%	0.221%	0.040%	0.020%	0.045%
3B1b	PM2.5	16.6	19.8	6%	50%	50%	0.135%	0.076%	0.127%	0.038%	0.012%	0.040%
3B2	PM2.5	2.4	2.1	6%	50%	50%	0.014%	0.006%	0.013%	0.003%	0.001%	0.003%
3B3	PM2.5	194.8	163.0	6%	50%	50%	1.118%	0.456%	1.048%	0.228%	0.095%	0.247%
3B4a	PM2.5	NA	0.0	6%	50%	50%	0.000%	NA	NA	NA	NA	NA
3B4d	PM2.5	0.4	0.4	6%	50%	50%	0.003%	0.002%	0.003%	0.001%	0.000%	0.001%
3B4e	PM2.5	0.2	0.3	6%	50%	50%	0.002%	0.002%	0.002%	0.001%	0.000%	0.001%
3B4f	PM2.5	0.0	0.1	6%	50%	50%	0.001%	0.001%	0.001%	0.000%	0.000%	0.000%
3B4gi	PM2.5	77.2	140.7	6%	50%	50%	0.965%	0.670%	0.904%	0.335%	0.082%	0.345%
3B4h	PM2.5	0.0	0.1	6%	0%	6%	0.000%	0.000%	0.001%	0.000%	0.000%	0.000%
5B2	PM2.5	NA	0.0	20%	100%	102%	0.001%	NA	NA	NA	NA	NA
5C1a	PM2.5	465.1	277.9	50%	30%	58%	2.204%	0.373%	1.786%	0.112%	1.263%	1.268%
5C1bi	PM2.5	0.5	-	30%	30%	42%	0.000%	-0.001%	0.000%	0.000%	0.000%	0.000%
5C1biii	PM2.5	33.0	-	30%	30%	42%	0.000%	-0.100%	0.000%	-0.030%	0.000%	0.030%
5C1biv	PM2.5	14.3	3.6	20%	34%	39%	0.019%	-0.020%	0.023%	-0.007%	0.006%	0.009%
5C1bv	PM2.5	4.4	1.1	5%	33%	33%	0.005%	-0.006%	0.007%	-0.002%	0.001%	0.002%
5C2	PM2.5	84.7	48.5	48%	133%	141%	0.933%	0.054%	0.312%	0.072%	0.212%	0.224%
5E	PM2.5	1.4	1.5	20%	30%	36%	0.007%	0.005%	0.010%	0.002%	0.003%	0.003%
6A	PM2.5	2.2	2.4	30%	40%	50%	0.016%	0.009%	0.015%	0.003%	0.007%	0.007%
Total		**15'564**	**7'354**	**Level uncertainty:**			**21.3%**	**Trend uncertainty:**				**4.357%**

Table A - 14: Uncertainty analysis of PM10 emissions 1990 and 2015.

A	B	C	D	E	F	G	H	I	J	K	L	M
NFR	Pollutant	Emissions 1990	Emissions 2015	AD uncertainty 2015	EF uncertainty 2015	Combined uncertainty 2015	Combined uncertainty as % of total national 2015	Type A sensitivity	Type B sensitivity	Uncertainty in trend introduced by emission factor uncertainty	Uncertainty in trend introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		t	t	%	%	%	%	%	%	%	%	%
1A1a	PM10	1'010.0	70.0	10%	71%	72%	0.282%	-2.245%	0.261%	-1.594%	0.037%	1.595%
1A1b	PM10	47.7	32.4	1%	20%	20%	0.036%	0.003%	0.121%	0.001%	0.002%	0.002%
1A1c	PM10	4.9	12.9	0%	0%	0%	0.000%	0.036%	0.048%	0.000%	0.000%	0.000%
1A2a	PM10	20.6	4.0	2%	28%	28%	0.006%	-0.036%	0.015%	-0.010%	0.000%	0.010%
1A2b	PM10	9.9	2.2	2%	30%	30%	0.004%	-0.016%	0.008%	-0.005%	0.000%	0.005%
1A2c	PM10	40.8	6.7	2%	10%	10%	0.004%	-0.076%	0.025%	-0.008%	0.001%	0.008%
1A2d	PM10	166.6	0.8	2%	33%	33%	0.001%	-0.411%	0.003%	-0.136%	0.000%	0.136%
1A2e	PM10	25.7	1.4	2%	10%	10%	0.001%	-0.059%	0.005%	-0.006%	0.000%	0.006%
1A2f	PM10	832.6	79.6	2%	65%	65%	0.290%	-1.770%	0.297%	-1.150%	0.008%	1.150%
1A2gvii	PM10	2'173.2	2'301.7	1%	50%	50%	6.460%	3.193%	8.591%	1.597%	0.157%	1.604%
1A2gviii	PM10	520.6	384.3	2%	65%	65%	1.403%	0.142%	1.435%	0.092%	0.042%	0.101%
1A3ai(i)	PM10	102.7	20.5	1%	30%	30%	0.035%	-0.178%	0.077%	-0.054%	0.001%	0.054%
1A3aii(i)	PM10	25.2	3.3	1%	30%	30%	0.006%	-0.050%	0.012%	-0.015%	0.000%	0.015%
1A3bi	PM10	717.7	385.9	1%	57%	57%	1.242%	-0.341%	1.440%	-0.196%	0.026%	0.197%
1A3bii	PM10	332.6	141.1	1%	48%	48%	0.383%	-0.299%	0.527%	-0.144%	0.010%	0.145%
1A3biii	PM10	1'072.9	263.0	1%	27%	27%	0.399%	-1.681%	0.982%	-0.454%	0.018%	0.454%
1A3bvi	PM10	2'288.9	3'005.5	1%	50%	50%	8.436%	5.531%	11.218%	2.765%	0.204%	2.773%
1A3c	PM10	969.8	1'259.9	1%	50%	50%	3.536%	2.294%	4.703%	1.147%	0.086%	1.150%
1A3dii	PM10	59.1	39.0	1%	50%	50%	0.109%	-0.001%	0.146%	-0.001%	0.003%	0.003%
1A3ei	PM10	0.1	0.2	2%	27%	27%	0.000%	0.000%	0.001%	0.000%	0.000%	0.000%
1A4ai	PM10	436.2	529.7	2%	78%	78%	2.319%	0.894%	1.977%	0.697%	0.044%	0.699%
1A4bi	PM10	5'019.9	1'820.2	4%	76%	76%	7.772%	-5.659%	6.794%	-4.301%	0.357%	4.315%
1A4ci	PM10	529.9	138.5	21%	39%	44%	0.345%	-0.798%	0.517%	-0.311%	0.155%	0.348%
1A4cii	PM10	2'502.8	1'926.6	1%	80%	80%	8.650%	0.976%	7.191%	0.781%	0.131%	0.792%
1A5b	PM10	284.9	272.8	1%	50%	50%	0.766%	0.311%	1.018%	0.155%	0.019%	0.157%
1B1a	PM10	1.6	0.7	30%	40%	50%	0.002%	-0.002%	0.002%	-0.001%	0.001%	0.001%
2A1	PM10	374.4	248.7	2%	30%	30%	0.420%	-0.001%	0.928%	0.000%	0.026%	0.026%
2A2	PM10	14.4	11.8	2%	50%	50%	0.033%	0.008%	0.044%	0.004%	0.001%	0.004%
2A5a	PM10	366.5	462.7	5%	20%	21%	0.535%	0.817%	1.727%	0.163%	0.122%	0.204%
2B5	PM10	52.6	39.0	2%	10%	10%	0.022%	0.015%	0.146%	0.001%	0.004%	0.004%
2B10a	PM10	17.1	1.8	2%	50%	50%	0.005%	-0.036%	0.007%	-0.018%	0.000%	0.018%
2C1	PM10	1'485.5	15.4	2%	50%	50%	0.043%	-3.628%	0.058%	-1.814%	0.002%	1.814%
2C3	PM10	113.1	-	5%	23%	24%	0.000%	-0.281%	0.000%	-0.065%	0.000%	0.065%
2C7a	PM10	5.5	0.7	5%	30%	30%	0.001%	-0.011%	0.003%	-0.003%	0.000%	0.003%
2C7c	PM10	3.3	2.9	5%	57%	57%	0.009%	0.003%	0.011%	0.002%	0.001%	0.002%
2D3c	PM10	200.0	94.5	20%	100%	102%	0.541%	-0.144%	0.353%	-0.144%	0.100%	0.175%
2D3i	PM10	24.0	-	30%	0%	30%	0.000%	-0.060%	0.000%	0.000%	0.000%	0.000%
2G	PM10	282.4	374.2	25%	30%	39%	0.820%	0.696%	1.397%	0.209%	0.494%	0.536%
2H1	PM10	243.8	226.6	30%	40%	50%	0.636%	0.240%	0.846%	0.096%	0.359%	0.371%
2H2	PM10	311.2	319.2	10%	41%	42%	0.756%	0.419%	1.191%	0.172%	0.168%	0.241%
2H3	PM10	15.6	13.3	3%	0%	3%	0.002%	0.011%	0.050%	0.000%	0.002%	0.002%
2I	PM10	951.4	364.4	1%	30%	30%	0.614%	-1.002%	1.360%	-0.301%	0.019%	0.301%
3B1a	PM10	307.0	228.6	6%	50%	50%	0.647%	0.091%	0.853%	0.046%	0.078%	0.090%
3B1b	PM10	108.6	129.8	6%	50%	50%	0.367%	0.215%	0.485%	0.107%	0.044%	0.116%
3B2	PM10	15.4	13.5	6%	50%	50%	0.038%	0.012%	0.051%	0.006%	0.005%	0.008%
3B3	PM10	1'297.4	1'085.9	6%	50%	50%	3.072%	0.832%	4.053%	0.416%	0.369%	0.556%
3B4a	PM10	NA	0.2	6%	50%	50%	0.001%	NA	NA	NA	NA	NA
3B4d	PM10	2.7	2.8	6%	50%	50%	0.008%	0.004%	0.010%	0.002%	0.001%	0.002%
3B4e	PM10	1.1	2.2	6%	50%	50%	0.006%	0.005%	0.008%	0.003%	0.001%	0.003%
3B4f	PM10	0.2	0.8	6%	50%	50%	0.002%	0.002%	0.003%	0.001%	0.000%	0.001%
3B4gi	PM10	510.7	930.9	6%	50%	50%	2.634%	2.206%	3.475%	1.103%	0.316%	1.148%
3B4h	PM10	0.1	0.5	6%	0%	6%	0.000%	0.002%	0.002%	0.000%	0.000%	0.000%
5A	PM10	0.7	0.5	10%	30%	32%	0.001%	0.000%	0.002%	0.000%	0.000%	0.000%
5B2	PM10	NA	0.0	20%	100%	102%	0.000%	NA	NA	NA	NA	NA
5C1a	PM10	516.8	308.8	50%	50%	71%	1.225%	-0.130%	1.153%	-0.065%	0.815%	0.818%
5C1bi	PM10	3.1	-	30%	30%	42%	0.000%	-0.008%	0.000%	-0.002%	0.000%	0.002%
5C1biii	PM10	48.0	-	30%	30%	42%	0.000%	-0.119%	0.000%	-0.036%	0.000%	0.036%
5C1biv	PM10	20.0	5.1	20%	35%	40%	0.012%	-0.030%	0.019%	-0.011%	0.005%	0.012%
5C1bv	PM10	4.4	1.1	5%	33%	33%	0.002%	-0.007%	0.004%	-0.002%	0.000%	0.002%
5C2	PM10	93.1	53.3	48%	133%	141%	0.423%	-0.032%	0.199%	-0.043%	0.135%	0.142%
5E	PM10	2.8	3.0	20%	30%	36%	0.006%	0.004%	0.011%	0.001%	0.003%	0.003%
6A	PM10	201.6	175.1	30%	40%	50%	0.491%	0.153%	0.654%	0.061%	0.277%	0.284%
Total		**26'791**	**17'820**	**Level uncertainty:**			**17.1%**	**Trend uncertainty:**				**6.480%**

Table A - 15: Uncertainty analysis: Overview and data sources.

NFR Code	Relative uncertainties (95%)													
	Activity data		EF NOx		EF NMVOC		EF SOx		EF NH3		EF PM2.5		EF PM10	
	Value	Source	Value	Source	Value	Source	Value	Source	Value	Source	Value	Source	Value	Source
1A1a	10.0%	GHGI	19%	EMIS	32%	EMIS	22%	EMIS	20%	EMIS	71%	EMIS	71%	EMIS
1A1b	1.3%	GHGI	20%	EMIS	20%	EMIS	20%	EMIS	10%	EMIS	20%	EMIS	20%	EMIS
1A1c	-	GHGI	20%	B (EMEP)	20%	B (EMEP)	-	-	-	-	-	-	-	-
1A2a	2.0%	GHGI	27%	EMIS	18%	EMIS	15%	EMIS	10%	EMIS	28%	EMIS	28%	EMIS
1A2b	2.0%	GHGI	20%	EMIS	19%	EMIS	10%	EMIS	10%	EMIS	30%	EMIS	30%	EMIS
1A2c	2.0%	GHGI	10%	EMIS	10%	EMIS	11%	EMIS	10%	EMIS	10%	EMIS	10%	EMIS
1A2d	2.0%	GHGI	10%	EMIS	10%	EMIS	14%	EMIS	10%	EMIS	33%	EMIS	33%	EMIS
1A2e	2.0%	GHGI	10%	EMIS	10%	EMIS	12%	EMIS	10%	EMIS	10%	EMIS	10%	EMIS
1A2f	2.0%	GHGI	17%	EMIS	30%	EMIS	19%	EMIS	9%	EMIS	65%	EMIS	65%	EMIS
1A2giv	2%	GHGI	17%	EMIS	30%	EMIS	19%	EMIS	9%	EMIS	65%	EMIS	65%	EMIS
1A2gvii	1.3%	GHGI	13%	UBA	34%	UBA	10%	A (EMEP)	50%	France	50%	UBA/INFRAS	50%	UBA/INFRAS
1A2gviii	2.1%	NIR CH	17%	EMIS	30%	EMIS	19%	EMIS	9%	EMIS	65%	EMIS	65%	EMIS
1A3ai(i)	1.3%	GHGI	20%	B (EMEP)	50%	C (EMEP)	10%	A (EMEP)	-	-	30%	UBA/INFRAS	30%	UBA/INFRAS
1A3aii(i)	1.3%	GHGI	20%	B (EMEP)	50%	C (EMEP)	10%	A (EMEP)	-	-	30%	UBA/INFRAS	30%	UBA/INFRAS
1A3bi	1.3%	GHGI	38%	UBA	52%	UBA	10%	A (EMEP)	50%	France	57%	UBA/INFRAS	57%	UBA/INFRAS
1A3bii	1.3%	GHGI	32%	UBA	46%	UBA	10%	A (EMEP)	50%	France	48%	UBA/INFRAS	48%	UBA/INFRAS
1A3biii	1.3%	GHGI	18%	UBA	22%	UBA	10%	A (EMEP)	50%	France	27%	UBA/INFRAS	27%	UBA/INFRAS
1A3biv	1.3%	GHGI	36%	UBA	400%	UBA	10%	A (EMEP)	50%	France	54%	UBA/INFRAS	54%	UBA/INFRAS
1A3bv	1.3%	GHGI	-	-	40%	UBA	-	-	-	-	-	-	-	-
1A3bvi	1.3%	GHGI	-	-	-	-	-	-	-	-	50%	UBA/INFRAS	50%	UBA/INFRAS
1A3bviii	1%	GHGI	38%	UBA	-	-	10%	A (EMEP)	50%	France	57%	UBA/INFRAS	57%	UBA/INFRAS
1A3c	1.3%	GHGI	13%	UBA	34%	UBA	10%	A (EMEP)	50%	France	50%	UBA/INFRAS	50%	UBA/INFRAS
1A3dii	1.3%	GHGI	13%	UBA	34%	UBA	10%	A (EMEP)	50%	France	50%	UBA/INFRAS	50%	UBA/INFRAS
1A3ei	2.0%	GHGI	50%	C (EMEP)	50%	C (EMEP)	10%	A (EMEP)	50%	France	27%	UBA/INFRAS	27%	UBA/INFRAS
1A4ai	1.6%	GHGI	16%	EMIS	56%	EMIS	10%	EMIS	10%	EMIS	78%	EMIS	78%	EMIS
1A4aii	1.3%	GHGI	13%	UBA	75%	Sweden	10%	A (EMEP)	10%	EMIS	50%	UBA/INFRAS	50%	UBA/INFRAS
1A4bi	3.7%	GHGI	13%	EMIS	68%	EMIS	10%	EMIS	10%	EMIS	76%	EMIS	76%	EMIS
1A4bii	1.3%	GHGI	30%	EMIS	75%	Sweden	10%	A (EMEP)	10%	EMIS	50%	UBA/INFRAS	50%	UBA/INFRAS
1A4ci	21.2%	GHGI	30%	EMIS	75%	EMIS	18%	EMIS	10%	EMIS	39%	EMIS	39%	EMIS
1A4cii	1.3%	GHGI	13%	UBA	75%	Sweden	10%	A (EMEP)	50%	France	80%	EMIS	80%	EMIS
1A5b	1.3%	GHGI	13%	UBA	34%	UBA	10%	A (EMEP)	50%	France	50%	UBA/INFRAS	50%	UBA/INFRAS
1B1a	30.0%	D.O.EMEP	-	-	-	-	-	-	-	-	40%	EMIS	40%	EMIS
1B2ai	30.0%	-	-	-	50%	C (EMEP)	-	-	-	-	-	-	-	-
1B2aiv	30.0%	D.O.EMEP	-	-	47%	EMIS	47%	EMIS	-	-	-	-	-	-
1B2av	1.3%	D.O.EMEP	-	-	26%	EMIS	-	-	-	-	-	-	-	-
1B2b	22.0%	-	-	-	50%	C (EMEP)	-	-	-	-	-	-	-	-
1B2c	22.0%	EMIS	30%	EMIS	51%	EMIS	31%	EMIS	-	-	-	-	-	-
2A1	2.0%	NIR CH	30%	EMIS	30%	EMIS	30%	EMIS	-	-	30%	EMIS	30%	EMIS
2A2	2.0%	NIR CH	30%	EMIS	30%	EMIS	30%	EMIS	-	-	50%	EMIS	50%	EMIS
2A5a	5.0%	EMIS	20%	EMIS	14%	EMIS	21%	EMIS	-	-	20%	EMIS	20%	EMIS
2B1	2.0%	NIR CH	-	-	-	-	-	-	10%	EMIS	-	-	-	-
2B2	2.0%	NIR CH	20%	EMIS	-	-	-	-	50%	EMIS	-	-	-	-
2B5	2.0%	NIR CH	-	-	-	-	20%	EMIS	-	-	10%	EMIS	10%	EMIS
2B10a	2.0%	NIR CH	-	-	20%	B (EMEP)	20%	B (EMEP)	5%	EMIS	50%	EMIS	50%	EMIS
2C1	2.0%	NIR CH	40%	EMIS	40%	EMIS	40%	EMIS	50%	France	57%	EMIS	50%	EMIS
2C3	5.0%	NIR CH	30%	EMIS	31%	EMIS	20%	B (EMEP)	-	-	23%	France	23%	France
2C7a	5.0%	EMIS	-	-	20%	EMIS	-	-	-	-	30%	EMIS	30%	EMIS
2C7c	5.0%	EMIS	10%	EMIS	-	-	40%	EMIS	40%	EMIS	80%	EMIS	57%	EMIS
2D3a	1.0%	EMIS	-	-	50%	EMIS	-	-	-	-	-	-	-	-
2D3b	5.0%	EMIS	-	-	30%	EMIS	-	-	-	-	-	-	-	-
2D3c	20.0%	EMIS	-	-	50%	EMIS	-	-	-	-	100%	France	100%	France
2D3d	30.0%	EMIS	-	-	30%	EMIS	-	-	-	-	-	-	-	-
2D3e	40.0%	EMIS	-	-	40%	EMIS	-	-	-	-	-	-	-	-
2D3f	20.0%	EMIS	-	-	20%	EMIS	-	-	-	-	-	-	-	-
2D3g	30.0%	EMIS	-	-	20%	EMIS	-	-	-	-	-	-	-	-
2D3h	15.0%	EMIS	-	-	20%	EMIS	-	-	-	-	-	-	-	-
2D3i	30.0%	D.O.EMEP	-	-	20%	EMIS	-	-	-	-	-	-	-	-
2G	25.0%	EMIS	30%	EMIS	25%	EMIS	17%	EMIS	60%	EMIS	30%	EMIS	30%	EMIS
2H1	30.0%	D.O.EMEP	-	-	19%	EMIS	-	-	-	-	40%	EMIS	40%	EMIS
2H2	10.0%	D.O.EMEP	-	-	30%	EMIS	-	-	90%	EMIS	41%	EMIS	41%	EMIS
2H3	3.0%	EMIS	-	-	28%	EMIS	50%	EMIS	50%	EMIS	-	-	-	-
2I	1.0%	EMIS	-	-	-	-	-	-	-	-	30%	EMIS	30%	EMIS
3B1a	6.4%	GHGI	50%	C (EMEP)	-	-	-	-	38%	Infras 2017	50%	EMIS	50%	EMIS
3B1b	6.4%	GHGI	50%	C (EMEP)	-	-	-	-	25%	Infras 2017	50%	EMIS	50%	EMIS
3B2	6.4%	GHGI	50%	C (EMEP)	-	-	-	-	54%	Infras 2017	50%	EMIS	50%	EMIS
3B3	6.4%	GHGI	50%	C (EMEP)	-	-	-	-	36%	Infras 2017	50%	EMIS	50%	EMIS
3B4a	6.4%	GHGI	50%	C (EMEP)	-	-	-	-	50%	Kupper 2012	50%	EMIS	50%	EMIS
3B4d	6.4%	GHGI	50%	C (EMEP)	-	-	-	-	57%	Infras 2017	50%	EMIS	50%	EMIS
3B4e	6.4%	GHGI	50%	C (EMEP)	-	-	-	-	34%	Infras 2017	50%	EMIS	50%	EMIS
3B4f	6.4%	GHGI	50%	C (EMEP)	-	-	-	-	47%	Infras 2017	50%	EMIS	50%	EMIS
3B4gi	6.4%	GHGI	50%	C (EMEP)	-	-	-	-	83%	Infras 2017	50%	EMIS	50%	EMIS
3B4gii	6.4%	GHGI	50%	C (EMEP)	-	-	-	-	69%	Infras 2017	-	-	-	-
3B4giii	6.4%	GHGI	50%	C (EMEP)	-	-	-	-	78%	Infras 2017	-	-	-	-
3B4giv	6.0%	GHGI	50%	C (EMEP)	-	-	-	-	55%	Infras 2017	-	-	-	-
3B4h	6.0%	GHGI	50%	C (EMEP)	-	-	-	-	50%	Infras 2017	-	-	-	-
3Da1	25.0%	GHGI	100%	C (EMEP)	-	-	-	-	50%	Kupper 2012	-	-	-	-
3Da2a	6.0%	GHGI	50%	C (EMEP)	-	-	-	-	22%	Infras 2017	-	-	-	-
3Da2b	6.4%	GHGI	100%	C (EMEP)	-	-	-	-	50%	Kupper 2012	-	-	-	-
3Da2c	6.4%	GHGI	100%	C (EMEP)	-	-	-	-	50%	Kupper 2012	-	-	-	-
3Da3	6.4%	GHGI	100%	C (EMEP)	-	-	-	-	38%	Infras 2017	-	-	-	-
3Db	6.4%	GHGI	-	-	75%	EMIS	-	-	50%	Kupper 2012	-	-	-	-
5A	10.0%	NIR CH	50%	EMIS	50%	EMIS	40%	EMIS	50%	EMIS	25%	EMIS	30%	EMIS
5B1	30.0%	EMIS	-	-	30%	EMIS	-	-	20%	EMIS	-	-	-	-
5B2	20.0%	EMIS	100%	C (EMEP)	30%	EMIS	100%	EMIS	75%	INFRAS 2014	100%	EMIS	100%	EMIS
5C1a	50.0%	EMIS	40%	EMIS	50%	EMIS	40%	EMIS	-	-	30%	EMIS	50%	EMIS
5C1bi	30.0%	EMIS	30%	EMIS	30%	EMIS	30%	EMIS	-	-	30%	EMIS	30%	EMIS
5C1biii	30.0%	EMIS	30%	EMIS	30%	EMIS	30%	EMIS	-	-	30%	EMIS	30%	EMIS
5C1biv	20.0%	EMIS	50%	EMIS	20%	EMIS	30%	EMIS	50%	EMIS	34%	EMIS	35%	EMIS
5C1bv	5.0%	EMIS	30%	EMIS	30%	EMIS	-	-	-	-	33%	EMIS	33%	EMIS
5C2	48.0%	EMIS	133%	EMIS	133%	EMIS	117%	EMIS	25%	EMIS	133%	EMIS	133%	EMIS
5D1	1.3%	EMIS	10%	EMIS	27%	EMIS	37%	EMIS	50%	EMIS	-	-	-	-
5D2	10.0%	EMIS	10%	EMIS	20%	EMIS	20%	EMIS	-	-	-	-	-	-
5E	20.0%	EMIS	-	-	24%	EMIS	-	-	-	-	30%	EMIS	30%	EMIS
6A	30.0%	GHGI	50%	EMIS	50%	EMIS	50%	EMIS	-	-	40%	EMIS	40%	EMIS

Legend:

A (EMEP), B (EMEP), C (EMEP), D (EMEP), D.O.EMEP: Default values of EMEP/EEA (2013) (activity data and emission factors) where the capital letters (A,B,C,D) indicate the rating definitions contained in Table 3-2, page 8, in the same document. “D.O.EMEP” refers to the value contained in Table 3-1 under “Default values, other sectors and data sources”.

EMIS: Uncertainties that are implemented in the EMIS database (activity data and emission factors).

France/Sweden: Uncertainties from France’s or Sweden’s Informative Inventory Reports (Citepa 2012, SEPA 2010); mainly emission factors.

GHGI: Uncertainty analysis of Switzerland’s greenhouse gas inventory (FOEN 2017); mainly activity data.

UBA: Uncertainties for mobile sources from IFEU/INFRAS (2009), in which uncertainties are evaluated for road and non-road vehicles via Monte Carlo simulation (emission factors).

UBA/INFRAS: PM10 emission factor uncertainties derived from raw data of IFEU/INFRAS (2009).

“-“: The emissions of a pollutant in a certain category are equal to zero.

“NA”: for source categories that are NA in 1990 no trend uncertainty can be calculated and corresponding entries are therefore indicated as NA.

Kupper 2012: see References (chp. 12.1).

Infras 2017: see References (chp. 12.1).

Annex 6: Emission time series of main air pollutants and PM2.5 for 1980–2015 and 2020–2030

A6.1 Emission time series by pollutant and aggregated sectors

A6.1.1 NO_x emission time series

Table A - 16: NO_x emissions by sectors 1-6 between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NOx	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1	158.0	157.4	156.2	156.3	158.0	158.3	155.1	151.4	146.1	139.6
2	1.6	1.6	1.6	1.6	1.5	1.3	1.1	1.0	0.8	0.6
3	6.3	6.2	6.1	6.1	6.0	5.9	5.9	5.8	5.7	5.7
5	0.8	0.8	0.9	0.9	0.9	0.9	0.8	0.7	0.6	0.5
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	166.6	166.0	164.8	164.9	166.5	166.5	162.9	158.8	153.3	146.4

NOx	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1	133.1	130.8	124.9	118.2	116.6	115.5	113.1	107.3	106.5	104.7
2	0.5	0.4	0.4	0.4	0.4	0.3	0.2	0.2	0.2	0.3
3	3.9	3.9	3.8	3.7	3.6	3.6	3.5	3.3	3.3	3.3
5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sum	137.9	135.6	129.7	122.8	121.1	119.8	117.4	111.3	110.5	108.7

NOx	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1	102.1	99.3	93.6	90.8	88.6	87.2	83.4	79.6	76.2	71.6
2	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
3	3.2	3.3	3.2	3.2	3.1	3.1	3.1	3.2	3.2	3.1
5	0.4	0.4	0.3	0.3	0.4	0.3	0.3	0.3	0.4	0.3
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sum	106.0	103.4	97.6	94.8	92.6	91.0	87.3	83.5	80.2	75.4

NOx	2010	2011	2012	2013	2014	2015	05-15
	kt						%
1	69.8	65.0	63.8	62.5	58.1	55.3	-37
2	0.3	0.4	0.3	0.3	0.3	0.3	9
3	3.2	3.1	3.1	3.0	3.1	3.0	-4
5	0.4	0.4	0.4	0.4	0.4	0.4	9
6	0.1	0.1	0.1	0.1	0.1	0.1	9
Sum	73.8	68.9	67.6	66.3	62.0	59.1	-35

Table A - 17: NO_x emissions by sectors 1-6 between 2020 and 2030.

NOx	2020	2025	2030
	kt		
1	45.5	38.6	34.4
2	0.3	0.3	0.3
3	2.9	2.9	2.9
5	0.4	0.4	0.4
6	0.1	0.1	0.1
Sum	49.3	42.3	38.2

A6.1.2 NMVOC emission time series

Table A - 18: NMVOC emissions by sectors 1-6 between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NMVOC total	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1	153.6	153.1	151.8	150.9	150.1	148.4	143.7	138.4	132.7	126.3
2	141.3	142.8	144.3	145.8	147.2	149.7	151.2	153.4	155.5	157.1
3	9.9	9.9	10.0	10.0	10.1	10.1	9.3	8.6	7.8	7.0
5	2.6	2.5	2.3	2.2	2.1	1.9	1.7	1.6	1.4	1.3
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sum	307.5	308.4	308.5	309.0	309.6	310.3	306.1	302.1	297.6	291.8

NMVOC total	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1	118.7	113.3	103.8	93.9	83.7	79.4	75.7	70.6	66.1	60.7
2	164.5	151.8	139.4	127.1	118.8	110.0	100.9	92.9	84.6	80.3
3	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
5	1.1	1.1	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.4
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sum	288.3	270.4	248.5	226.3	207.8	194.8	182.1	168.9	156.2	146.6

NMVOC total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1	57.3	54.8	50.3	47.3	44.4	41.9	39.0	36.1	34.4	32.0
2	75.4	70.7	65.3	59.7	53.5	52.1	51.2	49.8	50.0	50.0
3	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.9	3.9	3.9
5	1.7	1.7	1.8	1.8	1.8	1.8	1.9	1.9	2.0	2.0
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sum	138.5	131.2	121.4	112.8	103.8	99.8	96.1	91.9	90.5	87.9

NMVOC total	2010	2011	2012	2013	2014	2015	05-15
	kt						%
1	30.0	27.8	26.2	25.9	24.0	22.0	-47
2	50.4	50.0	49.9	48.9	49.1	48.7	-6
3	3.9	3.9	3.9	3.9	3.9	3.9	-2
5	2.0	2.1	2.2	2.3	2.3	2.4	34
6	0.1	0.1	0.1	0.1	0.1	0.1	-10
Sum	86.5	83.9	82.3	81.1	79.5	77.2	-23

Table A - 19: NMVOC emissions by sectors 1-6 between 2020 and 2030.

NMVOC total	2020	2025	2030
	kt		
1	19.6	17.1	14.8
2	48.5	48.8	49.0
3	3.8	3.8	3.8
5	3.6	5.2	6.9
6	0.1	0.1	0.1
Sum	75.6	75.0	74.6

A6.1.3 SO_x emission time series

Table A - 20: SO_x emissions by sectors 1-6 between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

SO2	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1	110.9	98.0	86.8	80.5	77.5	70.8	65.9	61.7	55.1	46.0
2	2.8	2.8	2.7	2.6	2.5	2.3	2.2	2.0	1.8	1.6
3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	114.0	101.0	89.8	83.3	80.2	73.4	68.4	63.9	57.1	47.8

SO2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1	38.0	34.8	31.5	25.4	26.2	24.9	24.5	22.4	21.3	15.9
2	1.5	1.4	1.4	1.1	1.0	0.9	0.9	0.9	0.8	0.7
3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	39.6	36.4	33.0	26.7	27.3	25.9	25.5	23.4	22.2	16.7

SO2	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1	14.4	17.1	14.6	14.1	13.8	14.0	13.0	11.0	11.1	9.5
2	0.8	0.8	0.9	0.9	1.1	1.1	0.7	0.7	0.7	0.5
3	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	15.3	18.0	15.5	15.1	15.0	15.2	13.8	11.7	11.9	10.0

SO2	2010	2011	2012	2013	2014	2015	05-15
	kt						%
1	9.7	7.9	8.1	8.0	7.2	6.0	-57
2	0.8	0.7	0.8	0.6	0.6	0.6	-40
3	NO	NO	NO	NO	NO	NO	NO
5	0.1	0.1	0.1	0.1	0.1	0.1	20
6	0.0	0.0	0.0	0.0	0.0	0.0	-2
Sum	10.5	8.7	8.9	8.7	7.9	6.7	-56

Table A - 21: SO_x emissions by sectors 1-6 between 2020 and 2030.

SO2	2020	2025	2030
	kt		
1	5.7	5.1	4.6
2	0.6	0.6	0.6
3	NO	NO	NO
5	0.1	0.1	0.1
6	0.0	0.0	0.0
Sum	6.4	5.9	5.4

A6.1.4 NH_3 emission time series

Table A - 22: NH_3 emissions by sectors 1-6 between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NH3	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.8	1.0	1.3
2	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.4	0.4
3	77.8	77.0	76.1	75.2	74.4	73.8	73.4	73.1	72.8	72.4
5	2.3	2.2	2.1	2.0	1.9	1.8	1.6	1.4	1.3	1.1
6	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sum	81.5	80.5	79.6	78.6	77.6	76.9	76.6	76.3	76.0	75.7

NH3	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1	1.6	1.9	2.2	2.4	2.7	2.9	3.1	3.3	3.5	3.7
2	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4
3	69.6	68.3	67.3	66.4	66.1	65.1	64.5	62.0	61.3	59.4
5	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
6	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
Sum	73.2	72.2	71.4	70.7	70.6	69.9	69.5	67.2	66.7	65.2

NH3	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1	4.9	4.8	4.6	4.3	4.1	3.9	3.6	3.5	3.3	3.1
2	0.4	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.3
3	58.7	58.7	57.8	57.1	57.1	58.0	58.6	59.5	59.8	58.7
5	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
6	1.0	1.0	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.9
Sum	65.6	65.5	64.3	63.4	63.1	63.8	64.1	64.7	64.9	63.6

NH3	2010	2011	2012	2013	2014	2015	05-15
	kt						%
1	2.9	2.8	2.6	2.5	2.4	2.3	-41
2	0.2	0.2	0.2	0.2	0.2	0.2	-53
3	58.8	57.9	57.3	56.7	57.2	56.5	-3
5	0.7	0.7	0.7	0.7	0.7	0.7	0
6	0.9	0.9	1.0	1.0	1.0	1.0	21
Sum	63.4	62.5	61.8	61.0	61.5	60.6	-5

Table A - 23: NH_3 emissions by sectors 1-6 between 2020 and 2030.

NH3	2020	2025	2030
	kt		
1	2.0	1.9	1.9
2	0.2	0.2	0.1
3	55.1	54.9	54.9
5	0.9	1.2	1.5
6	1.0	1.0	1.1
Sum	59.1	59.2	59.5

A6.1.5 PM2.5 emission time series

Table A - 24: PM2.5 emissions by sectors 1-6 between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

PM2.5	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1	25.6	23.3	20.8	18.7	17.3	16.9	16.5	15.9	15.1	14.1
2	2.9	2.8	2.7	2.6	2.5	2.4	2.4	2.4	2.4	2.4
3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
5	2.5	2.3	2.1	1.9	1.7	1.5	1.3	1.1	1.0	0.8
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	31.4	28.8	26.0	23.6	21.9	21.2	20.6	19.9	18.8	17.6

PM2.5	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1	12.2	12.5	11.9	11.4	10.8	10.9	10.9	10.0	9.8	9.5
2	2.4	2.4	2.4	2.4	2.4	2.0	1.9	1.9	1.5	1.4
3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
5	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	15.5	15.8	15.3	14.7	14.0	13.6	13.6	12.6	12.1	11.7

PM2.5	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1	9.0	8.8	8.2	8.1	7.9	7.8	7.5	7.0	6.9	6.6
2	1.4	1.3	1.4	1.3	1.4	1.3	1.3	1.4	1.4	1.3
3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	11.1	10.9	10.3	10.2	10.0	9.9	9.6	9.1	9.0	8.6

PM2.5	2010	2011	2012	2013	2014	2015	05-15
	kt						%
1	6.6	5.9	5.9	5.9	5.3	5.2	-33
2	1.3	1.4	1.3	1.3	1.3	1.2	-6
3	0.3	0.4	0.4	0.4	0.4	0.4	6
5	0.4	0.3	0.3	0.3	0.3	0.3	-12
6	0.0	0.0	0.0	0.0	0.0	0.0	-3
Sum	8.6	7.9	8.0	7.9	7.3	7.2	-27

Table A - 25: PM2.5 emissions by sectors 1-6 between 2020 and 2030.

PM2.5	2020	2025	2030
	kt		
1	4.9	4.3	3.7
2	1.4	1.3	1.3
3	0.4	0.4	0.4
5	0.3	0.3	0.3
6	0.0	0.0	0.0
Sum	7.0	6.3	5.6

A6.1.6 BC emission time series

Table A - 26: BC emissions by sectors 1-6 between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

BC	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1	5.24	5.21	5.16	5.13	5.14	5.18	5.27	5.36	5.43	5.49
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	0.17	0.16	0.15	0.13	0.12	0.10	0.09	0.08	0.07	0.05
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	5.42	5.37	5.31	5.27	5.26	5.28	5.37	5.44	5.50	5.55

BC	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1	4.96	5.20	4.97	4.83	4.52	4.59	4.63	4.19	4.12	3.97
2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	5.01	5.24	5.01	4.87	4.56	4.63	4.67	4.23	4.15	4.01

BC	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1	3.71	3.62	3.35	3.34	3.21	3.17	2.99	2.72	2.57	2.41
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	3.75	3.65	3.39	3.37	3.24	3.20	3.02	2.75	2.60	2.44

BC	2010	2011	2012	2013	2014	2015	05-15
	kt						%
1	2.33	2.00	1.92	1.83	1.55	1.48	-54
2	0.00	0.00	0.00	0.00	0.00	0.00	-69
3	NA	NA	NA	NA	NA	NA	NA
5	0.03	0.02	0.02	0.02	0.02	0.02	-12
6	0.00	0.00	0.00	0.00	0.00	0.00	-9
Sum	2.36	2.02	1.94	1.86	1.57	1.50	-53

Table A - 27: BC emissions by sectors 1-6 between 2020 and 2030.

BC	2020	2025	2030
	kt		
1	1.14	0.83	0.61
2	0.00	0.00	0.00
3	NA	NA	NA
5	0.02	0.02	0.02
6	0.00	0.00	0.00
Sum	1.16	0.85	0.63

A6.2 1 Energy

A6.2.1 1 Energy: NO_x

Table A - 28: NO_x emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NOx	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1A1	4.4	4.5	4.5	4.5	4.6	5.0	5.3	5.7	6.2	6.2
1A2	24.7	23.7	22.4	21.5	21.7	21.0	21.9	23.0	23.3	23.1
1A3	109.9	110.2	110.4	110.7	110.8	110.9	106.0	100.7	94.8	88.4
1A4	18.4	18.5	18.2	19.0	20.3	20.8	21.2	21.2	21.1	21.1
1A5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6
1B2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Sum	158.0	157.4	156.2	156.3	158.0	158.3	155.1	151.4	146.1	139.6

NOx	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1A1	6.8	6.8	6.5	5.4	5.1	4.7	4.7	4.2	4.4	4.0
1A2	22.9	21.9	20.6	19.7	20.1	19.7	18.7	16.4	16.1	16.0
1A3	81.6	79.2	75.2	71.2	71.1	69.9	68.0	66.7	65.8	65.5
1A4	21.1	22.2	21.9	21.1	19.7	20.5	21.0	19.3	19.4	18.5
1A5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1B2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Sum	133.1	130.8	124.9	118.2	116.6	115.5	113.1	107.3	106.5	104.7

NOx	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1A1	3.6	3.3	3.0	2.6	2.9	3.0	3.2	3.0	3.3	3.2
1A2	15.8	16.0	15.0	14.8	15.0	14.8	14.5	13.9	13.4	12.6
1A3	64.8	61.5	58.2	55.8	53.6	52.4	49.8	48.3	44.9	41.6
1A4	17.2	17.8	16.7	17.0	16.5	16.3	15.5	13.9	14.2	13.7
1A5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
1B2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Sum	102.1	99.3	93.6	90.8	88.6	87.2	83.4	79.6	76.2	71.6

NOx	2010	2011	2012	2013	2014	2015	05-15
	kt						%
1A1	3.3	3.2	3.3	3.5	3.3	2.7	-10.6
1A2	12.5	11.7	11.2	10.9	10.3	9.7	-34.5
1A3	39.5	37.9	36.5	35.0	33.5	31.7	-39.6
1A4	14.0	11.8	12.4	12.7	10.5	10.9	-33.5
1A5	0.4	0.4	0.4	0.3	0.3	0.3	-24.9
1B2	0.1	0.1	0.1	0.0	0.1	0.0	-83.0
Sum	69.8	65.0	63.8	62.5	58.1	55.3	-36.6

Table A - 29: NO_x emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 between 2020 and 2030.

NOx	2020	2025	2030
	kt		
1A1	4.9	6.0	6.7
1A2	7.4	6.5	6.0
1A3	23.2	17.5	14.4
1A4	9.7	8.2	7.0
1A5	0.3	0.3	0.3
1B2	0.0	0.0	0.0
Sum	45.5	38.6	34.4

A6.2.2 1 Energy: NMVOC

Table A - 30: NMVOC emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NMVOC total	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1A1	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.4	0.4
1A2	2.2	2.2	2.2	2.1	2.1	2.2	2.2	2.3	2.3	2.3
1A3	123.3	122.2	121.0	119.6	118.1	116.5	110.3	103.6	96.4	88.8
1A4	13.7	14.1	14.0	14.1	14.6	14.8	15.2	15.6	16.0	16.4
1A5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1B2	13.7	14.0	14.0	14.3	14.4	14.2	15.3	16.3	17.5	18.3
Sum	153.6	153.1	151.8	150.9	150.1	148.4	143.7	138.4	132.7	126.3

NMVOC total	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1A1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3
1A2	2.3	2.4	2.4	2.3	2.4	2.4	2.4	2.3	2.3	2.3
1A3	80.6	73.6	65.1	58.0	53.5	49.9	46.1	42.7	39.7	37.3
1A4	15.4	16.0	15.3	15.0	14.0	14.2	14.4	13.2	13.1	12.7
1A5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1B2	19.9	20.9	20.6	18.2	13.4	12.6	12.5	12.0	10.6	8.1
Sum	118.7	113.3	103.8	93.9	83.7	79.4	75.7	70.6	66.1	60.7

NMVOC total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1A1	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2
1A2	2.3	2.2	2.1	2.1	2.0	2.0	1.9	1.8	1.7	1.5
1A3	34.9	32.5	30.1	27.6	25.6	23.8	21.5	20.3	18.8	17.3
1A4	12.0	11.8	10.9	10.7	10.1	9.7	9.0	8.0	7.8	7.3
1A5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1B2	7.8	7.9	6.9	6.5	6.4	6.0	6.1	5.6	5.7	5.4
Sum	57.3	54.8	50.3	47.3	44.4	41.9	39.0	36.1	34.4	32.0

NMVOC total	2010	2011	2012	2013	2014	2015	05-15
	kt						%
1A1	0.2	0.2	0.2	0.2	0.2	0.2	-30
1A2	1.5	1.4	1.3	1.2	1.1	1.0	-48
1A3	16.1	15.2	14.3	13.6	12.9	12.2	-49
1A4	7.1	6.0	5.9	5.8	4.8	4.7	-51
1A5	0.1	0.1	0.1	0.1	0.1	0.1	-34
1B2	5.0	4.9	4.4	5.0	4.9	3.7	-38
Sum	30.0	27.8	26.2	25.9	24.0	22.0	-47

Table A - 31: NMVOC emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 between 2020 and 2030.

NMVOC total	2020	2025	2030
	kt		
1A1	0.2	0.3	0.3
1A2	0.9	0.8	0.7
1A3	9.9	8.5	7.3
1A4	4.3	3.7	3.2
1A5	0.1	0.1	0.1
1B2	3.8	3.9	4.0
Sum	19.6	17.1	14.8

A6.2.3 1 Energy: SO_x

Table A - 32: SO_x emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

SO2	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1A1	7.4	7.3	7.2	7.2	7.2	6.9	6.6	6.2	5.8	4.9
1A2	49.5	40.4	34.3	29.6	26.7	22.4	22.3	23.4	22.0	18.3
1A3	6.8	6.5	6.2	5.9	5.5	5.2	4.8	4.5	4.2	3.8
1A4	46.3	42.8	38.2	36.9	37.2	35.4	31.4	26.6	22.2	18.2
1A5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1B2	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7
Sum	110.9	98.0	86.8	80.5	77.5	70.8	65.9	61.7	55.1	46.0

SO2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1A1	4.4	4.7	4.9	2.9	2.8	2.9	3.0	2.4	3.4	2.2
1A2	13.5	11.7	9.6	8.5	8.2	8.2	7.4	5.9	6.1	4.6
1A3	3.9	3.8	3.6	3.2	2.3	2.1	2.2	2.2	2.3	2.4
1A4	15.5	13.7	12.5	10.1	12.3	11.2	11.4	11.3	8.9	6.1
1A5	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
1B2	0.6	0.8	0.7	0.7	0.6	0.5	0.5	0.5	0.5	0.5
Sum	38.0	34.8	31.5	25.4	26.2	24.9	24.5	22.4	21.3	15.9

SO2	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1A1	1.9	1.9	1.5	1.5	1.7	1.8	1.7	1.7	1.8	1.6
1A2	4.4	5.5	4.3	4.6	5.0	4.3	4.6	3.8	3.6	3.0
1A3	1.7	1.5	1.4	1.1	0.2	0.2	0.2	0.2	0.2	0.2
1A4	5.9	7.7	6.8	6.4	6.3	7.2	6.1	4.9	5.2	4.3
1A5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1B2	0.5	0.5	0.5	0.5	0.5	0.4	0.3	0.3	0.3	0.3
Sum	14.4	17.1	14.6	14.1	13.8	14.0	13.0	11.0	11.1	9.5

SO2	2010	2011	2012	2013	2014	2015	05-15
	kt						%
1A1	1.6	1.4	1.6	1.6	1.8	0.8	-54
1A2	2.9	2.5	2.4	2.4	2.3	2.2	-49
1A3	0.2	0.2	0.2	0.2	0.2	0.2	12
1A4	4.6	3.5	3.5	3.5	2.6	2.5	-65
1A5	0.0	0.0	0.0	0.0	0.0	0.0	-4
1B2	0.3	0.3	0.2	0.3	0.3	0.2	-66
Sum	9.7	7.9	8.1	8.0	7.2	6.0	-57

Table A - 33: SO_x emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 between 2020 and 2030.

SO2	2020	2025	2030
	kt		
1A1	1.7	1.8	1.9
1A2	2.0	1.7	1.5
1A3	0.2	0.2	0.2
1A4	1.5	1.1	0.8
1A5	0.0	0.0	0.0
1B2	0.2	0.2	0.2
Sum	5.7	5.1	4.6

A6.2.4 1 Energy: NH_3

Table A - 34: NH_3 emissions from sector 1 Energy by source categories 1A1-1A5 between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NH3	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1A1	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.003
1A2	0.11	0.12	0.12	0.12	0.12	0.12	0.13	0.14	0.14	0.15
1A3	0.08	0.08	0.08	0.08	0.08	0.09	0.30	0.52	0.76	1.02
1A4	0.10	0.10	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.14
1A5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	0.29	0.30	0.31	0.31	0.32	0.32	0.55	0.79	1.04	1.31

NH3	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1A1	0.005	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
1A2	0.16	0.15	0.14	0.13	0.14	0.14	0.14	0.13	0.14	0.15
1A3	1.28	1.63	1.92	2.11	2.38	2.59	2.79	3.00	3.21	3.43
1A4	0.14	0.15	0.14	0.14	0.13	0.13	0.14	0.13	0.13	0.12
1A5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	1.59	1.93	2.21	2.39	2.66	2.88	3.08	3.27	3.50	3.72

NH3	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1A1	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04
1A2	0.17	0.17	0.18	0.17	0.18	0.19	0.20	0.23	0.24	0.23
1A3	4.56	4.50	4.27	4.00	3.77	3.56	3.28	3.09	2.90	2.71
1A4	0.12	0.13	0.12	0.12	0.12	0.12	0.12	0.11	0.12	0.12
1A5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	4.87	4.82	4.59	4.32	4.09	3.89	3.63	3.46	3.29	3.10

NH3	2010	2011	2012	2013	2014	2015	05-15
	kt						%
1A1	0.04	0.04	0.05	0.05	0.05	0.04	50
1A2	0.25	0.24	0.23	0.23	0.27	0.23	23
1A3	2.52	2.37	2.23	2.10	1.99	1.89	-47
1A4	0.13	0.11	0.12	0.13	0.11	0.12	1
1A5	0.00	0.00	0.00	0.00	0.00	0.00	6
Sum	2.93	2.76	2.63	2.51	2.41	2.28	-41

Table A - 35: NH_3 emissions from sector 1 Energy by source categories 1A1-1A5 between 2020 and 2030.

NH3	2020	2025	2030
	kt		
1A1	0.10	0.14	0.16
1A2	0.15	0.14	0.13
1A3	1.60	1.50	1.44
1A4	0.12	0.12	0.12
1A5	0.00	0.00	0.00
Sum	1.97	1.90	1.85

A6.2.5 1 Energy: PM2.5

Table A - 36: PM2.5 emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

PM2.5	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1A1	1.07	1.06	1.05	1.04	1.03	1.01	0.99	0.96	0.91	0.84
1A2	14.94	12.40	10.06	8.02	6.45	6.08	5.65	5.07	4.22	3.16
1A3	3.90	3.83	3.76	3.69	3.62	3.55	3.35	3.14	2.92	2.70
1A4	5.59	5.91	5.87	5.86	6.11	6.19	6.42	6.70	6.95	7.28
1A5	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08
1B2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	25.56	23.27	20.81	18.68	17.28	16.91	16.48	15.94	15.08	14.06

PM2.5	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1A1	0.80	0.74	0.71	0.58	0.54	0.52	0.48	0.42	0.42	0.35
1A2	1.92	1.94	1.85	1.82	1.82	1.88	1.86	1.71	1.71	1.66
1A3	2.77	2.80	2.80	2.71	2.68	2.68	2.63	2.59	2.56	2.55
1A4	6.61	6.92	6.48	6.26	5.68	5.75	5.87	5.17	5.09	4.87
1A5	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07
1B2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	12.18	12.48	11.92	11.44	10.80	10.89	10.91	9.95	9.84	9.49

PM2.5	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1A1	0.31	0.26	0.19	0.14	0.14	0.14	0.13	0.15	0.16	0.16
1A2	1.61	1.63	1.49	1.52	1.48	1.44	1.39	1.29	1.22	1.09
1A3	2.54	2.40	2.29	2.25	2.19	2.19	2.15	2.07	1.92	1.81
1A4	4.44	4.50	4.16	4.17	4.01	3.99	3.79	3.46	3.56	3.49
1A5	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05
1B2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	8.96	8.85	8.19	8.13	7.88	7.82	7.52	7.03	6.92	6.60

PM2.5	2010	2011	2012	2013	2014	2015	05-15
	kt						%
1A1	0.16	0.16	0.19	0.19	0.19	0.11	-18
1A2	1.05	0.92	0.92	0.91	0.84	0.84	-41
1A3	1.72	1.63	1.55	1.46	1.39	1.32	-40
1A4	3.59	3.12	3.22	3.29	2.83	2.92	-27
1A5	0.05	0.05	0.05	0.05	0.05	0.05	-18
1B2	0.00	0.00	0.00	0.00	0.00	0.00	-5
Sum	6.57	5.88	5.93	5.90	5.30	5.24	-33

Table A - 37: PM2.5 emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 between 2020 and 2030.

PM2.5	2020	2025	2030
	kt		
1A1	0.26	0.31	0.32
1A2	0.79	0.71	0.64
1A3	1.05	0.88	0.80
1A4	2.77	2.32	1.87
1A5	0.04	0.04	0.04
1B2	0.00	0.00	0.00
Sum	4.92	4.27	3.67

A6.2.6 1 Energy: BC

Table A - 38: BC emissions from sector 1 Energy by source categories 1A1-1A5 and 1B1 between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

BC	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1A1	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
1A2	0.78	0.68	0.59	0.52	0.46	0.45	0.44	0.43	0.40	0.36
1A3	1.69	1.65	1.61	1.57	1.53	1.50	1.39	1.28	1.17	1.06
1A4	2.72	2.82	2.90	2.98	3.08	3.17	3.38	3.59	3.80	4.02
1A5	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1B1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	5.24	5.21	5.16	5.13	5.14	5.18	5.27	5.36	5.43	5.49

BC	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1A1	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.01
1A2	0.31	0.33	0.34	0.36	0.37	0.40	0.40	0.38	0.37	0.36
1A3	1.09	1.13	1.16	1.14	1.14	1.16	1.17	1.17	1.18	1.20
1A4	3.51	3.69	3.42	3.29	2.96	2.99	3.03	2.61	2.53	2.38
1A5	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1B1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	4.96	5.20	4.97	4.83	4.52	4.59	4.63	4.19	4.12	3.97

BC	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1A1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1A2	0.35	0.34	0.32	0.31	0.29	0.27	0.25	0.21	0.19	0.15
1A3	1.21	1.15	1.10	1.11	1.10	1.13	1.11	1.06	0.96	0.88
1A4	2.12	2.10	1.91	1.90	1.80	1.76	1.62	1.42	1.41	1.36
1A5	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1B1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	3.71	3.62	3.35	3.34	3.21	3.17	2.99	2.72	2.57	2.41

BC	2010	2011	2012	2013	2014	2015	05-15
	kt						%
1A1	0.01	0.01	0.01	0.01	0.01	0.01	-28
1A2	0.13	0.11	0.10	0.09	0.08	0.07	-75
1A3	0.82	0.72	0.62	0.54	0.47	0.41	-64
1A4	1.37	1.16	1.18	1.19	0.99	0.99	-43
1A5	0.01	0.01	0.00	0.00	0.00	0.00	-67
1B1	0.00	0.00	0.00	0.00	0.00	0.00	-5
Sum	2.33	2.00	1.92	1.83	1.55	1.48	-54

Table A - 39: BC emissions from sector 1 Energy by source categories 1A1-1A5 and 1B1 between 2020 and 2030.

BC	2020	2025	2030
	kt		
1A1	0.01	0.01	0.01
1A2	0.05	0.03	0.02
1A3	0.19	0.11	0.09
1A4	0.89	0.67	0.48
1A5	0.00	0.00	0.00
1B1	0.00	0.00	0.00
Sum	1.14	0.83	0.61

A6.3 2 Industrial processes and product use

A6.3.1 2 Industrial processes and product use: NO_x

Table A - 40: NO_x emissions from sector 2 Industrial processes and product use by source categories 2A-2C, 2G and 2H between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NOx	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
2A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
2B	1.24	1.23	1.22	1.21	1.20	0.99	0.79	0.59	0.41	0.24
2C	0.24	0.24	0.24	0.24	0.24	0.24	0.25	0.25	0.26	0.26
2G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2H	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Sum	1.59	1.58	1.57	1.55	1.54	1.33	1.14	0.95	0.78	0.61

NOx	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
2A	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2B	0.08	0.08	0.07	0.06	0.07	0.07	0.07	0.06	0.07	0.07
2C	0.27	0.27	0.29	0.29	0.28	0.15	0.14	0.14	0.13	0.14
2G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2H	0.09	0.08	0.07	0.06	0.05	0.05	0.02	0.03	0.04	0.06
Sum	0.46	0.45	0.45	0.43	0.42	0.28	0.24	0.24	0.25	0.27

NOx	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
2A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2B	0.07	0.08	0.08	0.07	0.07	0.06	0.07	0.07	0.08	0.07
2C	0.15	0.16	0.17	0.17	0.18	0.17	0.18	0.18	0.19	0.13
2G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2H	0.07	0.07	0.12	0.14	0.13	0.03	0.05	0.04	0.05	0.07
Sum	0.31	0.32	0.38	0.40	0.40	0.28	0.32	0.30	0.33	0.29

NOx	2010	2011	2012	2013	2014	2015	05-15
	kt						%
2A	0.01	0.01	0.01	0.01	0.01	0.01	-14
2B	0.07	0.07	0.07	0.04	0.06	0.03	-52
2C	0.17	0.19	0.18	0.17	0.19	0.18	6
2G	0.00	0.00	0.00	0.00	0.00	0.00	19
2H	0.08	0.10	0.08	0.08	0.07	0.08	178
Sum	0.34	0.37	0.34	0.31	0.33	0.30	9

Table A - 41: NO_x emissions from sector 2 Industrial processes and product use by source categories 2A-2C, 2G and 2H between 2020 and 2030.

NOx	2020	2025	2030
	kt		
2A	0.01	0.01	0.01
2B	0.07	0.07	0.07
2C	0.18	0.17	0.16
2G	0.00	0.00	0.00
2H	0.08	0.07	0.07
Sum	0.33	0.32	0.31

A6.3.2 2 Industrial processes and product use: NMVOC

Table A - 42: NMVOC emissions from sector 2 Industrial processes and product use by source categories 2A-2D, 2G and 2H between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NMVOC total	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
2A	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
2B	0.88	0.88	0.88	0.87	0.87	0.87	0.86	0.86	0.85	0.85
2C	0.99	0.84	0.69	0.56	0.43	0.40	0.36	0.32	0.28	0.24
2D	135.90	137.52	139.16	140.78	142.40	144.87	146.39	148.10	150.15	151.73
2G	0.25	0.26	0.28	0.29	0.30	0.31	0.32	0.79	0.94	0.98
2H	3.23	3.22	3.22	3.24	3.20	3.21	3.23	3.26	3.27	3.30
Sum	141.28	142.76	144.26	145.78	147.24	149.69	151.20	153.37	155.53	157.15

NMVOC total	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
2A	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03
2B	0.61	0.60	0.21	0.20	0.19	0.18	0.13	0.08	0.03	0.03
2C	1.11	0.94	0.92	0.75	0.76	0.76	0.67	0.68	0.72	0.72
2D	137.07	126.00	115.39	104.67	97.82	90.41	82.97	76.35	69.44	65.44
2G	22.15	20.68	19.27	17.85	16.49	15.13	13.79	12.47	11.19	10.79
2H	3.54	3.54	3.57	3.58	3.52	3.48	3.34	3.30	3.23	3.29
Sum	164.52	151.80	139.40	127.10	118.82	110.00	100.93	92.91	84.64	80.30

NMVOC total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
2A	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.03	0.03
2B	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.02
2C	0.71	0.64	0.53	0.49	0.47	0.45	0.44	0.45	0.48	0.31
2D	60.93	56.62	51.36	46.01	40.18	39.56	39.18	38.21	38.45	38.68
2G	10.42	10.02	9.88	9.66	9.35	8.65	8.06	7.57	7.53	7.48
2H	3.32	3.34	3.43	3.46	3.46	3.33	3.41	3.47	3.52	3.45
Sum	75.44	70.67	65.25	59.68	53.52	52.05	51.16	49.76	50.04	49.98

NMVOC total	2010	2011	2012	2013	2014	2015	05-15
	kt						%
2A	0.04	0.04	0.03	0.03	0.03	0.03	-14
2B	0.04	0.03	0.03	0.03	0.02	0.02	-27
2C	0.35	0.39	0.32	0.32	0.32	0.29	-36
2D	38.98	38.38	37.57	37.31	37.51	37.20	-6
2G	7.47	7.62	8.41	7.67	7.64	7.62	-12
2H	3.53	3.55	3.52	3.51	3.56	3.58	8
Sum	50.41	50.00	49.88	48.88	49.08	48.74	-6

Table A - 43: NMVOC emissions from sector 2 Industrial processes and product use by source categories 2A-2D, 2G and 2H between 2020 and 2030.

NMVOC total	2020	2025	2030
	kt		
2A	0.03	0.03	0.03
2B	0.02	0.02	0.02
2C	0.37	0.35	0.33
2D	36.77	36.93	37.06
2G	7.49	7.50	7.51
2H	3.80	3.92	4.02
Sum	48.50	48.75	48.98

A6.3.3 2 Industrial processes and product use: SO_2

Table A - 44: SO_2 emissions from sector 2 Industrial processes and product use by source categories 2A-2C and 2G-2H between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

SO2	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
2A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2B	1.43	1.43	1.43	1.42	1.42	1.29	1.16	1.03	0.89	0.75
2C	1.41	1.33	1.25	1.17	1.08	1.05	1.01	0.96	0.92	0.87
2G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	2.85	2.76	2.68	2.60	2.51	2.34	2.17	2.00	1.82	1.63

SO2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
2A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2B	0.61	0.62	0.62	0.63	0.63	0.63	0.60	0.65	0.53	0.45
2C	0.84	0.81	0.76	0.46	0.35	0.24	0.27	0.25	0.27	0.29
2G	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
2H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	1.46	1.43	1.39	1.09	0.99	0.88	0.88	0.91	0.81	0.75

SO2	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
2A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2B	0.48	0.52	0.51	0.49	0.66	0.69	0.59	0.63	0.67	0.44
2C	0.30	0.31	0.34	0.37	0.38	0.37	0.11	0.02	0.02	0.01
2G	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	0.78	0.83	0.86	0.87	1.05	1.07	0.71	0.66	0.69	0.47

SO2	2010	2011	2012	2013	2014	2015	05-15
	kt						%
2A	0.00	0.00	0.00	0.00	0.00	0.00	-14
2B	0.76	0.66	0.74	0.56	0.59	0.62	-11
2C	0.02	0.02	0.02	0.02	0.02	0.02	-95
2G	0.01	0.01	0.01	0.01	0.01	0.01	19
2H	0.00	0.00	0.00	0.00	0.00	0.00	178
Sum	0.79	0.69	0.77	0.59	0.62	0.65	-40

Table A - 45: SO_2 emissions from sector 2 Industrial processes and product use by source categories 2A-2C and 2G-2H between 2020 and 2030.

SO2	2020	2025	2030
	kt		
2A	0.00	0.00	0.00
2B	0.61	0.61	0.61
2C	0.02	0.02	0.02
2G	0.01	0.01	0.01
2H	0.00	0.00	0.00
Sum	0.64	0.64	0.64

A6.3.4 2 Industrial processes and product use: NH_3

Table A - 46: NH_3 emissions from sector 2 Industrial processes and product use by source categories 2B, 2C, 2G, 2H and 2L between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NH3	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
2B	0.36	0.36	0.35	0.34	0.33	0.27	0.22	0.16	0.11	0.06
2C	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2G	0.15	0.15	0.15	0.16	0.16	0.16	0.17	0.18	0.19	0.19
2H	0.05	0.07	0.08	0.09	0.10	0.10	0.11	0.12	0.12	0.13
2L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	0.60	0.60	0.61	0.61	0.61	0.57	0.52	0.48	0.44	0.40

NH3	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
2B	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01
2C	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02
2G	0.20	0.19	0.20	0.19	0.20	0.20	0.17	0.21	0.22	0.24
2H	0.13	0.11	0.11	0.11	0.09	0.10	0.13	0.13	0.12	0.11
2L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	0.37	0.33	0.33	0.33	0.32	0.32	0.33	0.35	0.36	0.38

NH3	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
2B	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01
2C	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2G	0.23	0.20	0.17	0.20	0.22	0.24	0.19	0.15	0.14	0.13
2H	0.13	0.10	0.12	0.10	0.10	0.09	0.09	0.12	0.12	0.13
2L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	0.39	0.32	0.31	0.32	0.33	0.35	0.30	0.29	0.28	0.28

NH3	2010	2011	2012	2013	2014	2015	05-15
	kt						%
2B	0.01	0.00	0.00	0.00	0.00	0.00	-18
2C	0.01	0.01	0.01	0.01	0.01	0.01	-13
2G	0.09	0.08	0.09	0.07	0.07	0.06	-75
2H	0.10	0.13	0.11	0.09	0.12	0.09	-7
2L	0.00	0.00	0.00	0.00	0.00	0.00	31
Sum	0.21	0.23	0.21	0.18	0.20	0.17	-53

Table A - 47: NH_3 emissions from sector 2 Industrial processes and product use by source categories 2B, 2C, 2G, 2H and 2L between 2020 and 2030.

NH3	2020	2025	2030
	kt		
2B	0.00	0.00	0.00
2C	0.01	0.01	0.01
2G	0.07	0.07	0.06
2H	0.09	0.07	0.05
2L	0.00	0.00	0.00
Sum	0.18	0.15	0.13

A6.3.5 2 Industrial processes and product use: PM2.5

Table A - 48: PM2.5 emissions from sector 2 Industrial processes and product use by source categories 2A-2D and 2G-2I between 1980 and 2015. The last column indicates the rel. trend between 2005 and 2015.

PM2.5	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
2A	0.33	0.34	0.34	0.34	0.35	0.35	0.37	0.39	0.40	0.42
2B	0.12	0.12	0.12	0.12	0.12	0.11	0.10	0.09	0.08	0.06
2C	0.99	0.96	0.94	0.91	0.89	0.89	0.89	0.90	0.90	0.90
2D	0.15	0.15	0.15	0.14	0.14	0.14	0.13	0.13	0.13	0.12
2G	0.17	0.18	0.18	0.19	0.19	0.19	0.19	0.20	0.20	0.20
2H	0.89	0.81	0.72	0.64	0.56	0.48	0.47	0.46	0.47	0.46
2I	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Sum	2.66	2.56	2.46	2.36	2.26	2.17	2.16	2.16	2.17	2.17

PM2.5	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
2A	0.43	0.40	0.39	0.38	0.39	0.39	0.37	0.35	0.36	0.36
2B	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.03
2C	0.90	0.93	0.99	0.98	0.93	0.56	0.58	0.61	0.17	0.07
2D	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.12
2G	0.21	0.20	0.21	0.20	0.20	0.22	0.22	0.19	0.24	0.29
2H	0.44	0.43	0.44	0.44	0.41	0.39	0.38	0.38	0.39	0.38
2I	0.24	0.24	0.24	0.24	0.24	0.23	0.21	0.20	0.18	0.16
Sum	2.40	2.39	2.45	2.41	2.35	1.96	1.93	1.91	1.49	1.40

PM2.5	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
2A	0.37	0.38	0.37	0.37	0.39	0.41	0.42	0.42	0.41	0.42
2B	0.03	0.04	0.04	0.03	0.05	0.05	0.04	0.04	0.04	0.03
2C	0.05	0.05	0.05	0.06	0.06	0.06	0.03	0.02	0.02	0.01
2D	0.11	0.11	0.10	0.10	0.09	0.08	0.08	0.07	0.07	0.07
2G	0.26	0.23	0.28	0.29	0.30	0.23	0.25	0.26	0.28	0.29
2H	0.40	0.38	0.42	0.40	0.41	0.41	0.43	0.48	0.48	0.43
2I	0.14	0.12	0.10	0.08	0.08	0.08	0.08	0.08	0.08	0.09
Sum	1.37	1.31	1.37	1.34	1.37	1.32	1.33	1.38	1.39	1.34

PM2.5	2010	2011	2012	2013	2014	2015	05-15
	kt						%
2A	0.44	0.44	0.42	0.43	0.42	0.40	-3
2B	0.04	0.03	0.04	0.03	0.03	0.03	-36
2C	0.01	0.01	0.01	0.01	0.01	0.01	-78
2D	0.07	0.07	0.07	0.07	0.07	0.07	-14
2G	0.25	0.28	0.28	0.31	0.25	0.23	-1
2H	0.44	0.45	0.42	0.40	0.43	0.40	0
2I	0.09	0.09	0.09	0.09	0.09	0.09	10
Sum	1.35	1.37	1.32	1.33	1.31	1.24	-6

Table A - 49: PM2.5 emissions from sector 2 Industrial processes and product use by source categories 2A-2D and 2G-2I between 2020 and 2030.

PM2.5	2020	2025	2030
	kt		
2A	0.42	0.40	0.38
2B	0.03	0.03	0.03
2C	0.01	0.01	0.01
2D	0.07	0.07	0.07
2G	0.26	0.26	0.26
2H	0.48	0.46	0.45
2I	0.10	0.10	0.10
Sum	1.37	1.34	1.31

A6.3.6 2 Industrial processes and product use: BC

Table A - 50: BC emissions from sector 2 Industrial processes and product use by source categories 2A, 2C, 2D and 2G between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

BC	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kg									
2A	60.1	59.8	59.4	59.1	58.8	58.5	61.9	65.3	68.7	72.1
2C	4'080.2	4'011.9	3'944.8	3'879.1	3'814.7	3'882.7	3'951.9	4'022.5	4'094.4	4'167.6
2D	15.4	15.0	14.7	14.4	14.0	13.7	13.3	13.0	12.7	12.3
2G	573.1	584.1	595.0	606.3	601.0	587.4	588.4	590.6	589.3	593.2
Sum	4'728.7	4'670.8	4'614.0	4'558.9	4'488.6	4'542.3	4'615.6	4'691.4	4'765.1	4'845.2

BC	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kg									
2A	75.5	65.9	61.9	56.4	62.0	58.5	52.8	47.4	47.5	47.5
2C	4'242.1	4'239.0	4'301.2	3'564.1	3'208.4	2'009.1	2'179.5	2'306.1	746.8	793.8
2D	12.0	11.9	11.7	11.6	11.5	11.3	11.1	11.0	10.8	10.9
2G	590.2	595.4	626.8	589.5	576.5	575.0	565.0	551.5	561.7	541.5
Sum	4'919.8	4'912.2	5'001.6	4'221.7	3'858.3	2'653.9	2'808.5	2'915.9	1'366.8	1'393.6

BC	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kg									
2A	51.0	51.9	50.0	49.0	51.9	54.6	54.8	55.8	55.0	54.4
2C	766.0	781.2	862.2	938.5	960.4	956.4	279.2	31.0	31.5	22.5
2D	11.0	11.2	10.4	9.7	8.9	8.4	7.9	7.4	7.4	7.4
2G	537.7	525.9	524.9	559.5	548.6	487.3	503.3	476.5	485.1	498.2
Sum	1'365.7	1'370.1	1'447.5	1'556.7	1'569.9	1'506.7	845.2	570.7	579.0	582.4

BC	2010	2011	2012	2013	2014	2015	05-15
	kg						%
2A	57.6	56.8	53.3	54.0	55.3	50.4	-8
2C	29.2	30.9	29.6	28.1	29.9	29.3	-97
2D	7.3	7.3	7.3	7.3	7.3	7.2	-14
2G	453.5	432.2	463.1	443.3	387.4	374.9	-23
Sum	547.7	527.1	553.3	532.7	479.9	461.8	-69

Table A - 51: BC emissions from sector 2 Industrial processes and product use by source categories 2A, 2C, 2D and 2G between 2020 and 2030.

BC	2020	2025	2030
	kg		
2A	53.2	48.8	43.8
2C	29.8	28.2	26.5
2D	7.1	7.1	7.1
2G	372.3	369.7	367.1
Sum	462.4	453.8	444.5

A6.4 3 Agriculture

A6.4.1 3 Agriculture: NO_x

Table A - 52: NO_x emissions from Sector 3 Agriculture by source categories 3B and 3D between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NOx	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
3B	3.5	3.4	3.4	3.3	3.3	3.2	3.2	3.1	3.1	3.0
3D	2.8	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.6
Sum	6.3	6.2	6.1	6.1	6.0	5.9	5.9	5.8	5.7	5.7

NOx	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
3B	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3D	3.5	3.5	3.5	3.4	3.3	3.3	3.2	3.0	3.0	3.0
Sum	3.9	3.9	3.8	3.7	3.6	3.6	3.5	3.3	3.3	3.3

NOx	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
3B	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.3
3D	2.9	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Sum	3.2	3.3	3.2	3.2	3.1	3.1	3.1	3.2	3.2	3.1

NOx	2010	2011	2012	2013	2014	2015	05-15
	kt						%
3B	0.3	0.3	0.2	0.2	0.2	0.2	-7
3D	3.0	2.9	2.8	2.8	2.9	2.8	-4
Sum	3.2	3.1	3.1	3.0	3.1	3.0	-4

Table A - 53: NO_x emissions from Sector 3 Agriculture by source categories 3B and 3D between 2020 and 2030.

NOx	2020	2025	2030
	kt		
3B	0.2	0.2	0.2
3D	2.7	2.7	2.7
Sum	2.9	2.9	2.9

A6.4.2 3 Agriculture: NMVOC

Table A - 54: NMVOC emissions from Sector 3 Agriculture by source category 3D between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NMVOC total	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
3D	9.9	9.9	10.0	10.0	10.1	10.1	9.3	8.6	7.8	7.0
Sum	9.9	9.9	10.0	10.0	10.1	10.1	9.3	8.6	7.8	7.0

NMVOC total	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
3D	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Sum	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0

NMVOC total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
3D	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.9	3.9	3.9
Sum	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.9	3.9	3.9

NMVOC total	2010	2011	2012	2013	2014	2015	05-15
	kt						%
3D	3.9	3.9	3.9	3.9	3.9	3.9	-1.6
Sum	3.9	3.9	3.9	3.9	3.9	3.9	-1.6

Table A - 55: NMVOC emissions from Sector 3 Agriculture by source category 3D between 2020 and 2030.

NMVOC total	2020	2025	2030
	kt		
3D	3.8	3.8	3.8
Sum	3.8	3.8	3.8

A6.4.3 3 Agriculture: SO_x

There are no SO_x emissions from sector 3 Agriculture.

A6.4.4 3 Agriculture: NH_3

Table A - 56: NH_3 emissions from Sector 3 Agriculture by source categories 3B and 3D between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NH3	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
3B	68.7	67.6	66.6	65.5	64.5	63.7	62.9	62.1	61.2	60.4
3D	9.2	9.3	9.5	9.7	9.9	10.1	10.6	11.1	11.5	12.0
Sum	77.8	77.0	76.1	75.2	74.4	73.8	73.4	73.1	72.8	72.4

NH3	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
3B	24.2	24.0	23.8	23.7	23.6	23.2	23.7	23.7	24.2	24.0
3D	45.3	44.3	43.5	42.7	42.5	41.9	40.8	38.3	37.0	35.5
Sum	69.6	68.3	67.3	66.4	66.1	65.1	64.5	62.0	61.3	59.4

NH3	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
3B	24.2	24.8	25.1	24.9	24.8	25.5	25.8	25.8	26.6	26.7
3D	34.5	33.9	32.7	32.2	32.3	32.5	32.9	33.6	33.2	32.0
Sum	58.7	58.7	57.8	57.1	57.1	58.0	58.6	59.5	59.8	58.7

NH3	2010	2011	2012	2013	2014	2015	05-15
	kt						%
3B	27.1	26.9	26.7	26.5	26.6	26.5	4
3D	31.7	31.1	30.6	30.2	30.6	29.9	-8
Sum	58.8	57.9	57.3	56.7	57.2	56.5	-3

Table A - 57: NH_3 emissions from Sector 3 Agriculture by source categories 3B and 3D between 2020 and 2030.

NH3	2020	2025	2030
	kt		
3B	25.9	26.0	26.0
3D	29.2	29.0	29.0
Sum	55.1	54.9	54.9

A6.4.5 3 Agriculture: PM2.5

Table A - 58: PM2.5 emissions from Sector 3 Agriculture by source category 3B between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

PM2.5	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
3B	0.44	0.43	0.43	0.42	0.41	0.41	0.40	0.40	0.39	0.39
Sum	0.44	0.43	0.43	0.42	0.41	0.41	0.40	0.40	0.39	0.39

PM2.5	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
3B	0.34	0.33	0.32	0.33	0.32	0.30	0.30	0.30	0.31	0.31
Sum	0.34	0.33	0.32	0.33	0.32	0.30	0.30	0.30	0.31	0.31

PM2.5	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
3B	0.31	0.32	0.32	0.32	0.33	0.34	0.34	0.34	0.34	0.34
Sum	0.31	0.32	0.32	0.32	0.33	0.34	0.34	0.34	0.34	0.34

PM2.5	2010	2011	2012	2013	2014	2015	05-15
	kt						%
3B	0.35	0.35	0.36	0.35	0.36	0.36	6
Sum	0.35	0.35	0.36	0.35	0.36	0.36	6

Table A - 59: PM2.5 emissions from Sector 3 Agriculture by source category 3B between 2020 and 2030.

PM2.5	2020	2025	2030
	kt		
3B	0.36	0.37	0.37
Sum	0.36	0.37	0.37

A6.5 5 Waste

A6.5.1 5 Waste: NO_x

Table A - 60: NO_x emissions from sector 5 Waste by source categories 5A-5D between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NOx	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
5A	0.24	0.22	0.19	0.17	0.14	0.11	0.09	0.06	0.04	0.02
5B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5C	0.25	0.25	0.25	0.26	0.26	0.27	0.27	0.28	0.28	0.29
5D	0.29	0.34	0.41	0.47	0.54	0.49	0.44	0.37	0.30	0.22
Sum	0.78	0.81	0.85	0.90	0.94	0.87	0.79	0.71	0.63	0.53

NOx	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
5A	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
5B	NA	NA	0.0000	0.0000	0.0001	0.0001	0.0002	0.0003	0.0003	0.0004
5C	0.29	0.27	0.25	0.23	0.21	0.20	0.20	0.19	0.19	0.18
5D	0.14	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.18	0.18
Sum	0.43	0.42	0.40	0.39	0.37	0.37	0.37	0.37	0.37	0.36

NOx	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
5A	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5B	0.0004	0.0005	0.0006	0.0006	0.0006	0.0007	0.0009	0.0011	0.0012	0.0016
5C	0.17	0.16	0.15	0.15	0.16	0.15	0.15	0.15	0.15	0.15
5D	0.18	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Sum	0.35	0.36	0.34	0.35	0.35	0.35	0.35	0.35	0.35	0.35

NOx	2010	2011	2012	2013	2014	2015	05-15
	kt						%
5A	0.00	0.00	0.00	0.00	0.00	0.00	-60
5B	0.0024	0.0030	0.0039	0.0043	0.0044	0.0047	562
5C	0.15	0.15	0.15	0.16	0.16	0.17	9
5D	0.20	0.21	0.21	0.21	0.21	0.20	9
Sum	0.36	0.36	0.36	0.38	0.38	0.38	9

Table A - 61: NO_x emissions from sector 5 Waste by source categories 5A-5D between 2020 and 2030.

NOx	2020	2025	2030
	kt		
5A	0.00	0.00	0.00
5B	0.013	0.025	0.037
5C	0.15	0.15	0.14
5D	0.22	0.23	0.24
Sum	0.39	0.41	0.42

A6.5.2 5 Waste: NMVOC

Table A - 62: NMVOC emissions from sector 5 Waste by source categories 5A-5E between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NMVOC total	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
5A	1.55	1.39	1.23	1.06	0.87	0.68	0.55	0.41	0.27	0.14
5B	NA	0.07	0.15	0.22	0.29	0.36	0.39	0.41	0.44	0.46
5C	0.99	0.96	0.93	0.90	0.87	0.83	0.78	0.73	0.67	0.62
5D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5E	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Sum	2.56	2.45	2.33	2.20	2.06	1.91	1.75	1.58	1.42	1.25

NMVOC total	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
5A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B	0.49	0.56	0.59	0.64	0.68	0.73	0.81	0.86	0.90	0.93
5C	0.56	0.55	0.54	0.52	0.48	0.46	0.43	0.43	0.42	0.43
5D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5E	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.06
Sum	1.08	1.14	1.17	1.20	1.20	1.23	1.30	1.35	1.38	1.42

NMVOC total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
5A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B	1.16	1.18	1.32	1.33	1.34	1.36	1.41	1.47	1.51	1.56
5C	0.43	0.41	0.41	0.39	0.38	0.37	0.38	0.38	0.38	0.35
5D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5E	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Sum	1.65	1.66	1.80	1.79	1.79	1.80	1.86	1.91	1.96	1.97

NMVOC total	2010	2011	2012	2013	2014	2015	05-15
	kt						%
5A	NA	NA	NA	NA	NA	NA	NA
5B	1.63	1.69	1.79	1.87	1.94	2.03	48
5C	0.36	0.35	0.34	0.34	0.33	0.33	-11
5D	0.00	0.00	0.00	0.00	0.00	0.00	6
5E	0.06	0.06	0.06	0.06	0.06	0.06	0
Sum	2.05	2.10	2.20	2.28	2.34	2.42	34

Table A - 63: NMVOC emissions from sector 5 Waste by source categories 5A-5E between 2020 and 2030.

NMVOC total	2020	2025	2030
	kt		
5A	NA	NA	NA
5B	3.22	4.89	6.57
5C	0.29	0.27	0.25
5D	0.01	0.01	0.01
5E	0.06	0.06	0.06
Sum	3.57	5.22	6.88

A6.5.3 5 Waste: SO_x

Table A - 64: SO_x emissions from sector 5 Waste by source categories 5A-5D between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

SO2	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
5A	0.07	0.07	0.06	0.05	0.04	0.03	0.03	0.02	0.01	0.01
5B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5C	0.16	0.17	0.18	0.18	0.19	0.19	0.19	0.19	0.19	0.19
5D	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Sum	0.24	0.24	0.24	0.24	0.24	0.23	0.23	0.22	0.21	0.20

SO2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
5A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B	NA	NA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
5C	0.18	0.16	0.14	0.12	0.10	0.09	0.09	0.08	0.08	0.07
5D	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Sum	0.20	0.18	0.16	0.14	0.12	0.11	0.10	0.10	0.10	0.09

SO2	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
5A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002
5C	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06
5D	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sum	0.08	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08

SO2	2010	2011	2012	2013	2014	2015	05-15
	kt						%
5A	NA	NA	NA	NA	NA	NA	NA
5B	0.0004	0.0005	0.0006	0.0007	0.0007	0.0007	562
5C	0.06	0.06	0.06	0.07	0.07	0.07	22
5D	0.02	0.02	0.02	0.02	0.02	0.02	11
Sum	0.09	0.09	0.09	0.10	0.10	0.10	20

Table A - 65: SO_x emissions from sector 5 Waste by source categories 5A-5D between 2020 and 2030.

SO2	2020	2025	2030
	kt		
5A	NA	NA	NA
5B	0.0020	0.0038	0.0056
5C	0.07	0.07	0.07
5D	0.02	0.03	0.03
Sum	0.09	0.10	0.10

A6.5.4 5 Waste: NH_3

Table A - 66: NH_3 emissions from sector 5 Waste by source categories 5A-5D between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NH3	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
5A	0.58	0.58	0.58	0.59	0.59	0.63	0.64	0.66	0.67	0.69
5B	0.00	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04
5C	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
5D	1.67	1.58	1.48	1.35	1.21	1.07	0.91	0.73	0.54	0.32
Sum	2.28	2.19	2.09	1.98	1.86	1.75	1.61	1.45	1.27	1.07

NH3	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
5A	0.61	0.54	0.54	0.50	0.46	0.46	0.45	0.44	0.43	0.42
5B	0.04	0.04	0.05	0.05	0.06	0.07	0.07	0.08	0.08	0.09
5C	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
5D	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Sum	0.76	0.70	0.71	0.68	0.64	0.64	0.64	0.64	0.63	0.63

NH3	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
5A	0.42	0.43	0.44	0.42	0.43	0.42	0.42	0.40	0.38	0.37
5B	0.11	0.11	0.12	0.12	0.12	0.12	0.13	0.14	0.15	0.16
5C	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
5D	0.10	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Sum	0.65	0.66	0.68	0.66	0.68	0.68	0.68	0.68	0.67	0.66

NH3	2010	2011	2012	2013	2014	2015	05-15
	kt						%
5A	0.35	0.33	0.32	0.31	0.29	0.28	-33
5B	0.17	0.18	0.21	0.22	0.23	0.25	102
5C	0.02	0.02	0.02	0.02	0.02	0.02	7
5D	0.11	0.12	0.12	0.12	0.12	0.12	11
Sum	0.66	0.65	0.66	0.67	0.67	0.67	-0.3

Table A - 67: NH_3 emissions from sector 5 Waste by source categories 5A-5D between 2020 and 2030.

NH3	2020	2025	2030
	kt		
5A	0.21	0.17	0.14
5B	0.50	0.85	1.20
5C	0.02	0.02	0.02
5D	0.13	0.13	0.14
Sum	0.86	1.17	1.50

A6.5.5 5 Waste: PM2.5

Table A - 68: PM2.5 emissions from sector 5 Waste by source categories 5A-5C and 5E between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

PM2.5	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
5A	1.4	1.3	1.1	1.0	0.8	0.6	0.5	0.4	0.2	0.1
5B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5C	1.1	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.7	0.7
5E	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sum	2.5	2.3	2.1	1.9	1.7	1.5	1.3	1.1	1.0	0.8

PM2.5	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
5A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B	NA	NA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5C	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4
5E	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002
Sum	0.60	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4

PM2.5	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
5A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5C	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
5E	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Sum	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

PM2.5	2010	2011	2012	2013	2014	2015	05-15
	kt						%
5A	NA	NA	NA	NA	NA	NA	NA
5B	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	562
5C	0.4	0.3	0.3	0.3	0.3	0.3	-12
5E	0.002	0.002	0.002	0.002	0.002	0.002	0
Sum	0.4	0.3	0.3	0.3	0.3	0.3	-12

Table A - 69: PM2.5 emissions from sector 5 Waste by source categories 5A-5C and 5E between 2020 and 2030.

PM2.5	2020	2025	2030
	kt		
5A	NA	NA	NA
5B	0.2925	0.2712	0.2498
5C	0.3	0.3	0.2
5E	0.002	0.002	0.002
Sum	0.3	0.3	0.3

A6.5.6 5 Waste: BC

Table A - 70: BC emissions from sector 5 Waste by source categories 5A-5C between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

BC	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
5A	0.10	0.09	0.08	0.07	0.06	0.04	0.03	0.03	0.02	0.01
5B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5C	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05
Sum	0.17	0.16	0.15	0.13	0.12	0.10	0.09	0.08	0.07	0.05

BC	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
5A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B	NA	NA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5C	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03
Sum	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03

BC	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
5A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5C	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Sum	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

BC	2010	2011	2012	2013	2014	2015	05-15
	kt						%
5A	NA	NA	NA	NA	NA	NA	NA
5B	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	562
5C	0.03	0.02	0.02	0.02	0.02	0.02	-12
Sum	0.03	0.02	0.02	0.02	0.02	0.02	-12

Table A - 71: BC emissions from sector 5 Waste by source categories 5A-5C between 2020 and 2030.

BC	2020	2025	2030
	kt		
5A	NA	NA	NA
5B	0.00000	0.00001	0.00001
5C	0.021	0.020	0.018
Sum	0.021	0.020	0.018

A6.6 6 Other

A6.6.1 6 Other: NO_x

Table A - 72: NO_x emissions from sector 6 Other by source categories 6Ab-6Ad between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NOx	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
6Ab	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6Ac	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6Ad	0.016	0.016	0.016	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Sum	0.016	0.016	0.016	0.017	0.017	0.017	0.017	0.017	0.017	0.017

NOx	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
6Ab	0.024	0.023	0.022	0.021	0.021	0.022	0.030	0.031	0.030	0.030
6Ac	0.050	0.051	0.050	0.047	0.044	0.044	0.043	0.037	0.037	0.039
6Ad	0.017	0.016	0.016	0.016	0.016	0.015	0.015	0.015	0.013	0.015
Sum	0.091	0.090	0.088	0.083	0.081	0.082	0.087	0.083	0.080	0.084

NOx	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
6Ab	0.029	0.028	0.026	0.025	0.024	0.023	0.022	0.021	0.022	0.025
6Ac	0.038	0.041	0.040	0.038	0.039	0.038	0.037	0.039	0.037	0.035
6Ad	0.015	0.016	0.015	0.017	0.016	0.016	0.015	0.016	0.015	0.015
Sum	0.083	0.085	0.082	0.080	0.079	0.077	0.074	0.076	0.074	0.075

NOx	2010	2011	2012	2013	2014	2015	05-15
	kt						%
6Ab	0.028	0.031	0.037	0.036	0.035	0.036	56
6Ac	0.040	0.035	0.034	0.033	0.037	0.033	-13
6Ad	0.015	0.016	0.016	0.017	0.013	0.015	-9
Sum	0.082	0.082	0.087	0.086	0.086	0.083	9

Table A - 73: NO_x emissions from sector 6 Other by source categories 6Ab-6Ad between 2020 and 2030.

NOx	2020	2025	2030
	kt		
6Ab	0.035	0.037	0.037
6Ac	0.032	0.032	0.032
6Ad	0.015	0.015	0.015
Sum	0.082	0.083	0.083

A6.6.2 6 Other: NMVOC

Table A - 74: NMVOC emissions from sector 6 Other by source category 6Ad between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NMVOC total	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
6Ad	0.1287	0.1287	0.1288	0.1288	0.1288	0.1288	0.1288	0.1289	0.1289	0.1289
Sum	0.1287	0.1287	0.1288	0.1288	0.1288	0.1288	0.1288	0.1289	0.1289	0.1289

NMVOC total	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
6Ad	0.1290	0.1268	0.1246	0.1224	0.1202	0.1180	0.1158	0.1139	0.1019	0.1131
Sum	0.1290	0.1268	0.1246	0.1224	0.1202	0.1180	0.1158	0.1139	0.1019	0.1131

NMVOC total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
6Ad	0.1174	0.1255	0.1164	0.1274	0.1258	0.1225	0.1120	0.1250	0.1166	0.1133
Sum	0.1174	0.1255	0.1164	0.1274	0.1258	0.1225	0.1120	0.1250	0.1166	0.1133

NMVOC total	2010	2011	2012	2013	2014	2015	05-15
	kt						%
6Ad	0.1107	0.1201	0.1260	0.1298	0.1017	0.1106	-10
Sum	0.1107	0.1201	0.1260	0.1298	0.1017	0.1106	-10

Table A - 75: NMVOC emissions from sector 7 Other by source category 6Ad between 2020 and 2030.

NMVOC total	2020	2025	2030
	kt		
6Ad	0.1106	0.1106	0.1106
Sum	0.1106	0.1106	0.1106

A6.6.3 6 Other: SO_x

Table A - 76: SO_2 emissions from sector 6 Other by source category 6Ad between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

SO2	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
6Ad	0.0097	0.0098	0.0099	0.0100	0.0100	0.0101	0.0101	0.0102	0.0102	0.0103
Sum	0.0097	0.0098	0.0099	0.0100	0.0100	0.0101	0.0101	0.0102	0.0102	0.0103

SO2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
6Ad	0.0104	0.0103	0.0102	0.0101	0.0100	0.0099	0.0098	0.0098	0.0091	0.0099
Sum	0.0104	0.0103	0.0102	0.0101	0.0100	0.0099	0.0098	0.0098	0.0091	0.0099

SO2	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
6Ad	0.0102	0.0108	0.0103	0.0110	0.0109	0.0108	0.0102	0.0110	0.0105	0.0103
Sum	0.0102	0.0108	0.0103	0.0110	0.0109	0.0108	0.0102	0.0110	0.0105	0.0103

SO2	2010	2011	2012	2013	2014	2015	05-15
	kt						%
6Ad	0.0102	0.0109	0.0113	0.0116	0.0099	0.0106	-2
Sum	0.0102	0.0109	0.0113	0.0116	0.0099	0.0106	-2

Table A - 77: SO_2 emissions from sector 6 Other by source category 6Ad between 2020 and 2030.

SO2	2020	2025	2030
	kt		
6Ad	0.0106	0.0106	0.0106
Sum	0.0106	0.0106	0.0106

A6.6.4 6 Other: NH_3

Table A - 78: NH_3 emissions from sector 6 Other by source categories 6Aa-6Ac between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

NH3	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
6Aa	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12	0.12
6Ab	0.33	0.34	0.34	0.34	0.34	0.34	0.34	0.35	0.35	0.35
6Ac	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sum	0.45	0.45	0.45	0.45	0.46	0.46	0.46	0.46	0.47	0.47

NH3	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
6Aa	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13
6Ab	0.73	0.72	0.70	0.68	0.68	0.70	0.80	0.81	0.80	0.83
6Ac	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.05
Sum	0.92	0.91	0.89	0.87	0.87	0.89	0.98	0.98	0.97	1.01

NH3	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
6Aa	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.14	0.14
6Ab	0.82	0.77	0.76	0.75	0.70	0.67	0.65	0.64	0.65	0.67
6Ac	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sum	1.00	0.95	0.95	0.93	0.88	0.86	0.84	0.83	0.84	0.86

NH3	2010	2011	2012	2013	2014	2015	05-15
	kt						%
6Aa	0.14	0.14	0.14	0.14	0.14	0.15	11
6Ab	0.69	0.75	0.83	0.83	0.83	0.84	25
6Ac	0.05	0.05	0.05	0.04	0.05	0.04	-13
Sum	0.89	0.94	1.02	1.02	1.02	1.03	21

Table A - 79: NH_3 emissions from sector 6 Other by source categories 6Aa-6Ac between 2020 and 2030.

NH3	2020	2025	2030
	kt		
6Aa	0.15	0.16	0.17
6Ab	0.82	0.84	0.84
6Ac	0.04	0.04	0.04
Sum	1.02	1.04	1.05

A6.6.5 6 Other: PM2.5

Table A - 80: PM2.5 emissions from sector 6 Other by source categories 6Ab and 6Ad between 1980 and 2015. The last column indicates the relative trend between 2005 and 2015.

PM2.5	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
6Ab	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6Ad	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Sum	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002

PM2.5	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
6Ab	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
6Ad	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Sum	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002

PM2.5	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
6Ab	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001
6Ad	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Sum	0.002	0.003	0.002	0.003	0.003	0.002	0.002	0.002	0.002	0.002

PM2.5	2010	2011	2012	2013	2014	2015	05-15
	kt						%
6Ab	0.001	0.001	0.001	0.001	0.001	0.001	18
6Ad	0.002	0.002	0.002	0.002	0.002	0.002	-9
Sum	0.002	0.003	0.003	0.003	0.002	0.002	-3

Table A - 81: PM2.5 emissions from sector 6 Other by source categories 6Ab and 6Ad between 2020 and 2030.

PM2.5	2020	2025	2030
	kt		
6Ab	0.001	0.001	0.001
6Ad	0.002	0.002	0.002
Sum	0.002	0.002	0.002