Switzerland's Informative Inventory Report 2019 (IIR)

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

Submission of March 2019
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)
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 (petroleum association)
ex	(in combination with PM2.5 ex and PM10 ex) exhaust fraction of PM2.5 or PM10 emission
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)
LPG	Liquefied Petroleum Gas (Propane/Butane)
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)
SBV	Swiss farmer's union ("Schweizer Bauernverband") or
	Swiss association of builders ("Schweizerischer Baumeisterverband")
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
SGPV	Swiss association for cereal production
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
VKTS	Swiss supervising association of textile cleaning
VOC	Volatile organic compounds
VTG	Verteidigung Luftwaffe (Swiss Air Force Administration)
VSG/SGIA	Swiss Gas Industry Association
VSLF	Swiss association for coating and paint applications
VSTB	Swiss Association of Grass Drying Plants
WAM	Scenario "With Additional Measures" (see chp. 9.2)
WM	Scenario "With Measures" (see chp. 9.2)
ZPK	Swiss association of pulp, paper and paperboard industry

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. 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. A revision of the Protocol including emission reduction commitments for 2020 and beyond expressed as a percentage reduction from the 2005 emission level was adopted in 2012. This amended protocol has been adopted by the two chambers of the Swiss parliament.

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 twelfth 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 2016). 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 2013 and 2016 (EMEP/EEA 2013, 2016). With a few exceptions, calculations of emissions are consistent with methodological approaches in the greenhouse gas (GHG) inventory under the

UNFCCC. However, some relevant differences 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 the so called “fuel tourism” and statistical differences 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 for the entire territory” (row 141 in the reporting tables) is reported as “fuel sold” in order to be comparable to other countries. **But the Swiss “national total for compliance” with Gothenburg Protocol commitments (row 144 in the reporting tables) 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 1990–2017 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

Key category analyses were conducted according to approaches 1 and 2. With approach 1, two level assessments were conducted for the years 2017 and 1990 and a trend assessment for 1990-2017. With approach 2, a level assessment for the year 2017 and a trend assessment for the period 1990-2017 were performed. The most relevant source categories stem from sectors 1 Energy, 2 IPPU 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; for agricultural NH_3 emissions, a Tier 2 approach was realised. The uncertainty analysis has been carried out for level uncertainties 2017 and trend uncertainties 1990-2017. Level uncertainty estimations range from 7% to 76%, trend uncertainties from 1% to 14%. The level uncertainty estimations increased as compared to the values of the previous submission 2018 for NO_x, NMVOC and PM2.5, the differences lie between 0.1 (NO_x) and 27 percentage points (NMVOC; mainly due to the revision of uncertainties for NMVOC in the industry sector and the inclusion of NMVOC emissions under 3B Manure management). For SO_x, NH_3 and PM10, level uncertainties are lower than they were in the previous submission (between -0.1 and -4.7 percentage points for NH_3 and PM10, respectively). The trend uncertainty estimations increased as compared to the values of the previous submission 2018 for NMVOC, SO_x and PM2.5, differences lie between 0.1 (for SO_x) and 6.5 percentage points (NMVOC). For NH_3 and PM10, trend uncertainties are slightly lower than in the previsous submission (by -0.1 and -0.2 percentage points, respectively). Trend uncertainties for NO_x are similar to previous submission.

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 9001:2015 standard (Swiss Safety Center 2018). It was certified by the Swiss Association for Quality and Management Systems in December 2007 and has been re-audited annually, last time on 7th June 2018. 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.

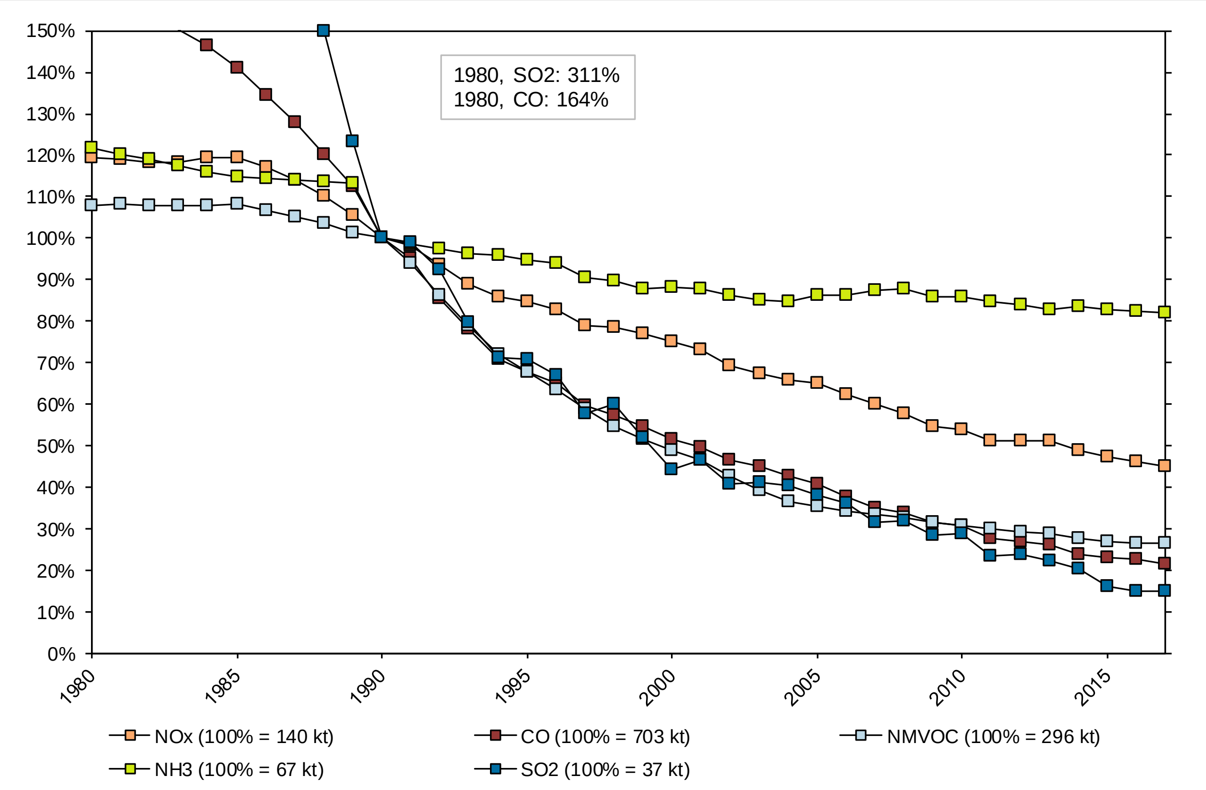
Emission trends

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 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 SO_x 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 decreasing trend since 1990 (with a short period with increasing emissions between 2003 and 2008). NMVOC emissions mainly stem from 3B Manure management. 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 (under 11B) and other natural emissions (under 11C) are reported 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 2016 (EMEP/EEA 2016), emissions from the combustion of waste-to-energy activities are therefore dealt within 1A Fuel combustion. The most important pollutants are NMVOC and NH_3. The waste sector is a relevant source of PCDD/PCDF emissions, mainly from 5C Incineration and open burning of waste. NMVOC emissions are mainly caused by 5B Biological treatment of solid waste, while NH_3 is emitted from composting activities and solid waste disposal. Emissions in sector 5 Waste have declined since 1990, with the exception of NMVOC (increase), and NH_3 which is about the same as in 1990.

- 6 Other: In this sector mainly emissions from human and pet ammonia, private application of synthetic fertiliser 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 1980-2017



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

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 2017 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.

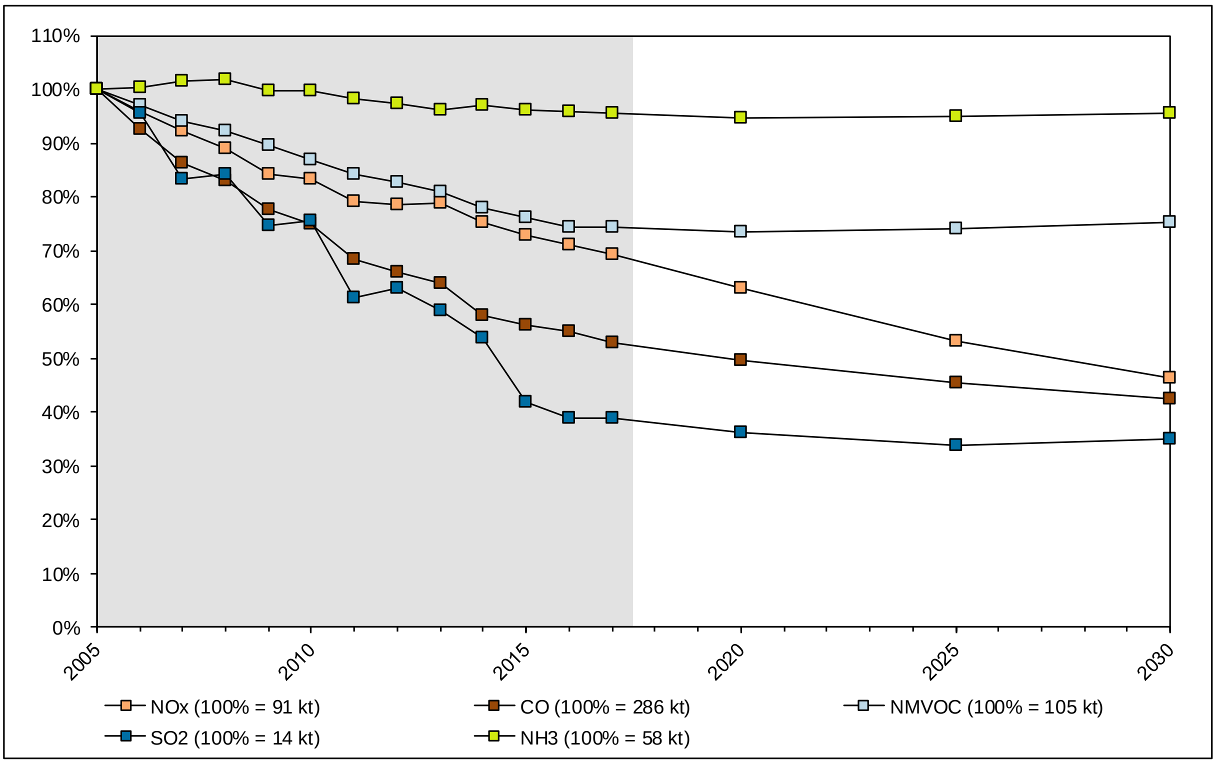
Projections for emissions until 2030

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 mainly in accordance with the scenarios of the Energy Perspectives 2050 (Prognos 2012a) from 2020 onwards. 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. For 1A3b Road transportation, modelled data for the whole period is available (FOEN 2017).

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 2005-2017 (grey area) 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 2005-2017 and the projected emissions until 2030 for main pollutants and CO in the WM scenario. 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 main pollutants, a further decrease is forecast: Overall emissions of NO_x, SO_x and CO indicate a decline until 2030. NH_3 emissions are projected to remain stable until 2030, while NMVOC are expected to slightly increase. Forecasts for suspended primary particulate matter predict a declining trend in emissions as well, whereas emissions of heavy metals are expected to stabilize (Pb, Hg) or increase (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 2020. 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. All emissions 2017 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 2017 of the current submission (2019).

Pollutants	**National emission ceilings for 2010** kt	**Emissions 2010 (Subm. 2019)** kt	**Emissions 2017 (Subm. 2019)** kt	**Compliance with emission ceilings 2010 in 2017**
SO_x	26.0	10.5	5.4	yes
NO_x	79.0	75.4	62.8	yes
NMVOC	144.0	91.0	77.9	yes
NH_3	63.0	57.4	55.1	yes

The revised Gothenburg Protocol included 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 2017.

ES Table 1.2 Reported emissions reductions in 2017 versus level of 2005 and reduction commitments per 2020.

Pollutant	**Emission reduction commitments 2020**	**Reduction achieved in 2017**
	%-reduction of 2005 level	
SO_x	21%	61%
NO_x	41%	31%
NMVOC	30%	26%
NH_3	8%	5%
PM2.5	26%	30%

Recalculations and improvements

For the year 2016, recalculations cause a lower emission level by at least 1% for SO_x, NH_3, PM2.5, PM10 and Pb emissions. An increase due to recalculations by at least 1% is observed for NMVOC, TSP, BC, and Cd.

In 1990, recalculations cause a decrease of more than 1% for SO_x, NH_3, PM10 and Pb. An increase by 1% or more is observed for NMVOC, TSP, BC and Cd emissions. Detailed information on recalculations is provided in chapter 8.1.

In the current submission, several improvements were conducted. Details are given in chp. 1.4.1. A number of further improvements are identified but could not yet be realised. They are documented 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 2019, Switzerland provides for the twelfth time an Informative Inventory Report (IIR) with the documentation on hand.

1.2 Institutional arrangements

The Swiss inventory system for the CLRTAP is developed and managed under the auspices of 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 2019/(*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.

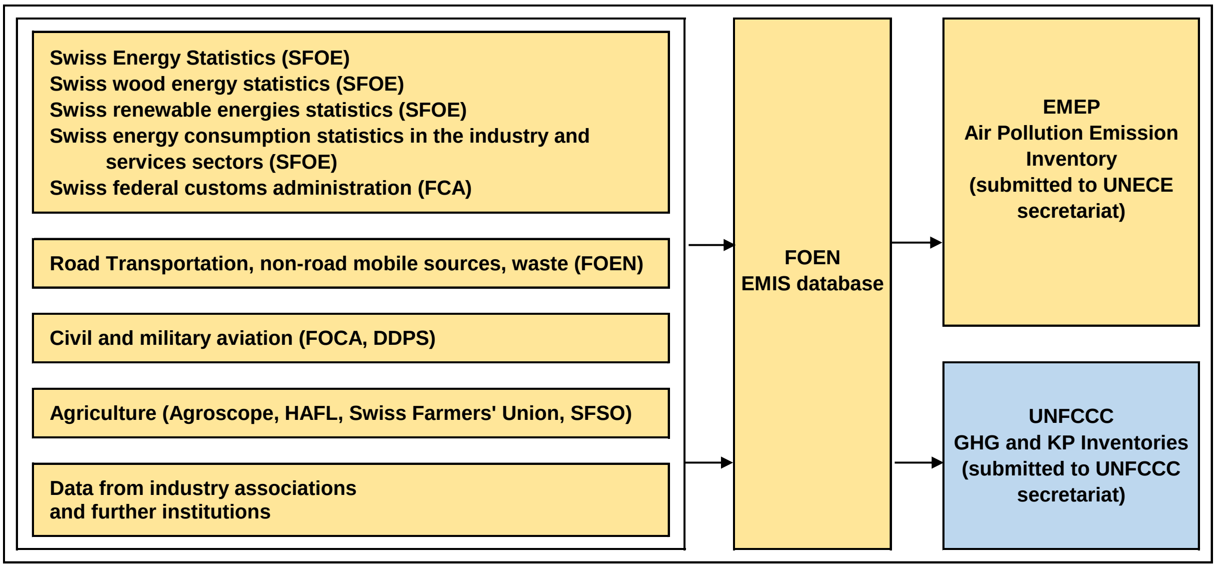


Figure 1-1: Data collection for EMIS database and CLRTAP air pollution emission inventory (GHG: Greenhouse Gas, KP: Kyoto Protocol).

The preparation of the CLRTAP Inventory is very closely connected to the preparation of the GHG inventory. Therefore, there are several 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 2019) 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 2018). 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 in 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 2018 in chp. 8.2 (FOEN 2018b). The list shows the current state of realisation:

- *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.*
Current state: in progress.
- *General: Possibilities of adding an approach 2 uncertainty analysis in subsequent submissions are currently assessed.*
Current state: in progress.
- *1A2gvii, 1A3d, 1A4aii, 1A4bii, 1A4cii, 1A5bii: A transcription error for EF (Pb) for non-road vehicles will be corrected in submission 2019.*
Current state: Done.
- *1A3b: Due to a mistake in importfile the BC emission factors have to be corrected for the years 2001-2009, 2011-2014, 2016-2019, etc. Those emission factors are 100 times too low in submission 2018.*
Current state: Done.
- *1A3b: A further update of the emission model is on-going.*
Current state: in progress (several updates have been done, more are to come).
- *1A5b: Revision of emission factors for military aircraft is planned.*
Current state: Done.
- *3B: Revision of NMVOC emission factors is on-going based on a comprehensive literature study and measurements as recommended in the Stage 3 review.*
Current state: Done (revision based on literature study but measurements are on-going).
- *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.*
Current state: Done.
- *3D: NMVOC emission factors will be revised in submission 2019 based on a comprehensive literature study.*
Current state: Done.
- *3B / 3D: An update of the calculation of NH_3 emissions from agriculture with AGRAMMON introducing other N species (N_2O, N_2, NO_x) to the N flux model and considering newest scientific findings is planned for the submission 2019.*
Current state: Done.

After the last UNECE Stage 3 Review in the year 2016, FOEN started a list including all encouragements and recommendations of the ERT (UNECE 2016). It contains comments on how and when FOEN plans to tackle ERT’s comments (FOEN 2017a).

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).
- CEIP: Extended guidance on reporting of national totals in the Annex I Emissions reporting template 'National Totals – Line 141' and 'National Totals for compliance – Line 144' and on adjustment reporting (CEIP 2018)
- EMEP/EEA air pollutant emission inventory guidebook — version 2016 (EMEP/EEA 2016), 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 2016 (EMEP/EEA 2016) 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 (military)	T2 (non-road), T2 (aviation)	CS	CS
2	**Industrial processes and product use**			
2A	Mineral products	T1, T2	CS	CS
2B	Chemical industry	T1, T2	CS	CS
2C	Metal production	T1, T2	CS	CS
2D	Other solvent and product use	T1, T2	CS	CS
2G	Other product use	T1, T2	CS	CS
2H	Other	T1, 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, T2, T3	CS, D	CS
3D	Crop production and agricultural soils	T1, T2, T3	CS, D	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	T1, T2, T3	CS, D	CS
11	**Natural emissions**			
11B	Forest fires	T2	CS	CS
11C	Other natural emissions	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					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								x			
12	Industry and 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	KBP	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 Emission Inventory Guidebook 2016 (EMEP/EEA 2016). 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”, in the reporting tables characterized as “National total for the entire territory (based on fuel sold” (in contrast to “fuels used”; for differentiation of the two approaches see chapter 3.1.6.1).

Key category analyses were conducted according to approach 1 and 2. Approach 1 level assessments are available for the base year (1990) and the current year (2017). Approach 2 level assessments are reported for the first time and are available for the current year (2017). All level assessments were performed for all emission sources accounting for 80% of the total national emissions. Additionally, approach 1 and 2 trend assessments 1990–2017 were conducted. The following pollutants are included in these analyses: NO_x, NMVOC, SO_x, NH_3, PM2.5 and PM10.

1.5.1 KCA approach 1 results

1.5.1.1 Level key category analysis (approach 1)

The results of the approach 1 level KCA 2017 are summarized in Table 1-3, and of the level KCA 1990 in Table 1-4. The numbers show the percentage level contribution to pollutant totals and the tables are ranked per source category. According to the approach 1 assessment, the following key categories contribute to the **level** analysis 2017 with 20% or more:

- 3Da2a Animal manure applied to soils NH_3 36.8%
- 1A3bi Passenger cars NO_x 33.8%
- 1A2f Non-metallic minerals SO_2 26.4%
- 1A4bi Residential: Stationary PM2.5 26.1%
- 3B1a Manure management - Dairy cattle NH_3 20.2%

Table 1-3: List of Switzerland's approach 1 level key categories 2017 for the main pollutants, PM2.5 and PM10. The table shows their percentage contributions to pollutant totals and the cumulative total.

NFR Code	Key categories: % level contribution to pollutant totals 2017 (cumulative 80%)						Sum of KC % contrib.
	NO_x (as NO_2)	NMVOC	SO_x (as SO_2)	NH_3	PM2.5	PM10	
1A1a	3.7		4.5				8
1A2c			6.0				6
1A2f	6.2		26.4				33
1A2gvii	4.3				6.2	15.5	26
1A2gviii			8.1		5.0	2.3	15
1A3bi	33.8	8.0			4.7	2.1	49
1A3bii	5.9						6
1A3biii	9.4						9
1A3bvi					6.2	18.1	24
1A3c					3.0	8.4	11
1A4ai	4.4		7.9		7.5	3.4	23
1A4bi	8.5	2.9	17.6		26.1	11.7	67
1A4ci					3.2		3
1A4cii	3.8				3.2		7
2A5a					3.5	3.1	7
2B5			13.1				13
2D3a		14.7					15
2D3b		3.6					4
2D3d		8.9					9
2D3e		2.5					3
2D3g		4.5					4
2D3h		3.6					4
2D3i		2.7					3
2G		8.6			6.8	4.0	19
2H1					3.3		3
2H2		3.1				2.3	5
2I						2.5	2
3B1a		9.9		20.2			30
3B1b		8.7		13.4			22
3B3				8.8			9
3Da1				5.1			5
3Da2a				36.8			37
3Da3						6.8	7
5C1a					4.0		4
cumulative 80%	*80.0*	*81.7*	*83.6*	*84.3*	*82.7*	*80.2*	

Table 1-4: List of Switzerland's approach 1 level key categories 1990 for the main pollutants, PM2.5 and PM10. The table contains their percentage contributions to pollutant totals and the cumulative total.

NFR Code	Key categories: % level contribution to pollutant totals 1990 (cumulative 80%)						Sum of KC % contrib.
	NO_x (as NO_2)	NMVOC	SO_x (as SO_2)	NH_3	PM2.5	PM10	
1A1a	4.5		9.8		5.0	4.2	23
1A2d			8.4				8
1A2f	7.5		9.6		2.9	3.5	24
1A2gvii	4.5				4.8	9.1	18
1A2gviii			8.8		3.3		12
1A3bi	34.6	17.7	5.3		4.5	2.8	65
1A3bii	3.9						4
1A3biii	18.1		4.3		6.6	4.2	33
1A3bv		4.5					5
1A3bvi						8.7	9
1A3c						4.0	4
1A4ai			10.2		2.8		13
1A4bi	8.2	2.7	25.2		32.6	20.9	90
1A4ci					3.5	2.2	6
1A4cii					2.9	2.1	5
1B2av		5.7					6
2C1					5.4	6.2	12
2D3a		3.1					3
2D3d		18.0					18
2D3e		3.7					4
2D3g		9.4					9
2D3h		6.8					7
2G		7.1			3.4	2.5	13
2I						4.0	4
3B1a		3.2		14.9			18
3B1b				8.3			8
3B3				9.0			9
3Da2a				49.2			49
3Da3						4.4	4
5C1a					3.1	2.2	5
cumula-tive 80%	*81.3*	*81.9*	*81.6*	*81.3*	*80.8*	*80.9*	

1.5.1.2 Trend key category analysis (approach 1)

The results of the approach 1 trend KCA 1990-2017 are summarized in Table 1-5. The numbers show the percentage contribution trend and the table is ranked per source category. According to the approach 1 assessment, the following source categories contribute with 20% or more to the **trend** analysis 1990-2017:

- 3Da2a Animal manure applied to soils NH_3 37.2%
- 1A3biii Heavy duty vehicles and busses NO_x 33.0%
- 1A2f Non metallic minerals SO_2 20.7%

Table 1-5: List of Switzerland's approach 1 trend key categories 1990–2017 for the main pollutants, PM2.5 and PM10. The table contains their percentage contributions to pollutant totals and the cumulative total

NFR Code	Key categories: % contribution to trend 1990-2017 (cumulative 80%)						Sum of KC % contrib.
	NO_x (as NO_2)	NMVOC	SO_x (as SO_2)	NH_3	PM2.5	PM10	
1A1a	2.9		6.5		7.0	5.7	22
1A2c			3.7				4
1A2d	3.0		10.3				13
1A2f	5.0		20.7		4.1	4.5	34
1A2gvii						10.0	10
1A2gviii	5.4				3.1		9
1A3ai(i)	9.6		3.2				13
1A3bi	3.0	12.5	5.1				21
1A3bii	7.5						7
1A3biii	33.0		5.1		10.1	5.7	54
1A3bv		5.0					5
1A3bvi					7.5	14.4	22
1A3c					3.4	6.8	10
1A3d	3.7						4
1A4ai	3.0		2.8		8.6	2.4	17
1A4bi			9.4		11.8	14.2	35
1A4cii	2.8						3
1B2av		4.7					5
2A5a					4.2	2.4	7
2B5			14.7				15
2C1					9.7	9.4	19
2D3a		15.0					15
2D3b		2.6					3
2D3d		11.7					12
2D3g		6.3					6
2D3h		4.1					4
2G					6.2	2.4	9
2H1					3.2		3
2H2		3.1			2.8		6
3B1a		8.6		16.0			25
3B1b		8.4		15.5			24
3Da2a	3.8			37.2			41
3Da2b				5.3			5
3Da2c				4.6			5
3Da3				3.8		3.7	7
cumulative 80%	*82.7*	*81.9*	*81.4*	*82.3*	*81.9*	*81.7*	

1.5.2 KCA approach 2 results

1.5.2.1 Level key category analysis (approach 2)

The results of the approach 2 level KCA 2017 are summarized in Table 1-6. The numbers show the percentage level contribution to pollutant totals and the tables are ranked per source category. According to the approach 2 assessment, the following source categories contribute to the **level** analysis 2017 with 20% or more:

- 1A3bi Passenger cars NO_x 45.9%
- 1A2f Non metallic minerals SO_2 26.9%
- 3Da2a Animal manure applied to soils NH_3 23.7%
- 3B1a Manure management - Dairy cattle NMVOC 23.0%
- 3B1a Manure management - Dairy cattle NH_3 22.2%
- 3B1b Manure management - Non-dairy cattle NMVOC 21.7%

Table 1-6: List of Switzerland's approach 2 level key categories 2017 for the main pollutants, PM2.5 and PM10. The table contains their percentage contributions to pollutant totals and the cumulative total.

NFR Code	Key categories: % level contribution to pollutant totals 2017 (cumulative 80%)						Sum of KC % contrib.
	NO_x (as NO_2)	NMVOC	SO_x (as SO_2)	NH_3	PM2.5	PM10	
1A1a	2.9		6.0				9
1A2f	3.6		26.9				31
1A2gvii					2.5	6.2	9
1A2gviii			8.4		3.0		11
1A3bi	45.9			3.5			49
1A3bii	6.4						6
1A3biii	5.9						6
1A3bvi					2.8	7.4	10
1A3c						3.6	4
1A4ai	2.5		4.3		5.1		12
1A4bi	4.1		10.8		16.7	7.2	39
1B2aiv			6.3				6
2A1					4.2	2.8	7
2A5a					16.1	13.2	29
2B5			14.5				14
2B10a			4.0				4
2D3a		14.9					15
2D3d		2.2					2
2D3g		3.5					4
2D3i		2.4					2
2G		8.5			6.3	3.6	18
2H1					5.8	2.5	8
2H2					12.4	9.7	22
2I					6.0	10.6	17
3B1a		23.0		22.2			45
3B1b		21.7		9.0			31
3B3		2.5		9.0			11
3B4gii		2.3				2.3	5
3Da1	5.0			7.5			12
3Da2a	4.4			23.7			28
3Da3						11.2	11
6A				5.2			5
cumula-tive 80%	*80.6*	*81.1*	*81.1*	*80.1*	*80.9*	*80.2*	

1.5.2.2 Trend key category analysis (approach 2)

The results of the approach 2 trend KCA 1990-2017 are summarized in Table 1-7. The numbers show the percentage contribution trend and the table is ranked per source category. According to the approach 2 assessment, the following source categories contribute with 20% or more to the **trend** analysis 1990-2017:

- 3Da2a Animal manure applied to soils NH_3 25.4%
- 3B1b Manure management - Non-dairy cattle NMVOC 23.1%
- 1A3biii Heavy duty vehicles and busses NO_x 22.9%
- 1A2f Non-metallic minerals SOx 22.7%
- 3B1a Manure management - Dairy cattle NMVOC 22.2%

Table 1-7: List of Switzerland's approach 2 trend key categories 1990–2017 for main pollutants, PM2.5 and PM10. The table contains their percentage contributions to pollutant totals and the cumulative total.

NFR Code	Key categories: % contribution to trend 1990-2017 (cumulative 80%)						Sum of KC % contrib.
	NO_x (as NO_2)	NMVOC	SO_x (as SO_2)	NH_3	PM2.5	PM10	
1A1a	2.5		9.3		4.2	3.9	20
1A2d			8.1				8
1A2f	3.2		22.7			2.8	29
1A2gvii						4.6	5
1A2gviii	3.6						4
1A3ai(i)	7.5						7
1A3bi	4.5	3.4	3.0				11
1A3bii	8.9						9
1A3biii	22.9		3.2		2.4		28
1A3biv	2.1	2.4					4
1A3bvi					3.5	6.7	10
1A3c						3.3	3
1A4ai					6.0		6
1A4bi			6.1		7.7	9.9	24
1B2aiv			3.6				4
2A1					2.9		3
2A5a					19.7	11.7	31
2B5			17.5				17
2B10a			4.0				4
2C1					10.5	10.9	21
2D3a		16.8					17
2D3d		3.2					3
2D3g		5.5					6
2G					5.9		6
2H1					5.7		6
2H2					12.8	7.4	20
2I						11.0	11
3B1a		22.2		18.6			41
3B1b		23.1		10.9			34
3B3		2.3					2
3B4gii		3.1		4.0		3.3	10
3Da1	8.5			5.9			14
3Da2a	7.5			25.4			33
3Da2c	2.5			7.1			10
3Da3	6.6			4.3		6.9	18
5B1				4.1			4
5C1biv			2.7				3
cumula-tive 80%	*80.2*	*81.9*	*80.3*	*80.4*	*81.3*	*82.3*	

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 9001:2015 standard. Certification has been obtained in 2007 and is upheld since through annual audits (Swiss Safety Center 2018). 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 copy of the 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 IIR authors. 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 an iterative process: a first check is done by collaborators of the Air Pollution Control and Chemicals division and sectoral experts, providing feedback and comments to the EMIS database experts. Based on the comments, changes to the reporting tables or database are made as required. The process is repeated two times before producing the final reporting tables.

The QA/QC process can therefore be summarised as follows: The preparation steps for the production of the CLRTAP Inventory including data collection, compilation, emissions 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 EMEP 2013 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 2016).

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 2019) 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 in 2013 (see next chapter).

Uncertainties are assessed in accordance with the EMEP/EEA Emission Inventory Guidebook 2016 (EMEP/EEA 2016: 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 2016).

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 2019).
- 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 of emission factors for sector 2 Industrial processes and product use are based on default uncertainty values from EMEP/EEA (2016) (part A, chp. 5, table 3-2).
- Uncertainties for NH_3 emissions from sector 3 Agriculture had been thoroughly 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 2017b). The results show slightly higher uncertainties but they generally confirm the results of the previous study (INFRAS 2015b). For the current

submission, uncertainties provided by INFRAS (2017b) are used for the uncertainty analysis.

- Detailed references for the uncertainties are shown in Annex 5.

1.7.3 Results of Tier 1 uncertainty evaluation

Table 1-8 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 1990-2017 are also shown in the table to give a quantitative meaning to the trend uncertainties.

Table 1-8: Relative Tier 1 uncertainties for total emission levels 2017 and for emission trends 1990-2017 of the main pollutants, PM2.5 and PM10. The last column shows the emission trends 1990-2017. Legend for example NO_x: Trend uncertainty is 1%, emission trend is -55%: This means that the emission trend 1990-2017 lies in the interval -54% and -56% with a probability of 95%.

Pollutant	**Level uncertainty 2017**	**Trend uncertainty 1990-2017**	**Emission trend 1990-2017**
NO_x	14%	1%	-57%
NMVOC	76%	14%	-74%
SO_x	7%	1%	-85%
NH_3	13%	5%	-18%
PM2.5	34%	8%	-57%
PM10	32%	11%	-38%

Level uncertainty estimations range from 7% to 76%, trend uncertainties from 1% to 14%. The level uncertainty estimations increased as compared to the values of the previous submission 2018 for NO_x, NMVOC and PM2.5, the differences lie between one percentage point (NO_x and PM2.5) and 27 percentage points (NMVOC; mainly due to the inclusion of NMVOC emissions under 3B Manure management, see chp. 5.2). For PM10, level uncertainties are 5 percentage points lower than they were in the previous submission. The trend uncertainty estimations increased as compared to the values of the previous submission 2018 for NMVOC by 6 percentage points and decreased for NO_x by one percentage point.

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.

Note that there is a mistake in the equation for the calculation of the type A sensitivity in the EMEP/EEA Guidebook 2016 (EMEP/EEA 2016, chp. 5 uncertainties, p.13, note B). The equation in note B has to be computed as an absolute value (as it is described in IPCC 2006, vol. 1, chp. 3, p. 32). From Submission 2019 on, the methodology from the IPCC 2006 guidelines is used for the uncertainty analysis for Switzerland's IIR. Unfortunately, also the Equation in Note B from the IPCC 2006 guidelines is not correct. When using LULUCF categories the emissions can be negative. Therefore, also in this equation the absolute values for C and D should be used.

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, BC in a couple of source categories within sector 2 IPPU (2A5a, 2B5, 2C7c, 2H2, 2H3) 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)

Emissions of a number of source categories 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.

2 Emission trends 1980-2017

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, the reader shall 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 1980-2017 (see Table 2-1). Note that there is a methodological discrepancy between data before 1990 and data from 1990 onward due to 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 (including trends). 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.

Pollutant	Unit	1980	2005	2017	1980-2017	2005-2017
NO_x	kt	166.89	90.59	62.84	-62.3%	-30.6%
NMVOC	kt	319.83	104.81	77.92	-75.6%	-25.7%
SO_2	kt	114.02	13.92	5.42	-95.2%	-61.0%
NH_3	kt	81.53	57.67	55.06	-32.5%	-4.5%
PM2.5	kt	20.01	9.44	6.57	-67.2%	-30.4%
PM10	kt	29.59	17.21	14.96	-49.4%	-13.1%
TSP	kt	53.27	31.18	28.99	-45.6%	-7.0%
BC	kt	5.03	3.05	1.41	-72.0%	-53.7%
CO	kt	1149.61	286.19	151.43	-86.8%	-47.1%
Pb	t	1325.64	19.67	14.78	-98.9%	-24.9%
Cd	t	5.65	1.03	1.16	-79.4%	13.0%
Hg	t	7.72	0.76	0.66	-91.4%	-12.2%
PCDD/PCDF	g I-Teq	453.82	32.54	20.53	-95.5%	-36.9%
BaP	t	3.61	2.34	0.82	-77.4%	-65.2%
BbF	t	3.67	2.41	0.86	-76.5%	-64.2%
BkF	t	1.84	1.27	0.56	-69.3%	-55.6%
IcdP	t	1.93	1.36	0.51	-73.8%	-62.9%
PAH tot	t	11.04	7.38	2.75	-75.1%	-62.8%
HCB	kg	97.39	0.35	0.35	-99.6%	-0.4%

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 were introduced in 1983 and 1985, respectively. The EPA contains the fundamental principles whereas the 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. Main goal of the OAPC is to protect human beings, animals, plants, their biological communities and habitats and the soil against harmful effects or nuisances of air pollution. In addition, the 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 with Regulation (EU) 2016/1628. 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 Constitution of the Swiss Confederation: Article 74 “Protection of the environment” (Swiss Confederation 1999)
- 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 “Concept on Air Pollution Control”: 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 incentive tax on volatile organic compounds (VOC) since 2000 (Swiss Confederation 1997).
- Federal Act on the reduction of CO_2 emissions (Swiss Confederation 2011).
- 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.

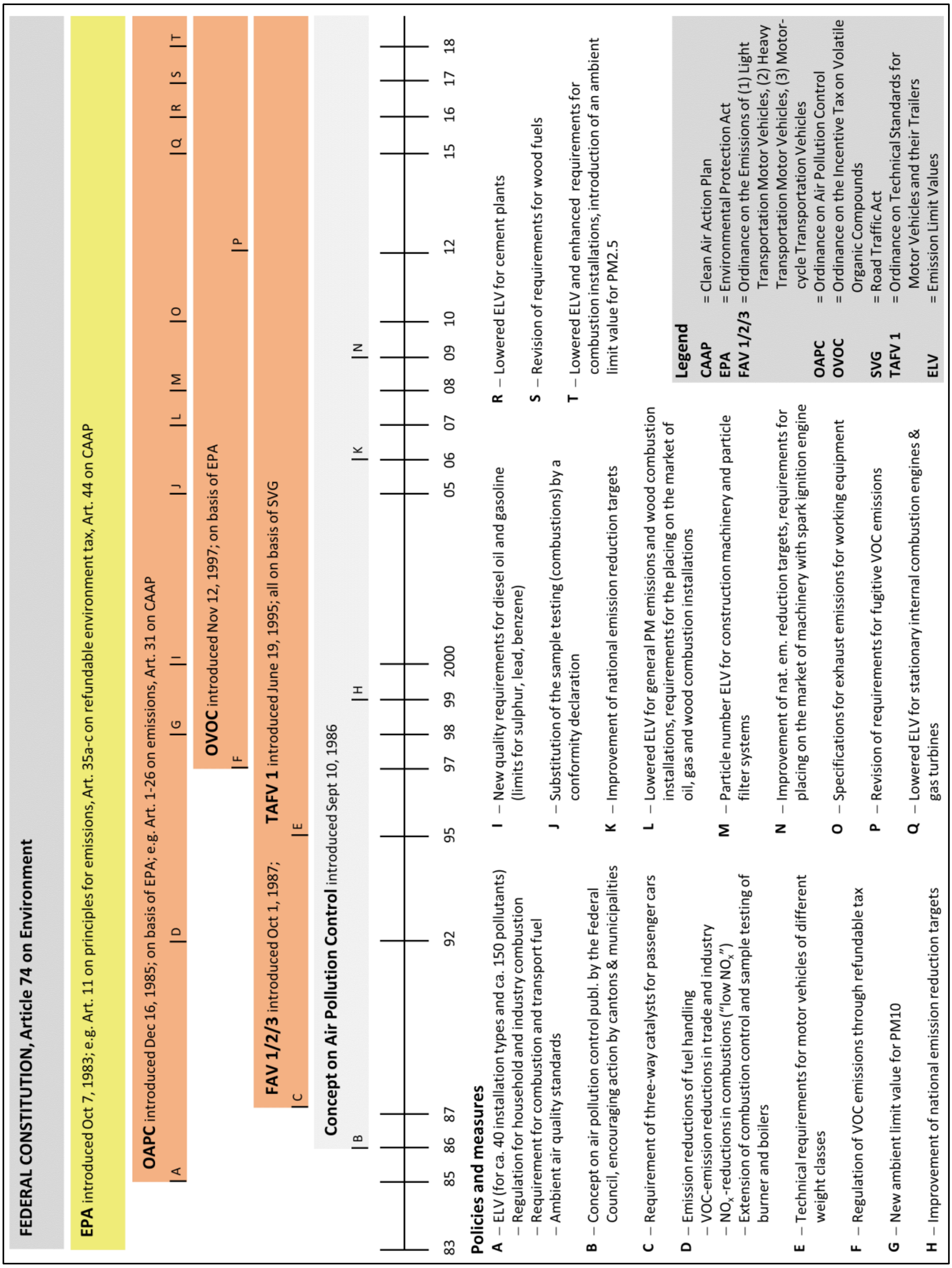


Figure 2-1: Overview of the OAPC Revisions in Switzerland. The Concept on Air Pollution Control is also referred to as the Air Pollution Control Strategy.

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 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 (see Figure 2-2 and Table 2-2).

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 2017.

Furthermore, due to legal restriction of sulphur content in liquid fuels and decrease in coal consumption, a decreasing trend can also be observed for SO_x emissions. 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. Annual fluctuations of SO_x emissions occur mainly due to annual variations of heating degree days (e.g., 1993, 2000, 2007, 2011), which reduced 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 influenced by changes in farm animal numbers, changes in housing systems due to developments in animal welfare regulations as well as changes in agricultural production techniques including a decline in the use of mineral fertiliser (see Figure 2-2).

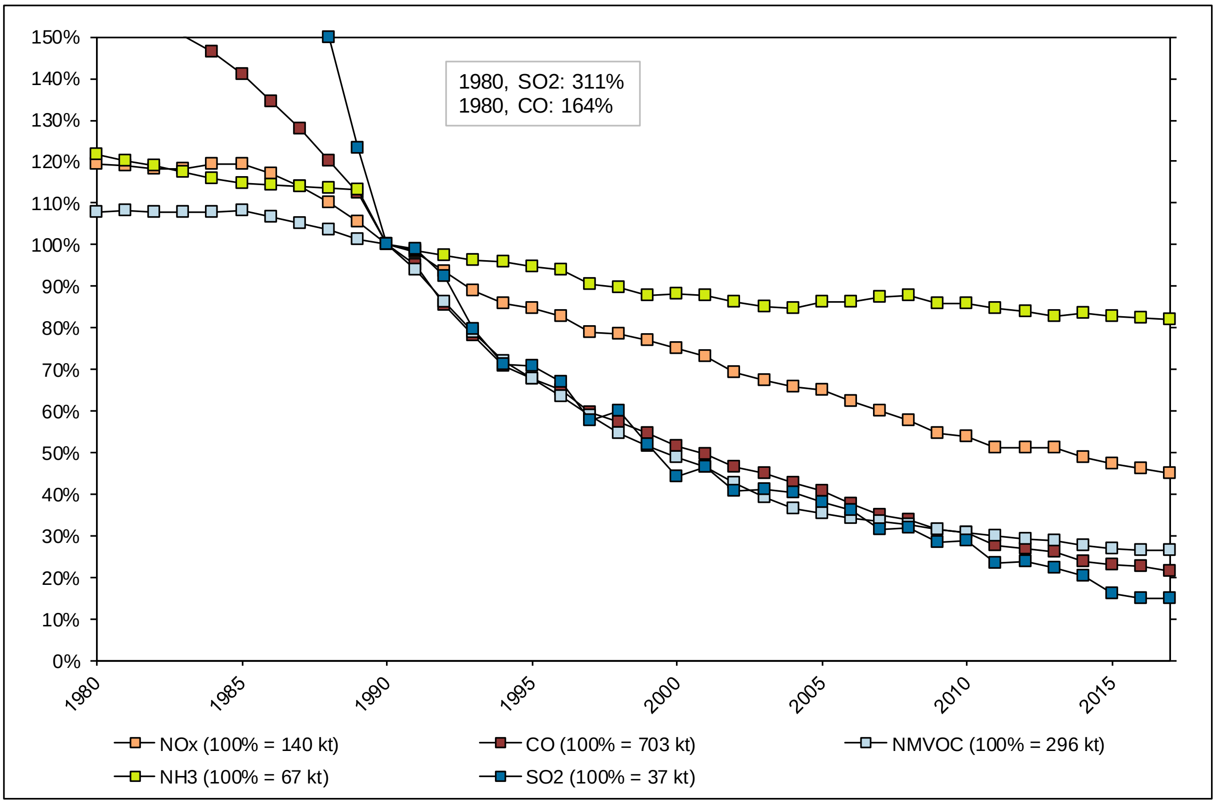


Figure 2-2: Relative trends for the total emissions of main air pollutants and CO in Switzerland 1980–2017 (in percentage of 1990). Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

Table 2-2: Main pollutants: Total emissions 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	166.89	319.83	114.02	81.53	1149.61
1985	166.74	320.52	73.31	76.98	991.22
1990	139.56	296.43	36.66	66.99	702.81
1995	118.35	200.86	25.98	63.36	477.28
2000	104.87	144.55	16.26	59.20	361.92
2004	92.08	107.74	14.86	56.81	299.85
2005	90.59	104.81	13.92	57.67	286.19
2006	86.97	101.87	13.29	57.89	265.07
2007	83.54	98.69	11.58	58.51	246.75
2008	80.54	96.85	11.70	58.71	237.26
2009	76.18	93.76	10.40	57.46	222.32
2010	75.37	90.98	10.52	57.45	214.72
2011	71.59	88.18	8.52	56.64	195.36
2012	71.28	86.87	8.78	56.22	188.86
2013	71.50	84.92	8.20	55.53	183.26
2014	68.10	81.63	7.50	56.03	166.05
2015	65.98	79.79	5.83	55.43	161.05
2016	64.51	77.92	5.42	55.23	157.69
2017	62.84	77.92	5.42	55.06	151.43
2005 to 2017 (%)	-31%	-26%	-61%	-5%	-47%

2.2.2 Suspended particulate matter

Emissions for suspended particulate matter (PM2.5, PM10, TSP and BC) show a significant decline since 1980 (see Figure 2-3 and Table 2-3). This decline minly resulted from the following measures:

- The abatement of exhaust emissions from road vehicles and from residential heating systems, mainly affecting the fractions of fine particles (PM2.5, BC).
- An action plan to reduce particulate matter emissions was initiated by the Federal Council in 2006, including 14 measures on the national level. Some of these measures led to an OAPC revision in 2007 and in 2018 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 machines and particle filter systems. It aims at reducing the fine fraction of particulate matter (PM2.5) and soot (see also Figure 2-1).

There are no condensables included in PM emissions except for few sources (i.e. 1A4bi Bonfire and 1A4bi Use of charcoal, see chp. 3.2.4.2). For wood combustion condensable components are estimated but included in NMVOC emissions (see chapter 3.2.1.1.2). For details see table Table A - 21 in Annex 6.

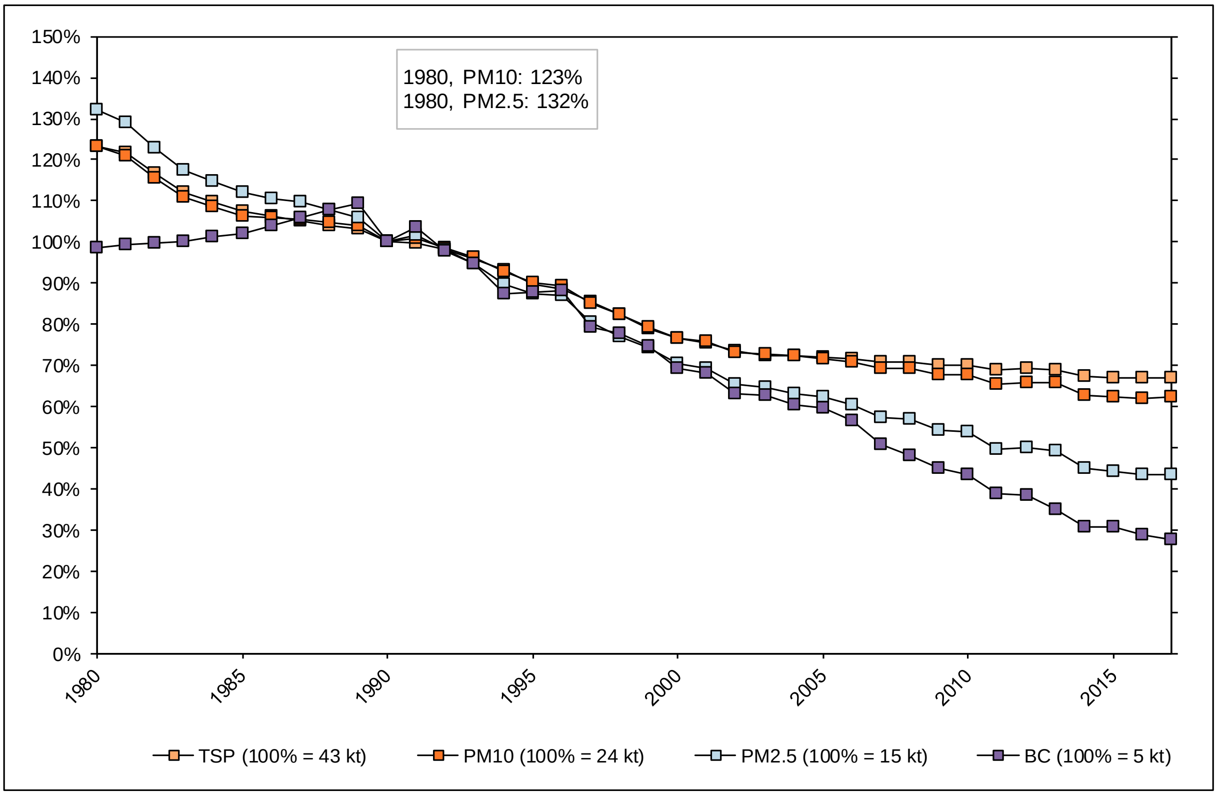


Figure 2-3: Total emissions of suspended particulate matter TSP, PM10, PM2.5 and BC in Switzerland 1980–2017 (in percentage of 1990). Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

Table 2-3: Total emissions of particulate matter 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	20.01	29.59	53.27	5.03
1985	16.98	25.58	46.42	5.21
1990	15.16	24.02	43.20	5.11
1995	13.26	21.61	38.70	4.48
2000	10.67	18.43	33.17	3.55
2005	9.44	17.21	31.18	3.05
2006	9.19	16.99	30.96	2.88
2007	8.71	16.63	30.56	2.59
2008	8.62	16.61	30.58	2.45
2009	8.22	16.26	30.23	2.29
2010	8.19	16.29	30.34	2.22
2011	7.54	15.72	29.75	1.98
2012	7.61	15.82	29.85	1.97
2013	7.47	15.77	29.81	1.78
2014	6.82	15.09	29.13	1.58
2015	6.72	14.99	29.01	1.57
2016	6.60	14.89	28.94	1.46
2017	6.57	14.96	28.99	1.41
2005 to 2017 (%)	-30%	-13%	-7%	-54%

2.2.3 Priority heavy metals

Between 1980 and 2003, emissions of priority heavy metals (Pb, Cd and Hg) show a pronounced decline (see Figure 2-4 and Table 2-4). 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. The decrease of Cd and Hg emissions is mainly due to the strict emission limit values for waste incineration plants. Since 2003, Pb and Hg emissions show a less pronounced decreasing trend, whereas Cd emissions are increasing due to an increase of total wood energy combustion (mainly in 1A1 and 1A2) as well as of emissions from special hazardous waste incineration plants.

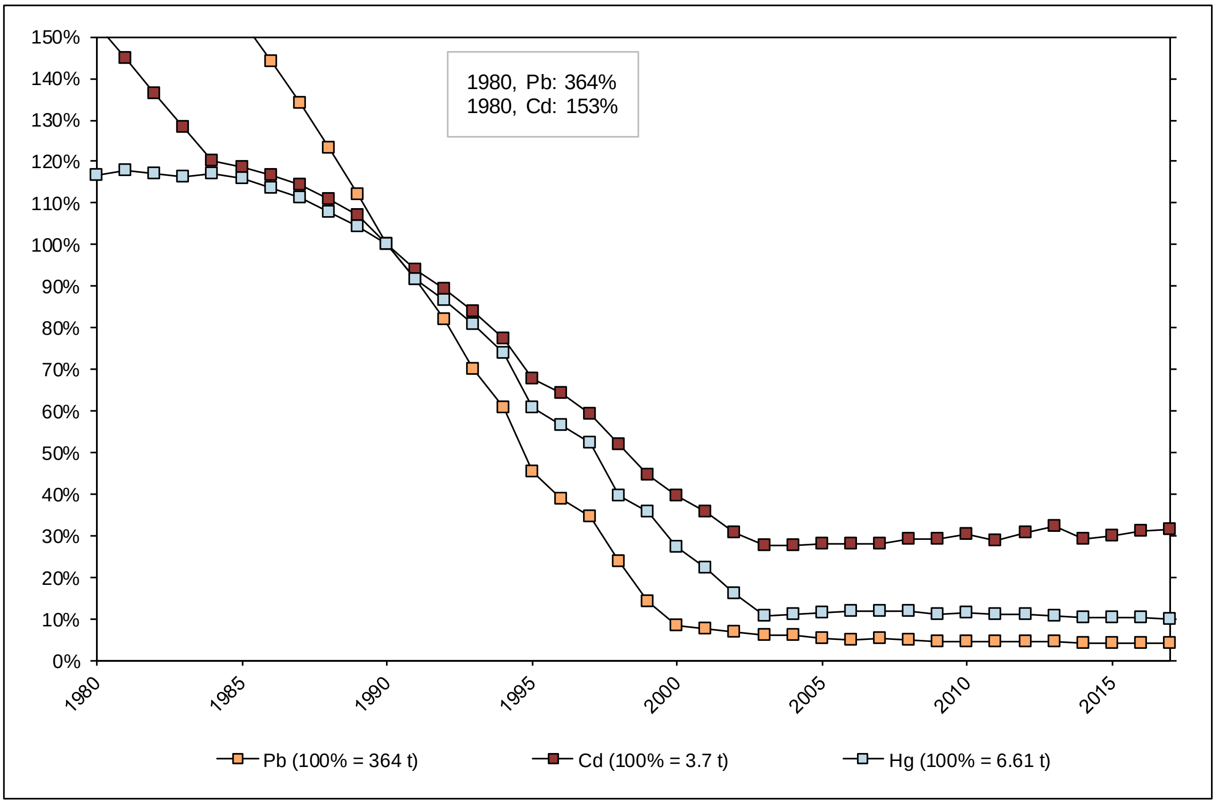


Figure 2-4: Emissions of priority heavy metals in Switzerland 1980–2017 (in percentage of 1990). Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

Table 2-4: Total emissions of priority heavy metal in tons. 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	1325.64	5.65	7.72
1985	559.07	4.39	7.65
1990	363.80	3.70	6.61
1995	164.94	2.50	4.03
2000	30.48	1.46	1.81
2005	19.67	1.03	0.76
2006	18.33	1.04	0.79
2007	18.57	1.03	0.79
2008	17.86	1.08	0.79
2009	16.77	1.08	0.74
2010	16.21	1.13	0.76
2011	15.94	1.06	0.74
2012	16.09	1.14	0.72
2013	16.17	1.19	0.71
2014	14.46	1.07	0.69
2015	14.82	1.10	0.69
2016	14.60	1.14	0.68
2017	14.78	1.16	0.66
2005 to 2017 (%)	-25%	13%	-12%

2.2.4 Persistent organic pollutants (POPs)

The emissions of persistent organic pollutants have generally declined since 1980 (see Figure 2-5 and Table 2-5).

Between 1980 and 2003, PCDD/PCDF emissions decreased as result of an indirect effect of the equipment of waste incineration plants with DeNOx techniques. From 2003 onward, emissions continue to decrease on a low level.

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 technological improvements of wood combustion installations in 1A Fuel combustion. In addition, the wood energy consumption decreased by half and increased by about a factor of six in manually operated furnaces and automatic combustion installations, respectively.

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 which ceased in 1993. Since then total HCB emissions are slightly increasing on a low level. The remaining sources of HCB emissions are waste incineration plants in source category 1A1 Energy industries, all wood combustion installations and with a smaller share the use of coal (other bituminous coal and lignite) in 1A Fuel combustion. The annual fluctuations in HCB emissions are due to the wood consumption in 1A4bi Residential: Stationary which is strongly influenced by climate variabilities, in particular by the winter mean temperatures.

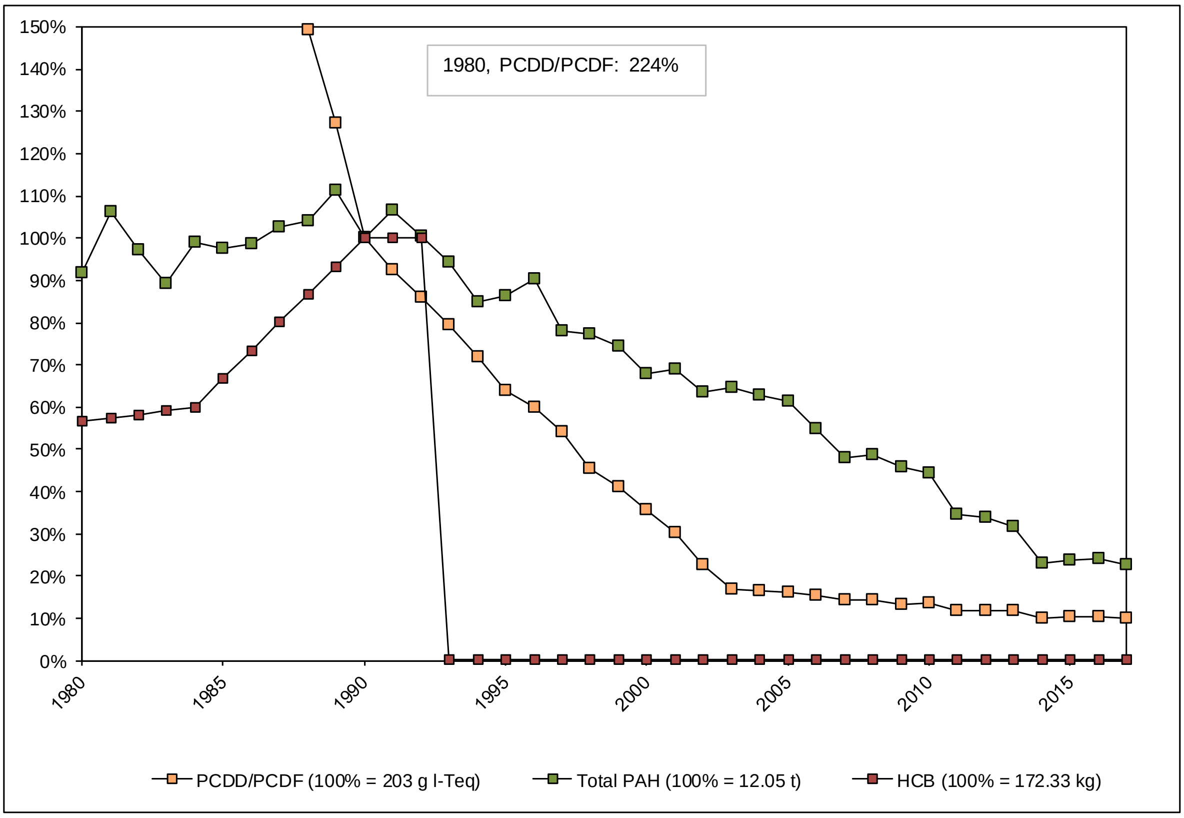


Figure 2-5: Emissions of POPs Annex III[1]: PAH – as the sum of benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene – PCDD/PCDF (PCDD/F) and HCB in Switzerland 1980–2017. Note that values for PCDD/PCDF before 1988 are not displayed here but illustrated in the table below. Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

Table 2-5: Total emissions of POPs Annex III (see footnote 1, p. 41). 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	3.61	3.67	1.84	1.93	11.04	97.39
1985	408	3.84	3.87	1.89	2.16	11.77	115.01
1990	203	3.88	3.93	1.97	2.26	12.05	172.33
1995	130	3.46	3.36	1.58	2.01	10.40	0.32
2000	72	2.64	2.65	1.32	1.55	8.16	0.31
2005	33	2.34	2.41	1.27	1.36	7.38	0.35
2006	32	2.15	2.13	1.08	1.24	6.60	0.36
2007	29	1.89	1.86	0.93	1.10	5.77	0.34
2008	29	1.92	1.89	0.95	1.12	5.89	0.36
2009	27	1.80	1.77	0.91	1.04	5.52	0.36
2010	28	1.73	1.72	0.90	1.01	5.35	0.38
2011	24	1.34	1.34	0.73	0.78	4.19	0.34
2012	24	1.28	1.30	0.73	0.76	4.07	0.36
2013	24	1.19	1.21	0.72	0.70	3.82	0.37
2014	20	0.83	0.87	0.56	0.50	2.76	0.33
2015	21	0.86	0.91	0.58	0.52	2.87	0.34
2016	21	0.87	0.92	0.59	0.53	2.92	0.35
2017	21	0.82	0.86	0.56	0.51	2.75	0.35
2005 to 2017 (%)	-37%	-65%	-64%	-56%	-63%	-63%	-0.4%

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

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) mainly stem from sector 1 Energy. The trend of NO_x emissions per sector is given in Table 2-6 and Figure 2-6. Overall, NO_x emissions in Switzerland constantly declined between 1990 and 2017.

The decline was mainly due to emission reductions in the energy sector. Within the energy sector, in particular categories 1A3 Transport, 1A2 Manufacturing industries and 1A4 Other sectors are relevant for NO_x emissions. The decrease of NO_x emissions in sector 1 Energy was primarily due to the abatement of exhaust emissions from road vehicles (category 1A3) and of fuel combustion emissions in manufacturing industries (1A2) and in residential, commercial and institutional heating (1A4).

- The reductions in road transportation (1A3b) were triggered by 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 first Euro standards in 1993, Switzerland adopted the subsequent reduction path (Euro 2/II in 1995, Euro 3/III in 2000, Euro 4/IV in 2005, Euro V in 2008, Euro 5 in 2009, Euro VI in 2013 and Euro 6 in 2014). However, the reduction of NO_x emissions because of emission standards has not been as pronounced as expected in the past few years due to an increasing share of diesel-powered passenger cars and higher EF than expected (the "dieselgate" scandal[2]).
- The reductions in manufacturing industries (1A2) were a result of three main factors: First, there has been a fuel switch from residual fuel oil, coal and gas oil towards natural gas and a reduction in total fuel use since 2008. Second, a reduction has been reached due to an on-going sectoral agreement (from 1998) targeting NO_x emissions of the cement industry. Third, manufacturing plants reduced NO_x emissions through technical improvements (e.g. $DeNO_x$ technology, selective non-catalytic reduction technology SNCR).
- 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. In contrary, higher standards were specified for insulation and for combustion equipment efficiency for both new and renovated buildings including low-NO_x standards. Furthermore, a substantial substitution of gas oil by natural gas under 1A4 resulted in further reductions of NO_x emissions (i.e. natural gas consumption almost doubled from 1990 to 2017). These two effects compensated for the additional heated area, and lead to a reduction of NO_x emissions under category 1A4.

[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

Table 2-6: NO_x emissions, trends and share per sector as well as the emission ceiling for 2010 from the Gothenburg Protocol (national total for compliance; fuels used).

NO_x emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	133.77	86.18	70.77	58.41	-62.99	-27.77	-32.2%	92.9%
1A Fuel combustion	133.63	86.00	70.70	58.41	-62.93	-27.59	-32.1%	92.9%
1A1 Energy industries	6.81	2.98	3.22	2.63	-3.58	-0.36	-11.9%	4.2%
1A2 Manufacturing industries	22.75	14.73	12.37	9.17	-10.37	-5.56	-37.8%	14.6%
1A3 Transport	82.07	51.37	40.53	35.73	-41.53	-15.63	-30.4%	56.9%
1A4 Other sectors	21.13	16.31	14.03	10.44	-7.10	-5.88	-36.0%	16.6%
1A5 Other (Military)	0.88	0.60	0.54	0.45	-0.34	-0.16	-26.0%	0.7%
1B Fugitive emissions from fuels	0.13	0.18	0.07	0.00	-0.06	-0.18	-99.2%	0.0%
2 IPPU	0.49	0.30	0.37	0.29	-0.12	-0.01	-4.5%	0.5%
3 Agriculture	4.88	3.86	3.98	3.85	-0.91	-0.01	-0.1%	6.1%
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.32	0.16	0.16	0.19	-0.16	0.02	13.9%	0.3%
6 Other	0.10	0.09	0.10	0.10	0.00	0.01	14.9%	0.2%
National total for compliance	139.56	90.59	75.37	62.84	-64.18	-27.75	-30.6%	100.0%
Gothenburg Protocol, emission ceiling			79.00					

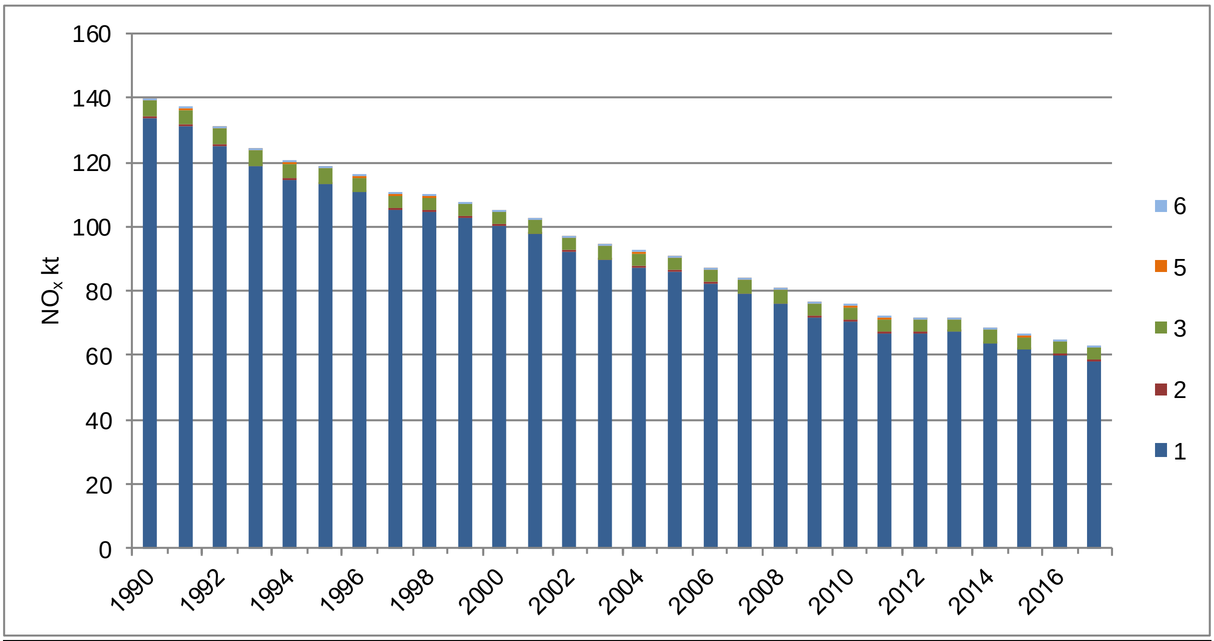


Figure 2-6: Trend of NO_x emissions (kt) in Switzerland by sectors 1-6.

2.3.2 Trends for NMVOC

Switzerland's emissions of NMVOC mainly stem from the sectors 2 IPPU, 3 Agriculture and 1 Energy. The trend of NMVOC emissions per sector is given in Table 2-7 and Figure 2-7. The NMVOC emissions have decreased in the time span 1990-2017.

The relevant reductions were achieved in sectors 2 IPPU and 1 Energy:

- In sector 2 IPPU, the emission reduction was more pronounced for the years 1990-2005 than from 2005 onwards. The reduction of 1990-2005 can be mainly attributed to category 2D3d Coating applications, where the paint composition changed from solvent based to water based paints. In addition, paint consumption in 2D3d decreased for construction (1990-1998) as well as for industrial and non-industrial paint application (2001-2004) which is partly due to substitution of conventional paints by powder coatings
  Despite an increase of emissions from 2D3a Domestic solvent use including fungicides from 2007-2017 due to changing emission factors and population growth,

the trend of NMVOC emissions from sector 2 IPPU was still slightly decreasing from 2005-2017. This was a result of reduced emissions in categories 2D3d Coating applications, 2D3h Printing and 2G Other product manufacture and use, caused by the ordinance on the VOC incentive tax (enactment of the tax in 2000).

- In sector 1 Energy, the emission reduction was mainly influenced from category 1A3b Road transportation, mainly resulting from the higher Euro standards for passenger cars (Euro 1 in 1993, Euro 2 in 1995, Euro 3 in 2000, Euro 4 in 2005, Euro 5 in 2009 and Euro 6 in 2014). Furthermore, the share of diesel oil in fuels used under 1A3b has increased compared to gasoline between 1990 and 2017, which leads to a decrease of NMVOC emissions.

NMVOC emissions from agriculture show a slightly fluctuating and decreasing trend. They are mainly depending on the development of animal numbers.

Table 2-7: NMVOC emissions, trends and share per sector as well as the emission ceiling for 2010 from the Gothenburg Protocol (national total for compliance; fuels used).

NMVOC emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	113.81	37.10	25.24	16.61	-88.57	-20.49	-55.2%	21.3%
1A Fuel combustion	94.01	31.40	21.53	13.91	-72.48	-17.49	-55.7%	17.9%
1A1 Energy industries	0.30	0.22	0.20	0.16	-0.11	-0.06	-28.9%	0.2%
1A2 Manufacturing industries	2.30	1.96	1.47	0.98	-0.83	-0.98	-50.1%	1.3%
1A3 Transport	76.12	19.65	12.76	8.26	-63.36	-11.39	-57.9%	10.6%
1A4 Other sectors	15.12	9.46	7.01	4.44	-8.11	-5.02	-53.0%	5.7%
1A5 Other (Military)	0.16	0.11	0.09	0.07	-0.07	-0.04	-36.2%	0.1%
1B Fugitive emissions from fuels	19.81	5.70	3.72	2.70	-16.09	-3.00	-52.7%	3.5%
2 IPPU	162.87	48.79	46.50	42.02	-116.37	-6.78	-13.9%	53.9%
3 Agriculture	18.77	17.98	18.08	17.71	-0.68	-0.27	-1.5%	22.7%
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.74	0.75	0.95	1.36	0.21	0.61	80.8%	1.8%
6 Other	0.23	0.19	0.19	0.21	-0.04	0.03	16.1%	0.3%
National total for compliance	296.43	104.81	90.98	77.92	-205.45	-26.89	-25.7%	100.0%
Gothenburg Protocol, emission ceiling			144.00					

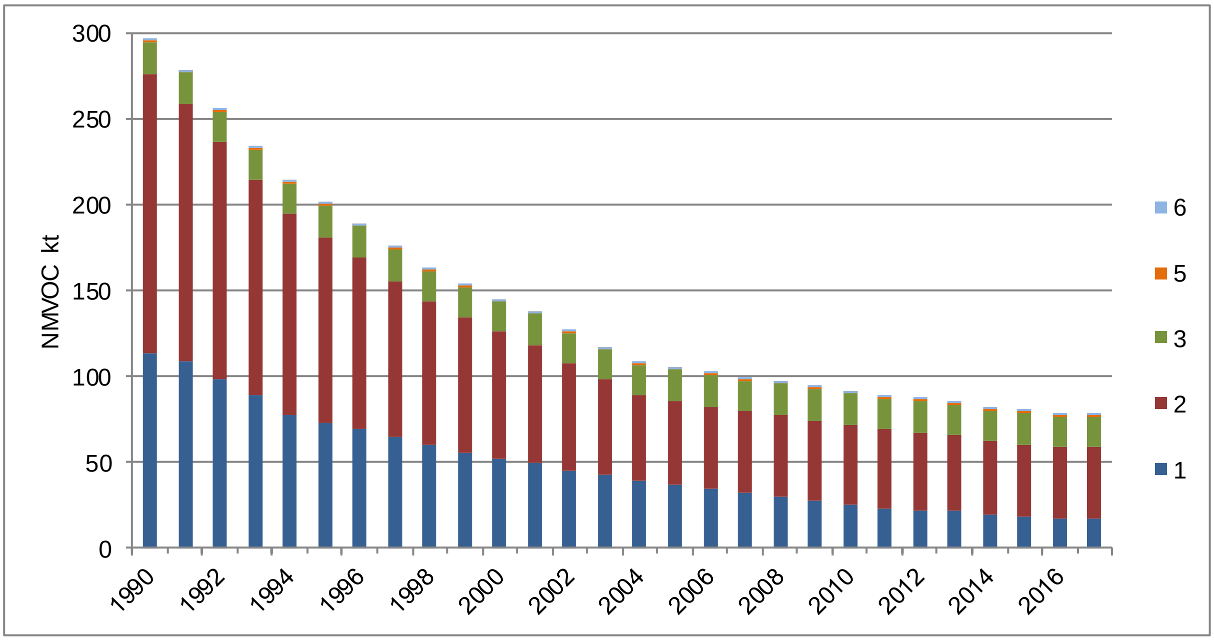


Figure 2-7: Trend of NMVOC emissions (kt) in Switzerland by sectors 1-6.

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) mainly stem from sector 1 Energy. The trend of SO_x emissions per sector is given in Table 2-8 and Figure 2-8. SO_x emissions show a decreasing trend with some fluctuations between 1990 and 2017.

The decrease can be mainly attributed to three measures in Switzerland in the sector Energy:

- First, a limitation of the sulphur content in fuels (stepwise lowering in 1993, 1999, 2000, 2005 and 2009) by the Ordinance on Air Pollution Control (Swiss Confederation 1985) resulted in a significant decrease of the sulphur oxide emissions from fuel combustion under 1A3 Transport and 1A4 Other sectors (gas oil, diesel and gasoline, see Table 3-8) between 1990 and 2010.
- Second, a substantial substitution of gas oil with natural gas and eco-grade gas oil (with low sulphur and nitrogen content, from 2006 onwards) under 1A4 (natural gas consumption almost doubled from 1990 to 2017) resulted in further reductions of sulphur emissions.
- Third, a similar substitution of residual fuel oil, coal and gas oil by natural gas has reduced sulphur emissions as well in 1A2 Manufacturing industries (i.e. coal and residual fuel oil from 1990, gas oil from about 2005 onwards).

Table 2-8: SO_x emissions, trends and share per sector as well as the emission ceiling for 2010 from the Gothenburg Protocol (national total for compliance; fuels used).

SO_x emissions	**1990**	**2005**	**2010**	**2017**	**1990-2010**	**2005-2017**	**2005-2017**	**share in 2017**
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	35.01	12.77	9.66	4.50	-25.35	-8.27	-64.8%	82.9%
1A Fuel combustion	34.40	12.32	9.38	4.39	-25.01	-7.94	-64.4%	80.8%
1A1 Energy industries	4.23	1.63	1.71	0.40	-2.52	-1.24	-75.7%	7.3%
1A2 Manufacturing industries	12.70	4.05	2.89	2.25	-9.80	-1.79	-44.3%	41.5%
1A3 Transport	4.08	0.21	0.23	0.25	-3.85	0.04	19.5%	4.7%
1A4 Other sectors	13.32	6.39	4.52	1.45	-8.80	-4.94	-77.3%	26.7%
1A5 Other (Military)	0.08	0.04	0.04	0.03	-0.04	0.00	-9.5%	0.6%
1B Fugitive emissions from fuels	0.61	0.45	0.28	0.11	-0.34	-0.34	-75.0%	2.1%
2 IPPU	1.46	1.07	0.79	0.83	-0.67	-0.24	-22.3%	15.4%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.18	0.06	0.06	0.08	-0.12	0.02	33.4%	1.5%
6 Other	0.01	0.01	0.01	0.01	0.00	0.00	-0.5%	0.2%
National total for compliance	36.66	13.92	10.52	5.42	-26.14	-8.49	-61.0%	100.0%
Gothenburg Protocol, emission ceiling			26.00					

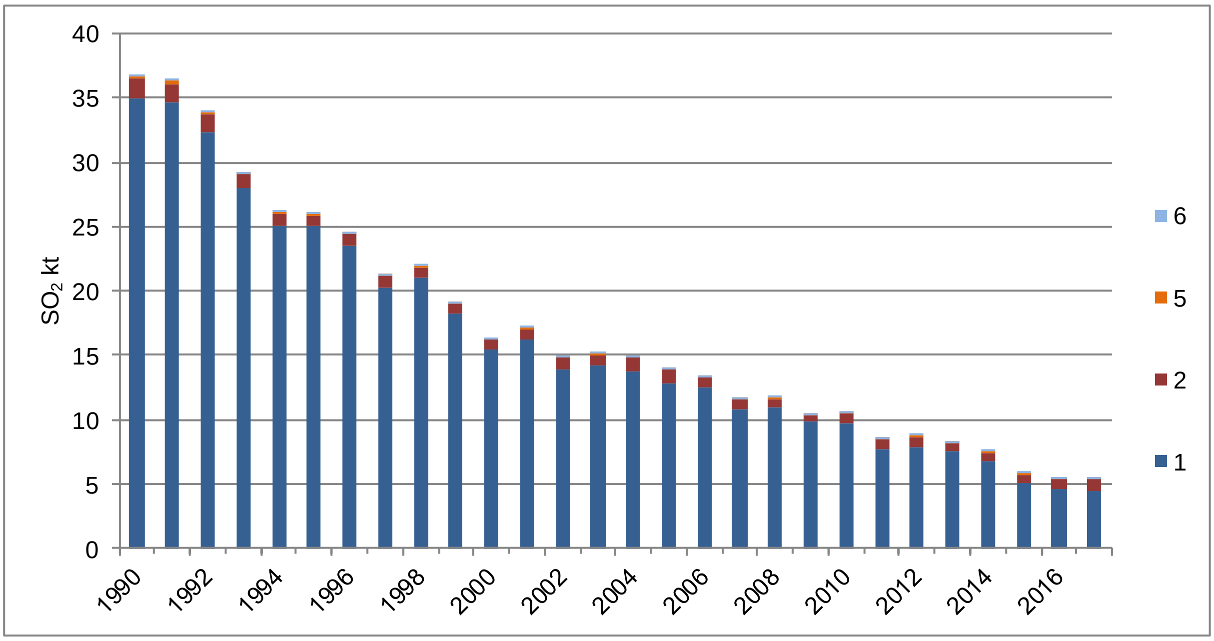


Figure 2-8: Trend of SO_2 emissions (kt) in Switzerland by sectors 1-6 (SO_x as SO_2).

2.3.4 Trends for NH_3

Switzerland's emissions of NH_3 mainly stem from sector 3 Agriculture. The trend of NH_3 emissions per sector is given in Table 2-9 and Figure 2-9. NH_3 emissions show a decreasing trend between 1990 and 2017.

The emission reduction (with fluctuations) can be mainly attributed to source category 3D Agricultural soils (especially 3Da2a Animal manure applied to soils). 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 fertiliser. The decrease continued until 2003, followed by a slight 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 (Kupper et al. 2015).

Table 2-9: NH_3 emissions, trends and share per sector as well as the emission ceiling for 2010 from the Gothenburg Protocol (national total for compliance; fuels used).

NH_3 emissions	**1990**	**2005**	**2010**	**2017**	**1990-2010**	**2005-2017**	**2005-2017**	**share in 2017**
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	1.65	3.80	2.75	1.77	1.10	-2.04	-53.6%	3.2%
1A Fuel combustion	1.65	3.80	2.75	1.77	1.10	-2.04	-53.6%	3.2%
1A1 Energy industries	0.00	0.03	0.04	0.04	0.03	0.02	68.7%	0.1%
1A2 Manufacturing industries	0.16	0.19	0.25	0.24	0.09	0.06	30.9%	0.4%
1A3 Transport	1.35	3.47	2.34	1.35	0.99	-2.12	-61.1%	2.5%
1A4 Other sectors	0.14	0.12	0.13	0.13	-0.01	0.01	5.7%	0.2%
1A5 Other (Military)	0.00	0.00	0.00	0.00	0.00	0.00	4.6%	0.0%
1B Fugitive emissions from fuels	NA	NA	NA	NA	–	–	–	–
2 IPPU	0.37	0.35	0.21	0.18	-0.16	-0.17	-49.1%	0.3%
3 Agriculture	63.08	51.71	52.70	51.21	-10.38	-0.50	-1.0%	93.0%
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.91	0.93	0.88	0.90	-0.03	-0.02	-2.7%	1.6%
6 Other	0.98	0.87	0.91	1.01	-0.07	0.13	15.3%	1.8%
National total for compliance	66.99	57.67	57.45	55.06	-9.54	-2.60	-4.5%	100.0%
Gothenburg Protocol, emission ceiling			63.00					

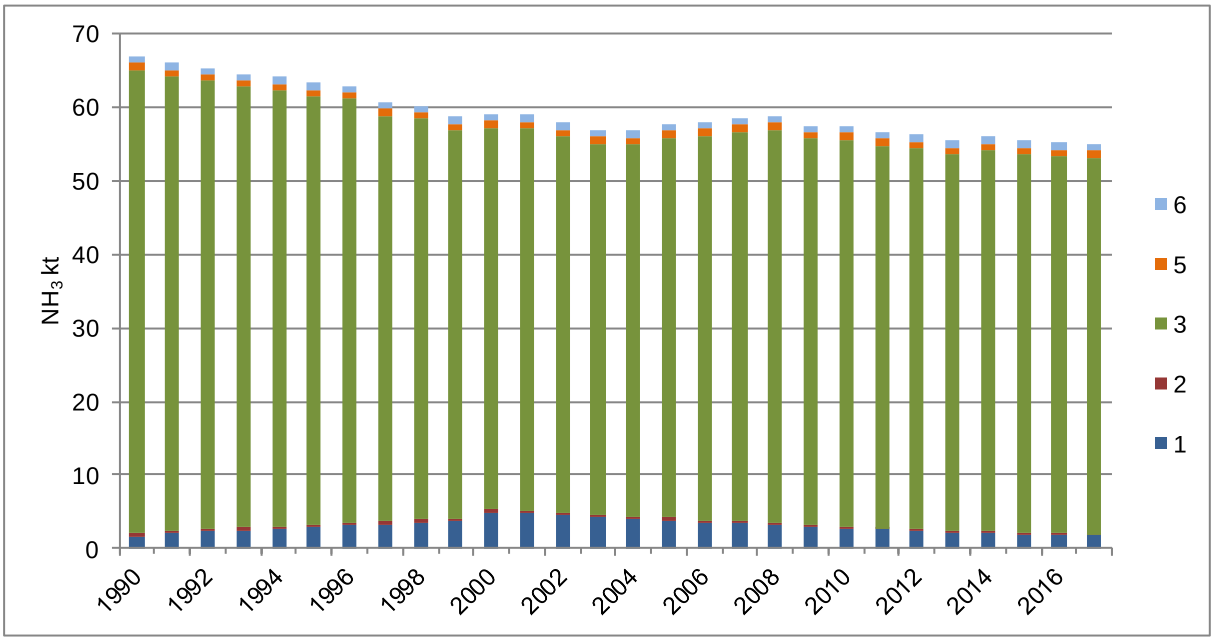


Figure 2-9: Trend of NH_3 emissions (kt) in Switzerland by sectors 1-6.

2.4 Trends of particulate matter per pollutant

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

Switzerland's emissions of particulate matter (PM2.5, PM10, TSP and BC) mainly stem from sector 1 Energy. 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. All particulate matter emissions – except from sector 3 Agriculture – show decreasing trends from 1990 on.

The observed reduction of emissions in PM2.5, PM10, TSP and BC were achieved in sectors 1 Energy and 2 IPPU and can mainly be attributed to the following effects:

- A reduction of exhaust emissions under 1A4 Other sectors was due to technological improvements of wood combustion installations and a reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves). In addition, the wood energy consumption decreased by half and increased by about a factor of six in manually operated furnaces and automatic combustion installations (mainly in 1A1, 1A2), respectively. Furthermore, the revision of the Ordinance of Air Pollution (Swiss Confederation 1985) in 2007 with more stringent emission limits (2007, 2008 and 2012) for mainly automatic wood combustion installations.
- A further reduction of exhaust emissions under 1A3 Transport was 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.
- Particulate matter 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 contributed the most to the particulate matter emissions. The emission reductions up to 1999 occurred in category 2C1 Iron and steel production in to steps. In 1995, two steel production sites were closed down in Switzerland, whereas the drastic drop in emission in 1998/1999 was due to the installation of new filters in the remaining two steel plants. Afterwards, IPPU emissions (e.g. from cement production, gravel plants and use of fireworks and tobacco) became a minor source of total particulate matter emissions.
- Under category 1A2 Manufacturing industries and construction, a reduction of exhaust emissions resulted from technological improvements (i.e. installation of particle filters) and from a fuel switch (i.e. from coal, residual fuel oil and gas oil to natural gas).

2.4.2 Trends for PM2.5

Switzerland's emissions of PM2.5 per sector are given in Table 2-10. In addition to the main trends mentioned in chp. 2.4.1, there is an underlying increasing trend of non-exhaust particulate emissions mainly driven by non-exhaust emissions from passenger cars (1A3bi) and non-road vehicles and machines in manufacturing industry and construction (1A2gvii). This increase is most distinctive for TSP, less for PM10 and even less for PM2.5 (see chp. 2.4.4).

Table 2-10: PM2.5 emissions, trends and share per sector (national total for compliance; fuels used).

PM2.5 emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	11.84	7.44	6.18	4.73	-5.66	-2.71	-36.4%	72.0%
1A Fuel combustion	11.84	7.44	6.18	4.73	-5.66	-2.71	-36.4%	72.0%
1A1 Energy industries	0.80	0.14	0.16	0.10	-0.64	-0.04	-29.6%	1.5%
1A2 Manufacturing industries	1.91	1.42	1.03	0.79	-0.89	-0.62	-44.0%	12.1%
1A3 Transport	2.74	2.12	1.63	1.17	-1.11	-0.95	-44.8%	17.8%
1A4 Other sectors	6.30	3.71	3.32	2.62	-2.98	-1.09	-29.3%	39.9%
1A5 Other (Military)	0.09	0.06	0.05	0.05	-0.04	-0.01	-19.3%	0.7%
1B Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	-18.5%	0.0%
2 IPPU	2.59	1.49	1.51	1.38	-1.08	-0.11	-7.1%	21.1%
3 Agriculture	0.12	0.13	0.13	0.14	0.01	0.01	7.9%	2.1%
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.60	0.38	0.36	0.31	-0.24	-0.06	-16.7%	4.8%
6 Other	0.01	0.00	0.00	0.01	0.00	0.00	35.0%	0.1%
National total for compliance	15.16	9.44	8.19	6.57	-6.97	-2.87	-30.4%	100.0%

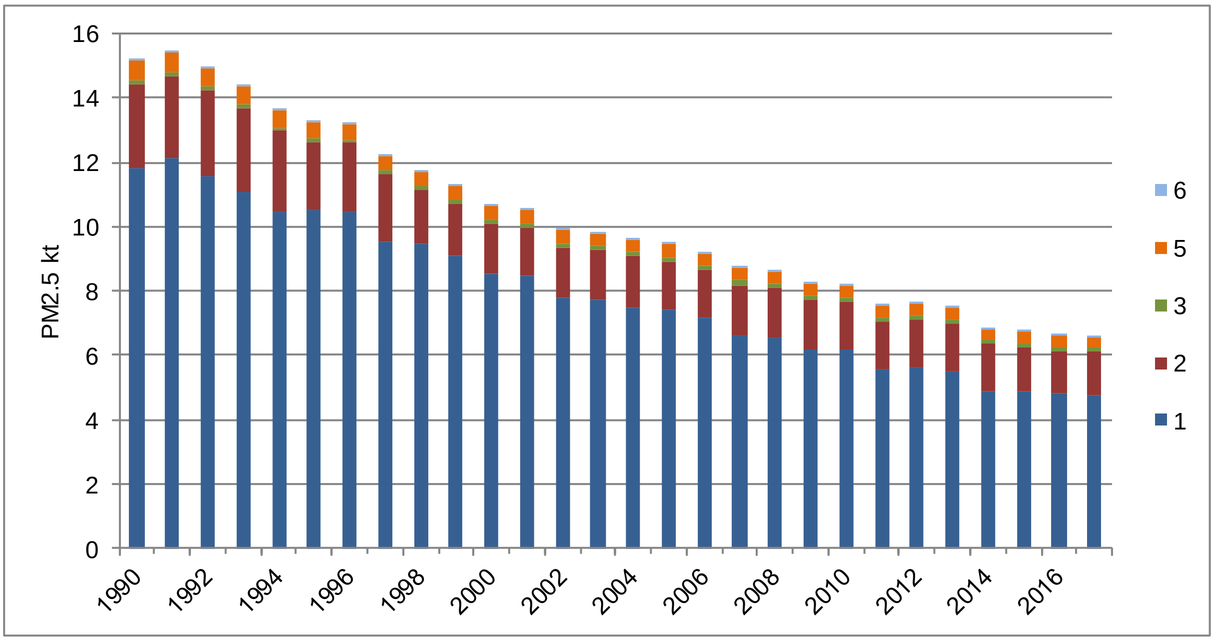


Figure 2-10: Trend of PM2.5 emissions (kt) in Switzerland by sectors 1-6.

2.4.3 Trends for PM10

Switzerland’s emissions of PM10 per sector are given in Table 2-11. In addition to the main trends mentioned in chp. 2.4.1, there is an underlying increasing trend of non-exhaust particulate emissions (most distinctive for TSP, less for PM10 and even less for PM2.5; see chp. 2.4.4).

Table 2-11: PM10 emissions, trends and share per sector (national total for compliance; fuels used).

PM10 emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	16.91	12.59	11.60	10.40	-5.31	-2.19	-17.4%	69.5%
1A Fuel combustion	16.91	12.59	11.60	10.40	-5.31	-2.19	-17.4%	69.5%
1A1 Energy industries	1.06	0.14	0.16	0.10	-0.90	-0.04	-29.3%	0.7%
1A2 Manufacturing industries	3.79	3.28	2.93	2.76	-0.86	-0.52	-15.8%	18.4%
1A3 Transport	5.28	5.06	4.79	4.54	-0.49	-0.52	-10.2%	30.3%
1A4 Other sectors	6.49	3.85	3.45	2.74	-3.04	-1.11	-28.8%	18.3%
1A5 Other (Military)	0.29	0.27	0.27	0.26	-0.02	0.00	-1.0%	1.8%
1B Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	-18.5%	0.0%
2 IPPU	4.59	2.37	2.47	2.34	-2.12	-0.04	-1.5%	15.6%
3 Agriculture	1.62	1.63	1.64	1.69	0.02	0.06	3.6%	11.3%
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.69	0.42	0.40	0.35	-0.29	-0.07	-16.6%	2.4%
6 Other	0.21	0.20	0.18	0.18	-0.03	-0.01	-7.5%	1.2%
National total for compliance	24.02	17.21	16.29	14.96	-7.73	-2.25	-13.1%	100.0%

2.4.4 Trends for TSP

Switzerland’s emissions of TSP per sector are given in Table 2-12. In addition to the main (mostly) decreasing trends mentioned in chp. 2.4.1, there is an underlying increasing trend in TSP due to non-exhaust particulate emissions from growing activity data (annual mileage and machine hours) of mobile sources 1A3 and 1A2gvii which affects TSP emissions more than PM10 and even more than PM2.5. This is due to a larger share of non-exhaust emissions with a particle diameter of more than 10 micrometers. Therefore, the overall decreasing trend in TSP emissions is less and considerably less pronounced as compared to the decrease in PM10 and PM2.5 emissions, respectively. An important source for (non-exhaust) TSP emissions is 3Dc Farm-level agricultural operations. These emissions remained on a rather constant level since 1990 and account for a high share of TSP emissions in 2017.

Table 2-12: TSP emissions, trends and share per sector (national total for compliance; fuels used).

TSP emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	19.04	14.39	13.46	12.26	-5.58	-2.13	-14.8%	42.3%
1A Fuel combustion	19.04	14.39	13.46	12.26	-5.58	-2.13	-14.8%	42.3%
1A1 Energy industries	1.08	0.16	0.18	0.11	-0.91	-0.05	-31.1%	0.4%
1A2 Manufacturing industries	5.11	4.35	4.04	3.91	-1.07	-0.43	-10.0%	13.5%
1A3 Transport	5.59	5.44	5.20	4.95	-0.39	-0.48	-8.9%	17.1%
1A4 Other sectors	6.85	4.06	3.64	2.89	-3.21	-1.17	-28.8%	10.0%
1A5 Other (Military)	0.40	0.39	0.40	0.39	-0.01	0.00	0.7%	1.3%
1B Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	-18.5%	0.0%
2 IPPU	10.38	3.62	3.78	3.66	-6.60	0.04	1.1%	12.6%
3 Agriculture	12.69	12.41	12.37	12.41	-0.31	0.00	0.0%	42.8%
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.84	0.51	0.49	0.43	-0.35	-0.08	-16.5%	1.5%
6 Other	0.26	0.25	0.23	0.23	-0.03	-0.01	-5.8%	0.8%
National total for compliance	43.20	31.18	30.34	28.99	-12.87	-2.19	-7.0%	100.0%

2.4.5 Trends for BC

Switzerland’s emissions of BC mainly stem from sector 1 Energy. The trend of BC emissions per sector is given in Table 2-13. BC emissions have decreased throughout the time period 1990-2017.

Table 2-13: BC emissions, trends and share per sector (national total for compliance; fuels used).

BC emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	5.06	3.02	2.19	1.39	-2.86	-1.63	-54.0%	98.3%
1A Fuel combustion	5.06	3.02	2.19	1.39	-2.86	-1.63	-54.0%	98.3%
1A1 Energy industries	0.03	0.01	0.01	0.00	-0.03	0.00	-39.3%	0.3%
1A2 Manufacturing industries	0.38	0.29	0.13	0.07	-0.25	-0.22	-76.9%	4.7%
1A3 Transport	1.11	1.05	0.74	0.40	-0.37	-0.65	-61.7%	28.5%
1A4 Other sectors	3.51	1.66	1.31	0.91	-2.19	-0.75	-45.2%	64.5%
1A5 Other (Military)	0.03	0.01	0.01	0.00	-0.02	-0.01	-64.5%	0.2%
1B Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00	0.00	-18.5%	0.0%
2 IPPU	0.01	0.00	0.00	0.00	0.00	0.00	-47.5%	0.1%
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	-16.9%	1.6%
6 Other	0.00	0.00	0.00	0.00	0.00	0.00	-8.2%	0.0%
National total for compliance	5.11	3.05	2.22	1.41	-2.89	-1.64	-53.7%	100.0%

2.5 Trends of other gases

2.5.1 Trends for CO

Switzerland’s emissions of CO mainly stem from sector 1 Energy. The trend of CO emissions per sector is given in Table 2-14. The CO emissions have decreased in the time span 1990-2017.

The relevant reductions were achieved in sector 1 Energy:

- Reductions of CO emissions in road transportation (1A3b) through the abatement of exhaust emissions from road vehicles (similar as for NMVOC emissions, see chp. 2.3.2).
- A reduction of CO emissions under 1A4 Other sectors due to technological improvements of wood combustion installations, a reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves) and a decrease in wood energy consumption in manually operated furnaces by half.

Table 2-14: CO emissions, trends and share per sector (national total for compliance; fuels used).

CO emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	kt	kt	kt	kt	kt	kt	%	%
1 Energy	692.08	279.59	209.73	147.29	-482.36	-132.30	-47.3%	97.3%
1A Fuel combustion	692.05	279.55	209.71	147.29	-482.34	-132.26	-47.3%	97.3%
1A1 Energy industries	1.53	1.18	1.44	0.97	-0.09	-0.21	-18.2%	0.6%
1A2 Manufacturing industries	28.05	20.65	18.57	14.72	-9.49	-5.93	-28.7%	9.7%
1A3 Transport	493.91	156.29	107.59	70.71	-386.32	-85.57	-54.8%	46.7%
1A4 Other sectors	167.35	100.51	81.24	60.10	-86.11	-40.41	-40.2%	39.7%
1A5 Other (Military)	1.21	0.92	0.87	0.79	-0.34	-0.13	-14.1%	0.5%
1B Fugitive emissions from fuels	0.03	0.04	0.02	0.00	-0.01	-0.04	-99.3%	0.0%
2 IPPU	7.08	3.92	2.56	1.90	-4.51	-2.02	-51.5%	1.3%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	2.85	1.92	1.75	1.55	-1.10	-0.37	-19.1%	1.0%
6 Other	0.80	0.76	0.69	0.69	-0.11	-0.07	-9.1%	0.5%
National total for compliance	702.8	286.19	214.72	151.43	-488.09	-134.76	-47.1%	100.0%

2.6 Trends of priority heavy metals per pollutant

2.6.1 Lead (Pb)

Switzerland’s emissions of Pb mainly stem from the sectors 1 Energy and 6 Other (from 2000 onwards). The trend of Pb emissions per sector is given in Table 2-15. Pb emissions have strongly declined between 1990 and 2000 and from then on continued a slightly decreasing trend.

The most relevant reductions were achieved in sectors 1 Energy and 2 IPPU:

- A pronounced decrease of Pb emissions in the energy sector (in particular 1A3) was achieved due to a stepwise reduction of lead content in gasoline, and finally due to the introduction of unleaded gasoline in the OAPC revision of the year 2000 (see Figure 2-1).
- Further measures that resulted in a significant decrease of the emissions under 2C1 Iron and steel production were the closing down of two production sites and the installation of new filters in the electric arc furnaces of the remaining secondary steel production plants in 1995 and 1998/1999, respectively.
- Furthermore, a significant reduction was achieved under category 1A1 Energy industries in the period 1990–2003 by equipping municipal solid waste incineration plants with flue gas treatment or improving the technology installed already.

Since 2003, the emissions further decrease on a lower level. The main reductions in this time period were achieved in the sectors 2 IPPU (i.e. ban of Pb in fireworks (2G) in 2003) and 1 Energy, specifically source category 1A2f Non-metallic minerals (dominated by the emission reduction in container glass production due to reduced lead contamination of the glass cullet and installation of electrofilters in 2011) as well as 1A3 Transport due to a higher share of diesel oil in comparison to gasoline since gasoline has a much higher emission factor than diesel oil.

Table 2-15: Pb emissions, trends and share per sector (national total for compliance; fuels used).

Pb emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	t	t	t	t	t	t	%	%
1 Energy	285.17	8.70	7.29	5.97	-277.88	-2.73	-31.4%	40.4%
1A Fuel combustion	281.64	8.70	7.29	5.97	-274.35	-2.73	-31.4%	40.4%
1A1 Energy industries	29.53	1.68	1.57	1.45	-27.96	-0.24	-14.1%	9.8%
1A2 Manufacturing industries	5.44	1.96	1.25	0.75	-4.19	-1.21	-61.8%	5.1%
1A3 Transport	243.33	4.28	3.61	2.96	-239.73	-1.31	-30.7%	20.1%
1A4 Other sectors	3.30	0.78	0.86	0.81	-2.44	0.03	4.2%	5.5%
1A5 Other (Military)	0.03	0.00	0.00	0.00	-0.03	0.00	-12.3%	0.0%
1B Fugitive emissions from fuels	3.54	NO	NO	NO	–	–	–	–
2 IPPU	67.14	2.10	0.69	0.69	-66.45	-1.40	-67.0%	4.7%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	4.70	2.28	2.21	1.97	-2.50	-0.31	-13.5%	13.3%
6 Other	6.78	6.60	6.02	6.14	-0.76	-0.46	-6.9%	41.6%
National total for compliance	363.80	19.67	16.21	14.78	-347.60	-4.90	-24.9%	100.0%

2.6.2 Cadmium (Cd)

Switzerland’s emissions of Cd mainly stem from sector 1 Energy. The trend of Cd emissions per sector is given in Table 2-16. Cd emissions showed a decreasing trend between 1990 and 2003, but started to increase again from 2003 on.

The decrease 1990-2003 was mainly achieved with the following measures within the sectors 1 Energy and 2 IPPU:

- By equipping municipal solid waste incineration plants with flue gas treatment or improving the already installed technologies, a significant reduction has been achieved in the period 1990–2003 under category 1A1a.
- A significant reduction occurred also in source category 1A2 Manufacturing industries dominated by an emission decrease in the production of mixed goods (1A2f). (Please note that the data basis, i.e. Cd emission measurements are extremely limited and thus these emissions are associated with a high uncertainty.)
- Further measures, resulting in a significant decrease of emissions under 2C1 Iron and steel production, were the closing down of two production sites and the installation of new filters in the electric arc furnaces of the remaining secondary steel production plants in 1995 and 1998/1999, respectively.

The increase since 2003 can be attributed to an increase of total wood energy combustion (mainly 1A4) as well as in emissions from special hazardous waste incineration plants.

Table 2-16: Cd emissions, trends and share per sector (national total for compliance; fuels used).

Cd emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	t	t	t	t	t	t	%	%
1 Energy	2.92	0.76	0.87	0.91	-2.05	0.15	19.8%	77.9%
1A Fuel combustion	2.92	0.76	0.87	0.91	-2.05	0.15	19.8%	77.9%
1A1 Energy industries	1.75	0.18	0.23	0.25	-1.52	0.06	33.3%	21.1%
1A2 Manufacturing industries	0.75	0.16	0.18	0.19	-0.57	0.03	17.8%	16.3%
1A3 Transport	0.07	0.08	0.08	0.09	0.01	0.01	15.5%	7.6%
1A4 Other sectors	0.34	0.33	0.38	0.38	0.03	0.05	14.3%	32.9%
1A5 Other (Military)	NA	NA	NA	NA	–	–	–	–
1B Fugitive emissions from fuels	NA	NA	NA	NA	–	–	–	–
2 IPPU	0.56	0.09	0.09	0.08	-0.47	-0.01	-9.2%	7.2%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.05	0.01	0.01	0.02	-0.03	0.00	28.1%	1.6%
6 Other	0.17	0.16	0.15	0.15	-0.02	-0.01	-6.9%	13.2%
National total for compliance	3.69	1.03	1.12	1.16	-2.57	0.13	13.0%	100.0%

2.6.3 Mercury (Hg)

Switzerland’s emissions of Hg mainly stem from sector 1 Energy. The trend of Hg emissions per sector is shown in Table 2-17. Hg emissions showed a decreasing trend between 1990 and 2003, and from then on continued a slightly decreasing trend.

The decrease 1990-2003 was mainly achieved with the following measures within the sectors 1 Energy and 2 IPPU:

- A significant reduction under category 1A1 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.
- The closing down of two production sites and the installation of new filters in the two remaining secondary steel production plants in 1998/1999 were the leading measures in reducing emissions under 2C1.

Since 2003, the decreasing trend continued on a lower level, still dominated by emissions from municipal solid waste incineration (1A1) and manufacturing industries of non-metallic minerals (1A2f, e.g. cement production).

Table 2-17: Hg emissions, trends and share per sector (national total for compliance; fuels used).

Hg emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	t	t	t	t	t	t	%	%
1 Energy	4.25	0.54	0.56	0.51	-3.69	-0.03	-5.1%	77.6%
1A Fuel combustion	4.25	0.54	0.56	0.51	-3.69	-0.03	-5.1%	77.6%
1A1 Energy industries	3.92	0.34	0.32	0.29	-3.60	-0.05	-15.1%	43.8%
1A2 Manufacturing industries	0.25	0.11	0.16	0.15	-0.09	0.04	32.9%	22.5%
1A3 Transport	0.04	0.04	0.04	0.03	0.00	0.00	-7.1%	5.2%
1A4 Other sectors	0.05	0.05	0.05	0.04	0.00	-0.01	-20.0%	6.1%
1A5 Other (Military)	NA	NA	NA	NA	–	–	–	–
1B Fugitive emissions from fuels	NA	NA	NA	NA	–	–	–	–
2 IPPU	1.50	0.07	0.07	0.05	-1.44	-0.01	-19.8%	8.1%
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	-63.0%	3.9%
6 Other	0.08	0.08	0.07	0.07	-0.01	-0.01	-9.2%	10.4%
National total for compliance	6.61	0.76	0.76	0.66	-5.85	-0.09	-12.2%	100.0%

2.7 Trends of POPs

2.7.1 PCDD/PCDF

Switzerland’s emissions of PCDD/PCDF mainly stem from sector 1 energy. The trend of PCDD/PCDF emissions per sector is given in Table 2-18. PCDD/PCDF emissions were significantly reduced between 1990 and 2003. From then on, the decrease continues on a lower level.

The significant decrease between 1990 and 2003 was mainly achieved in category 1A1a by retrofitting municipal solid waste incineration plants with flue gas treatment or improving the technology installed already. Further reductions between 1990 and 2003 were achieved in source categories 5C1 Waste incineration (i.e. a continuous reduction of clinical waste incinerated at the hospital sites themselves which ceased in 2002 completely) and 2C1 Iron and steel production (i.e. closing down of two production sites and installation of new filters in the electric arc furnaces of the remaining secondary steel production plants in 1995 and 1998/1999, respectively). In source category 1A4bi Residential: Stationary a continuous emission reduction occurred over the entire time series (technological improvements of wood combustion installations, reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves) and wood energy consumption decreased by half).

Since 2003, the slightly decreasing trend is mainly shaped through reductions in categories 1A1a (mainly due to further technical improvements in municipal solid waste incineration plants) and 1A4b.

Table 2-18: PCDD/PCDF emissions, trends and share per sector (national total for compliance; fuels used).

PCDD/PCDF emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	g I-Teq	g I-Teq	g I-Teq	g I-Teq	g I-Teq	g I-Teq	%	%
1 Energy	163.19	23.44	19.71	13.56	-143.48	-9.89	-42.2%	66.1%
1A Fuel combustion	163.19	23.44	19.71	13.56	-143.48	-9.89	-42.2%	66.1%
1A1 Energy industries	130.35	5.16	3.56	2.00	-126.79	-3.16	-61.3%	9.7%
1A2 Manufacturing industries	7.92	2.23	1.79	0.96	-6.13	-1.27	-56.8%	4.7%
1A3 Transport	2.16	0.24	0.22	0.22	-1.94	-0.02	-9.3%	1.1%
1A4 Other sectors	22.75	15.81	14.14	10.38	-8.62	-5.43	-34.4%	50.6%
1A5 Other (Military)	NA	NA	NA	NA	–	–	–	–
1B Fugitive emissions from fuels	NA	NA	NA	NA	–	–	–	–
2 IPPU	16.98	2.11	1.23	0.78	-15.75	-1.34	-63.2%	3.8%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	20.08	4.53	4.38	3.89	-15.69	-0.64	-14.2%	18.9%
6 Other	2.54	2.47	2.26	2.30	-0.29	-0.17	-6.9%	11.2%
National total for compliance	202.79	32.56	27.58	20.52	-175.21	-12.03	-37.0%	100.0%

2.7.2 Polycyclic aromatic hydrocarbons (PAHs)

Switzerland's emissions of PAH mainly stem from sector 1 Energy. The trend of PAH emissions per sector is given in Table 2-19. PAH emissions have been reduced continuously between 1990 and 2017.

The PAH emissions are dominated by wood energy combustion and their reduction has mainly been achieved in the dominant source category 1A4, mainly through technological improvements of wood furnaces and a reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves). In addition, the wood energy consumption decreased by half and increased by about a factor of six in manually operated furnaces and automatic combustion installations (1A1 and 1A2, respectively). The superimposed fluctuations in the emission trend reflect the climate variabilities (i.e. warm or cold winters).

Table 2-19: PAH emissions, trends and share per sector (national total for compliance; fuels used).

PAHs emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	t	t	t	t	t	t	%	%
1 Energy	10.65	6.54	5.03	2.43	-5.62	-4.11	-62.9%	88.4%
1A Fuel combustion	10.65	6.54	5.03	2.43	-5.62	-4.11	-62.9%	88.4%
1A1 Energy industries	0.10	0.11	0.18	0.01	0.07	-0.09	-86.4%	0.5%
1A2 Manufacturing industries	1.10	0.89	0.62	0.11	-0.49	-0.78	-88.0%	3.9%
1A3 Transport	0.18	0.16	0.20	0.26	0.02	0.10	62.8%	9.6%
1A4 Other sectors	9.27	5.38	4.04	2.04	-5.23	-3.34	-62.0%	74.4%
1A5 Other (Military)	0.00	0.00	0.00	0.00	0.00	0.00	-2.8%	0.0%
1B Fugitive emissions from fuels	NA	NA	NA	NA	–	–	–	–
2 IPPU	0.95	0.50	0.01	0.01	-0.94	-0.48	-97.5%	0.5%
3 Agriculture	NA	NA	NA	NA	–	–	–	–
4 LULUCF	NR	NR	NR	NR	–	–	–	–
5 Waste	0.371	0.25	0.21	0.19	-0.16	-0.05	-22.0%	7.1%
6 Other	0.07	0.09	0.10	0.11	0.03	0.02	18.1%	4.0%
National total for compliance	12.05	7.38	5.35	2.75	-6.70	-4.63	-62.8%	100.0%

2.7.3 HCB

Switzerland's emissions of HCB exclusively stem from sector 1 Energy. The trend of HCB emissions per sector is shown in Table 2-20. HCB emissions have significantly dropped in 1993 and then started to slightly increase on a very low level.

The decrease of HCB emissions in 1993 occurred in category 1A2b Non-ferrous metals due to the shutdown of the secondary aluminium production plant. Since then, the trend of HCB emissions is slightly increasing, mainly due to the development in fuel use. For instance, the amount of municipal solid waste incinerated has increased (1A1a). In contrast, HCB emissions are decreasing in category 1A4 due to changes in wood energy combustion (i.e. technological improvements of wood combustion installations, reduction in the number of emission intensive types of wood furnaces and decrease in wood energy consumption in manually operated furnaces by half).

Table 2-20: HCB emissions, trends and share per sector (national total for compliance; fuels used).

HCB emissions	1990	2005	2010	2017	1990-2010	2005-2017	2005-2017	share in 2017
	kg	kg	kg	kg	kg	kg	%	%
1 Energy	172.33	0.35	0.38	0.35	-171.95	0.00	-0.4%	100.0%
1A Fuel combustion	172.33	0.35	0.38	0.35	-171.95	0.00	-0.4%	100.0%
1A1 Energy industries	0.11	0.15	0.17	0.19	0.06	0.03	21.8%	53.4%
1A2 Manufacturing industries	172.04	0.04	0.04	0.03	-172.00	-0.01	-18.8%	9.5%
1A3 Transport	NA	NA	NA	NA	–	–	–	–
1A4 Other sectors	0.17	0.16	0.16	0.13	-0.01	-0.03	-17.4%	37.1%
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 for compliance	172.33	0.35	0.38	0.35	-171.95	0.00	-0.4%	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. All emissions 2017 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.

Pollutants	National emission ceilings for 2010 kt	Emissions 2010 (Subm. 2019) kt	Emissions 2017 (Subm. 2019) kt	Compliance with emission ceilings 2010 in 2017
SO_x	26.0	10.5	5.4	yes
NO_x	79.0	75.4	62.8	yes
NMVOC	144.0	91.0	77.9	yes
NH_3	63.0	57.4	55.1	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 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 2017.

Table 2-22: Reported emissions levels for 2017 compared to reduction commitments 2020. The Emission commitments 2020 are defined as reductions in percentages from 2005.

Pollutant	Emission reduction commitments 2020	Reduction achieved in 2017
	%-reduction of 2005 level	
SO_x	21%	61%
NO_x	41%	31%
NMVOC	30%	26%
NH_3	8%	5%
PM2.5	26%	30%

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 2017. 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 (1990–2017). 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, emissions from 1B are negligible.

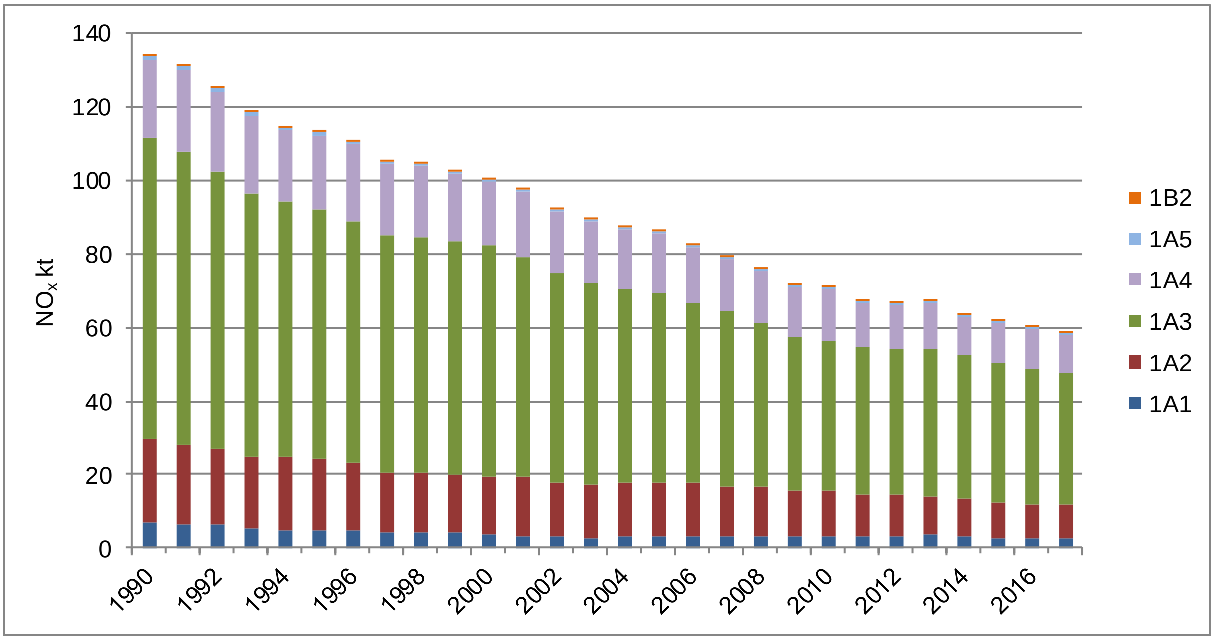


Figure 3-1: Switzerland's NO_x emissions from the energy sector by source categories 1A1-1A5 and 1B2 between 1990 and 2017. The corresponding data table can be found in Annex A7.2.

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 2017. 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 2017. 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.

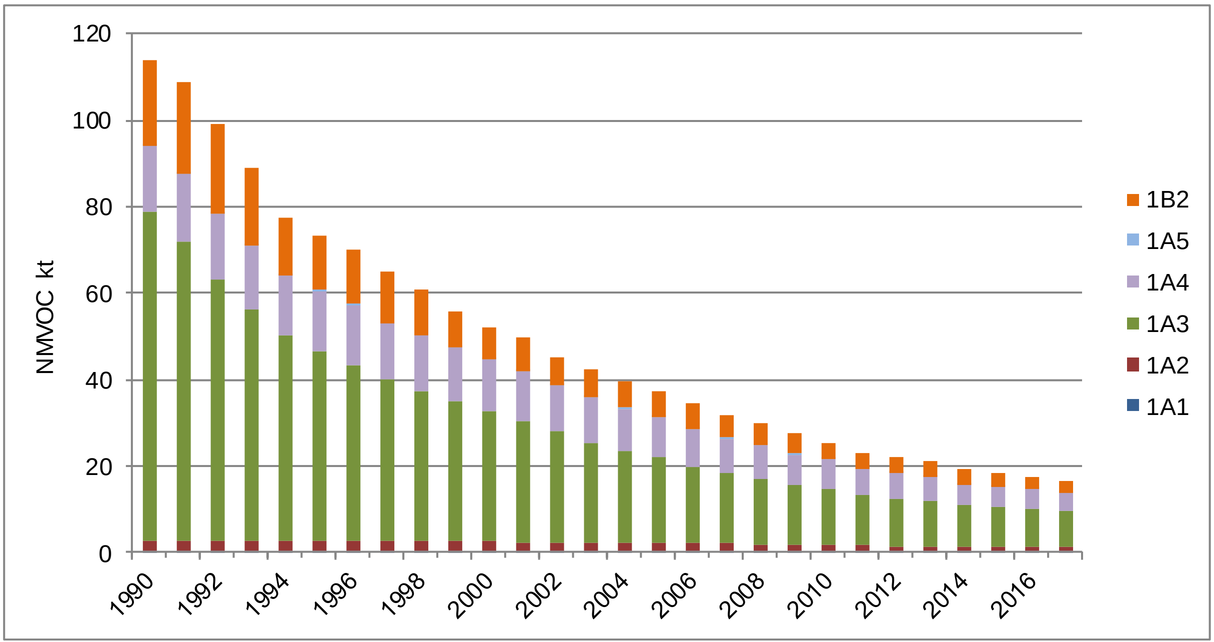


Figure 3-2: Switzerland's NMVOC emissions from the energy sector by source categories 1A1-1A5 and 1B2 between 1990 and 2017. The corresponding data table can be found in Annex A7.2.

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 (1990–2017), 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 2017 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.

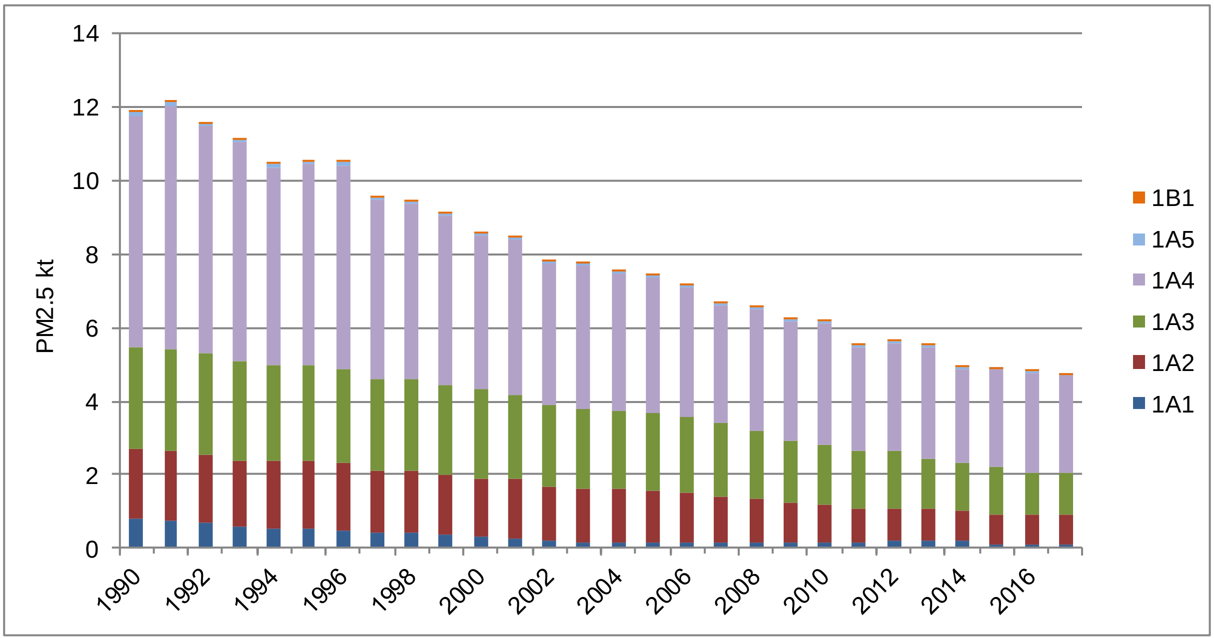


Figure 3-3: Switzerland's PM2.5 emissions from the energy sector by source categories 1A1-1A5 and 1B1 between 1990 and 2017. The corresponding data table can be found in Annex A7.2.

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.

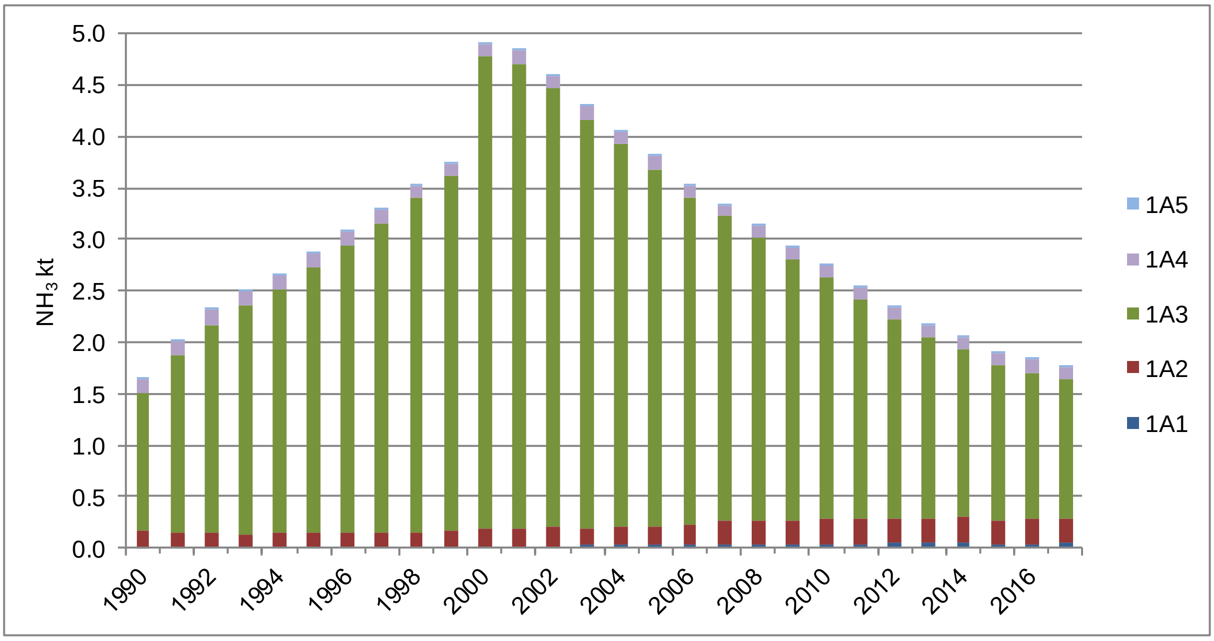


Figure 3-4: Switzerland's NH_3 emissions from the energy sector by source category 1A1-1A5 between 1990 and 2017. There are no emissions from 1B. The detailed corresponding data table can be found in Annex A7.2.

3.1.5 Overview and trend for SO_2

Figure 3-4 depicts the SO_2 emissions in energy related sectors since 1990. In 2017, the main contributions from the sector 1 Energy are SO_2 emissions from the source categories 1A2 Manufacturing industries and construction and 1A4 Other. SO_2 emissions from the other source categories (1A3, 1A5 and 1B2) are comparably small. Overall, there is a decreasing trend since 1990, particularly between 1990 and 2000. The strongest reduction happened in source category 1A4. This reduction mainly bases on two effects: first, decreasing consumption and substitution of liquid and solid fuels by gaseous fuels, and second, the reduction of the sulphur content of gas oil (by about a factor of 6 between 1990 and 2017). 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 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.

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.

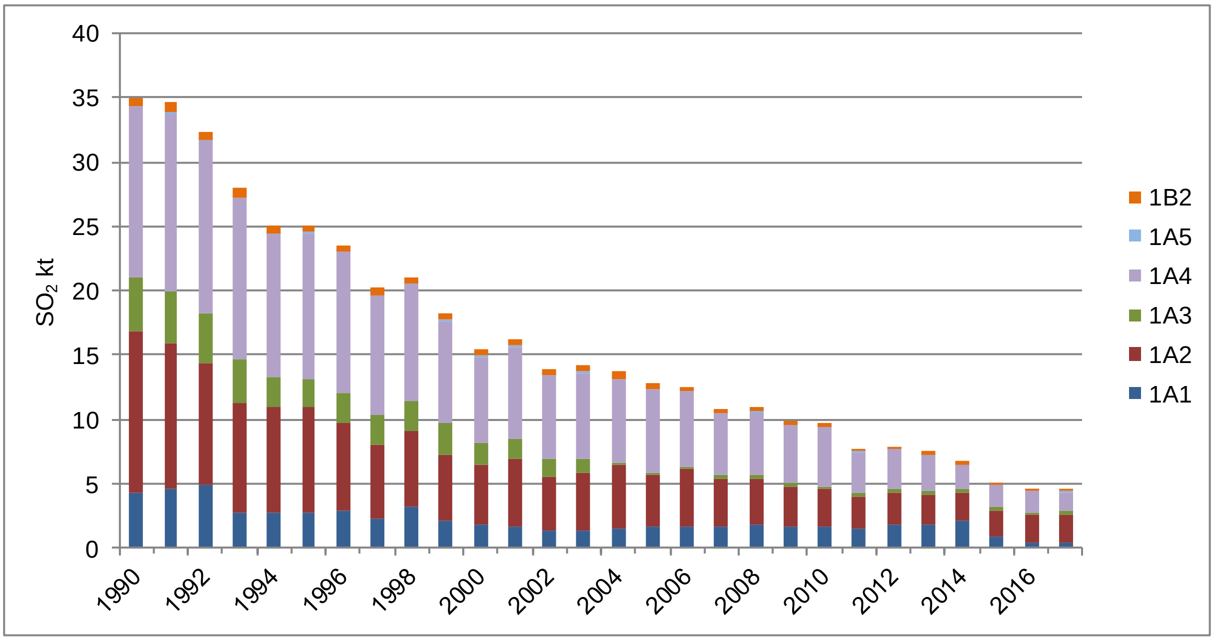


Figure 3-5: Switzerland's SO_2 emissions from the energy sector by source category 1A1-1A5 and 1B2 between 1990 and 2017. The detailed corresponding data table can be found in Annex A7.2.

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. One difference occurs for 1A3b Road transportation as can be seen from Figure 3-6, columns CLRTAP / NFR Template "national total" and UNFCCC/CRF-Tables "national total" compared to CLRTAP / NFR Template "national total for compliance". The CLRTAP / NFR Template 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 1A3a 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 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. 3.2.6.2.2
- 1A3aii(ii) Domestic aviation cruise (civil) Emission modelling see chp. 3.2.6.2.2
- 1A3b Road Transportation (fuel used) Emission modelling see chp. 3.2.6.2.2
- 1A3di(i) International maritime navigation Emission modelling see chp. 3.2.6.2.2
- 11B Forest fires Emission modelling see chp. 7.3
- 11C Other natural emissions Emission modelling see chp. 7.4

1A3ai(ii) includes emissions from 1D1 – International aviation / aviation bunkers.

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). More detailed explanations including information about the origin of the NCVs of the different fuels are given below.

- 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 2018, SFOE 2018b) partly based on measurements from the cement industry (Cemsuisse 2010a, Cemsuisse 2018).
- 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. For the NCVs of natural gas and biogas see Table 3-2.

Fuel	**Data sources**	**NCV [GJ/t]**
Gasoline	EMPA (1999), SFOE/FOEN (2014)	42.5 (1998), 42.6 (2013)
Jet kerosene	EMPA (1999), SFOE/FOEN (2014)	43.0 (1998), 43.2 (2013)
Diesel oil	EMPA (1999), SFOE/FOEN (2014)	42.8 (1998), 43.0 (2013)
Gas oil	EMPA (1999), SFOE/FOEN (2014)	42.6 (1998), 42.9 (2013)
Residual fuel oil	EMPA (1999)	41.2 (1998)
Liquefied petroleum gas	SFOE (2018)	46.0
Petroleum coke	SFOE (2018), Cemsuisse (2010a)	35.0 (1998), 31.8 (2010)
Other bituminous coal	SFOE (2018), Cemsuisse (2010a)	28.052 (1998), 25.5 (2010)
Lignite	SFOE (2018), Cemsuisse (2010a)	20.097 (1998), 23.6 (2010)
Natural gas	SGWA	*see caption*
Biofuel	**Data sources**	
Biodiesel	SFOE (2018)	38.0
Bioethanol	SFOE (2018)	26.5
Biogas	*assumed equal to natural gas*	*see caption*
Wood	SFOE (2018b)	8.6-14.6

Gasoline, jet kerosene, diesel oil and gas oil

The NCVs of gasoline, jet kerosene, diesel oil and gas oil are provided by national measurement campaigns and are the same as used by the Swiss Federal Office of Energy (SFOE 2018). A first campaign was conducted by the Swiss Federal Laboratories for Materials Science and Technology (EMPA) in 1998 (EMPA 1999). Since previous data are not available, the values for 1990–1998 are assumed to be constant at the 1998 levels. A second campaign, commissioned by the Swiss Federal Office of Energy (SFOE) and the Swiss Federal Office for the Environment (FOEN), was conducted in 2013 (SFOE/FOEN 2014). This study was based on representative samples covering summer and winter fuel qualities from the main import streams. The sampling started in July 2013 and lasted six months. Samples were taken fortnightly from nine different sites (large-scale storage facilities and the two Swiss refineries) and analysed for carbon contents and NCVs amongst other. These updated values are used from 2013 onwards, while the NCVs for 1999–2012 are linearly interpolated between the measured values of 1998 and 2013.

Residual fuel oil

Residual fuel oil plays only a minor role in the Swiss energy supply. Therefore, this fuel was not analysed in the most recent measurement campaign in 2013 (SFOE/FOEN 2014). Thus, the respective NCV refers to the measurement campaign in 1998 (EMPA 1999). The NCV for residual fuel oil, which is the same as used by the Swiss Federal Office of Energy (SFOE 2018), is assumed to be constant over the entire reporting period. The same approach is applied for the CO_2 emission factor.

Liquefied petroleum gas

The NCV of liquefied petroleum gas is the same as used by the Swiss Federal Office of Energy (SFOE 2018) and is – as in the Swiss overall energy statistics – constant over the entire reporting period. It is assumed that LPG consists of 50% propane and 50% butane.

Petroleum coke, other bituminous coal, lignite

For the entire reporting period the NCVs of petroleum coke, other bituminous coal and lignite are the same as used by the Swiss Federal Office of Energy (SFOE 2018). For these fuels, the Swiss overall energy statistics contains NCVs for the years 1998 and 2010. In between values are interpolated, before the first and after the last year of available data values are held constant. The NCVs for 2010 are based on measured samples taken from Switzerland's cement plants as they are the largest consumers of these fuels in Switzerland. Samples from the individual plants were taken from January to September 2010 and analysed for NCVs by an independent analytical laboratory (Cemsuisse 2010a). For each fuel, the measurements from the individual plants were weighted according to the relative consumption of each plant.

Natural gas / biogas

The NCV of natural gas (see Table 3-2) and also the CO_2 emission factor of natural gas are calculated based on measurements of gas properties and corresponding import shares of individual gas import stations. Measurements of gas properties are available from the Swiss Gas and Water Industry Association (SGWA) on an annual basis since 2009 and for selected years before. The latest report is SGWA (2018). Import shares are available for 1991, 1995, 2000, 2005, 2007 and from 2009 onwards on an annual basis. Estimated import shares for the years 1991, 1995 and 2000 are taken from Quantis (2014). Values for the years in between are interpolated. The calculation procedure is documented in FOEN (2018k). The NCV of biogas is assumed to be equal to the NVC of natural gas since the raw biogas is treated to become the same quality level including its energetic properties as natural gas.

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 2018k.

Net calorific value of natural gas and biogas	
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
2016	47.1
2017	47.3

Wood

The net calorific value of wood depends on the type of wood fuel (for e.g. log wood, wood chips, pellets) and is based on the Swiss wood energy statistics (SFOE 2018b).

Table 3-1 illustrates the range of the NCV for all wood fuel types.

Bioethanol and biodiesel

The NCVs of bioethanol and biodiesel are the same as used by the Swiss Federal Office of Energy (SFOE 2018) and are – as in the Swiss overall energy statistics – constant over the entire reporting period.

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 2018). 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 2018), 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 2018). 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 (EV 2018).
- Annual import data for natural gas from the Swiss gas industry association.
- 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.
- Swiss wood energy statistics.
- Swiss statistics on combined heat and power generation.

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 4.

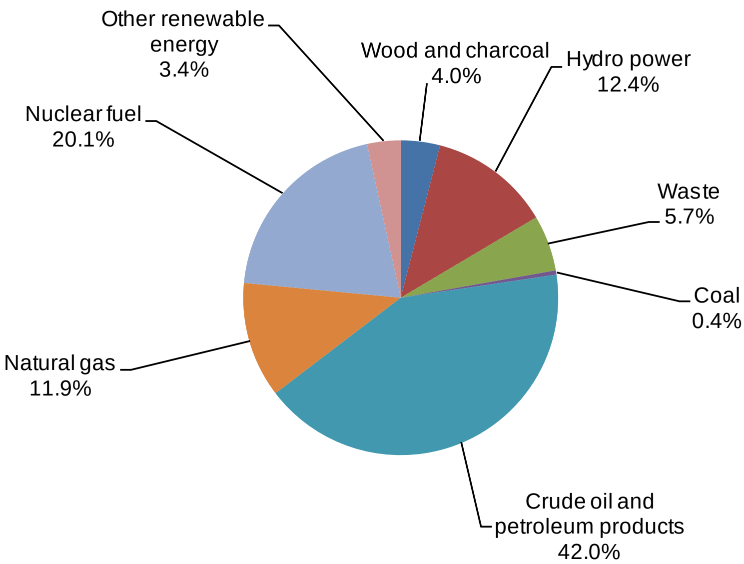


Figure 3-7: Switzerland’s energy consumption in 2017 by fuel type (see corresponding data in SFOE 2018).

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 by fuel type. Only those fuels are shown that are implemented in the EMIS database (no hydro 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	Gasoline	Kerosene	Diesel	Gas oil	Residual fuel oil	Refinery gas & LPG	Petroleum 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	19'161	46'574	652'786
1991	162'225	46'562	48'154	238'602	23'590	12'437	980	12'162	76'902	18'596	48'552	688'762
1992	168'100	49'099	46'706	236'809	24'170	11'492	315	8'758	80'808	19'009	47'449	692'714
1993	155'897	50'776	44'978	225'920	17'165	12'388	1'120	7'442	84'758	19'158	47'713	667'315
1994	156'087	52'109	47'748	207'141	17'860	13'455	1'470	7'632	83'587	19'155	45'649	651'893
1995	151'290	54'947	48'604	217'523	17'278	12'756	1'260	7'962	92'123	19'688	47'615	671'047
1996	155'209	56'753	45'597	226'289	15'097	13'939	1'015	5'456	99'710	20'584	51'132	690'780
1997	161'171	58'774	47'385	212'223	12'581	14'236	280	4'590	96'260	21'655	48'066	677'221
1998	162'477	61'268	49'209	222'407	15'882	15'259	455	3'960	99'065	23'802	49'566	703'350
1999	168'025	65'244	52'184	212'349	11'058	15'805	521	4'105	102'588	24'403	50'279	706'561
2000	168'165	68'060	55'677	196'137	7'923	13'649	551	6'120	101'970	26'536	49'898	694'686
2001	163'543	64'208	56'709	213'089	9'942	14'069	410	6'233	106'132	27'068	53'222	714'626
2002	160'375	59'406	58'721	196'655	6'446	15'584	679	5'565	104'170	27'876	52'732	688'211
2003	159'636	53'438	62'251	208'040	7'061	13'642	202	5'663	110'116	27'642	55'202	702'894
2004	156'812	50'441	66'893	203'370	7'561	16'429	1'819	5'420	113'615	28'845	56'051	707'256
2005	152'062	51'101	73'065	205'729	5'805	16'432	2'906	5'940	116'646	29'236	58'115	717'036
2006	147'436	53'571	79'063	195'926	6'419	18'578	3'324	6'467	113'412	31'233	60'736	716'166
2007	146'012	57'165	84'885	171'313	5'179	15'587	2'730	7'196	110'395	30'015	59'468	689'946
2008	142'801	61'151	93'143	178'833	4'606	16'288	3'616	6'562	117'589	30'854	63'050	718'492
2009	138'968	58'665	94'569	173'219	3'575	16'301	3'254	6'193	112'807	29'811	62'898	700'259
2010	134'043	61'620	98'247	182'305	2'987	15'463	3'498	6'208	126'013	31'185	67'187	728'756
2011	128'856	65'696	100'876	143'760	2'292	14'856	2'957	5'792	111'774	30'882	63'182	670'924
2012	124'301	67'306	106'996	154'448	2'780	12'247	3'148	5'269	122'521	31'145	68'723	698'885
2013	118'634	68'068	111'824	162'532	1'959	15'053	2'735	5'567	129'027	30'925	71'916	718'239
2014	113'875	68'541	114'688	122'704	1'621	14'473	3'148	5'704	111'770	31'320	67'086	654'930
2015	105'591	70'788	113'161	129'349	892	9'822	1'145	5'205	119'420	32'084	70'285	657'742
2016	102'297	74'161	114'392	132'335	378	9'136	890	4'795	125'456	33'583	75'818	673'241
2017	99'155	75'933	114'022	123'736	355	8'770	763	4'609	125'730	33'342	78'823	665'239

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 2018). 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 2018), the Swiss renewable energy statistics (SFOE 2018a), the energy consumption statistics in the industry and services sectors (SFOE 2018d) as well as additional information from the industry and the Swiss wood energy statistics (SFOE 2018b).

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.

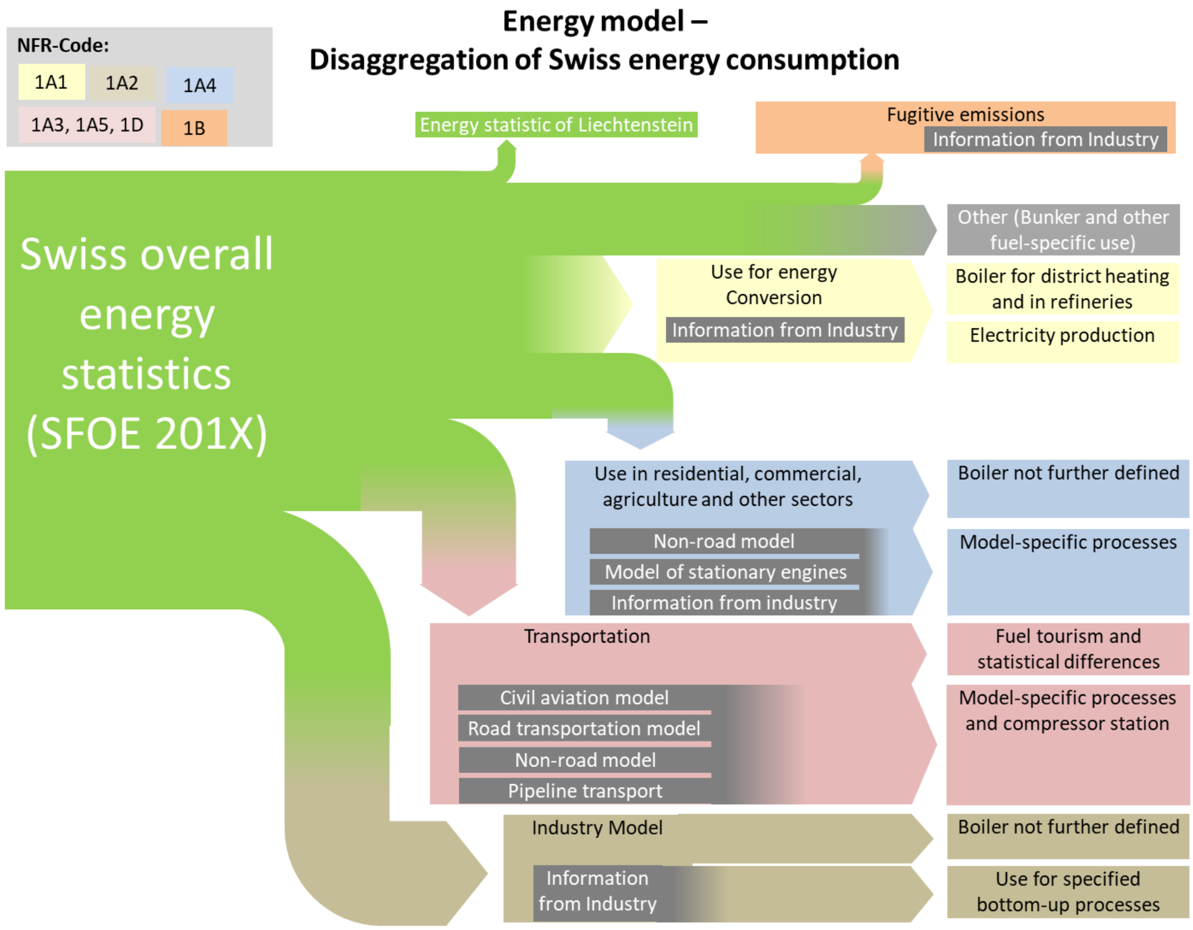


Figure 3-8 Overview of Switzerland's energy model. In the abbreviation SFOE 201X the "X" refers to the latest edition of the Swiss overall energy statistics.

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 2018d), 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 differences.

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 2018b), 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 2018) 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.

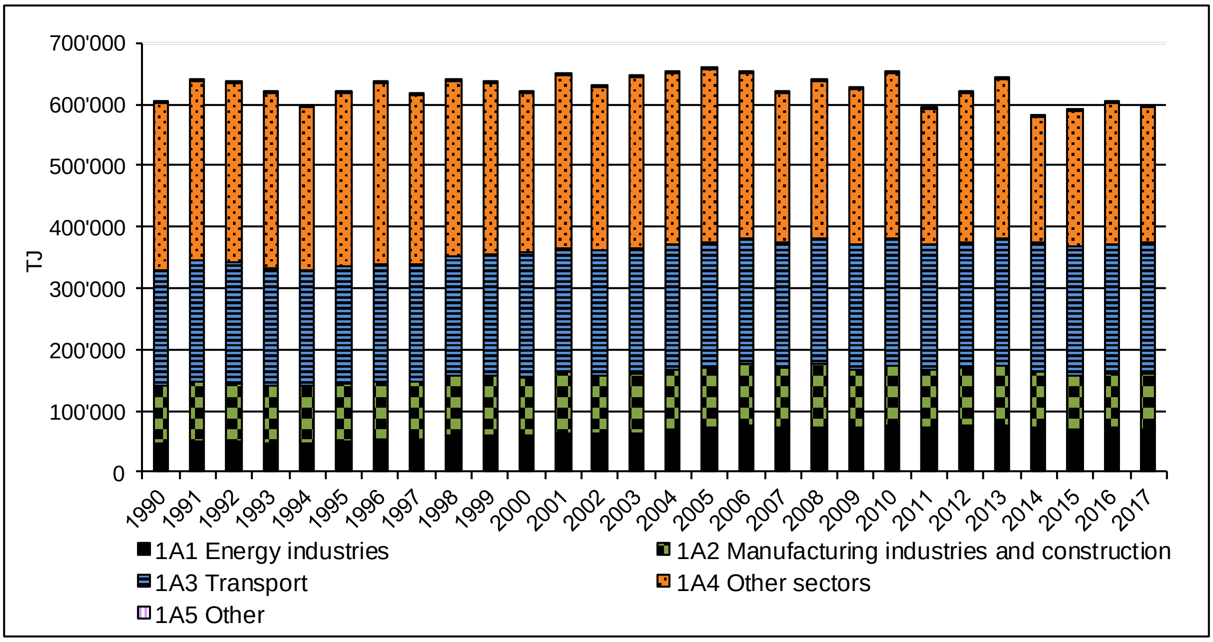


Figure 3-9: Switzerland's energy consumption by source categories 1A1-1A5 based on the Swiss energy model. Note that in the same period population increased by about 25%, industrial production by about 70% and the motor vehicle fleet by about 60% (SFOE 2018, table 43b)

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 2015c). 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 1A4ai Other sectors – Commercial/institutional (stationary combustion) and 1A3bviii Fuel tourism and statistical differences.

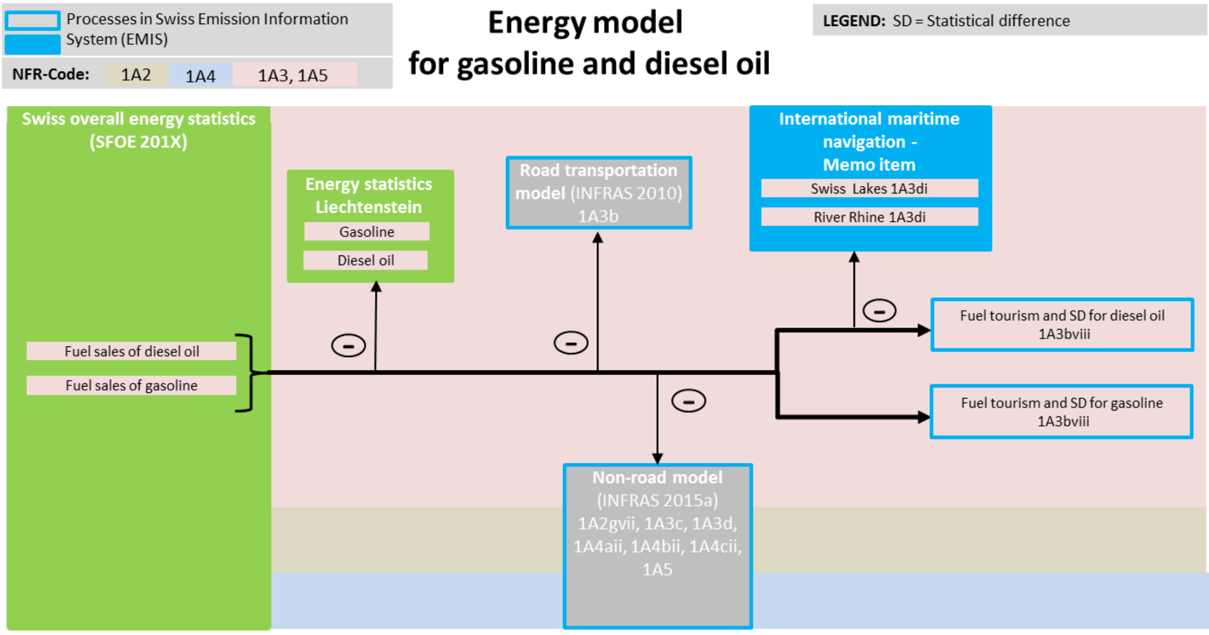


Figure 3-10: Schematic disaggregation of 1A Fuel consumption for gasoline and diesel oil. Marine bunker fuel consumption is based on the national customs statistics (see chapter 3.1.6.2 on memo items)

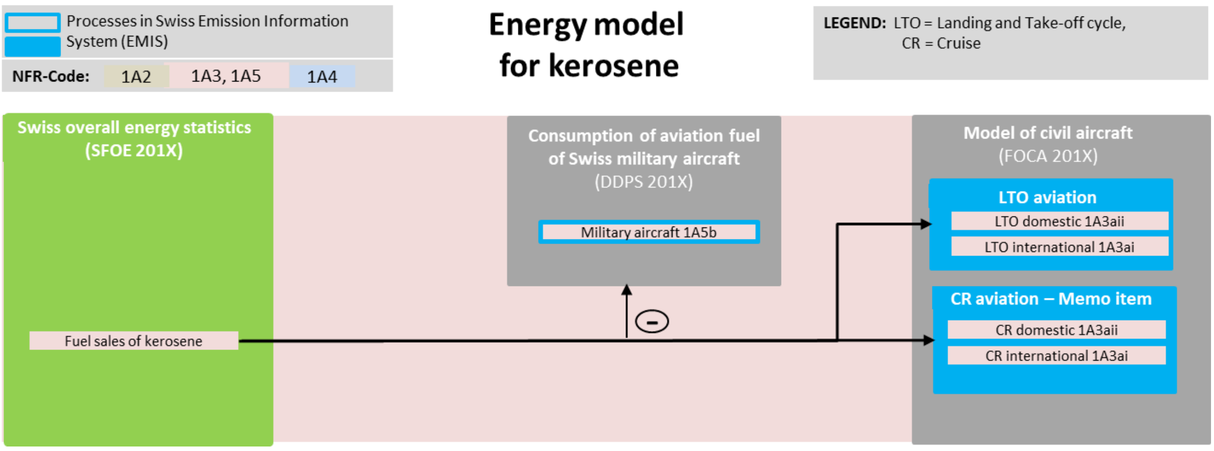


Figure 3-11: Schematic disaggregation of 1A Fuel consumption for kerosene. Fuel consumption for military aircraft is provided by the Federal Department of Defence, Civil Protection and Sport (DDPS). The differentiation between domestic and international aviation as well as between CR and LTO is provided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

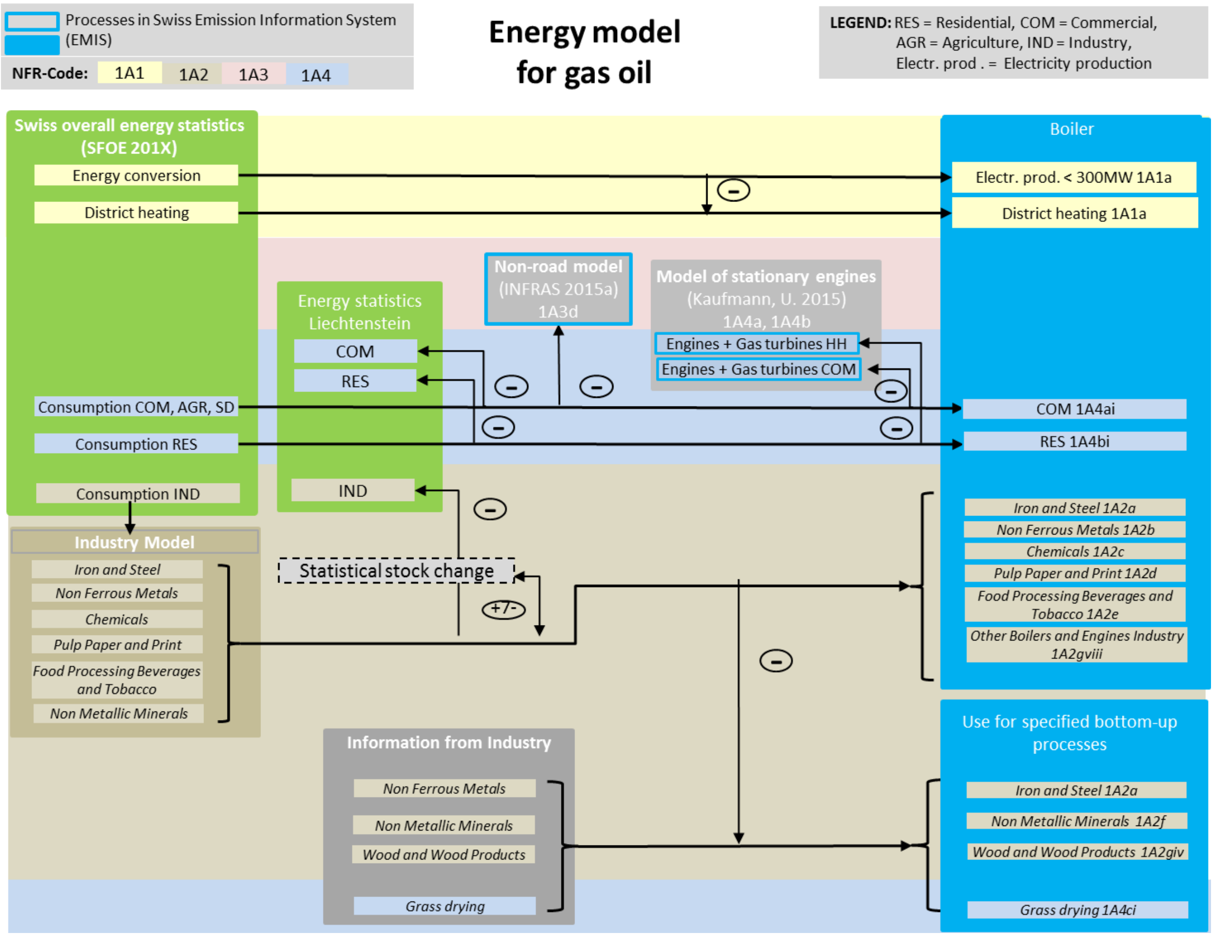


Figure 3-12: Schematic disaggregation of 1A Fuel consumption for gas oil. The Swiss overall energy statistics provide gas oil use for energy conversion and the amount thereof being used for district heating. Based on this information, gas oil use is split into 1A1ai Electricity generation and 1A1aiii Heat plants. According to the non-road model, a small amount of gas oil is consumed in source category 1A3d navigation (steam-powered vessels).

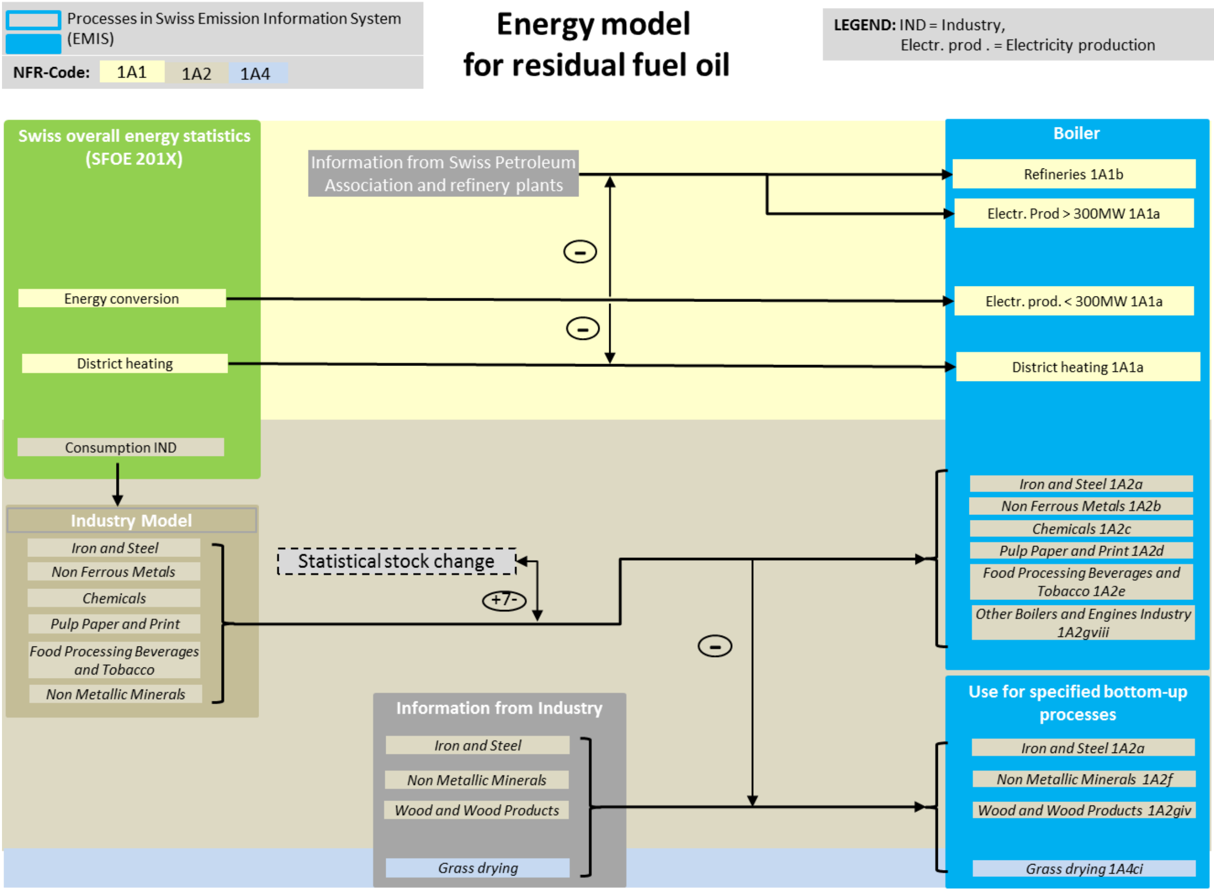


Figure 3-13: Schematic disaggregation of 1A Fuel consumption for residual fuel oil. The Swiss overall energy statistics report residual fuel oil use in energy conversion and the amount thereof consumed in electricity production (one single fossil fuel power station, operational from 1985 to 1994), district heating, and in petroleum refineries. Based on this information, residual fuel oil use in Energy industries is split into 1A1ai Electricity generation, 1A1aiii Heat plants and 1A1b Petroleum refining.

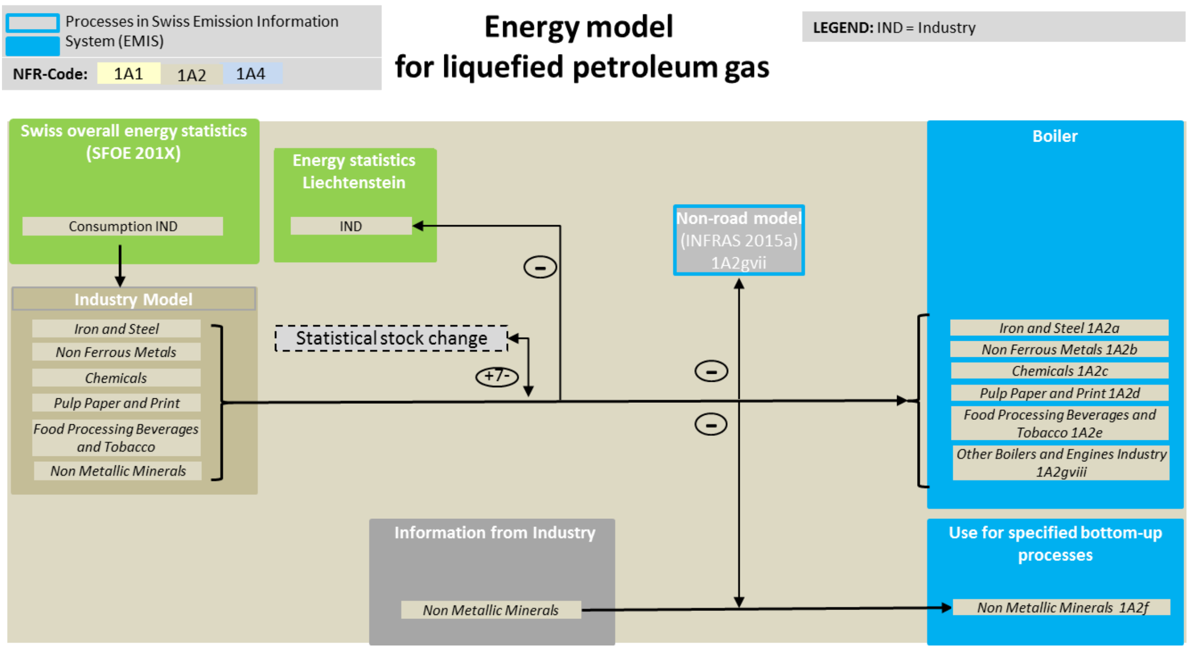


Figure 3-14: Schematic disaggregation of 1A Fuel consumption for liquefied petroleum gas.

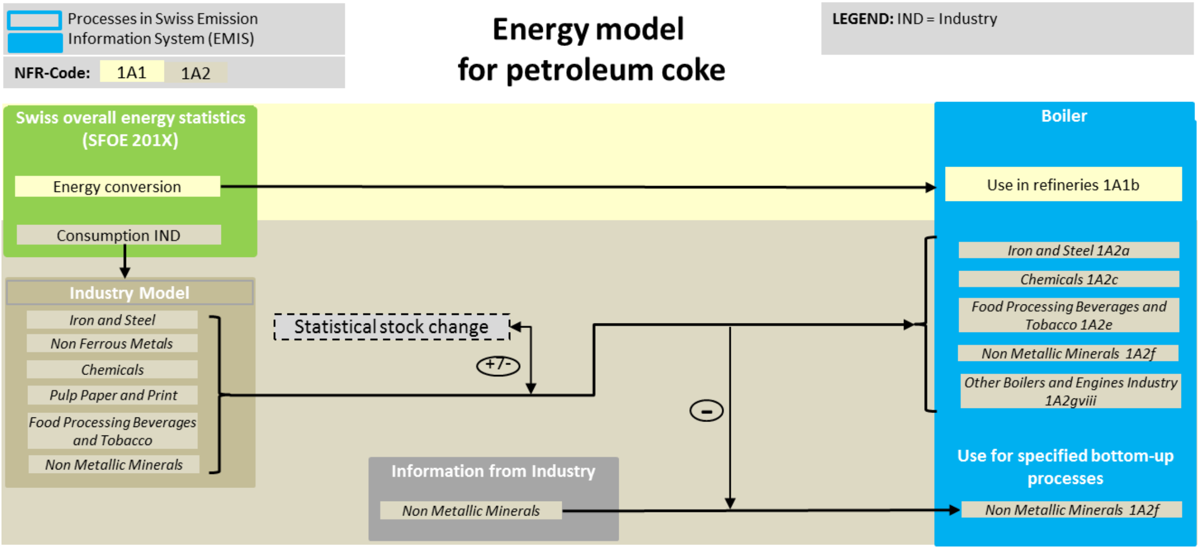


Figure 3-15: Schematic disaggregation of 1A Fuel consumption for petroleum coke.

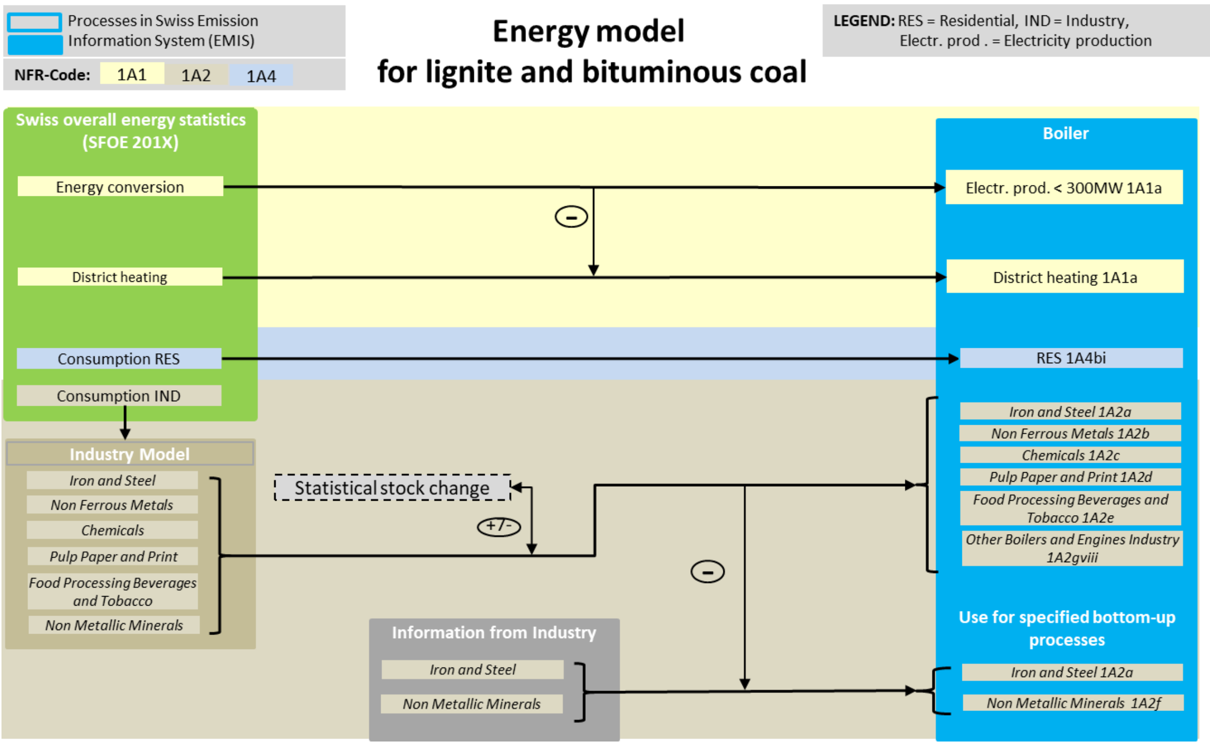


Figure 3-16: Schematic disaggregation of 1A Fuel consumption for lignite and bituminous coal. The Swiss overall energy statistics provide bituminous coal use for energy conversion and the amount thereof being used for district heating. Based on this information, use of bituminous coal in energy industries is split into 1A1ai Electricity generation and 1A1aiii Heat plants up to 1995. Coal consumption for Public electricity and heat production ceased thereafter.

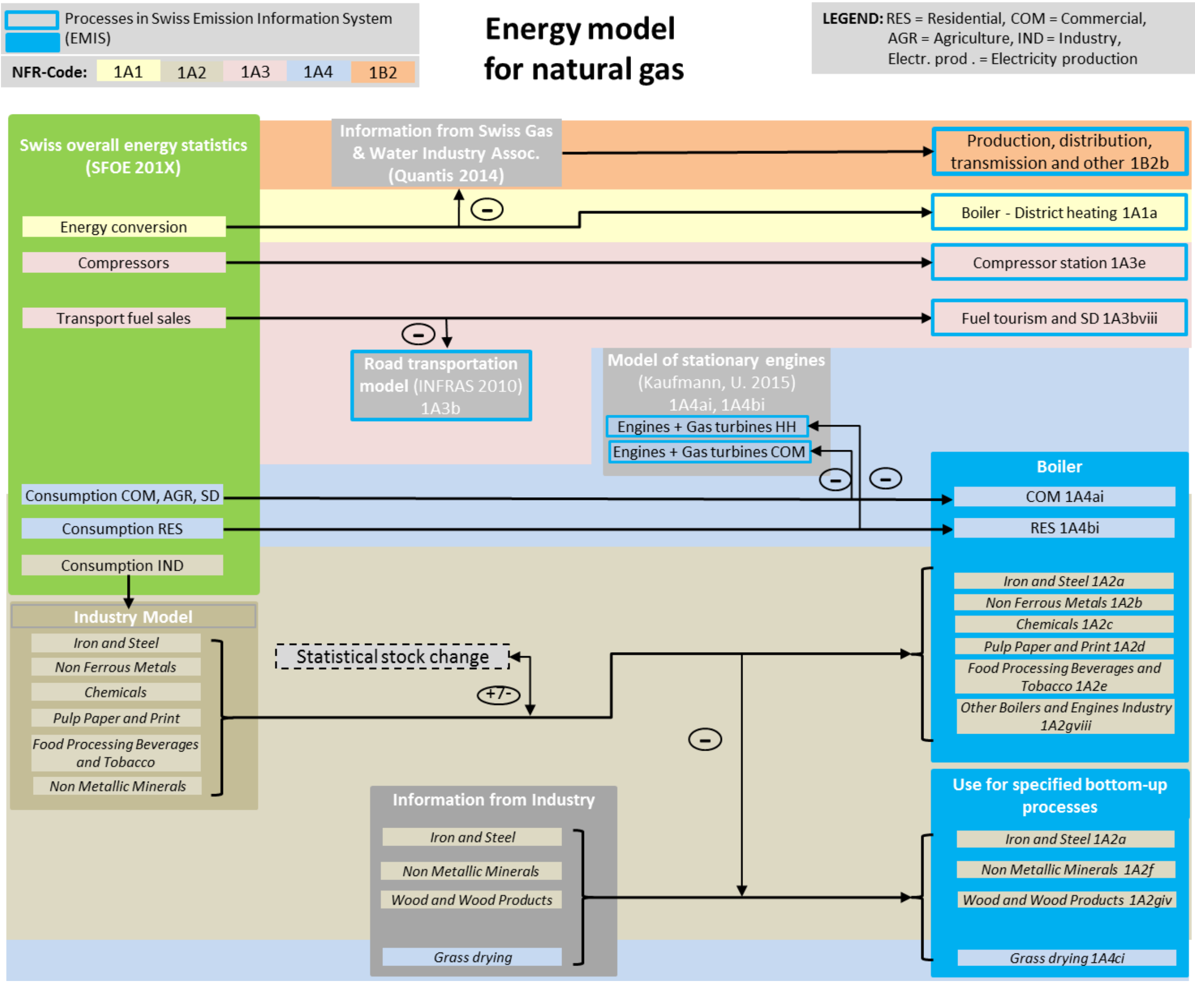


Figure 3-17: Schematic disaggregation of 1A Fuel consumption (and 1B Fugitive emissions from fuels) for natural gas. The Swiss overall energy statistics (SFOE 2018) provide gas use in the transformation sector (energy conversion and distribution losses). Distribution losses as estimated by the Swiss 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.

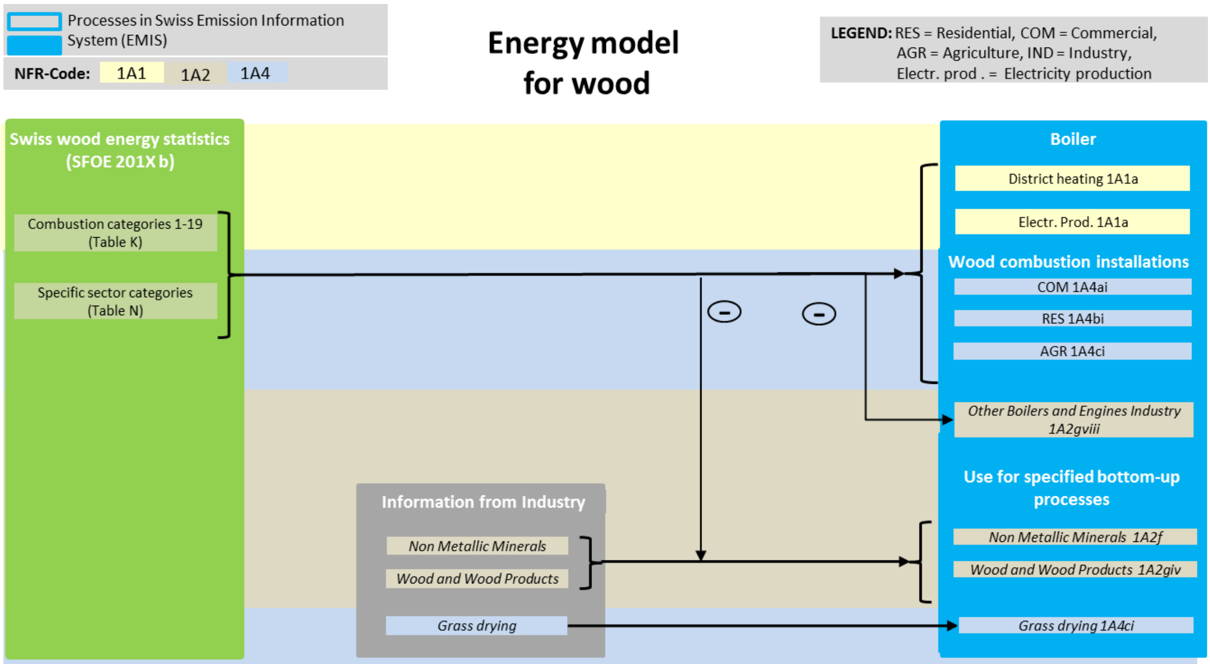


Figure 3-18: Schematic disaggregation of 1A Fuel consumption for wood. For a detailed description of the Energy model for wood combustion, see chapter 3.2.1.1.2.

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 2016 (EMEP/EEA 2016). 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:

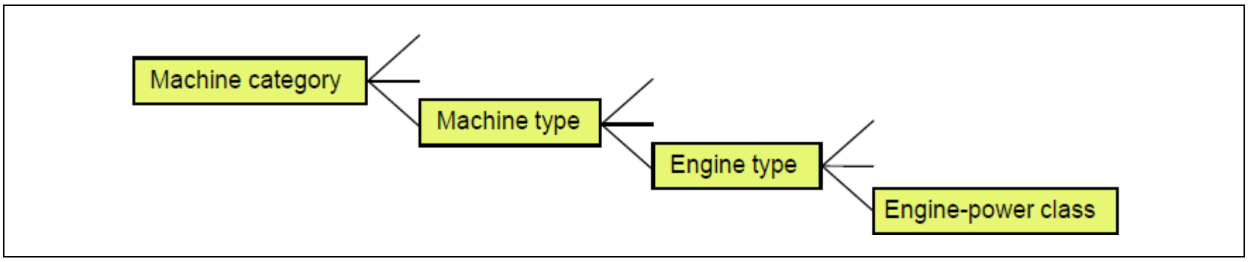


Figure 3-19: Each non-road vehicle is classified by its engine-power class, engine type, machine type and machine category.

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 3-19):

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

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 included in the 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 the 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 (2016) 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)[3], 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.

All emission factors are taken from EMEP/EEA (2016).

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 construction 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

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

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.

In addition, some minor improvements for the activity data have been realised for the current submission resulting in recalculations. The updated activity data deviate by 1% compared to the previous submission (see chp. 3.2.5.3, 3.2.7.3, 3.2.8.3).

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 (2016).

Methodology

The Swiss wood energy statistics (SFOE 2018b) 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 2018b.

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) and CO: Emission factors are taken from a country-specific emission factor model for wood energy developed by Nussbaumer and Hälg (2015). Please note that the emission factors of NMVOC comprise emission shares of so-called condensable particulate matter as well. The model assumes that 50% of the NMVOC have to be considered as condensable particulate matter.

- PM2.5, PM10 and 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 and Pb: Default emission factors from EMEP/EEA (2013) are used (chp. 1A4).
- PCDD/PCDF, PAH and 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 2017 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	PM10	TSP	BC	CO
					g/GJ				
Open fireplaces	80	176	10	5	90	92	97	63	2929
Closed fireplaces, log wood stoves	80	141	10	5	85	87	91	56	2357
Pellet stoves	60	16	10	2	50	51	54	19	271
Log wood hearths	70	227	10	5	173	176	186	121	3786
Log wood boilers	80	69	10	2	42	43	45	12	1143
Log wood dual chamber boilers	70	214	10	5	166	170	179	116	3571
Automatic chip boilers < 50 kW	120	11	10	2	86	88	93	9	543
Automatic pellet boilers < 50 kW	60	4	10	2	42	43	44	8	179
Automatic chip boilers 50-500 kW w/o wood proc. companies	120	9	10	2	67	69	72	7	450
Automatic pellet boilers 50-500 kW	60	3	10	2	33	34	36	7	134
Automatic chip boilers 50-500 kW within wood proc. companies	217	9	10	2	67	69	72	7	450
Automatic chip boilers > 500 kW w/o wood proc. companies	133	5	10	2	57	59	61	2	271
Automatic pellet boilers > 500 kW	70	3	10	2	30	30	31	3	132
Automatic chip boilers > 500 kW within wood proc. companies	217	5	10	2	57	59	61	2	271
Combined chip heat and power plants	117	2	10	5	10	10	11	0.4	93
Plants for renewable waste from wood products	99	2	20	5	7	8	8	0.1	93

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	971	49	49	30	30	0.005
Closed fireplaces, log wood stoves	27	13	0.6	943	47	47	29	29	0.005
Pellet stoves	27	13	0.6	46	4.6	4.6	2.7	2.7	0.005
Log wood hearths	27	13	0.6	943	94	94	57	57	0.005
Log wood boilers	27	13	0.6	91	23	23	14	14	0.005
Log wood dual chamber boilers	27	13	0.6	900	90	90	54	54	0.005
Automatic chip boilers < 50 kW	27	13	0.6	90	4.6	4.6	2.7	2.7	0.005
Automatic pellet boilers < 50 kW	27	13	0.6	45	1.9	1.9	1.9	1.9	0.004
Automatic chip boilers 50-500 kW w/o wood proc. companies	27	13	0.6	90	2.7	2.7	1.9	1.9	0.005
Automatic pellet boilers 50-500 kW	27	13	0.6	45	1.9	1.9	1.9	1.9	0.004
Automatic chip boilers 50-500 kW within wood proc. companies	27	13	0.6	90	2.7	2.7	1.9	1.9	0.005
Automatic chip boilers > 500 kW w/o wood proc. companies	27	13	0.6	90	1.9	1.9	1.9	1.9	0.001
Automatic pellet boilers > 500 kW	27	13	0.6	44	1.9	1.9	1.9	1.9	0.001
Automatic chip boilers > 500 kW within wood proc. companies	27	13	0.6	90	1.9	1.9	1.9	1.9	0.001
Combined chip heat and power plants	27	13	0.6	46	0.9	0.9	0.9	0.9	0.001
Plants for renewable waste from wood products	27	13	0.6	46	0.9	0.9	0.9	0.9	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 2009b, see there in chp. 3.1) and since then all activity data is based on those statistics, see Table 3-7 (SFOE 2018b).

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, 1A2gviii and 1A4ci are allocated on the basis of industry information. The information on the specific processes is documented in the respective EMIS database (EMIS 2019/1A 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 1990-2017.

1A Wood combustion	Unit	1990	1995	2000	2005
Total	TJ	27'774	28'844	26'391	29'727
Open fireplaces	TJ	226	270	195	180
Closed fireplaces, log wood stoves	TJ	7'273	7'165	6'487	7'029
Pellet stoves	TJ	NO	NO	7	48
Log wood hearths	TJ	8'520	7'017	4'736	4'017
Log wood boilers	TJ	5'307	5'563	5'105	5'352
Log wood dual chamber boilers	TJ	1'964	1'777	977	479
Automatic chip boilers < 50 kW	TJ	239	433	550	753
Automatic pellet boilers < 50 kW	TJ	NO	NO	56	803
Automatic chip boilers 50-500 kW w/o wood proc. companies	TJ	687	1'323	1'774	2'665
Automatic pellet boilers 50-500 kW	TJ	NO	NO	2	93
Automatic chip boilers 50-500 kW within wood proc. companies	TJ	1'278	1'708	1'739	1'892
Automatic chip boilers > 500 kW w/o wood proc. companies	TJ	325	1'004	1'601	2'225
Automatic pellet boilers > 500 kW	TJ	NO	NO	NO	9
Automatic chip boilers > 500 kW within wood proc. companies	TJ	1'277	1'987	2'177	2'461
Combined chip heat and power plants	TJ	NO	3	170	116
Plants for renewable waste from wood products	TJ	678	594	814	1'605

1A Wood combustion	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total	TJ	31'339	32'104	34'380	28'924	32'170	34'974	30'524	33'109	36'352	36'525
Open fireplaces	TJ	150	136	123	87	84	84	62	64	68	67
Closed fireplaces, log wood stoves	TJ	6'833	6'999	7'915	6'571	7'462	8'364	6'739	7'452	7'913	7'643
Pellet stoves	TJ	93	109	140	127	156	185	157	182	202	201
Log wood hearths	TJ	2'841	2'487	2'269	1'572	1'484	1'357	900	918	913	836
Log wood boilers	TJ	4'897	4'743	4'906	3'682	3'823	3'900	2'823	2'972	3'032	2'853
Log wood dual chamber boilers	TJ	339	288	272	194	190	182	125	119	112	88
Automatic chip boilers < 50 kW	TJ	834	860	1'008	799	867	946	740	787	798	742
Automatic pellet boilers < 50 kW	TJ	1'563	1'727	2'105	1'809	2'151	2'511	2'102	2'378	2'610	2'620
Automatic chip boilers 50-500 kW w/o wood proc. companies	TJ	3'179	3'240	3'724	3'197	3'755	4'251	3'491	4'017	4'403	4'391
Automatic pellet boilers 50-500 kW	TJ	359	429	534	509	622	727	696	875	1'050	1'175
Automatic chip boilers 50-500 kW within wood proc. companies	TJ	1'843	1'840	1'974	1'705	1'838	1'975	1'627	1'772	1'883	1'864
Automatic chip boilers > 500 kW w/o wood proc. companies	TJ	3'068	3'336	3'823	3'494	4'195	4'799	4'151	4'849	5'427	5'578
Automatic pellet boilers > 500 kW	TJ	80	84	92	139	161	191	181	203	236	233
Automatic chip boilers > 500 kW within wood proc. companies	TJ	2'340	2'348	2'626	2'244	2'399	2'562	2'120	2'236	2'345	2'241
Combined chip heat and power plants	TJ	1'247	1'730	1'155	1'240	1'441	1'431	1'438	1'172	1'246	1'558
Plants for renewable waste from wood products	TJ	1'673	1'748	1'714	1'555	1'542	1'509	3'173	3'113	4'115	4'435

3.2.1.2 Emission factors for 1A Fuel combustion

There are no so-called general emission factors for all sources belonging to source category 1A Fuel combustion except for SO_2. Table 3-8 shows sulphur contents and SO_2 emission factors per fuel type. Explanations:

- For liquid and solid fuels the SO_2 emission factors are determined by the sulphur content. The upper table depicts the maximum values as defined in the Federal Ordinance on Air Pollution Control OAPC (Swiss Confederation 1985).
- The middle table contains the effective sulphur contents. They are based on measurements: Summary and annual reports of the Swiss Petroleum Association (EV), reports by the Federal Customs Administration (FCA) since 2000, as well as their measurement project 'Schwerpunktaktion Brenn und Treibstoffe'. For diesel oil and gasoline, the measurement project 'Tankstellensurvey', arranged by the FOEN, is a central data source.
- The lower table shows the emission factors in kg/TJ. They are calculated from the effective sulphur content S, the net calorific value NCV and the quotient of the molar masses of S and SO_2.

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

- Gas oil: starting from 1990 and for each fifth subsequent year up to and including 2015 the values for the SO_2 emission factors are based on five-year averages (eg. the value for 1995 is based on an average of the years 1993-1997). 1990 is the exception: for this year, the value is based on an average of the three years 1990-1992. The values for all other years are linear interpolations between the two nearest five-year averages as described above. Furthermore, 2006 saw the introduction to the market of low-sulphur eco-grade gas oil with a maximum legal sulphur limit of 50 ppm. From this year onwards, FCA measurements include both standard Euro- and eco-grade gas oil. For each year, the two grades are weighted by the respective total annual fuel consumption. Additionally, as of 2018 heating gas is also classified as gas oil.

- Coal: The legal limit of sulphur content depends on the size of the heat capacity of the combustion system. The value of 1% sulphur content (350 kg SO_2/TJ) shown in Table 3-8 holds for heat capacity below 1 MW (see OAPC Annex 3, §513 (Swiss Confederation 1985)). For larger capacities, the value is 3% (OAPC Annex 5, §2, Swiss Confederation 1985). For industrial combustion plants, the limit for the exhaust emissions actually sets the corresponding maximum sulphur content to 1.4% (500 kg SO_2/TJ).
- Residual fuel oil: OAPC Annex 5, §11, lit.2 sets 2.8% for the legal limit (denoted as class B in the upper table). Simultaneously, OAPC dispenses from emission control measurements if residual fuel oil of class A is used with sulphur content of maximum 1% (see OAPC Annex 3, §421, lit.2, Swiss Confederation 1985), which holds for most combustion plants. The emission factors are based on five-year averages in the case of 1995, 2000 and 2015. 1990 is based on an average of the years 1990-1992 because no non-interpolated data is available for 1988 and 1989. Similarly, because the emission factors of the years 2006-2008 are not available, the average of 2005 is based on the years 2003-2005 and that of 2010 on 2009-2012. The values for all other years are linear interpolations between the two nearest five-year averages as described above.
- Natural gas: OAPC Annex 5, §42 sets 190 ppm as the legal limit for natural gas.

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 (Euro)	Natural gas	Res. fuel oil	Res. fuel oil	Coal
	ppm	ppm	ppm	ppm	Class A, %	Class B, %	%
1990	1400	200	2000	190	1.0	2.8	1-3
1991	1300	200	2000	190	1.0	2.8	1-3
1992	1200	200	2000	190	1.0	2.8	1-3
1993	1000	200	2000	190	1.0	2.8	1-3
1994	500	200	2000	190	1.0	2.8	1-3
2000	350	150	2000	190	1.0	2.8	1-3
2005	50	50	2000	190	1.0	2.8	1-3
2008	50	50	1000	190	1.0	2.8	1-3
2009	10	50	1000	190	1.0	2.8	1-3
2010-2017	10	10	1000	190	1.0	2.8	1-3

Year	Effective sulphur content			
	Diesel oil	Gasoline	Gas oil	Res. fuel oil
	ppm	ppm	ppm	%
1990	1400	200	1600	0.97
1991	1300	200	1300	0.89
1992	1200	200	1200	0.86
1993	1000	200	1000	0.87
1994	434	200	1350	0.77
1995	341	200	1170	0.78
1996	372	200	1160	0.78
1997	353	200	1250	0.70
1998	402	200	926	0.83
1999	443	200	650	0.62
2000	272	142	680	0.66
2001	250	121	830	0.82
2002	235	101	798	0.78
2003	200	81	700	0.79
2004	10	8.0	700	0.76
2005	10	8.0	799	0.78
2006	10	8.0	699	0.74
2007	10	8.0	630	0.71
2008	10	8.0	641	0.67
2009	7.6	5.3	549	0.92
2010	6.7	4.7	519	0.88
2011	6.6	5.0	417	0.90
2012	7.0	5.3	503	0.91
2013	7.1	4.8	224	0.90
2014	6.8	4.8	341	1.11
2015	7.7	4.5	348	1.93
2016	7.0	4.6	159	1.92
2017	7.7	5.2	146	0.98

Year	SO_2 emission factor used for Switzerland's emission inventory								
	Diesel oil (average in 1A3b)	Gasoline (average in 1A3b)	Gas oil (boilers and engines in 1A1a, 1A2, 1A4) *	Natural gas (boilers and engines in 1A1, 1A2, 1A4, 1A3e)	Natural gas (for 1A3b only)	Res. fuel oil (boilers in 1A1a, 1A2) *	Lignite (boilers in 1A2g)	Bituminous coal (boilers in 1A4b)	Kerosene (average)
	kg/TJ								
1990	65	9.4	64			440			23.2
1991	61	9.4	*62*			*428*			23.2
1992	56	9.4	*61*			*416*			23.2
1993	47	9.4	*59*			*404*			23.3
1994	20	9.4	*58*			*392*			23.3
1995	16	9.4	56			380			23.3
1996	17	9.4	*52*			*376*			23.3
1997	16	9.4	*48*			*372*	NO		23.3
1998	19	9.4	*45*			*368*			23.2
1999	21	9.4	*41*			*364*			23.2
2000	13	6.7	37			360			23.2
2001	12	5.7	*36*			*364*			23.2
2002	11	4.8	*35*			*368*			23.2
2003	9.3	3.8	*35*	0.5	NE	*372*		350	23.2
2004	0.47	0.38	*34*			*376*			23.2
2005	0.47	0.38	33			380			23.2
2006	0.47	0.38	*31*			*392*			23.1
2007	0.47	0.38	*30*			*404*			23.2
2008	0.47	0.38	*28*			*416*			23.2
2009	0.47	0.38	*27*			*428*			23.2
2010	0.47	0.38	25			440			23.2
2011	0.47	0.38	*22*			*480*	500		23.2
2012	0.47	0.38	*19*			*520*			23.2
2013	0.47	0.38	*17*			*560*			23.1
2014	0.47	0.38	*14*			*600*			23.1
2015	0.47	0.38	11			640			23.1
2016	0.47	0.38	*10*			*633*			23.1
2017	0.47	0.38	*9*			*626*			23.1

** grey cells = interpolation*

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 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 1A1 Energy Industries.

Code	Source Category	Pollutant	Identification Criteria
1A1a	Public electricity and heat production	NOx	L1, L2, T1, T2
1A1a	Public electricity and heat production	SO2	L1, L2, T1, T2
1A1a	Public electricity and heat production	PM2.5	T1, T2
1A1a	Public electricity and heat production	PM10	T1, T2

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 2016 (EMEP/EEA 2016).

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 2019/1A1a Kehrichtverbrennungsanlagen and EMIS 2019/1A1a 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) and have been revised according to this 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 landfill gas are considered to be the same as for natural gas engines in commercial and institutional buildings or stem from the Clearinghouse for Inventories and Emissions Factors (CHIEF) by US EPA (CO, NO_x, PM exhaust, PM10 exhaust, PM2.5 exhaust) (EMIS 2019/1A1a 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 2019/1A 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 2017.

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	33.2	2	9.2	0.002	0.2	0.2	0.2	0.0078	6.3
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	17.6	2.00	0.5	0.001	0.1	0.1	0.1	0.0054	9.6
Other fuels (MSW)	31.2	2.10	3.5	0.45	0.61	0.61	0.61	0.0055	7.6
Other fuels (special waste)	37.4	5.04	4.33	0.61	1.43	1.43	1.43	0.013	16
Biomass (wood)	114	1.86	11.8	5	9.8	9.9	10.7	0.37	92.9
Biogas	131.3	NE	NE	NE	24.08	24.08	24.08	0.602	218.9

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)	25.2	2.52	5.3	0.034	NE	NE	NE	NE	3.80
Other fuels (special waste)	28.7	15.6	7.3	0.043	NE	NE	NE	NE	NE
Biomass (wood)	27	13	0.6	0.046	0.93	0.93	0.93	0.93	0.93
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 2018i) 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).

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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total Other fuels	kt	3'865	3'827	3'968	3'924	4'104	4'035	4'066	4'150	4'264	4'248
Municipal solid waste	kt	3'610	3'597	3'717	3'676	3'841	3'773	3'817	3'889	4'010	4'011
Special waste	kt	255	230	252	247	263	262	249	261	254	236

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 2018; Tables 21, 26, and 28).

Activity data for combined heat and power generation from landfill gas are taken from the Swiss renewable energies statistics (SFOE 2018a). 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 2018b) as described in chapter 3.2.1.1.2 Energy model for wood combustion.

Table 3-13: Activity data of 1A1a Public electricity/heat.

1A1a Public electricity and heat production	Unit	1990	1995	2000	2005
Total fuel consumption	TJ	40'359	39'141	49'875	56'959
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	227	576	535	191

1A1a Public electricity and heat production	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total fuel consumption	TJ	58'876	57'792	61'746	59'792	63'398	63'331	59'363	61'359	65'025	64'757
Gas oil	TJ	490	540	500	400	800	670	780	660	440	500
Residual fuel oil	TJ	180	130	40	10	NO	NO	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	8'468	8'073	9'926	7'512	8'213	8'449	5'072	7'060	8'956	7'927
Other fuels (waste-to-energy)	TJ	47'344	46'102	48'277	47'847	49'313	48'228	49'161	50'548	52'422	52'316
Biomass (wood)	TJ	2'312	2'877	2'958	3'983	5'032	5'949	4'321	3'071	3'196	4'005
Biogas	TJ	83	70	45	40	40	35	28	19	11	8

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 2016 (EMEP/EEA 2016), 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 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 Swiss overall energy statistics (SFOE 2018) and 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 2018). Since one of the refineries ceased operation in 2015, the data are considered confidential since 2014. Data are available to reviewers on request.

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 and since 2015 natural gas is used additionally to residual fuel oil and refinery gas.

Net calorific values are provided by the annual monitoring reports of the refining industries for the years 2005-2011 and 2013-2017 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 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 2018).

Table 3-14: Activity data of 1A1b Petroleum Refining in 2017.

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
Natural gas	TJ	NO	NO	NO	NO

1A1b Petroleum refining	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total fuel consumption	TJ	15'118	14'473	14'176	13'169	11'242	13'834	14'173	7'232	6'355	6'298
Residual fuel oil	TJ	692	733	891	764	1'212	1'094	C	C	C	C
Refinery gas	TJ	11'978	11'706	11'282	10'720	8'249	11'055	C	C	C	C
Petroleum coke	TJ	2'449	2'035	2'003	1'685	1'781	1'685	C	C	NO	NO
Natural gas	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	C

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

Methodology (1A1c)

Based on the decision tree Fig. 5.1 in chapter 1A1c Manufacture of solid fuels and other energy industries of the EMEP/EEA Guidebook 2016 (EMEP/EEA 2016), 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 and TSP exhaust based on US-EPA (1995). PM2.5 exhaust is supposed to be 95% from PM10 exhaust (EMIS 2019/1A1c).

Table 3-15: Emission factors of 1A1c charcoal production in 2017.

1A1c Charcoal	Unit	NO_x	NMVOC	SO2	NH3	PM2.5 exh.	PM10 exh.	TSP	BC exh.	CO
Charcoal production	kg/TJ	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	kg/TJ	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 2019/1A1c).

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

1A1c Charcoal	Unit	1990	1995	2000	2005
Charcoal production	TJ	1.25	1.43	2.20	3.37

1A1c Charcoal	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Charcoal production	TJ	3.64	3.60	3.30	3.42	3.73	2.94	3.94	3.43	3.90	3.76

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

- 1A1a: Emissions from biogas usage in engines and boilers of gas produced by digestion in agricultural and industrial biogas plants have been reported in source category 1A1a and 1A2gviii / 1A4ai as well. This led to a double counting of emissions. The processes for agricultural and industrial digestion have now been removed from source category 1A1a and are only reported in 1A2gviii and 1A4ai. This leads to a decrease of activity data and emissions for the years 1990-2016 in 1A1a.
- 1A1a: The SO_x EF of all gas oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A1a: The SO_2 EF of all residual fuel oil boilers have been recalculated for the time series 1990–2011. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A1a: Activity data for natural gas in sector 1A1a has changed due to recalculation in gas losses of 1B2b for the year 2016.
- 1A1a: Acitvity data (wood, wood waste) of all wood combustion installations have been revised for 2014-2016 due to recalculations in the Swiss wood energy statistics (SFOE 2018b).
- 1A1b: Emission factors for NMVOC, NO_x and CO were revised because the sources were not transparent: revision of emission factor of NMVOC and NO_x from residual fuel oil and refinery gas; revision of emission factor of SO_2 from residual fuel oil, refinery gas and petroleum coke; revision of emission factor of CO from residual fuel oil. The new emission factors lead to 40-80% less emissions of NMVOC in the years 1991-2016, 1-4% less emissions of CO and 7-20% less emissions of NO_x in the years 1991-1994 in this source category.
- 1A1b: Emission factors of so-called refinery petroleum coke boilers (2004–2015) were adjusted for all air pollutants: the same emission factors as of residual fuel oil boilers are assumed. The SO_2 EF of all residual fuel oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A1c: Activity data of charcoal production in 1A1c has been updated due to production figures from an additional charcoal pile for 2006–2016.

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 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 1A2 Manufacturing Industries and Construction.

1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	SO2	L1, T1
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	NOx	T1
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	SO2	T1, T2
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	NOx	L1, L2, T1, T2
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	SO2	L1, L2, T1, T2
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PM2.5	T1
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PM10	T1, T2
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	NOx	T1, T2
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	SO2	L1, L2
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	PM2.5	L1, L2, T1
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	PM10	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 (2016), the emissions are calculated according to a Tier 2 approach based on country-specific emission factors.

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.

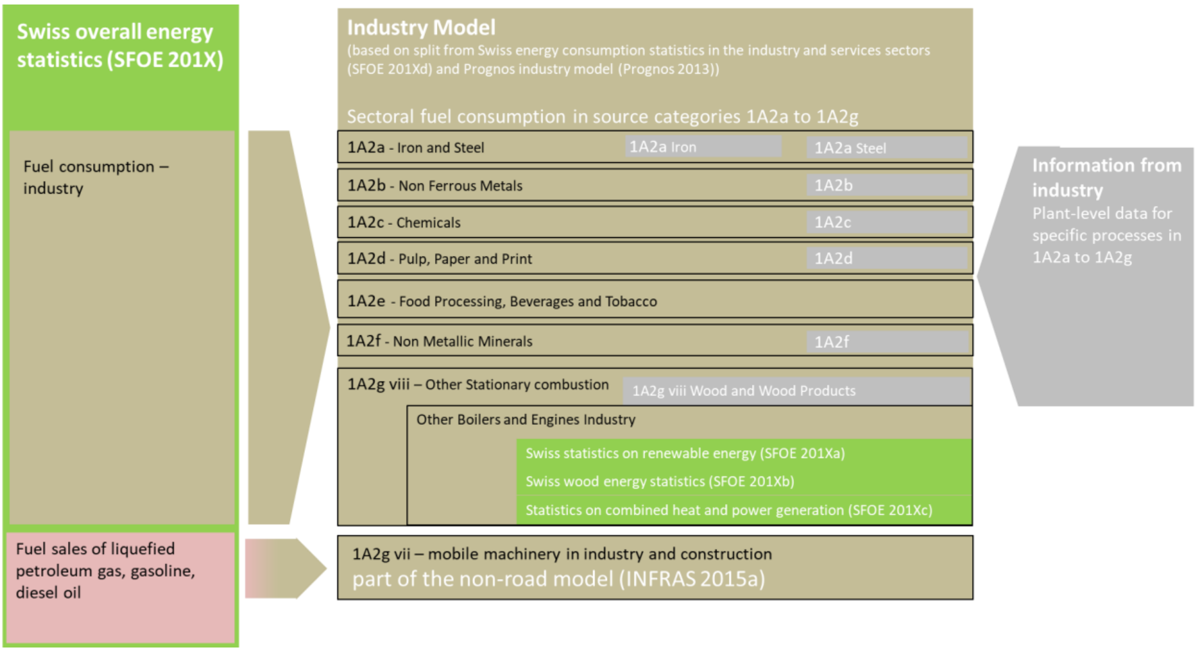


Figure 3-20: Schematic presentation of the data sources used for the industrial sectors 1A2a – 1A2g. The references SFOE 201X, SFOE 201Xa, 201Xb and 201Xc refer to the 2018 edition of the corresponding energy statistics. For each fuel type, the Swiss overall energy statistics provide the total consumption for industry. The total consumption is then distributed to the different source categories based on information from industry surveys (SFOE 2018d) and the Prognos industry model (Prognos 2013). 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 (SFOE 2018, see also description 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 2018d). 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 paragraphs.

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 2018c).

Energy consumption statistics in the industry and services sectors

The energy consumption statistics in the industry and services sectors (SFOE 2018d) 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 life 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 (since 2013) 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 by multiplication of the process activity data with the process-specific fuel consumption factor.

The model 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 disaggregation methods 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 (IPCC 2006, Volume 1, Chapter 5, consistent overlap). To illustrate the approach, an example for gas oil attributed to source category 1A2c is provided in Figure 3-21. 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 2019/1A2_Sektorgliederung Industrie).

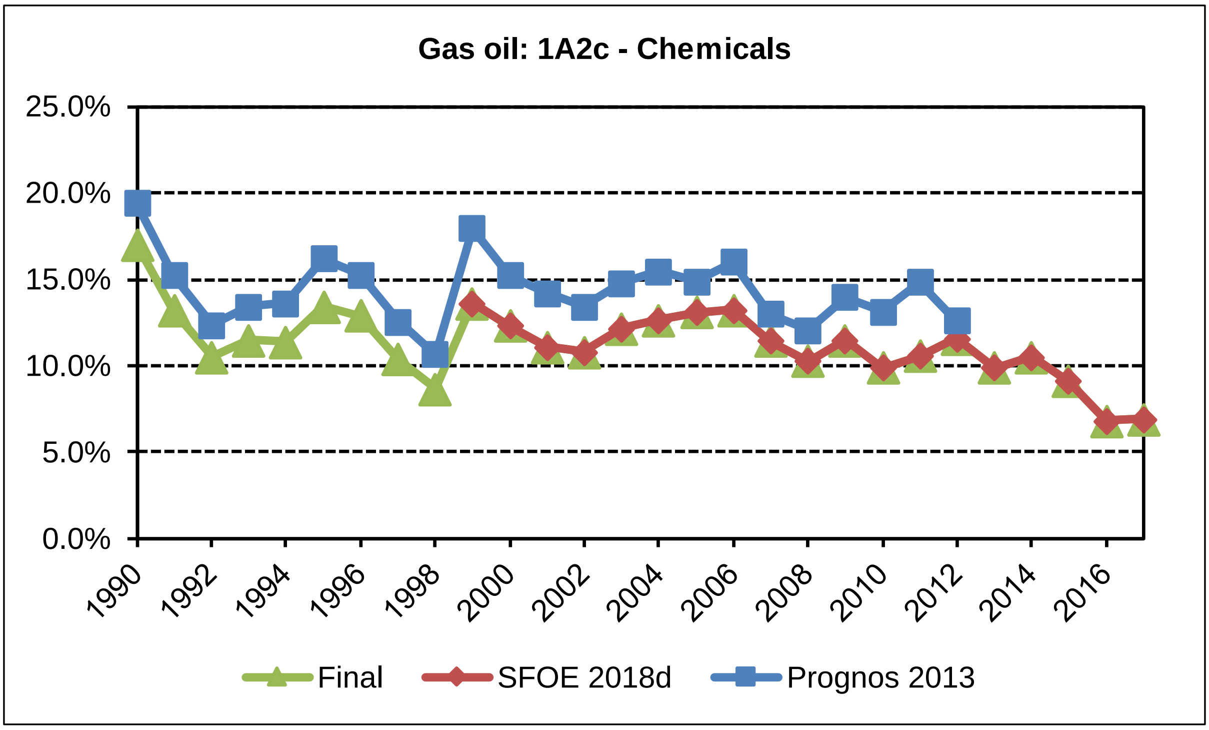


Figure 3-21: Illustrative example for combining time series with consistent overlap according to the 2006 IPCC Guidelines (IPCC 2006, Volume 1, chp. 5). The y-axis indicates the share of source category 1A2c of total gas oil consumption in the industry sector. The green line corresponds to the share finally used to calculate the fuel consumption in 1A2c and is based on the combination of the shares from the energy consumption statistics in the industry and services sectors (SFOE 2018d, red line from 1999 to 2017) and the bottom-up industry model (Prognos 2013, blue line from 1990 to 2012).. Similar calculations are performed for each source category and fuel type.

Bottom-up industry data

Grey colored boxes in Figure 3-20 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 2018d).

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 2018b) as well as on data from the Swiss renewable energy statistics (SFOE 2018a) and the Statistics on combined heat and power generation in Switzerland (SFOE 2018c), 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.

For liquefied petroleum gas and petroleum coke the same emission factors as of natural gas and residual fuel oil, respectively, are assumed for all air pollutants.

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, 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 (except for gas oil and residual fuel oil), NH_3, PM2.5, PM10 and TSP are country-specific and documented in the Handbook on emission factors for stationary sources (SAEFL 2000). Since submission 2019, the emission factors of SO_2 for gas oil and residual fuel oil are based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA), see also description in chp. 3.2.1.2.

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 2017

1A2 Boiler	NO_x	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	g/GJ								
Boiler gas oil	32	2	9	0.002	0.2	0.2	0.2	0.008	7
Boiler residual fuel oil	125	4	626	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	8
Boiler petroleum coke	125	4	626	0.002	20	20	23	2	10
Boiler other bituminous coal	200	10	500	0.003	45	45	50	2.88	100
Boiler lignite	205	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	8

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	87'948	88'830	87'652	91'209
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	4'354	4'458	5'627	4'309
Petroleum coke	TJ	1'400	1'260	551	1'093
Other bituminous coal	TJ	13'476	7'303	5'866	4'799
Lignite	TJ	265	153	124	742
Natural gas	TJ	18'711	27'898	31'373	34'372
Other fossil fuels	TJ	2'556	2'818	4'053	4'525
Biomass	TJ	6'562	7'733	9'237	12'046

Source	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1A2 Manufacturing industries and constr. (stationary sources)	TJ	93'239	87'549	90'276	83'921	85'232	87'118	81'725	80'233	81'256	81'518
Gas oil	TJ	21'386	21'005	20'686	16'771	17'157	17'902	12'340	12'636	12'726	11'371
Residual fuel oil	TJ	3'734	2'713	2'056	1'518	1'568	848	271	226	155	128
Liquefied petroleum gas	TJ	4'033	4'322	3'912	3'876	3'746	3'755	3'304	3'358	2'772	3'151
Petroleum coke	TJ	1'167	1'219	1'495	1'272	1'367	1'049	1'240	795	890	763
Other bituminous coal	TJ	4'445	4'263	4'348	3'868	3'794	3'910	2'403	1'946	1'517	1'634
Lignite	TJ	1'717	1'531	1'460	1'624	1'175	1'357	3'102	3'060	3'078	2'876
Natural gas	TJ	38'719	35'126	38'042	36'903	38'013	39'400	39'956	39'137	39'601	40'582
Other fossil fuels	TJ	4'975	4'958	5'183	5'307	4'883	5'186	5'270	5'252	5'926	5'912
Biomass	TJ	13'064	12'414	13'094	12'783	13'528	13'711	13'840	13'824	14'590	15'101

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	1'031	1'005	966	1'085
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	118	419	322	429
Other fossil fuels	TJ	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO
1A2b Non-ferrous metals	TJ	2'243	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	1'764	1'605	1'309	845
Other fossil fuels	TJ	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO
1A2c Chemicals	TJ	14'431	15'158	13'497	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	9'039	11'138	10'017	12'086
Other fossil fuels	TJ	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO
1A2d Pulp, paper and print	TJ	9'675	12'343	9'883	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	3'151	7'389	6'916	5'678
Other fossil fuels	TJ	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO
1A2e Food processing, beverages and tobacco	TJ	9'858	8'784	10'437	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	4'250	5'635
Other fossil fuels	TJ	NO	NO	NO	NO
Biomass	TJ	NO	NO	NO	NO
1A2g viii Other	TJ	16'112	20'651	21'642	22'919
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	3'091	3'288	4'164	3'116
Petroleum coke	TJ	765	914	15	383
Other bituminous coal	TJ	205	140	12	88
Lignite	TJ	NO	NO	NO	5
Natural gas	TJ	42	1'486	4'111	4'893
Other fossil fuels	TJ	NO	NO	NO	NO
Biomass	TJ	509	535	555	539

Continuation of Table 3-21, fuel consumption in boilers of 1A2 Stationary combustion in manufacturing industries and construction.

Source (Boilers)	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1A2a Iron and steel	TJ	1'607	1'422	1'649	1'526	1'455	1'428	1'506	1'913	1'885	2'189
Gas oil	TJ	307	279	315	271	172	139	86	136	134	126
Residual fuel oil	TJ	51	39	51	2	NO	NO	NO	NO	NO	NO
Liquefied petroleum gas	TJ	246	214	219	226	438	438	388	393	327	368
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	1'003	890	1'065	1'027	845	851	1'032	1'384	1'424	1'695
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	1'038	1'004	1'214	1'174	1'743	1'592	1'916	1'791	1'682	1'646
Gas oil	TJ	107	164	108	73	150	127	89	77	75	79
Residual fuel oil	TJ	0.02	0.02	0.02	0.02	0.8	23	NO	44	NO	4
Liquefied petroleum gas	TJ	7	7	8	8	11	11	10	10	8	0
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	924	833	1'098	1'093	1'581	1'430	1'817	1'660	1'599	1'563
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	14'610	12'611	11'814	12'167	13'909	14'125	12'131	12'528	14'374	13'972
Gas oil	TJ	2'261	2'498	2'103	1'847	2'055	1'797	1'321	1'167	881	803
Residual fuel oil	TJ	79	91	66	0.2	0.2	1	NO	NO	NO	NO
Liquefied petroleum gas	TJ	9	9	8	7	10	10	9	9	8	8
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	12'261	10'014	9'637	10'312	11'845	12'317	10'800	11'352	13'485	13'160
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	8'131	6'124	6'773	6'051	5'374	5'474	4'645	3'656	2'983	2'874
Gas oil	TJ	1'019	948	852	561	623	711	297	383	410	292
Residual fuel oil	TJ	1'887	1'084	279	4.0	2.8	0.02	21.8	19	9	9
Liquefied petroleum gas	TJ	60	62	61	62	67	67	60	60	50	57
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	5'164	4'030	5'581	5'424	4'681	4'696	4'266	3'194	2'513	2'516
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	10'975	12'558	13'161	11'374	11'310	13'079	12'442	11'574	10'976	11'404
Gas oil	TJ	3'376	3'687	3'778	3'197	3'237	3'681	2'395	2'522	2'503	2'182
Residual fuel oil	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Liquefied petroleum gas	TJ	535	736	659	675	935	935	828	838	699	785
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	7'064	8'135	8'723	7'502	7'138	8'463	9'220	8'214	7'774	8'438
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	24'022	23'466	23'581	20'471	20'756	20'232	17'383	18'440	18'255	17'688
Gas oil	TJ	13'007	12'166	12'255	9'581	9'821	10'267	6'947	7'253	7'698	6'769
Residual fuel oil	TJ	58	49	29	2	0.3	2	40	33	8	9
Liquefied petroleum gas	TJ	3'016	3'200	2'855	2'771	2'176	2'180	1'965	1'995	1'635	1'890
Petroleum coke	TJ	91	203	318	154	405	181	108	104	155	113
Other bituminous coal	TJ	50	6	11	16	50	110	105	134	125	102
Lignite	TJ	121	152	111	131	95	75	189	204	197	182
Natural gas	TJ	7'131	7'134	7'415	7'163	7'557	6'792	7'373	8'087	7'799	7'998
Other fossil fuels	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	TJ	549	557	587	653	652	624	656	630	638	623

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.

Electric arc furnaces in steel production:

In the electric arc furnaces of secondary steel production also so-called injection coal and petroleum coke for slag formation as well as natural gas are used. Until 2017, the consumption of these fuels has been reported within the respective boilers of source categories 1A2gviii Other (petroleum coke, other bituminous coal) and 1A2a Iron and steel (natural gas). This resulted in a double counting of all air pollutant emissions since the emissions from the electric arc furnaces reported under source category 2C1 Steel production are based on air pollution control measurements at the chimney including emissions from injection coal and coke as well as from natural gas. In order to avoid double counting, these fuel consumptions are subtracted from the respective boilers in source categories 1A2gviii Other (petroleum coke, other bituminous coal) and 1A2a Iron and steel (natural gas) based on plant-specific data from monitoring reports of the Swiss ETS for the years 2005-2011 and from 2013 onwards.

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 2019/1A2a 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, see US-EPA (1998a) and EMIS 2019/1A2a Eisengiessereien Kupolöfen). The Hg emission factor is 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 2017.

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 2019/1A2a).

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. Bituminous coal used in cupola furnaces primarily acts as fuel, but also as carburization material and reductant. Therefore, emissions are accounted for in source category 1A2a. This allows to be consistent with the allocation of bituminous coal in the Swiss overall energy statistics (SFOE 2018).

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	1'082

1A2a Iron and steel	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Iron foundries, cupola	kt iron	37	15	13	15	11	11	11	9	9	9
Steel plants, reheating furnaces	kt steel	1'269	850	1'082	1'183	1'162	1'126	1'176	1'144	1'085	1'138

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 2019/1A2b 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 2017.

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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Aluminium production	kt aluminium	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Foundries	kt non-ferrous metals	21	15	20	12	18	6.8	7.4	6.8	6.6	6.1

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 2019/1A2c 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 2019/1A2d).

Activity data (1A2d)

Activity data on annual cellulose production are provided by the industry as documented in the EMIS database (EMIS 2019/1A2d Zellulose-Produktion Feuerung). The only plant closed in 2008.

In 2017, natural gas is the most important fuel in this category (see Table 3-21). 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 2017, the fuels used in this category were mainly natural gas as well as gas oil and small amounts of 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 2019/1A2f). 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 2019/1A2f).

Table 3-26: Emission factors for Non-metallic minerals 1A2f in 2017.

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	1	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)

Table 3-27 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 2019/1A2f).

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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Cement	kt	3'461	3'443	3'642	3'587	3'368	3'415	3'502	3'195	3'296	3'279
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	44	33	36	41	39	33	32	31	32	36
Tableware glass	kt	C	C	C	C	C	C	C	C	C	C
Brick and tile	kt	865	701	879	800	792	785	765	726	660	622
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	5'160	5'200	5'250	5'300	4'770	4'770	5'260	4'850	4'710	5'260

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 2017 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 2019/1A2f 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 (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 Table 3-28. 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 2019/1A2f 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	17'194	12'774	11'017	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	3.9
Cement, waste derived fuel	TJ	1'874	2'781	3'685	5'415
Used oil	TJ	1'170	1'485	1'520	1'411
Sewage sludge (dry)	TJ	9.4	128	333	494
Used wood	TJ	NO	322	NO	NO
Solvents	TJ	283	181	426	976
Used tires	TJ	330	415	421	645
Plastics	TJ	NO	55	572	841
Animal meal	TJ	NO	NO	198	856
CSS	TJ	23	135	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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Cement, total incl. waste	TJ	11'954	11'816	12'388	12'187	11'462	11'866	12'339	11'348	11'583	11'476
Cement fossil without waste	TJ	6'389	6'127	6'278	5'859	5'406	5'512	5'847	4'917	4'544	4'354
Gas oil	TJ	NO	NO	5.4	0.7	0.1	88	75	87	50	56
Residual fuel oil	TJ	135	100	112	101	297	86	58	45	90	59
Petroleum coke	TJ	1'036	994	1'130	1'081	920	815	1'052	622	658	574
Other bituminous coal	TJ	3'618	3'650	3'662	3'167	3'097	3'203	1'713	1'267	826	938
Lignite	TJ	1'596	1'379	1'348	1'493	1'081	1'283	2'912	2'856	2'881	2'694
Gas	TJ	3.9	4.3	21	16	11	38	37	41	39	34
Cement, waste derived fuel	TJ	5'565	5'689	6'109	6'329	6'056	6'354	6'492	6'431	7'039	7'122
Used oil	TJ	866	1'278	1'253	1'170	839	876	923	1'142	1'567	1'311
Sewage sludge (dry)	TJ	511	475	477	483	527	418	428	420	479	499
Used wood	TJ	NO	61	292	409	586	732	886	896	811	840
Solvents	TJ	1'476	1'032	1'189	1'264	1'294	1'414	1'273	1'292	1'534	1'398
Used tires	TJ	794	828	842	1'033	964	985	1'021	958	951	1'041
Plastics	TJ	995	1'119	1'252	1'163	1'092	1'299	1'360	1'177	1'171	1'398
Animal meal	TJ	658	621	624	614	572	479	457	412	409	470
CSS	TJ	157	131	123	96	100	96	103	80	98	78
Used charcoal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	66
Other fossil waste fuels	TJ	105	137	45	55	36	25	19	12	11	5.7
Industrial waste	TJ	0.8	0.5	NO	NO	NO	NO	NO	NO	NO	NO
Agricultural waste	TJ	2.0	7.4	7.3	18	28	NO	NO	NO	NO	9.2
Other biomass	TJ	NO	NO	5.7	24	17	32	21	42	7.9	5.6

Fuel consumption in cement plants has decreased since 1990. 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 mix of fuels mentioned above. 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 2019/1A2f 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.

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 2019/1A2f 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 2019/1A2f 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 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 auto produce 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 2019/1A2f). The emission factor of BC (% PM2.5) is taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013) (EMIS 2019/1A2f 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 (EMIS 2019/1A2f 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 2017 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 2019/1A2f 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 since 1990.

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 2019/1A2f 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. Since 1990, 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 2017. Emission factors of SO_2, Hg and PCCD/PCDF are based on data from the industry association (Schweizerische Mischgut-Industrie) (EMIS 2019/1A2f 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 (1A2gviii)

Methodology (1A2gviii)

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 (1A2gviii)

Emission factors of fossil fuel consumption in 1A2gviii in boilers and in fibreboard production are determined top-down (see Table 3-19). For animal grease which was used as fuel in the fibreboard production (2001 – 2013) the same emission factors as of residual fuel are assumed for all air pollutants. 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 2017 for 1A2gviii

1A2gviii Other	NO_x	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	g/GJ								
Boiler industrial sewage gas	19	2	0.5	0.001	0.1	0.1	0.1	0.0054	7.9
Boiler municipal sewage gas	19	2	0.5	0.001	0.1	0.1	0.1	0.0054	7.9
Engines biogas	23	1	0.5	NE	0.1	0.1	0.1	0.0025	56
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 industrial sewage gas	0.0015	0.00025	0.1	0.5	0.00056	0.00084	0.00084	0.00084	NA
Boiler municipal 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 (1A2gviii)

In 2015, fuel consumption of 1A2gviii Other comprises mainly biomass, gas oil and natural gas. Overall, there has been a shift in fuel consumption between 1990 and 2017 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 this source category is based on the Swiss wood energy statistics (SFOE 2018b) as well as on data from the Swiss renewable energy statistics (SFOE 2018a) and the Statistics on combined heat and power generation in Switzerland (SFOE 2018c) (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 2017 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 2019/1A2giv).

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

- 1A2: The SO_x EF of all gas oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A2: The SO_x EF of all residual fuel oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A2: Activity data for natural gas in all the industry sectors 1A2a-g has changed for the year 2016.
- 1A2: Activity data for use of gas oil has changed for the year 2016 in the industry sectors 1A2a-e and 1A2gviii. The change is less than -1%.
- 1A2: Activity data for use of residual fuel oil in other boilers has changed due to necessary stock changes in the year 2010 and 2014.
- 1A2c: The so-called heating gas (a cracker by-product which is used for steam production) is of similar fuel quality as gas oil. Therefore, the same emission factors as of gas oil boilers are assumed for all air pollutants. The SO_2 EF of all gas oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A2c: The so-called gasolio (a cracker by-product which is used for steam production) is of similar fuel quality as residual fuel oil. Therefore, the same emission factors as of residual fuel oil boilers are assumed for all air pollutants. The SO_2 EF of all residual fuel oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A2f: The activity data of 1A2f Brick and tile production has been corrected for 2016.
- 1A2gviii: Emissions from biogas usage in engines of gas produced by digestion in industrial biogas plants have been reported in source category 1A1a and 1A2gviii as well. This led to a double counting of emissions. The corresponding processes for industrial digestion have been removed from source category 1A1a and are now only reported in 1A2gviii. In connection with these adjustments calculations for biogas usage have been revised in the energy model. This leads to a small decrease of activity data and emissions for the years 1990-2016 in 1A2gviii.
- 1A2gviii: Emissions from sewage gas usage in engines or boilers of gas produced by digestion in wastewater treatment plants have been reported in source category 5 and 1A2gviii as well. This led to a double counting of emissions. The emissions from sewage gas used in engines have been removed from source category 5 and are now only reported in 1A2gviii. In connection with these adjustements calculations for sewage gas

usage in the energy model have been revised. This leads to an increase of activity data and emissions for the years 1990-2016 in 1A2gviii.

- 1A2gviii: Acitvity data (wood, wood waste) of all wood combustion installations have been revised for the entire time series 1990-2016 due to recalculations in the Swiss wood energy statistics (SFOE 2018b). Main recalculations include changes in automatic boilers.
- 1A2gviii: For animal grease which was used as fuel in the fibreboard production (2001 – 2013) the same emission factors as of residual fuel oil boilers are assumed for all air pollutants. The SO_2 EF of all residual fuel oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A2gviii: For petroleum coke boilers the same emission factors as of residual fuel oil boilers are assumed for all air pollutants. The SO_2 EF of all residual fuel oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).

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 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 1A4 Other Sectors (stationary).

1A4ai	Commercial/institutional: Stationary	NOx	L1, L2, T1
1A4ai	Commercial/institutional: Stationary	SO2	L1, L2, T1
1A4ai	Commercial/institutional: Stationary	PM2.5	L1, L2, T1, T2
1A4ai	Commercial/institutional: Stationary	PM10	L1, T1
1A4bi	Residential: Stationary	NOx	L1, L2
1A4bi	Residential: Stationary	NMVOC	L1
1A4bi	Residential: Stationary	SO2	L1, L2, T1, T2
1A4bi	Residential: Stationary	PM2.5	L1, L2, T1, T2
1A4bi	Residential: Stationary	PM10	L1, L2, T1, T2
1A4ci	Agriculture/Forestry/Fishing: Stationary	PM2.5	L1

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 (2016). 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

Table 3-32 presents the emission factors applied for source categories 1A4ai, 1A4bi and 1A4ci. Please note the following additional information:

- 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 NMVOC for combustion boilers, turbines and engines in the residential, commercial institutional and agricultural sectors are documented in SAEFL (2000).
- Emission factors for SO_2 of gas oil are based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA) (see chp. 3.2.1.2).
- The emission factor for SO_2 of natural gas is based on the legal limit of 190 ppm (see chp. 3.2.1.2).
- The emission factor for SO_2 of coal is based on 1% sulphur content which holds for heat capacities below 1MW (see chp. 3.2.1.2).
- Emission factors for Pb, Cd, Hg and PAH are taken from EMEP/EEA emission inventory guidebook 2013 (EMEP/EEA 2013).
- 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 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 and Hälg 2015).
- 1A4ai/bi Pb/Cd and PAH, natural gas (NG) engines: the EF for Pb/Cd are taken from Table 3-32 (boilers), since these emission factors are mainly determined by the Pb and Cd content of the fuel used but for PAH from Table 3-32 (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 representing 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.
- 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).
- 1A4ci Emission factors for grass drying 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.
- HCB emission factors of boilers, stationary engines, turbines and CCGT-plants (combined cycle gas turbines) using gaseous and liquid fuels are based on the approach of the Danish Emission Inventory for hexachlorobenzene and polychlorinated biphenyls (Nielsen et al. 2013).

Table 3-32: Emission factors for 1A4ai and 1A4bi (without charcoal and bonfires) and 1A4ci for 2017.

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)	33.2	6.0	9.2	2.4	0.25	0.25	0.25	0.01	6.4
Gas oil (heat only boilers)	33	6.0	9.2	1.0	0.2	0.2	0.2	0.0078	6.3
Gas oil (turbines)	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gas oil (engines)	40	8.0	9.2	600	20	20	20	0.78	30
Natural gas (weighted average)	20.2	1.9	0.5	1.1	0.1	0.1	0.1	0.005	12.1
NG (heat only boilers)	16.9	2.0	0.5	1.0	0.1	0.1	0.1	0.005	10
NG (turbines)	60	0.1	0.5	480	0.2	0.2	0.2	0.005	15
NG (engines)	78	1.0	0.5	NA	0.1	0.2	0.1	0.003	56.3
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)	102	28	9.5	2'486	50	52	54	12	607
Biomass (wood)	116	32.5	10.8	2'867	58	60	63	14	699
Biomass (biogas)	16.9	2.0	0.5	1.0	0.1	0.1	0.1	0.01	9.6
1A4bi Other sectors (stationary): Residential									
Gas oil (weighted average)	35	6.0	9.20	1.2	0.2	0.2	0.2	0.0081	11.6
Gas oil (heat only boilers)	35	6.0	9.20	1.0	0.2	0.2	0.2	0.0078	11.6
Gas oil (turbines)	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gas oil (engines)	40	8.0	9.20	600	20	20	20	0.78	30
Natural gas (weighted average)	16	4.0	0.5	1.0	0.1	0.1	0.1	0.0054	13.0
NG (heat only boilers)	15.9	4.0	0.5	1.0	0.1	0.1	0.1	0.0054	12.6
NG (turbines)	NO	NO	NO	NO	NO	NO	NO	NO	NO
NG (engines)	33	1.0	0.5	NA	0.1	0.1	0.1	0.0025	56.3
Other bituminous coal	65	100	350	1'600	72	76	105	4.6	1'600
Lignite	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass (wood, charcoal, bonfires)	92	84	10	5'222	88	90	95	30	1'382
1A4ci Other sectors (stationary): Agriculture/forestry/fishing									
Drying of grass	29	39.3	33	NA	112	112	112	63	225
Biomass (wood)	156	24	19	4'150	69	71	74	8	653

Continuation of Table 3-32 Emission factors for 1A4ai and 1A4bi (without charcoal and bonfires) and 1A4ci for 2017.

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	1.28	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)	23	11	0.53	9'400	9'400	6'044	6'044	0.21	2.82
Biomass (wood)	27	13	0.60	10'842	10'842	6'971	6'971	0.24	2.82
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	0.91	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	26'916	26'637	15'673	16'483	0.42	4.07
1A4ci Other sectors (stationary): Agriculture/forestry/fishing									
Drying of grass	2.5	0.50	0.26	NE	NE	NE	NE	NE	NE
Biomass (wood)	39	19	0.86	8'569	8'569	5'514	5'514	0.12	4.1

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, Tier 2 level of source category open fireplaces burning biomass (EMEP/EEA 2013) as shown in Table 3-33. According to the EMEP/EEA Guidebook 2016 (EMEP/EEA 2016, chp.1A4, Table 3-39), the values for particulate matter correspond to total particles including both filterable and condensable particulate matter. More details are described in the EMIS database documentation (EMIS2019/1A4bi Lagerfeuer and EMIS2019/1A4bi Holzkohle Verbrauch).

Table 3-33: Emission factors of 1A4bi (bonfires and charcoal use) in 2017.

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 2018).

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 EMIS 2019/1A4ci 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	78'214	85'584	81'910	87'967
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	17'648	22'955	24'539	27'721
NG heat only boilers	TJ	17'372	21'784	22'802	25'688
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	2'944	3'818	4'358	5'309
Biomass (wood)	TJ	2'885	3'769	4'296	5'181
Biomass (biogas)	TJ	59	49	62	128
1A4bi Other sectors (stationary): Residential	TJ	185'288	189'216	170'384	185'847
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	25'864	34'088	36'261	42'633
NG heat only boilers	TJ	25'804	33'830	35'822	42'103
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	21'907	21'120	17'698	18'790
1A4ci Other sectors (stationary): Agriculture/forestry/fishing	TJ	2'323	2'051	1'728	1'639
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	507	505	645

Source/fuel	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1A4ai Other sectors (stationary): Commercial/institutional	TJ	79'141	77'105	83'366	69'037	75'900	80'649	64'079	70'142	73'488	71'444
Gas oil	TJ	47'585	45'699	48'778	38'900	41'814	44'328	34'191	36'406	37'592	35'485
Gas oil heat only boilers	TJ	47'416	45'545	48'660	38'796	41'720	44'242	34'109	36'324	37'510	35'403
Gas oil turbines	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gas oil engines	TJ	169	154	119	105	94	86	82	82	82	82
Natural gas	TJ	25'257	24'761	27'469	24'057	27'025	28'455	22'187	25'070	26'419	26'392
NG heat only boilers	TJ	23'399	22'948	25'764	22'476	25'472	26'957	20'751	23'634	24'983	24'956
NG turbines	TJ	29	26	23	17	5	7	7	7	7	7
NG engines	TJ	1'829	1'787	1'681	1'564	1'548	1'490	1'429	1'429	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	6'299	6'645	7'119	6'080	7'061	7'866	7'701	8'666	9'476	9'566
Biomass (wood)	TJ	5'934	6'237	6'622	5'525	6'386	7'054	6'774	7'625	8'284	8'294
Biomass (biogas)	TJ	365	408	497	555	674	812	928	1'041	1'192	1'272
1A4bi Other sectors (stationary): Residential	TJ	170'156	166'738	180'835	145'117	160'143	171'220	134'072	143'721	149'767	143'669
Gas oil	TJ	108'715	105'296	111'731	86'989	94'103	99'373	75'136	79'406	81'340	76'113
Gas oil heat only boilers	TJ	108'663	105'254	111'695	86'955	94'072	99'344	75'109	79'379	81'312	76'085
Gas oil turbines	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Gas oil engines	TJ	52	42	36	34	32	29	27	27	27	27
Natural gas	TJ	42'385	42'469	48'229	40'910	47'043	50'957	42'367	46'106	48'835	48'344
NG heat only boilers	TJ	41'848	41'931	47'723	40'440	46'577	50'509	41'937	45'676	48'405	47'914
NG turbines	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
NG engines	TJ	537	538	506	470	466	448	430	430	430	430
Other bituminous coal	TJ	400	400	400	300	300	300	200	200	200	100
Lignite	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass (wood, charcoal, bonfires)	TJ	18'656	18'573	20'474	16'917	18'697	20'590	16'369	18'009	19'392	19'112
1A4ci Other sectors (stationary): Agriculture/forestry/fishing	TJ	1'441	1'481	1'427	1'452	1'386	1'094	1'221	1'212	1'571	1'716
Drying of grass	TJ	822	856	739	891	685	458	524	431	492	610
Gas oil	TJ	502	522	451	543	418	106	104	89	86	118
Residual fuel oil	TJ	NO	NO	NO	NO	NO	17	20	22	18	25
Natural gas	TJ	321	334	288	347	267	220	264	233	279	338
Biomass	TJ	NO	NO	NO	NO	NO	114	136	88	109	129
Biomass (wood)	TJ	619	625	688	561	701	636	697	781	1'078	1'106

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 2018).

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 EMIS2019/1A4bi 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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Use of charcoal	GJ	353'637	343'602	343'304	343'419	343'735	342'938	353'938	353'428	333'901	373'755
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)

- 1A4: Activity data (wood, wood waste) of all wood combustion installations in source categories 1A4ai, 1A4bi and 1A4ci have been revised for the entire time series 1990-2016 due to recalculations in the Swiss wood energy statistics (SFOE 2018b). Main recalculations include changes in automatic boilers.
- 1A4bi: Higher use of natural gas in 1A4bi households (residential; +400 GJ) for the year 1990 leads to less use of natural gas in boilers in the commercial sector 1A4ai. This is just a redistribution, no change of total use of natural gas.
- 1A4: The SO_x EF of all gas oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A4ai: Emissions from biogas usage in engines or boilers of gas produced by digestion in agricultural biogas plants were reported in source category 1A1a and 1A4ai in the previous submission. This led to a double counting of emissions. The processes for agricultural digestion have been removed from source category 1A1a and are now only reported in 1A4ai. Further, calculations in the energy model have been revised. This leads to an increase of activity data and emissions for the years 1990-2003 and a decrease of activity data and emissions for the years 2005-2016 in 1A4ai.
- 1A4bi: Activity data of charcoal use in 1A4bi has been updated due to revised data in 1A1c Charcoal production for 2006–2016. In addition the so far interpolated AD values of 1991 and 1992 have been replaced by effective import data of the Swiss overall energy statistics (SFOE 2018).

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 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source categories 1A2 Mobile combustion in manufacturing industry and construction.

Code	Source Category	Pollutant	Identification Criteria
1A2gvii	Mobile Combustion in manufacturing industries and construction	NOx	L1
1A2gvii	Mobile Combustion in manufacturing industries and construction	PM2.5	L1, L2
1A2gvii	Mobile Combustion in manufacturing industries and construction	PM10	L1, L2, T1, T2

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

Methodology (1A2gvii)

Based on the decision tree Fig. 3.1 in chapter Non-road mobile sources and machinery of the EMEP/EEA Guidebook 2016 (EMEP/EEA 2016), 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 (1A2gvii)

- The emission factors are country-specific. Power class and emission standard specific emission factors are shown in Table 3-38 to Table 3-41.
- Emission factors for NO_x, VOC/CH_4, CO, particulate matter are given in FOEN (2015j) and INFRAS (2015a)
- NMVOC is not modelled bottom-up; the NMVOC emissions are calculated as the difference of VOC and CH_4 emissions.
- For SO_x the emission factors are country- and fuel-specific, see implied emission factors 2017 below and Table 3-8 (column diesel oil, gasoline, natural gas)
- Emission factors for NH_3, priority heavy metals and POPs are taken from EMEP/EEA (2016).
- Implied emission factors 2017 are shown in Table 3-42.

Note that all emission factors (in kg/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)[4]. They can be queried by vehicle type, fuel type, power class and emission standard either at aggregated or disaggregated levels.

[4] https://www.bafu.admin.ch/bafu/en/home/topics/air/state/non-road-datenbank.html [05.02.2019]

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	2000	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 2017.

1A2gvii Non-road vehicles and other machinery	NO_x	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	g/GJ								
Gasoline	106	699	0.38	0.09	0.10	0.10	0.10	NA	19'583
Diesel oil	307	26	0.47	0.17	7.8	7.8	7.8	4.5	134
LPG	103	8.8	NA	0.22	0.47	0.47	0.47	0.024	24
Biodiesel	262	23	0.40	0.15	6.6	6.6	6.6	NA	115
Bioethanol	52	258	0.24	0.06	0.07	0.07	0.07	NA	12'105

1A2gvii Non-road vehicles and other machinery	Pb	Cd	Hg	PCDD/ PCDF	BaP	BbF	BkF	IcdP	HCB
	g/GJ	mg/GJ		ng/GJ	mg/GJ				ng/t
Gasoline	0.031	2.23	0.19	2.68	1.02	1.02	0.10	0.30	NA
Diesel oil	NA	2.16	0.11	1.51	0.68	1.13	0.84	0.19	NA
LPG	NA	0.23	NA	NA	0.004	NA	0.004	0.004	NA
Biodiesel	NA	1.85	0.098	1.294	0.58	0.96	0.72	0.16	NA
Bioethanol	0.015	1.44	0.125	1.724	0.66	0.66	0.06	0.19	NA

Activity data (1A2gvii)

Table 3-43 shows the activity data of 1A2gvii 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 2018a). Detailed activity data can be downloaded from the online database INFRAS (2015a).

Table 3-43: Activity data for 1A2gvii.

Source/Fuel	Unit	1990	1995	2000	2005
1A2gvii Non-road vehicles and other machinery	TJ	5'721	6'852	7'636	8'169
Gasoline	TJ	196	224	227	225
Diesel oil	TJ	5'359	6'380	7'106	7'626
LPG	TJ	165	248	294	290
Biodiesel	TJ	NO	NO	9.2	28
Bioethanol	TJ	NO	NO	NO	NO

Source/Fuel	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1A2gvii Non-road vehicles and other machinery	TJ	8'535	8'657	8'779	8'811	8'843	8'875	8'906	8'938	8'944	8'949
Gasoline	TJ	222	221	220	213	206	198	191	184	180	177
Diesel oil	TJ	8'003	8'129	8'254	8'283	8'312	8'341	8'370	8'399	8'380	8'361
LPG	TJ	277	273	269	260	252	243	235	226	215	203
Biodiesel	TJ	33	34	36	54	73	91	110	128	166	205
Bioethanol	TJ	0.003	0.004	0.005	0.26	0.51	0.76	1.02	1.27	1.96	2.65

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

- 1A2gvii: Due to statistical stock changes of reaidual fuel oil consumption in the energy model (see Figure 3-13), stock numbers had to be adjusted for the years 2014 and 2015.
- 1A2gvii: Correction of wrong Pb emission factors in Non-road categories. Values were 100 times too high for gasoline and bioethanol. Also the wrong allocation of Pb emissions for processes with diesel, biodiesel and liquified petroleum gas was deleted.
- 1A2gvii: Due to an error few BC emission factors were missing. This leads to 20-30% higher BC emissions in 1A2gvii.
- 1A2gvii: The wrong allocation of SO_2 emissions from liquefied petroleum gas in the nonroad sector 1A2gvii was deleted for all the years 1990-2016.

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)	LTO: Landing/Take-off
1A3ai(ii)	International aviation CR (civil)	CR: Cruise Memo item - not to be included in national total
1A3aii(i)	Domestic aviation LTO (civil)	LTO: Landing/Take-off Large (jet, turboprop) & small (piston) aircrafts, helicopters
1A3aii(ii)	Domestic aviation CR (civil)	CR: Cruise Large (jet, turboprop) & small (piston) aircrafts, helicopters Memo item - not to be included in national total
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 are reported under “memo items” but are not considered for the national total. These are the emissions from the cruise in civil aviation (see also Figure 3-6; 1A3ai(ii) International aviation CR and 1A3aii(ii) Domestic aviation CR) as well as emissions from international inland waterways.

Table 3-45: Key categories, level 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source categories 1A3 Transport.

Code	Source Category	Pollutant	Identification Criteria
1A3ai(i)	International aviation LTO (civil)	NOx	T1, T2
1A3ai(i)	International aviation LTO (civil)	SO2	T1
1A3bi	Road transport: Passenger cars	NOx	L1, L2, T1, T2
1A3bi	Road transport: Passenger cars	NMVOC	L1, T1, T2
1A3bi	Road transport: Passenger cars	SO2	T1, T2
1A3bi	Road transport: Passenger cars	NH3	L2
1A3bi	Road transport: Passenger cars	PM2.5	L1
1A3bi	Road transport: Passenger cars	PM10	L1
1A3bii	Road transport: Light duty vehicles	NOx	L1, L2, T1, T2
1A3biii	Road transport: Heavy duty vehicles and buses	NOx	L1, L2, T1, T2
1A3biii	Road transport: Heavy duty vehicles and buses	SO2	T1, T2
1A3biii	Road transport: Heavy duty vehicles and buses	PM2.5	T1, T2
1A3biii	Road transport: Heavy duty vehicles and buses	PM10	T1
1A3biv	Road transport: Mopeds & motorcycles	NOx	T2
1A3biv	Road transport: Mopeds & motorcycles	NMVOC	T2
1A3bv	Road transport: Gasoline evaporation	NMVOC	T1
1A3bvi	Road transport: Automobile tyre and brake wear	PM2.5	L1, L2, T1, T2
1A3bvi	Road transport: Automobile tyre and brake wear	PM10	L1, L2, T1, T2
1A3c	Railways	PM2.5	L1, T1
1A3c	Railways	PM10	L1, L2, T1, T2
1A3d	International inland waterways	NOx	T1

3.2.6.2 Methodological issues for 1A3 Transport

3.2.6.2.1 Civil aviation (1A3a)

Methodology (1A3a)

According to the decision tree Figure 3-1 in chapter 1A3a Aviation in EMEP/EEA (2016), 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 and international cruise are 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, 2005, 2007-2017. The results of the emission modelling have been transmitted from FOCA to FOEN in an aggregated form (FOCA 2006, 2006a, 2007a, 2008-2018). FOEN calculated the implied emission factors 1990, 1995, 2000, 2002, 2004, 2005, 2007 and carried out a linear interpolation for the years in-between. The interpolated implied emission factors were multiplied by the annual fuel sold from Swiss overall energy statistics (SFOE 2018), providing the missing emissions of domestic aviation for the years 1991-1994, 1996-1999, 2001, 2003, and 2006. Also, the split of domestic/international is linearly interpolated. Further details of emission modelling are described in FOEN (2019).

Emission factors (1A3a)

The emission factors used are country-specific or taken from the ICAO engine emissions database from EMEP/CORINAIR databases (EMEP/EEA 2016), Swedish Defence Research Agency (FOI) and Swiss FOCA measurements. Emission factors are case sensitive and for that reason separated into emission factors concerning the LTO cycle and cruise phase. Values of EF see Table 3-46.

- NO_x, VOC, CO are differentiated by engine type and by phases of a flight (taxi, take-off etc.)
- NMVOC is calculated as fraction of VOC. For LTO EF(NMVOC) = 0.47 EF(VOC), whereas for cruise EF(NMVOC) = EF(VOC), i.e, there is no emission of CH_4 for the cruise phase.
- SO_2 is based on the suphur content of kerosene (see Table 3-8)
- PM10 and PM2.5 have been determined by the Federal Office of Civil Aviation (FOCA 2016a). For exhaust emissions, PM10 exhaust = PM2.5 exhaust = PM exhaust is assumed. During the high-power operating state of the engines, PM exhaust is equal to BC, during other operating states PM exhaust also contains volatile compounds. FOCA recommends to set EF(PM exhaust) = 2 x EF(BC), see also chapter 1.A.3.a, 1.A.5.b * Aviation of EMEP/EEA (2016), notes to table 3.1 on p.29.
- For non-exhaust emissions as tyre, break and airstrip abrasion, the findings the FOCA provide the weighted non-exhaust emission factor of 0.1 g per LTO-cycle, which is based on 0.08 g per landing of a short-distant flight and 0.27 g per landing of a long-distant flight.
- EF(Pb) is based on the content of the aviation fuels.

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

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.

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 Civil aviation, year 2017. (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	233	102.3	20.8	6.7	6.7	6.7	6.3
Kerosene, domestic, CR	280	52.3	21.9	2.7	2.7	2.7	1.3
Kerosene, international, LTO	309	28.6	23.2	3.0	3.0	3.0	1.9
Kerosene, international, CR	351	8.1	23.2	0.3	0.3	0.3	0.24

1A3a Civil aviation	CO	Pb	PCDD/PCDF	HCB
	kg/TJ	kg/TJ	kg/TJ	kg/TJ
Kerosene, domestic, LTO	2'605	1.88	NE	NE
Kerosene, domestic, CR	572	1.06	NE	NE
Kerosene, international, LTO	293	0.005	NE	NE
Kerosene, international, CR	42	0.004	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 civil aviation. Note that the cruise emissions are included in international bunkers and reported as memo items (1A3ai(ii) and 1A3aii(ii). 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 for the entire territory (based on fuel sold), whereas domestic and international cruise emissions are reported under memo items only.

1A3a Civil aviation	**1990**	**1995**	**2000**	**2005**
	Fuel consumption in TJ			
Kerosene, domestic, LTO	1'050	935	773	518
Kerosene, domestic, CR (not part of national total)	2'401	2'139	1'768	1'184
Kerosene, international, LTO	4'277	5'097	6'507	4'878
Kerosene, international, CR (not part of national total)	37'608	44'821	57'219	42'896
Total Civil aviation	45'334	52'993	66'267	49'477
1990 = 100%	100%	117%	146%	109%

1A3a Civil aviation	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
	Fuel consumption in TJ									
Kerosene, domestic, LTO	514	499	464	509	504	494	525	387	421	384
Kerosene, domestic, CR (not part of national total)	1'109	1'211	1'230	1'306	1'371	1'323	1'396	1'500	1'511	1'257
Kerosene, international, LTO	5'755	5'468	5'643	6'041	6'226	6'208	6'142	6'459	6'529	6'728
Kerosene, international, CR (not part of national total)	52'269	49'958	52'691	56'420	57'677	58'501	58'864	60'874	64'073	66'096
Total Civil aviation	59'646	57'136	60'028	64'277	65'778	66'526	66'927	69'220	72'534	74'465
1990 = 100%	132%	126%	132%	142%	145%	147%	148%	153%	160%	164%

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 Road transport 2016 in EMEP/EEA (2016).
- The non-exhaust air pollutant emissions are calculated by a Tier 2 method based on the decision trees Figs. 3.1 in the chapters 1A3b i-iv Road transport 2016 in EMEP/EEA (2016)

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 differences. 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 differences add up to emissions from fuel sold. Further details to emission modelling of fuel tourism and statistical differences are described in FOEN (2019).

The emission computation is based on emission factors and activity data. For general methods see FOEN (2010i), updated emission factors see Keller et al. (2017) and Hausberger et al. (2017). 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" for gasoline/bioethanol driven PC only)

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, 2010 and 2017 (FOEN 2010i, Keller et al 2017, Hausberger and Matzer 2017). These emission factors are compiled in a database called "Handbook of Emission Factors for Road Transport" (INFRAS 2017a). Version 3.3 is presented and documented on the website http://www.hbefa.net/. The resulting emission factors refer to so-called "traffic situations", which represent characteristic patterns of driving behaviour (i.e. speed profiles) and which serve as a key to the disaggregation of the activity data. They are defined by spatial characteristics (urban/rural areas, three gradient classes), road type, speed limit) and temporal features (levels of services from free flow to stop-and-go). 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.

- All emission factors for exhaust pollutants NO_x, NMVOC, NH_3, CO, PM2.5, PM10 and for Pb are taken from the updated Handbook of Emission Factors for Road Transport (INFRAS 2017a).
- Emission factors for PCDD/PCDF and PAH are taken from the EMEP Guidebook (EMEP/EEA 2016).
- Emission factors for non-exhaust emissions of particulate matter (TSP, PM10, PM2.5, Cd) have been determined in a specific measurement campaign (EMPA/PSI 2009). Details to non-exhaust emission factors can be found in EMIS 2019/1A3b-Strassenverkehr.

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

Table 3-48 shows a selection of implied emission factors for 2017.

Emission factors for fuel tourism and statistical differences: From the territorial model implied emission factors for all pollutants are derived per fuel type (gasoline and diesel oil) corresponding to mean emission factors for Switzerland (containing weighted average over all vehicle categories). These factors are then applied to calculate the emissions resulting from fuel tourism. This approach has been verified by comparing implied emission factors with the neighbouring countries. The differences turned out to be small between Switzerland, Austria, and Germany, which all use emission factors from HBEFA, whereas there were some differences when comparing with France and Italy that use emission factors from another source (COPERT[5]). Therefore, the use of the mean Swiss emission factors is considered to be the consistent approach.

The ERT of the Stage 3 Review (UNECE 2016) recommended that Switzerland increases the completeness of the inventory by estimating (exhaust) 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 2018 or 2019. These are supposed to be integrated in the EMIS inventory for submission 2020 including also cadmium and mercury exhaust emissions. Details of modifications and extensions of the model are documented in Keller et al. (2016).

[5] see Euopean Environment Agency http://www.eea.europa.eu/publications/TEC05 [01.02.2019]

Table 3-48: Implied emission factors for road transport, passenger cars in 2017.

1A3b Road Transportation	NO_X	NMVOC	SO_2	NH_3	PM2.5 ex	PM2.5 nx	PM10 ex	PM10 nx	TSP ex	TSP nx
Gasoline / Bioethanol	kg/TJ									
1A3bi: Passenger cars	32.4	60.9	0.38	14.7	0.82	1.96	0.82	13.0	0.82	13.0
1A3bii: Light duty vehicles	118.1	128.1	0.38	16.1	2.32	1.95	2.32	13.0	2.32	13.0
1A3biii: Heavy duty vehicles	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3biv: Motorcycles	143.6	295.1	0.38	1.4	NE	0.95	NE	6.32	NE	6.32
1A3bv: Gasoline evaporation	NA	5.0	NA	NA	NA	NA	NA	NA	NA	NA
1A3bvii: Automobile road abrasion	NA	NA	NA	NA	NA	IE	NA	IE	NA	IE
1A3bi: Fuel tourism and statistical differnces	37.1	74.2	0.38	14.3	0.82	1.93	0.82	12.9	0.82	12.9

1A3b Road Transportation	BC ex	BC nx	CO	Pb	Cd nx	BaP	BbF	BkF	IcdP	PCDD/PCDF
Gasoline / Bioethanol	kg/TJ			g/TJ	g/TJ	g/TJ	g/TJ	g/TJ	g/TJ	mg/TJ
1A3bi: Passenger cars	0.140	0.196	508	23.9	0.36	0.11	0.13	0.09	0.14	0.001
1A3bii: Light duty vehicles	0.454	0.195	1'789	23.9	0.654	0.11	0.12	0.09	0.13	0.001
1A3biii: Heavy duty vehicles	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3biv: Motorcycles	NE	0.114	3'901	23.9	0.36	0.21	0.24	0.17	0.26	NE
1A3bv: Gasoline evaporation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1A3bvii: Automobile road abrasion	NA	IE	NA	NA	NA	NA	NA	NA	NA	NA
1A3bi: Fuel tourism and statistical differnces	0.14	0.19	629	23.9	0.36	0.12	0.13	0.10	0.14	0.001

1A3b Road Transportation	NO_X	NMVOC	SO_2	NH_3	PM2.5 ex	PM2.5 nx	PM10 ex	PM10 nx	TSP ex	TSP nx
Diesel / Biodiesel	kg/TJ									
1A3bi: Passenger cars	269.1	7.2	0.47	0.4	3.52	2.01	3.52	13.4	3.52	13.4
1A3bii: Light duty vehicles	291.4	6.1	0.47	0.3	8.68	1.83	8.68	12.2	8.68	12.2
1A3biii: Heavy duty vehicles	231.8	5.9	0.47	0.3	3.19	2.25	3.19	15.0	3.19	15.0
1A3biv: Motorcycles	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3bvii: Automobile road abrasion	NA	NA	NA	NA	NA	IE	NA	IE	NA	IE
1A3bi: Fuel tourism and statistical differnces	260	6.7	0.47	0.3	3.97	2.06	3.97	13.7	3.97	13.7

1A3b Road Transportation	BC ex	BC nx	CO	Pb	Cd nx	BaP	BbF	BkF	IcdP	PCDD/PCDF
Diesel / Biodiesel	kg/TJ			g/TJ	g/TJ	g/TJ	g/TJ	g/TJ	g/TJ	mg/TJ
1A3bi: Passenger cars	2.51	0.201	38	NA	0.36	0.63	0.71	0.56	0.59	0.001
1A3bii: Light duty vehicles	6.83	0.183	39	NA	0.62	0.20	0.19	0.06	0.22	0.001
1A3biii: Heavy duty vehicles	2.13	0.225	67	NA	0.61	0.12	0.50	0.54	0.16	0.001
1A3biv: Motorcycles	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3bvii: Automobile road abrasion	NA	IE	NA	NA	NA	NA	NA	NA	NA	NA
1A3bi: Fuel tourism and statistical differnces	2.88	0.21	47	NA	0.46	0.43	0.59	0.50	0.42	0.001

1A3b Road Transportation	NO_X	NMVOC	SO_2	NH_3	PM2.5 ex	PM2.5 nx	PM10 ex	PM10 nx	TSP ex	TSP nx
Gas / Biogas	kg/TJ									
1A3bi: Passenger cars	28.3	0.5	NE	NA	0.7	2.2	0.7	14.3	0.7	14.3
1A3bii: Light duty vehicles	13.23	0.39	NE	NA	1.42	2.47	1.42	16.48	1.42	16.5
1A3biii: Heavy duty vehicles	132	0.9	NE	0.1	0.83	2.35	0.83	15.67	0.83	15.7
1A3biv: Motorcycles	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3bvii: Automobile road abrasion	NA	NA	NA	NA	NA	IE	NA	IE	NA	IE
1A3bi: Fuel tourism and statistical differnces	82.7	0.7	NA	0.1	0.8	2.3	0.8	15.1	0.8	15.1

1A3b Road Transportation	BC ex	BC nx	CO	Pb	Cd nx	BaP	BbF	BkF	IcdP	PCDD/PCDF
Gas / Biogas	kg/TJ			g/TJ	g/TJ	g/TJ	g/TJ	g/TJ	g/TJ	mg/TJ
1A3bi: Passenger cars	NA	0.215	196	NA	0.39	0.13	0.14	0.10	0.15	NA
1A3bii: Light duty vehicles	NA	0.247	497.7	NA	0.83	0.13	0.15	0.11	0.16	NA
1A3biii: Heavy duty vehicles	NA	0.235	84	NA	0.46	0.04	0.05	0.03	0.05	NA
1A3biv: Motorcycles	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A3bvii: Automobile road abrasion	NA	IE	NA	NA	NA	NA	NA	NA	NA	NA
1A3bi: Fuel tourism and statistical differnces	NA	0.23	149	NA	0.45	0.08	0.09	0.07	0.10	NA

1A3b Road Transportation	NO_X	NMVOC	SO_2	NH_3	PM2.5 ex	PM2.5 nx	PM10 ex	PM10 nx	TSP ex	TSP nx
Hydrogen / electricity	kg/TJ									
1A3bi: Passenger cars	NA	NA	NA	NA	NA	6.4	NA	42.9	NA	42.9
1A3bii: Light duty vehicles	NA	NA	NA	NA	NA	6.7	NA	44.7	NA	44.7
1A3biii: Heavy duty vehicles	NA	NA	NA	0.84	NA	10.9	NA	72.8	NA	72.8
1A3biv: Motorcycles	NA	NA	NA	NA	NA	243	NA	1623	NA	1623
1A3bvii: Automobile road abrasion	NA	NA	NA	NA	NA	IE	NA	IE	NA	IE
1A3bi: Fuel tourism and statistical differnces	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

1A3b Road Transportation	BC ex	BC nx	CO	Pb	Cd nx	BaP	BbF	BkF	IcdP	PCDD/PCDF
Hydrogen / electricity	kg/TJ			g/TJ	g/TJ	g/TJ	g/TJ	g/TJ	g/TJ	mg/TJ
1A3bi: Passenger cars	NA	0.64	NA	NA	1.2	NA	NA	NA	NA	NA
1A3bii: Light duty vehicles	NA	0.670	NA	NA	2.2	NA	NA	NA	NA	NA
1A3biii: Heavy duty vehicles	NA	1.09	NA	NA	2.0	NA	NA	NA	NA	NA
1A3biv: Motorcycles	NA	29.22	NA	NA	94.1	NA	NA	NA	NA	NA
1A3bvii: Automobile road abrasion	NA	IE	NA	NA	NA	NA	NA	NA	NA	NA
1A3bi: Fuel tourism and statistical differnces	NO	NO	NO	NO	NO	NO	NO	NO	NO	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 2018b). 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”]).
- The transport performance, i.e. the mileage per vehicle category is an input from Swiss Federal Statistical Office (SFSO 2018c). It is based on periodical surveys/Mikrozensus (ARE 2002, ARE/SFSO 2005, ARE/SFSO 2012). By means of the vehicle stock data (see paragraph above), the specific mileage per vehicle category can be derived (SFOE 2017e, SFOE 2017f, INFRAS 2017).
- Numbers of starts/stops: Derived from vehicles stock, with data on trip length distributions and parking time distributions (ARE/SFSO 2005 and 2012).
- 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/2019 1A3bi-viii “Strassenverkehr”), Consumption of biofuels is provided by the statistics of renewable energies (SFOE 2018a).

The transport performance is attributed to “traffic situations” (characteristic patterns of driving behaviour) which serve as a key to select the appropriate emission factor and which are also available per traffic situation (see above). The relative shares of the traffic situations are derived from a national road traffic model (operated by the Federal Office of Spatial Development, see ARE 2016). 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, and top-down by the total of the mileage per vehicle category. The assignment of traffic situations to the modelled mileage is described in INFRAS (2017). The traffic model in combination with consumption factors (per vehicle category, size class, fuel type, emissions 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 mileage per vehicle category. 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	42'649	41'324	45'613	48'040
LDV	2'600	2'746	2'957	3'228
HDV	1'992	2'107	2'273	2'120
Coaches	108	110	99	106
Urban Bus	174	192	200	229
2-Wheelers	2'025	1'563	1'700	1'785
Sum	49'548	48'042	52'841	55'507
(1990=100%)	100%	97%	107%	112%

Veh. category	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	million vehicle-km									
PC	49'467	50'373	50'949	51'575	52'582	53'493	54'313	55'114	55'726	55'765
LDV	3'415	3'432	3'502	3'635	3'776	3'874	3'998	4'129	4'290	4'221
HDV	2'218	2'164	2'226	2'258	2'229	2'243	2'236	2'235	2'235	2'283
Coaches	114	116	118	122	124	125	128	131	151	133
Urban Bus	228	238	244	250	254	262	267	272	259	285
2-Wheelers	1'850	1'847	1'852	1'894	1'934	1'957	1'992	2'027	2'054	2'051
Sum	57'292	58'171	58'891	59'734	60'899	61'953	62'933	63'908	64'716	64'739
(1990=100%)	114%	116%	117%	119%	121%	123%	125%	127%	129%	131%

Since 1990, the total mileage has been growing by about 1.0 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 1990–2017.

Table 3-50: Specific fuel consumption of road transport. Data are adopted from the territorial road transportation model. They include excess fuel consumption by cold starts.

Veh. cat.	Fuel	1990	1995	2000	2005
		MJ/veh-km			
PC	Gasoline	3.37	3.44	3.35	3.23
	Diesel	3.60	3.61	3.49	3.02
	CNG	NO	NO	NO	NO
LDV	Gasoline	3.32	3.30	3.29	3.31
	Diesel	3.93	3.92	3.81	3.53
HDV	Diesel	11.3	11.2	10.7	11.0
Coach	Diesel	12.4	12.2	11.8	11.7
Urban Bus	Diesel	15.8	15.9	15.5	15.1
	CNG	NO	NO	NO	NO
2-Wheeler	Gasoline	1.24	1.33	1.25	1.33
Average		**3.68**	**3.80**	**3.68**	**3.51**
		100%	**103%**	**100%**	**95%**

Veh. cat.	Fuel	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		MJ/veh-km									
PC	Gasoline	3.12	3.09	3.05	3.02	2.98	2.93	2.89	2.85	2.81	2.77
	Diesel	2.89	2.87	2.85	2.83	2.81	2.80	2.78	2.75	2.71	2.69
	CNG	2.10	2.15	2.10	2.06	2.07	1.99	2.01	1.94	1.99	1.90
LDV	Gasoline	3.33	3.32	3.30	3.29	3.26	3.22	3.17	3.11	3.06	3.02
	Diesel	3.44	3.44	3.44	3.43	3.40	3.37	3.33	3.26	3.20	3.18
HDV	Diesel	10.9	10.9	10.9	10.9	10.9	10.9	10.8	10.7	10.6	10.6
Coach	Diesel	11.6	11.6	11.6	11.7	10.9	10.9	10.8	10.7	11.7	11.7
Urban Bus	Diesel	14.7	14.6	14.5	14.4	14.3	14.3	14.3	14.1	14.0	14.1
	CNG	15.3	15.7	15.5	15.2	15.3	14.7	14.7	14.2	14.7	14.3
2-Wheeler	Gasoline	1.31	1.31	1.31	1.33	1.34	1.32	1.35	1.37	1.35	1.38
Average		**3.40**	**3.35**	**3.33**	**3.30**	**3.25**	**3.21**	**3.17**	**3.12**	**3.08**	**3.06**
		94%	**93%**	**92%**	**91%**	**90%**	**89%**	**88%**	**87%**	**86%**	**85%**

For modelling of evaporative emissions, the stock, mileage, and numbers of stops of gasoline passenger cars and gasoline light duty vehicles are used. For modelling of cold start emissions, also start numbers of passenger cars and light duty vehicles 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, 2012).

Table 3-51: Vehicle stock numbers (gasoline vehicles only – relevant for diurnal evaporation) and average number of starts per vehicle per day (gasoline, diesel oil, and CNG vehicles).

Veh. Category	1990	1995	2000	2005
	stock in 1000 veh. (gasoline/bioeth.)			
PC	2'831	3'041	3'296	3'224
LDV	167	164	148	114
2-Wheelers	764	688	712	746
	starts per veh. per day			
PC	2.61	2.53	2.46	2.40
LDV	1.97	1.97	1.96	1.96

Veh. Category	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	stock in 1000 veh. (gasoline/bioeth.)									
PC	3'044	2'959	2'922	2'892	2'846	2'795	2'747	2'698	2'663	2'614
LDV	92	85	81	77	73	68	65	62	60	58
2-Wheelers	770	767	766	775	780	793	802	804	803	790
	starts per veh. per day									
PC	2.37	2.35	2.34	2.34	2.33	2.33	2.32	2.33	2.33	2.32
LDV	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96

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 (EMEP/EEA 2016), 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 except for catenary abrasion where the share is 20%.

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.
- Exhaust emission factors for NO_x, VOC/CH_4, CO, particulate matter are given in FOEN (2015j) and INFRAS (2015a).
- 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 2017 below and Table 3-8 (column diesel oil)
- PM2.5 non-exhaust emission factors distinguish between passenger and freight rail transport. Details to non-exhaust emission factors can be found in EMIS 2019/1A3c-Schienenverkehr.
- Emission factors for NH_3, priority heavy metals and POPs are taken from EMEP/EEA (2016).
- Implied emission factors 2017 are shown in Table 3-53.

Note that all emission factors (in kg/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.) in 2017

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 2017 for 1A3c Railways. Data per TJ refer to exhaust emissions (ex), whereas data per km refer to non-exhaust emissions (nx).

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	998	116	0.47	182	8.6	0.017	8.6	0.11	8.6	0.15	2.9	NA
Biodiesel	853	99	0.40	155	7.3	NE	7.3	NE	7.3	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	532	NA	2.3	0.12	855	1425	1061	195	0.002	NA
Biodiesel	455	NA	1.9	0.10	731	1219	907	167	0.001	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	0.6	1.7
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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Diesel	TJ	484	488	492	471	451	431	410	390	388	387
Biodiesel	TJ	2.0	2.0	2.1	2.9	3.7	4.4	5.2	5.9	7.7	9.4
Total Railways	TJ	486	490	494	474	455	435	416	396	396	396
1990=100%		125%	126%	127%	122%	117%	112%	107%	102%	102%	102%
tonne-kilometers	Mio. km	11'136	11'318	11'500	11'500	11'500	11'500	11'500	11'500	11'500	11'500
passenger-kilometers	Mio. km	16'800	17'100	17'400	17'400	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 2016 in the EMEP/EEA Guidebook (EMEP/EEA 2016), 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 Lake Geneva and Lake Constance, some of the boats cross the border and go abroad (France, Germany). 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)

- The emission factors are country-specific. Power class and emission standard specific emission factors are shown in Table 3-55 to Table 3-58 (FOEN 2015j).
- Emission factors for NO_x, VOC/CH_4, CO, particulate matter are given in FOEN (2015j) and INFRAS (2015a).
- 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 2017 below and Table 3-8 (column diesel oil).
- Emission factors for NH_3, priority heavy metals and POPs are taken from EMEP/EEA (2016).
- Implied emission factors 2017 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 2017 for 1A3d Navigation.

1A3d Navigation	NO_X	NMVOC	SO_2	NH_3	PM2.5	PM10	TSP	BC	CO
	kg/TJ								
Gasoline	541	385	0.38	0.09	0.36	0.36	0.36	0.018	7'939
Diesel oil	878	267	0.47	0.18	38.4	38.4	38.4	20.6	522
Gas oil	26.3	1.6	9.3	0.042	0.13	0.13	0.13	0.020	6.9
Biodiesel	751	228	0.40	0.16	32.8	32.8	32.8	NA	446
Bioethanol	348	236	0.24	0.055	NA	NA	NA	NA	5'010

1A3d Navigation	Pb	Cd	Hg	BaP	BbF	BkF	IcdP	PCDD/PCDF	HCB
	g/TJ		mg/TJ						
Gasoline	24	2.1	187	1'072	NA	NA	285	0.003	NA
Diesel oil	NA	2.3	122	812	1'354	1'007	198	0.002	NA
Gas oil	NA	NA	NA	NA	NA	NA	NA	NA	NA
Biodiesel	NA	2.0	104	695	1'158	861	169	0.001	NA
Bioethanol	15	1.4	120	691	691	67	184	0.002	NA

Note that all emission factors (in kg/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	1.0	2.9
Bioethanol	TJ	NO	NO	NO	NO
Total Domestic navigation	TJ	1'550	1'517	1'556	1'518
1990 = 100%		100%	98%	100%	98%

1A3d Domestic navigation	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Gasoline	TJ	547	541	535	530	526	522	518	514	512	511
Diesel	TJ	841	854	868	870	872	874	876	878	873	867
Gas oil	TJ	155	157	159	157	156	154	153	151	150	149
Biodiesel	TJ	3.4	3.6	3.8	5.7	7.6	9.5	11.5	13.4	17.3	21.2
Bioethanol	TJ	0.01	0.01	0.01	0.79	1.57	2.35	3.13	3.90	6.25	8.60
Total Domestic navigation	TJ	1'546	1'556	1'565	1'564	1'563	1'562	1'561	1'560	1'559	1'557
1990 = 100%		100%	100%	101%	101%	101%	101%	101%	101%	101%	100%

3.2.6.2.5 Other transportation – pipeline transport (1A3e)

This source category contains only emissions from 1A3ei Pipeline transport of natural gas due to one compressor station of the main gas pipeline.

Methodology (1A3e)

For source 1A3ei Pipeline transport, 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 2016 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 based on different sources which are listed in the section “Gasturbinen; Erdgas” of SAEFL (2000).

Table 3-61: Emission factors of 1A3e for 2017.

1A3ei Pipeline transport	Pollutant	Fuel	Unit	Emission factor 2017
	NO_x	Gas	g/GJ	60
	NMVOC	Gas	g/GJ	0.10
	SO_2	Gas	g/GJ	0.50
	NH_3	Gas	g/GJ	0.60
	PM2.5 exh.	Gas	g/GJ	0.20
	PM10 exh.	Gas	g/GJ	0.20
	TSP exh.	Gas	g/GJ	0.20
	BC exh.	Gas	g/GJ	NA
	CO	Gas	g/GJ	15
	Hg	Gas	mg/GJ	0.20
	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 2018; Table 17e).

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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Natural gas	TJ	1'460	950	830	840	810	410	830	760	340	470
1990=100%		261%	170%	148%	150%	145%	73%	148%	136%	61%	84%

3.2.6.3 Category-specific recalculations for 1A3 Transport

- 1A3ai(ii) Memo item: The emission factor of NMVOC for fuel dumping was 58% too high for the year 2016 under 1A3ai(ii) International aviation / aviation bunkers.
- 1A3b: In the road sector, the ex post analysis 2016 (SFOE 2017e, SFOE 2017f) now forms the basis for the time series up to 2016. For the years starting from 2017 (forecast with current data), the same data basis continues to apply as for Submission 2018, i.e. the FOEN pilot study on greenhouse gas emissions up to 2050 (INFRAS 2017).

  The ex post analysis 2016 contains the following new features:

  - New driving performance for 2016 (slightly higher overall than in the pilot study on greenhouse gas emissions).
  - Specific consumption of passenger cars adjusted in 2016.
  - Time series of fuel sales, thus also adjusted proportions of biofuels, especially 2016.
  - Retrospective adjustments to the fleet composition of motorcycles.
  - NCV from biogas was adjusted to be the same as for natural gas.
  - Further small correction of emission factors due to less rounding.

- An error in the database led to a double count of NH_3 emissions and activity data from biogas in 1A3bi and 1A3biii instead of 1A3biii only.

All these adjustments lead to small changes in emissions in this source category comparing to submission 2018 especially of

- 2-3% lower emissions of Hg
- 2-6% lower emissions for BaP, BbF, BkF, IcdP
- negligible (<1%) higher CO, NMVOC, Pb, PCDD/F and lower NO_x, NH_3, Cd, TSP, PM10, PM2.5, SO_2, Zn emissions

- 1A3b: Correction of wrong BC emission factors, which were 100 times too low for all years except for 1A3biii only in the years 2001-2009, 2011-2014 and 2016. This results in almost 1000% higher emissions for the years 2001-2009, 2011-2014 and 2016 and 50-300% higher emissions in the other years.
- 1A3c, 1A3d: Correction of wrong Pb emission factors in Non-road categories. Values were 100 times too high for gasoline and bioethanol. Also, the wrong allocation of Pb emissions for processes with diesel, biodiesel and liquified petroleum gas was deleted.
- 1A3: Due to recalculations in diesel consumption in Liechtenstein, the total of diesel sold in Switzerland has changed slightly (<1%) for the year 2016. This leads also to recalculation in 1A3bviii of -7%.

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 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source categories 1A4 – Non-road mobile sources and machinery.

Code	Source Category	Pollutant	Identification Criteria
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	NOx	L1, T1
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	PM2.5	L1

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 2016 (EMEP/EEA 2016), 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 1A4aii and 1A4bii only gasoline and bioethanol being used as fuel. In category 1A4cii 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).
- Exhaust emission factors for NO_x, VOC/CH_4, CO, particulate matter are given in FOEN (2015j) and INFRAS (2015a).
- 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 2017 below and Table 3-8 (column gasoline, diesel oil).
- PM2.5 non-exhaust emission factors apply for vehicles in agriculture and forestry. In last year's submission there was a double-counting of the emissions of PM2.5, PM10 and TSP from resuspension of non-road vehicles and machinery in agriculture since they are also included in the particle emissions from source categories 3Dc Soils operation of cropland and 3Dc Soils operation of grassland, see chp. 5.3.2. Therefore, source category 1A4cii Resuspension of non-road vehicles and machinery in agriculture has been deleted.
- Emission factors for NH_3, priority heavy metals and POPs are taken from EMEP/EEA (2016).
- Implied emission factors 2017 for all pollutants are shown in Table 3-65.

Note that all emission factors (in kg/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 2017.

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	1'412	0.38	84	NA	IE	NA	IE	NA	IE	NA	IE
Bioethanol	86	487	0.24	60	NA	IE	NA	IE	NA	IE	NA	IE
1A4bii Other sectors (mobile): Residential												
Gasoline	157	965	0.38	90	NA	IE	NA	IE	NA	IE	NA	IE
Bioethanol	94	477	0.24	60	NA	NA	NA	NA	NA	NA	NA	NA
1A4cii Other sectors (mobile): Agriculture/forestry/fishing												
Gasoline	175	1'477	0.38	80	NA	20	NA	133	NA	200	NA	1.6
Diesel	459	54	0.47	161	41	IE	41	IE	41	IE	27	IE
Biodiesel	393	46	0.40	137	35	IE	35	IE	35	IE	NE	IE
Bioethanol	82	595	0.24	54	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	ng/TJ	mg/TJ
1A4aii Other sectors (mobile): Commercial/institutional										
Gasoline	26'504	24	2.3	0.20	955	955	93	310	2'795	NA
Bioethanol	15'561	15	1.5	0.13	620	620	60	200	1'803	NA
1A4bii Other sectors (mobile): Residential										
Gasoline	25'117	24	2.3	0.20	958	958	93	310	2'800	NA
Bioethanol	15'621	15	1.5	0.13	618	618	60	200	1'806	NA
1A4cii Other sectors (mobile): Agriculture/forestry/fishing										
Gasoline	24'066	24	2.1	0.19	1'062	1'062	104	286	2'576	NA
Diesel	269	NA	2.0	0.11	672	1'120	833	173	1'405	NA
Biodiesel	230	NA	1.7	0.09	575	958	713	148	1'201	NA
Bioethanol	14'768	15	1.3	0.12	712	712	69	179	1'618	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
Bioethanol	TJ	NO	NO	NO	NO
1A4bii Other sectors (mobile): Residential	TJ	142	155	165	166
Gasoline	TJ	142	155	165	166
Bioethanol	TJ	NO	NO	NO	NO
1A4cii Other sectors (mobile): Agriculture/forestry/fishing	TJ	5'429	5'674	5'889	5'642
Gasoline	TJ	1'160	1'070	963	824
Diesel	TJ	4'269	4'604	4'920	4'802
Biodiesel	TJ	NO	NO	6	17
Bioethanol	TJ	NO	NO	NO	NO

Source/Fuel	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1A4ai Other sectors (mobile): Commercial/institutional	TJ	290	289	287	280	273	266	260	253	251	250
Gasoline	TJ	290	289	287	280	273	266	260	253	251	250
Bioethanol	TJ	0.002	0.003	0.004	0.24	0.48	0.72	0.95	1.19	1.90	2.61
1A4bii Other sectors (mobile): Residential	TJ	164	163	163	162	161	160	159	157	157	157
Gasoline	TJ	164	163	163	162	160	159	158	156	155	154
Bioethanol	TJ	0.002	0.003	0.003	0.21	0.43	0.64	0.85	1.1	1.7	2.3
1A4cii Other sectors (mobile): Agriculture/forestry/fishing	TJ	5'612	5'602	5'592	5'573	5'554	5'535	5'517	5'498	5'487	5'477
Gasoline	TJ	743	716	689	665	641	616	592	568	551	535
Diesel	TJ	4'850	4'866	4'882	4'876	4'870	4'864	4'859	4'853	4'835	4'817
Biodiesel	TJ	20	20	21	32	42	53	63	74	96	118
Bioethanol	TJ	0.01	0.01	0.01	0.66	1.3	2.0	2.6	3.3	4.8	6.4

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

- 1A4cii: In last year's submission there was a double-counting of the emissions of PM2.5, PM10 and TSP from resuspension of non-road vehicles and machinery in agriculture since they are also included in the particle emissions from 3Dc Soils operation of cropland and 3Dc Soils operation of grassland. Therefore, source category 1A4ci Resuspension of non-road vehicles and machinery in agriculture has been deleted.
- 1A4cii: Correction of wrong Pb emission factors in Non-road categories. Values were 100 times too high for gasoline and bioethanol. Also the wrong allocation of Pb emissions for processes with diesel, biodiesel and liquified petroleum gas was deleted.

The ERT noted during the Stage 3 review in 2016 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 1A4aii and 1A4bii and they consume gasoline and bioethanol 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 2 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 2016 (EMEP/EEA 2016), 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)

Emission factors 1A5bi military aviation

- NO_x, NMVOC, CO: average emission factors for military aircraft are calculated by the Federal Office of Civil Aviation (FOCA) based on informations from the Federal Department of Defence, Civil Protection and Sport (DDPS) concerning fuel consumption per aircraft type in the year 2016-2017 (DDPS 2018b). These emission factors stay constant for the whole time series from 1990 onwards.

- SO_x: the SO_2 emission factor is taken from the EMEP/EEA Guidebook (EMEP/EEA 2016, Table 3.11, row "Switzerland/CCD") and is assumed to be constant over the period 1990–2017. CCD means climb/cruise/descent.
- TSP, PM10, PM2.5 exhaust: emission factors for TSP, PM10, and PM2.5 exhaust are assumed to be equal. The implied emission factor from territorial processes (means all flights only in Swiss territory) are taken for the years 1990 (15.5 g/GJ), 1995 (7.8 g/GJ), 2000 (4.5 g/GJ) and linearly interpolated in between. From 2015 onwards an average emission factor (3.4 g/GJ) could be calculated by FOCA based on infomrations from DDPS the same way as for NO_x, NMVOC, CO (see explanation above).
- TSP, PM10, PM2.5 nonexhaust: emission factors for TSP, PM10, PM2.5 nonexhaust are assumed to be equal. The implied emission factor (0.0016 g/GJ) from territorial processes (means all flights only in Swiss territory) in the year 1990 are taken for the whole time period.
- BC exhaust: the BC-factor is the same as for civil aviation with 48% from PM2.5 exhaust and constant over the period 1990-2017.
- Implied emission factors 2017 are shown in Table 3-68.

Emission factors of military non-road vehicles and machines

- The emission factors are country-specific.
- Emission factors for NO_x, VOC/CH_4, CO, particulate matter are given in FOEN (2015j) and INFRAS (2015a)
- 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 (column gasoline, diesel oil).
- Emission factors for NH_3, priority heavy metals and POPs are taken from EMEP/EEA (2016).
- Implied emission factors 2017 are shown in Table 3-68.

Note that all emission factors (in kg/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) in 2017.

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	133	774	0.4	0.09	NA	NA	NA	NA	NA	NA	NA	NA
Kerosene	232	33	23.0	NA	3.4	0.002	3.4	0.002	3.4	0.002	1.6	NA
Diesel	402	33	0.5	0.16	9.0	NA	9.0	NA	9.0	NA	4.3	NA
Biodiesel	343	28	0.4	0.13	7.7	NA	7.7	NA	7.7	NA	NA	NA
Bioethanol	72	301	0.2	0.06	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	24'199	23.9	2.3	0.20	964	964	94	309	0.003	NA
Kerosene	235	NA	NA	NA	NA	NA	NA	NA	NA	NA
Diesel	172	0.86	1.9	0.10	632	1'053	783	167	0.001	NA
Biodiesel	147	0.74	1.7	0.09	540	900	669	143	0.001	NA
Bioethanol	15'371	15.4	1.5	0.13	622	622	61	199	0.002	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 (2018a) 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	0.9
Bioethanol	NO	NO	NO	NO

1A5b	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	fuel consumption in TJ									
Military aviation										
Jet kerosene	1'505	1'529	1'592	1'420	1'527	1'542	1'615	1'567	1'627	1'469
Military non-road	268	272	275	275	275	275	275	275	274	273
Gasoline	18	18	18	18	18	17	17	17	17	16
Diesel oil	249	252	256	256	255	255	254	254	252	250
Biodiesel	1.0	1.1	1.1	1.7	2.2	2.8	3.3	3.9	5.0	6.1
Bioethanol	0.0002	0.0003	0.0004	0.023	0.046	0.069	0.092	0.11	0.18	0.25

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

- 1A5b: Correction of wrong Pb emission factors in Non-road categories. Values were 100 times too high for gasoline and bioethanol. Also, the wrong allocation of Pb emissions for processes with diesel, biodiesel and liquified petroleum gas was deleted.
- 1A5b: Due to an error few BC emission factors were missing. This leads to 20-30% higher BC emissions in 1A5b.
- 1A5b: Revision of the emission factors for the main air pollutants in military aviation for all the years 1990-2050. The new emission factors for NMVOC, NO_x and CO are based on country specific calculations from FOCA using fuel consumption per engine type occurring in military aviation in Switzerland. For SO_2 the emission factor from EMEP Guidebook 2016 is used for the whole timeserie 1990 onwards.
These recalculations lead to:
  - 33% higher NMVOC emissions for 1990 and 2% in 2016
  - 70-80% higher NO_x emissions 1990-2016
  - 50-65% lower CO emissions 1990-2016
  - 1% lower SO_2 emissions 1990-2016
- 1A5b: Revision of the emission factors used for TSP, PM10 and PM2.5 exhaust/noneshaust in military aviation for all the years 1990-2050. The new emission factors for exhaust PM emissions for 1990-2000 are based on the mean value from civil aviation only on Swiss territory and are linearly interpolated to 2015. The value for 2015 is based on country specific calculations from FOCA using fuel consumption per engine

type occuring in military aviation in Switzerland. It is assumed that TSP exhaust = PM2.5 exhaust = PM10 exhaust. The emission factors stay constant from 2015 onwards. For nonexhaust emission factor the mean value from civil aviation on Swiss territory is used for the years 1990-2050.
These recalculations lead to:

- 30% higher PM2.5 emissions in 1990 down to 5% lower PM2.5 emissions in 2016
- 4% higher PM10 emissions in 1990 down to 61% lower PM10 emissions in 2016
- 10% lower TSP emissions in 1990 up to 71% lower TSP emissions in 2016

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 (2016), 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 TSP, PM10 and PM2.5 are based on EMEP/EEA (2016). No literature BC-factors are available for coal turnover. It is assumed that coal persists of 60% of carbon and that the share is equal independent of its size.

Table 3-71: Emission factors in 1B1 Fugitive emissions from solid fuels in 2017.

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 2018).

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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1B1a Coal handling	Other bituminous coal imported	t	261'466	247'002	248'060	230'305	206'436	222'598	233'487	213'788	197'752	189'824

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

There are no category-specific recalculations for 1B1 Fugitive emissions from solid fuels.

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 i	Fugitive emissions oil: Exploration, production, transport	Oil production is not occurring in Switzerland. Emissions only stem from pipeline transport.
1B2a iv	Fugitive emissions oil: Refining / storage	Emissions from Claus-units in refineries.
1B2a v	Distribution of oil products	Distribution of oil products (gasoline distribution).
1B2b	Fugitive emissions from natural gas (exploration, 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 Categories, level 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 1B2 Oil and Natural Gas

Code	Source Category	Pollutant	Identification Criteria
1B2aiv	Fugitive emissions oil: Refining / storage	SO2	L2, T2
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.

1B2ai Exploration, production, transport of oil – pipeline transport: Crude oil is imported only by underground pipelines. Emissions are estimated using the emission factor from 2006 IPCC Guidelines (IPCC 2006) per tonne crude oil imported,

1B2aiv Refining and storage - leakage and emissions from Claus-units in refineries: Following the decision tree, Figure 3-1 in EMEP/EEA (2016), emissions due to leackage reported under 1B2aiv 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 these emissions.

1B2av Distribution of oil products - gasoline distribution: Following the decision tree, Figure 3-1 in EMEP/EEA (2016), emissions reported under 1B2av are estimated using a Tier 2 approach where technology-specific activity data and emission factors are available. Basis for the method is a database of Swiss storage tanks and gasoline vapour recovery systems. For this database, a model is used in which data is calibrated with spot checks of the gas recovery systems of gas stations. Further information is provided in the EMIS database (EMIS 2019/1B2av Benzinumschlag Tanklager, EMIS 2019/1B2av Benzinumschlag Tankstellen).

1B2b Fugitive emissions from natural gas

In source category 1B2b Fugitive emissions from natural gas, fugitive emissions from production and from pipeline transport of natural gas are reported. Therefore, only NMVOC emissions are occur in this source category.

Production of natural gas

Emissions from natural 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 (2016) for 1B2ai and 1B2b (Fugitive emissions - Exploration production transport) emissions resulting from natural gas production under 1B2b Natural gas are estimated using a Tier 2 approach where technology specific activity data and specific emission factors are available.

Transport of natural gas

For emission calculations concerning natural gas transport (including transmission, distribution and other leakage), 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 composition of the gas lost.

Source category 1B2b covers emissions from gas transport and includes emissions from transport in 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 this source category. 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 are also included. 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 tree in EMEP/EEA (2016). Emissions 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 (2016).

Note that 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, Figure 3-1 in EMEP/EEA (2016), 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

1B2ai Exploration, production, transport of oil – pipeline transport of crude oil: NMVOC emission factors for pipeline transport of crude oil in 1B2aiii a Tier 1 emission factor is taken from 2006 IPCC Guidelines (IPCC 2006), table 4.24. Values provided in Table 3-75 are converted using a crude oil density of 0.82 t/m3.

1B2aiv, NMVOC from leakage in refineries: The emission factor of NMVOC for 1B2aiv, leakage in refineries is country-specific and is documented in the EMIS database (EMIS 2019/1B2aiv_Raffinerie, Leckverluste). It is delineated from an emission estimation project in one of the refineries in 1992 called CRISTAL (Raffinerie de Cressier 1992). The estimation from the other refinery is assumed to be twice as high, because the technology of the plant is older. Then a weighted mean based on the quantity of crude oil used in both refineries was calculated (for further details see the internal documentation of the EMIS database, EMIS 2019/1B2aiv). This emission factor is used for all the years until 1995. For the years 2007-2016 total NMVOC emissions from 1A1b, 1B2aiv and 1B2c correspond to those reported in the Swiss PRTR (PRTR 2018) database from the two refineries. Therefore emission factors in 1B2aiv are adapted to reach the total NMVOC emission reported in Swiss PRTR. Between the years 1995 and 2007 the emission factors are interpolated linearly.

1B2aiv, SO_2 emission factors from Claus-units: 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).

1B2av Distribution of oil products - gasoline distribution: The emission factors of NMVOC from 1B2av are country-specific and are provided by Weyer und Partner (Schweiz) AG using a database of Swiss storage tanks and gasoline vapour recovery systems.

1B2b Fugitive emissions from natural gas

Production of natural gas

For natural gas production occurring in the years 1985-1994, NMVOC default emission factors are taken from the 2006 IPCC Guidelines (IPCC 2006) as documented in the internal emission database documentation (EMIS 2019/1B2b Gasproduktion).

Transport of natural gas

Emission factors of NMVOC for gas transport (transmission and distribution) as well as emissions from accidents in the gas pipeline are based on a study by Quantis (2014). They are calculated based on the average NMVOC concentrations of natural gas and its average net calorific value in Switzerland as described in Quantis (2014) and in the EMIS database (EMIS 2019/1B2b 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.

Since Submission 2017, the net 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 1B2c Venting and flaring are based on data from the refining industry as documented in the EMIS database (EMIS 2019/1B2c 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 2017 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 2017.

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	C
1B2a Refinery	NMVOC	Crude oil transported	g/t	C
1B2a Refinery Claus units	SO_2	Crude oil	g/t	C
1B2b Gas distribution losses, Transit	NMVOC	Natural gas	g/GJ	1'400
1B2b Gas distribution losses, Distribution	NMVOC	Natural gas	g/GJ	1'400
1B2b Gas distribution losses, Other	NMVOC	Natural gas	g/GJ	1'400
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 1B2ai and 1B2aiv are based on the use and transport of crude oil. The Swiss petroleum association provides data on an annual basis (EV 2018). For 1B2aiv, activity data of the crude oil for the “Claus units” are based on data from the Swiss petroleum association (EV 2018) and the Swiss overall energy statistics (SFOE 2018).

The activity data for 1B2av concerning fugitive emissions from storage tanks and gasoline stations are gasoline sales based on the Swiss overall energy statistics (SFOE 2018), corrected for consumption of Liechtenstein, as documented in the EMIS database (EMIS 2019/1B2av Benzinumschlag Tanklager, EMIS 2019/1B2av Benzinumschlag Tankstellen).

1B2b Fugitive emissions from natural gas

Production of natural gas

Note that production of natural gas only occurred until 1994 in Switzerland. Activity data are based on Swiss overall energy statistics (SFOE 2018)

Transport of natural gas

For gas transmission, distribution and other leakage, the activity data have been reassessed in a study by Quantis (2014) and are documented in the EMIS database (EMIS 2019/1B2b Diffuse Emissionen Erdgas). The activity data represent the amount of natural gas lost from the gas network.

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 2019/1B2b Diffuse Emissionen Erdgas).

The calculation of losses from distribution network 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. This amount is added 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. Depending on the process, a second, third or fourth order polynomial interpolation is applied.

For significant emission events due to accidents the Swiss Pollutant Release and Transfer Register is considered. So far, two events have been reported by the transit pipeline operator, one in 2010 and one in 2011.

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. 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	156'516	151'672	168'353	152'182
1B2a Refining and transport	Crude oil used	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	28'226	30'874	32'571	33'491
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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2017 to 1990
1B2a Gasoline distribution	Gasoline sold	TJ	142'904	139'067	134'129	128'941	124'386	118'717	113'954	105'664	102'367	99'223	-37%
1B2a Refining and transport	Crude oil used	t	5'133'000	4'833'000	4'546'000	4'452'000	3'455'000	4'935'000	C	C	C	C	C
1B2b Gas production	Natural gas	GJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	-
1B2b Gas distribution losses, Transit	Natural gas	GJ	34'572	34'586	34'595	34'569	34'483	34'852	35'125	35'468	35'743	35'813	27%
1B2b Gas distribution losses, Distribution	Natural gas	GJ	471'734	459'197	449'418	441'857	435'545	399'993	389'310	388'251	390'185	390'968	-45%
1B2b Gas distribution losses, Other	Natural gas	GJ	NO	NO	35'444	28'114	NO	NO	NO	NO	NO	NO	-
1B2c2 Venting and flaring	Crude oil used	t	5'133'000	4'833'000	4'546'000	4'452'000	3'455'000	4'935'000	C	C	C	C	C

3.3.2.3 Category-specific recalculations for 1B2 Oil, natural gas, venting/flaring

- 1B2a: The NMVOC and CH_4 emissions of leakage losses in refineries have been modified in such a way that the total NMVOC emissions from refineries (i.e. 1A1b + 1B2 excluding pipeline transport) from 2007 onwards are the same as those reported in the PRTR (PRTR 2018) database. The emission factors are now interpolated linearly from 1995 to 2007. For the years before 1995 the emission factors were taken from a study carried out at that time and have not been changed. The ratio CH_4:NMVOC remains 1:10 over the entire period.
- 1B2b: The calorific value is rounded less strongly in the calculation model, therefore a slight shift in the calculation of activity data and emission factors of CH_4 and NMVOC occured.
- 1B2c: Emission factors for flaring in refineries changed due to less rounding. This results in 30% less NO_x, 50% less NMVOC and 10% less SO_2 emissions for the year 2016.

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 2017 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 emissions of SO_x and particulate matter. Industrial processes and product use are also important sources for 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 2004 with a slight decreasing trend afterwards. The trend until 2004 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 2017, the largest shares in source category 2D come from 2D3a Domestic solvent use including fungicides and 2D3d Coating applications 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 for all commercial and industrial applications show a significant decrease between 1990 and 2004. 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 and replacing of conventional paints by powder coatings. In 1990 the NMVOC emissions from 2D3d Coating applications are dominated by the emissions from paint application in construction. In 2017 emissions from paint application in construction and on wood contributed about comparable amounts.

The NMVOC emissions from the most important single source category 2D3a Household cleaning agents increase between 1990 and 1998, then they drop until 2001. From 2002 until

2017, 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 2017 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 1990–2017. In addition, general technological improvements and post-combustion installations contribute to further emission reductions.

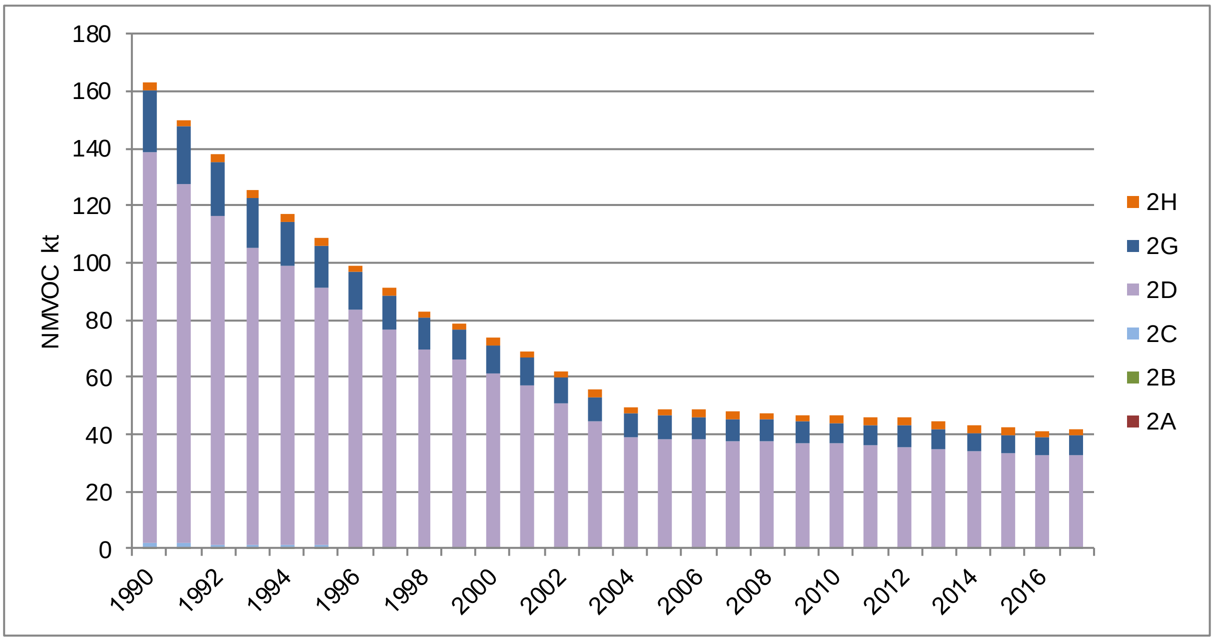


Figure 4-1: Switzerland’s NMVOC emissions from industrial processes and product use by source categories 2A-2D and 2G-2H between 1990 and 2017. The corresponding data table can be found in Annex A7.3.

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 about 50% in the period 1990-2017. Since 2013, there is again an increase in SO_2 emissions. 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 2017, 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 2017. In 2017, 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 primary 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.

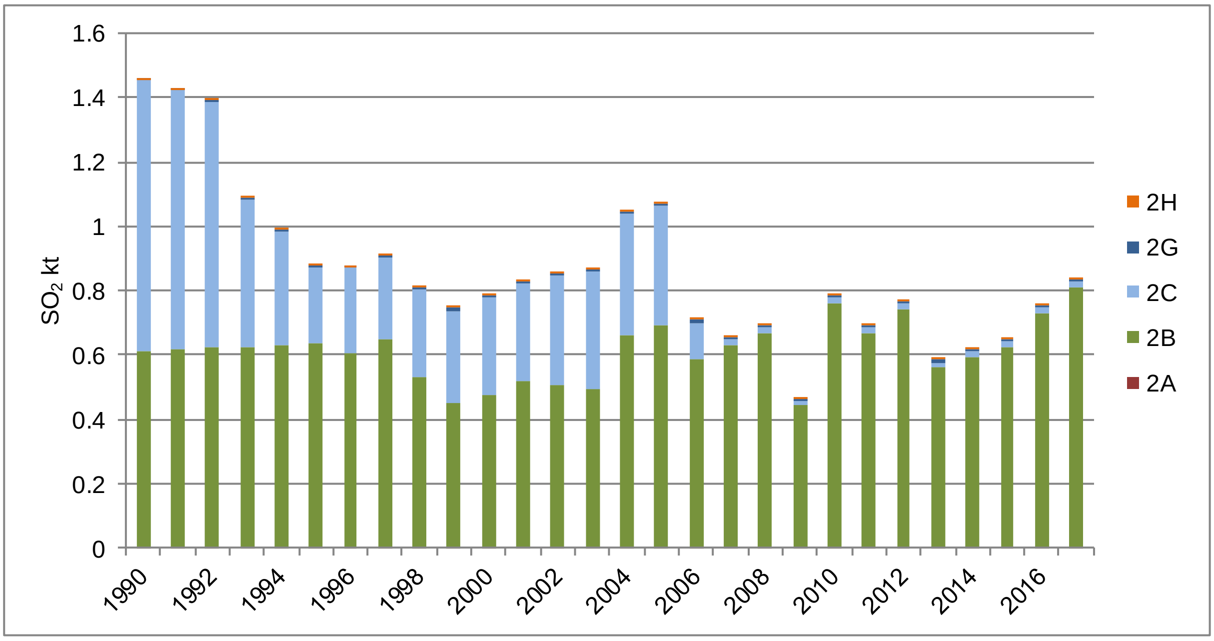


Figure 4-2: Switzerland's SO_2 emissions from industrial processes and product use by source categories 2A–2C and 2G-2H between 1990 and 2017. The corresponding data table can be found in Annex A7.3.

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. Since 2013 emissions are fluctuating with a slight decreasing trend. In 1990, the source categories 2A Mineral products, 2C Metal production, 2G Other product use and 2H Other contribute the most to the total PM2.5 emissions. In 2017, the highest contribution to the total PM2.5 emissions is due to the source categories 2A, 2G and 2H. The other source categories are of minor importance in 2017. 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 time period. 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 2017 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, i.e. from the use of fireworks and tobacco, remained about constant between 1990 and 2013 and show a slight decreasing trend since then. In 1990, 2G emissions were dominated by tobacco use. In 2017, tobacco use is still the major emission source but also the use of fireworks contributed considerable amounts. The emissions in 2H Other remain about constant since 1990. In this source category, the main contributions arise from 2H1 Chipboard and fibreboard production.

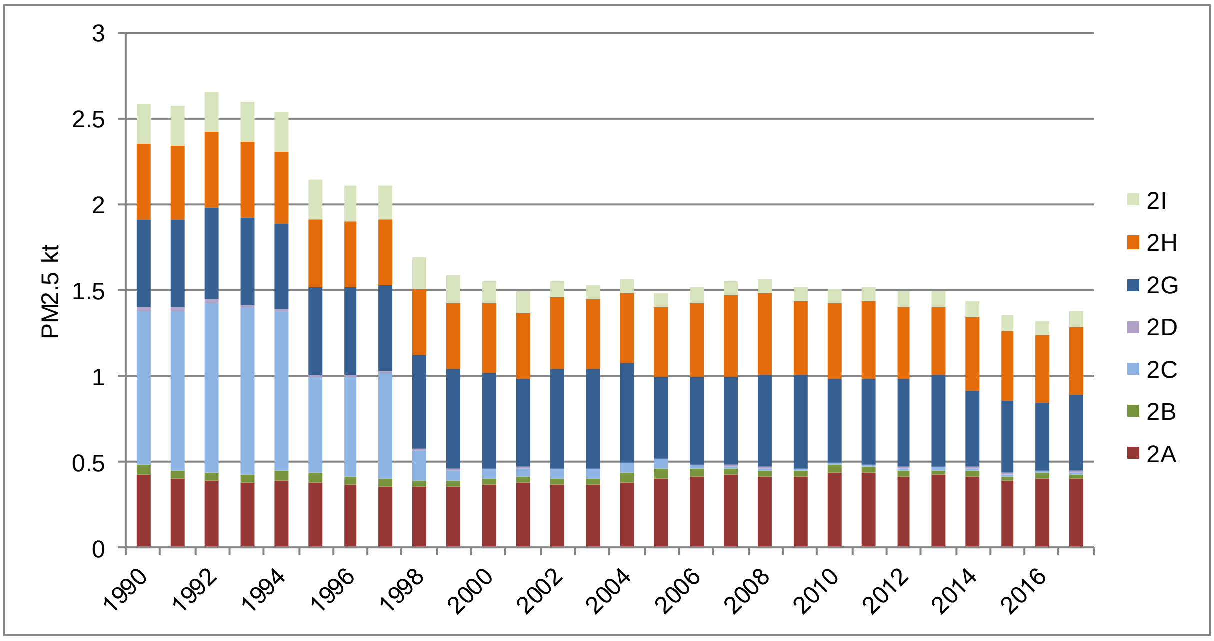


Figure 4-3: Switzerland's PM2.5 emissions from industrial processes and product use by source categories 2A-2D and 2G-2I between 1990 and 2017. The corresponding data table can be found in Annex A7.3.

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 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 2A Mineral products in Switzerland

Code	Source Category	Pollutant	Identification Criteria
2A1	Cement production	PM2.5	L2, T2
2A1	Cement production	PM10	L2
2A5a	Quarrying and mining of minerals other than coal	PM2.5	L1, L2, T1, T2
2A5a	Quarrying and mining of minerals other than coal	PM10	L1, L2, T1, T2

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 (2016), 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 (2016), 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 2019/2A1. 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 PM2.5 exh.) is taken from EMEP/EEA (2013).

Table 4-3: Emission factors for blasting operations of 2A1 Cement production in 2017.

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	0.015	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 2019/2A1_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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
clinker	kt	3'461	3'443	3'642	3'587	3'368	3'415	3'502	3'195	3'296	3'279

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 (2016), emissions from blasting operations in the quarry are determined by a Tier 2 method using country-specific emission factors (EMIS 2019/2A2). 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 (2016), 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 2019/2A5a). 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 2017.

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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Gravel plants	kt gravel	46'560	48'310	50'540	51'940	49'780	53'940	53'090	50'610	52'750	52'063
Plaster production	kt rocks	295	293	335	293	271	213	166	140	148	146

4.2.3 Category-specific recalculations

Recalculations in 2A Mineral products

- 2A5a: Last year's extrapolated activity data of 2A5a Gravel plants for 2016 has been revised based on effective production data from the 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 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 2B Chemical industry

Code	Source Category	Pollutant	Identification Criteria
2B5	Carbide production	SO2	L1, L2, T1, T2
2B10a	Other Chemical industry	SO2	L2, T2

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 (2016), the emissions from 2B1 Ammonia production are calculated by a Tier 2 method using plant-specific emission factors documented in EMIS 2019/2B1.

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 2013 – 2017 is applied.

Table 4-9: Emission factor for 2B1 Ammonia production in 2017.

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 1990-2017. 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 (2016), 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 2019/2B2).

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 2017.

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 (2016), 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 2019/2B5). 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 2017.

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. 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 (2016), emissions from 2B10a Chemical industry are calculated by a Tier 2 method using plant-specific emission factors (EMIS 2019/2B10a).

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 2019/2B10 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 2017.

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	NA
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 2019/2B10 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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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	18	28	20	18	12	10	C	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, which are available for 2009, 2012, 2013 and 2016 as documented in EMIS 2019/2B10 2B10 Ammoniumnitrat Produktion. From 1990-2013 average emission factors are applied based on the measurements from 2009, 2012 and 2013. 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 2019/2B10 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 was produced by chlorinealkaline electrolysis in a mercury-cell process until 2016. In the course of 2016, the production has been switched to mercury-free membrane process technology. Thus, from 2017 onwards, there are no more Hg emissions.

Emission factors

The emission factor for Hg from chlorine gas production by chlorinealkaline electrolysis in a mercury-cell process between 1990 and 2016 in Switzerland is plant-specific and based on measurement data from industry and expert estimates documented in EMIS 2019/2B10 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 2019/2B10 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 2019/2B10 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 2019/2B10 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 2019/2B10 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 2019/2B10 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 2019/2B10 PVC-Produktion).

Activity data

The annual amount of PVC produced is based on data from industry and expert estimates documented in EMIS 2019/2B10 PVC-Produktion (see Table 4-13).

4.3.3 Category-specific recalculations

Recalculations in 2B Chemical industry

- 2B1: Air pollution control measurements of NH_3 emissions at the ammonia production plant in 2017 result in revised average values of the NH_3 EF for the years 2002-2010 and 2012.

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 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 2C Metal production

Code	Source Category	Pollutant	Identification Criteria
2C1	Iron and steel production	PM2.5	T1, T2
2C1	Iron and steel production	PM10	T1, T2

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 (2016), the emissions from 2C1 Iron and steel production are calculated by a Tier 2 method using country-specific emission factors (EMIS 2019/2C1).

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. 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 2017.

2C1 Iron and steel 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
Iron production, electric melting furnace	g/t iron	NA	33	NA	NA	7	NA	10	NA	13	NA	0.03	93
Iron production, other processes	g/t iron	10	4'000	NA	70	NA	50	NA	130	NA	150	NA	4'000
Steel production, electric melting furnace	g/t steel	140	70	14	NA	6	NA	8	NA	9	NA	0.02	700
Steel production, rolling mill	g/t steel	NA	40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

2C1 Iron and steel production	Unit	Pb	Cd	Hg	PCDD/ PCDF	BaP	BbF	BkF	IcdP
Iron production, electric melting furnace	mg/t iron	320	1.3	NA	0.00013	NA	NA	NA	NA
Iron production, other processes	mg/t iron	NA	NA	NA	0.0013	NA	NA	NA	NA
Steel production, electric melting furnace	mg/t steel	200	4	40	0.00011	0.8	3.4	0.9	2.2
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.

2C1 Iron and steel production	Unit	1990	1995	2000	2005
Iron production, electric melting furnace	kt	80	70	65	35
Iron production, other processes	kt	170	130	120	67
Steel production, electric melting furnace	kt	1'108	716	1'022	1'159
Steel production, other processes	kt	1'108	716	NO	NO
Steel production, rolling mill	kt	1'108	716	1'022	1'082

2C1 Iron and steel production	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Iron production, electric melting furnace	kt	41	34	40	46	34	34	33	28	26	27
Iron production, other processes	kt	78	49	53	61	46	45	43	37	34	35
Steel production, electric melting furnace	kt	1'315	935	1'218	1'322	1'252	1'231	1'315	1'296	1'238	1'270
Steel production, other processes	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Steel production, rolling mill	kt	1'269	850	1'082	1'183	1'162	1'126	1'176	1'144	1'085	1'138

4.4.2.2 Aluminium production (2C3)

Methodology (2C3)

Today, there is no more primary 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 (2016), emissions from source category 2C3 are calculated by a Tier 2 method using country-specific emission factors (EMIS 2019/2C3).

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 2017.

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.

2C3 Aluminium production	Unit	1990	1995	2000	2005
	kt	87	21	36	45

2C3 Aluminium production	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	kt	NO	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 (2016), emissions from source category 2C7a are calculated by a Tier 2 method (EMIS 2019/2C7a) 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 2017.

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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Foundries of non-ferrous metals	kt	21	15	20	12	18	6.8	7.4	6.8	6.6	6.1

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 (2016), emissions from source category 2C7c are calculated by a Tier 2 approach (EMIS 2019/2C7c) 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.

Since 2003 emission factors of NO_x, SO_2, TSP, CO, Pb, Cd, Hg and PCDD/F are assumed constant based on air pollution control measurements from 2003 and 2012.

Emission factors of NMVOC and NH_3 are also based on air pollution control measurements from 2003 and 2012. Emission factors are assumed constant for the entire time period.

All emission factors of battery recycling are confidential. These data are available to reviewers on request.

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 2017.

2C7c Other metal	Unit	NO_x	NMVOC	SO_2	NH_3	PM2.5	PM2.5	PM10	PM10	TSP	TSP	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	C	C	C	C	C	NA	C	NA	C	NA	NE	C

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	C	C	C	C

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 2019/2C7c_Batterie-Recycling, EMIS 2019/2C7c_Verzinkereien).

Activity data of battery recycling are confidential. These data are available to reviewers on request.

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	C	C	C	C

2C7c Other metal production	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Galvanazing plants	kt	92	85	93	96	92	92	91	91	91	90
Battery recycling	kt	C	C	C	C	C	C	C	C	C	C

4.4.3 Category-specific recalculations

Recalculations in 2C Metal production

- There are no category-specific recalculations for 2C Metal production.

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 (ceased in 2015)
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 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 2D Other solvent use

Code	Source Category	Pollutant	Identification Criteria
2D3a	Domestic solvent use	NMVOC	L1, L2, T1, T2
2D3b	Road paving with asphalt	NMVOC	L1, T1
2D3d	Coating applications	NMVOC	L1, L2, T1, T2
2D3e	Degreasing	NMVOC	L1
2D3g	Chemical products	NMVOC	L1, L2, T1, T2
2D3h	Printing	NMVOC	L1, T1
2D3i	Other solvent use	NMVOC	L1, L2

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 (2016), the emissions are calculated by a Tier 2 method (EMIS 2019/2D3a) 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 (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 a Swiss study conducted in 2013/2014. This study provided more accurate data of aerosol contents of domestic spray cans 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. It is assumed constant for the time period since 1998.

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 2017

2D3a Domestic solvent use	Unit	NMVOC
Household cleaning agents	g/inhabitant	977
Domestic use of spray cans	g/inhabitant	360
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 2018a).

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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	inhabitants	7'711'000	7'801'000	7'878'000	7'912'000	7'997'000	8'089'000	8'189'000	8'282'000	8'373'000	8'452'000

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 (2016), 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 2019/2D3b. 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 2017.

2D3b Road paving with asphalt	Unit	NMVOC	PM2.5 exh.	PM10 exh.	TSP exh.	BC exh.
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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Asphalt concrete	kt	5'160	5'200	5'250	5'300	4'770	4'770	5'260	4'850	4'710	5'260

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 (2016), the emissions of NMVOC from Asphalt roofing are determined by a Tier 2 method based on country-specific emission factors as documented in EMIS 2019/2D3c. Emissions of PM2.5, PM10, TSP and CO are determined based on a Tier 1 method using default emission factors (EMEP/EEA 2016). In previous submissions, four processes related to asphalt roofing were differentiated, i.e. production of sheeting, production of prime coat, laying of sheeting and use of prime coat. For this submission, these processes were aggregated and revised resulting in an implied emission factor for the entire asphalt roofing process.

Emission factors (2D3c)

The NMVOC emission factors from Asphalt roofing are based on information from the industry association, literature and expert estimates as documented in the EMIS database. Tier 1 emission factors of CO and PM10 are taken from the EMEP/EEA Guidebook 2016 (EMEP/EEA 2016).

Table 4-29: Emission factors of 2D3c Asphalt roofing in 2017.

2D3c Asphalt roofing	Unit	NMVOC	PM2.5 exh.	PM10 exh.	TSP exh.	BC exh.	CO
Asphalt roofing	kg/t sheeting	5.40	0.05	0.2	1.0	0.000005	0.01

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
Asphalt roofing	kt sheeting	54	56	58	51

2D3c Asphalt roofing	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Asphalt roofing	kt sheeting	55	61	68	74	74	73	73	73	72	72

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 (2016), 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 2017, the most important emission sources are 2D3d Paint application in construction, 2D3d Paint application, wood and 2D3 Paint application, industrial.

Emission factors (2D3d)

Emission factors for NMVOC are derived from the solvent contents of the paints and thinners based on data from the Swiss association for coating and paint applications (VSLF) and retailers as documented in the EMIS database (EMIS 2019/2D3d). The emission factors for all commercial and industrial coating applications declined significantly between 1990 and 2004 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). But since 2004, their mean solvent content has remained about constant. For paint application, wood and paint application, car repair, even a slight increase in solvent content has been observed in the last few years. Source category 2D3d Paint application, households has been updated substantially based on a comprehensive study including all major Swiss DIY (do it yourself) companies resulting in revised emission factor values from 1999 onwards.

Table 4-31: Emission factors of 2D3d Coating applications in 2017.

2D3d Coating applications	Unit	NMVOC
Paint application, construction	kg/t paint	61
Paint application, households	kg/t paint	65
Paint application, industrial	kg/t paint	282
Paint application, wood	kg/t paint	319
Paint application, car repair	kg/t paint	550

Activity data (2D3d)

The activity data correspond to the annual consumption of paints which are estimated according to information from VSLF and relevant retailers for paint applications in households (EMIS 2019/2D3d). In submission 2019, source category 2D3d Paint application, households has been updated substantially based on a comprehensive study including all major Swiss DIY companies resulting in revised activity data from 1999 onwards. Between 1990 and 1998, the total consumption of paint decreased considerably, increased continuously from 2004 onwards and dropped again after 2013. This trend results from the opposing trends in the different source categories:

- 2D3d Paint application, construction: The paint consumption in construction shows a substantial reduction compared to 1990 levels. The increasing tendency in paint application between 2001 and 2013 and the drop afterwards can be explained to a certain extent by the evolution in the construction activity in Switzerland. Before 2001, there was a decline in construction activity, which explains the decreasing tendency in paint application.
- 2D3d Paint application, wood: The paint consumption for applications on wood increased moderately between 1990 and 1998. But from 2001 onwards it shows a comparable development as the paint application in construction.

- 2D3d Paint application, industrial & non-industrial: Between 1990 and 2016, the activity of industrial and non-industrial paint application decreased significantly. There was a clear decrease between 2001 and 2004 due to structural changes in the industrial sectors and a widespread application of powder coatings from 2004 onwards. Since powder coatings are solvent-free their amounts are not included in the activity data.

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	12
Paint application, industrial	kt	20	21	21	5.7
Paint application, wood	kt	6.0	6.3	6.5	7.7
Paint application, car repair	kt	2.7	2.2	2.0	1.9

2D3d Coating applications	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Paint application, construction	kt	48	51	54	56	59	61	42	42	40	41
Paint application, households	kt	11	11	11	11	11	11	10	10	10	10
Paint application, industrial	kt	5.7	5.5	5.3	5.2	5.1	5.0	5.0	5.0	5.0	5.0
Paint application, wood	kt	8.7	9.3	10	10	10	10	7.2	6.7	6.3	6.3
Paint application, car repair	kt	1.8	1.7	1.7	1.5	1.4	1.2	1.1	1.0	0.9	0.9

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 (2016), the NMVOC emissions from 2D3e Degreasing are calculated by a Tier 2 method (EMIS 2019/2D3e) 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 2017.

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 2019/2D3e). 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 2019/2D3e).

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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Cleaning of electronic components	kt	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Degreasing of metal	kt	2.3	2.2	2.1	2.0	1.9	1.9	1.9	1.9	1.9	1.9
Other industrial cleaning	kt	1.2	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 (2016), the NMVOC emissions from 2D3f Dry cleaning are calculated by a Tier 2 method (EMIS 2019/2D3f) using country-specific emission factors.

For the submission 2019, the source category 2D3f Dry cleaning has been revised completely from 2001 onwards based on information and data from the Swiss supervising association of textile cleaning (VKTS), emission control authority and Swiss federal statistical office (SFSO).

Emission factors (2D3f)

Emission factors for NMVOC are estimated based on information from the emission control authority and analysis of about 170 VKTS inspection protocols from the four biggest Swiss cantons (AG, BE, VD and ZH) of 2017 as documented in the EMIS database.

Table 4-35: Emission factors of 2D3f Dry cleaning in 2017.

2D3f Dry cleaning	Unit	NMVOC
	kg/t solvent	900

Activity data (2D3f)

For dry cleaning, activity data is the amount of tetrachloroethylene (PER) and non-halogenated solvents used. The activity data from 2001 onwards has been calculated based on the (annual) number of dry-cleaning facilities in Switzerland according to VKTS and SFSO (business census) and the mean solvent consumption per facility based on an analysis of about 170 VKTS inspection protocols from the four biggest Swiss cantons (AG, BE, VD and ZH) of 2017. Activity data for 1990 are based on net imports of PER. For the years in between, data are interpolated linearly.

Table 4-36: Activity data of 2D3f Dry cleaning.

2D3f Dry cleaning	Unit	1990	1995	2000	2005
solvent	kt	1.300	0.767	0.234	0.097

2D3f Dry cleaning	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
solvent	kt	0.091	0.086	0.081	0.076	0.074	0.072	0.072	0.071	0.071	0.070

4.5.2.7 Chemical products (2D3g)

Methodology (2D3g)

Based on the decision tree Fig. 3.1 in chapter 2D3g in EMEP/EEA (2016), for source category 2D3g Chemical products a Tier 2 method using country-specific emission factors is used for calculating the NMVOC emissions (EMIS 2019/2D3g).

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 (ceased production in 2015): 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 2017.

2D3g Chemical products	Unit	NMVOC
Fine chemicals production	t/production index	3.5
Glue production	kg/t glue	0.80
Handling and storing of solvents	t/production index	1.7
Ink production	kg/t ink	8.4
Paint production	kg/t paint	3.3
Pharmaceutical production	kg/t pharmaceuticals	7.5
Polyester processing	kg/t polyester	50
Polystyrene processing	kg/t polystyrene	15
Polyurethane processing	kg/t polyurethane	3.4
PVC processing	kg/t PVC	4.0
Rubber processing	kg/tyres	0.14

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. The last Swiss tannery ceased production in 2015.

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	10.8	7.0	6.5	6.9
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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Fine chemicals production	prod. index	280	295	314	299	302	305	307	310	313	316
Glue production	kt	64	64	63	63	63	62	62	62	61	61
Handling and storing of solvents	prod. index	280	295	314	299	302	305	307	310	313	316
Ink production	kt	19	19	19	21	24	26	26	26	25	25
Paint production	kt	125	126	126	126	126	126	125	124	123	123
Pharmaceutical production	kt	29	30	30	30	30	30	31	31	31	31
Polyester processing	kt	6.2	4.8	3.4	3.5	3.7	3.7	3.7	3.7	3.7	3.7
Polystyrene processing	kt	29	31	34	36	31	32	32	33	33	34
Polyurethane processing	kt	67	52	54	40	40	38	38	37	37	36
Production of adhesive tape	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
PVC processing	kt	73	62	52	55	40	38	37	36	35	34
Rubber processing	tyres	72'500	75'000	77'500	80'000	80'000	81'000	82'000	83'000	84'000	85'000
Tanning of leather	employees	87	76	65	54	44	33	22	11	NO	NO

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 (2016), a Tier 2 method using country-specific emission factors is used for calculating the NMVOC emissions from the ink applications (EMIS 2019/2D3h).

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 2005) and expert estimates, as documented in the EMIS database.

Table 4-39: Emission factors of 2D3h Printing in 2017.

2D3h Printing	Unit	NMVOC
Printing	kg/t ink	280
Package printing	kg/t ink	173

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	5.5
Package printing	kt	5.9	5.9	5.5	9.1

2D3h Printing	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Printing	kt	2.5	2.5	2.4	2.2	2.0	1.9	1.9	1.9	1.9	2.0
Package printing	kt	13	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 (2016), 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 2019/2D3i). 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 2017.

2D3i Other solvent use	Unit	NMVOC
Production of cosmetics	kg/employee	63
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	kg/t removal agent	400
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 number of employees in the respective industrial sectors (SFSO 2018b). 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 amount of removal agent based on information from producers and retail trade.

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	2'733	2'700
Removal of paint and lacquer	t	700	600	490	378
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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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	1'700	1'540	1'540	1'380	1'372	1'363	1'355	1'346	1'338	1'329
Production of perfume and flavour	employees	3'425	3'450	3'475	3'500	3'521	3'542	3'563	3'583	3'604	3'625
Production of textiles	employees	16'200	14'200	13'800	14'800	14'768	14'737	14'705	14'674	14'642	14'611
Production of tobacoo	employees	3'200	3'200	3'200	3'200	3'200	3'200	3'200	3'200	3'200	3'200
Removal of paint and lacquer	t	310	288	265	243	220	198	175	153	130	130
Scientific laboratories	employees	23'000	23'000	23'000	23'000	23'083	23'167	23'250	23'333	23'417	23'500
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

- 2D3d: The activity data and NMVOC emission factor of 2D3d Paint application, car repair have been revised for 2016 and 2005-2016, respectively based on new data and information from the industry association.
- 2D3d: The activity data and NMVOC emission factor of 2D3d Paint application, construction have been revised for 2014–2016 based on new data and information from the industry association.
- 2D3d: The activity data and NMVOC emission factor of 2D3d Paint application, wood have been revised for 2014–2016 and 2013–2016, respectively, based on new data and information from the industry association.
- 2D3d: The activity data and NMVOC emission factor of 2D3d Paint application, households have been revised for 2016 based on a comprehensive study including all major Swiss DIY companies resulting in recalculated interpolated values for 1999–2015 as well.
- 2D3f: The source category 2D3f Dry cleaning has been revised completely from 2001 onwards based on information and data from industry associations, emission control authorities and the Swiss Federal Statistical Office yielding recalculated activity data and NMVOC emission factors for the time series 1991-2016.
- 2D3g: The activity data of source category 2D3g Leather tanning has been revised from 2009 onwards since the last Swiss tannery ceased production in the beginning of 2015.
- 2D3i: The source category 2D3i Removal of paint and lacquer has been revised completely for the entire time series 1990–2016. The so far used activity data of Swiss population has been replaced by the amount of removal agent. In addition, activity data and emission factor have been updated from 1997 onwards based on new values for 2016.

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, BC, CO, Pb, Cd, Hg, PCDD/PCDF 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, antifreeze agents in vehicles, concrete additives, cooling and other lubricants, pesticides, tobacco and fireworks; car underbody sealant; de-icing of airplanes and airport surfaces (ceased in 2011); 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 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 2G Other product use

Code	Source Category	Pollutant	Identification Criteria
2G	Other product use	NMVOC	L1, L2
2G	Other product use	PM2.5	L1, L2, T1, T2
2G	Other product use	PM10	L1, L2, T1

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 2017 are 2G Commercial and industrial use of cleaning agents and 2G Health care, other.

Based on the decision tree Fig. 3.1 in chapter 2G in EMEP/EEA (2016), 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 2019/2G).

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.

Source category 2G De-icing of airplanes (and other de-icing operations) which was the second important emission source within 2G in the past has been revised completely for submission 2019. The revised calculations are based on a comprehensive study including information and data from three Swiss airports (i.e. the two most important and a regional one) yielding recalculated activity data and NMVOC emission factors for the entire time series 1990-2016. The source category is now split into three source categories, i.e. 2G De-icing of airplanes and 2G De-icing of airport surfaces as well as 2G Use of antifreeze agents in vehicles. Since 2011 no NMVOC containing agents are used for de-icing of airport surfaces anymore.

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 2017.

2G Other product use	Unit	NMVOC
Application of glues and adhesives	kg/t solvent	734
Commercial and industrial use of cleaning agents	g/employee	432
Cosmetic institutions	kg/employee	28
De-icing of airplanes	kg/t de-icing agent	54
Glass wool enduction	g/t glass wool	156
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	440
Underseal treatment and conservation of vehicles	kg/t underseal agent	450
Use of antifreeze agents in vehicles	kg/Mio vehicle km	8
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.	5

Emission factors for pollutants other than NMVOC from 2G Use of fireworks and tobacco (EMIS 2019/2G) are displayed in Table 4-46. Emission factors of fireworks are documented in FOEN (2014d). Emission factors for use of tobacco are according to the EMEP/EEA Guidebook 2016 (EMEP/EEA 2016). The emission factor for PCDD/PCDF is according to the UK National Atmospheric Emissions Inventory (UK NAEI 2019). For tobacco consumption, new emission factors for the so far missing pollutants NOx, Cd and PCDD/PCDF have been introduced in submission 2019 and those for NMVOC, NH_3, particulate matter, BC, CO and PAHs have been updated for 1990-2017.

Table 4-46: Emission factors of all pollutants other than NMVOC from 2G Other product use in 2017.

2G	Unit	NO_x	SO_x	NH_3	PM2.5 exh.	PM10 exh.	TSP exh.	BC exh.	CO
Fireworks	kg/t fireworks	0.26	4.1	NA	90	180	180	NE	7.4
Use of tobacco	kg/Mio cigarette eq.	1.8	NE	4.2	27	27	27	0.12	55

2G	Unit	Pb	Cd	Hg	PCDD/PCDF	BaP	BbF	BkF	IcdP
Fireworks	g/t fireworks	130	3.0	0.1	NE	NE	NE	NE	NE
Use of tobacco	g/Mio cigarette eq.	NE	5.4	NE	0.0000001	0.11	0.05	0.05	0.05

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 2018), 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	4.0	3.0	2.0	1.5
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	1.2	2.4	1.8	2.5
De-icing of airport surfaces	kt	0.3	0.4	0.3	0.4
Fireworks	kt	0.8	1.0	1.5	1.4
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	6.0	7.9	8.7	7.2
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 antifreeze agents in vehicles	Mio vehicle km	47'523	46'479	51'142	53'723
Use of concrete additives	kt	24	25	29	36
Use of cooling lubricants	kt	5.0	5.2	5.8	4.5
Use of lubricants	kt	1.3	1.3	1.3	3.7
Use of pesticides	kt	2.4	2.0	1.7	1.5
Use of tobacco	Mio cigarette eq.	16'192	15'774	15'381	13'369

2G Other product use	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Application of glues and adhesives	kt solvent	1.2	1.2	1.1	1.0	1.9	1.0	1.0	1.0	1.0	1.0
Commercial and industrial use of cleaning agents	employees	4'323'333	4'363'667	4'404'000	4'333'333	4'262'667	4'192'000	4'236'000	4'280'000	4'324'000	4'368'000
Cosmetic institutions	employees	4'400	4'600	4'800	5'000	5'111	5'222	5'333	5'444	5'556	5'667
De-icing of airplanes	kt	3.0	4.0	3.3	2.6	3.8	3.1	2.3	2.3	2.3	2.3
De-icing of airport surfaces	kt	NO	0.004	0.018	NO	NO	NO	NO	NO	NO	NO
Fireworks	kt	2.0	2.0	1.7	2.0	1.9	2.3	1.8	1.6	1.2	1.7
Glass wool enduction	kt	44	33	36	41	39	33	32	31	32	36
Hairdressers	employees	23'000	23'000	23'000	23'000	23'000	23'000	23'000	23'000	23'000	23'000
Health care, other	employees	163'000	163'000	163'000	163'000	163'000	163'000	163'000	163'000	163'000	163'000
Medical practices	employees	58'700	58'700	58'700	58'700	58'700	58'700	58'700	58'700	58'700	58'700
Preservation of wood	kt	6.1	5.3	4.5	3.6	2.8	2.0	2.0	2.0	2.0	2.0
Rock wool enduction	kt	58	53	56	57	57	54	53	47	52	52
Underseal treatment and conservation of vehicles	kt	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Use of antifreeze agents in vehicles	Mio vehicle km	55'713	56'376	57'039	58'007	58'976	59'944	60'913	61'881	62'260	62'638
Use of concrete additives	kt	34	34	41	44	38	38	37	37	36	36
Use of cooling lubricants	kt	4.9	3.1	3.9	4.4	4.1	4.1	4.1	4.1	4.1	4.0
Use of lubricants	kt	0.4	0.3	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Use of pesticides	kt	1.7	1.9	2.0	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Use of tobacco	Mio cigarette eq.	13'310	13'667	12'443	11'856	12'705	12'162	10'628	10'284	10'731	10'731

4.6.3 Category-specific recalculations

- 2G: The source category 2G De-icing of airplanes (and other de-icing oparations) has been revised completely based on a comprehensive study including information and data from three Swiss airports (i.e. the two most important and a regional one) yielding recalculated activity data and NMVOC emission factors for the entire time series 1990-2016. The source category is now split into three sources, i.e. 2G De-icing of airplanes and 2G De-icing of airport surfaces as well as 2G Use of antifreeze agents in vehicles. Since 2011 no VOC-containing agents are used for de-icing of airport surfaces anymore.
- 2G: Activity data and NMVOC emission factor of source category 2G Underseal treatment and conservation of vehicles have been updated from 2013 onwards.
- 2G: Activity data for tobacco consumption for the year 2016 has been provisional in Submission 2018 and is now corrected according to the underlyling updated statistics.
- 2G: For tobacco consumption, new emission factors for tobacco consumption for the so far missing pollutants NOx, Cd and PCDD/PCDF have been introduced based on EMEP/EEA Guidebook 2016 (EMEP/EEA 2016) and UK National Atmospheric Emissions Inventory (UK NAEI 2019), respectively. Emission factors for NMVOC, NH_3, particulate matter, BC, CO and PAHs have been updated for 1990-2016 (EMEP/EEA 2016).

4.7 Source categories 2H – Other, 2I – Wood processing and 2L – Other production, consumption, storage, transportation or handling of bulk products

4.7.1 Source category description of 2H Other, 2I Wood processing and 2L Other production, consumption, storage, transportation or handling of bulk products

Table 4-48: Specification of source category 2H Other, 2I Wood processing and 2L Other production, consumption, storage, transportation or handling of bulk products in Switzerland.

2H, 2I, 2L	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
2L	Other production, consumption, storage, transportation or handling of bulk products	Ammonia emissions from freezers (filling and storage)

Table 4-49: Key categories, level 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 2H Other, 2I Wood processing and 2L Other production, consumption, storage, transportation or handling of bulk products

Code	Source Category	Pollutant	Identification Criteria
2H1	Pulp and paper	PM2.5	L1, L2, T1, T2
2H1	Pulp and paper	PM10	L2
2H2	Food and beverages industry	NMVOC	L1, T1
2H2	Food and beverages industry	PM2.5	L2, T1, T2
2H2	Food and beverages industry	PM10	L1, L2, T2
2I	Wood processing	PM2.5	L2
2I	Wood processing	PM10	L1, L2, T2

Source category 2L Other production, consumption, storage, transportation or handling of bulk products is not a key category.

4.7.2 Methodological issues of 2H Other, 2I Wood processing and 2L Other production, consumption, storage, transportation or handling of bulk products

4.7.2.1 Pulp and paper industry (2H1)

Methodology (2H1)

In 2016, 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 (2016), the emissions are calculated by a Tier 2 method using country-specific emission factors (EMIS 2019/2H1).

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 2017.

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	551	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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Sum of chipboard, fibreboard and cellulose production	kt	765	544	602	564	533	510	516	519	503	507

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 (2016), the emissions from the source category 2H2 Food and beverages industry, are calculated by a Tier 2 method using country-specific emission factors (EMIS 2019/2H2).

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 of the Swiss bread producers as documented in the EMIS database (EMIS 2019/2H2 Brot Produktion).

Table 4-52: Emission factors for 2H2 Food and beverages industry in 2017.

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	4'500	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	309

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 2018a) and the annual bread consumption per inhabitant provided by the Swiss bread statistics (Schweizerische Brotinformation, SBI) for the time period between 1990 and 2012. From 2013 onwards, activity data in terms of per capita consumption of bread are estimated based on statistics on grain processing (Swiss association for cereal production, Schweizerischer Getreideproduzenten-Verband, SGPV) as documented in the EMIS database (EMIS 2019/2H2 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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Breweries	m³	367'758	359'608	357'435	357'591	354'293	339'348	345'861	346'214	348'171	346'300
Spirits production	m³	1'707	1'229	1'945	1'340	1'989	1'158	1'150	1'636	1'211	1'010
Bread production	kt	386	383	388	422	409	413	383	421	326	465
Meat smokehouses	kt	65	64	67	66	65	66	67	67	67	67
Roasting facilities	kt	87	93	102	110	110	120	119	125	127	131
Milling companies	kt	1'606	1'613	1'602	1'633	1'648	1'602	1'625	1'645	1'620	1'557
Wine production	m³	109'828	104'916	108'319	102'522	98'621	108'564	99'556	99'859	90'174	88'116
Sugar production	kt	284	314	241	331	286	245	344	261	240	299

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 1B2aiv 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 2017.

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 2018).

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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Blasting and shooting	kt explosive	1.4	2.1	2.4	2.9	2.3	2.2	2.1	2.1	0.7	0.7

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 (2016), 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 2019/2I Holzbearbeitung).

Emission factors (2I)

Emission factors of wood processing are based on an industry survey (EMPA 2004).

Table 4-56: Emission factors for 2I Wood processing and 2L Ammonia in freezers in 2017.

	Unit	NH_3	PM2.5 nonexh.	PM10 nonexh.	TSP nonexh.
2I Wood processing					
Wood processing	g/inhabitant	NA	11	44	110
2L Ammonia from freezers					
Freezers filling	kg/t	1	NA	NA	NA
Freezers storage	kg/t	2	NA	NA	NA

Activity data (2I)

Activity data on annual wood processing are not known and therefore the Swiss population (SFSO 2018a) is used.

Table 4-57: Activity data of 2I Wood processing and 2L Other production, consumption, storage, transportation or handling of bulk products use.

	Unit	1990	1995	2000	2005
2I Wood processing					
Wood processing	Inhabitants	6'796'000	7'081'000	7'209'000	7'501'000
2L Ammonia from freezers					
Freezers filling	t	178	201	224	246
Freezers storage	t	1'100	1'100	1'200	1'200

	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
2I Wood processing											
Wood processing	Inhabitants	7'711'000	7'801'000	7'878'000	7'912'000	7'997'000	8'089'000	8'189'000	8'282'000	8'373'000	8'452'000
2L Ammonia from freezers											
Freezers filling	t	260	264	269	273	278	283	287	292	295	298
Freezers storage	t	1'200	1'200	1'200	1'279	1'357	1'436	1'515	1'593	1'616	1'638

4.7.2.5 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 2019/2 F_2 L_NH3 aus Kühlanlagen). Emission factors are assumed constant over the entire time period (see Table 4-56).

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 2019/2 F_2 L_NH3 aus Kühlanlagen) (see Table 4-57).

4.7.3 Category-specific recalculations

Recalculations in 2H Other, 2I Wood processing and 2L Other production, consumption, storage, transportation or handling of bulk products:

- 2H2: Activity data for bread production has increased by 4% to 8% for the years 2011 and 2012 due to a correction in the underlying statistics.
- 2H2: Emission factors for bread production for CO_2 biog. and NMVOC were interchanged and had to be swapped.
- 2H2: The self-supply rate of grain has been changed in the underying statistics. This correction leads to changes in the activity data of mills for the years 2009, 2012 and 2014-2016.
- 2H2: Activity data for 2016 for meat production has been provisional in Submission 2018 and is now corrected according to the underlyling updated statistics.

5 Agriculture

5.1 Overview of emissions

This introductory chapter contains an overview of emissions from sector 3 Agriculture. NO_x, NMVOC and NH_3 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 (not as standing trees).

5.1.1 Overview and trend for NO_x

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 1990-2017 (see Figure 5-1). Main source is category 3D Agricultural soils, where NO_x emissions correlate with NH_3 emissions (precursor).

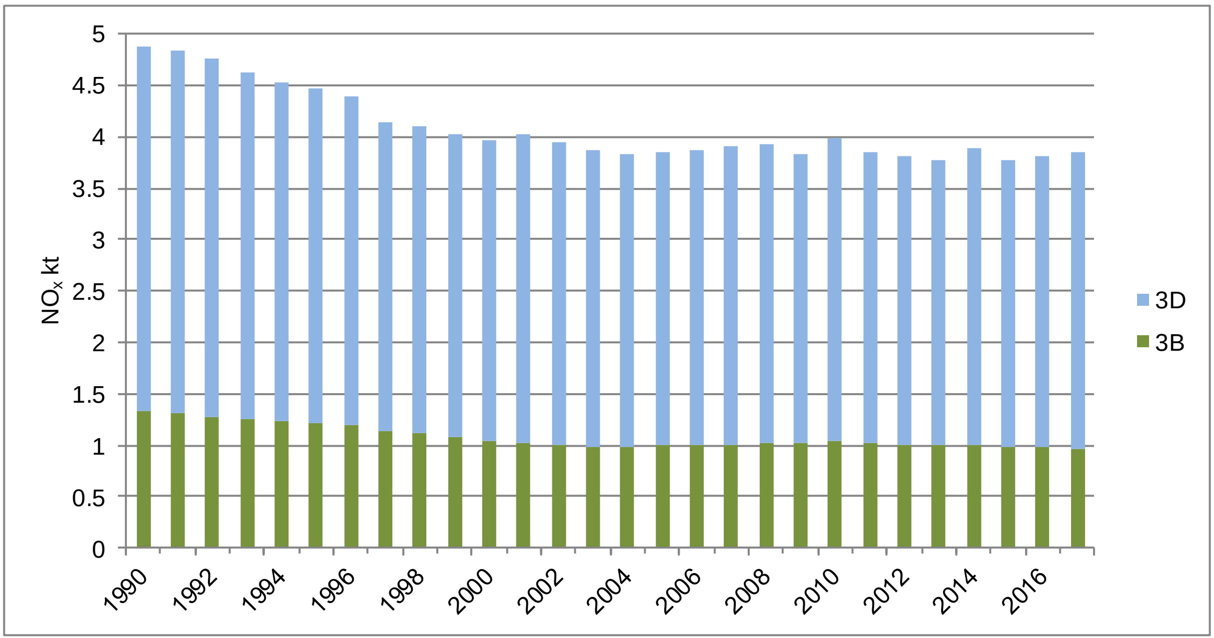


Figure 5-1: Switzerland's NO_x emissions from agriculture by source categories 3B and 3D. The corresponding data table can be found in Annex A7.4.1.

5.1.2 Overview and trend for NMVOC

With the reporting of the so far missing NMVOC emissions from animal husbandry from submission 2019 onwards, the emissions from sector agriculture provide a considerable contribution to the national total of the NMVOC emissions (see Table 2-7). The trend of NMVOC emissions within agriculture is depicted in Figure 5-2. The emissions are dominated by source category 3B Manure management and show a minor decreasing trend only between 1990 and 2017 with some fluctuations in between. The main emission share stems from cattle husbandry with silage feeding as important emission source besides manure management.

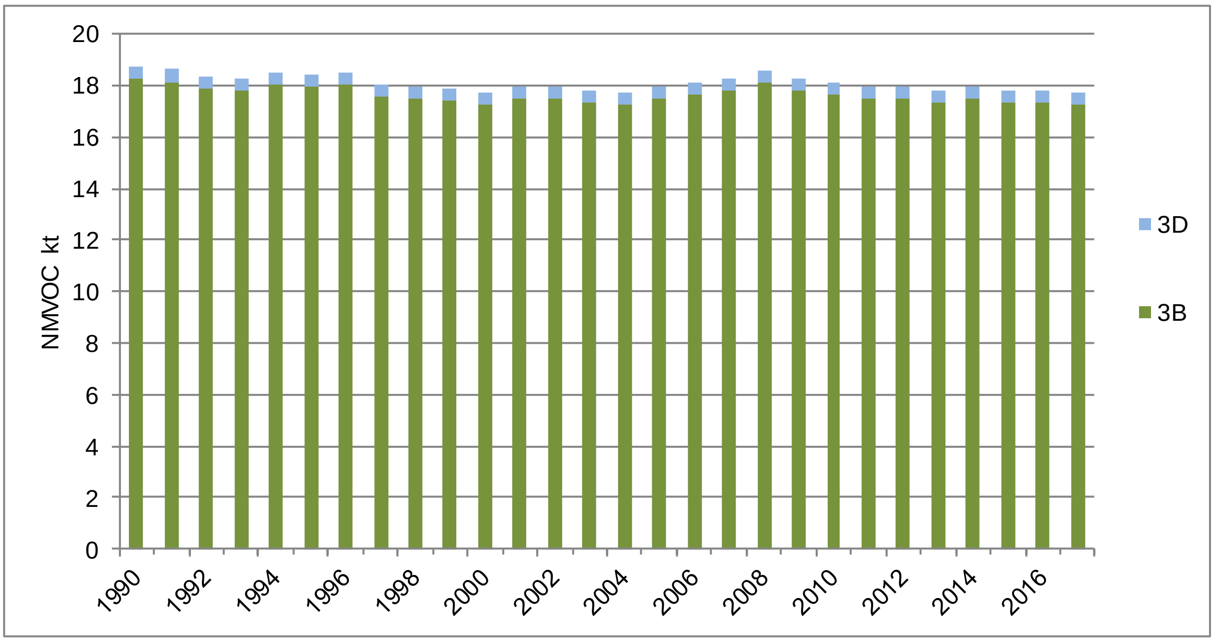


Figure 5-2: Switzerland's NMVOC emissions from agriculture by source categories 3B and 3D. The corresponding data table can be found in Annex A7.4.2.

5.1.3 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 5-3. While category 3B Manure management is subject to little variation throughout the period 1990-2017, 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 fertiliser. The decrease continued until 2003, followed by a slight 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 (Kupper et al. 2015).

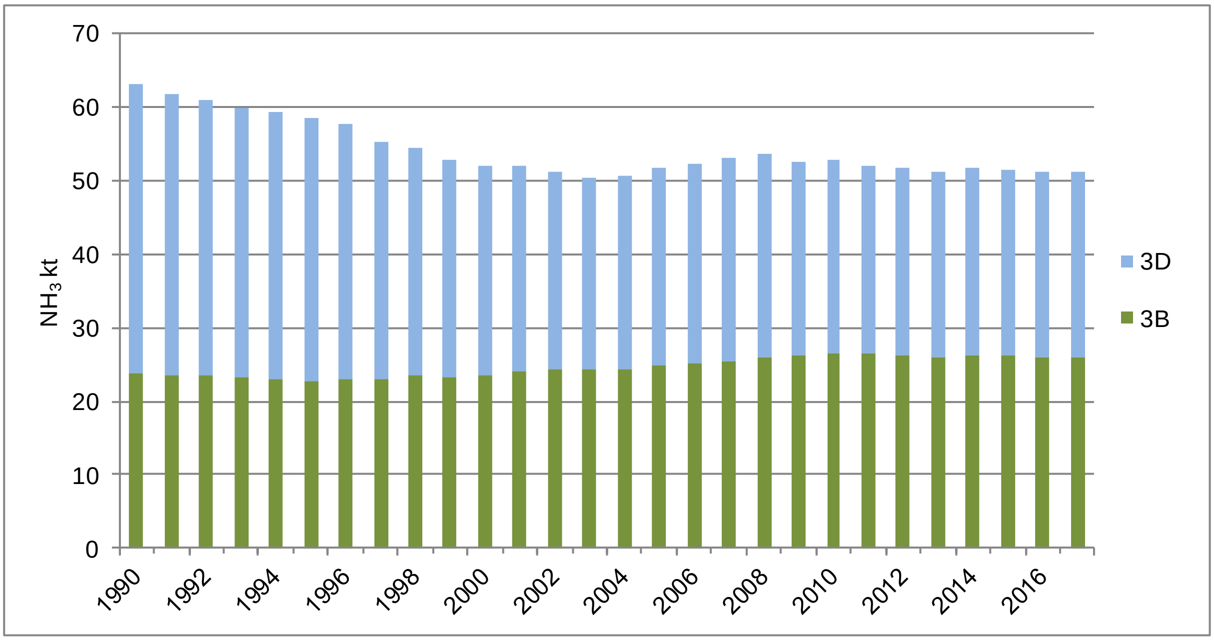


Figure 5-3: Switzerland's NH_3 emissions from agriculture by source categories 3B and 3D. The corresponding data table can be found in Annex A7.4.4.

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). From submission 2019 onwards also the so far missing NMVOC emissions from animal husbandry are reported in the inventory with silage feeding as important emission source besides manure management. Emissions from physical activities of the animals (PM from abrasion and resuspension of dust) are included in source category 3B.

Table 5-1: Specification of source category 3B Manure Management.

3B	Source	Specification
3B1a	Manure management - Dairy cattle	Mature dairy cattle, buffalos
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	Dry sows, nursing sows, boars, fattening pigs, piglets
3B4a	Manure management - Buffalo	IE (included in 3B1a)
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	Growers, other poultry (geese, ducks, ostriches, quails)
3B4h	Manure management - Other animals	Camels and llamas (3B4b), deer (3B4c), rabbits (3B4h i), bisons (3B4h ii)

Table 5-2: Key Categories approach 1, level 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 3B Manure Management

Code	Source Category	Pollutant	Identification Criteria
3B1a	Manure management - Dairy cattle	NMVOC	L1, L2, T1, T2
3B1a	Manure management - Dairy cattle	NH3	L1, L2, T1, T2
3B1b	Manure management - Non-dairy cattle	NMVOC	L1, L2, T1, T2
3B1b	Manure management - Non-dairy cattle	NH3	L1, L2, T1, T2
3B3	Manure management - Swine	NMVOC	L2, T2
3B3	Manure management - Swine	NH3	L1, L2
3B4gii	Manure management - Broilers	NMVOC	L2, T2
3B4gii	Manure management - Broilers	NH3	T2
3B4gii	Manure management - Broilers	PM10	L2, T2

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 2016 (EMEP/EEA 2016).

An internet-based model called AGRAMMON was developed in Switzerland allowing the calculation of ammonia emissions for single farms and for regions (https://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. In the the last revision of the model (Kupper et al. 2018) the model was extended to cover not only NH_3 emissions but all N flows (including N_2O, NO_x and N_2).

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 data on farm and manure management at farm-level with a detailed representative questionnaire in 2002, 2007, 2010 and 2015. Each survey consisted of a representative stratified random sample covering approximately 2000 to 3000 farms (in total, there are about 50'000 farms in Switzerland). The strata cover several farm types, regions of Switzerland, several classes of elevation above sea level, several production techniques and housing systems and specific animal categories. For each farm in the survey farm-specific emission calculations were done with AGRAMMON. These results were then used to calculate livestock category specific average national emission factors for the four respective survey 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 for 2019/2020) are available. The experience gained from the detailed surveys between 2002 and 2015 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 detailed reports accessible on the internet site of AGRAMMON (Kupper et al. 2018).

Additionally, a larger survey - but less detailed with respect to ammonia relevant farm data - was carried out in 2013 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. 2018).

For the volatilisation of NO_x which is newly also integrated in the Agrammon model. A Tier 2 approach based on emission factors from van Bruggen et al. (2014) was used.

The calculation of non-methane volatile organic compounds (NMVOC) and particulate matter (PM, except for all cattle categories) emissions was conducted with a Tier 1 approach using country specific and default Tier 1 emission factors (EMEP/EEA 2016). The PM emissions from all cattle categories (3B1) are calculated by a Tier 2 method using country specific emission factors based on literature data and expert judgement (Bühler and Kupper 2018).

A comprehensive literature study by Bühler and Kupper (2018) has shown that the data base of NMVOC emissions from animal husbandry is very scarce and the derived emission factors differ widely. The studies on which the emission factors in the EMEP/EEA Guidebook 2016 (EMEP/EEA 2016) are based show several inconsistencies that could affect significantly the emission factors. It remains also unknown, how the emissions from the studies performed in the United States were adapted to European agricultural feeding conditions and how the corresponding emission factors were derived. Therefore, a study was launched in 2018 in order to measure NMVOC emissions from dairy cattle with and without silage feeding in an experimental housing during summer, winter and transitional season. In the meantime, NMVOC emissions are reported in the inventory based on a Tier 1 approach using default Tier 1 emission factors (EMEP/EEA 2016). Preliminary measurements indicate that emissions based on default Tier 1 emission factors rather tend to overestimate the actual NMVOC emissions.

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 2018, Kupper et al. 2015, Kupper et al. 2018). N excretions of livestock categories have been revised based on new national standard data on N excretion rates (Richner et al. 2017 in Agroscope 2017), considering animal category specific correction factors for various feeding strategies as well as for milk yield of dairy cows (Kupper et al. 2018).

For the volatilisation of NO_x which is newly also integrated in the Agrammon model, default values from van Bruggen et al. (2014) were used. Accordingly, it is estimated that 0.2%, 0.5%, 1.0% and 0.1% of the total nitrogen in liquid/slurry, solid storage, deep litter and poultry manure systems, respectively, are lost to the atmosphere. These values are considerably higher than the ones based on the EMEP/EEA Guidebook 2016 (Table 3.10 and A1.7; EMEP/EEA 2016) which were used previously, especially for liquid/slurry systems which account for 67% of the total N flow through manure storage. In this context the management systems “anaerobic digestion” is treated as liquid/slurry system.

The resulting NH_3 and NO_x emission factors for the livestock categories 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 NMVOC emission factors for all livestock categories are based on default Tier 1 emission factors (EMEP/EEA 2016, chp. 3B Manure management, Table 3.4) taking into account the fractions of cattle getting silage feeding, see Table 5-5.

The particulate matter emission factors (PM2.5, PM10, and TSP) are listed in Table 5-6. They have been revised completely based on a comprehensive literature study by Bühler and Kupper (2018). The emission factors of all cattle categories were derived from literature data and expert judgment distinguishing loose- and tied-housing systems. For dairy cattle the emission factors are based on PM10 emission measurements in a loose-housing system in Switzerland (Schrade 2009). For all livestock categories other than cattle, except for fattening pigs (TSP) and sheeps and goats (PM2.5 and PM10) default Tier 1 emission factors (EMEP/EEA 2016, chp. 3B, Table 3.5) are used. For the mentioned exceptions other literature values are assumed. For camels/llamas, deer and bisons the same emission factors as for goats are assumed whereas for rabbits the emission factors of fur animals are applied. All these emission factors are kept constant over the entire time series, except for the emission factors of the aggregated category swine. For the animals outside agriculture, i.e. sheeps, goats, horses, mules and asses the same EFs as for the corresponding agricultural animals are applied (see chp. 7.2.2).

Table 5-3: Time series of NH_3 Emission factors for livestock categories. 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	12.8	13.5	15.3	17.0
3 B 1 b	Non-dairy cattle	13.2	14.2	14.3	15.8
3 B 1 c	Young cattle	5.07	5.32	5.57	5.81
3 B 2	Sheep	1.35	1.35	1.37	1.23
3 B 3	Swine	3.37	3.40	3.70	3.64
3 B 4 a	Buffalos	IE	IE	IE	IE
3 B 4 b	Camels and llamas	NO	NO	2.39	1.93
3 B 4 c	Deer	3.60	3.87	3.78	3.29
3 B 4 d	Goats	2.42	2.35	2.43	2.15
3 B 4 e	Horses	9.85	9.61	8.78	8.54
3 B 4 f	Mules and asses	3.62	3.54	3.25	3.02
3 B 4 g i	Layers	0.31	0.30	0.23	0.21
3 B 4 g ii	Broilers	0.10	0.10	0.09	0.09
3 B 4 g iii	Turkey	0.36	0.36	0.32	0.32
3 B 4 g iv	Growers	0.17	0.15	0.16	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
3 B 4 h ii	Bisons	NO	4.80	5.55	5.65

Emission factors		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
		kg NH_3 / animal									
3 B 1 a	Dairy cattle	18.1	18.6	19.1	19.2	19.3	19.4	19.5	19.6	19.6	19.6
3 B 1 b	Non-dairy cattle	16.4	16.0	15.6	15.7	15.7	15.8	15.9	15.9	15.9	15.9
3 B 1 c	Young cattle	6.02	6.07	6.13	6.20	6.26	6.31	6.36	6.40	6.38	6.36
3 B 2	Sheep	1.21	1.29	1.34	1.33	1.33	1.33	1.31	1.29	1.28	1.29
3 B 3	Swine	3.52	3.55	3.55	3.50	3.44	3.41	3.36	3.36	3.38	3.37
3 B 4 a	Buffalos	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 B 4 b	Camels and llamas	1.86	1.93	1.97	1.98	1.98	1.98	1.96	1.93	1.91	1.91
3 B 4 c	Deer	3.25	3.40	3.52	3.50	3.50	3.54	3.51	3.49	3.52	3.54
3 B 4 d	Goats	2.10	2.27	2.38	2.40	2.39	2.38	2.37	2.30	2.30	2.30
3 B 4 e	Horses	8.35	8.14	7.91	8.02	8.15	8.28	8.41	8.57	8.58	8.58
3 B 4 f	Mules and asses	2.91	2.87	2.84	2.90	2.97	3.04	3.10	3.17	3.17	3.17
3 B 4 g i	Layers	0.22	0.22	0.22	0.21	0.21	0.20	0.19	0.18	0.18	0.18
3 B 4 g ii	Broilers	0.09	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
3 B 4 g iii	Turkey	0.31	0.29	0.28	0.29	0.30	0.30	0.31	0.32	0.32	0.32
3 B 4 g iv	Growers	0.10	0.09	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
3 B 4 g iv	Other poultry	0.16	0.15	0.15	0.15	0.15	0.15	0.16	0.16	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
3 B 4 h ii	Bisons	5.33	5.81	6.07	6.27	6.06	6.08	6.02	6.04	6.03	5.95

Table 5-4: Time series of NO_x emission factors for livestock categories.

Emission factors		1990	1995	2000	2005
		g NO_x / animal			
3 B 1 a	Dairy cattle	879	848	766	740
3 B 1 b	Non-dairy cattle	681	698	567	546
3 B 1 c	Young cattle	325	324	290	279
3 B 2	Sheep	171	174	179	168
3 B 3	Swine	92	87	72	63
3 B 4 a	Buffalos	IE	IE	IE	IE
3 B 4 b	Camels and llamas	NO	NO	0.3	0.3
3 B 4 c	Deer	0.5	0.5	0.5	0.4
3 B 4 d	Goats	317	314	323	333
3 B 4 e	Horses	667	665	579	558
3 B 4 f	Mules and asses	245	245	214	200
3 B 4 g i	Layers	2.3	2.3	2.2	2.3
3 B 4 g ii	Broilers	1.3	1.3	1.3	1.4
3 B 4 g iii	Turkey	4.6	4.6	4.5	4.5
3 B 4 g iv	Growers	1.1	1.1	1.1	1.0
3 B 4 g iv	Other poultry	1.8	1.8	1.8	1.8
3 B 4 h i	Rabbits	16	16	16	16
3 B 4 h ii	Bisons	NO	280	275	244

Emission factors		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		g NO_x / animal									
3 B 1 a	Dairy cattle	750	756	762	758	753	749	745	740	739	739
3 B 1 b	Non-dairy cattle	554	541	528	524	519	514	510	505	504	504
3 B 1 c	Young cattle	283	290	296	295	292	291	289	288	288	287
3 B 2	Sheep	168	179	184	182	181	181	177	174	174	176
3 B 3	Swine	61	62	62	61	61	61	60	60	61	61
3 B 4 a	Buffalos	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 B 4 b	Camels and llamas	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3 B 4 c	Deer	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3 B 4 d	Goats	337	340	332	337	338	338	339	331	331	331
3 B 4 e	Horses	554	545	534	539	545	552	558	567	568	568
3 B 4 f	Mules and asses	201	205	208	208	207	206	205	204	204	204
3 B 4 g i	Layers	2.4	2.5	2.5	2.5	2.5	2.5	2.5	2.4	2.4	2.4
3 B 4 g ii	Broilers	1.5	1.5	1.5	1.4	1.4	1.3	1.2	1.2	1.2	1.2
3 B 4 g iii	Turkey	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
3 B 4 g iv	Growers	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3 B 4 g iv	Other poultry	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
3 B 4 h i	Rabbits	16	16	16	16	16	16	16	16	16	16
3 B 4 h ii	Bisons	216	232	239	245	235	234	230	229	229	226

Table 5-5: Time series of NMVOC emission factors for livestock categories.

Emission factors		1990	1995	2000	2005
		g NMVOC / animal			
3 B 1 a	Dairy cattle	12'183	12'767	13'352	13'882
3 B 1 b	Non-dairy cattle	8'637	8'637	8'637	8'637
3 B 1 c	Young cattle	6'108	6'408	6'567	6'811
3 B 2	Sheep	169	169	169	169
3 B 3	Swine	575	573	553	551
3 B 4 a	Buffalos	IE	IE	IE	IE
3 B 4 b	Camels and llamas	NO	NO	271	271
3 B 4 c	Deer	45	45	45	45
3 B 4 d	Goats	542	542	542	542
3 B 4 e	Horses	4'275	4'275	4'275	4'275
3 B 4 f	Mules and asses	1'470	1'470	1'470	1'470
3 B 4 g i	Layers	165	165	165	165
3 B 4 g ii	Broilers	108	108	108	108
3 B 4 g iii	Turkey	489	489	489	489
3 B 4 g iv	Growers	165	165	165	165
3 B 4 g iv	Other poultry	489	489	489	489
3 B 4 h i	Rabbits	59	59	59	59
3 B 4 h ii	Bisons	NO	3'602	3'602	3'602

Emission factors		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		g NMVOC / animal									
3 B 1 a	Dairy cattle	13'981	13'882	13'783	13'744	13'704	13'665	13'625	13'585	13'585	13'585
3 B 1 b	Non-dairy cattle	8'637	8'637	8'637	8'637	8'637	8'637	8'637	8'637	8'637	8'637
3 B 1 c	Young cattle	6'919	6'846	6'791	6'786	6'803	6'803	6'792	6'777	6'764	6'753
3 B 2	Sheep	169	169	169	169	169	169	169	169	169	169
3 B 3	Swine	550	551	549	548	545	549	548	551	551	550
3 B 4 a	Buffalos	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 B 4 b	Camels and llamas	271	271	271	271	271	271	271	271	271	271
3 B 4 c	Deer	45	45	45	45	45	45	45	45	45	45
3 B 4 d	Goats	542	542	542	542	542	542	542	542	542	542
3 B 4 e	Horses	4'275	4'275	4'275	4'275	4'275	4'275	4'275	4'275	4'275	4'275
3 B 4 f	Mules and asses	1'470	1'470	1'470	1'470	1'470	1'470	1'470	1'470	1'470	1'470
3 B 4 g i	Layers	165	165	165	165	165	165	165	165	165	165
3 B 4 g ii	Broilers	108	108	108	108	108	108	108	108	108	108
3 B 4 g iii	Turkey	489	489	489	489	489	489	489	489	489	489
3 B 4 g iv	Growers	165	165	165	165	165	165	165	165	165	165
3 B 4 g iv	Other poultry	489	489	489	489	489	489	489	489	489	489
3 B 4 h i	Rabbits	59	59	59	59	59	59	59	59	59	59
3 B 4 h ii	Bisons	3'602	3'602	3'602	3'602	3'602	3'602	3'602	3'602	3'602	3'602

Table 5-6: Emission factors of PM2.5, PM10 and TSP for livestock categories in year 2017 (based on measurements in Switzerland, literature data and the EMEP/EEA Guidebook 2016).

Emission factors		g PM2.5 / animal	g PM10 / animal	g TSP / animal
3 B 1 a	Dairy cattle	44	178	612
3 B 1 b	Non-dairy cattle	23	93	321
3 B 1 c	Young cattle	23	92	317
3 B 2	Sheep	2	50	140
3 B 3	Swine	5	98	426
3 B 4 b	Camels and llamas	2	50	140
3 B 4 c	Deer	2	50	140
3 B 4 d	Goats	2	50	140
3 B 4 e	Horses	140	220	480
3 B 4 f	Mules and asses	100	160	340
3 B 4 g i	Layers	3	40	190
3 B 4 g ii	Broilers	2	20	40
3 B 4 g iii	Turkey	20	110	110
3 B 4 g iv	Growers	2	20	40
3 B 4 g iv	Other poultry	25	190	190
3 B 4 h i	Rabbits	4	8	18
3 B 4 h ii	Bisons	2	50	140

Activity data (3B)

The number of animals in the different livestock categories (SBV 2018, SFSO 2018) for the time period 1990 to 2017 is shown in Table 5-7. The figures represent harmonized livestock numbers coming from various sources since 1990. The methodology of the harmonization is documented in HAFL (2011).

Table 5-7: Time series of animal numbers in different livestock categories from (in thousand animals).

Activity data 3B, animal numbers		1990	1995	2000	2005
		1'000 animals			
3 B 1 a	Dairy cattle	783	740	669	621
3 B 1 b	Non-dairy cattle	12	23	45	78
3 B 1 c	Young cattle	1'060	986	874	856
3 B 2	Sheep	395	387	421	446
3 B 3	Swine	1'787	1'446	1'498	1'609
3 B 4 a	Buffalos	IE	IE	IE	IE
3 B 4 b	Camels and llamas	NO	NO	1.0	3.1
3 B 4 c	Deer	0.17	1.4	2.8	3.8
3 B 4 d	Goats	68	53	62	74
3 B 4 e	Horses	28	41	50	55
3 B 4 f	Mules and asses	6	8	12	16
3 B 4 g i	Layers	3'083	2'118	2'150	2'189
3 B 4 g ii	Broilers	2'020	3'231	3'808	5'060
3 B 4 g iii	Turkey	95	170	173	132
3 B 4 g iv	Growers	719	714	832	868
3 B 4 g iv	Other poultry	22	17	21	11
3 B 4 h i	Rabbits	61	41	28	25
3 B 4 h ii	Bisons	NO	0.10	0.26	0.37

Activity data 3B, animal numbers		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		1'000 animals									
3 B 1 a	Dairy cattle	629	599	589	589	591	587	587	583	576	569
3 B 1 b	Non-dairy cattle	98	108	111	111	114	117	118	118	121	123
3 B 1 c	Young cattle	877	890	891	877	859	854	857	853	859	852
3 B 2	Sheep	446	432	434	424	417	409	403	395	397	398
3 B 3	Swine	1'540	1'557	1'589	1'579	1'544	1'485	1'498	1'496	1'454	1'445
3 B 4 a	Buffalos	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 B 4 b	Camels and llamas	4.4	4.7	6.1	6.0	5.8	5.9	6.1	6.4	6.5	6.6
3 B 4 c	Deer	4.8	5.1	5.5	5.7	5.7	5.7	5.7	6.0	6.0	6.0
3 B 4 d	Goats	81	81	83	83	85	85	85	84	85	88
3 B 4 e	Horses	59	60	62	57	58	57	57	55	56	56
3 B 4 f	Mules and asses	18	19	20	19	20	20	20	20	20	21
3 B 4 g i	Layers	2'255	2'318	2'438	2'437	2'521	2'589	2'665	2'822	3'056	3'174
3 B 4 g ii	Broilers	5'300	5'456	5'580	5'984	6'282	6'360	6'784	6'898	6'878	7'151
3 B 4 g iii	Turkey	54	52	58	58	51	55	57	49	71	77
3 B 4 g iv	Growers	919	967	926	970	1'076	1'055	1'196	1'033	959	1'084
3 B 4 g iv	Other poultry	15	16	23	29	25	20	22	23	30	16
3 B 4 h i	Rabbits	25	28	35	34	28	28	27	25	25	22
3 B 4 h ii	Bisons	0.49	0.56	0.51	0.51	0.52	0.50	0.53	0.56	0.56	0.57

5.2.3 Category-specific recalculations 3B Manure management

- 3B: The so far missing NMVOC emissions from manure management are now included in the inventory for all agricultural livestock categories based on a Tier 1 approach according to the EMEP/EEA emission inventory guidebook 2016 (EMEP/EEA 2016) for the entire time series.
- 3B: All estimates based on AGRAMMON data were recalculated for the whole time series due to the implementation of a new model version. The most important changes were the switch to a full nitrogen flow model (including N_2O, NO_x and N_2) and the revision of nitrogen excretion rates of several livestock categories following the 2017 revision of the Swiss Fertiliser Guidelines (Agroscope 2017, Richner et al. 2017). More details on AGRAMMON recalculations can be found in chapter 3.6 of Kupper et al. (2018).
- 3B1: The emission factors of PM2.5, PM10 and TSP from 3B1a Manure management - Dairy cattles, 3B1b Manure management - Non-dairy cattle and 3B1a Manure management - Young cattle have been revised for the entire time series. They have been changed from rounded to unrounded values in accordance with all other implied emission factors in sector 3 Agriculture.
- 3B3: The emission factors of PM2.5, PM10 and TSP from 3B3 Manure management - Swine have been corrected for the entire time series.

- 3B3 and 3B4: AD of 3B3 Manure management – Swine (EF) and 3B4gii Manure management – Broilers (AD and EF) were revised for the years 2011-2016 based on a new assessment of animal turnover rates in stables for fattening pigs over 25 kg and broilers, respectively.

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 fertiliser (mineral (inorganic N-) fertiliser, sewage sludge, compost and other residue fertilisers,) and animal manure applied on these soils as well as excretion during grazing.

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 5-8: Specification of source category 3D Agricultural Soils.

3D	Source	Specification
3Da1	Inorganic N-fertilizers	Application of urea-containing fertilizers and other inorganic fertilizers
3Da2a	Animal manure applied to soils	Application of animal manure to soils (dairy cattle, non-dairy cattle, sheep, swine, buffalos, goats, horses, mules/asses, laying hens, broilers, turkeys, other poultry, other animals)
3Da2b	Sewage sludge applied to soils	Application of sewage sludge to soils (NO after 2009)
3Da2c	Other organic fertilisers applied to soils (including compost)	Application of compost derived from organic residues (incl. liquid and solid digestate)
3Da3	Urine and dung deposited by grazing animals	Deposition of urine and dung by grazing animals
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	For particulate matter emissions: Soil cultivation and crop harvesting (operation of tractors and machinery). For NMVOC emissions: Crop production, differentiated for cropland, grassland and summering pastures.

Table 5-9: Key Categories approach 1, level 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 3D Agricultural Soils (NFR codes as of EMEP/EEA 2013).

Code	Source Category	Pollutant	Identification Criteria
3Da1	Inorganic N-fertilizers (includes also urea application)	NOx	L2, T2
3Da1	Inorganic N-fertilizers (includes also urea application)	NH3	L1, L2, T2
3Da2a	Animal manure applied to soils	NOx	L2, T1, T2
3Da2a	Animal manure applied to soils	NH3	L1, L2, T1, T2
3Da2b	Sewage sludge applied to soils	NH3	T1
3Da2c	Other organic fertilisers applied to soils	NOx	T2
3Da2c	Other organic fertilisers applied to soils	NH3	T1, T2
3Da3	Urine and dung deposited by grazing animals	NOx	T2
3Da3	Urine and dung deposited by grazing animals	NH3	T1, T2
3Da3	Urine and dung deposited by grazing animals	PM10	L1, L2, T1, T2

5.3.2 Methodological issues of 3D Crop production and agricultural soils

Methodology (3D)

The emissions are calculated by Tier 3 (3Da2a), Tier 2 (3Da1, 3Dc) and Tier 1 (3Da2b/3Da2c) methods based on the decision tree in Fig. 3.1 in chapter 3D Crop production and agricultural soils of the EMEP/EEA Guidebook 2016 (EMEP/EEA 2016).

- 3Da1: For the application of nitrogen containing inorganic fertilisers the Tier 2 method and NH_3 emission factors according to the EMEP/EEA Guidebook 2016 (EMEP/EEA 2016) were used. In 3Da1 only the agricultural use of inorganic fertilisers and urea is reported, while private use is reported under 6Ac.
- 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 farm types, regions, height above sea level 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 fertiliser is prohibited since 2006 (with some exceptions in certain cantons until the end of 2008).
- 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.
- 3Dc: In this source category, NMVOC and particulate matter (PM2.5, PM10 and TSP) emissions from agricultural soils are reported based on a study by Bühler and Kupper (2018). The NMVOC emissions from agricultural soils have been revised completely for the entire times series using a Tier 2 approach according to the EMEP/EEA Guidebook 2016 differentiating three agricultural areas, i.e. cropland, grassland and summering pastures. The particulate matter emissions from soil cultivation and crop harvesting originate at the sites at which the tractors and other machinery operate, and are thought to consist of a mixture of organic fragments from the crop and soil mineral and organic matter. There is considerable settling of dust close to the sources and washing out of fine particles by large particles. Field operations may also lead to the resuspension of dust that has already settled (reentrainment). For the emission calculation it was differentiated between cropland and grassland. In last year's submission, there was a double-counting in particle emissions from resuspension since they were also reported in source category 1A4cii Non-road vehicles and machinery in agriculture (chp. 3.2.7.2) but they are now deleted.

Emission factors (3Da)

For fertiliser default Tier 2 NH_3 emission factors from the EMEP/EEA Guidebook 2016 (EMEP/EEA 2016, 3D Crop production and agricultural soils, Table 3.2) were used for the whole time series. The climate zone for Switzerand is "cool". The soil pH was assessed based on the Swiss agricultural soil use capability map (Bodeneignungskarte; first published by Frei et al. 1980), which indicated that 54% of the soils on which inorganic fertiliser is applied are of normal pH (<7) and 46% of high pH (>7). A detailed description of the methodology is given by Kupper et al. (2018; chapters 7.8 – 7.10).

Table 5-10 shows NH_3 and NO_x emission factors for nitrogen containing fertiliser, sewage sludge and compost applied to soils. In Table 5-10 the weighted mean emission factors of urea containing and other synthetic N fertiliser are shown. A fertiliser-induced emission (FIE) value of 0.55% from Stehfest and Bouwman (2006) is used for NO_x emission factors, both for mineral and organic fertiliser. This means that 0.0055/14*46 kg NO_x (as NO_2) is emitted per ton of nitrogen applied.

Table 5-10: NH_3 and NO_x emission factors 2017 for nitrogen containing fertiliser.

Emission factors		kg NH_3 / tN	kg NO_x / tN
3 D a 1	Urea containing fertiliser	159	18
3 D a 1	Other synthetic N-fertiliser	34	18
3 D a 2 b	Sewage sludge	317	18
3 D a 2 c	Organic compost	145	18

Emission factors for the application of animal manure are displayed in Table 5-11 and Table 5-12.

Table 5-11: Time series of NH_3 emission factors for the application of animal manure to soils.

Emission factors		1990	1995	2000	2005
		kg NH_3 / animal			
3 D a 2 a 1 a	Dairy cattle	25.6	25.5	22.4	22.3
3 D a 2 a 1 b	Non-dairy cattle	14.7	14.1	11.0	11.6
3 D a 2 a 1 c	Young cattle	6.76	6.76	5.41	5.19
3 D a 2 a 2	Sheep	0.17	0.20	0.20	0.24
3 D a 2 a 3	Swine	2.84	2.59	1.82	1.52
3 D a 2 a 4 a	Buffalos	IE	IE	IE	IE
3 D a 2 a 4 b	Camels and llamas	NO	NO	0.34	0.38
3 D a 2 a 4 c	Deer	0.45	0.58	0.54	0.64
3 D a 2 a 4 d	Goats	0.32	0.38	0.34	0.66
3 D a 2 a 4 e i	Horses	1.41	1.67	1.20	1.24
3 D a 2 a 4 f i	Mules and asses	0.52	0.61	0.42	0.44
3 D a 2 a 4 g i	Layers	0.07	0.08	0.09	0.09
3 D a 2 a 4 g ii	Broilers	0.05	0.06	0.05	0.05
3 D a 2 a 4 g iii	Turkey	0.17	0.20	0.17	0.20
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	0.06	0.05
3 D a 2 a 4 h i	Rabbits	0.09	0.09	0.08	0.08
3 D a 2 a 4 h ii	Bisons	NO	7.07	6.20	5.53

Emission factors		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		kg NH_3 / animal									
3 D a 2 a 1 a	Dairy cattle	22.4	21.8	21.3	21.1	20.9	20.7	20.5	20.3	20.3	20.3
3 D a 2 a 1 b	Non-dairy cattle	12.5	12.1	11.7	11.7	11.6	11.6	11.5	11.4	11.4	11.4
3 D a 2 a 1 c	Young cattle	5.38	5.27	5.17	5.15	5.13	5.10	5.06	5.02	4.99	4.98
3 D a 2 a 2	Sheep	0.27	0.28	0.28	0.27	0.26	0.25	0.24	0.23	0.23	0.23
3 D a 2 a 3	Swine	1.48	1.45	1.40	1.40	1.41	1.41	1.42	1.44	1.44	1.44
3 D a 2 a 4 a	Buffalos	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 D a 2 a 4 b	Camels and llamas	0.42	0.41	0.40	0.40	0.39	0.38	0.37	0.35	0.35	0.35
3 D a 2 a 4 c	Deer	0.73	0.73	0.72	0.70	0.68	0.68	0.66	0.64	0.64	0.64
3 D a 2 a 4 d	Goats	0.73	0.59	0.44	0.46	0.48	0.50	0.52	0.53	0.53	0.53
3 D a 2 a 4 e i	Horses	1.40	1.43	1.45	1.48	1.52	1.56	1.60	1.65	1.66	1.66
3 D a 2 a 4 f i	Mules and asses	0.61	0.73	0.84	0.78	0.71	0.64	0.58	0.51	0.51	0.51
3 D a 2 a 4 g i	Layers	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10
3 D a 2 a 4 g ii	Broilers	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
3 D a 2 a 4 g iii	Turkey	0.20	0.18	0.15	0.16	0.16	0.16	0.16	0.16	0.16	0.16
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	0.07	0.08	0.09	0.08	0.08	0.07	0.06	0.05	0.05	0.05
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
3 D a 2 a 4 h ii	Bisons	4.98	5.19	5.20	5.28	5.01	4.94	4.80	4.72	4.72	4.65

Table 5-12: Time series of NO_x emission factors for the application of anial manure to soils.

Emission factors		1990	1995	2000	2005
		g NO_x / animal			
3 D a 2 a 1 a	Dairy cattle	1430	1414	1315	1309
3 D a 2 a 1 b	Non-dairy cattle	903	888	751	765
3 D a 2 a 1 c	Young cattle	411	410	356	339
3 D a 2 a 2	Sheep	67	69	71	68
3 D a 2 a 3	Swine	196	183	137	114
3 D a 2 a 4 a	Buffalos	IE	IE	IE	IE
3 D a 2 a 4 b	Camels and llamas	NO	NO	124	106
3 D a 2 a 4 c	Deer	179	197	196	181
3 D a 2 a 4 d	Goats	126	126	129	138
3 D a 2 a 4 e i	Horses	561	563	484	465
3 D a 2 a 4 f i	Mules and asses	206	207	179	167
3 D a 2 a 4 g i	Layers	7.9	8.0	8.6	9.4
3 D a 2 a 4 g ii	Broilers	5.5	5.5	5.7	6.2
3 D a 2 a 4 g iii	Turkey	19	19	19	19
3 D a 2 a 4 g iv	Growers	3.5	3.7	3.6	3.8
3 D a 2 a 4 g iv	Other poultry	7.7	7.7	7.4	7.2
3 D a 2 a 4 h i	Rabbits	13.3	13.3	13.3	13.3
3 D a 2 a 4 h ii	Bisons	NO	414	388	342

Emission factors		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		g NO_x / animal									
3 D a 2 a 1 a	Dairy cattle	1333	1333	1333	1339	1345	1350	1356	1361	1361	1361
3 D a 2 a 1 b	Non-dairy cattle	800	789	777	780	782	784	786	788	788	788
3 D a 2 a 1 c	Young cattle	348	349	351	353	354	355	355	355	354	352
3 D a 2 a 2	Sheep	68	72	74	73	73	73	71	70	70	71
3 D a 2 a 3	Swine	111	112	112	112	111	112	111	112	113	112
3 D a 2 a 4 a	Buffalos	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 D a 2 a 4 b	Camels and llamas	105	108	109	109	109	109	108	107	106	106
3 D a 2 a 4 c	Deer	184	190	194	193	193	195	194	192	194	195
3 D a 2 a 4 d	Goats	141	140	135	137	137	138	138	135	135	135
3 D a 2 a 4 e i	Horses	464	457	449	453	457	462	467	474	475	475
3 D a 2 a 4 f i	Mules and asses	170	175	179	177	175	173	171	169	169	169
3 D a 2 a 4 g i	Layers	10	10	10	10	10	10	10	10	10	10
3 D a 2 a 4 g ii	Broilers	6.6	6.6	6.7	6.4	6.1	5.8	5.5	5.2	5.2	5.2
3 D a 2 a 4 g iii	Turkey	19	20	20	20	20	19	19	19	19	19
3 D a 2 a 4 g iv	Growers	3.9	4.0	4.1	4.2	4.2	4.2	4.2	4.2	4.2	4.2
3 D a 2 a 4 g iv	Other poultry	7.3	7.4	7.6	7.5	7.4	7.4	7.3	7.2	7.2	7.2
3 D a 2 a 4 h i	Rabbits	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
3 D a 2 a 4 h ii	Bisons	308	330	340	349	335	334	328	327	327	322

The following tables list the emission factors for NH_3 and NO_x for N excretion on pasture and paddock during grazing.

Table 5-13: Time series of NH_3 emission factors for N excretion during grazingfor different of livestock categories.

Emission factors		1990	1995	2000	2005
		g NH_3 / animal			
3 D a 3 1 a	Dairy cattle	470	547	915	1079
3 D a 3 1 b	Non-dairy cattle	1'239	1'237	1'669	1'556
3 D a 3 1 c	Young cattle	288	290	444	461
3 D a 3 2	Sheep	136	139	158	182
3 D a 3 3	Swine	NO	NO	1.5	13
3 D a 3 4 a	Buffalos	IE	IE	IE	IE
3 D a 3 4 b	Camels and llamas	NO	NO	280	292
3 D a 3 4 c	Deer	373	408	443	499
3 D a 3 4 d	Goats	92	91	86	62
3 D a 3 4 e i	Horses	181	181	508	590
3 D a 3 4 f i	Mules and asses	67	67	179	234
3 D a 3 4 g i	Layers	NO	2.1	14	25
3 D a 3 4 g ii	Broilers	NO	0.80	1.1	2.1
3 D a 3 4 g iii	Turkey	NO	2.8	16	22
3 D a 3 4 g iv	Growers	NO	1.0	0.53	1.52
3 D a 3 4 g iv	Other poultry	NO	NO	6.3	8.8
3 D a 3 4 h i	Rabbits	NO	NO	NO	NO
3 D a 3 4 h ii	Bisons	NO	529	791	800

Emission factors		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		g NH_3 / animal									
3 D a 3 1 a	Dairy cattle	1'073	1'056	1'039	1'029	1'020	1'010	1'000	991	991	991
3 D a 3 1 b	Non-dairy cattle	1'420	1'474	1'529	1'519	1'510	1'501	1'492	1'483	1'483	1'483
3 D a 3 1 c	Young cattle	438	425	411	412	415	413	412	411	409	411
3 D a 3 2	Sheep	186	182	173	176	181	185	187	189	189	191
3 D a 3 3	Swine	14	7.9	2.0	1.7	1.4	1.0	0.70	0.37	0.37	0.37
3 D a 3 4 a	Buffalos	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 D a 3 4 b	Camels and llamas	298	283	263	269	275	280	282	283	281	280
3 D a 3 4 c	Deer	520	497	468	476	484	499	505	512	515	519
3 D a 3 4 d	Goats	55	62	68	72	74	77	79	80	80	80
3 D a 3 4 e i	Horses	604	641	680	662	641	618	595	566	564	563
3 D a 3 4 f i	Mules and asses	228	214	201	204	208	211	215	218	218	218
3 D a 3 4 g i	Layers	28	26	25	25	26	27	27	28	28	28
3 D a 3 4 g ii	Broilers	2.0	1.3	0.60	0.59	0.57	0.55	0.53	0.52	0.52	0.52
3 D a 3 4 g iii	Turkey	19	16	14	15	17	19	20	22	22	22
3 D a 3 4 g iv	Growers	2.2	2.0	1.9	1.6	1.4	1.1	0.83	0.56	0.56	0.56
3 D a 3 4 g iv	Other poultry	7.0	5.2	3.4	4.2	4.9	5.7	6.4	7.2	7.2	7.2
3 D a 3 4 h i	Rabbits	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 D a 3 4 h ii	Bisons	682	709	709	732	707	709	701	703	702	693

Table 5-14: Time series of NO_x emission factors for N excretion during grazing for different livestock categories.

Emission factors		1990	1995	2000	2005
		g NO_x / animal			
3 D a 3 1 a	Dairy Cattle	150	175	294	348
3 D a 3 1 b	Non dairy Cattle	404	403	544	507
3 D a 3 1 b	Young Cattle	94	95	145	150
3 D a 3 2	Sheep	41	41	47	54
3 D a 3 3	Swine	NO	NO	0.16	1.34
3 D a 3 4 a	Buffalos	IE	IE	IE	IE
3 D a 3 4 b	Camels and llamas	NO	NO	83	87
3 D a 3 4 c	Deer	111	121	132	148
3 D a 3 4 d	Goats	27	27	26	18
3 D a 3 4 e i	Horses	54	54	151	176
3 D a 3 4 f i	Mules and Asses	20	20	53	70
3 D a 3 4 g i	Layers	NO	0.08	0.49	0.90
3 D a 3 4 g ii	Broilers	NO	0.03	0.04	0.07
3 D a 3 4 g iii	Turkey	NO	0.10	0.58	0.78
3 D a 3 4 g iv	Growers	NO	0.04	0.02	0.05
3 D a 3 4 g iv	Other poultry	NO	NO	0.22	0.31
3 D a 3 4 h i	Rabbits	NO	NO	NO	NO
3 D a 3 4 h ii	Bisons	NO	172	258	261

Emission factors		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		g NO_x / animal									
3 D a 3 1 a	Dairy Cattle	347	342	337	334	331	328	325	322	322	322
3 D a 3 1 b	Non dairy Cattle	463	481	498	495	492	489	486	483	483	483
3 D a 3 1 b	Young Cattle	143	139	134	134	135	135	134	134	133	134
3 D a 3 2	Sheep	55	54	52	52	54	55	56	56	56	57
3 D a 3 3	Swine	1.46	0.84	0.21	0.18	0.14	0.11	0.07	0.04	0.04	0.04
3 D a 3 4 a	Buffalos	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
3 D a 3 4 b	Camels and llamas	89	84	78	80	82	83	84	84	84	83
3 D a 3 4 c	Deer	155	148	139	142	144	149	150	152	153	154
3 D a 3 4 d	Goats	16	19	20	21	22	23	24	24	24	24
3 D a 3 4 e i	Horses	180	191	202	197	191	184	177	168	168	167
3 D a 3 4 f i	Mules and Asses	68	64	60	61	62	63	64	65	65	65
3 D a 3 4 g i	Layers	1.00	0.94	0.88	0.90	0.93	0.95	0.97	1.00	1.00	1.00
3 D a 3 4 g ii	Broilers	0.07	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
3 D a 3 4 g iii	Turkey	0.68	0.58	0.48	0.54	0.60	0.66	0.72	0.78	0.78	0.78
3 D a 3 4 g iv	Growers	0.08	0.07	0.07	0.06	0.05	0.04	0.03	0.02	0.02	0.02
3 D a 3 4 g iv	Other poultry	0.25	0.18	0.12	0.15	0.17	0.20	0.23	0.25	0.25	0.25
3 D a 3 4 h i	Rabbits	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 D a 3 4 h ii	Bisons	222	231	231	239	230	231	229	229	229	226

Emission factors (3Dc)

For the calculation of the NMVOC emissions from crop production and agricultural soils three types of agricultural areas are differentiated, i.e. cropland, grassland and summering pastures. The NMVOC emission factors for cropland and grassland are based on the values for wheat and grass (15°C), respectively, of Table 3.3 of the EMEP/EEA Guidebook 2016 taking into account country-specific values for the mean dry matter yield (Agroscope 2017). For summering pastures, the same NMVOC emission value as of grass (15°C) and a fraction of the growing period of 0.3 (Bühler and Kupper 2018) are assumed using a country-specific value for the mean dry matter yield (Agroscope 2017). The resulting NMVOC emission factors are constant for the entire time series and are given in Table 5-15.

The particulate matter emission factors consist of an operation-specific emission factor for soil cultivation or harvesting and a factor for the annual number of the respective agricultural operation. The crop- and operation-specific emission factors are based on the Tier 2 emission factors for wet conditions of the EMEP/EEA Guidebook 2016 (chp. 3D, Tables 3.5 and 3.7). The factors for the annual number of agricultural operations are country-specific and are based mainly on expert judgements (Bühler and Kupper 2018). Only for the number of grass harvests in the valley and alpine area literature values are available (Agroscope 2017). In order to derive the emission factors of the aggregated source categories cropland and grassland, the emissions from the cultivation of each single type of crop and of grassland have to be calculated, summed up and then divided by the total area of the respective crop and grassland types. Since the relative shares of grassland in the valley and the alpine area remain about constant over the entire time period constant emission factors result for grassland.

Unfortunately, the guidebook provides emission factors for PM10 and PM2.5 only. Thus, in last year's submission of the inventory the same values as of PM10 were assumed for TSP in line with the reporting of a couple of other European countries. But this assumption is not reasonable since particulate matter emissions from soil cultivation and harvesting have a large mass fraction in the coarse fraction. Therefore, the TSP emission factors have been revised for this submission according to the Danish emission inventory (Danish Informative Inventory Report 2018) with a fraction of PM10/TSP of 10%. The particulate matter emission factors are also given in Table 5-15.

Table 5-15: NMVOC and PM2.5 emission factors of 2017 for 3Dc Crop production and agricultural soils.

Emission factors		g NMVOC / ha	g PM2.5 / ha	g PM10 / ha	g TSP / ha
3 D c	Cropland	376	40	752	7'522
3 D c	Grassland	397	47	1'100	11'000
3 D c	Summering pastures	141	NA	NA	NA

Activity data (3Da)

The nitrogen amount applied with urea-containing and other synthetic fertilisers (SBV 2018, Agricura 2017, AGRAMMON 2018) as well as the amount applied with sewage sludge and compost (including solid and liquid digestate) derived from organic residues are shown in Table 5-16.

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 which are given in Table 5-7. The application of sewage sludge to soils has been prohibited (too high heavy metal content), therefore the activity data is NO from 2009 onwards.

The underlying data for compost and digestate (liquid and solid) from biogas plants are based on a study from the year 2017 (Schleiss 2017) and on data from the statistics of renewable energies (SFOE 2018a), respectively, see description in chp. 6.3.2. Schleiss 2017 differentiates so-called back yard and industrial composting. The compost applied to soil as fertiliser in agriculture is part of the industrial compost.

Table 5-16: Time series of nitrogen amount applied on agricultural soils: synthetic N-fertilisers (urea-containing and other N-containing synthetic fertilisers), sewage sludge and compost (derived from organic residues in t N). Additionally, agricultural areas (in ha; cropland, grassland, summering pastures) are displayed.

Activity data of agricultural soils			1990	1995	2000	2005
3 D a 1	Urea containing fertiliser	tN	16'284	10'707	7'631	6'605
3 D a 1	Other synthetic N-fertiliser	tN	50'391	47'652	43'042	43'478
3 D a 2 b	Sewage sludge	tN	4'815	4'942	3'356	1'054
3 D a 2 c	Organic compost	tN	817	1'286	1'829	2'201
3 D c	Cropland	ha	313'247	308'284	290'954	283'802
3 D c	Grassland	ha	724'556	737'229	743'849	742'474
3 D c	Summering pastures	ha	538'676	499'774	496'667	487'956

Activity data of agricultural soils			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
3 D a 1	Urea containing fertiliser	tN	6'600	5'302	7'101	6'487	5'338	5'748	7'890	6'914	8'818	9'001
3 D a 1	Other synthetic N-fertiliser	tN	41'985	40'456	45'986	40'243	39'810	37'969	41'446	36'830	37'585	40'362
3 D a 2 b	Sewage sludge	tN	286	NO	NO	NO	NO	NO	NO	NO	NO	NO
3 D a 2 c	Organic compost	tN	2'762	3'012	3'370	3'773	4'466	4'812	5'065	5'446	5'800	5'969
3 D c	Cropland	ha	276'186	273'803	270'371	267'683	267'531	269'820	269'337	270'092	269'536	270'557
3 D c	Grassland	ha	742'879	742'494	741'837	744'727	743'594	739'588	740'097	737'463	736'455	732'125
3 D c	Summering pastures	ha	485'812	485'330	486'382	483'414	481'379	479'745	475'690	474'575	472'432	472'567

Activity data (3Dc)

As activity data of source category 3Dc Crop production and agricultural soils two different types of agricultural areas were considered, i.e. cropland and grassland. They consist of aggregated agricultural areas based on the (annual) farm structure survey of the Swiss Federal Statistical Office (SFSO 2018d). In addition, for NMVOC emissions also the emissions from summering pastures (Bretscher 2017) are included where no agricultural crop operations take place. The activity data of these agricultural areas are also given in Table 5-16.

5.3.3 Category-specific recalculations for 3D Crop production and agricultural soils

- 3D: All estimates based on AGRAMMON data were recalculated for the whole time series due to the implementation of a new model version. The most important changes were the switch to a full nitrogen flow model (including N_2O, NO_x and N_2) and the revision of nitrogen excretion rates of several livestock categories following the 2017 revision of the Swiss Fertiliser Guidelines (Agroscope 2017, Richner et al. 2017). More details on AGRAMMON recalculations can be found in chapter 3.6 of Kupper et al. (2018).
- 3Da2a3 Animal manure applied to soil - Swine and 3Da2a4gii Animal manure applied to soil - Broilers: AD were revised for the years 2011-2016 based on a new assessment of animal turnover rates in stables for fattening pigs over 25 kg and broilers, respectively.
- 3Da2c Other organic fertilisers applied to soils: Since AD were revised for the whole time series due to new AD for recycling fertilisers (compost, digestates). As the relative shares of compost and digestates have changed, this alo leads to revised NH_3 emission factors.
- 3Dc: The NMVOC emissions from agricultural soils have been revised completely for the entire times series based on a Tier 2 approach according to the EMEP/EEA emission inventory guidebook 2016 (EMEP/EEA 2016). The source category is now split into three sources, i.e. 3Dc soils operation of cropland, 3Dc soils operation of grassland and 3Dc soils operation of summering pastures.
- 3Dc: The TSP emission factors of 3Dc Soils operation of cropland and 3Dc Soils operation of grassland have been revised for the entire times series based on the Danish emission inventory (Danish Informative Inventory Report 2018).
- 3Dc: The PM2.5 and PM10 emission factors of 3Dc soils operation of cropland and 3Dc soils operation of grassland have been updated for the entire times series.

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 2017. 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 in 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 2006 to 2017 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 an increase of industrial and commercial composting activities and in particular the digesting of organic waste. Digestion has become economical more attractive due to cost covering feed-in tariffs for electricity and due to additional revenues as CO_2 compensation projects. The increase of treated quantities is also linked to population growth.

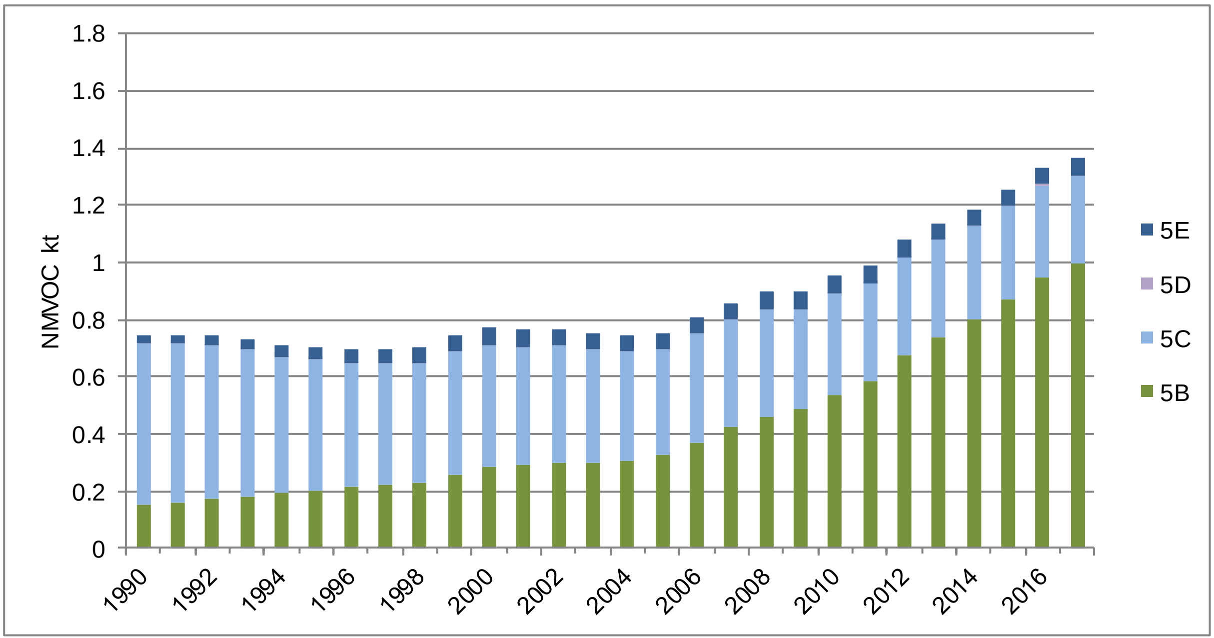


Figure 6-1: Switzerland's NMVOC emissions from the waste sector by source categories 5B-5E. The corresponding data table can be found in Annex A7.5.

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 2017 a continuous decrease of total PM2.5 emissions occurred that largely can be affiliated with the emission reductions achieved in 5C Waste incineration. This is mainly because of the reduction of the emissions from sewage sludge incineration, refurbishment of crematoriums, the cessation of burning cable insulation in 1995 as well as clinical waste incineration in 2002 and a decreasing trend in the open burning of natural residues in agriculture and households.

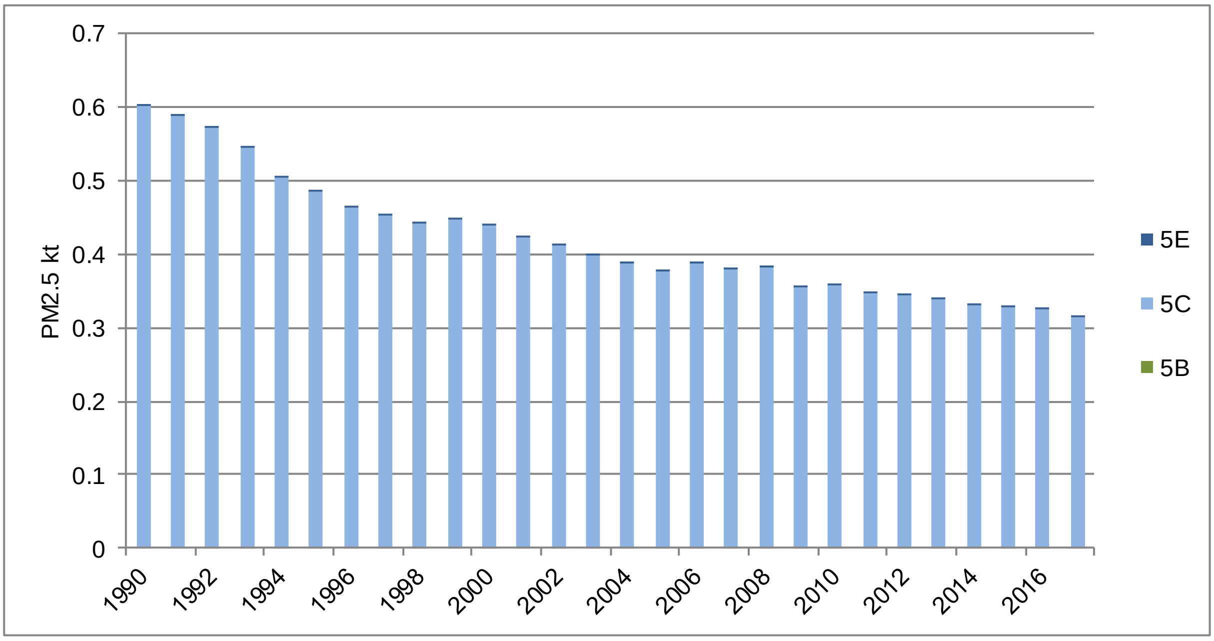


Figure 6-2: Switzerland's PM2.5 emissions from the waste sector by source categories 5B, 5C and 5E. Note that PM2.5 emissions from 5D are not occurring. The corresponding data table can be found in Annex A7.5.

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 active landfill sites where organic material is degraded in biological processes are equipped to recover landfill gas (SFOE 2018a). 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 (reported under 5A).

The methane emissions are calculated using a First Order Decay (FOD) model that is compliant with IPCC 2006 (see below). By reason of legal requirements and regulations it is assumed that open burning did not take place after 1990 anymore (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 emission from landfills is the greenhouse gas CH_4, which is not relevant for the CLRTAP Inventory. However, methane is used for combined heat and power generation or it is flared. 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 (1A1a Public electricity and heat production), 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 2019):

1. CH_4 emissions are modelled with the FOD model according to 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. Their amount is proportional to the CH_4 burnt.

Emission factors (5A)

Emission factors are country-specific based on measurements and expert estimates, documented in EMIS (EMIS 2019/1A1a & 5A), see Table 6-2. 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 2017 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)

The main activity data for 5A Biological treatment of waste - Solid waste disposal on land are the waste quantities disposed on landfills that are used for calculating the amount of methane produced. Activity data are taken from EMIS 2019/1A1a & 5A. Table 6-3 documents the decrease of municipal solid waste, construction waste and sewage sludge disposed in landfill sites in the reporting period. The reason for this is that incineration of combustible waste is mandatory in Switzerland since the year 2000 and therefore amounts deposited have dropped to zero in the following years.

Table 6-3: Activity data for 5A Biological treatment of waste - Solid waste disposal on land (source EMIS 2019/1A1a & 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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Municipal solid waste (MSW)	kt	1.2	NO	NO	NO	NO	NO	NO	NO	NO	NO
Construction waste (CW)	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sewage sludge (SS)	kt (dry)	NO	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	1.2	NO	NO	NO	NO	NO	NO	NO	NO	NO

The resulting set of activity data for 5A Biological treatment of waste - Solid waste disposal on land is the amount of CH_4 flared (see Table 6-4). 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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CH_4 flared	kt	2.6	2.4	2.4	2.1	1.8	1.6	1.4	1.4	1.4	1.4

The emissions from using methane as fuel for combined heat and power generation in engines are reported under 1A1a Energy industries.

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. Emissions from combined heat and power generation that use biogas from digestion are reported under 1A2gviii Other and 1A4a Commercial/Institutional.

Within 5B1 Composting two kinds of composting are distinguished, i.e. industrial composting and backyard composting. Industrial composting covers the emissions from centralized composting activities with a capacity of more than 100 tonnes of organic matter per year as well as the composting of organic material at the border of agricultural fields. Backyard composting in private households or communities is also common practice in Switzerland. Activity data and emission factors for industrial and backyard composting have been thoroughly reassessed in 2017, new data were gained and EMIS 2019/5B1 Kompostierung has been revised accordingly.

Within 5B2 Anaerobic digestion at biogas facilities two plant types are distinguished: i) industrial biogas plants and ii) agricultural biogas plants. Biogas upgrading is treated as a separate process covered in this source category, however this only induces methane emissions due to leakage and is therefore not relevant for the CLRTAP Inventory. 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 directly used as fertiliser, respectively. The biogas generated during the digestion process is used for combined heat and power generation (CHP) 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

Table 6-6: Key Categories approach 1, level 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 5B Biological treatment of waste.

Code	Source Category	Pollutant	Identification Criteria
5B1	Biological treatment of waste - Composting	NH3	T2

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).

Figure 6-3 depicts a schematic design of an industrial biogas plant. Six process steps are taken into account where emissions occur. For each process step separate activity data and emission factors are used:

- P1: Emissions from the storage of organic waste
- P2: Emissions from fermentation
- P3: Emissions from the interim storage of liquid digestate
- P4: Emissions from on site aerobic after treatment of solid digestate
- P5: Emissions from the utilisation of biogas in the CHP units
- P6: Emissions from flaring of biogas

P5 as energy-related emissions are reported in sector 1 Energy source category 1A2gviii Other.

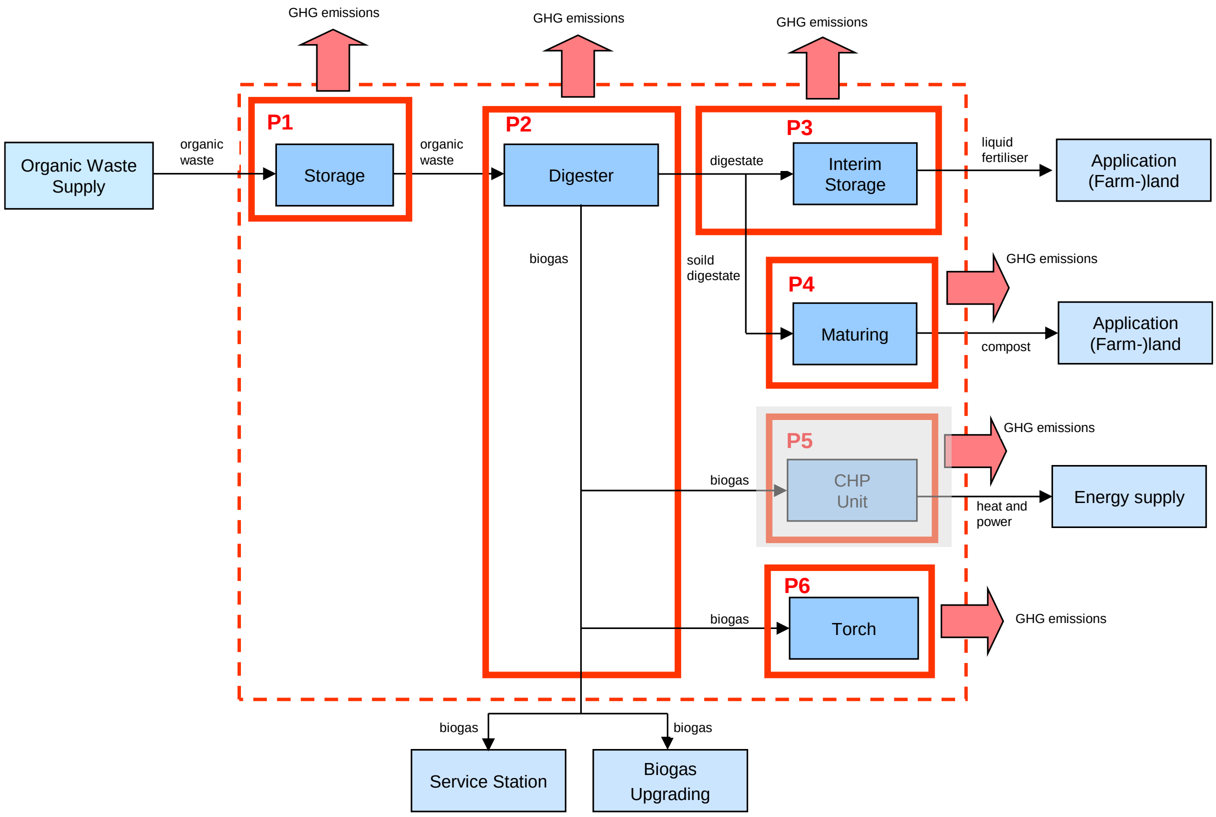


Figure 6-3: Schematic design of an industrial biogas plant.

Figure 6-4 depicts a schematic design of an agricultural biogas plant. It is very similar to the scheme of the industrial biogas plant described above. Seven process steps are distinguished where emissions might occur. For each process step separate activity data and emission factors are used:

- P1: Emissions from the intermediate storage of the waste from animal husbandry (liquid and solid manure) and the additional co-substrate.
- P2: Losses due to leakage from the fermenter, gas piping and overproduction
- P3: Emissions from the storage of liquid digestate
- P4: Emissions from aerobic after treatment of solid digestate
- P5: Emissions from the utilisation of biogas in the CHP units
- P6: Emissions from the utilisation of biogas in the gas boiler
- P7: Emissions from flaring of biogas

Emissions from P1 are reported in sector 3 Agriculture, and emissions from P5 and P6 are reported in sector 1 Energy source category 1A4ai Commercial/Institutional.

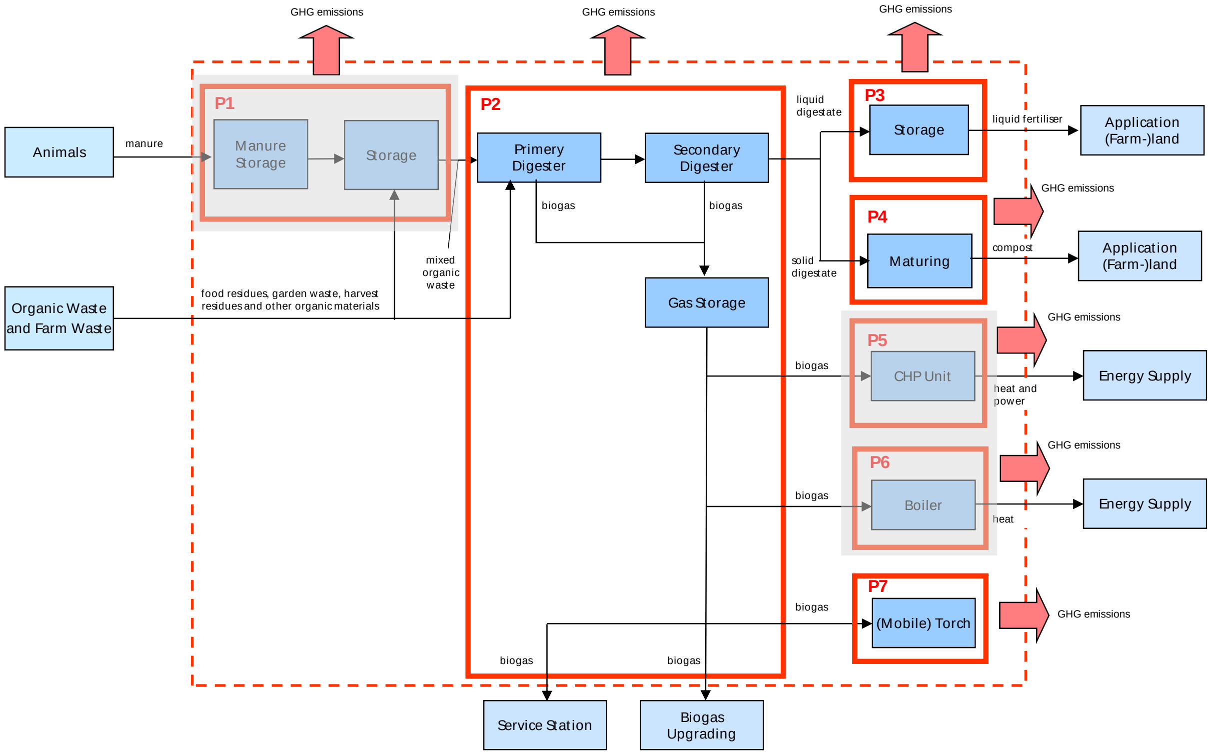


Figure 6-4: Schematic design of an agricultural biogas plant.

Emission factors (5B)

Emission factors for composting are country-specific based on measurements and expert estimates, documented in comment of the database (EMIS 2019/5B1 Kompostierung). For all years emission factors are considered to remain constant.

Emission factors for digestion are country-specific based on measurements according to Edelmann and Schleiss (2001), Cuhls (2010) and Butz (2003). Emission factors for digestion are documented in comments to the database (EMIS 2019/1A2g and 5B2 Vergärung IG and EMIS 2019/1A4a and 5B2 Vergärung LW). The following table presents the emission factors used in 5B.

Table 6-7: Emission factors of 5B Biological treatment of waste - Composting and anaerobic digestion at biogas facilities in 2017.

5B Composting and anaerobic digestion at biogas facilities	**Pollutant**	**Unit**	**Emission factors**
Composting (industrial)	NMVOC	g/t composted waste	300
	NH3	g/t composted waste	500
Composting (backyard)	NMVOC	g/t composted waste	300
	NH3	g/t composted waste	500
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 2019/5B1 Kompostierung, EMIS 2019/1A1a and 5B2 Vergärung IG and EMIS 2019/1A1a and 5B2 Vergärung LW. Activity data for digestion are based on reliable statistical data from the statistics of renewable energies (SFOE 2018a). Activity data for industrial and backyard composting are based on a study from the year 2017 (Schleiss 2017). Activity data for composting are based on data from the years 1989, 1993, 2000 and 2013, supplied by plant operators. Activity data for intermediate years are calculated by linear interpolation.

The continous increase of organic material composted until the year 2000 and the strong increase afterwards of organic material digested is the reason that 5B Biological treatment of waste is key category regarding trend.

Table 6-8: Activity data of 5B Biological treatment of waste.

5B Composting and anaerobic digestion at biogas facilities	Unit	1990	1995	2000	2005
Composting (industrial)	kt wet	240	360	519	526
Composting (backyard)	kt wet	110	155	180	170
Digestion (ind., digestable waste / storage)	kt wet	NO	27	60	108
Digestion (ind., digested waste liquid / storage)	kt wet	NO	15	33	60
Digestion (ind., digested waste solid / rotting)	kt wet	NO	9.4	20	37
Digestion (ind., flaring, CH_4)	kt	NO	0.04	0.10	0.18
Digestion (agr., digested waste liquid / process water)	kt wet	113	94	125	181
Digestion (agr., digested waste solid / rotting)	kt wet	5.9	4.9	6.5	10
Digestion (agr., flaring, CH_4)	kt	NO	NO	NO	NO

5B Composting and anaerobic digestion at biogas facilities	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Composting (industrial)	kt wet	530	532	530	532	534	536	540	545	550	555
Composting (backyard)	kt wet	140	130	120	110	100	100	100	100	100	100
Digestion (ind., digestable waste / storage)	kt wet	176	225	289	372	508	561	590	650	695	712
Digestion (ind., digested waste liquid / storage)	kt wet	98	125	161	207	283	313	329	362	387	397
Digestion (ind., digested waste solid / rotting)	kt wet	60	77	99	127	174	192	201	222	237	243
Digestion (ind., flaring, CH_4)	kt	0.32	0.41	0.51	0.63	0.84	0.91	0.90	0.95	1.00	1.03
Digestion (agr., digested waste liquid / process water)	kt wet	460	489	569	612	711	829	941	1053	1202	1292
Digestion (agr., digested waste solid / rotting)	kt wet	24	26	30	32	37	44	50	55	63	68
Digestion (agr., flaring, CH_4)	kt	NO	NO	0.12	0.13	0.16	0.20	0.23	0.26	0.29	0.31

6.3.3 Category-specific recalculations in 5B - Biological treatment of waste - Anaerobic digestion at biogas facilities

- 5B2: An error has been corrected in the calculation of the amount of biogas from digestion that is torched in industrial biogas facilities. Emissions from torches slightly increase for the years 1992-2016. This recalculation also influences the total amount of organic waste treated in biogas facilities and therefore the emissions from the intermediate storage of organic waste, from fermentation and from the storage of liquid and solid digestate.
- 5B2: An error has been corrected in the calculation of the amount of biogas from digestion that is torched in agricultural biogas facilities. Emissions from torches slightly increase for the years 2008-2016. This recalculation also influences the total amount of organic waste treated in biogas facilities and the emissions from fermentation and from the storage of liquid and solid digestate.

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 in installations 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 Table 6-9.

Table 6-9: 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).

Table 6-10 gives an overview of other waste incineration sources in Switzerland and the source category, where respective emissions are reported in the national inventory.

Table 6-10: 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 6-11: Key Categories, level 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 5C Waste incineration and open burning of waste (NFR code as of EMEP/EEA 2016).

Code	Source Category	Pollutant	Identification Criteria
5C1a	Municipal waste incineration	PM2.5	L1
5C1biv	Sewage sludge incineration	SO2	T2

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 burning of municipal waste) a Tier 2 method is used (see decision tree in chapter 5C1a Municipal waste incineration EMEP/EEA Guidebook 2016 (EMEP/EEA 2016).

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 5C1biv Industrial waste incineration including hazardous waste and sewage sludge EMEP/EEA Guidebook 2016 (EMEP/EEA 2016).

For the calculation of the emissions from clinical waste incineration a Tier 2 method is used (see decision tree in chapter 5C1biii Clinical waste incineration EMEP/EEA Guidebook 2016 (EMEP/EEA 2016).

For the calculation of the emissions from sewage sludge incineration plants a Tier 2 method is used (see decision tree in chapter 5C1biv Industrial waste incineration including hazardous waste and sewage sludge EMEP/EEA Guidebook 2016 (EMEP/EEA 2016).

For the calculation of the emissions from cremation a Tier 2 method is used (see decision tree in chapter 5C1bv Cremation EMEP/EEA Guidebook 2016 (EMEP/EEA 2016).

For the calculation of the emissions from burning of agricultural and private gardening waste a country-specific Tier 2 method is used (see decision tree in chapter 5C2 Open burning of waste EMEP/EEA Guidebook 2016 (EMEP/EEA 2016).

Emission factors (5C)

Emission factors are country-specific based on measurements and expert estimates as documented in the EMIS database (EMIS 2019/5C1 Abfallverbrennung illegal, EMIS 2019/5C1 Kabelbrand, EMIS 2019/5C1 Spitalabfallverbrennung, EMIS 2019/5C1 Krematorien, EMIS 2019/5C1 Klärschlammverbrennung, EMIS 2019/5C2 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 agricultural and private gardening 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 6-12 depicts the emission factors used in 5C.

Table 6-12: Emission factors for 5C Waste incineration and open burning of waste in 2017.

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	6.6	NA	NA	17	17	19	51

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	0.16	NA	0.001	NE	NE	NE	NE

Activity data (5C)

The clinical waste incineration quantities are based on rough expert estimates (EMIS 2019/5C1 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 2019/5C1 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 2010 and onwards quantities are calculated assuming a per capita value of 26 kg/a (EAWAG 2018) multiplied by the population number. Values between 2006 and 2010 are interpolated. This approach is used because total sewage sludge quantities in the yearly waste statistics (FOEN 2018b) are held constant since 2006. The total amount of sewage sludge incinerated is then calculated using the total amount generated minus the sewage sludge 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 (see Table 6-13) is about to decrease since legal burning is more strongly restricted since a revision of the corresponding article in the Swiss Federal Ordinance on Air Pollution Control in the year 2009 (EMIS 2019/5C2 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 (5C2ii) were moved to sector 4V in the greenhouse gas inventory. The corresponding air pollutant emissions have been moved to 11B within the informative inventory report (Natural sources, natural and man induced forest fires).

Table 6-13: Activity data for the various emission sources within source category 5C Waste incineration and open burning of waste.

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**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Clinical waste incineration	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Illegal waste incineration	kt	22.4	20.7	21.0	20.3	20.3	19.9	19.3	19.3	19.0	18.3
Insulation material from cables	kt	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sewage sludge incineration	kt dry	95.1	96.2	97.4	98.1	98.7	121.2	123.9	132.9	139.6	142.6
Open burning of natural residues in agriculture	kt	12.0	11.8	11.5	11.4	11.3	11.2	11.1	11.0	10.8	10.7
Open burning of natural residues in private households	kt	1.7	1.5	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1
Total	kt	131.2	130.2	131.2	131.0	131.4	153.4	155.4	164.3	170.6	172.7
Cremation	Numb.	51'116	52'402	52'813	52'530	50'567	53'205	55'616	59'664	54'634	57'694

Note that since 2002, all specific clinical waste incineration plants have ceased operation and all hospital waste is incinerated in municipal solid waste incineration plants (accounted for in 1A1 Energy industry). All burning of insulation material cables (industrial waste incineration in the table above) has ceased as well since 1995.

6.4.3 Category-specific recalculations in 5C – Waste incineration and open burning of waste

- 5C1: Activity data for sewage sludge incineration has been re-estimated for the years 2010-2016 according to a recommendation in EAWAG (2018). Values for 2007-2009 have also changed because of the interpolation of the data between 2006 and 2010.

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 plants (WWTP) 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 2017c). The vast majority of WWTP apply an anaerobic sludge treatment with sewage gas recovery and use the sewage gas for combined heat and power 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 6-14: 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 6-5 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 the use of sewage gas for combined heat and power generation as well as in boilers are reported in sector 1 Energy in source category 1A2gviii Other.

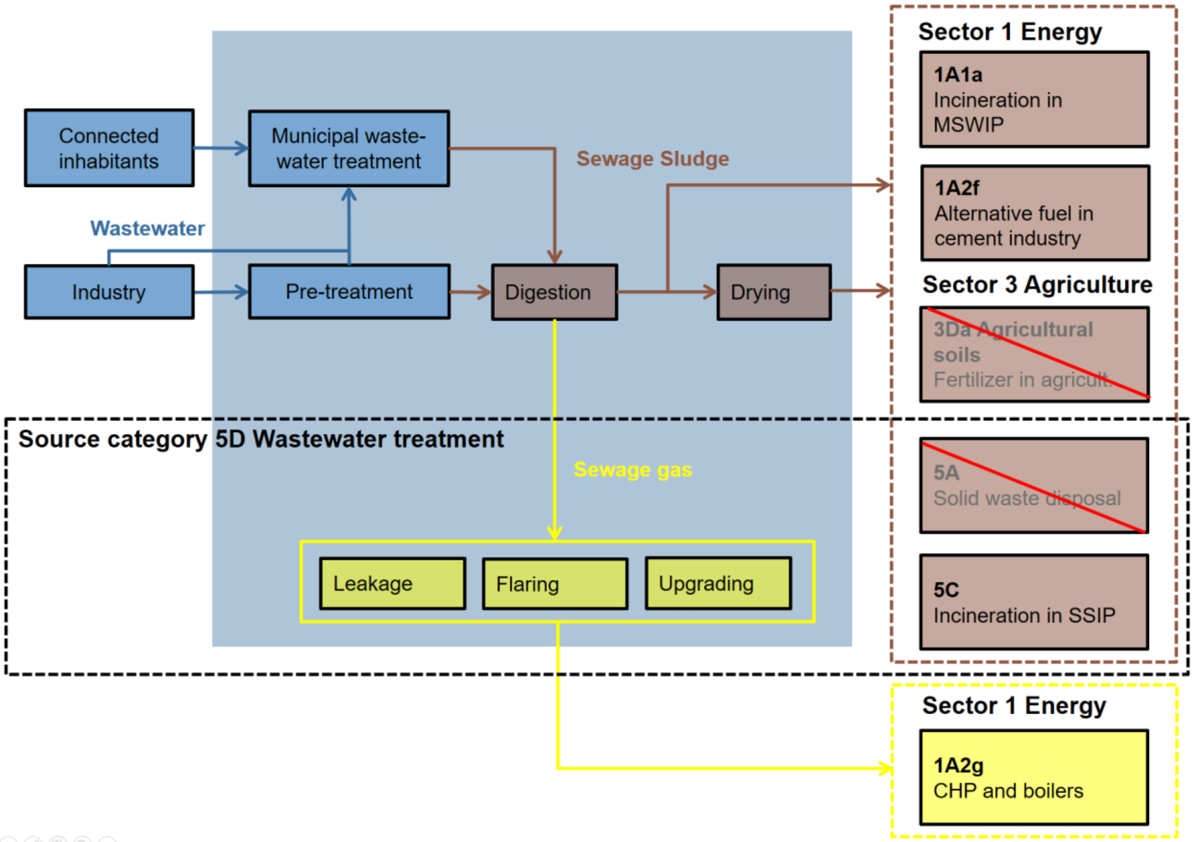


Figure 6-5: System boundaries of emissions related to wastewater handling. Abbreviations: CHP Combined Heat and Power Generation, MSWIP municipal solid waste incinearion plant, SSIP sewage sludge incineration plant.

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 2016 (EMEP/EEA 2016).

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 wastewater system.

Emission factors (5D)

Emission factors are country-specific based on measurements and expert estimates, documented in the EMIS database (EMIS 2019/5D1, EMIS 2019/5D2), see Table 6-15.

Table 6-15: Emission factors for 5D Wastewater handling in 2017.

5D Wastewater handling	NO_x	NMVOC	SO_x	NH_3	CO
	g/person				
5D1 Domestic wastewater handling	0.6	0.011	0.003	14.6	0.3
5D2 Industrial wastewater handling	0.2	0.003	0.001	NA	0.1

Activity data (5D)

Activity data for 5D1 Domestic wastewater handling and 5D2 Industrial wastewater handling are the total number of inhabitants extracted from SFSO (2018a). The number of inhabitants 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 6-16: 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	%	90.0	93.7	95.4	96.8
Inhabitants connected	persons in 1000	6'116	6'635	6'877	7'261

5D Wastewater handling	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Inhabitants	persons in 1000	7'711	7'801	7'878	7'912	7'997	8'089	8'189	8'282	8'373	8'452
Fraction connected to waste water treatment plants	%	97.1	97.2	97.2	97.3	97.3	97.3	97.3	97.3	97.3	97.3
Inhabitants connected	persons in 1000	7'487	7'583	7'657	7'698	7'781	7'871	7'968	8'058	8'147	8'224

6.5.3 Category-specific recalculations in 5D - Wastewater handling

The following recalculations were implemented in submission 2019:

- 5D1: Emission factors have changed from 2007-2016 because of a recalculation of the amount of sewage sludge treated during that time. Changes occur as well because the parameter T_{plant} (inhabitants being connected to the public sewer system) has changed for the years 1995, 1998, 2006, 2008 and following years. The calculations for sewage gas flared and losses have been corrected according to the review recommendations for the years 2006-2016. The amount of biogas used in CHP installations has been changed in the underlying statistics by the SFOE for the years 2010 and 2013-2016 (however this process is reported in 1A2gviii).
- 5D1: Emissions from combined heat and power generation (CHP) and boilers in domestic wastewater treatment plants have been reported in source category 5D1 and 1A2gviii as well. This lead to a double counting of emissions. Emissions in 5D1 have been removed from source category 5D1 and are now solely reported in 1A2gviii. This leads to a decrease of emissions for the years 1990-2016 in 5D1.
- 5D2: Emissions from combined heat and power generation (CHP) and boilers in industrial wastewater treatment plants have been reported in source category 5D2 and 1A2gviii as well. This lead to a double counting of emissions. Emissions in 5D2 have been removed from source category 5D2 and are now solely reported in 1A2gviii. This leads to a decrease of emissions for the years 1990-2016 in 5D2.

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 6-17: 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 2019/5E Shredder Anlagen). For all years, emission factors are considered to remain constant.

Table 6-18: Emission factors for 5E Other waste, car shredding in 2017.

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 2019/5E Shredder Anlagen).

Table 6-19: Activity data for car shredding (source EMIS 2019/5E Shredder Anlagen)

5E Other waste	Unit	1990	1995	2000	2005
Shredding	kt	280	300	300	300

5E Other waste	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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 2017. In sectors 6 and 11 Other and natural emissions NH_3, NO_x, PM2.5 and NMVOC are the most relevant pollutants.

The following source categories are reported:

- 6Aa Humans
- 6Ab Pets
- 6Ac Fertilisers
- 6Ad Fire damages estates and motor vehicles
- 11B Forest fires and open burning of residues in forestry
- 11C Other natural emissions (NMVOC from forest stands)

Active volcanoes (11A) do not occur in Switzerland.

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 Fertilisers remain considerably stable in total during past years, although 6Aa shows a very slight increase with population.

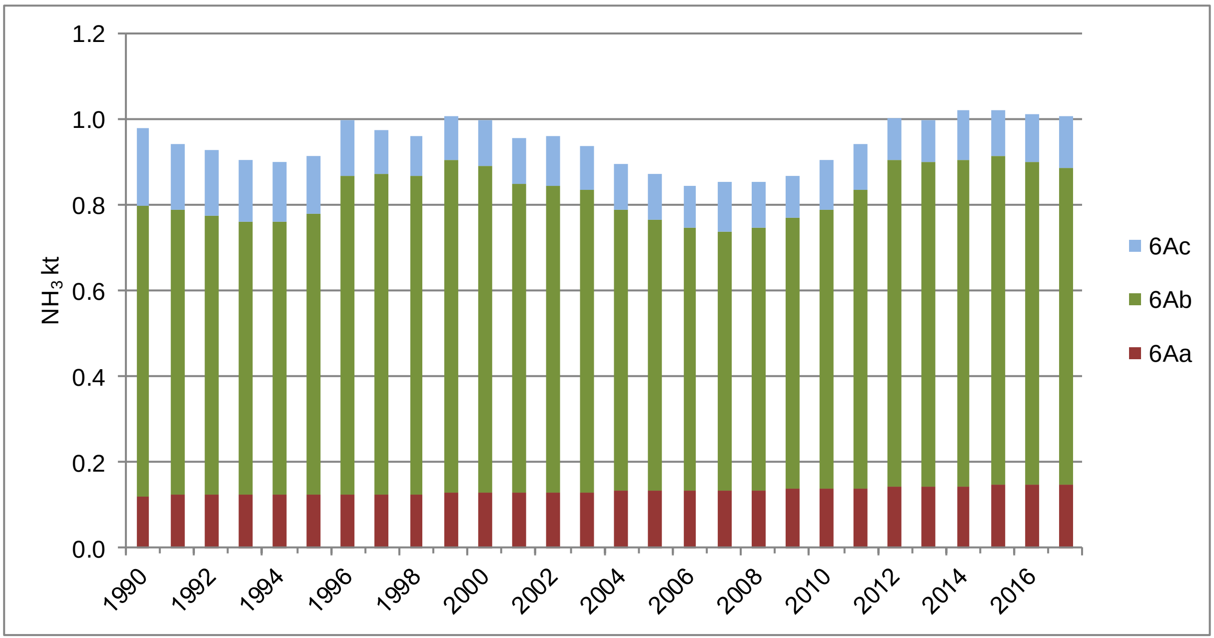


Figure 7-1: Switzerland's NH_3 emissions from sector 6 Other and natural emissions by source categories 6Aa, 6Ab and 6Ac. The corresponding data table can be found in Annex A7.6.

7.1.2 Overview and trend for NO_x

NO_x emissions from the source categories 6Ab Pets, 6Ac Fertilisers and 6Ad Fire damages estates and motor vehicles between 1990 and 2017 are summarised in Figure 7-2. The overall emissions fluctuate but remain at about the same level within the reporting period. For all years, 6Ab Pets and 6Ac Fertilisers contribute the bulk to total emissions. Emissions from 6Ad Fire damages estates and motor vehicles remained stable.

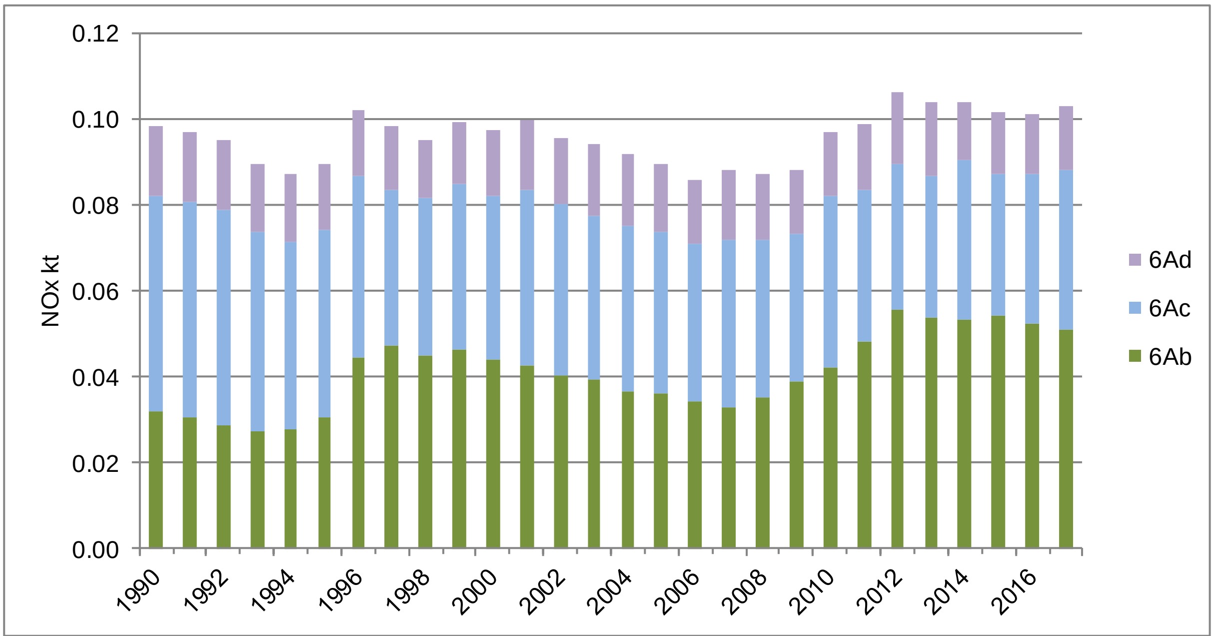


Figure 7-2: Switzerland's NO_x emissions from the sector 6 Other and natural emissions by source categories 6Ab-6Ad. The corresponding data table can be found in Annex A7.6.

7.1.3 Overview and trend for PM2.5

PM2.5 emissions in the sector 6 Other and natural emissions stem predominantly from 6Ab Pets. Emissions from 6Ad Fire damages estates and motor vehicles are the other relevant source category. Total emissions slightly decreased in the reporting period, however they show an increasing trend since 2008.

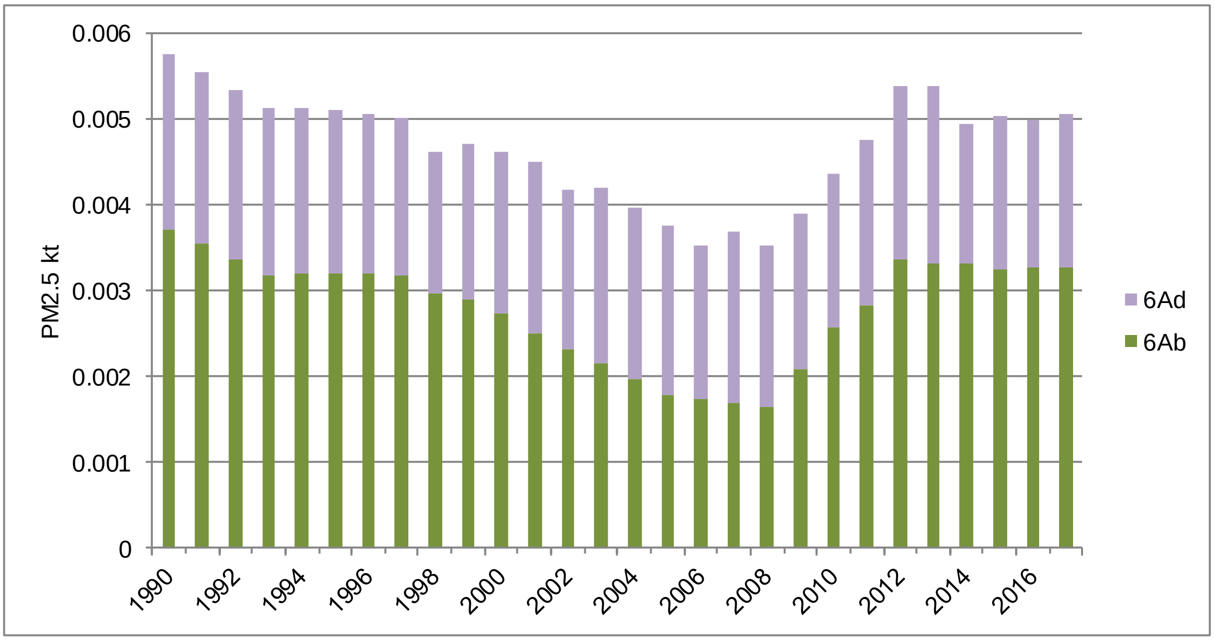


Figure 7-3: Switzerland's PM2.5 emissions from the sector 6 Other and natural emissions. The corresponding data table can be found in Annex A7.6.

7.1.4 Overview and trend for NMVOC from Forests

NMVOC emissions in the sector 11C Other natural emissions stem predominantly from Norway spruce and fir stands. Total emissions in 1990 were 60.8 kt; they are increasing on average by 0.34 % per year.

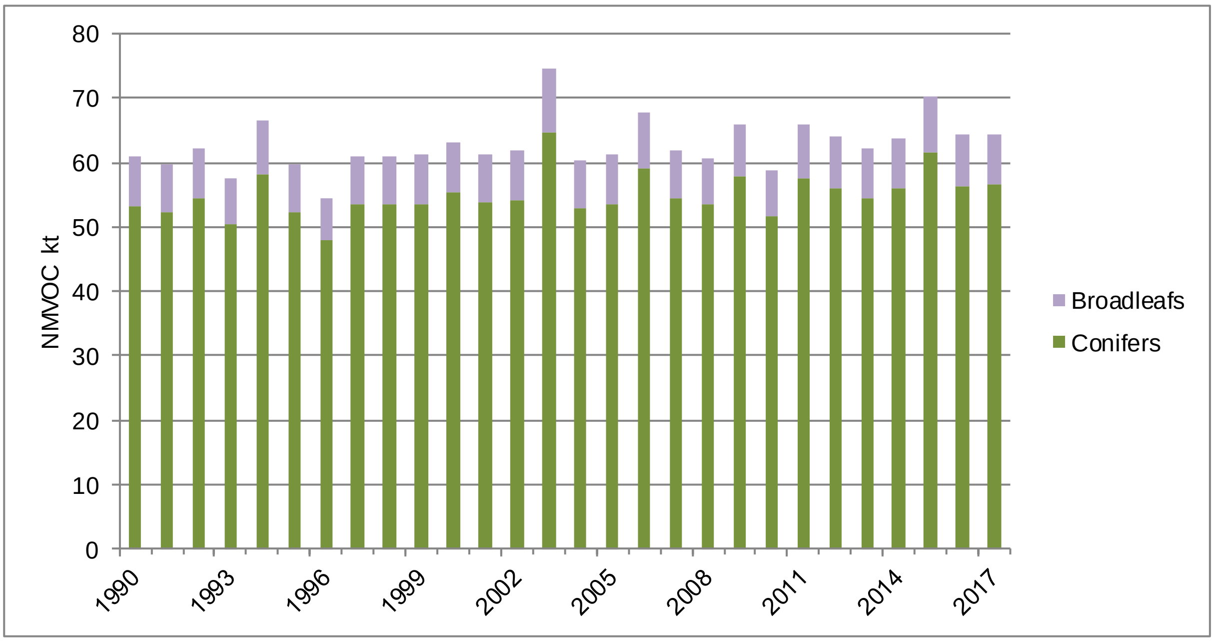


Figure 7-4: Switzerland's NMVOC emissions from the sector 11C Other natural emissions (forest stands).

7.2 Source category 6 - Other emissions

7.2.1 Source category description of 6 - Other emissions

Within the sector 6 Other emissions, emissions from the sources as shown in Table 7-1 are considered.

Table 7-1: Specification of sector 6 Other emissions.

6A	Source	Specification
6Aa	Human emissions	Ammonia emissions from respiration and transpiration and diapers
6Ab	Pets and livestock outside agriculture	NOx, NMVOC, ammonia, PM2.5, PM10 and TSP emissions of domestic and zoo animals and of livestock not included in sector 3 Agriculture
6Ac	Private application of synthetic fertilizer and urea	NOx and ammonia emissions
6Ad	Fire damage estates and motor vehicles	Emissions from fires in buildings and emissions from fires and fire damage in motor vehicles

Table 7-2: Key Categories approach 1, level 2017 (L1, L2) and trend 1990-2017 (T1, T2), for source category 6A Other emissions.

Code	Source Category	Pollutant	Identification Criteria
6A	Other sources	NH3	L2

7.2.2 Methodological issues of 6 - Other emissions

Methodology (6A)

Human emissions (6Aa)

Ammonia emissions of human respiration and transpiration and of diapers are considered.

Emissions from pets and livestock outside agriculture (6Ab)

Ammonia emissions of domestic animals such as cats and dogs as well as of zoo animals are considered.

Emissions of NO_x, NMVOC, NH_3 and particulate matter (PM2.5, PM10 and TSP) from manure management of so-called livestock outside agriculture (i.e. asses, goats, horses and sheep) are considered. This livestock is not covered by the agricultural census as it consists of animals held for non-agricultural purposes (e.g. horses for sports and leisure) and/or livestock held by private persons or enterprises that do not fulfil the criteria of an agricultural enterprise. The methodology is the same as for animal husbandry in agriculture (see chp. 5.2.2).

Emissions from private fertiliser use (6Ac)

Emissions from the use of mineral fertilisers are calculated by multiplying activity data of Table 7-5 by the emission factors of Table 7-3. The methodology is the same as for fertilisers used and reported in the agricultural sector (see chp. 5.3.2). The methodology for calculating NH_3 emissions from application of inorganic fertilisers in agriculture (source category 3Da1) is a Tier 2 approach of EMEP/EEA (2016) taking into account the specified list of fertilisers, climate zone and pH. This methodology is applied to source category 6Ac.

Emissions from fire damage estates and motor vehicles (6Ad)

Emissions from fire damage in estates are calculated as follows: 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 2019/6A).

Emissions from fire damage of motor vehicles are calculated based on data from a Swiss car insurance company with 25% market share in 2002. The number of reported cases of fire damage from this company 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 annual 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 2019/6A). 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 amount of material burnt can be calculated from the total number of cars in Switzerland.

Emission factors (6A)

The emission factors for the source categories 6Aa to 6Ac are depicted in Table 7-3. Emission factors for fertiliser see also Table 5-10.

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). The ammonia emission factor for livestock outside agriculture is derived from category 3B – Manure management (see chp. 5.2.2).

NOx, NMVOC, PM2.5, PM10 and TSP nonexhaust (6Ab)

The emission factors for NOx, NMVOC, PM2.5, PM10 and TSP from livestock outside agriculture are in accordance with the unrounded values of the implied emission factors in source category 3B. For detailed information about these emission factors please refer to 3B – Manure management (see chp. 5.2.2).

Table 7-3: Emission factors for the year 2017 in sector 6 Other emissions (source EMIS 2019/6A).

EMIS nomenclature	Source	Pollutant	Unit	Emission factor
6 A a	Human respiration	NH_3	g/person	3
6 A a	Human transpiration	NH_3	g/person	14
6 A a	Children <1y	NH_3	g/person	12
6 A a	Children 1-3y	NH_3	g/person	15
6 A a	Aged inhabitants	NH_3	g/person	41
6 A b	Livestock, outside agriculture	NO_x	g/animal	494
6 A b	Livestock, outside agriculture	NMVOC	g/animal	993
6 A b	Livestock, outside agriculture	NH_3	g/animal	3'557
6 A b	Livestock, outside agriculture	PM2.5 nonexhaust	g/animal	32
6 A b	Livestock, outside agriculture	PM10 nonexhaust	g/animal	86
6 A b	Livestock, outside agriculture	TSP nonexhaust	g/animal	210
6 A b	Cats	NH_3	g/animal	90
6 A b	Dogs	NH_3	g/animal	422
6 A b	Zoo animals	NH_3	g/t	41
6 A c	Fertilizer, outside agriculture	NO_x	kg/t	18
6 A c	Fertilizer, outside agriculture	NH_3	kg/t	57

Fire damages (6Ad)

Fire damages estates: Emission factors for CO, NO_x and SO_2 are country-specific based on measurements and expert estimates originally derived for illegal waste incineration. It is assumed that emissions are similar in fire damage in estates (EMIS 2019/6A "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/F emission factor is the same as for illegal waste incineration. The emission factor for B(a)P is taken from US-EPA (1998a).

Fire damage motor vehicles: Emission factors for CO, NO_x and SO_2 are country-specific based on measurements and expert estimates originally derived for wire burn off, documented in EMIS 2019/6A Brand- und Feuerschäden Motorfahrzeuge". The PCDD/F emission factors for 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 7-4 presents the emission factors used. Units for the pollutants in the upper and lower table rows are different. The emission factors for Pb, Cd, Hg, and B(a)P are identical for estates and motor vehicles.

Table 7-4: Emission factors for fires reported under 6Ad Fire damages estates and motor vehicles in 2017 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 of 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.

Pets and livestock outside agriculture (6Ab)

Activity data for pet ammonia as well as NO_x, NMVOC, PM2.5, PM10 and TSP emissions (for livestock outside agriculture) 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[6].

Emissions from private fertiliser use (6Ac)

For 6Ac only mineral fertilisers (no urea based fertilisers) are used for private applications.

Table 7-5: Activity data causing N emissions in sector 6 Other emissions.

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	82'203	78'458	72'903
6 A a	Children 1-3y	person	238'030	253'652	237'941	217'302
6 A a	Aged inhabitants	person	9'000	9'752	10'504	11'029
6 A b	Livestock outside agriculture	animals	27'876	29'597	93'829	85'694
6 A b	Cats	animals	1'164'786	1'205'000	1'379'000	1'417'000
6 A b	Dogs	animals	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, outside agriculture	t	2'778	2'432	2'111	2'087

EMIS nomenclature	Source	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
6 A a	Human respiration	person	7'711'000	7'801'000	7'878'000	7'912'000	7'997'000	8'089'000	8'189'000	8'282'000	8'373'000	8'452'000
6 A a	Human transpiration	person	7'711'000	7'801'000	7'878'000	7'912'000	7'997'000	8'089'000	8'189'000	8'282'000	8'373'000	8'452'000
6 A a	Children <1y	person	76'691	78'286	80'290	80'808	82'164	82'731	85'287	86'559	87'883	87'381
6 A a	Children 1-3y	person	220'768	224'556	229'471	235'267	239'384	243'262	245'703	250'182	254'577	259'729
6 A a	Aged inhabitants	person	11'338	17'080	17'357	17'393	17'972	18'389	18'679	19'278	19'244	19'426
6 A b	Livestock outside agriculture	animals	85'504	90'019	91'367	99'185	111'750	107'347	105'572	112'350	106'260	103'468
6 A b	Cats	animals	1'392'000	1'449'500	1'507'000	1'497'000	1'487'000	1'543'317	1'618'406	1'655'951	1'655'951	1'645'096
6 A b	Dogs	animals	508'000	476'500	445'000	475'500	506'000	511'297	518'360	521'891	521'891	513'816
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, outside agriculture	t	2'024	1'907	2'212	1'947	1'881	1'822	2'056	1'823	1'933	2'057

Fire damages (6Ad)

Activity data for source category fire damages (6Ad) are given in Table 7-6.

Table 7-6: Activity data in source category 6Ad Fire damages: Burnt goods (source EMIS 2019/6A).

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	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Fire damage estates	kt	7.2	7.0	6.8	7.4	7.8	8.0	6.3	6.8	6.6	6.9
Fire damage motor vehicles	kt	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8

7.2.3 Recalculations in 6 - Other emissions

- 6Aa: Activity data for human emissions from diapers have changed for the year 2016 due to an update in the underlying statistics provided by SFOS.
- 6Ab: The so far missing NMVOC emissions from manure management of livestock outside agriculture are now included in the inventory along with all agricultural livestock

[6]Verband für Heimtiernahrung VHN (http://www.vhn.ch/)

categories based on a Tier 1 approach according to the EMEP/EEA emission inventory guidebook – 2016 (EMEP/EEA 2016) for the entire time series.

- 6Ab: The emission factors of PM2.5, PM10 and TSP from 6Ab Manure management - Livestock outside agriculture have been revised for the entire time series. They have been changed from rounded to unrounded values in accordance with the implied emission factors in sector 3 Agriculture.
- 6Ab: All estimates based on AGRAMMON data were recalculated for the whole time series due to the implementation of a new model version. The most important changes were the switch to a full nitrogen flow model (including N_2O, NO_x and N_2) and the revision of nitrogen excretion rates of several livestock categories. More details on AGRAMMON recalculations resulting in revised NH_3 and NO_x emission factors can be found in chapter 3.6 of Kupper et al. (2018).
- 6Ac: In last year's submission of the inventory the methodology for calculating NH_3 emissions from application of inorganic fertilisers in agriculture (source category 3Da1) was revised according to the Tier 2 approach of EMEP/EEA (2016) taking into account the specified list of fertilisers, climate zone and pH. This methodology has been applied to source category 6Ac Private use of fertiliser as well yielding revised NH_3 emission factors for the entire time series.

7.3 Source category 11B - Forest fires

7.3.1 Source category description of 11B - Forest fires

Within 11B Forest fires following source categories are reported:

- Emissions from forest wildfires 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 within source category 11B.

7.3.2 Methodology of 11B - Forest fires

For calculating the emissions of forest fires a country-specific Tier 2 method is used (see decision tree in chapter 11B Forest fires in EMEP Guidebook (EMEP/EEA 2016). Emissions of forest fires are calculated by multiplying the annual area of forest burnt by the different emission factors.

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 Guidebook (EMEP/EEA 2016).

Emission factors (11B)

Emission factors for Forest fires are specified in the EMIS database (see old comment “Waldbrände”).

Emission factors for open burning of natural residues in forestry are taken from EMEP Guidebook 2013 (EMEP/EEA 2013) as documented in EMIS 2019/5C2 Abfallverbrennung Land- und Forstwirtschaft.

Table 7-7: Emission factors 2017 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 comment “Waldbrände”).

The activity data for burning of silvicultural waste is decreasing since 1990 since legal burning is more strongly restricted, especially since the last revision of the corresponding article in the Swiss Federal Ordinance on Air Pollution Control in the year 2009 (Swiss Confederation 1985 as at 1 January 2009). Activity data are documented in EMIS 2019/5C2 Abfallverbrennung Land- und Forstwirtschaft.

Table 7-8: Activity data of 11B Forest Fires.

11B Forest fires	Unit	1990	1995	2000	2005
Forest fires	ha	1'698	445	69	45
Open burning of natural residues in forestry	kt	28.8	24.5	20.2	15.9

11B Forest fires	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Forest fires	ha	67	51	27	225	28	28	45	46	463	455
Open burning of natural residues in forestry	kt	13.3	12.4	11.5	11.4	11.3	11.2	11.1	11.0	10.8	10.7

7.3.3 Recalculations in 11B - Forest fires

- 11B: Activity data for forest fires has changed for all years due to recalculations in the LULUCF model (see FOEN 2019 chp. 6.4. LULUCF).

7.4 Category 11C – Other natural emissions

7.4.1 Category description of 11C – Other natural emissions

Within 11C Other natural emissions NMVOC emissions of Swiss forest stands are reported for different tree species.

Note that emissions are reported under Natural emissions (11C) but are not accounted for in the national totals and are reported as memo item only.

7.4.2 Methodology of 11C – Other natural emissions

The biogenic NMVOC emissions from forests were calculated for the years 1990-2016 on the basis of monthly maps for the parameters temperature, vegetation period and for 12 different tree species (Meteotest 2019a). This corresponds to the simplified method according to chapter 11C in EMEP/EEA (2016) which represents a Tier 2 approach. With the method used, the emissions for isoprene, monoterpene and OVOC (Oxygenated VOC) could be modelled for each month with a spatial resolution of 100 x 100 m.

Emission factors (11C)

Emission factors for NMVOC emissions of different tree species are specified in the EMIS database (Table 7-9Table 7-7). They represent annual implied emission factors derived from the monthly emission maps. The values after 2016 are interpolated between the modelled years 2016 and 2050.

Table 7-9: Emission factors 2017 of 11C NMVOC for different tree species.

11C Tree species	Unit	NMVOC
Norway spruce	g/ha	74'923
Fir	g/ha	79'290
Scots pine	g/ha	20'163
European larch	g/ha	9'819
Cembra pine	g/ha	13'359
Other conifers	g/ha	104'018
European beech	g/ha	10'072
Maple	g/ha	19'954
Ash	g/ha	7'367
European oak	g/ha	162'340
Chestnut	g/ha	11'653
Other broadleaf	g/ha	10'071

Figure 7-5 shows the time series of emission factors for a coniferous species and a broadleaf species. The interannual variation is due to the monthly climatic data used in the model (Meteotest 2019a).

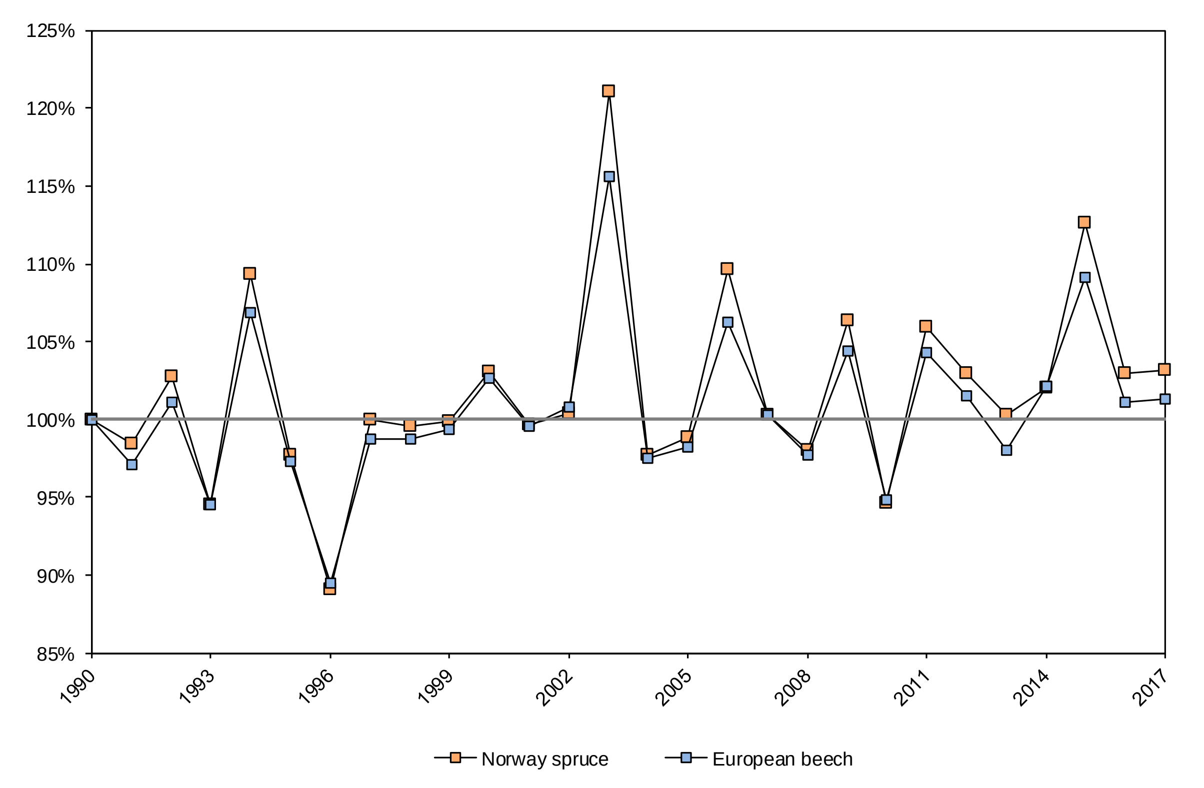


Figure 7-5: Relative trends oft the (implied) NMVOC emission factors for two selected tree species 1990-2017.

Activity data (11C)

On the basis of several forest and area statistics, the area proportions of the various tree species and their temporal change over the years could be determined (Meteotest 2019a) as shown in Table 7-10.

Table 7-10: Activity data of 11C; forest areas covered by the twelve selected tree species.

11C Tree species	Unit	1990	1995	2000	2005
Norway spruce	ha	554'168	558'151	562'292	566'457
Fir	ha	138'196	138'374	138'497	138'634
Scots pine	ha	49'503	49'823	50'136	50'400
European larch	ha	73'421	74'919	76'432	77'933
Cembra pine	ha	11'025	11'261	11'502	11'745
Other conifers	ha	3'257	3'261	3'268	3'269
European beech	ha	226'751	227'722	228'738	229'799
Maple	ha	15'325	15'461	15'614	15'729
Ash	ha	28'555	28'655	28'782	28'911
European oak	ha	24'911	24'919	24'978	25'023
Chestnut	ha	26'877	27'097	27'353	27'578
Other broadleaf	ha	59'662	60'540	61'459	62'357

11C Tree species	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Norway spruce	ha	569'205	570'107	571'009	571'930	572'879	573'867	574'751	575'680	576'601	577'451
Fir	ha	138'784	138'845	138'905	138'963	139'010	139'066	139'130	139'193	139'248	139'283
Scots pine	ha	50'547	50'587	50'624	50'668	50'722	50'781	50'821	50'873	50'926	50'981
European larch	ha	78'642	78'850	79'036	79'244	79'457	79'672	79'894	80'118	80'333	80'611
Cembra pine	ha	11'865	11'906	11'943	11'983	12'030	12'067	12'106	12'154	12'190	12'236
Other conifers	ha	3'272	3'274	3'278	3'280	3'283	3'284	3'285	3'287	3'288	3'289
European beech	ha	230'251	230'398	230'564	230'699	230'842	230'981	231'153	231'310	231'446	231'635
Maple	ha	15'792	15'813	15'831	15'861	15'880	15'905	15'931	15'951	15'975	16'000
Ash	ha	28'956	28'969	28'978	28'989	29'000	29'010	29'016	29'033	29'038	29'059
European oak	ha	25'021	25'021	25'023	25'024	25'027	25'027	25'027	25'029	25'031	25'037
Chestnut	ha	27'654	27'657	27'660	27'665	27'671	27'679	27'685	27'690	27'694	27'733
Other broadleaf	ha	62'692	62'760	62'812	62'872	62'936	63'004	63'064	63'122	63'186	63'341

7.4.3 Recalculations in 11C - Other natural emissions

- 11C: The model for calculating NMVOC emissions from forest stands has been fundamentally revised (Meteotest 2019a) and the resulting emissions are reported for the first time in the memo items.

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 for 1A1 (stationary)

- 1A1a: Emissions from biogas usage in engines and boilers of gas produced by digestion in agricultural and industrial biogas plants have been reported in source category 1A1a and 1A2gviii / 1A4ai as well. This led to a double counting of emissions. The processes for agricultural and industrial digestion have now been removed from source category 1A1a and are only reported in 1A2gviii and 1A4ai. This leads to a decrease of activity data and emissions for the years 1990-2016 in 1A1a.
- 1A1a: The SO_x EF of all gas oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A1a: The SO_2 EF of all residual fuel oil boilers have been recalculated for the time series 1990–2011. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A1a: Activity data for natural gas in sector 1A1a has changed due to recalculation in gas losses of 1B2b for the year 2016.
- 1A1a: Acitvity data (wood, wood waste) of all wood combustion installations have been revised for 2014-2016 due to recalculations in the Swiss wood energy statistics (SFOE 2018b).
- 1A1b: Emission factors for NMVOC, NO_x and CO were revised because the sources were not transparent: revision of emission factor of NMVOC and NO_x from residual fuel oil and refinery gas; revision of emission factor of SO_2 from residual fuel oil, refinery gas and petroleum coke; revision of emission factor of CO from residual fuel oil. The new emission factors lead to 40-80% less emissions of NMVOC in the years 1991-2016, 1-4% less emissions of CO and 7-20% less emissions of NO_x in the years 1991-1994 in this source category.
- 1A1b: Emission factors of so-called refinery petroleum coke boilers (2004–2015) were adjusted for all air pollutants: the same emission factors as of residual fuel oil boilers are assumed. The SO_2 EF of all residual fuel oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A1c: Activity data of charcoal production in 1A1c has been updated due to production figures from an additional charcoal pile for 2006–2016.

8.1.1.2 Category-specific recalculations for 1A2 (stationary)

- 1A2: The SO_x EF of all gas oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).

- 1A2: The SO_x EF of all residual fuel oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A2: Activity data for natural gas in all the industry sectors 1A2a-g has changed for the year 2016.
- 1A2: Activity data for use of gas oil has changed for the year 2016 in the industry sectors 1A2a-e and 1A2gviii. The change is less than -1%.
- 1A2: Activity data for use of residual fuel oil in other boilers has changed due to necessary stock changes in the year 2010 and 2014.
- 1A2c: The so-called heating gas (a cracker by-product which is used for steam production) is of similar fuel quality as gas oil. Therefore the same emission factors as of gas oil boilers are assumed for all air pollutants. The SO_2 EF of all gas oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A2c: The so-called gasolio (a cracker by-product which is used for steam production) is of similar fuel quality as residual fuel oil. Therefore, the same emission factors as of residual fuel oil boilers are assumed for all air pollutants. The SO_2 EF of all residual fuel oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A2f: The activity data of 1A2f Brick and tile production has been corrected for 2016.
- 1A2gviii: Emissions from biogas usage in engines of gas produced by digestion in industrial biogas plants have been reported in source category 1A1a and 1A2gviii as well. This led to a double counting of emissions. The corresponding processes for industrial digestion have been removed from source category 1A1a and are now only reported in 1A2gviii. In connection with these adjustments calculations for biogas usage have been revised in the energy model. This leads to a small decrease of activity data and emissions for the years 1990-2016 in 1A2gviii.
- 1A2gviii: Emissions from sewage gas usage in engines or boilers of gas produced by digestion in wastewater treatment plants have been reported in source category 5 and 1A2gviii as well. This led to a double counting of emissions. The emissions from engines have been removed from source category 5 and are now only reported in 1A2gviii. In connection with these adjustments calculations for sewage gas usage have been revised in the energy model. This leads to an increase of activity data and emissions for the years 1990-2016 in 1A2gviii.
- 1A2gviii: Acitvity data (wood, wood waste) of all wood combustion installations have been revised for the entire time series 1990-2016 due to recalculations in the Swiss wood energy statistics (SFOE 2018b). Main recalculations include changes in automatic boilers.
- 1A2gviii: For animal grease which was used as fuel in the fibreboard production (2001 – 2013) the same emission factors as of residual fuel oil boilers are assumed for all air pollutants. The SO_2 EF of all residual fuel oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).

- 1A2gviii: For petroleum coke boilers the same emission factors as of residual fuel oil boilers are assumed for all air pollutants. The SO_2 EF of all residual fuel oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).

8.1.1.3 Category-specific recalculations for 1A4 (stationary)

- 1A4: Activity data (wood, wood waste) of all wood combustion installations in source categories 1A4ai, 1A4bi and 1A4ci have been revised for the entire time series 1990-2016 due to recalculations in the Swiss wood energy statistics (SFOE 2018b). Main recalculations include changes in automatic boilers.
- 1A4bi: Higher use of natural gas in 1A4bi households (residential; +400 GJ) for the year 1990 leads to less use of natural gas in boilers in the commercial sector 1A4ai. This is just a redistribution, no change of total use of natural gas.
- 1A4: The SO_x EF of all gas oil boilers have been recalculated for the entire time series 1990–2016. They are now based on five-year averages of the annual sulphur analysis by the Swiss Federal Laboratories for Materials Science and Techology (EMPA, up to 2000) and Federal Customs Administration (FCA).
- 1A4ai: Emissions from biogas usage in engines or boilers of gas produced by digestion in agricultural biogas plants were reported in source category 1A1a and 1A4ai in the previous submission. This led to a double counting of emissions. The processes for agricultural digestion have been removed from source category 1A1a and are now only reported in 1A4ai. In connection with these adjustments calculations in the energy model have been revised. This leads to an increase of activity data and emissions for the years 1990-2003 and a decrease of activity data and emissions for the years 2005-2016 in 1A4ai.
- 1A4bi: Activity data of charcoal use in 1A4bi has been updated due to revised data in 1A1c Charcoal production for 2006–2016. In addition the so far interpolated AD values of 1991 and 1992 have been replaced by effective import data of the Swiss overall energy statistics (SFOE 2018).

8.1.1.4 Category-specific recalculations for 1A2g Mobile combustion in manufacturing industry and construction (1A2gvii)

- 1A2gvii: Due to statistical stock changes of reaidual fuel oil consumption in the energy model (see Figure 3-13), stock numbers had to be adjusted for the years 2014 and 2015.
- 1A2gvii: Correction of wrong Pb emission factors in Non-road categories. Values were 100 times too high for gasoline and bioethanol. Also the wrong allocation of Pb emissions for processes with diesel, biodiesel and liquified petroleum gas was deleted.
- 1A2gvii: Due to an error few BC emission factors were missing. This leads to 20-30% higher BC emissions in 1A2gvii.
- 1A2gvii: The wrong allocation of SO_2 emissions from liquefied petroleum gas in the nonroad sector 1A2gvii was deleted for all the years 1990-2016.

8.1.1.5 Category-specific recalculations for 1A3 Transport

- 1A3ai(ii) Memo item: The emission factor of NMVOC for fuel dumping was 58% too high for the year 2016 under 1A3ai(ii) International aviation / aviation bunkers.

- 1A3b: In the road sector, the ex post analysis 2016 (SFOE 2017e, SFOE 2017f) now forms the basis for the time series up to 2016. For the years starting from 2017 (forecast with current data), the same data basis continues to apply as for Submission 2018, i.e. the FOEN pilot study on greenhouse gas emissions up to 2050 (INFRAS 2017).

  The ex post analysis 2016 contains the following new features:

  - New driving performance for 2016 (slightly higher overall than in the pilot study on greenhouse gas emissions).
  - Specific consumption of passenger cars adjusted in 2016.
  - Time series of fuel sales, thus also adjusted proportions of biofuels, especially 2016.
  - Retrospective adjustments to the fleet composition of motorcycles.
  - NCV from biogas was adjusted to be the same as for natural gas.
  - Further small correction of emission factors due to less rounding.
  - An error in the database led to a double count of NH_3 emissions and activity data from biogas in 1A3bi and 1A3biii instead of 1A3biii only.

  All these adjustments lead to small changes in emissions in this source category comparing to submission 2018 especially of

  - 2-3% lower emissions of Hg
  - 2-6% lower emissions for BaP, BbF, BkF, IcdP
  - negligible (<1%) higher CO, NMVOC, Pb, PCDD/F and lower NO_x, NH_3, Cd, TSP, PM10, PM2.5, SO_2, Zn emissions

- 1A3b: Correction of wrong BC emission factors, which were 100 times too low for all years except for 1A3biii only in the years 2001-2009, 2011-2014 and 2016. This results in almost 1000% higher emissions for the years 2001-2009, 2011-2014 and 2016 and 50-300% higher emissions in the other years.
- 1A3c, 1A3d: Correction of wrong Pb emission factors in Non-road categories. Values were 100 times too high for gasoline and bioethanol. Also, the wrong allocation of Pb emissions for processes with diesel, biodiesel and liquified petroleum gas was deleted.
- 1A3: Due to recalculations in diesel consumption in Liechtenstein, the total of diesel sold in Switzerland has changed slightly (<1%) for the year 2016. This leads also to recalculation in 1A3bviii of -7%.

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

- 1A4cii: In last year's submission there was a double-counting of the emissions of PM2.5, PM10 and TSP from resuspension of non-road vehicles and machinery in agriculture since they are also included in the particle emissions from 3Dc Soils operation of cropland and 3Dc Soils operation of grassland. Therefore, source category 1A4ci Resuspension of non-road vehicles and machinery in agriculture has been deleted.
- 1A4cii: Correction of wrong Pb emission factors in non-road categories. Values were 100 times too high for gasoline and bioethanol. Also the wrong allocation of Pb emissions for processes with diesel, biodiesel and liquified petroleum gas was deleted.

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

- 1A5b: Correction of wrong Pb emission factors in non-road categories. Values were 100 times too high for gasoline and bioethanol. Also, the wrong allocation of Pb emissions for processes with diesel, biodiesel and liquified petroleum gas was deleted.
- 1A5b: Due to an error few BC emission factors were missing. This leads to 20-30% higher BC emissions in 1A5b.
- 1A5b: Revision of the emission factors for the main air pollutants in military aviation for all the years 1990-2050. The new emission factors for NMVOC, NO_x and CO are based on country specific calculations from FOCA using fuel consumption per engine type occurring in military aviation in Switzerland. For SO_2 the emission factor from EMEP Guidebook 2016 is used for the whole timeserie 1990 onwards.
  These recalculations lead to:
  - 33% higher NMVOC emissions for 1990 and 2% in 2016
  - 70-80% higher NO_x emissions 1990-2016
  - 50-65% lower CO emissions 1990-2016
  - 1% lower SO_2 emissions 1990-2016
- 1A5b: Revision of the emission factors used for TSP, PM10 and PM2.5 exhaust/noneshaust in military aviation for all the years 1990-2050. The new emission factors for exhaust PM emissions for 1990-2000 are based on the mean value from civil aviation only on Swiss territory and are linearly interpolated to 2015. The value for 2015 is based on country specific calculations from FOCA using fuel consumption per engine type occuring in military aviation in Switzerland. It is assumed that TSP exhaust = PM2.5 exhaust = PM10 exhaust. The emission factors stay constant from 2015 onwards. For nonexhaust emission factor the mean value from civil aviation on Swiss territory is used for the years 1990-2050.
  These recalculations lead to:
  - 30% higher PM2.5 emissions in 1990 down to 5% lower PM2.5 emissions in 2016
  - 4% higher PM10 emissions in 1990 down to 61% lower PM10 emissions in 2016
  - 10% lower TSP emissions in 1990 up to 71% lower TSP emissions in 2016

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

- There are no category-specific recalculations for 1B1 Fugitive emissions from solid fuels.

8.1.1.9 Category-specific recalculations for 1B2 Oil, natural gas, venting/flaring

- 1B2a: The NMVOC and CH_4 emissions of leakage losses in refineries have been modified in such a way that the total NMVOC emissions from refineries (i.e. 1A1b + 1B2 excluding pipeline transport) from 2007 onwards are the same as those reported in the PRTR (PRTR 2018) database. The emission factors are now interpolated linearly from 1995 to 2007. For the years before 1995 the emission factors were taken from a study carried out at that time and have not been changed. The ratio CH_4:NMVOC remains 1:10 over the entire period.
- 1B2b: The calorific value is rounded less strongly in the calculation model, therefore a slight shift in the calculation of activity data and emission factors of CH_4 and NMVOC occured.

- 1B2c: Emission factors for flaring in refineries changed due to less rounding. This results in 30% less NO_x, 50% less NMVOC and 10% less SO_2 emissions for the year 2016.

8.1.2 2 Industrial processes and product use

8.1.2.1 Category-specific recalculations in 2A Mineral products

- 2A5a: Last year's extrapolated activity data of 2A5a Gravel plants for 2016 has been revised based on effective production data from the industry association.

8.1.2.2 Category-specific recalculations in 2B Chemical industry

- 2B1: Air pollution control measurements of NH_3 emissions at the ammonia production plant in 2017 result in revised average values of the NH_3 EF for the years 2002-2010 and 2012.

8.1.2.3 Category-specific recalculations in 2C Metal production

- There are no category-specific recalculations for 2C Metal production.

8.1.2.4 Category-specific recalculations in 2D Other solvent use

- 2D3d: The activity data and NMVOC emission factor of 2D3d Paint application, car repair have been revised for 2016 and 2005-2016, respectively based on new data and information from the industry association.
- 2D3d: The activity data and NMVOC emission factor of 2D3d Paint application, construction have been revised for 2014–2016 based on new data and information from the industry association.
- 2D3d: The activity data and NMVOC emission factor of 2D3d Paint application, wood have been revised for 2014–2016 and 2013–2016, respectively, based on new data and information from the industry association.
- 2D3d: The activity data and NMVOC emission factor of 2D3d Paint application, households have been revised for 2016 based on a comprehensive study including all major Swiss DIY companies resulting in recalculated interpolated values for 1999–2015 as well.
- 2D3f: The source category 2D3f Dry cleaning has been revised completely from 2001 onwards based on information and data from industry associations, emission control authorities and the Swiss Federal Statistical Office yielding recalculated activity data and NMVOC emission factors for the time series 1991-2016.
- 2D3g: The activity data of source category 2D3g Leather tanning has been revised from 2009 onwards since the last Swiss tannery ceased production in the beginning of 2015.
- 2D3i: The source category 2D3i Removal of paint and lacquer has been revised completely for the entire time series 1990–2016. The so far used activity data of Swiss population has been replaced by the amount of removal agent. In addition, activity data and emission factor have been updated from 1997 onwards based on new values for 2016.

8.1.2.5 Category-specific recalculations in 2G Other product use

- 2G: The source category 2G De-icing of airplanes (and other de-icing oparations) has been revised completely based on a comprehensive study including information and data from three Swiss airports (i.e. the two most important and a regional one) yielding recalculated activity data and NMVOC emission factors for the entire time series 1990-2016. The source category is now split into three sources, i.e. 2G De-icing of airplanes and 2G De-icing of airport surfaces as well as 2G Use of antifreeze agents in vehicles. Since 2011 no VOC-containing agents are used for de-icing of airport surfaces anymore.
- 2G: Activity data and NMVOC emission factor of source category 2G Underseal treatment and conservation of vehicles have been updated from 2013 onwards.
- 2G: Activity data for tobacco consumption for the year 2016 has been provisional in Submission 2018 and is now corrected according to the underlying updated statistics.
- 2G: For tobacco consumption, new emission factors for tobacco consumption for the so far missing pollutants NOx, Cd and PCDD/PCDF have been introduced based on EMEP/EEA Guidebook 2016 (EMEP/EEA 2016) and UK National Atmospheric Emissions Inventory (UK NAEI 2019), respectively. Emission factors for NMVOC, NH_3, particulate matter, BC, CO and PAHs have been updated for 1990-2016 (EMEP/EEA 2016).

8.1.2.6 Category-specific recalculations in 2H Other industry production, 2I Wood processing and 2L Other production, consumption, storage, transportation or handling of bulk products

- 2H2: Activity data for bread production has increased by 4% to 8% for the years 2011 and 2012 due to a correction in the underlying statistics.
- 2H2: Emission factors for bread production for CO2 biog. and NMVOC were interchanged and had to be swapped.
- 2H2: The self-supply rate of grain has been changed in the underying statistics. This correction leads to changes in the activity data of mills for the years 2009, 2012 and 2014-2016.
- 2H2: Activity data for 2016 for meat production has been provisional in Submission 2018 and is now corrected according to the underlying updated statistics.

8.1.3 3 Agriculture

8.1.3.1 Category-specific recalculations in 3B Manure management

- 3B: The so far missing NMVOC emissions from manure management are now included in the inventory for all agricultural livestock categories based on a Tier 1 approach according to the EMEP/EEA emission inventory guidebook 2016 (EMEP/EEA 2016) for the entire time series.
- 3B: All estimates based on AGRAMMON data were recalculated for the whole time series due to the implementation of a new model version. The most important changes were the switch to a full nitrogen flow model (including N_2O, NO_x and N_2) and the revision of nitrogen excretion rates of several livestock categories following the 2017 revision of the Swiss Fertiliser Guidelines (Agroscope 2017, Richner et al. 2017). More details on AGRAMMON recalculations can be found in chapter 3.6 of Kupper et al. (2018).
- 3B1: The emission factors of PM2.5, PM10 and TSP from 3B1a Manure management - Dairy cattle, 3B1b Manure management - Non-dairy cattle and 3B1a Manure management - Young cattle have been revised for the entire time series. They have been

changed from rounded to unrounded values in accordance with all other implied emission factors in sector 3 Agriculture.

- 3B3: The emission factors of PM2.5, PM10 and TSP from 3B3 Manure management - Swine have been corrected for the entire time series.
- 3B3 and 3B4: AD of 3B3 Manure management – Swine (EF) and 3B4gii Manure management – Broilers (AD and EF) were revised for the years 2011-2016 based on a new assessment of animal turnover rates in stables for fattening pigs over 25 kg and broilers, respectively.

8.1.3.2 Category-specific recalculations in 3D Crop production and agricultural soils

- 3D: All estimates based on AGRAMMON data were recalculated for the whole time series due to the implementation of a new model version. The most important changes were the switch to a full nitrogen flow model (including N_2O, NO_x and N_2) and the revision of nitrogen excretion rates of several livestock categories following the 2017 revision of the Swiss Fertiliser Guidelines (Agroscope 2017, Richner et al. 2017). More details on AGRAMMON recalculations can be found in chapter 3.6 of Kupper et al. (2018).
- 3Da2a3 Animal manure applied to soil - Swine and 3Da2a4gii Animal manure applied to soil - Broilers: AD were revised for the years 2011-2016 based on a new assessment of animal turnover rates in stables for fattening pigs over 25 kg and broilers, respectively.
- 3Da2c Other organic fertilisers applied to soils: AD were revised for the whole time series due to new AD for recycling fertilisers (compost, digestates).
- 3Da2c Other organic fertilisers applied to soils: Since AD were revised for the whole time series due to new AD for recycling fertilisers (compost, digestates). As the relative shares of compost and digestates have changed, this alo leads to revised NH_3 emission factors.
- 3Dc: The NMVOC emissions from agricultural soils have been revised completely for the entire times series based on a Tier 2 approach according to the EMEP/EEA emission inventory guidebook 2016 (EMEP/EEA 2016). The source category is now split into three sources, i.e. 3Dc soils operation of cropland, 3Dc soils operation of grassland and 3Dc soils operation of summering pastures.
- 3Dc: The TSP emission factors of 3Dc Soils operation of cropland and 3Dc Soils operation of grassland have been revised for the entire times series based on the Danish emission inventory (Danish Informative Inventory Report 2018).
- 3Dc: The PM2.5 and PM10 emission factors of 3Dc soils operation of cropland and 3Dc soils operation of grassland have been updated for the entire times series.

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 Biological treatment of waste - Anaerobic digestion at biogas facilities

- 5B2: An error has been corrected in the calculation of the amount of biogas from digestion that is torched in industrial biogas facilities. Emissions from torches slightly increase for the years 1992-2016. This recalculation also influences the total amount of organic waste treated in biogas facilities and therefore the emissions from the intermediate storage of organic waste, from fermentation and from the storage of liquid and solid digestate.

- 5B2: An error has been corrected in the calculation of the amount of biogas from digestion that is torched in agricultural biogas facilities. Emissions from torches slightly increase for the years 2008-2016. This recalculation also influences the total amount of organic waste treated in biogas facilities and the emissions from fermentation and from the storage of liquid and solid digestate.

8.1.4.3 Category-specific recalculations in 5C Waste incineration and open burning of waste

- 5C1: Activity data for sewage sludge incineration has been re-estimated for the years 2010-2016 according to a recommendation in EAWAG (2018). Values for 2007-2009 have also changed because of the interpolation of the data between 2006 and 2010.

8.1.4.4 Category-specific recalculations in 5D Wastewater handling

- 5D1: Emission factors have changed from 2007-2016 because of a recalculation of the amount of sewage sludge treated during that time. Changes occur as well because the parameter T_{plant} (inhabitants being connected to the public sewer system) has changed for the years 1995, 1998, 2006, 2008 and following years. The calculations for sewage gas flared and losses have been corrected according to the review recommendations for the years 2006-2016. The amount of biogas used in CHP installations has been changed in the underlying statistics by the SFOE for the years 2010 and 2013-2016 (however this process is reported in 1A2gviii).
- 5D1: Emissions from combined heat and power generation (CHP) and boilers in domestic wastewater treatment plants have been reported in source category 5D1 and 1A2gviii as well. This lead to a double counting of emissions. Emissions in 5D1 have been removed from source category 5D1 and are now solely reported in 1A2gviii. This leads to a decrease of emissions for the years 1990-2016 in 5D1.
- 5D2: Emissions from combined heat and power generation (CHP) and boilers in industrial wastewater treatment plants have been reported in source category 5D2 and 1A2gviii as well. This lead to a double counting of emissions. Emissions in 5D2 have been removed from source category 5D2 and are now solely reported in 1A2gviii. This leads to a decrease of emissions for the years 1990-2016 in 5D2.

8.1.4.5 Category-specific recalculations in 5E Other waste, car shredding

- No recalculations were carried out for source category 5E.

8.1.5 6 Other

8.1.5.1 Recalculations in 6 Other and natural emissions

- 6Aa: Activity data for human emissions from diapers have changed for the year 2016 due to an update in the underlying statistics provided by SFOS.
- 6Ab: The so far missing NMVOC emissions from manure management of livestock outside agriculture are now included in the inventory along with all agricultural livestock

categories based on a Tier 1 approach according to the EMEP/EEA emission inventory guidebook – 2016 (EMEP/EEA 2016) for the entire time series.

- 6Ab: The emission factors of, PM2.5, PM10 and TSP from 6Ab Manure management - Livestock outside agriculture have been revised for the entire time series. They have been changed from rounded to unrounded values in accordance with the implied emission factors in sector 3 Agriculture.
- 6Ab: All estimates based on AGRAMMON data were recalculated for the whole time series due to the implementation of a new model version. The most important changes were the switch to a full nitrogen flow model (including N_2O, NO_x and N_2) and the revision of nitrogen excretion rates of several livestock categories. More details on AGRAMMON recalculations resulting in revised NH_3 and NO_x emission factors can be found in chapter 3.6 of Kupper et al. (2018).
- 6Ac: In last year's submission of the inventory the methodology for calculating NH_3 emissions from application of inorganic fertilisers in agriculture (source category 3Da1) was revised according to the Tier 2 approach of EMEP/EEA (2016) taking into account the specified list of fertilisers, climate zone and pH. This methodology has been applied to source category 6Ac Private use of fertiliser as well yielding revised NH_3 emission factors for the entire time series.

8.1.5.2 Recalculations in 11B natural emissions

- 11B: Activity data for forest fires has changed for all years due to recalculations in the LULUCF model (see FOEN 2019 chp. 6.4. LULUCF).

8.1.5.3 Recalculations in 11C natural emissions

- 11C: The model for calculating NMVOC emissions from forest stands has been fundamentally revised (Meteotest 2019a) and the resulting emissions are reported for the first time in the memo items.

8.1.6 Implications of recalculation for emission levels

Table 8-1 shows the effect of recalculations on the emission levels 2016 and 1990, based on the previous (2018) and latest (2019) NFR submission. In 2016, recalculations cause a lower emission level by at least 1% for SO_x, NH_3, PM2.5, PM10 and Pb emissions. An increase due to recalculations by at least 1% is observed for NMVOC, TSP, BC, and Cd.

In 1990, recalculations cause a decrease of more than 1% for SO_x, NH_3, PM10 and Pb. An increase by 1% or more is observed for NMVOC, TSP, BC and Cd emissions.

Table 8-1: Recalculations: Implications for the emission levels 2016 and 1990. The values refer to the NFR submission 2018 (previous) and 2019 (latest). Differences are given in absolute and relative numbers for all pollutants.

Pollutant	Units	2016			
		previous subm. 2018	latest subm. 2019	difference (abs.)	difference (rel.) previous = 100%
NO_x	kt	64.21	64.51	0.31	0.5%
NMVOC	kt	70.28	77.92	7.64	10.9%
SO_x	kt	6.20	5.42	-0.77	-12.5%
NH_3	kt	57.11	55.23	-1.89	-3.3%
PM2.5	kt	6.71	6.60	-0.11	-1.6%
PM10	kt	16.52	14.89	-1.64	-9.9%
TSP	kt	22.25	28.94	6.69	30.0%
BC	kt	1.07	1.46	0.39	36.8%
CO	kt	158.06	157.69	-0.37	-0.2%
Pb	t	19.02	14.60	-4.42	-23.2%
Cd	t	1.09	1.14	0.05	4.8%
Hg	t	0.69	0.68	0.00	-0.1%
PCDD/PCDF	g I-TEQ	20.99	21.15	0.16	0.8%
PAH (total)	t	2.92	2.92	0.00	0.1%
HCB	kg	0.35	0.35	0.00	0.0%

Pollutant	Units	1990			
		previous subm. 2018	latest subm. 2019	difference (abs.)	difference (rel.) previous = 100%
NO_x	kt	138.43	139.56	1.13	0.8%
NMVOC	kt	282.46	296.43	13.97	4.9%
SO_x	kt	39.66	36.66	-2.99	-7.5%
NH_3	kt	69.23	66.99	-2.24	-3.2%
PM2.5	kt	15.16	15.16	0.00	0.0%
PM10	kt	25.85	24.02	-1.83	-7.1%
TSP	kt	36.53	43.20	6.67	18.3%
BC	kt	4.57	5.11	0.54	11.7%
CO	kt	704.16	702.81	-1.35	-0.2%
Pb	t	761.47	363.80	-397.67	-52.2%
Cd	t	3.61	3.70	0.09	2.4%
Hg	t	6.61	6.61	0.00	0.0%
PCDD/PCDF	g I-TEQ	202.82	202.79	-0.03	0.0%
PAH (total)	t	12.09	12.05	-0.04	-0.4%
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 2019 in terms of absolute emissions are listed in Table 8-2 and Table 8-3 for the years 2016 and 1990, respectively. The two most important recalculations for each year and each pollutant are the following:

NO_x

- All NO_x emission factors for 3B Manure management were recalculated for the whole time series 1990-2016 based on the revision of the AGRAMMON model. In particular, this leads to higher NO_x emissions from source categories 3B1a Manure management - Dairy cattle and 3B1b Manure management – Non-dairy cattle for 1990 and 2016, and for 3B3 Manure management – Swine for 1990.

- For the year 2016, NO_x emissions from 1A3bi Passenger cars are slightly lower due to the use of the ex post analysis 2016 (SFOE 2017e, 2017f) as a new source for activity data.
- The decrease in NO_x emissions from 5D1 Domestic waste water handling in 2016 and 1990 is mainly due to the revision of the emission factors for the whole time series (EAWAG 2018). Furthermore, a double counting error was corrected which also leads to a decrease of NO_x emissions under 5D1 (CHP and boilers in domestic wastewater treatment plants were reported under 5D1 and 1A2gvii and are now solely reported in the energy sector).
- The revision of emission factors in military aviation for the whole time series (based on country specific calculations from FOCA using fuel consumption per engine type occurring in military aviation in Switzerland) is one of the main factors leading to the increase of NO_x emissions in source category 1A5b Other, mobile (Military) in 1990 and 2016.

NMVOC

- The so far missing NMVOC emissions from 3B Manure management were included in the inventory for all agricultural livestock categories and for the entire time series. This leads to the listed increase in NMVOC emissions in source categories 3B1a Manure management – Dairy cattle and 3B1b Manure management – Non-dairy cattle for both years, 2016 and 1990 as well as in source catregory 3B3 Manure management – Swine in 1990.
- NMVOC emission factors and activity data for 2D3d Coating applications (car repair, construction, households and wood) have been revised from 1999 onwards, which leads to considerable lower NMVOC emissions in 2016.
- The NMVOC emissions from 3Dc Farm-level agricultural operations decreased for both years 2016 and 1990 due to a complete revision of the entire NMVOC emission times series using a Tier 2 approach according to the EMEP/EEA Guidebook 2016 differentiating three agricultural areas, i.e. cropland, grassland and summering pastures

SO_x

- The SO_2 emission factors of all gas oil and residual oil boilers have been revised for the entire time series (1990-2016) based on five-year averages of annual sulphur analysis. These recalculations are the main reasons for the lower SO_2 emissions from 1A4bi Residential: Stationary and 1A4ai Commercial/institutional: Stationary in 1990 and 2016 as well as from 1A2gviii Other, 1A2d Pulp, paper and print, and 1A2e Food processing, beverages and tobacco in the year 1990.

NH_3

- All estimates based on the AGRAMMON data were recalculated for the whole time series due to the implementation of a new model version. An important change was the revision of nitrogen excretion rates of several livestock categories based on the 2017 revision of the Swiss Fertiliser Guidelines. This is the main reason for the reduction of NH_3 emissions from source category 3Da2a Animal manure applied to soils in the years 2016 and 1990.
- The revision of the estimates on the AGRAMMON also leads to an increase of NH3 emissions from 3B3 Manure management – Swine in 1990.

PM2.5

- A double-counting from last year's submission of PM2.5 emissions from resuspension of non-road vehicles and machinery in agriculture was corrected. Particulate matter emissions from resuspension were included in 1A4cii Non-road vehicles and other machinery and in 3Dc Soils operation. The emissions were now removed from 1A4cii, which leads to a decrease of PM2.5 emissions in the years 2016 and 1990.
- The PM2.5 emission factor for source category 2G Other product use: Tobacco consumption has been updated for the entire time serises (EMEP/EEA 2016). This leads to an increase of emissions for the years 2016 and 1990.

Table 8-2: NFR categories with most important implications of recalculations on emission levels in 2016 in terms of absolute differences for the main pollutants and PM2.5. The values refer to the NFR submission 2018 and 2019. The list is ranked for each pollutant in terms of the absolute difference in emission levels due to recalculations.

NO_x (as NO_2)	kt	NMVOC	kt	SO_x (as SO_2)	kt	NH_3	kt	$PM_{2.5}$	kt
3B1a_Manure management - Dairy cattle	0.363	3B1a_Manure management - Dairy cattle	7.822	1A4bi_Residential: Stationary	-0.473	3Da2a_Animal manure applied to soils	-1.837	1A4cii_Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	-0.242
3B1b_Manure management - Non-dairy cattle	0.229	3B1b_Manure management - Non-dairy cattle	6.853	1A4ai_Commercial/institutional: Stationary	-0.221	3Da2c_Other organic fertilisers applied to soils (including compost)	0.081	2G _Other product use (please specify in the IIR)	0.203
1A3bi_Road transport: Passenger cars	-0.192	2D3d_Coating applications	-3.765	1A1b_Petroleum refining	-0.092	3B1b_Manure management - Non-dairy cattle	-0.038	1A3bi_Road transport: Passenger cars	-0.040
5D1_Domestic wastewater handling	-0.171	3Dc_Farm-level agricultural operations including storage, handling and transport of agricultural products	-3.424	1A2c_Stationary combustion in manufacturing industries and construction: Chemicals	0.066	3B3_Manure management - Swine	-0.033	1A4ai_Commercial/institutional: Stationary	-0.012
1A5b_Other, Mobile (including military, land based and recreational boats)	0.161	1B2aiv_Fugitive emissions oil: Refining / storage	-0.957	5D1_Domestic wastewater handling	-0.019	3B2_Manure management - Sheep	-0.031	1A2gviii_Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	-0.012

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 2018 and 2019. The list is ranked for each pollutant in terms of the absolute difference in emission levels due to recalculations.

NO_x (as NO_2)	kt	NMVOC	kt	SO_x (as SO_2)	kt	NH_3	kt	$PM_{2.5}$	kt
3B1a_Manure management - Dairy cattle	0.502	3B1a_Manure management - Dairy cattle	9.540	1A4bi_Residential: Stationary	-1.522	3Da2a_Animal manure applied to soils	-2.482	2G _Other product use (please specify in the IIR)	0.306
1A5b_Other, Mobile (including military, land based and recreational boats)	0.299	3B1b_Manure management - Non-dairy cattle	6.579	1A4ai_Commercial/institutional: Stationary	-0.641	3B3_Manure management - Swine	0.247	1A4cii_Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	-0.299
3B1b_Manure management - Non-dairy cattle	0.243	3Dc_Farm-level agricultural operations including storage, handling and transport of agricultural products	-3.472	1A2gviii_Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	-0.271	6A_Other (included in national total for entire territory) (please specify in IIR)	0.031	1A5b_Other, Mobile (including military, land based and recreational boats)	0.009
3B3_Manure management - Swine	0.160	3B3_Manure management - Swine	1.028	1A2d_Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	-0.187	3B1a_Manure management - Dairy cattle	-0.016	3Dc_Farm-level agricultural operations including storage, handling and transport of agricultural products	-0.007
5D1_Domestic wastewater handling	-0.112	2H2_Food and beverages industry	-0.850	1A2e_Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	-0.121	3B4gi_Manure mangement - Laying hens	-0.014	1A2gviii_Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	-0.005

8.1.7 Implications of recalculation for emission trends of main pollutants and PM2.5

The emission trends 1990–2016 are affected through the recalculations by less than one and a half percent for the main pollutants and PM2.5. For NMVOC, the difference to the previous submission adds up to +1.4 percentage points yielding a slightly stronger decreasing trend. For NO_x, SO_x, NH_3 and PM2.5 the change is negative (between 0.1 and 0.8 percentage points, i.e. a slightly weaker decreasing trend).

Table 8-4: Recalculations: Implications for the emission trends between 1990 and 2016 for the main pollutants. The values refer to the NFR submission 2018 and 2019.

Pollutant	Trend 1990-2016 (1990 = 100%)	
	previous subm. 2018	latest subm. 2019
	%	%
NO_x	46.4	46.2
NMVOC	24.9	26.3
SO_x	15.6	14.8
NH_3	82.5	82.4
PM2.5	44.3	43.5

8.2 Planned improvements

The following improvements are planned for the submission 2020:

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 in subsequent submissions are currently assessed.

Energy (stationary)

- 1A2gviii, 1A4ci: The classification of the use of biogas and sewage gas in engines in industry and agriculture needs to be further revised.

Energy (mobile) no planned improvements

IPPU no planned improvements

Agriculture

- 3B: Since the data basis of the NMVOC emission factors proposed in the EMEP/EEA Guidebook 2016 (EMEP/EEA 2016) seems to be rather unclear (Bühler and Kupper 2018) a study was launched in 2018 in order to measure NMVOC emissions from dairy cattle with and without silage feeding in an experimental housing during summer, winter and transitional season.

Waste no planned improvements

Other and Natural no planned improvements

9 Emission projections 2017–2030

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 2030 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 (according to Swiss Confederation 2013 for WM and FOAG 2011 for WAM).

Note that all emission data for the projections refer to the “national total for compliance” assessment based on 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 (2019)
- Road transportation: EMEP/EEA (2016), INFRAS (2017a), Keller et al. (2017)
- Domestic aviation: EMEP/EEA (2013), FOCA (2006, 2006a, 2007a, 2008-2018)
- Non-road vehicles: EMEP/EEA (2016), FOEN (2015j), INFRAS (2015a, 2018)

Emission factors for the sector 3 Agriculture are derived mainly from the AGRAMMON model (Kupper et al. 2018) and EMEP/EEA Guidebook 2016 (EMEP/EEA 2016).

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. For the WM scenario, updated EF and AD are applied for 1A3b Road transport and for non-road vehicles and machines. Note that since one of the two petroleum refineries in Switzerland ceased operation in 2015, the corresponding projections were revised accordingly. 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 was 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 2011-2017, statistical and projected data exist. The statistical data available between 2010 and 2017 (Swiss overall energy statistics) are used to calculate the emissions as reported in the preceeding sectoral chapters. Data from 2018 to 2029 is linearly interpolated between statistical data 2017 and projected data 2030, and from 2030 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) INFRAS (2017) EPFL (2017)
	WAM	Energy scenario "new energy policy", electricity generation option E from Energy Perspectives	Prognos (2012a) INFRAS (2017)
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 2017d). 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, INFRAS 2017 for vehicle km)

Indicator	2010	2015	2020	2025	2030	2010-2030
Population (million)	7.82	8.13	8.38	8.58	8.73	12%
GDP (prices 2010, billion CHF)	547	584	618	646	671	23%
Oil price (prices 2010, CHF/barrel)	79.3	93.7	98.3	101.3	101.7	28%
Gas price (prices 2010, CHF/tonne)	321	518	561	598	627	95%
Heating degree days	3'585	3'335	3'244	3'154	3'064	-15%
Cooling degree days	153	169	186	203	219	43%
Energy reference area (million m2)	709	754	799	836	863	22%
Passenger transport (million vehicle km)	50'949	55'114	56'618	58'628	60'471	19%

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 2017-2030 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.

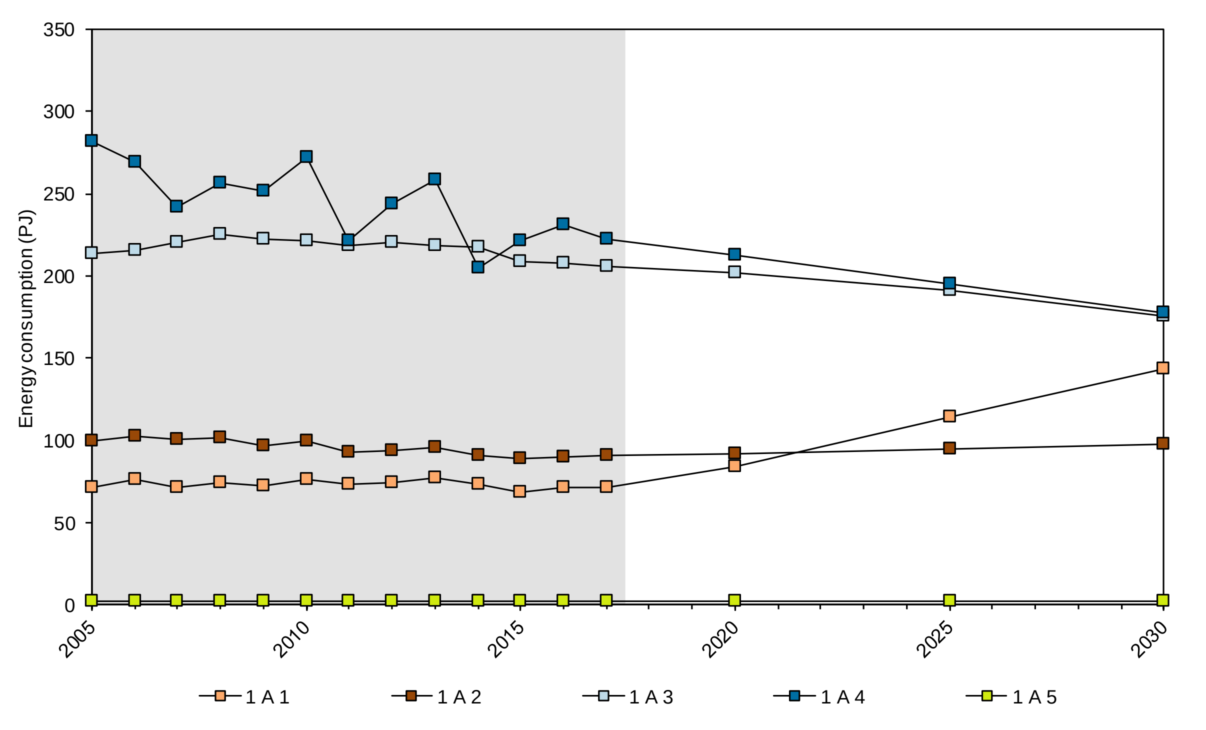


Figure 9-1: Energy demand in Switzerland as projected in the WM (WEM) scenario in source categories 1A1 – 1A5 of the sector 1 Energy.

Energy demand in 1A1 Energy industries is mainly caused by waste generation. It is assumed to remain at the current levels per capita. Due to population growth, the amount of waste is increasing leading to growing energy demand. Another relevant assumption under source category 1A1 is that wood energy consumption will strongly increase (about 6-times higher wood energy consumption for electricity generation and about 3-times higher wood energy consumption with CHP in 2030 compared to 2010). This assumption was based on the effects of a package of measures which was part of the political process within the Parliament during the time the projections were established. Note that since one of the two petroleum refineries in Switzerland ceased operation in 2015, the corresponding projections were revised accordingly (see chp. 3.2.2.2.2).

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. In the past years it became visible that the projected wood energy consumption in industry for 2030 is probably too low. Accordingly, the development between 2017 and 2030 shows a decrease (since the consumption 2017 is larger than the projected consumption 2030). Under actual circumstances, a decrease of wood energy consumption between 2017 and 2030 – as it is estimated based on the projections made in 2012 – is not realistic.

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 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 from commercial and institutional buildings 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 gas 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 INFRAS (2017). The projections of the fuel consumption factors are based on the expected development of the vehicle fleets (INFRAS 2017a).
- 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). In addition, CNG in non-road has been replaced with LPG, which is a more accurate reflection of the situation in Switzerland

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 2A5a Plaster production), food (all 2H2 source categories except 2H2 Bread production), metals (2C1 Iron and steel production and 2C7a 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 as well.

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 fertiliser use. Emission factors are kept constant as in 2015 due to uncertain assumptions about the evolution of production parameters (Kupper et al. 2018). The main measures and underlying assumptions are:

- Livestock populations: Direct payments have been decoupled to a certain degree from cropping area and particularly from the number 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 particularly cattle numbers are projected to decline. Beyond 2024 (the time horizon of Möhring et al. 2015) constant population numbers were assumed for all animal categories due to the lack of further projections.
- Manure management: the shares of manure excreted during grazing as well as the shares of the individual manure management systems cannot be predicted satisfactorily and are thus left constant as in 2015.
- Crops: 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 2024, constant yields and areas were assumed due to the lack of further projections.
- Fertilisers and fertiliser management: Use of commercial fertilisers is projected to further decrease until 2024 according to Möhring et al. (2015). Beyond 2024, constant fertiliser use was assumed due to the lack of further projections.

Sector 5 Waste

Per capita waste generation is assumed to remain at the level of 2017 in the projections up to 2030. 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). A detailed description of the WAM scenario can be found in Switzerland’s 7th National Communication under the UNFCCC (FOEN 2017d). The scenario is a long-term target scenario that follows the strategic orientation in key policy areas (FOEN 2017d, 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.
- 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.

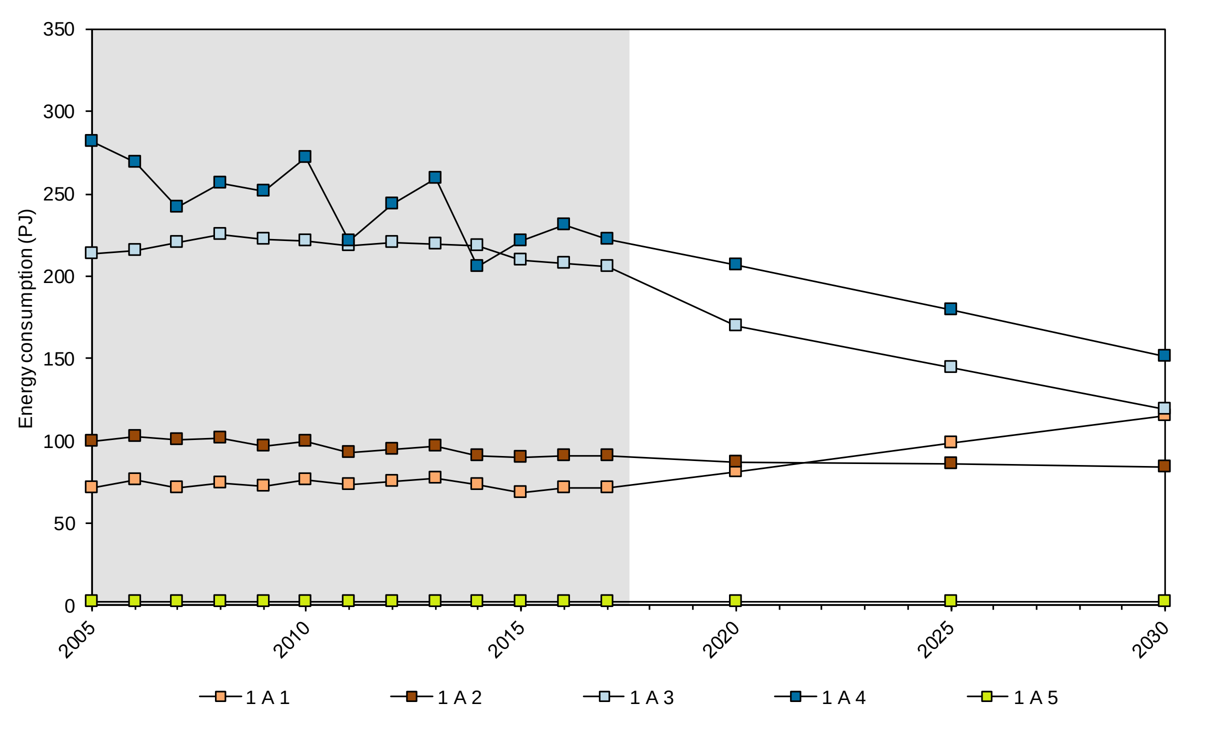


Figure 9-2: Energy demand in Switzerland as projected in the WAM scenario in source categories 1A1 – 1A5 of sector 1 Energy.

9.3 Main pollutants and CO for the WM scenario

Overall projections of the emissions for NO_x, NMVOC, SO_x and CO indicate a decline between 2005 and 2030 (Figure 9-3). NH_3 emissions are projected to be only slightly below 2005 levels in 2030.

NO_x emission reductions are projected to continue their decrease until 2030. The reductions are mainly projected to happen in source category 1A Fuel combustion. For 1A3b road transportation, improved emission abatement technology and in-use compliance under real driving conditions are relevant drivers. For 1A2 Manufacturing industry and construction and 1A4 Other sectors, reduced emissions from domestic and commercial heating, higher shares of solar heating and heat pumps and increased use of eco-grade gas oil are expected. NMVOC emissions are projected to slightly increase compared to the current levels. The main driver for the overall increase is sector 5 Waste. This increase is based on the assumption that the production of biogas will strongly increase, in particular anaerobic digestion at biogas facilities under 5B2. Furthermore, population growth and, to some extent, the stagnation of the effects of the VOC incentive tax (Swiss Confederation 1997) will lead to an increase of NMVOC emissions in sector 2 IPPU. The SO_x emissions are projected to decrease until 2025 which is mainly due to the revision of the Ordinance on Air Pollution Control (Swiss Confederation 1985) in 2018 that eco-grade gas oil (with low sulphur content) only is allowed to be used in installations of a rated thermal input of less than 5 MW from 2023 onwards. The slight increase in SO_x emissions between 2025 and 2030 is due to a large projected wood energy consumption as well as a projected reintroduction of residual fuel oil for electricity production (which seems to be rather unrealistic). NH_3 emissions are projected to remain more or less on constant levels (mainly depending on animal numbers, which are projected to decrease only slightly up to 2024 and remain constant afterwards). Concerning CO emissions, a continuous decreasing trend is projected mainly because of improved emission abatement technology for road vehicles, better insulation of buildings and a higher share of solar heating and heat pumps.

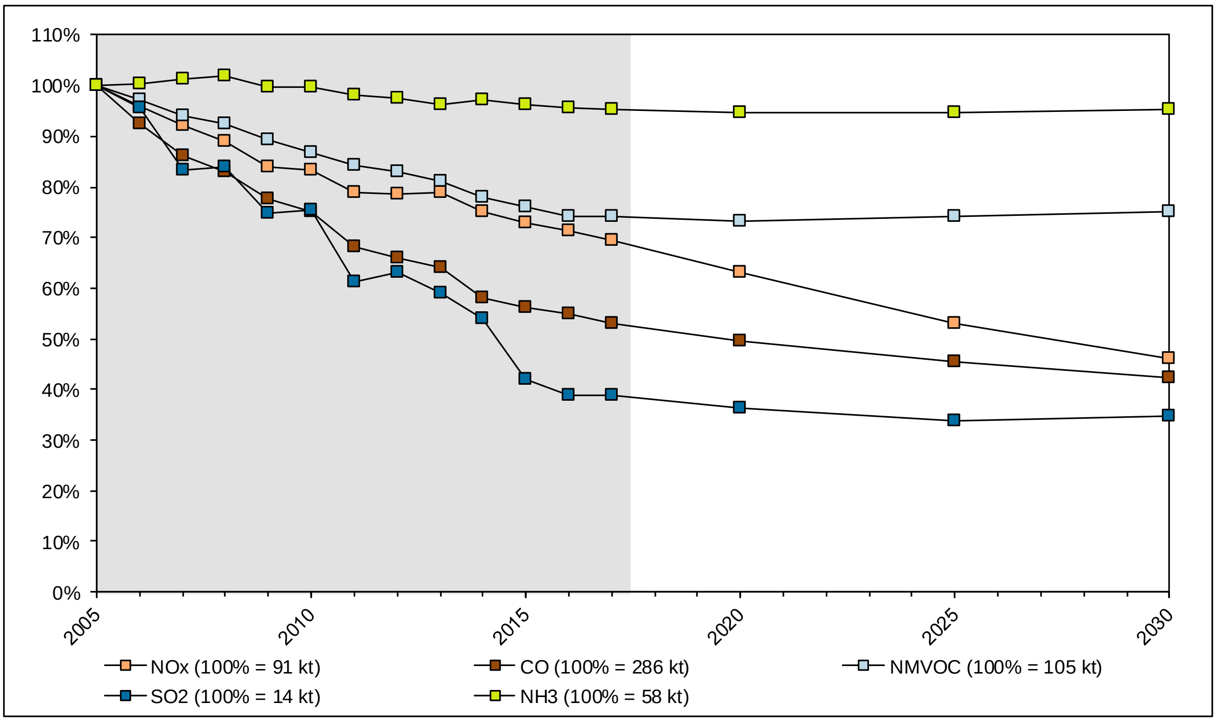


Figure 9-3: Relative trends for the total emissions of main air pollutants and CO in Switzerland as projected in the WM (WEM) scenario. 100% corresponds to the 2005 levels (base year of Gothenburg Protocol).

Table 9-3: Main air pollutants and CO: 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	90.59	104.81	13.92	57.67	286.19
2010	75.37	90.98	10.52	57.45	214.72
2011	71.59	88.18	8.52	56.64	195.36
2012	71.28	86.87	8.78	56.22	188.86
2013	71.50	84.92	8.20	55.53	183.26
2014	68.10	81.63	7.50	56.03	166.05
2015	65.98	79.79	5.83	55.43	161.05
2016	64.51	77.92	5.42	55.23	157.69
2017	62.84	77.92	5.42	55.06	151.43
2018	61.13	77.51	5.29	54.77	147.75
2019	59.36	77.23	5.17	54.89	144.49
2020	57.16	76.92	5.04	54.60	141.55
2025	48.10	77.67	4.71	54.69	129.81
2030	41.86	78.83	4.86	55.05	121.19
2017 to 2030 (%)	-33%	1%	-10%	1%	-20%

9.3.1 Projections for NO_x

The decreasing trend for NO_x emissions which is visible since 2005 is expected to continue until 2030 (see Table 9-4). The most significant reductions happen in source category 1A Fuel combustion – especially in 1A3b with the largest absolute contribution and the strongest relative decrease – but also in source categories 1A2 and 1A4. Reductions under 1A 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-grade gas oil (with low sulphur and nitrogen content). The emission increase of 1A1 is caused by growing amount of waste incinerated and a large projected wood energy consumption for electricity production. Compared to the energy sector, the other sectors are less relevant for the development of NO_x emissions. In sector 2 Industrial processes and product use, emissions in 2030 are projected to be lower than in the base year 2005 but to remain about at the current level. In sector 3 Agriculture, emissions are expected to decrease slightly. In sector 5 Waste, a continuous increase in emissions is expected until 2030 compared to 2005 (mainly due to population growth). However, this trend has a minimal impact on total emissions in absolute terms. In sector 6 Other, emissions are on a very low level and are expected to slighty increase until 2030 compared to 2005.

Table 9-4: WM (WEM) projections: Relative trends of NO_x emissions per sector (2005 represents 100%).

NO_x emissions	**2005**	**2017**	**2020**	**2025**	**2030**
	kt	%	%		
1 Energy	86.18	68%	61%	51%	43%
1A Fuel combustion	86.00	68%	61%	51%	43%
1A1 Energy industries	2.98	88%	118%	168%	216%
1A2 Manufacturing industries and constr.	14.73	62%	56%	51%	50%
1A3 Transport	51.37	70%	61%	44%	31%
1A4 Other sectors	16.31	64%	57%	49%	43%
1A5 Other (Military)	0.60	74%	71%	69%	70%
1B Fugitive emissions from fuels	0.18	1%	1%	1%	1%
2 IPPU	0.30	96%	94%	95%	96%
3 Agriculture	3.86	100%	99%	98%	98%
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.16	114%	231%	243%	254%
6 Other	0.09	115%	115%	116%	116%
National total	90.59	69%	63%	53%	46%

9.3.2 Projections for NMVOC

The bulk of NMVOC emission reductions has been achieved until 2017, and a minor increase of emissions is expected from 2017 up to 2030 (see Table 9-3 and Table 9-5). NMVOC emission reductions mainly occur in 1A Fuel combustion. A substantial reduction will take place in 1A3b caused by improved emission abatement technology for road vehicles. However, the main driver for the overall increase is sector 5 Waste. This increase is based on the assumption that the production of biogas will strongly increase, in particular anaerobic digestion at biogas facilities under 5B2. Another driver for the increase is sector 2 IPPU, where a slight increase of emissions is projected due to population growth and, to some extent, due to stagnating effects of the VOC incentive tax (Swiss Confederation 1997). In sector 3 Agriculture, emissions are expected to slightly decrease due to a projected slight decrease in population number of cattle until 2024. In sector 6 Other, emissions are expected to decrease on a low level.

Table 9-5: WM (WEM) projections: Relative trends of NMVOC emissions per sector (2005 represents 100%).

NMVOC emissions	**2005**	**2017**	**2020**	**2025**	**2030**
	kt	%	%		
1 Energy	37.10	45%	41%	36%	33%
1A Fuel combustion	31.40	44%	40%	36%	33%
1A1 Energy industries	0.22	71%	82%	97%	110%
1A2 Manufacturing industries and constr.	1.96	50%	45%	42%	41%
1A3 Transport	19.65	42%	38%	33%	30%
1A4 Other sectors	9.46	47%	44%	39%	35%
1A5 Other (Military)	0.11	64%	62%	61%	62%
1B Fugitive emissions from fuels	5.70	47%	44%	39%	35%
2 IPPU	48.79	86%	85%	87%	88%
3 Agriculture	17.98	99%	97%	97%	97%
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.75	181%	320%	557%	794%
6 Other	0.19	116%	116%	118%	118%
National total	104.81	74%	73%	74%	75%

9.3.3 Projections for SO_x

The decreasing trend of SO_x emissions is expected to continue until 2025, before there is a slight increase between 2025 and 2030 (see Table 9-6). The projected decrease is mainly due to the revision of the Ordinance on Air Pollution Control (Swiss Confederation 1985) in 2018 that eco-grade gas oil (with low sulphur content) only is allowed to be used in installations of a rated thermal input of less than 5 MW from 2023 onwards and a reduced use of gas oil because of better insulation of buildings, a higher share of solar heating and heat pumps as well as a fuel switch to natural gas (revised CO_2 law, Swiss Confederation 2011). The slight increase in SO_x emissions between 2025 and 2030 is due to a large projected wood energy consumption as well as a projected reintroduction of residual fuel oil for electricity production (which seems to be rather unrealistic). Only marginal emission reductions or stable levels are projected for all other source categories.

Table 9-6: WM (WEM) projections: Relative trends of SO_x emissions per sector (2005 represents 100%).

SO_x emissions	**2005**	**2017**	**2020**	**2025**	**2030**
	kt	%	%		
1 Energy	12.77	35%	33%	31%	32%
1A Fuel combustion	12.32	36%	34%	31%	32%
1A1 Energy industries	1.63	24%	39%	61%	82%
1A2 Manufacturing industries and constr.	4.05	56%	52%	48%	45%
1A3 Transport	0.21	120%	119%	117%	114%
1A4 Other sectors	6.39	23%	17%	9%	8%
1A5 Other (Military)	0.04	90%	92%	96%	99%
1B Fugitive emissions from fuels	0.45	25%	24%	21%	19%
2 IPPU	1.07	78%	66%	66%	66%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.06	133%	144%	151%	158%
6 Other	0.01	100%	100%	100%	100%
National total	13.92	39%	36%	34%	35%

9.3.4 Projections for NH_3

Emission projections for NH_3 are highly dependend on sector 3 Agriculture. Overall, NH_3 emissions are expected to be constant between 2017 and 2030.

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 2015 (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 Manure Management - Swine consisting of animal categories piglets, fattening pig, dry sows, nursing sows, boars with constant emission factors for 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 between 2017 and 2030 is also expected due to projected decreasing livestock numbers for cattle until 2024.

Ammonia emissions from all other sectors are of minor relevance in comparison with the agriculture sector. NH_3 emissions show decreasing trends for sectors 1 Energy (due to new low emission vehicles and machinery) and 2 Industrial processes and product use. An increase compared to 2005 level is expected to occur in sector 5 Waste due to a growing population. In sector 6 Other, emissions have increased between 2005 and 2017 but are expected to remain relatively constant at the current level until 2030.

Table 9-7: WM (WEM) projections: Relative trends of NH_3 emissions per sector (2005 represents 100%).

NH_3 emissions	**2005**	**2017**	**2020**	**2025**	**2030**
	kt	%	%		
1 Energy	3.80	46%	43%	41%	41%
1A Fuel combustion	3.80	46%	43%	41%	41%
1A1 Energy industries	0.03	169%	272%	445%	617%
1A2 Manufacturing industries and constr.	0.19	131%	122%	114%	106%
1A3 Transport	3.47	39%	35%	32%	31%
1A4 Other sectors	0.12	106%	103%	102%	102%
1A5 Other (Military)	0.00	105%	103%	103%	103%
1B Fugitive emissions from fuels	NA	NA	NA	NA	NA
2 IPPU	0.35	51%	47%	42%	36%
3 Agriculture	51.71	99%	98%	98%	98%
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.93	97%	120%	159%	199%
6 Other	0.87	115%	115%	117%	117%
National total	57.67	95%	95%	95%	95%

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. Accordingly, the bulk of emission reductions occur in 1A Fuel combustion, particularly in 1A3 Transport as well as in in source category 1A4 Other sectors (see chp. 2). An increase in emissions can be observed in 1A1 Energy industries (due to the large projected wood energy consumption for electricity production).

Table 9-8: WM (WEM) projections: Relative trends of CO emissions per sector (2005 represents 100%).

CO emissions	2005	2017	2020	2025	2030
	kt	%	%		
1 Energy	279.59	53%	49%	45%	42%
1A Fuel combustion	279.55	53%	49%	45%	42%
1A1 Energy industries	1.18	82%	143%	239%	314%
1A2 Manufacturing industries and constr.	20.65	71%	67%	63%	59%
1A3 Transport	156.29	45%	41%	36%	33%
1A4 Other sectors	100.51	60%	57%	52%	48%
1A5 Other (Military)	0.92	86%	85%	86%	87%
1B Fugitive emissions from fuels	0.04	1%	1%	1%	0%
2 IPPU	3.92	49%	50%	52%	54%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	1.92	81%	93%	90%	87%
6 Other	0.76	91%	91%	91%	91%
National total	286.19	53%	49%	45%	42%

9.4 Suspended particulate matter

Projected trends for suspended particulate matter PM2.5, PM10, TSP and BC show an overall decline since 2005 and up to 2030 (see Figure 9-4 and Table 9-9). The decline can be explained by two main measures: The tightening of emission standards for diesel engine vehicles that will prescribe lower limit values, and the tightening of emission limit values for particle emissions of (wood) combustion installations. 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 (vehicle kilometres).

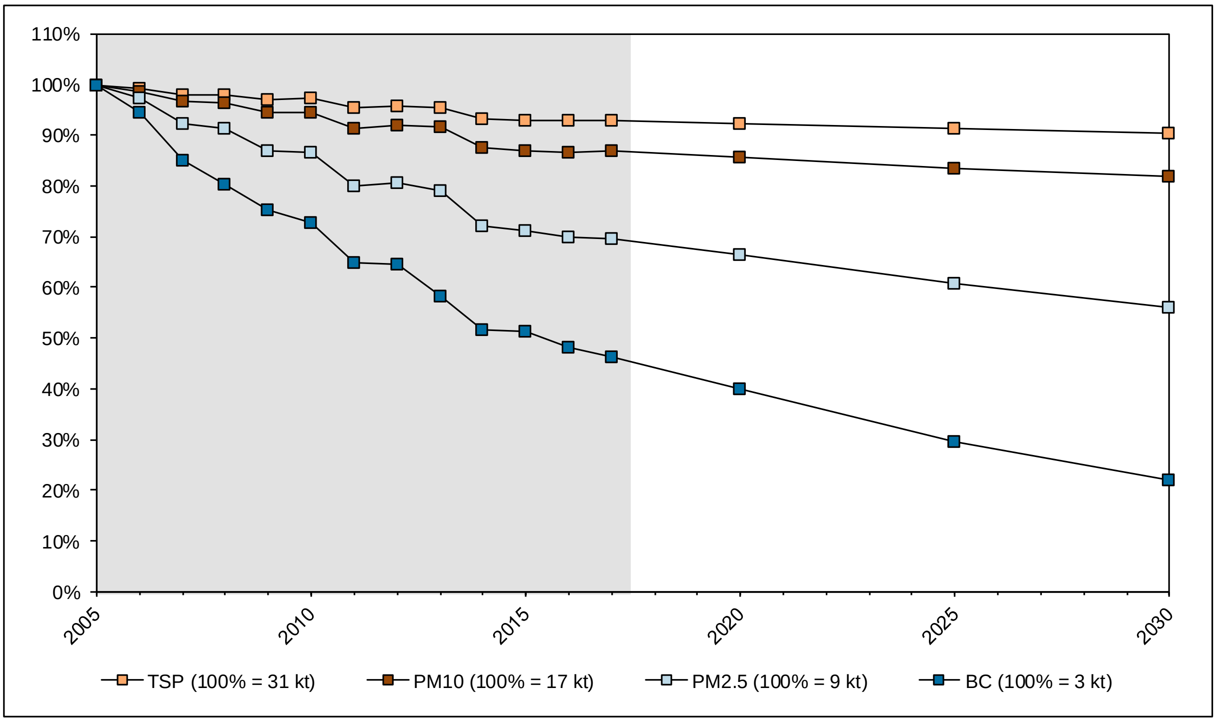


Figure 9-4: Projection of total emissions of suspended particulate matter TSP, PM10, PM2.5 and BC in Switzerland of the WM (WEM) scenario (in percentage of 2005). The figure shows the sum of exhaust and non-exhaust particles.

Table 9-9: Projected total emissions of the WEM scenario concerning particulate matter until 2030 in kt.

Year	PM2.5	PM10	TSP	BC
	kt	kt	kt	kt
2005	9.44	17.21	31.18	3.05
2010	8.19	16.29	30.34	2.22
2011	7.54	15.72	29.75	1.98
2012	7.61	15.82	29.85	1.97
2013	7.47	15.77	29.81	1.78
2014	6.82	15.09	29.13	1.58
2015	6.72	14.99	29.01	1.57
2016	6.60	14.89	28.94	1.46
2017	6.57	14.96	28.99	1.41
2018	6.46	14.88	28.91	1.34
2019	6.36	14.82	28.88	1.28
2020	6.26	14.75	28.82	1.22
2025	5.73	14.37	28.48	0.90
2030	5.29	14.08	28.22	0.67
2017 to 2030 (%)	-19%	-6%	-3%	-52%

9.4.1 Projections for PM2.5

The overall decreasing trend of emissions from PM2.5 emissions is expected to continue until 2030 (see Figure 9-4 and Table 9-10). The largest future reductions are expected to occur in 1A Fuel combustion, particularly in 1A3 Transport and in small combustion intallations in source category 1A4. There are three main arguments that can back these expectations: The Euro 6/VI standard and a limit value for particle number emissions for non-road vehicles (under the EU stage V emission standard starting in January 2019) will both diminish future emissions, and wood-fired installations must comply with stricter air pollution control requirements from 2007 onwards.

The other sectors are of minor importance compared to the energy sector. In sector 2 IPPU, the emission reduction stopped in 2016 and is projected to turn into a slightly increasing trend until 2030 mainly due to an increase in food production (however, emissions in 2030 are still projected to be lower than in 2005). Emissions from sectors 3 Agriculture and 6 Other are expected to remain about constant (but on a higher level than in 2005). In sector 5 Waste, a reduction occurs between the current year and 2030.

Table 9-10: WM (WEM) projections: Relative trends of PM2.5 emissions per sector (2005 represents 100%).

PM2.5 emissions	2005	2017	2020	2025	2030
	kt	%	%		
1 Energy	7.44	64%	60%	52%	47%
1A Fuel combustion	7.44	64%	60%	52%	47%
1A1 Energy industries	0.14	70%	105%	156%	197%
1A2 Manufacturing industries and constr.	1.42	56%	53%	48%	44%
1A3 Transport	2.12	55%	49%	43%	40%
1A4 Other sectors	3.71	71%	66%	55%	45%
1A5 Other (Military)	0.06	81%	80%	80%	80%
1B Fugitive emissions from fuels	0.0001	81%	81%	80%	80%
2 IPPU	1.49	93%	95%	96%	96%
3 Agriculture	0.13	108%	108%	109%	109%
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.38	83%	73%	68%	62%
6 Other	0.004	135%	135%	138%	138%
National total	9.44	70%	66%	61%	56%

9.4.2 Projections for PM10

The decreasing trend of emissions from PM10 emissions is expected to continue until 2030 (see Figure 9-4 and Table 9-11). The largest future reductions are expected to occur in 1A Fuel combustion, particularly in 1A4 and to a lesser extent also in 1A3. The measures for the projected reductions of exhaust PM10 emissions are the same as for PM2.5, i.e. tightening of emission standards for diesel engine vehicles that will prescribe lower limit values, EU stage V emission standard for non-road vehicles (starting from January 2019) and tightening of emission limit values for particle emissions of (wood) combustion installations as well.

However, in addition to the generally expected decline of PM10 emissions, an increase is expected in non-exhaust particulate emissions (mainly larger particles, i.e. PM10 and TSP). A growth of activity data from mobile sources 1A3 and 1A2gvii is projected for the future (i.e. increasing annual mileage and machine hours). Therefore, the projected decrease for PM10 is less pronounced as compared to the projected decrease in PM2.5 emissions.

Table 9-11: WM (WEM) projections: Relative trends of PM10 emissions per sector (2005 represents 100%).

PM10 emissions	2005	2017	2020	2025	2030
	kt	%	%		
1 Energy	12.59	83%	81%	78%	75%
1A Fuel combustion	12.59	83%	81%	78%	75%
1A1 Energy industries	0.14	71%	106%	157%	198%
1A2 Manufacturing industries and constr.	3.28	84%	84%	83%	83%
1A3 Transport	5.06	90%	88%	87%	88%
1A4 Other sectors	3.85	71%	66%	56%	46%
1A5 Other (Military)	0.27	99%	99%	99%	99%
1B Fugitive emissions from fuels	0.0007	81%	81%	80%	80%
2 IPPU	2.37	99%	101%	102%	103%
3 Agriculture	1.63	104%	104%	105%	105%
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.42	83%	73%	68%	62%
6 Other	0.20	93%	93%	93%	93%
National total	17.21	87%	86%	84%	82%

9.4.3 Projections for BC

The decreasing trend of emissions from PM2.5 and PM10 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 future 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 6/VI standard and the EU stage V emission standard for non-road vehicles 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**	**2017**	**2020**	**2025**	**2030**
	kt	%	%		
1 Energy	3.02	46%	40%	29%	22%
1A Fuel combustion	3.02	46%	40%	29%	22%
1A1 Energy industries	0.01	61%	84%	122%	153%
1A2 Manufacturing industries and constr.	0.29	23%	19%	11%	7%
1A3 Transport	1.05	38%	27%	16%	11%
1A4 Other sectors	1.66	55%	51%	40%	30%
1A5 Other (Military)	0.01	35%	35%	34%	34%
1B Fugitive emissions from fuels	0.0000	81%	81%	80%	80%
2 IPPU	0.003	53%	52%	51%	50%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.03	83%	73%	68%	63%
6 Other	0.0001	92%	92%	92%	92%
National total	3.05	46%	40%	29%	22%

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 emissions are projected to continue a slight decrease between 2017 and 2030, Cd is considered to continue the increase that started in 2014. This increase is related to a huge predicted increase of wood energy consumption mainly for electricity production.

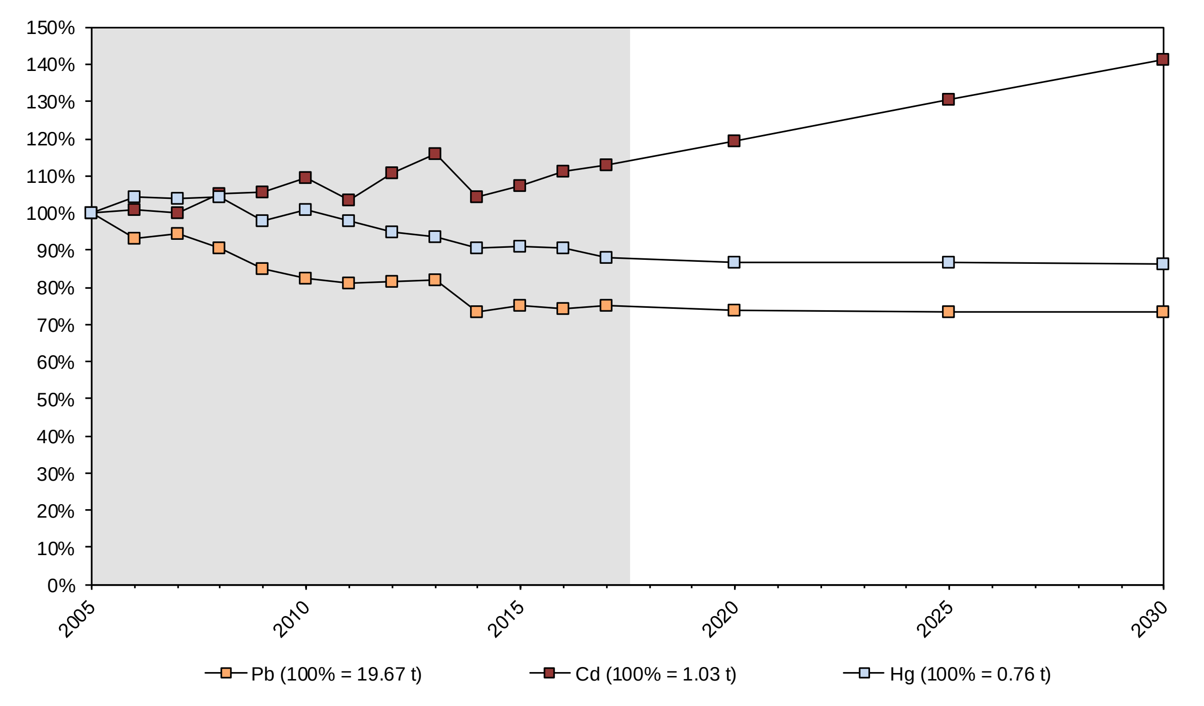


Figure 9-5: Projected emissions of priority heavy metals in Switzerland until 2030 of the WM (WEM) scenario (in percentage of 2005 level).

Table 9-13: WM (WEM) projected total emissions of priority heavy metal in tonnes.

Year	Pb	Cd	Hg
	t	t	t
2005	19.67	1.03	0.76
2010	16.21	1.13	0.76
2011	15.94	1.06	0.74
2012	16.09	1.14	0.72
2013	16.17	1.19	0.71
2014	14.46	1.07	0.69
2015	14.82	1.10	0.69
2016	14.60	1.14	0.68
2017	14.78	1.16	0.66
2018	14.69	1.18	0.66
2019	14.61	1.21	0.66
2020	14.53	1.23	0.66
2025	14.46	1.34	0.66
2030	14.43	1.45	0.65
2017 to 2030 (%)	-2%	25%	-2%

9.5.1 Projections for lead (Pb)

The annual national total of lead emissions will presumably continue decreasing until 2030 (see Table 9-14 and Figure 9-5). However, in the energy sector emissions are slightly increasing since 2015 and this trend is projected to continue until 2030. This increase is mainly because of increasing emissions from source category 1A1 due to growing amount of waste incinerated and large projected wood energy consumption for electricity production. On contrary, Pb emissions from 1A3 Transport are projected to continue their decreasing trend due to the assumption that in the future, the share of diesel will continue to increase compared to gasoline. Also for sector 5 Waste, the decreasing trend is projected to continue, mainly based on the assumption that the amount of illegally burned waste (under 5C1a) is reduced in the future. The emissions from sector 2 Industrial processes and product use are projected to remain about constant from now on. 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 per sector (2005 represents 100%).

Pb emissions	**2005**	**2017**	**2020**	**2025**	**2030**
	t	%	%		
1 Energy	8.70	69%	69%	70%	71%
1A Fuel combustion	8.70	69%	69%	70%	71%
1A1 Energy industries	1.68	86%	96%	113%	130%
1A2 Manufacturing industries and constr.	1.96	38%	39%	40%	41%
1A3 Transport	4.28	69%	66%	60%	56%
1A4 Other sectors	0.78	104%	102%	99%	96%
1A5 Other (Military)	0.00	88%	86%	85%	84%
1B Fugitive emissions from fuels	NO	NO	NO	NO	NO
2 IPPU	2.10	33%	34%	34%	34%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	2.28	86%	74%	68%	62%
6 Other	6.60	93%	93%	93%	93%
National total	19.67	75%	74%	73%	73%

9.5.2 Projections for cadmium (Cd)

Cadmium emissions are expected to increase until 2030 (see Table 9-15 and Figure 9-5). Responsible for the large increase in cadmium emissions is the predicted increase of wood energy consumption until 2030 mainly for electricity production in source category 1A1 Energy industries.

Table 9-15: WM (WEM) projections: Relative trends of Cd emissions per sector (2005 represents 100%).

Cd emissions	**2005**	**2017**	**2020**	**2025**	**2030**
	t	%	%		
1 Energy	0.76	120%	129%	144%	159%
1A Fuel combustion	0.76	120%	129%	144%	159%
1A1 Energy industries	0.18	133%	173%	239%	305%
1A2 Manufacturing industries and constr.	0.16	118%	117%	116%	115%
1A3 Transport	0.08	116%	118%	122%	127%
1A4 Other sectors	0.33	114%	113%	111%	108%
1A5 Other (Military)	NA	NA	NA	NA	NA
1B Fugitive emissions from fuels	NA	NA	NA	NA	NA
2 IPPU	0.09	91%	91%	90%	88%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.01	128%	100%	102%	103%
6 Other	0.16	93%	93%	93%	93%
National total	1.03	113%	119%	130%	142%

9.5.3 Projections for mercury (Hg)

Overall, the annual national total of mercury emissions is expected to be reduced only slightly until 2030 (see Table 9-16 and Figure 9-5). Emissions from sector 1 Energy are expected to remain on an almost constant level from 2017 on. Emissions from sector 2 Industrial processes and product use are expected to decrease until 2030. 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 emissions from other (fire damages) are expected to remain constant.

Table 9-16: WM (WEM) projections: Relative trends of Hg emissions per sector (2005 represents 100%).

Hg emissions	**2005**	**2017**	**2020**	**2025**	**2030**
	t	%		%	
1 Energy	0.54	95%	95%	96%	96%
1A Fuel combustion	0.54	95%	95%	96%	96%
1A1 Energy industries	0.34	85%	88%	93%	97%
1A2 Manufacturing industries and constr.	0.11	133%	128%	120%	112%
1A3 Transport	0.04	93%	90%	84%	76%
1A4 Other sectors	0.05	80%	77%	71%	65%
1A5 Other (Military)	NA	NA	NA	NA	NA
1B Fugitive emissions from fuels	NA	NA	NA	NA	NA
2 IPPU	0.07	80%	79%	75%	71%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.07	37%	27%	26%	24%
6 Other	0.08	91%	91%	91%	91%
National total	0.76	88%	87%	87%	87%

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. For PCDD/PCDF and PAH, a major part of this reduction is expected in the energy sector under 1A4 Other sectors (technical improvement of wood furnaces, similar to particulate matter emissions). For HCB, the decrease will mainly be achieved in source categories 1A4 (technical improvement of wood furnaces, similar to particulate matter emissions) and 1A2gviii (due to the low projection of wood energy consumption of industry, which turns out to currently already being higher than projected; accordingly, this decrease is probably not accurate).

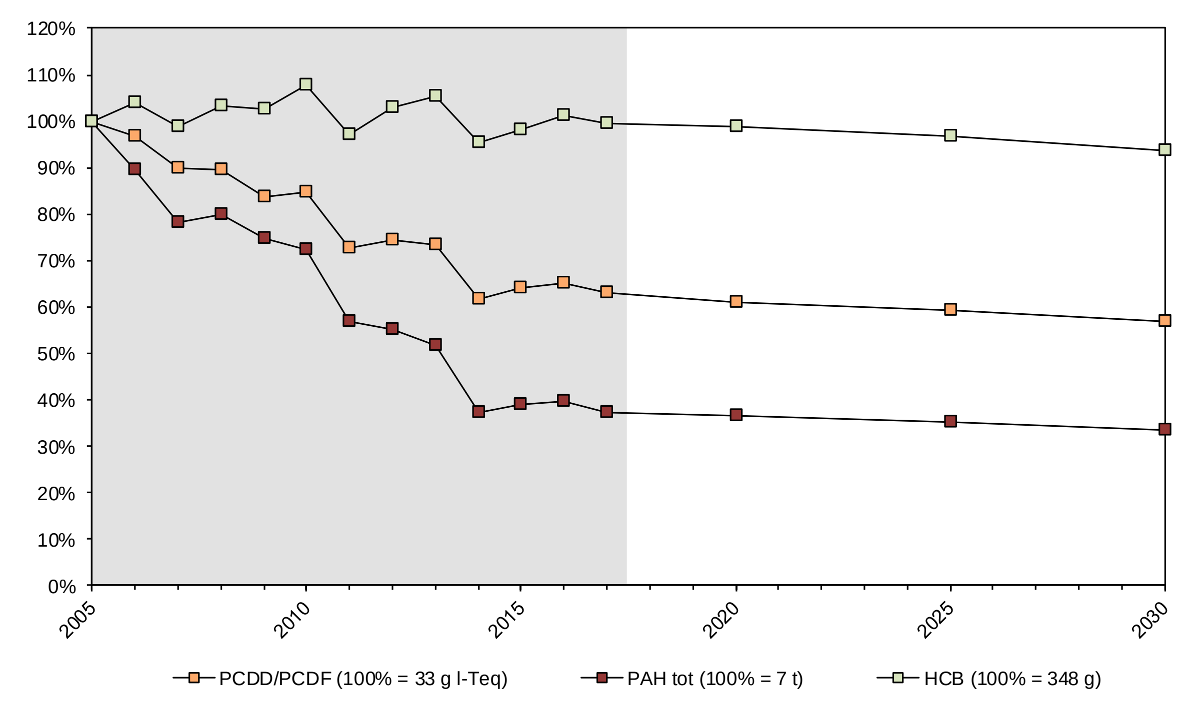


Figure 9-6: Emissions of POPs: PCDD/PCDF, PAH as the sum of benzo(a)pyrene), benzo(b)fluoranthene, benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, and HCB in Switzerland in the WM (WEM) scenario (in percent of 2005).

Table 9-17: Projected total emissions of POPs. 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	32.5	2.34	2.41	1.27	1.36	7.38	0.35
2010	27.6	1.73	1.72	0.90	1.01	5.35	0.38
2011	23.6	1.34	1.34	0.73	0.78	4.19	0.34
2012	24.2	1.28	1.30	0.73	0.76	4.07	0.36
2013	23.9	1.19	1.21	0.72	0.70	3.82	0.37
2014	20.0	0.83	0.87	0.56	0.50	2.76	0.33
2015	20.8	0.86	0.91	0.58	0.52	2.87	0.34
2016	21.2	0.87	0.92	0.59	0.53	2.92	0.35
2017	20.5	0.82	0.86	0.56	0.51	2.75	0.35
2018	20.3	0.81	0.86	0.56	0.50	2.73	0.35
2019	20.1	0.80	0.85	0.56	0.50	2.71	0.34
2020	19.8	0.79	0.84	0.56	0.50	2.69	0.34
2025	19.3	0.76	0.81	0.55	0.48	2.60	0.34
2030	18.5	0.71	0.77	0.53	0.46	2.47	0.33
2017 to 2030 (%)	-10%	-13%	-11%	-6%	-8%	-10%	-6%

9.6.1 Projections for PCDD/PCDF

PCDD/PCDF emissions are expected to continue a decreasing trend until 2030 (see Table 9-18 and Figure 9-6). The decrease is expected to be less pronounced between 2017-2030 as it has been between 2005 and 2017. The major part of this reduction is expected in source category 1A Fuel combustion, in particular under 1A4 Other sectors (technical improvement of wood furnaces, similar to particulate matter emissions). The emissions from sector 5 Waste (mainly due to a reduction of illegally incinerated waste under 5C1a) will decrease as well. In contrast, an increase is projected under 1A1 Energy industries (mainly from wood energy consumption for electricity production and waste incineration plants).

Table 9-18: WM (WEM) projections: Relative trends of PCDD/PCDF emissions per sector (2005 represents 100%).

PCDD/PCDF emissions	2005	2017	2020	2025	2030
	g I-Teq	%		%	
1 Energy	23.43	58%	57%	55%	52%
1A Fuel combustion	23.43	58%	57%	55%	52%
1A1 Energy industries	5.16	39%	44%	50%	55%
1A2 Manufacturing industries and constr.	2.23	43%	41%	37%	32%
1A3 Transport	0.22	99%	98%	93%	86%
1A4 Other sectors	15.81	66%	63%	59%	54%
1A5 Other (Military)	NA	NA	NA	NA	NA
1B Fugitive emissions from fuels	NA	NA	NA	NA	NA
2 IPPU	2.11	37%	40%	46%	52%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	4.53	86%	73%	68%	63%
6 Other	2.47	93%	93%	93%	93%
National total	32.54	63%	61%	59%	57%

9.6.2 Projections for polycyclic aromatic hydrocarbons (PAH)

Overall, the annual national total of PAH emissions is expected to continue its decrease until 2030 (see Table 9-19 and Figure 9-6), but less pronounced after 2017 than before. The main relevant source of PAH emissions remaining in the future are small wood combustion installations of source category 1A4. Important reductions are projected for 1A4 (e.g., wood furnaces). A significant increase of PAH emissions is expected under 1A3 Transport. It is assumed that 1A3 will be a major source of PAH emissions in 2030. The reason for this emission increase is the rising share of diesel oil use under 1A3b, which leads to increasing implied emission factors.

Table 9-19: WM (WEM) projections: Relative trends of PAHs emissions per sector (2005 represents 100%).

PAHs emissions	2005	2017	2020	2025	2030
	t	%		%	
1 Energy	6.54	37%	36%	35%	33%
1A Fuel combustion	6.54	37%	36%	35%	33%
1A1 Energy industries	0.11	14%	29%	50%	62%
1A2 Manufacturing industries and constr.	0.89	12%	13%	16%	18%
1A3 Transport	0.16	163%	171%	181%	185%
1A4 Other sectors	5.38	38%	36%	33%	30%
1A5 Other (Military)	0.00	97%	94%	92%	91%
1B Fugitive emissions from fuels	NA	NA	NA	NA	NA
2 IPPU	0.50	3%	2%	2%	2%
3 Agriculture	NA	NA	NA	NA	NA
4 LULUCF	NR	NR	NR	NR	NR
5 Waste	0.25	78%	75%	75%	75%
6 Other	0.09	118%	118%	118%	118%
National total	7.38	37%	36%	35%	33%

9.6.3 Projections for hexachlorobenzene (HCB)

HCB emissions on national level are projected to slightly decrease from 2017 until 2030 (see Table 9-20 and Figure 9-6). Absolute emissions are expected to be slightly lower in 2030 than in 2017. The only source categories causing HCB emissions are 1A1 Energy industries, 1A2 Manufacturing industries and construction and stationary combustion of 1A4. A decrease will mainly be achieved in source categories 1A4 (technical improvement of wood furnaces, similar to particulate matter emissions) and 1A2gviii (due to the low projection of wood energy consumption of industry, which turns out to currently already being higher than projected; accordingly, this decrease is probably not accurate). In contrast, HCB in 1A1a will increase due to the predicted increase of wood energy consumption and an increase of energy generation from waste incineration plants.

Table 9-20: WM (WEM) projections: Relative trends of HCB emissions per sector (2005 represents 100%).

HCB emissions	**2005**	**2017**	**2020**	**2025**	**2030**
	kg	%	%		
1 Energy	0.35	100%	99%	97%	94%
1A Fuel combustion	0.35	100%	99%	97%	94%
1A1 Energy industries	0.15	122%	128%	136%	142%
1A2 Manufacturing industries and constr.	0.04	81%	77%	70%	62%
1A3 Transport	NE	NE	NE	NE	NE
1A4 Other sectors	0.16	83%	76%	65%	55%
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	100%	99%	97%	94%

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 EMEP grid domain (in comparison with the domain of the old EMEP grid for 1999-2003).

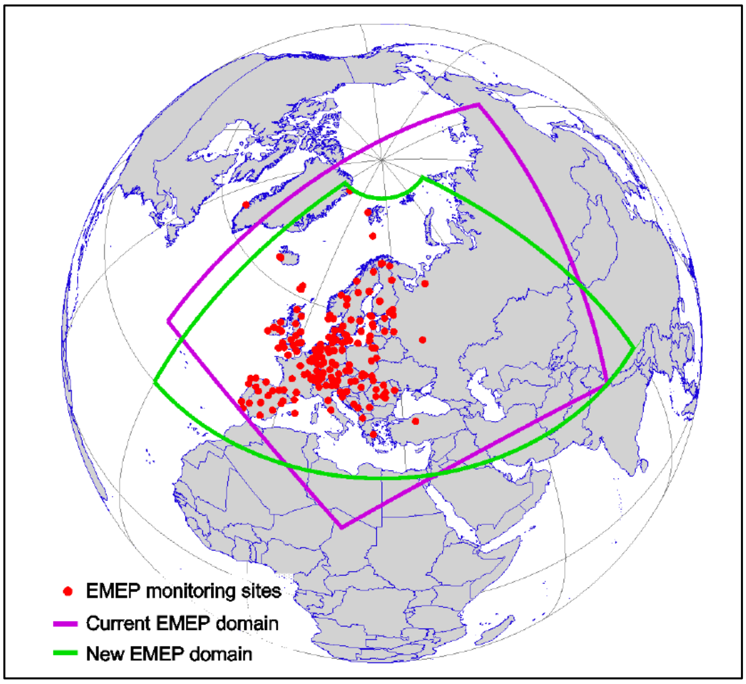


Figure 10-1: EMEP domain. Green line: EMEP domain (currently in place) in the latitude-longitude projection (30°N-82°N, 30°W-90°E); magenta line: old EMEP domain in the polar-stereographic projection; red dots: EMEP monitoring sites (EMEP 2012a).

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 EMEP grid resolution for Europe as used on local scales. In total, approximately 624’000 grid cells exist within the local EMEP domain.

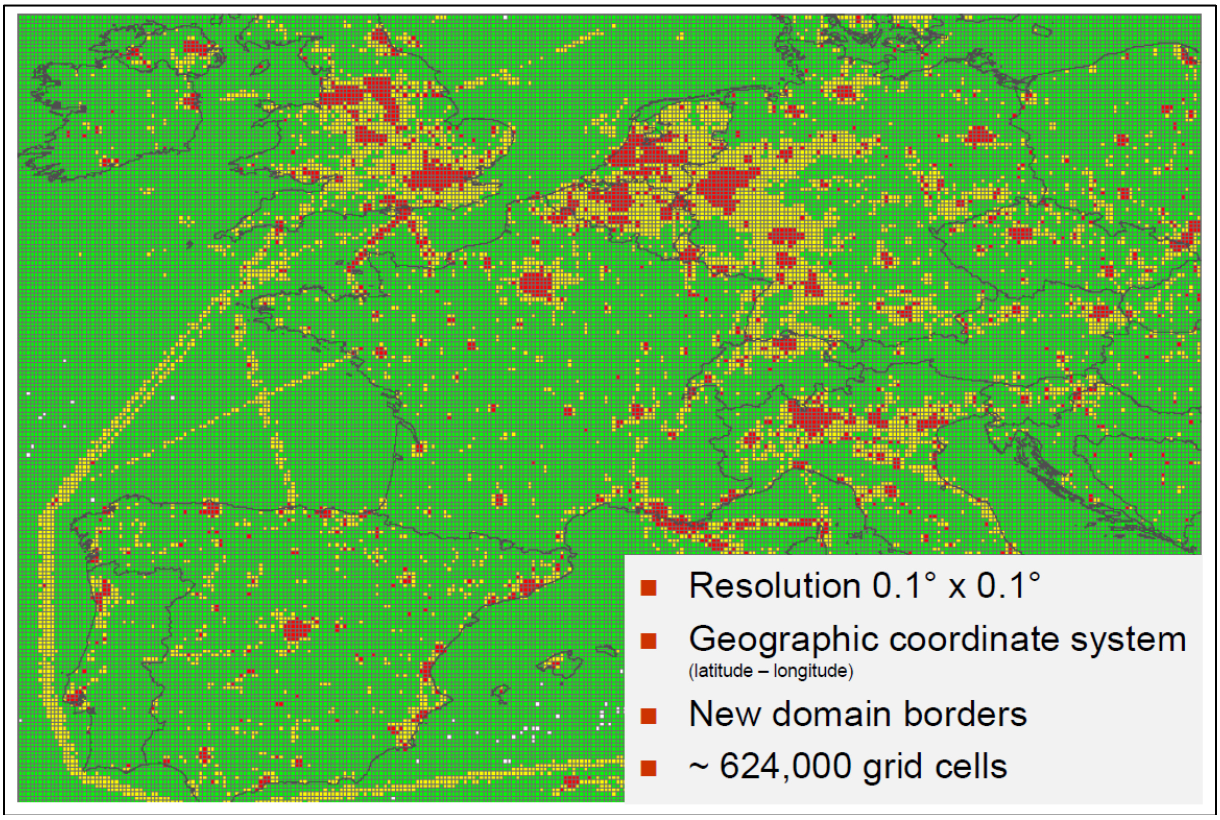


Figure 10-2: Resolution of the EMEP grid for Europe (EMEP 2012b).

In Switzerland’s air pollution inventory of current submission 2018, the EMEP grid on local scale (0.1° x 0.1°) is applied for the fifth 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 local-based EMEP grid. To achieve that, a separate study has been carried out which provides the allocation of the emissions sources within the local-scale EMEP grid (see Meteotest 2013, 2014 and 2015).

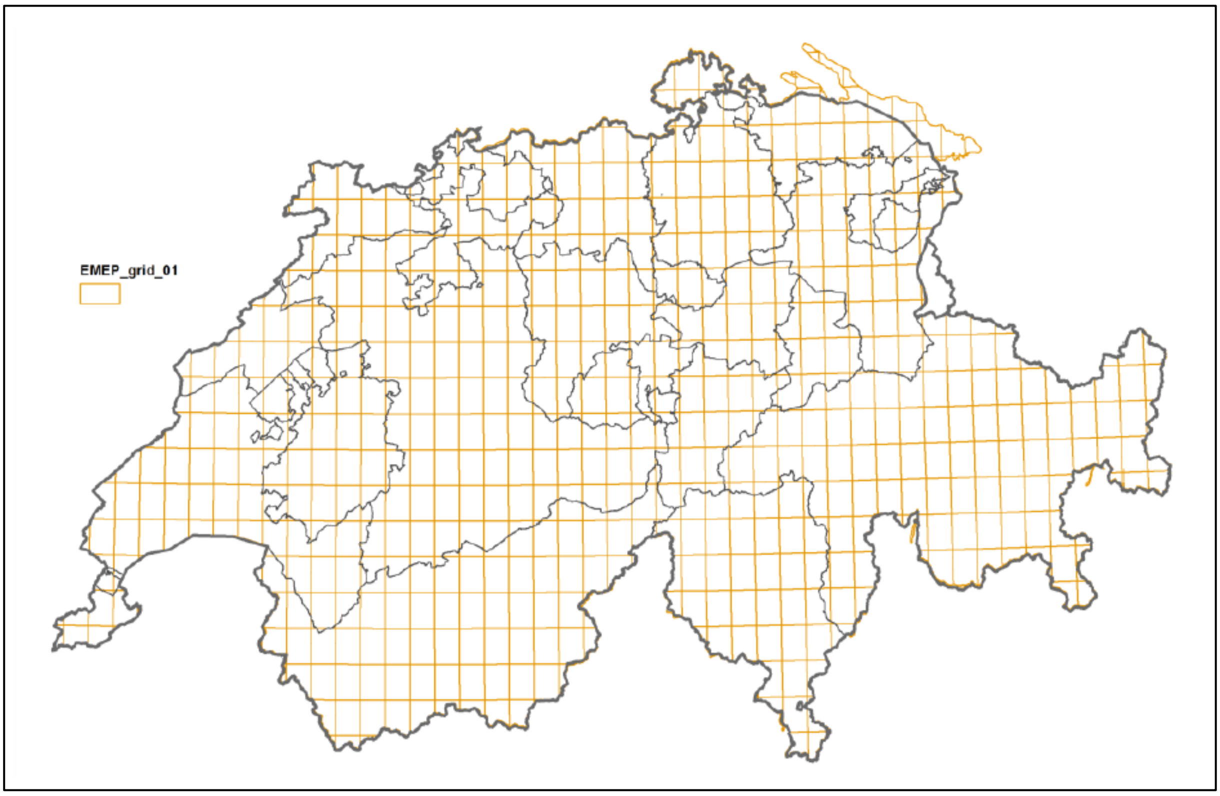


Figure 10-3: EMEP grid in Switzerland with 0.1° x 0.1° spatial resolution (from Meteotest 2013, downloaded from EMEP).

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 2017 for all main air pollutants including PM2.5.

Table 10-1: GNFR categories and their part (%) of total emissions in 2017 (national total) for the main air pollutants including PM2.5.

GNFR aggregated sectors	NO_x	NMVOC	SO_x	NH_3	PM2.5
A_PublicPower	3.72%	0.19%	4.50%	0.08%	1.16%
B_Industry	11.66%	8.79%	59.56%	0.64%	20.64%
C_OtherStatComb	13.10%	3.68%	26.65%	0.23%	36.84%
D_Fugitive	0.00%	3.44%	2.07%	0.00%	0.00%
E_Solvents	0.03%	45.63%	0.13%	0.12%	6.79%
F_RoadTransport	49.69%	10.21%	1.57%	2.62%	13.64%
G_Shipping	1.74%	0.55%	0.04%	0.00%	0.52%
H_Aviation	3.55%	0.30%	3.02%	0.00%	0.35%
I_Offroad	9.72%	2.59%	0.76%	0.01%	13.08%
J_Waste	0.31%	1.74%	1.51%	1.63%	4.80%
K_AgriLivestock	1.59%	22.02%	0.00%	46.99%	1.41%
L_AgriOther	4.71%	0.59%	0.00%	45.86%	0.69%
M_Other	0.17%	0.27%	0.20%	1.82%	0.08%
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

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 1980-2017. 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).

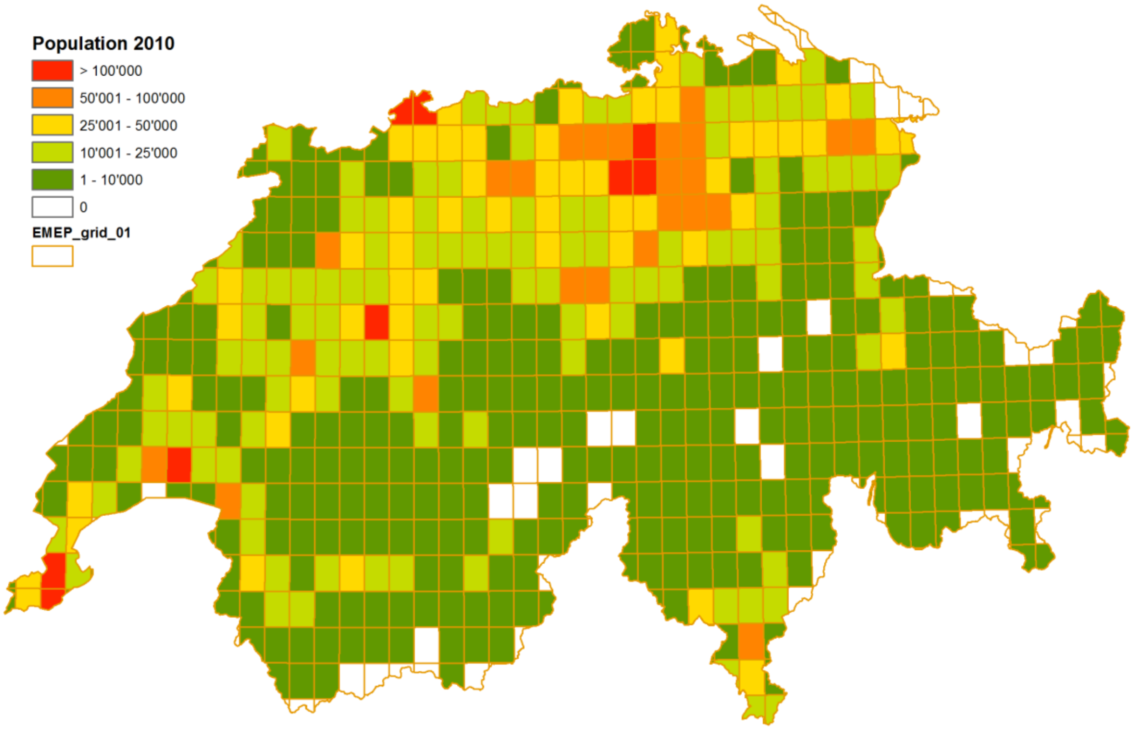


Figure 10-4: Population number per EMEP grid cell in Switzerland in 2010 (SFSO 2011a, Meteotest).

Census of enterprises/number of employee by economic sectors

Statistical surveys exist for enterprises, from which information about the specific economic use per hectare (100x100 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 (100x100 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 2014, 2015). 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 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 2014, 2015).

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 2014, 2015).

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 2017

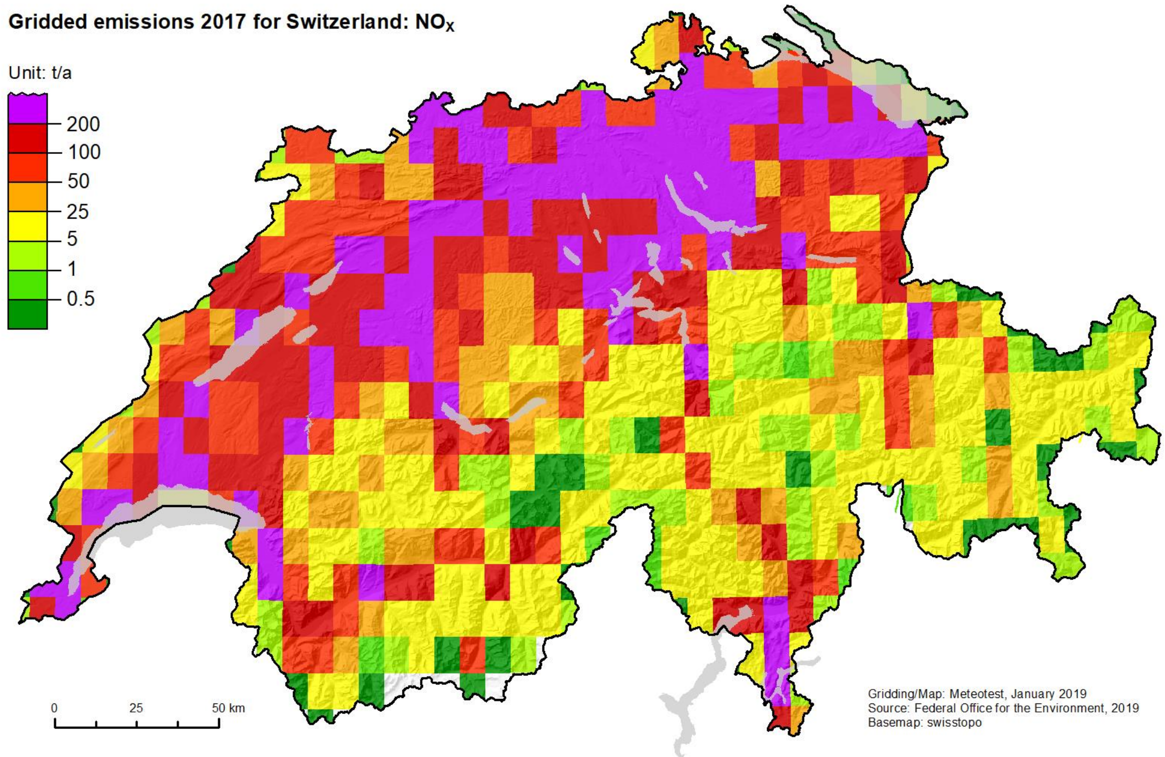


Figure 10-5: Spatial distribution of the NO_x emissions in Switzerland.

10.3.2 Spatial distribution of Switzerland's NMVOC emissions 2017

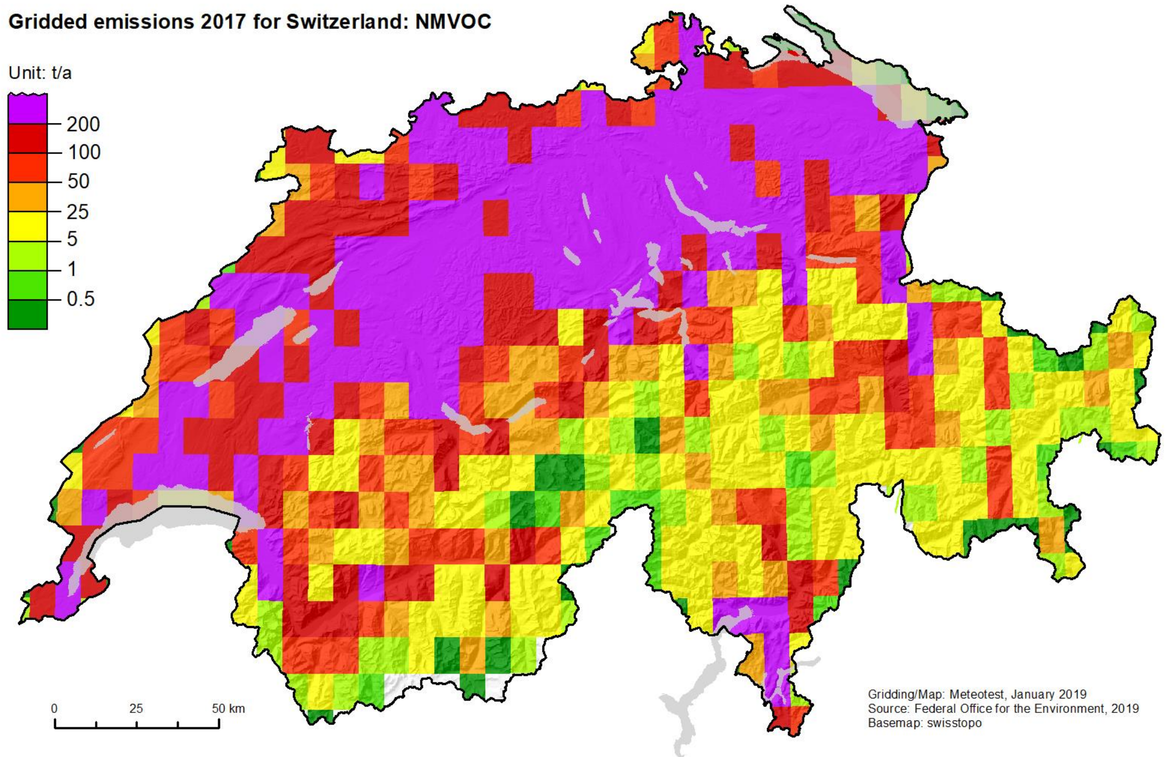


Figure 10-6: Spatial distribution of the NMVOC emissions in Switzerland.

10.3.3 Spatial distribution of Switzerland's SO_x emissions 2017

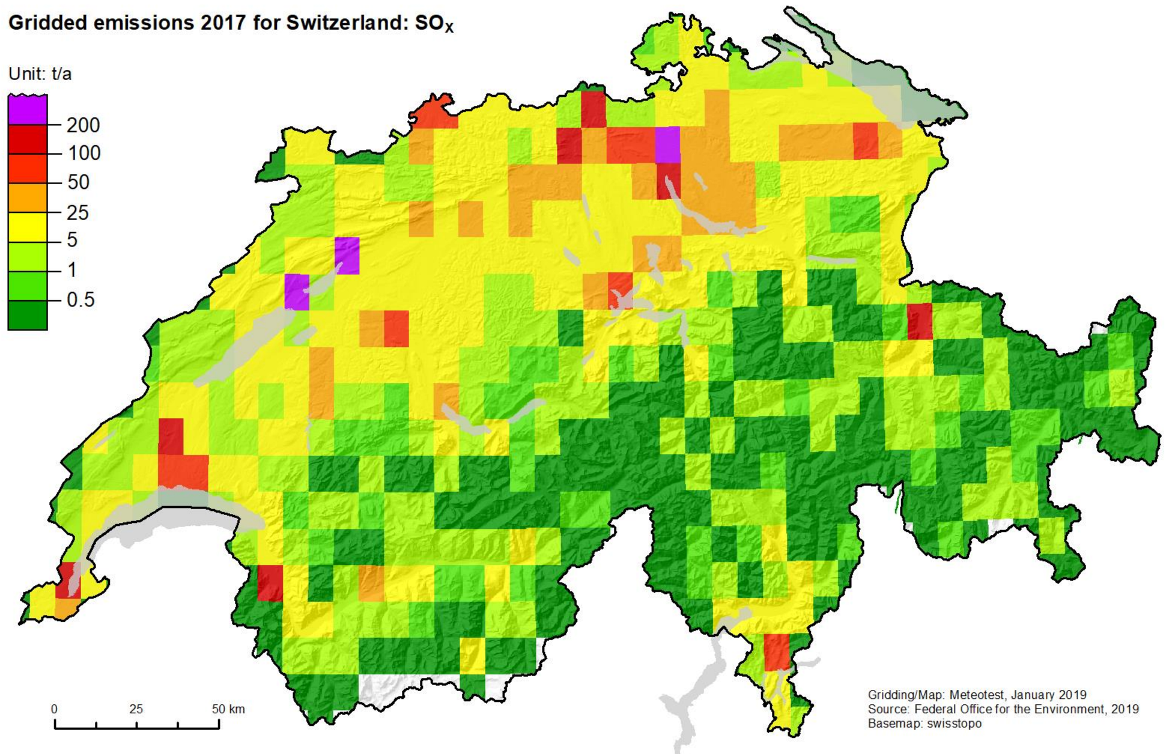


Figure 10-7: Spatial distribution of the SO_x emissions in Switzerland.

10.3.4 Spatial distribution of Switzerland's NH_3 emissions 2017

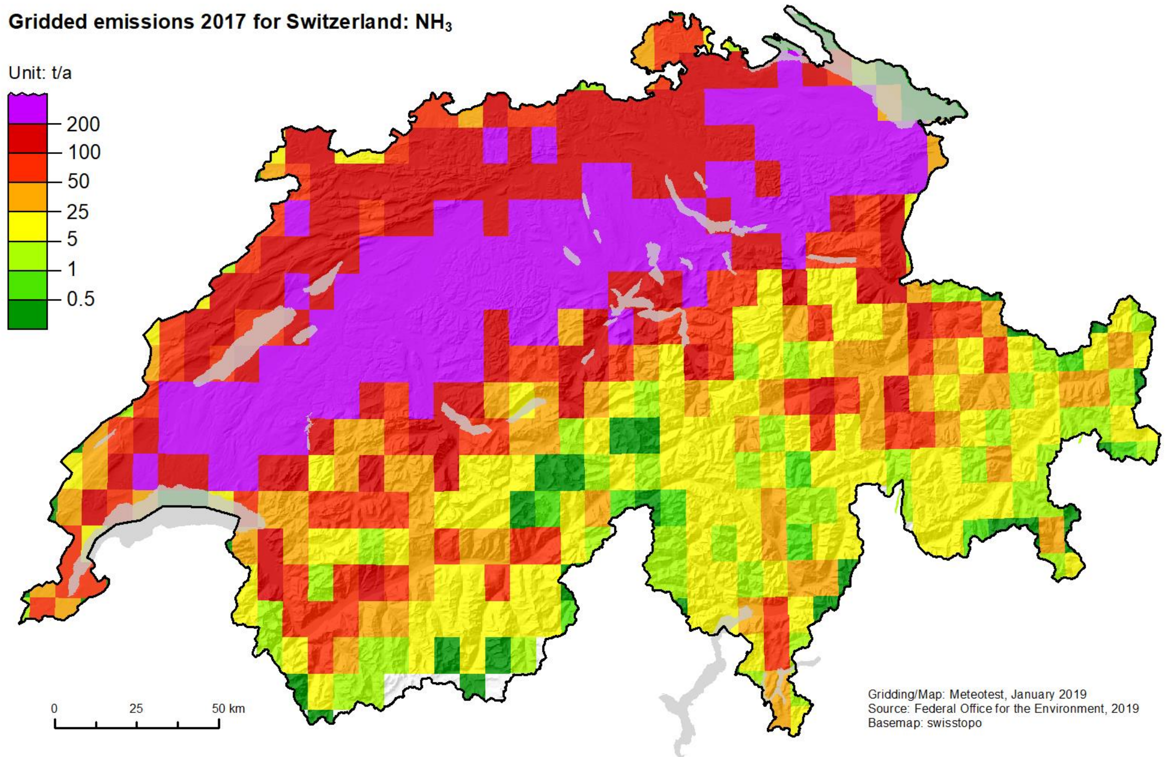


Figure 10-8: Spatial distribution of the NH_3 emissions in Switzerland.

10.3.5 Spatial distribution of Switzerland's PM2.5 emissions 2017

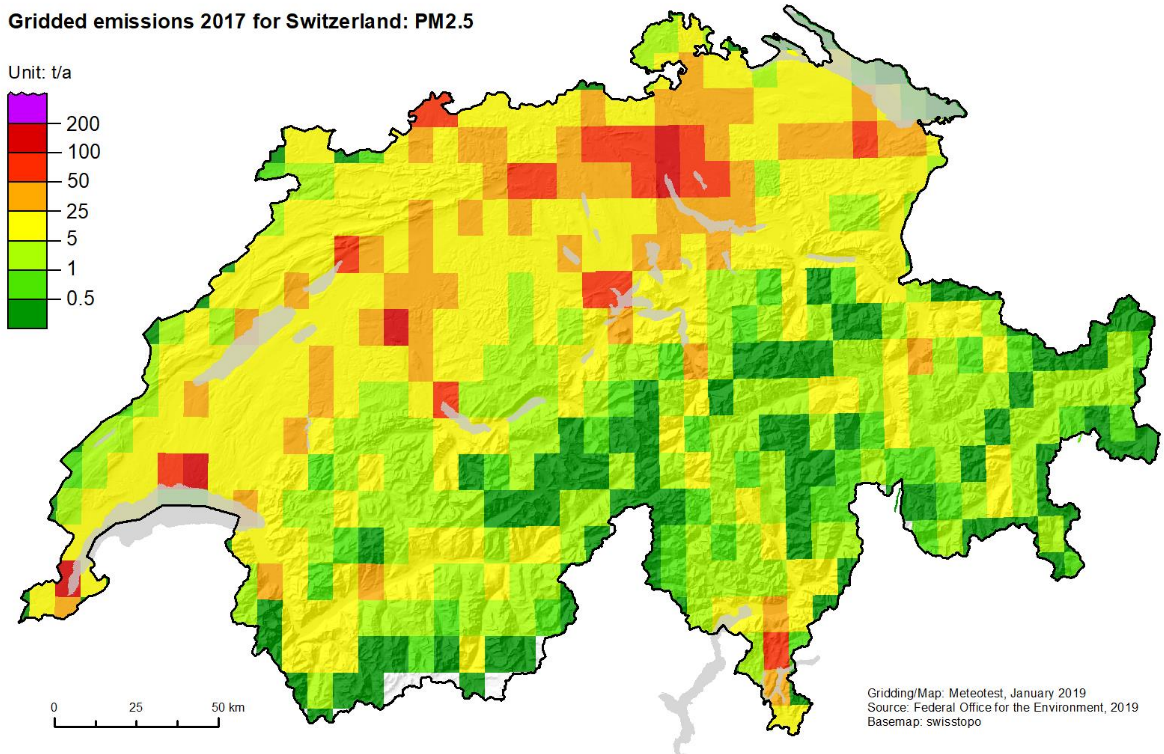


Figure 10-9: Spatial distribution of the PM2.5 emissions in Switzerland.

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 years 2007-2017 are reported based on the most recent data of the Swiss Pollution Release and Transfer Register (PRTR 2019). 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 2017, the list of Switzerland's LPS includes 28 facilities, in particular of the industrial and waste sectors. This represents the lowest number of LPS since the implementation of the Swiss PRTR in 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-Swiss PRTR facility IDs correspond to the BER-Code (Business and Enterprise Register) of the Swiss Federal Statistical Office.

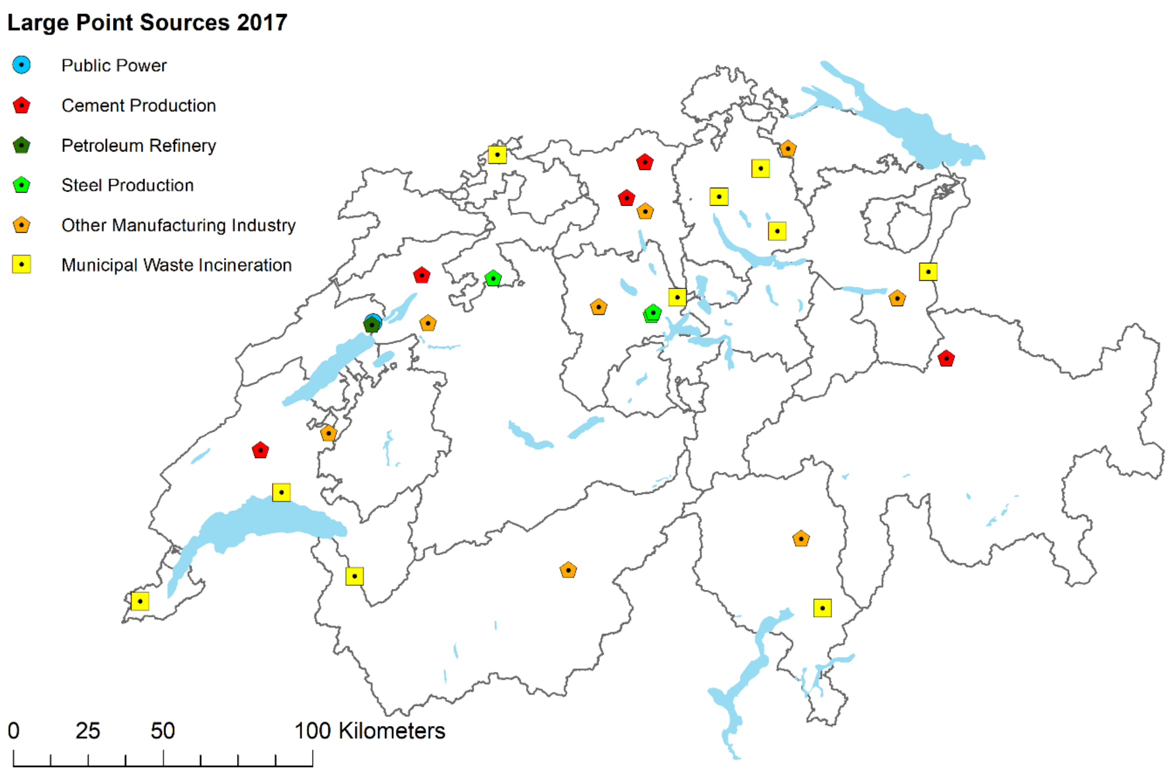


Figure 10-10: Spatial distribution of Switzerland's LPS in 2017.

11 Adjustments

There are no adjustments in Switzerland’s air pollutant emission inventory.

12 References and assignments to EMIS categories

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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	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	Dachpappe**
1 A 2 c & 2 B 8 b [2 B 10 a]	Ethen-Produktion*	2 D 3 d	Urea (AdBlue) Einsatz Strassenverkehr
1 A 2 d & 2 A 4 d	Zellulose-Produktion Feuerung*	2 G 3 a	Lachgasanwendung Spitäler**
1 A 2 f	Kalkproduktion, Feuerung*	2 G 3 b	Lachgasanwendung Haushalt**
1 A 2 f	Mischgut Produktion	2 G 4 [2 D 3 a]	Pharma-Produkte im Haushalt
1 A 2 f	Zementwerke Feuerung	2 G 4 [2 D 3 a]	Reinigungs- und Lösemittel; Haushalte
1 A 2 f & 2 A 3	Glas übrige Produktion*	2 G 4 [2 D 3 a]	Spraydosen Haushalte**
1 A 2 f & 2 A 3	Glaswolle Produktion Rohprodukt*	2 G 4 [2 D 3 h]	Verpackungsdruckereien**
1 A 2 f & 2 A 3	Hohlglas Produktion*	2 G 4 [2 D 3 h]	Druckereien uebrige
1 A 2 f & 2 A 4 a	Feinkeramik Produktion*	2 G 4 [2 D 3 i]	Entfernung von Farben und Lacken**
1 A 2 f & 2 A 4 a	Ziegeleien**	2 G 4 [2 D 3 i]	Entwachsung von Fahrzeugen
1 A 2 f & 2 A 4 d	Steinwolle Produktion*	2 G 4 [2 D 3 i]	Kosmetika-Produktion**
1 A 2 g iv	Faserplatten Produktion**	2 G 4 [2 D 3 i]	Lösungsmittel-Emissionen IG nicht zugeordnet
1 A 3 a & 1 A 5	Flugverkehr	2 G 4 [2 D 3 i]	Öl- und Fettgewinnung
1 A 3 b i-viii	Strassenverkehr	2 G 4 [2 D 3 i]	Papier- und Karton-Produktion**
1 A 3 c	Schienenverkehr	2 G 4 [2 D 3 i]	Parfum- und Aromen-Produktion**
1 A 3 e	Gastransport Kompressorstation	2 G 4 [2 D 3 i]	Tabakwaren Produktion**
1 A 4 b i	Holzkohle-Verbrauch	2 G 4 [2 D 3 i]	Textilien-Produktion
1 A 4 b i	Lagerfeuer	2 G 4 [2 D 3 i]	Wissenschaftliche Laboratorien
1 A 4 c i	Grastrocknung**	2 G 4 [2 G]	Korrosionsschutz im Freien
1 B 2 a iv	Raffinerie, Leckverluste	2 G 4 [2 G]	Betonzusatzmittel-Anwendung
1 B 2 a v	Benzinumschlag Tanklager	2 G 4 [2 G]	Coiffeursalons
1 B 2 a v	Benzinumschlag Tankstellen	2 G 4 [2 G]	Fahrzeug-Unterbodenschutz**
1 B 2 b ii & 1 B 2 c ii	Gasproduktion und Flaring	2 G 4 [2 G]	Feuerwerke
1 B 2 b iv-vi	Netzverluste Erdgas	2 G 4 [2 G]	Flaechenenteisung Flughaefen
1 B 2 c	Raffinerie, Abfackelung	2 G 4 [2 G]	Flugzeug-Enteisung
1 Energy Model***	Energie New	2 G 4 [2 G]	Froststschutzmittel Automobil
1A	Holzfeuerungen	2 G 4 [2 G]	Gas-Anwendung
1A2gvii, 1A3c, 1A3e, 1A4aii/bii/cii, 1A5b (without military aviation)	Off-Road	2 G 4 [2 G]	Gesundheitswesen, übrige**
2 A 1	Zementwerke Rohmaterial	2 G 4 [2 G]	Glaswolle Imprägnierung*
2 A 1	Zementwerke übriger Betrieb	2 G 4 [2 G]	Holzschutzmittel-Anwendung
2 A 2	Kalkproduktion, Rohmaterial*	2 G 4 [2 G]	Klebstoff-Anwendung
2 A 2	Kalkproduktion, übriger Betrieb*	2 G 4 [2 G]	Kosmetik-Institute
2 A 4 d	Kehrichtverbrennungsanlagen Karbonat**	2 G 4 [2 G]	Kühlschmiermittel-Verwendung
2 A 4 d	Karbonatanwendung weitere	2 G 4 [2 G]	Medizinische Praxen**
2 A 5 a	Gips-Produktion übriger Betrieb**	2 G 4 [2 G]	Pflanzenschutzmittel-Verwendung
2 A 5 a	Kieswerke	2 G 4 [2 G]	Reinigung Gebäude IGD**
2 B 1	Ammoniak-Produktion*	2 G 4 [2 G]	Schmierstoff-Verwendung
2 B 10 [2 B 10 a]	Ammoniumnitrat-Produktion*	2 G 4 [2 G]	Spraydosen IndustrieGewerbe
2 B 10 [2 B 10 a]	Chlorgas-Produktion*	2 G 4 [2 G]	Tabakwaren Konsum
2 B 10 [2 B 10 a]	Essigsäure-Produktion*	2 G 4 [2 G]	Steinwolle-Imprägnierung*
2 B 10 [2 B 10 a]	*Formaldehyd-Produktion*	2 H 1	Faserplatten Produktion**
2 B 10 [2 B 10 a]	PVC-Produktion	2 H 1	Zellulose Produktion übriger Betrieb*
2 B 10 [2 B 10 a]	*Salzsäure-Produktion**	2 H 1	Spanplatten Produktion*
2 B 10 [2 B 10 a]	Schwefelsäure-Produktion*	2 H 2	Bierbrauereien
2 B 10	Kalksteingrube*	2 H 2	Branntwein Produktion
2 B 10	Niacin-Produktion*	2 H 2	Brot Produktion
2 B 2	Salpetersäure Produktion*	2 H 2	Fleischräuchereien
2 B 5	Graphit und Siliziumkarbid Produktion*	2 H 2	Kaffeeröstereien
2 C - 2 G	Synthetische Gase	2 H 2	Müllereien
2 C 1	Eisengiessereien Elektroschmelzöfen	2 H 2	Wein Produktion
2 C 1	Eisengiessereien übriger Betrieb	2 H 2	Zucker Produktion
2 C 1 & 1 A 2 a	Stahl-Produktion Elektroschmelzöfen**	2 H 3	Sprengen und Schiessen
2 C 1	Stahl-Produktion übriger Betrieb**	2 I	Holzbearbeitung
2 C 1	Stahl-Produktion Walzwerke**	2 L	NH3 aus Kühlanlagen
2 C 7 a	Buntmetallgiessereien Elektroöfen**	3	Landwirtschaft
2 C 7 c	Verzinkereien	3 B	Tierhaltung
2 C 7 c	Batterie-Recycling*	3 C	Reisanbau
2 D 1	Schmiermittel-Anwendung	3 D c	Landwirtschaftsflächen
2 D 1	Schmiermittel-Verbrauch B2T	5 B 1	Kompostierung
2 D 2	Paraffinwachs-Anwendung	5 B 2	Biogasaufbereitung (Methanverlust)
2 D 3 a [2 D 3 d]	Farben-Anwendung Bau	5 C 1 [5 C 1 a]	Abfallverbrennung illegal
2 D 3 a [2 D 3 d]	Farben-Anwendung andere	5 C 1 [5 C 1 b i]	Kabelabbrand
2 D 3 a [2 D 3 d]	Farben-Anwendung Haushalte**	5 C 1 [5 C 1 b iii]	Spitalabfallverbrennung
2 D 3 a [2 D 3 d]	Farben-Anwendung Holz	5 C 1 [5 C 1 b iv]	Klärschlammverbrennung
2 D 3 a [2 D 3 d]	Farben-Anwendung Autoreparatur**	5 C 1 [5 C 1 b v]	Krematorien
2 D 3 a [2 D 3 e]	Elektronik-Reinigung	5 C 2 / 4 V A 1 (Forstwirtscha	Abfallverbrennung Land- und Forstwirtschaft und Private
2 D 3 a [2 D 3 e]	Metallreinigung	5 D 1 [5 D]	Kläranlagen kommunal (Luftschadstoffe)
2 D 3 a [2 D 3 e]	Reinigung Industrie übrige	5 D 2 [5 D]	Kläranlagen industriell (Luftschadstoffe)
2 D 3 a [2 D 3 f]	Chemische Reinigung**	5 D 1 / 5 D 2 [5 D]	Kläranlagen GHG
2 D 3 a [2 D 3 g]	Druckfarben Produktion	5 E	Shredder Anlagen
2 D 3 a [2 D 3 g]	Farben-Produktion	6 A d	Brand- und Feuerschäden Immobilien
2 D 3 a [2 D 3 g]	Feinchemikalien-Produktion**	6 A d	Brand- und Feuerschäden Motorfahrzeuge
2 D 3 a [2 D 3 g]	Gummi-Verarbeitung**	6 A d	Brand- und Feuerschäden Motorfahrzeuge
2 D 3 a [2 D 3 g]	Klebband-Produktion		

* confidential process
** confidential EMIS comment
*** work in progress
Cursive: process not relevant for the years after 1990.
New comment for the current submission.

References and assignments to EMIS categories

Annexes

Annex 1 Key category analysis (KCA)

A1.1 Overview

The following table gives an overview over the level (2017) and trend (1990-2017) assessments with approach 1 and approach 2. Note that the key category analysis is performed based on the approach “fuels sold”, in the reporting tables characterized as “National total for the entire territory based on fuel sold” (in contrast to “fuels used”; for differentiation of the two approaches see chapter 3.1.6.1).

Table A - 1: Summary of Switzerland's key category analysis. Legend: L = Level (2017), T = Trend (1990-2017), 1 = approach 1 and 2 = approach 2.

KeyCategories		NO_x (as NO_2)	NMVOC	SO_x (as SO_2)	NH_3	PM2.5	PM10
NFR	Longname						
1A1a	Public electricity and heat production	L1, L2, T1, T2		L1, L2, T1, T2		T1, T2	T1, T2
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals			L1, T1			
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	T1		T1, T2			
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	L1, L2, T1, T2		L1, L2, T1, T2		T1	T1, T2
1A2gvii	Mobile Combustion in manufacturing industries and construction	L1				L1, L2	L1, L2, T1, T2
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	T1, T2		L1, L2		L1, L2, T1	L1
1A3ai(i)	International aviation LTO (civil)	T1, T2		T1			
1A3bi	Road transport: Passenger cars	L1, L2, T1, T2	L1, T1, T2	T1, T2	L2	L1	L1
1A3bii	Road transport: Light duty vehicles	L1, L2, T1, T2					
1A3biii	Road transport: Heavy duty vehicles and buses	L1, L2, T1, T2		T1, T2		T1, T2	T1
1A3biv	Road transport: Mopeds & motorcycles	T2	T2				
1A3bv	Road transport: Gasoline evaporation		T1				
1A3bvi	Road transport: Automobile tyre and brake wear					L1, L2, T1, T2	L1, L2, T1, T2
1A3c	Railways					L1, T1	L1, L2, T1, T2
1A3d	International inland waterways	T1					
1A4ai	Commercial/institutional: Stationary	L1, L2, T1		L1, L2, T1		L1, L2, T1, T2	L1, T1
1A4bi	Residential: Stationary	L1, L2	L1	L1, L2, T1, T2		L1, L2, T1, T2	L1, L2, T1, T2
1A4ci	Agriculture/Forestry/Fishing: Stationary					L1	
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	L1, T1				L1	
1B2aiv	Fugitive emissions oil: Refining / storage			L2, T2			
1B2av	Distribution of oil products		T1				
2A1	Cement production					L2, T2	L2
2A5a	Quarrying and mining of minerals other than coal					L1, L2, T1, T2	L1, L2, T1, T2
2B5	Carbide production			L1, L2, T1, T2			
2B10a	Other Chemical industry			L2, T2			
2C1	Iron and steel production					T1, T2	T1, T2
2D3a	Domestic solvent use		L1, L2, T1, T2				
2D3b	Road paving with asphalt		L1, T1				
2D3d	Coating applications		L1, L2, T1, T2				
2D3e	Degreasing		L1				
2D3g	Chemical products		L1, L2, T1, T2				
2D3h	Printing		L1, T1				
2D3i	Other solvent use		L1, L2				
2G	Other product use		L1, L2			L1, L2, T1, T2	L1, L2, T1
2H1	Pulp and paper					L1, L2, T1, T2	L2
2H2	Food and beverages industry		L1, T1			L2, T1, T2	L1, L2, T2
2I	Wood processing					L2	L1, L2, T2
3B1a	Manure management - Dairy cattle		L1, L2, T1, T2		L1, L2, T1, T2		
3B1b	Manure management - Non-dairy cattle		L1, L2, T1, T2		L1, L2, T1, T2		
3B3	Manure management - Swine		L2, T2		L1, L2		
3B4gii	Manure management - Broilers		L2, T2		T2		L2, T2
3Da1	Inorganic N-fertilizers (includes also urea application)	L2, T2			L1, L2, T2		
3Da2a	Animal manure applied to soils	L2, T1, T2			L1, L2, T1, T2		
3Da2b	Sewage sludge applied to soils				T1		
3Da2c	Other organic fertilisers applied to soils	T2			T1, T2		
3Da3	Urine and dung deposited by grazing animals	T2			T1, T2		L1, L2, T1, T2
5B1	Biological treatment of waste - Composting				T2		
5C1a	Municipal waste incineration					L1	
5C1biv	Sewage sludge incineration			T2			
6A	Other sources				L2		

A1.2 Detailed results of approach 1 assessment

The following tables depict the detailed results for the approach 1 level and trend assessments.

Table A - 2: List of Switzerland's approach 1 level key categories 2017 for the main pollutants, PM2.5 and PM10 ranked per pollutant and level contribution (Lx,t).

APPROACH 1 LEVEL ASSESSMENT FOR 2017						
Code	**Source Category**	**Pollutant**	**Ex,t (kt)**	**|Ex,t| (kt)**	**Lx,t**	**Cumula-tive Total**
1A3bi	Road transport: Passenger cars	NOx	20653	20653	33.8%	33.8%
1A3biii	Road transport: Heavy duty vehicles and	NOx	5740	5740	9.4%	43.2%
1A4bi	Residential: Stationary	NOx	5169	5169	8.5%	51.6%
1A2f	Stationary combustion in manufacturing	NOx	3776	3776	6.2%	57.8%
1A3bii	Road transport: Light duty vehicles	NOx	3607	3607	5.9%	63.7%
1A4ai	Commercial/institutional: Stationary	NOx	2693	2693	4.4%	68.1%
1A2gvii	Mobile Combustion in manufacturing	NOx	2657	2657	4.3%	72.4%
1A4cii	Agriculture/Forestry/Fishing: Off-road	NOx	2352	2352	3.8%	76.3%
1A1a	Public electricity and heat production	NOx	2275	2275	3.7%	80.0%
3Da2a	Animal manure applied to soils	NH3	20301	20301	36.8%	36.8%
3B1a	Manure management - Dairy cattle	NH3	11156	11156	20.2%	57.0%
3B1b	Manure management - Non-dairy cattle	NH3	7383	7383	13.4%	70.4%
3B3	Manure management - Swine	NH3	4864	4864	8.8%	79.2%
3Da1	Inorganic N-fertilizers (includes also urea	NH3	2813	2813	5.1%	84.3%
2D3a	Domestic solvent use	NMVOC	11555	11555	14.7%	14.7%
3B1a	Manure management - Dairy cattle	NMVOC	7733	7733	9.9%	24.6%
2D3d	Coating applications	NMVOC	7008	7008	8.9%	33.6%
3B1b	Manure management - Non-dairy cattle	NMVOC	6819	6819	8.7%	42.3%
2G	Other product use	NMVOC	6747	6747	8.6%	50.9%
1A3bi	Road transport: Passenger cars	NMVOC	6306	6306	8.0%	58.9%
2D3g	Chemical products	NMVOC	3511	3511	4.5%	63.4%
2D3b	Road paving with asphalt	NMVOC	2840	2840	3.6%	67.0%
2D3h	Printing	NMVOC	2802	2802	3.6%	70.6%
2H2	Food and beverages industry	NMVOC	2391	2391	3.1%	73.6%
1A4bi	Residential: Stationary	NMVOC	2272	2272	2.9%	76.5%
2D3i	Other solvent use	NMVOC	2110	2110	2.7%	79.2%
2D3e	Degreasing	NMVOC	1964	1964	2.5%	81.7%
1A3bvi	Road transport: Automobile tyre and brake	PM10	2695	2695	18.1%	18.1%
1A2gvii	Mobile Combustion in manufacturing	PM10	2318	2318	15.5%	33.6%
1A4bi	Residential: Stationary	PM10	1753	1753	11.7%	45.3%
1A3c	Railways	PM10	1260	1260	8.4%	53.8%
3Da3	Urine and dung deposited by grazing	PM10	1009	1009	6.8%	60.5%
2G	Other product use	PM10	600	600	4.0%	64.6%
1A4ai	Commercial/institutional: Stationary	PM10	507	507	3.4%	68.0%
2A5a	Quarrying and mining of minerals other than	PM10	461	461	3.1%	71.0%
2I	Wood processing	PM10	372	372	2.5%	73.5%
2H2	Food and beverages industry	PM10	342	342	2.3%	75.8%
1A2gviii	Stationary combustion in manufacturing	PM10	339	339	2.3%	78.1%
1A3bi	Road transport: Passenger cars	PM10	307	307	2.1%	80.2%
1A4bi	Residential: Stationary	PM2.5	1712	1712	26.1%	26.1%
1A4ai	Commercial/institutional: Stationary	PM2.5	493	493	7.5%	33.7%
2G	Other product use	PM2.5	445	445	6.8%	40.5%
1A3bvi	Road transport: Automobile tyre and brake	PM2.5	404	404	6.2%	46.6%
1A2gvii	Mobile Combustion in manufacturing	PM2.5	404	404	6.2%	52.8%
1A2gviii	Stationary combustion in manufacturing	PM2.5	327	327	5.0%	57.8%
1A3bi	Road transport: Passenger cars	PM2.5	307	307	4.7%	62.5%
5C1a	Municipal waste incineration	PM2.5	264	264	4.0%	66.5%
2A5a	Quarrying and mining of minerals other than	PM2.5	230	230	3.5%	70.0%
2H1	Pulp and paper	PM2.5	215	215	3.3%	73.3%
1A4cii	Agriculture/Forestry/Fishing: Off-road	PM2.5	212	212	3.2%	76.6%
1A4ci	Agriculture/Forestry/Fishing: Stationary	PM2.5	208	208	3.2%	79.7%
1A3c	Railways	PM2.5	195	195	3.0%	82.7%
1A2f	Stationary combustion in manufacturing	SO2	1430	1430	26.4%	26.4%
1A4bi	Residential: Stationary	SO2	956	956	17.6%	44.0%
2B5	Carbide production	SO2	710	710	13.1%	57.1%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	SO2	440	440	8.1%	65.2%
1A4ai	Commercial/institutional: Stationary	SO2	430	430	7.9%	73.1%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	SO2	325	325	6.0%	79.1%
1A1a	Public electricity and heat production	SO2	244	244	4.5%	83.6%

Table A - 3: List of Switzerland's approach 1 level key categories in the base year 1990 for the main pollutants, PM2.5 and PM10 ranked per pollutant and level contribution (Lx,0).

APPROACH 1 LEVEL ASSESSMENT FOR BASE YEAR						
Code	**Source Category**	**Pollutant**	**Ex,0 (kt)**	**|Ex,0| (kt)**	**Lx,0**	**Cumula-tive Total**
1A3bi	Road transport: Passenger cars	NOx	48610	48610	34.6%	34.6%
1A3biii	Road transport: Heavy duty vehicles and buses	NOx	25481	25481	18.1%	52.7%
1A4bi	Residential: Stationary	NOx	11551	11551	8.2%	60.9%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	NOx	10535	10535	7.5%	68.4%
1A2gvii	Mobile Combustion in manufacturing industries and construction	NOx	6334	6334	4.5%	72.9%
1A1a	Public electricity and heat production	NOx	6312	6312	4.5%	77.4%
1A3bii	Road transport: Light duty vehicles	NOx	5518	5518	3.9%	81.3%
3Da2a	Animal manure applied to soils	NH3	32979	32979	49.2%	49.2%
3B1a	Manure management - Dairy cattle	NH3	10000	10000	14.9%	64.1%
3B3	Manure management - Swine	NH3	6020	6020	9.0%	73.1%
3B1b	Manure management - Non-dairy cattle	NH3	5538	5538	8.3%	81.3%
2D3d	Coating applications	NMVOC	54168	54168	18.0%	18.0%
1A3bi	Road transport: Passenger cars	NMVOC	53363	53363	17.7%	35.8%
2D3g	Chemical products	NMVOC	28314	28314	9.4%	45.2%
2G	Other product use	NMVOC	21487	21487	7.1%	52.3%
2D3h	Printing	NMVOC	20354	20354	6.8%	59.1%
1B2av	Distribution of oil products	NMVOC	17189	17189	5.7%	64.8%
1A3bv	Road transport: Gasoline evaporation	NMVOC	13537	13537	4.5%	69.3%
2D3e	Degreasing	NMVOC	11218	11218	3.7%	73.0%
3B1a	Manure management - Dairy cattle	NMVOC	9540	9540	3.2%	76.2%
2D3a	Domestic solvent use	NMVOC	9311	9311	3.1%	79.3%
1A4bi	Residential: Stationary	NMVOC	7974	7974	2.7%	81.9%
1A4bi	Residential: Stationary	PM10	5017	5017	20.9%	20.9%
1A2gvii	Mobile Combustion in manufacturing industries and construction	PM10	2173	2173	9.1%	30.0%
1A3bvi	Road transport: Automobile tyre and brake wear	PM10	2094	2094	8.7%	38.7%
2C1	Iron and steel production	PM10	1485	1485	6.2%	44.9%
3Da3	Urine and dung deposited by grazing animals	PM10	1054	1054	4.4%	49.3%
1A1a	Public electricity and heat production	PM10	1010	1010	4.2%	53.5%
1A3biii	Road transport: Heavy duty vehicles and buses	PM10	1001	1001	4.2%	57.7%
1A3c	Railways	PM10	970	970	4.0%	61.7%
2I	Wood processing	PM10	951	951	4.0%	65.7%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PM10	833	833	3.5%	69.2%
1A3bi	Road transport: Passenger cars	PM10	675	675	2.8%	72.0%
2G	Other product use	PM10	588	588	2.5%	74.4%
1A4ci	Agriculture/Forestry/Fishing: Stationary	PM10	530	530	2.2%	76.6%
5C1a	Municipal waste incineration	PM10	517	517	2.2%	78.8%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	PM10	511	511	2.1%	80.9%
1A4bi	Residential: Stationary	PM2.5	4912	4912	32.6%	32.6%
1A3biii	Road transport: Heavy duty vehicles and buses	PM2.5	1001	1001	6.6%	39.2%
2C1	Iron and steel production	PM2.5	818	818	5.4%	44.6%
1A1a	Public electricity and heat production	PM2.5	750	750	5.0%	49.6%
1A2gvii	Mobile Combustion in manufacturing industries and construction	PM2.5	729	729	4.8%	54.5%
1A3bi	Road transport: Passenger cars	PM2.5	675	675	4.5%	58.9%
1A4ci	Agriculture/Forestry/Fishing: Stationary	PM2.5	528	528	3.5%	62.4%
2G	Other product use	PM2.5	513	513	3.4%	65.8%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	PM2.5	495	495	3.3%	69.1%
5C1a	Municipal waste incineration	PM2.5	465	465	3.1%	72.2%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PM2.5	438	438	2.9%	75.1%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	PM2.5	435	435	2.9%	78.0%
1A4ai	Commercial/institutional: Stationary	PM2.5	426	426	2.8%	80.8%
1A4bi	Residential: Stationary	SO2	9214	9214	25.2%	25.2%
1A4ai	Commercial/institutional: Stationary	SO2	3726	3726	10.2%	35.4%
1A1a	Public electricity and heat production	SO2	3572	3572	9.8%	45.1%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	SO2	3530	3530	9.6%	54.8%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	SO2	3213	3213	8.8%	63.6%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	SO2	3091	3091	8.4%	72.0%
1A3bi	Road transport: Passenger cars	SO2	1940	1940	5.3%	77.3%
1A3biii	Road transport: Heavy duty vehicles and buses	SO2	1572	1572	4.3%	81.6%

Table A - 4: List of Switzerland's approach 1 trend key categories 1990-2017 for the main pollutants, PM2.5 and PM10 ranked per pollutant and contribution to trend.

APPROACH 1 TREND ASSESSMENT FOR 2017							
Code	**Source Category**	**Pollutant**	**Ex,0 (kt)**	**Ex,t (kt)**	**Trend Assess-ment**	**Contri-bution to Trend**	**Cumula-tive Total**
1A3biii	Road transport: Heavy duty vehicles and buses	NOx	25481	5740	0.038%	33.0%	33.0%
1A3ai(i)	International aviation LTO (civil)	NOx	1214	2081	0.011%	9.6%	42.6%
1A3bii	Road transport: Light duty vehicles	NOx	5518	3607	0.009%	7.5%	50.0%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	NOx	2423	1936	0.006%	5.4%	55.5%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	NOx	10535	3776	0.006%	5.0%	60.5%
3Da2a	Animal manure applied to soils	NOx	2010	1483	0.004%	3.8%	64.2%
1A3d	International inland waterways	NOx	1055	1061	0.004%	3.7%	67.9%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	NOx	1261	58	0.003%	3.0%	71.0%
1A4ai	Commercial/institutional: Stationary	NOx	5067	2693	0.003%	3.0%	74.0%
1A3bi	Road transport: Passenger cars	NOx	48610	20653	0.003%	3.0%	77.0%
1A1a	Public electricity and heat production	NOx	6312	2275	0.003%	2.9%	79.9%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	NOx	4358	2352	0.003%	2.8%	82.7%
3Da2a	Animal manure applied to soils	NH3	32979	20301	0.102%	37.2%	37.2%
3B1a	Manure management - Dairy cattle	NH3	10000	11156	0.044%	16.0%	53.2%
3B1b	Manure management - Non-dairy cattle	NH3	5538	7383	0.042%	15.5%	68.7%
3Da2b	Sewage sludge applied to soils	NH3	1169	0	0.014%	5.3%	74.0%
3Da2c	Other organic fertilisers applied to soils	NH3	34	864	0.012%	4.6%	78.5%
3Da3	Urine and dung deposited by grazing animals	NH3	754	1317	0.010%	3.8%	82.3%
2D3a	Domestic solvent use	NMVOC	9311	11555	0.030%	15.0%	15.0%
1A3bi	Road transport: Passenger cars	NMVOC	53363	6306	0.025%	12.5%	27.5%
2D3d	Coating applications	NMVOC	54168	7008	0.024%	11.7%	39.1%
3B1a	Manure management - Dairy cattle	NMVOC	9540	7733	0.017%	8.6%	47.7%
3B1b	Manure management - Non-dairy cattle	NMVOC	6579	6819	0.017%	8.4%	56.1%
2D3g	Chemical products	NMVOC	28314	3511	0.013%	6.3%	62.5%
1A3bv	Road transport: Gasoline evaporation	NMVOC	13537	489	0.010%	5.0%	67.4%
1B2av	Distribution of oil products	NMVOC	17189	1585	0.010%	4.7%	72.2%
2D3h	Printing	NMVOC	20354	2802	0.008%	4.1%	76.3%
2H2	Food and beverages industry	NMVOC	1977	2391	0.006%	3.1%	79.4%
2D3b	Road paving with asphalt	NMVOC	4895	2840	0.005%	2.6%	81.9%
1A3bvi	Road transport: Automobile tyre and brake wear	PM10	2094	2695	0.058%	14.4%	14.4%
1A4bi	Residential: Stationary	PM10	5017	1753	0.057%	14.2%	28.6%
1A2gvii	Mobile Combustion in manufacturing industries and construction	PM10	2173	2318	0.040%	10.0%	38.6%
2C1	Iron and steel production	PM10	1485	15	0.038%	9.4%	48.1%
1A3c	Railways	PM10	970	1260	0.027%	6.8%	54.9%
1A1a	Public electricity and heat production	PM10	1010	76	0.023%	5.7%	60.6%
1A3biii	Road transport: Heavy duty vehicles and buses	PM10	1001	76	0.023%	5.7%	66.3%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PM10	833	82	0.018%	4.5%	70.8%
3Da3	Urine and dung deposited by grazing animals	PM10	1054	1009	0.015%	3.7%	74.4%
1A4ai	Commercial/institutional: Stationary	PM10	435	507	0.010%	2.4%	76.9%
2G	Other product use	PM10	588	600	0.010%	2.4%	79.3%
2A5a	Quarrying and mining of minerals other than coal	PM10	367	461	0.010%	2.4%	81.7%
1A4bi	Residential: Stationary	PM2.5	4912	1712	0.028%	11.8%	11.8%
1A3biii	Road transport: Heavy duty vehicles and buses	PM2.5	1001	76	0.024%	10.1%	21.9%
2C1	Iron and steel production	PM2.5	818	10	0.023%	9.7%	31.6%
1A4ai	Commercial/institutional: Stationary	PM2.5	426	493	0.020%	8.6%	40.3%
1A3bvi	Road transport: Automobile tyre and brake wear	PM2.5	314	404	0.018%	7.5%	47.8%
1A1a	Public electricity and heat production	PM2.5	750	76	0.017%	7.0%	54.8%
2G	Other product use	PM2.5	513	445	0.015%	6.2%	61.0%
2A5a	Quarrying and mining of minerals other than coal	PM2.5	183	230	0.010%	4.2%	65.3%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PM2.5	438	44	0.010%	4.1%	69.4%
1A3c	Railways	PM2.5	173	195	0.008%	3.4%	72.7%
2H1	Pulp and paper	PM2.5	236	215	0.007%	3.2%	75.9%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	PM2.5	495	327	0.007%	3.1%	79.0%
2H2	Food and beverages industry	PM2.5	189	183	0.007%	2.8%	81.9%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	SO2	3530	1430	0.025%	20.7%	20.7%
2B5	Carbide production	SO2	445	710	0.018%	14.7%	35.4%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	SO2	3091	9	0.012%	10.3%	45.7%
1A4bi	Residential: Stationary	SO2	9214	956	0.011%	9.4%	55.1%
1A1a	Public electricity and heat production	SO2	3572	244	0.008%	6.5%	61.6%
1A3bi	Road transport: Passenger cars	SO2	1940	66	0.006%	5.1%	66.6%
1A3biii	Road transport: Heavy duty vehicles and buses	SO2	1572	12	0.006%	5.1%	71.7%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	SO2	1103	325	0.004%	3.7%	75.4%
1A3ai(i)	International aviation LTO (civil)	SO2	100	156	0.004%	3.2%	78.6%
1A4ai	Commercial/institutional: Stationary	SO2	3726	430	0.003%	2.8%	81.4%

A1.3 Detailed results of appoach 2 assessment

The following tables depict detailed results for the approach 2 level and trend assessments. Note that for approach 2 only the level assessment for the current year (2017) is available.

Table A - 5: List of Switzerland's approach 2 level key categories 2017 for the main pollutants, PM2.5 and PM10 ranked per pollutant and level contribution (Lx,t).

APPROACH 2 LEVEL ASSESSMENT FOR 2017						
Code	**Source Category**	**Pollutant**	**Ex,t (kt)**	**|Ex,t| (kt)**	**Lx,t**	**Cumulative Total**
1A3bi	Road transport: Passenger cars	NOx	20653	20653	45.9%	45.9%
1A3bii	Road transport: Light duty vehicles	NOx	3607	3607	6.4%	52.2%
1A3biii	Road transport: Heavy duty vehicles and buses	NOx	5740	5740	5.9%	58.1%
3Da1	Inorganic N-fertilizers (includes also urea application)	NOx	892	892	5.0%	63.1%
3Da2a	Animal manure applied to soils	NOx	1483	1483	4.4%	67.5%
1A4bi	Residential: Stationary	NOx	5169	5169	4.1%	71.5%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	NOx	3776	3776	3.6%	75.2%
1A1a	Public electricity and heat production	NOx	2275	2275	2.9%	78.1%
1A4ai	Commercial/institutional: Stationary	NOx	2693	2693	2.5%	80.6%
3Da2a	Animal manure applied to soils	NH3	20301	20301	23.7%	23.7%
3B1a	Manure management - Dairy cattle	NH3	11156	11156	22.2%	45.9%
3B3	Manure management - Swine	NH3	4864	4864	9.0%	55.0%
3B1b	Manure management - Non-dairy cattle	NH3	7383	7383	9.0%	63.9%
3Da1	Inorganic N-fertilizers (includes also urea application)	NH3	2813	2813	7.5%	71.4%
6A	Other sources	NH3	1006	1006	5.2%	76.6%
1A3bi	Road transport: Passenger cars	NH3	1405	1405	3.5%	80.1%
3B1a	Manure management - Dairy cattle	NMVOC	7733	7733	23.0%	23.0%
3B1b	Manure management - Non-dairy cattle	NMVOC	6819	6819	21.7%	44.7%
2D3a	Domestic solvent use	NMVOC	11555	11555	14.9%	59.6%
2G	Other product use	NMVOC	6747	6747	8.5%	68.1%
2D3g	Chemical products	NMVOC	3511	3511	3.5%	71.7%
3B3	Manure management - Swine	NMVOC	794	794	2.5%	74.1%
2D3i	Other solvent use	NMVOC	2110	2110	2.4%	76.5%
3B4gii	Manure management - Broilers	NMVOC	772	772	2.3%	78.9%
2D3d	Coating applications	NMVOC	7008	7008	2.2%	81.1%
2A5a	Quarrying and mining of minerals other than coal	PM10	461	461	13.2%	13.2%
3Da3	Urine and dung deposited by grazing animals	PM10	1009	1009	11.2%	24.3%
2I	Wood processing	PM10	372	372	10.6%	34.9%
2H2	Food and beverages industry	PM10	342	342	9.7%	44.6%
1A3bvi	Road transport: Automobile tyre and brake wear	PM10	2695	2695	7.4%	52.0%
1A4bi	Residential: Stationary	PM10	1753	1753	7.2%	59.2%
1A2gvii	Mobile Combustion in manufacturing industries and construction	PM10	2318	2318	6.2%	65.4%
1A3c	Railways	PM10	1260	1260	3.6%	69.0%
2G	Other product use	PM10	600	600	3.6%	72.6%
2A1	Cement production	PM10	255	255	2.8%	75.4%
2H1	Pulp and paper	PM10	221	221	2.5%	77.9%
3B4gii	Manure management - Broilers	PM10	143	143	2.3%	80.2%
1A4bi	Residential: Stationary	PM2.5	1712	1712	16.7%	16.7%
2A5a	Quarrying and mining of minerals other than coal	PM2.5	230	230	16.1%	32.8%
2H2	Food and beverages industry	PM2.5	183	183	12.4%	45.2%
2G	Other product use	PM2.5	445	445	6.3%	51.5%
2I	Wood processing	PM2.5	93	93	6.0%	57.5%
2H1	Pulp and paper	PM2.5	215	215	5.8%	63.2%
1A4ai	Commercial/institutional: Stationary	PM2.5	493	493	5.1%	68.3%
2A1	Cement production	PM2.5	164	164	4.2%	72.6%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	PM2.5	327	327	3.0%	75.6%
1A3bvi	Road transport: Automobile tyre and brake wear	PM2.5	404	404	2.8%	78.4%
1A2gvii	Mobile Combustion in manufacturing industries and construction	PM2.5	404	404	2.5%	80.9%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	SO2	1430	1430	26.9%	26.9%
2B5	Carbide production	SO2	710	710	14.5%	41.3%
1A4bi	Residential: Stationary	SO2	956	956	10.8%	52.1%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	SO2	440	440	8.4%	60.5%
1B2aiv	Fugitive emissions oil: Refining / storage	SO2	110	110	6.3%	66.8%
1A1a	Public electricity and heat production	SO2	244	244	6.0%	72.8%
1A4ai	Commercial/institutional: Stationary	SO2	430	430	4.3%	77.1%
2B10a	Other Chemical industry	SO2	99	99	4.0%	81.1%

Table A - 6: List of Switzerland's approach 2 trend key categories 1990-2017 for the main pollutants, PM2.5 and PM10 ranked per pollutant and contribution to trend.

APPROACH 2 TREND ASSESSMENT WITH UNCERTAINTIES FOR 2017							
Code	**Source Category**	**Pollutant**	**Ex,0 (kt)**	**Ex,t (kt)**	**Trend Assess-ment**	**Contri-bution to Trend**	**Cumula-tive Total**
1A3biii	Road transport: Heavy duty vehicles and buses	NOx	25481	5740	0.007%	22.9%	22.9%
1A3bii	Road transport: Light duty vehicles	NOx	5518	3607	0.003%	8.9%	31.8%
3Da1	Inorganic N-fertilizers (includes also urea application)	NOx	1205	892	0.003%	8.5%	40.3%
3Da2a	Animal manure applied to soils	NOx	2010	1483	0.002%	7.5%	47.8%
1A3ai(i)	International aviation LTO (civil)	NOx	1214	2081	0.002%	7.5%	55.2%
3Da3	Urine and dung deposited by grazing animals	NOx	241	397	0.002%	6.6%	61.8%
1A3bi	Road transport: Passenger cars	NOx	48608	20652	0.001%	4.5%	66.3%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	NOx	2423	1936	0.001%	3.6%	69.9%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	NOx	10534	3776	0.001%	3.2%	73.1%
1A1a	Public electricity and heat production	NOx	6312	2275	0.001%	2.5%	75.7%
3Da2c	Other organic fertilisers applied to soils	NOx	15	108	0.001%	2.5%	78.1%
1A3biv	Road transport: Mopeds & motorcycles	NOx	337	387	0.001%	2.1%	80.2%
3Da2a	Animal manure applied to soils	NH3	32981	20301	0.024%	25.4%	25.4%
3B1a	Manure management - Dairy cattle	NH3	10000	11155	0.017%	18.6%	44.0%
3B1b	Manure management - Non-dairy cattle	NH3	5537	7383	0.010%	10.9%	55.0%
3Da2c	Other organic fertilisers applied to soils	NH3	34	864	0.007%	7.1%	62.1%
3Da1	Inorganic N-fertilizers (includes also urea application)	NH3	4258	2812	0.005%	5.9%	67.9%
3Da3	Urine and dung deposited by grazing animals	NH3	754	1317	0.004%	4.3%	72.3%
5B1	Biological treatment of waste - Composting	NH3	175	328	0.004%	4.1%	76.4%
3B4gii	Manure management - Broilers	NH3	210	521	0.004%	4.0%	80.4%
3B1b	Manure management - Non-dairy cattle	NMVOC	6580	6818	0.088%	23.1%	23.1%
3B1a	Manure management - Dairy cattle	NMVOC	9534	7735	0.085%	22.2%	45.3%
2D3a	Domestic solvent use	NMVOC	9309	11550	0.064%	16.8%	62.0%
2D3g	Chemical products	NMVOC	28311	3511	0.021%	5.5%	67.6%
1A3bi	Road transport: Passenger cars	NMVOC	53366	6306	0.013%	3.4%	71.0%
2D3d	Coating applications	NMVOC	54160	7007	0.012%	3.2%	74.1%
3B4gii	Manure management - Broilers	NMVOC	218	772	0.012%	3.1%	77.2%
1A3biv	Road transport: Mopeds & motorcycles	NMVOC	5586	796	0.009%	2.4%	79.6%
3B3	Manure management - Swine	NMVOC	1027	794	0.009%	2.3%	81.9%
2A5a	Quarrying and mining of minerals other than coal	PM10	366	460	0.051%	11.7%	11.7%
2I	Wood processing	PM10	951	371	0.048%	11.0%	22.7%
2C1	Iron and steel production	PM10	1485	15	0.047%	10.9%	33.7%
1A4bi	Residential: Stationary	PM10	5017	1753	0.043%	9.9%	43.5%
2H2	Food and beverages industry	PM10	311	342	0.032%	7.4%	50.9%
3Da3	Urine and dung deposited by grazing animals	PM10	1054	1009	0.030%	6.9%	57.8%
1A3bvi	Road transport: Automobile tyre and brake wear	PM10	2095	2696	0.029%	6.7%	64.5%
1A2gvii	Mobile Combustion in manufacturing industries and construction	PM10	2173	2318	0.020%	4.6%	69.1%
1A1a	Public electricity and heat production	PM10	1010	76	0.017%	3.9%	73.0%
3B4gii	Manure management - Broilers	PM10	40	143	0.014%	3.3%	76.3%
1A3c	Railways	PM10	970	1260	0.014%	3.3%	79.5%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PM10	833	82	0.012%	2.8%	82.3%
2A5a	Quarrying and mining of minerals other than coal	PM2.5	183	231	0.054%	19.7%	19.7%
2H2	Food and beverages industry	PM2.5	189	183	0.035%	12.8%	32.5%
2C1	Iron and steel production	PM2.5	818	10	0.029%	10.5%	43.0%
1A4bi	Residential: Stationary	PM2.5	4913	1712	0.021%	7.7%	50.8%
1A4ai	Commercial/institutional: Stationary	PM2.5	426	493	0.016%	6.0%	56.8%
2G	Other product use	PM2.5	513	445	0.016%	5.9%	62.6%
2H1	Pulp and paper	PM2.5	236	215	0.015%	5.7%	68.3%
1A1a	Public electricity and heat production	PM2.5	750	76	0.012%	4.2%	72.5%
1A3bvi	Road transport: Automobile tyre and brake wear	PM2.5	314	404	0.010%	3.5%	76.0%
2A1	Cement production	PM2.5	240	164	0.008%	2.9%	78.9%
1A3biii	Road transport: Heavy duty vehicles and buses	PM2.5	1001	76	0.006%	2.4%	81.3%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	SO2	3530	1430	0.005%	22.7%	22.7%
2B5	Carbide production	SO2	445	710	0.004%	17.5%	40.2%
1A1a	Public electricity and heat production	SO2	3572	244	0.002%	9.3%	49.5%
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	SO2	3091	9	0.002%	8.1%	57.7%
1A4bi	Residential: Stationary	SO2	9214	956	0.001%	6.1%	63.8%
2B10a	Other Chemical industry	SO2	168	99	0.001%	4.0%	67.8%
1B2aiv	Fugitive emissions oil: Refining / storage	SO2	419	110	0.001%	3.6%	71.4%
1A3biii	Road transport: Heavy duty vehicles and buses	SO2	1572	12	0.001%	3.2%	74.6%
1A3bi	Road transport: Passenger cars	SO2	1940	66	0.001%	3.0%	77.6%
5C1biv	Sewage sludge incineration	SO2	74	67	0.001%	2.7%	80.3%

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[7]), which is the data pool of FOEN (2015j). They can be queried by year, non-road family (see categories in Table A - 8), machine type, engine type (diesel, gasoline/2-/4-stroke, LPG, gas oil), engine capacity (power class) and emission concept (standard), pollutant either at aggregated or disaggregated levels. The following table illustrates a query for the family 'construction machinery'.

Table A - 7: 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

[7] https://www.bafu.admin.ch/bafu/en/home/topics/air/state/non-road-datenbank.html [15.02.2019]

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 - 8: Number of vehicles, specific operating hours per year and total operating hours per year for all non-road families/categories (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 - 9: Explanation of the NE notation key in NFR table 2 Add Info from current submission.

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 3	PCDD/PCDF	no EF available (production until 2006)
2 C 7 c	BC	no EF available
2 H 2	BC	no EF available
2 H 3	BC	no EF available

Table A - 10: Explanation of the IE Notation key in NFR table 2 Add Info from current submission.

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)
3 B 4 a	NOx, NMVOC, NH3, PM2.5, PM10, TSP	3 B 1 a (from 1990 onwards)
3 B 4 f	NOx, NMVOC, NH3, PM2.5, PM10, TSP	3 B 4 e (1980-1989)
3 B 4 g ii	PM2.5, PM10, TSP	3 B 4 g i (1980-1989)
3 B 4 g iv	PM2.5, PM10, TSP	3 B 4 g i (1980-1989)
3 D a 2 a	NH3	3 B 1-3 B 4 (1980-1989)
3 D a 2 c	NOx, NH3	3 D a 1 (1980-1989)
3 D a 3	NOx, NH3	3 B 1-3 B 4 (1980-1989)
3 D b	NMVOC, NH3	3 D a 1 (1980-1989)
5 D 2	NOx, NMVOC, SOx, NH3, CO	5 D 1 (for the years 1980-1989)

Table A - 11: List of sub-sources accounted for in reporting codes "other" in NFR table 2 Add Info from current submission.

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 nonroads)
1B1c	-	NO
1B2d	-	NO
2 A 6	-	NO
2 B 10 a	NMVOC, SOx, NH3, PM2.5, PM10, TSP, CO, Hg	Production of acetic acid, ammonium nitrate, chlorine gas (Hg emissions until 2016), ethylene, 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
2 G	NOx, NMVOC, SOx, NH3, PM2.5, PM10, TSP, BC, CO, Pb, Cd, Hg, PCDD/PCDF, PAHs	Application of glues and adhesives, commercial and industrial use of cleaning agents, cosmetic institutions, de-icing of airplanes, de-icing of airport surfaces (until 2010), 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 aerosol cans in industry and commerce, antifreeze agents in vehicles, concrete additives, cooling lubricants, fireworks, lubricants, pesticides and tobacco
2 H 3	NOx, NMVOC, SOx, NH3, PM2.5, PM10, TSP, CO, Pb	Blasting and shooting
2 L	NH3	Use of NH3 as refrigerant
3 B 4 h	NOx, NMVOC, NH3, PM2.5, PM10, TSP	Camels and Llamas (3 B 4 b), Deer (3 B 4 c), Rabbits (3 B 4 h i), Bisons (3 B 4 h ii)
3 I	-	NO
5 E	NMVOC, PM2.5, PM10, TSP, CO, Pb, Cd, PCDD/F	Car shredding
5 C 1 b vi	-	NO
5 D 3	-	NO
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, emissions of livestock outside agriculture (asses, goats, horses and sheep), domestic use of fertilizers, fire damages estates and motor vehicles

Table A - 12: Basis for estimating emissions from mobile sources as listed in NFR table 2 Add Info from current submission.

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 (Domestic,	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 2017 and 1990 in TJ as published by the Swiss Federal Office of Energy (SFOE 2018, SFOE 1991) in German and French.

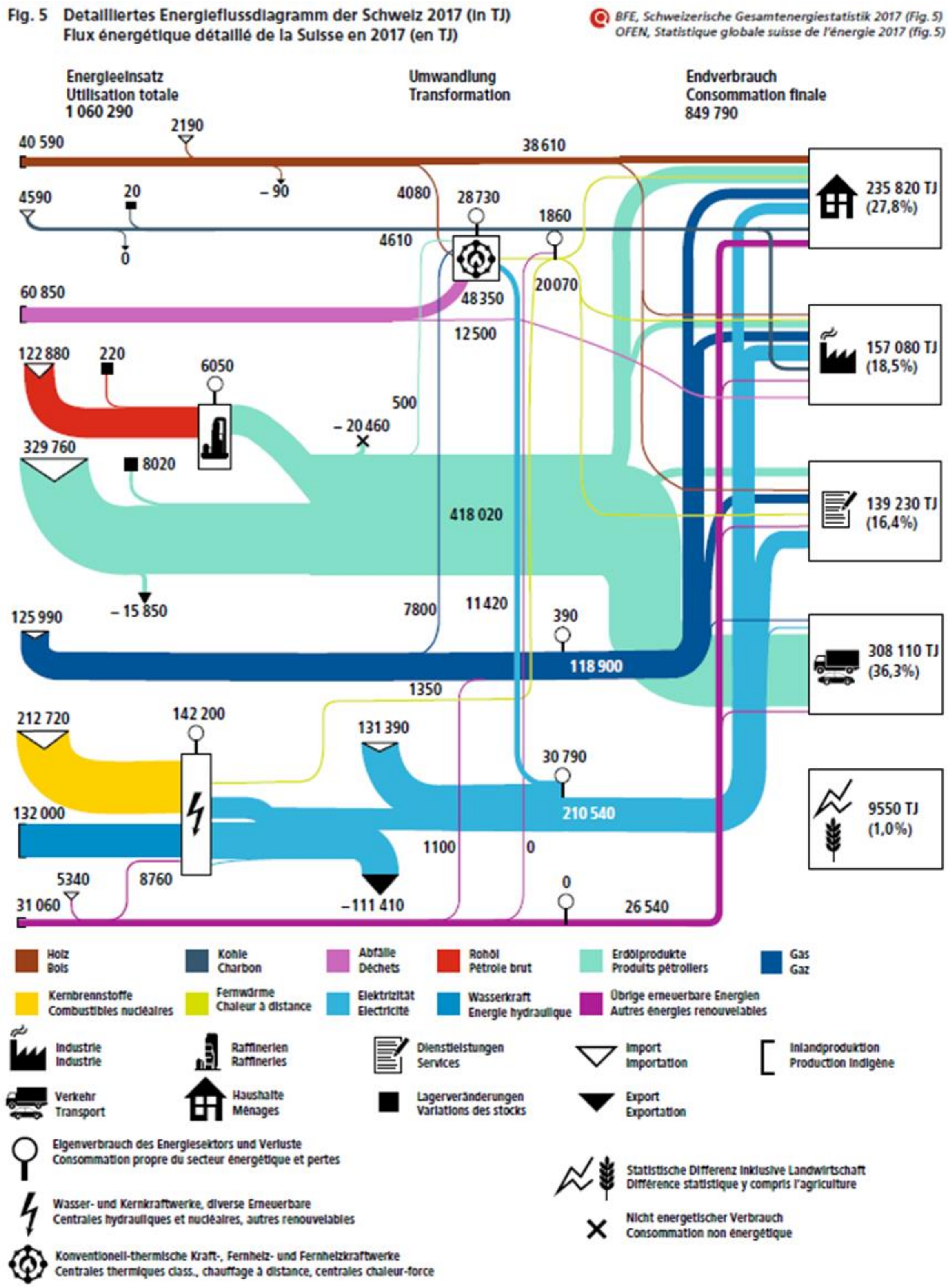

Figure A - 1: Energy flow in Switzerland 2017 (SFOE 2018). Depicted values are in TJ.

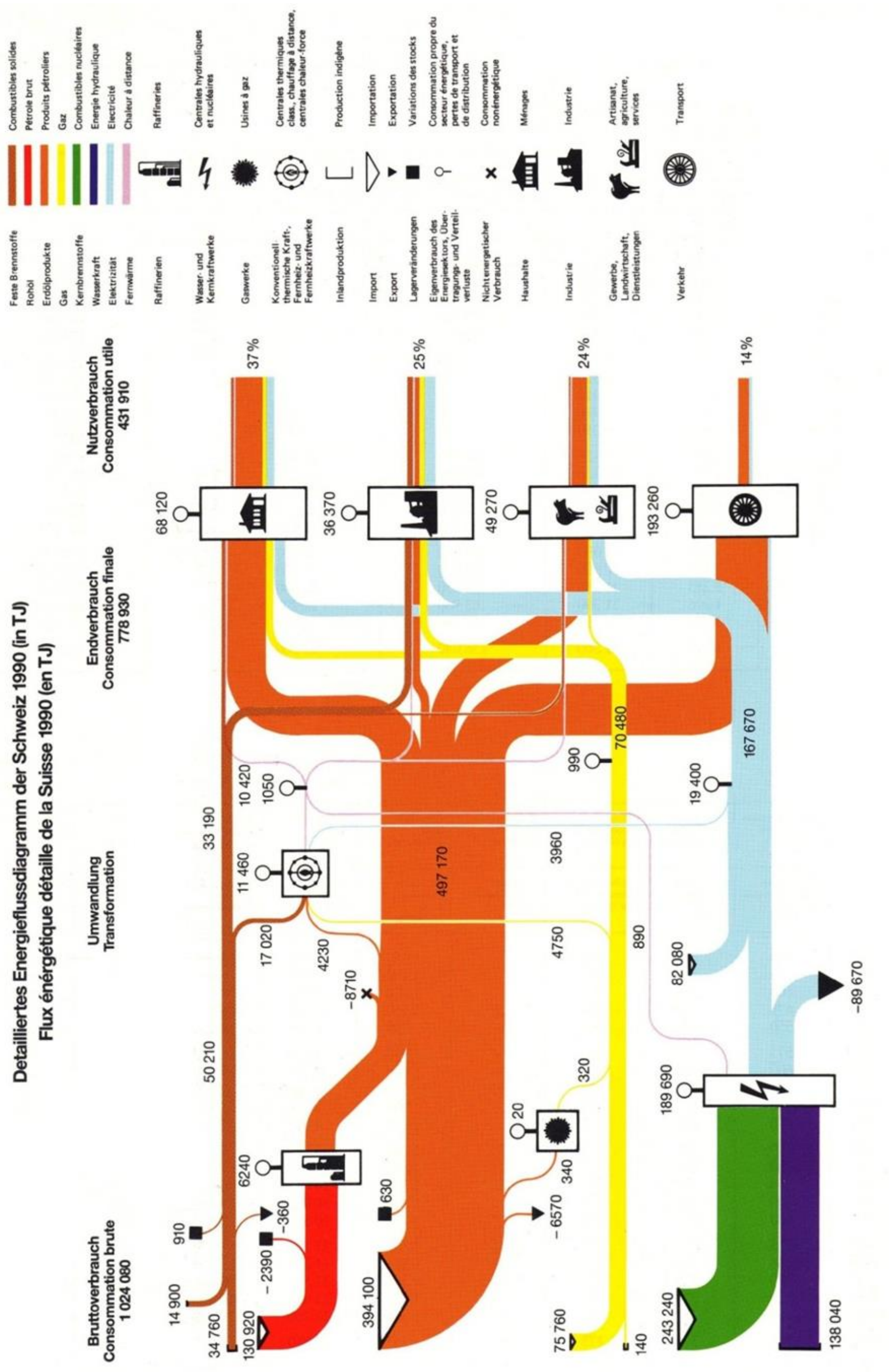

Figure A - 2: Energy flow in Switzerland 1990 (SFOE 1991). Depicted values are in TJ.

Table A - 13: Energy balance for Switzerland 2017 (table 4, Swiss overall energy statistics, SFOE 2018) in TJ.[8].

Tab. 4 Energiebilanz der Schweiz für das Jahr 2017 (in TJ)
Bilan énergétique de la Suisse pour 2017 (en TJ)

		Holzenergie	Kohle	Müll und Industrie-abfälle	Rohöl	Erdöl-produkte	Gas	Wasserkraft	Kernbrenn-stoffe	Übrige erneuerbare Energien	Elektrizität	Fernwärme	Total	
		Energie du bois	Charbon	Ord. mén. et déchets ind.	Pétrole brut	Produits pétroliers	Gaz	Energie hydraulique	Combustibles nucléaires	Autres énergies renouvelables	Electricité	Chaleur à distance		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	
Inlandproduktion	(a)	40 590	–	60 850	–	–	0	132 000	–	31 060	–	–	264 500	Production indigène
+ Import	(b)	2 190	4 590	–	122 880	329 760	125 990	–	212 720	5 340	131 390	–	934 860	+ Importation
+ Export	(c)	−90	0	–	–	−15 850	–	–	–	–	−111 410	–	−127 350	+ Exportation
+ Lagerveränderung[1]	(d)	–	20	–	220	8 020	–	–	–	–	–	–	8 260	+ Variation de stock[1]
= Bruttoverbrauch	(e)	42 690	4 610	60 850	123 100	321 930	125 990	132 000	212 720	36 400	19 980	0	1 080 270	= Consommation brute
+ Energieumwandlung:													0	+ Transformation d'énergie:
- Wasserkraftwerke	(f)	–	–	–	–	–	–	−132 000	–	–	132 000	–	0	- Centrales hydrauliques
- Kernkraftwerke	(g)	–	–	–	–	–	–	–	−212 720	–	70 200	1 350	−141 170	- Centrales nucléaires
- konventionell-thermische Kraft-, Fernheiz- und Fernheizkraft-werke	(h)	−2 310	0	−48 350	–	−500	−7 800	–	–	–	10 260	20 580	−28 120	- Centrales thermiques class., chauffage à distance, centrales chaleur-force
- Gaswerke	(i)	–	–	–	–	–	0	–	–	–	–	–	0	- Usines à gaz
- Raffinerien	(j)	–	–	–	−123 100	123 140							40	- Raffineries
- Diverse Erneuerbare	(k)	−1 770	–	–	–	–	1 100	–	–	−9 860	8 890	0	−1 640	- Renouvelables div.
+ Eigenverbrauch des Energie-sektors, Netzverluste, Verbrauch der Speicherungen	(l)	–	–	–	–	−6 090	−390	–	–	–	−30 790	−1 860	−39 130	+ Consommation propre du secteur énergétique, pertes de réseau, pompage d'accumulation
+ Nichtenergetischer Verbrauch	(m)	–	–	–	–	−20 460	–	–	–	–	–	–	−20 460	+ Consommation non énergétique
= Endverbrauch	(n)	38 610	4 610	12 500	0	418 020	118 900	0	0	26 540	210 540	20 070	849 790	= Consommation finale
Haushalte	(o)	18 620	100	–	–	76 210	48 500	–	–	15 440	69 220	7 730	235 820	Ménages
Industrie	(p)	11 170	4 510	12 500	–	14 670	40 920	–	–	1 760	64 430	7 120	157 080	Industrie
Dienstleistungen	(q)	7 990	0	–	–	34 060	26 460	–	–	3 440	62 060	5 220	139 230	Services
Verkehr	(r)	–	–	–	–	290 100	1 040	–	–	5 630	11 340	0	308 110	Transport
Statistische Differenz inkl. Landwirtschaft	(s)	830	0	–	–	2 980	1 980	–	–	270	3 490	0	9 550	Différence statistique, y compris l'agriculture

[1] + Lagerabnahme
− Lagerzunahme

[1] + diminution de stock
− augmentation de stock

BFE, Schweizerische Gesamtenergiestatistik 2017 (Tab. 4)
OFEN, Statistique globale suisse de l'énergie 2017 (tabl. 4)

[8] 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 2017.

Table A - 14: Uncertainty analysis of NO_x emissions 1990 and 2017.

NFR	Pollutant	Emissions 1990	Emissions 2017	AD uncertainty 2017	EF uncertainty 2017	Combined uncertainty 2017	Combined uncertainty as % of total national 2017	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	6'312.1	2'275.1	10%	19%	21%	0.799%	0.334%	1.618%	0.064%	0.229%	0.237%
1A1b	NOx	494.2	352.1	1%	20%	20%	0.115%	0.098%	0.250%	0.020%	0.005%	0.020%
1A1c	NOx	0.0	0.0	0%	20%	20%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A2a	NOx	278.4	128.4	2%	27%	27%	0.057%	0.005%	0.091%	0.001%	0.003%	0.003%
1A2b	NOx	126.8	32.1	2%	20%	20%	0.011%	0.016%	0.023%	0.003%	0.001%	0.003%
1A2c	NOx	1'046.5	338.9	2%	10%	10%	0.057%	0.083%	0.241%	0.008%	0.007%	0.011%
1A2d	NOx	1'260.6	58.3	2%	10%	10%	0.010%	0.348%	0.041%	0.035%	0.001%	0.035%
1A2e	NOx	743.2	240.9	2%	10%	10%	0.040%	0.059%	0.171%	0.006%	0.005%	0.008%
1A2f	NOx	10'534.5	3'775.6	2%	17%	17%	1.057%	0.573%	2.685%	0.097%	0.076%	0.124%
1A2gvii	NOx	6'333.9	2'656.6	1%	13%	13%	0.568%	0.070%	1.890%	0.009%	0.034%	0.036%
1A2gviii	NOx	2'423.0	1'935.6	2%	17%	17%	0.542%	0.627%	1.377%	0.107%	0.040%	0.114%
1A3ai(i)	NOx	1'214.3	2'081.3	1%	20%	20%	0.682%	1.105%	1.480%	0.221%	0.027%	0.223%
1A3aii(i)	NOx	153.8	89.6	1%	20%	20%	0.029%	0.016%	0.064%	0.003%	0.001%	0.003%
1A3bi	NOx	48'609.5	20'653.4	1%	38%	38%	12.916%	0.346%	14.690%	0.132%	0.268%	0.299%
1A3bii	NOx	5'518.1	3'607.4	1%	32%	32%	1.901%	0.858%	2.566%	0.276%	0.047%	0.280%
1A3biii	NOx	25'480.8	5'739.7	1%	18%	18%	1.694%	3.793%	4.082%	0.683%	0.074%	0.687%
1A3biv	NOx	336.6	387.2	1%	36%	36%	0.228%	0.171%	0.275%	0.062%	0.005%	0.062%
1A3c	NOx	595.5	393.8	1%	13%	13%	0.084%	0.096%	0.280%	0.012%	0.005%	0.013%
1A3dii	NOx	1'054.7	1'061.2	1%	13%	13%	0.227%	0.429%	0.755%	0.056%	0.014%	0.057%
1A3ei	NOx	145.6	28.2	2%	50%	50%	0.023%	0.025%	0.020%	0.012%	0.001%	0.013%
1A4ai	NOx	5'067.0	2'692.7	2%	16%	16%	0.708%	0.348%	1.915%	0.056%	0.043%	0.070%
1A4aii	NOx	16.3	46.3	1%	13%	13%	0.010%	0.028%	0.033%	0.004%	0.001%	0.004%
1A4bi	NOx	11'550.7	5'169.1	4%	13%	14%	1.143%	0.103%	3.676%	0.013%	0.193%	0.194%
1A4bii	NOx	18.8	24.5	1%	30%	30%	0.012%	0.012%	0.017%	0.003%	0.000%	0.003%
1A4ci	NOx	119.5	151.3	21%	30%	37%	0.091%	0.071%	0.108%	0.021%	0.032%	0.039%
1A4cii	NOx	4'357.5	2'352.0	1%	13%	13%	0.502%	0.325%	1.673%	0.042%	0.030%	0.052%
1A5b	NOx	883.0	445.1	1%	13%	13%	0.095%	0.043%	0.317%	0.006%	0.006%	0.008%
1B2c	NOx	134.5	1.4	22%	30%	37%	0.001%	0.041%	0.001%	0.012%	0.000%	0.012%
2A1	NOx	15.9	10.8	2%	200%	200%	0.035%	0.003%	0.008%	0.006%	0.000%	0.006%
2A2	NOx	0.3	0.2	2%	500%	500%	0.002%	0.000%	0.000%	0.000%	0.000%	0.000%
2A5a	NOx	1.8	0.8	5%	500%	500%	0.007%	0.000%	0.001%	0.000%	0.000%	0.000%
2B2	NOx	82.8	52.2	2%	10%	10%	0.009%	0.012%	0.037%	0.001%	0.001%	0.002%
2C1	NOx	245.5	178.1	2%	50%	50%	0.146%	0.051%	0.127%	0.025%	0.004%	0.026%
2C3	NOx	17.4	-	5%	200%	200%	0.000%	0.005%	0.000%	0.011%	0.000%	0.011%
2C7c	NOx	2.6	1.7	5%	100%	100%	0.003%	0.000%	0.001%	0.000%	0.000%	0.000%
2G	NOx	29.4	19.8	25%	100%	103%	0.033%	0.005%	0.014%	0.005%	0.005%	0.007%
2H3	NOx	91.0	25.5	3%	200%	200%	0.083%	0.010%	0.018%	0.020%	0.001%	0.020%
3B1a	NOx	688.5	420.5	6%	50%	50%	0.347%	0.086%	0.299%	0.043%	0.027%	0.051%
3B1b	NOx	352.9	306.7	6%	50%	50%	0.253%	0.109%	0.218%	0.054%	0.020%	0.058%
3B2	NOx	67.6	69.9	6%	50%	50%	0.058%	0.029%	0.050%	0.014%	0.005%	0.015%
3B3	NOx	163.9	87.4	6%	50%	50%	0.072%	0.011%	0.062%	0.006%	0.006%	0.008%
3B4d	NOx	21.6	29.0	6%	50%	50%	0.024%	0.014%	0.021%	0.007%	0.002%	0.007%
3B4e	NOx	18.8	31.6	6%	50%	50%	0.026%	0.017%	0.022%	0.008%	0.002%	0.009%
3B4f	NOx	1.4	4.2	6%	50%	50%	0.003%	0.003%	0.003%	0.001%	0.000%	0.001%
3B4gi	NOx	7.2	7.8	6%	50%	50%	0.006%	0.003%	0.006%	0.002%	0.001%	0.002%
3B4gii	NOx	2.7	8.4	6%	50%	50%	0.007%	0.005%	0.006%	0.003%	0.001%	0.003%
3B4giii	NOx	0.4	0.3	6%	50%	50%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
3B4giv	NOx	0.8	1.1	6%	50%	50%	0.001%	0.001%	0.001%	0.000%	0.000%	0.000%
3B4h	NOx	1.0	5.1	6%	50%	50%	0.004%	0.003%	0.004%	0.002%	0.000%	0.002%
3Da1	NOx	1'204.9	892.1	5%	100%	100%	1.461%	0.262%	0.634%	0.262%	0.045%	0.266%
3Da2a	NOx	2'009.7	1'483.4	6%	50%	50%	1.223%	0.433%	1.055%	0.217%	0.096%	0.237%
3Da2b	NOx	87.0	-	6%	100%	100%	0.000%	0.027%	0.000%	0.027%	0.000%	0.027%
3Da2c	NOx	14.8	107.9	6%	100%	100%	0.177%	0.072%	0.077%	0.072%	0.007%	0.072%
3Da3	NOx	241.3	397.1	6%	100%	100%	0.651%	0.208%	0.282%	0.208%	0.026%	0.209%
5A	NOx	1.8	1.4	10%	50%	51%	0.001%	0.000%	0.001%	0.000%	0.000%	0.000%
5B2	NOx	NA	5.5	20%	100%	102%	0.009%	NA	NA	NA	NA	NA
5C1a	NOx	80.8	45.8	50%	40%	64%	0.048%	0.008%	0.033%	0.003%	0.023%	0.023%
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	99.8	20%	50%	54%	0.088%	0.036%	0.071%	0.018%	0.020%	0.027%
5C1bv	NOx	11.3	12.1	5%	30%	30%	0.006%	0.005%	0.009%	0.002%	0.001%	0.002%
5C2	NOx	31.1	16.4	48%	133%	141%	0.038%	0.002%	0.012%	0.003%	0.008%	0.008%
5D1	NOx	25.4	4.7	1%	10%	10%	0.001%	0.005%	0.003%	0.000%	0.000%	0.000%
5D2	NOx	0.2	1.4	10%	10%	14%	0.000%	0.001%	0.001%	0.000%	0.000%	0.000%
6A	NOx	98.7	103.1	30%	50%	58%	0.098%	0.043%	0.073%	0.021%	0.031%	0.038%
Total		**140'598**	**61'149**	**Level uncertainty:**			**14%**	**Trend uncertainty:**				**1%**

Table A - 15: Uncertainty analysis of NMVOC emissions 1990 and 2017.

NFR	Pollutant	Emissions 1990	Emissions 2017	AD uncertainty 2017	EF uncertainty 2017	Combined uncertainty 2017	Combined uncertainty as % of total national 2017	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	295.1	148.0	10%	32%	34%	0.063%	0.024%	0.049%	0.008%	0.007%	0.010%
1A1b	NMVOC	6.9	3.6	1%	20%	20%	0.001%	0.001%	0.001%	0.000%	0.000%	0.000%
1A1c	NMVOC	2.1	6.4	0%	20%	20%	0.002%	0.002%	0.002%	0.000%	0.000%	0.000%
1A2a	NMVOC	8.9	7.9	2%	18%	18%	0.002%	0.002%	0.003%	0.000%	0.000%	0.000%
1A2b	NMVOC	51.7	5.8	2%	19%	19%	0.001%	0.003%	0.002%	0.000%	0.000%	0.000%
1A2c	NMVOC	34.1	30.3	2%	10%	10%	0.004%	0.007%	0.010%	0.001%	0.000%	0.001%
1A2d	NMVOC	29.8	5.8	2%	10%	10%	0.001%	0.001%	0.002%	0.000%	0.000%	0.000%
1A2e	NMVOC	22.0	22.8	2%	10%	10%	0.003%	0.006%	0.008%	0.001%	0.000%	0.001%
1A2f	NMVOC	596.6	457.5	2%	30%	30%	0.176%	0.100%	0.152%	0.030%	0.004%	0.030%
1A2gvii	NMVOC	1'331.5	351.8	1%	34%	34%	0.153%	0.002%	0.117%	0.001%	0.002%	0.002%
1A2gviii	NMVOC	227.9	95.7	2%	30%	30%	0.037%	0.012%	0.032%	0.004%	0.001%	0.004%
1A3ai(i)	NMVOC	247.5	192.2	1%	50%	50%	0.123%	0.042%	0.064%	0.021%	0.001%	0.021%
1A3aii(i)	NMVOC	58.8	39.3	1%	50%	50%	0.025%	0.008%	0.013%	0.004%	0.000%	0.004%
1A3bi	NMVOC	53'362.6	6'306.4	1%	52%	52%	4.203%	2.521%	2.097%	1.317%	0.038%	1.317%
1A3bii	NMVOC	4'029.4	266.8	1%	46%	46%	0.156%	0.260%	0.089%	0.119%	0.002%	0.119%
1A3biii	NMVOC	1'928.9	146.0	1%	22%	22%	0.041%	0.119%	0.049%	0.026%	0.001%	0.026%
1A3biv	NMVOC	5'587.6	795.4	1%	400%	400%	4.060%	0.220%	0.264%	0.878%	0.005%	0.878%
1A3bv	NMVOC	13'536.8	489.2	1%	40%	40%	0.250%	1.010%	0.163%	0.404%	0.003%	0.404%
1A3c	NMVOC	83.8	45.8	1%	34%	34%	0.020%	0.008%	0.015%	0.003%	0.000%	0.003%
1A3dii	NMVOC	1'640.6	434.9	1%	34%	34%	0.189%	0.002%	0.145%	0.001%	0.003%	0.003%
1A3ei	NMVOC	0.1	0.0	2%	50%	50%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A4ai	NMVOC	1'050.3	536.6	2%	56%	56%	0.384%	0.087%	0.178%	0.049%	0.004%	0.049%
1A4aii	NMVOC	1'091.7	354.0	1%	75%	75%	0.339%	0.023%	0.118%	0.017%	0.002%	0.017%
1A4bi	NMVOC	7'974.3	2'271.8	4%	68%	68%	1.974%	0.065%	0.755%	0.044%	0.040%	0.059%
1A4bii	NMVOC	398.2	150.1	1%	75%	75%	0.144%	0.015%	0.050%	0.012%	0.001%	0.012%
1A4ci	NMVOC	234.6	72.8	21%	75%	78%	0.072%	0.004%	0.024%	0.003%	0.007%	0.008%
1A4cii	NMVOC	4'369.1	1'057.7	1%	75%	75%	1.012%	0.027%	0.352%	0.020%	0.006%	0.021%
1A5b	NMVOC	160.3	69.7	1%	34%	34%	0.030%	0.009%	0.023%	0.003%	0.000%	0.003%
1B2ai	NMVOC	205.9	190.3	30%	50%	58%	0.142%	0.045%	0.063%	0.023%	0.027%	0.035%
1B2aiv	NMVOC	1'344.6	322.8	30%	47%	56%	0.230%	0.009%	0.107%	0.004%	0.046%	0.046%
1B2av	NMVOC	17'189.0	1'585.3	1%	26%	26%	0.527%	0.961%	0.527%	0.250%	0.010%	0.250%
1B2b	NMVOC	1'054.9	597.5	22%	50%	55%	0.416%	0.107%	0.199%	0.054%	0.062%	0.082%
1B2c	NMVOC	10.9	0.1	22%	51%	56%	0.000%	0.001%	0.000%	0.000%	0.000%	0.000%
2A1	NMVOC	41.3	28.1	2%	200%	200%	0.072%	0.006%	0.009%	0.012%	0.000%	0.012%
2A2	NMVOC	0.7	0.6	2%	500%	500%	0.004%	0.000%	0.000%	0.001%	0.000%	0.001%
2A5a	NMVOC	4.6	2.1	5%	500%	500%	0.013%	0.000%	0.001%	0.002%	0.000%	0.002%
2B10a	NMVOC	608.6	12.6	2%	40%	40%	0.006%	0.049%	0.004%	0.019%	0.000%	0.019%
2C1	NMVOC	1'053.6	276.8	2%	100%	100%	0.353%	0.001%	0.092%	0.001%	0.003%	0.003%
2C3	NMVOC	56.6	-	5%	200%	200%	0.000%	0.005%	0.000%	0.010%	0.000%	0.010%
2C7a	NMVOC	2.8	0.3	5%	200%	200%	0.001%	0.000%	0.000%	0.000%	0.000%	0.000%
2C7c	NMVOC	0.6	0.5	5%	100%	100%	0.001%	0.000%	0.000%	0.000%	0.000%	0.000%
2D3a	NMVOC	9'310.5	11'555.1	1%	200%	200%	29.489%	3.034%	3.842%	6.068%	0.054%	6.069%
2D3b	NMVOC	4'895.0	2'840.4	5%	100%	100%	3.629%	0.520%	0.944%	0.520%	0.067%	0.524%
2D3c	NMVOC	2'430.0	388.2	20%	100%	102%	0.505%	0.081%	0.129%	0.081%	0.037%	0.089%
2D3d	NMVOC	54'168.0	7'007.6	30%	40%	50%	4.471%	2.358%	2.330%	0.943%	0.988%	1.366%
2D3e	NMVOC	11'218.0	1'964.3	40%	100%	108%	2.700%	0.319%	0.653%	0.319%	0.369%	0.488%
2D3f	NMVOC	910.0	63.0	20%	100%	102%	0.082%	0.058%	0.021%	0.058%	0.006%	0.058%
2D3g	NMVOC	28'313.8	3'510.6	30%	150%	153%	6.852%	1.284%	1.167%	1.926%	0.495%	1.989%
2D3h	NMVOC	20'353.8	2'802.4	15%	100%	101%	3.616%	0.831%	0.932%	0.831%	0.198%	0.854%
2D3i	NMVOC	5'325.0	2'109.6	30%	180%	182%	4.912%	0.240%	0.701%	0.432%	0.298%	0.525%
2G	NMVOC	21'487.3	6'746.9	25%	200%	202%	17.352%	0.382%	2.243%	0.763%	0.793%	1.101%
2H1	NMVOC	555.0	272.1	30%	200%	202%	0.702%	0.042%	0.090%	0.085%	0.038%	0.093%
2H2	NMVOC	1'977.0	2'390.6	10%	100%	100%	3.066%	0.624%	0.795%	0.624%	0.112%	0.634%
2H3	NMVOC	156.0	43.7	3%	200%	200%	0.111%	0.001%	0.015%	0.002%	0.001%	0.002%
3B1a	NMVOC	9'540.4	7'732.6	6%	500%	500%	49.339%	1.744%	2.571%	8.719%	0.234%	8.722%
3B1b	NMVOC	6'579.2	6'819.5	6%	500%	500%	43.512%	1.697%	2.267%	8.485%	0.207%	8.487%
3B2	NMVOC	66.8	67.3	6%	500%	500%	0.429%	0.017%	0.022%	0.083%	0.002%	0.083%
3B3	NMVOC	1'027.8	794.0	6%	500%	500%	5.066%	0.175%	0.264%	0.875%	0.024%	0.875%
3B4d	NMVOC	37.0	47.5	6%	500%	500%	0.303%	0.013%	0.016%	0.063%	0.001%	0.063%
3B4e	NMVOC	120.4	237.4	6%	500%	500%	1.515%	0.069%	0.079%	0.343%	0.007%	0.343%
3B4f	NMVOC	8.6	30.4	6%	500%	500%	0.194%	0.009%	0.010%	0.047%	0.001%	0.047%
3B4gi	NMVOC	508.7	523.6	6%	500%	500%	3.341%	0.130%	0.174%	0.650%	0.016%	0.650%
3B4gii	NMVOC	218.1	772.3	6%	500%	500%	4.928%	0.238%	0.257%	1.189%	0.023%	1.190%
3B4giii	NMVOC	46.3	37.7	6%	500%	500%	0.241%	0.009%	0.013%	0.043%	0.001%	0.043%
3B4giv	NMVOC	129.3	186.5	6%	500%	500%	1.190%	0.051%	0.062%	0.254%	0.006%	0.254%
3B4h	NMVOC	3.6	5.4	6%	500%	500%	0.034%	0.001%	0.002%	0.007%	0.000%	0.007%
3Dc	NMVOC	481.4	459.0	5%	200%	200%	1.172%	0.111%	0.153%	0.222%	0.011%	0.222%
5B1	NMVOC	105.1	196.5	100%	100%	141%	0.355%	0.056%	0.065%	0.056%	0.092%	0.108%
5B2	NMVOC	46.4	796.9	20%	30%	36%	0.367%	0.261%	0.265%	0.078%	0.075%	0.108%
5C1a	NMVOC	516.8	292.8	50%	50%	71%	0.264%	0.053%	0.097%	0.026%	0.069%	0.074%
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	0.7	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	17.4	48%	133%	141%	0.031%	0.003%	0.006%	0.004%	0.004%	0.006%
5D1	NMVOC	0.5	0.1	1%	27%	27%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
5D2	NMVOC	0.0	0.0	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	234.6	214.9	30%	50%	58%	0.160%	0.051%	0.071%	0.026%	0.030%	0.040%
Total		**300'781**	**78'369**	**Level uncertainty:**			**76%**	**Trend uncertainty:**				**14%**

Table A - 16: Uncertainty analysis of SO_x emissions 1990 and 2017.

NFR	Pollutant	Emissions 1990	Emissions 2017	AD uncertainty 2017	EF uncertainty 2017	Combined uncertainty 2017	Combined uncertainty as % of total national 2017	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	3'572.0	244.2	10%	22%	24%	1.088%	0.779%	0.668%	0.171%	0.094%	0.196%
1A1b	SOx	660.4	153.7	1%	20%	20%	0.568%	0.153%	0.420%	0.031%	0.008%	0.031%
1A2a	SOx	357.9	16.3	2%	15%	15%	0.045%	0.101%	0.044%	0.015%	0.001%	0.015%
1A2b	SOx	63.6	3.9	2%	10%	10%	0.007%	0.015%	0.011%	0.002%	0.000%	0.002%
1A2c	SOx	1'102.7	324.6	2%	11%	11%	0.669%	0.440%	0.887%	0.048%	0.025%	0.055%
1A2d	SOx	3'091.3	9.5	2%	14%	14%	0.025%	1.226%	0.026%	0.172%	0.001%	0.172%
1A2e	SOx	985.2	24.7	2%	12%	12%	0.055%	0.332%	0.067%	0.040%	0.002%	0.040%
1A2f	SOx	3'530.3	1'430.5	2%	19%	19%	5.039%	2.477%	3.910%	0.471%	0.111%	0.483%
1A2gvii	SOx	352.4	4.1	1%	10%	10%	0.008%	0.132%	0.011%	0.013%	0.000%	0.013%
1A2gviii	SOx	3'213.5	440.0	2%	19%	19%	1.550%	0.099%	1.203%	0.019%	0.035%	0.040%
1A3ai(i)	SOx	99.7	156.0	1%	10%	10%	0.290%	0.386%	0.426%	0.039%	0.008%	0.039%
1A3aii(i)	SOx	24.9	8.0	1%	10%	10%	0.015%	0.012%	0.022%	0.001%	0.000%	0.001%
1A3bi	SOx	1'940.4	66.1	1%	10%	10%	0.123%	0.605%	0.181%	0.061%	0.003%	0.061%
1A3bii	SOx	247.4	6.1	1%	10%	10%	0.011%	0.084%	0.017%	0.008%	0.000%	0.008%
1A3biii	SOx	1'572.3	11.9	1%	10%	10%	0.022%	0.604%	0.032%	0.060%	0.001%	0.060%
1A3biv	SOx	23.6	1.0	1%	10%	10%	0.002%	0.007%	0.003%	0.001%	0.000%	0.001%
1A3c	SOx	25.5	0.2	1%	10%	10%	0.000%	0.010%	0.001%	0.001%	0.000%	0.001%
1A3dii	SOx	63.2	2.0	1%	10%	10%	0.004%	0.020%	0.005%	0.002%	0.000%	0.002%
1A3ei	SOx	0.3	0.2	2%	10%	10%	0.000%	0.001%	0.001%	0.000%	0.000%	0.000%
1A4ai	SOx	3'726.3	430.1	2%	10%	10%	0.803%	0.334%	1.176%	0.033%	0.026%	0.042%
1A4aii	SOx	1.8	0.1	1%	10%	10%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A4bi	SOx	9'213.8	955.8	4%	10%	11%	1.880%	1.118%	2.612%	0.112%	0.137%	0.177%
1A4bii	SOx	1.3	0.1	1%	10%	10%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A4ci	SOx	83.1	59.4	21%	18%	28%	0.304%	0.129%	0.162%	0.023%	0.049%	0.054%
1A4cii	SOx	290.2	2.5	1%	10%	10%	0.005%	0.111%	0.007%	0.011%	0.000%	0.011%
1A5b	SOx	77.4	33.9	1%	10%	10%	0.063%	0.061%	0.093%	0.006%	0.002%	0.006%
1B2aiv	SOx	419.0	109.8	30%	47%	56%	1.129%	0.130%	0.300%	0.061%	0.127%	0.141%
1B2c	SOx	193.9	2.3	22%	31%	38%	0.016%	0.072%	0.006%	0.022%	0.002%	0.022%
2A1	SOx	0.7	0.5	2%	200%	200%	0.017%	0.001%	0.001%	0.002%	0.000%	0.002%
2A2	SOx	0.0	0.0	2%	500%	500%	0.001%	0.000%	0.000%	0.000%	0.000%	0.000%
2A5a	SOx	0.1	0.0	5%	500%	500%	0.003%	0.000%	0.000%	0.000%	0.000%	0.000%
2B5	SOx	444.8	709.7	2%	20%	20%	2.630%	1.759%	1.940%	0.352%	0.055%	0.356%
2B10a	SOx	168.0	99.2	2%	40%	40%	0.732%	0.203%	0.271%	0.081%	0.008%	0.082%
2C1	SOx	144.0	17.8	2%	100%	100%	0.328%	0.010%	0.049%	0.010%	0.001%	0.010%
2C3	SOx	696.3	-	5%	200%	200%	0.000%	0.282%	0.000%	0.564%	0.000%	0.564%
2C7c	SOx	0.0	0.0	5%	100%	100%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2G	SOx	3.4	7.1	25%	100%	103%	0.134%	0.018%	0.019%	0.018%	0.007%	0.019%
2H3	SOx	1.3	0.4	3%	200%	200%	0.013%	0.000%	0.001%	0.001%	0.000%	0.001%
5B2	SOx	NA	0.8	20%	100%	102%	0.016%	NA	NA	NA	NA	NA
5C1a	SOx	24.2	13.7	50%	40%	64%	0.162%	0.028%	0.038%	0.011%	0.027%	0.029%
5C1bi	SOx	45.0	-	30%	30%	42%	0.000%	0.018%	0.000%	0.005%	0.000%	0.005%
5C1biii	SOx	39.0	-	30%	30%	42%	0.000%	0.016%	0.000%	0.005%	0.000%	0.005%
5C1biv	SOx	74.1	67.0	20%	30%	36%	0.445%	0.153%	0.183%	0.046%	0.052%	0.069%
5C2	SOx	0.7	0.4	48%	117%	126%	0.008%	0.001%	0.001%	0.001%	0.001%	0.001%
5D1	SOx	0.1	0.0	1%	37%	37%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
5D2	SOx	0.0	0.0	10%	20%	22%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
6A	SOx	10.4	10.8	30%	50%	58%	0.116%	0.025%	0.029%	0.013%	0.012%	0.018%
Total		**36'585**	**5'424**	**Level uncertainty:**			**7%**	**Trend uncertainty:**				**1%**

Table A - 17: Uncertainty analysis of NH_3 emissions 1990 and 2017.

NFR	Pollutant	Emissions 1990	Emissions 2017	AD uncertainty 2017	EF uncertainty 2017	Combined uncertainty 2017	Combined uncertainty as % of total national 2017	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	44.5	10%	20%	22%	0.018%	0.061%	0.066%	0.012%	0.009%	0.015%
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	202.9	2%	9%	9%	0.034%	0.122%	0.303%	0.011%	0.009%	0.014%
1A2gvii	NH3	1.0	1.5	1%	50%	50%	0.001%	0.001%	0.002%	0.001%	0.000%	0.001%
1A2gviii	NH3	9.2	39.1	2%	9%	9%	0.007%	0.047%	0.058%	0.004%	0.002%	0.005%
1A3bi	NH3	1'414.6	1'404.6	1%	50%	50%	1.274%	0.360%	2.094%	0.180%	0.038%	0.184%
1A3bii	NH3	8.6	28.2	1%	50%	50%	0.026%	0.032%	0.042%	0.016%	0.001%	0.016%
1A3biii	NH3	6.2	6.6	1%	50%	50%	0.006%	0.002%	0.010%	0.001%	0.000%	0.001%
1A3biv	NH3	3.3	3.8	1%	50%	50%	0.003%	0.002%	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	0.3	2%	50%	50%	0.000%	NA	NA	NA	NA	NA
1A4ai	NH3	11.7	23.9	2%	10%	10%	0.004%	0.021%	0.036%	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	100.1	4%	10%	11%	0.019%	0.006%	0.149%	0.001%	0.008%	0.008%
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	2.9	21%	10%	23%	0.001%	0.003%	0.004%	0.000%	0.001%	0.001%
1A4cii	NH3	0.8	0.8	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	0.0	2%	10%	10%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
2B2	NH3	0.7	0.0	2%	10%	10%	0.000%	0.001%	0.000%	0.000%	0.000%	0.000%
2B10a	NH3	7.7	5.3	2%	40%	40%	0.004%	0.002%	0.008%	0.001%	0.000%	0.001%
2C1	NH3	11.9	2.5	2%	200%	200%	0.009%	0.011%	0.004%	0.022%	0.000%	0.022%
2C7c	NH3	9.2	8.1	5%	500%	500%	0.074%	0.001%	0.012%	0.004%	0.001%	0.004%
2G	NH3	203.2	67.4	25%	40%	47%	0.058%	0.149%	0.101%	0.059%	0.036%	0.069%
2H2	NH3	132.3	92.3	10%	500%	500%	0.837%	0.025%	0.138%	0.123%	0.019%	0.125%
2H3	NH3	1.0	0.3	3%	200%	200%	0.001%	0.001%	0.000%	0.002%	0.000%	0.002%
2L	NH3	2.4	3.6	25%	100%	103%	0.007%	0.002%	0.005%	0.002%	0.002%	0.003%
3B1a	NH3	10'000.5	11'155.6	6%	38%	39%	7.847%	4.365%	16.632%	1.670%	1.515%	2.255%
3B1b	NH3	5'537.5	7'383.1	6%	25%	26%	3.435%	4.215%	11.008%	1.047%	1.003%	1.450%
3B2	NH3	533.6	515.5	6%	54%	54%	0.506%	0.114%	0.769%	0.061%	0.070%	0.093%
3B3	NH3	6'020.2	4'863.6	6%	36%	37%	3.231%	0.130%	7.251%	0.047%	0.660%	0.662%
3B4d	NH3	165.1	201.1	6%	57%	58%	0.211%	0.097%	0.300%	0.056%	0.027%	0.062%
3B4e	NH3	277.3	476.4	6%	34%	35%	0.301%	0.370%	0.710%	0.127%	0.065%	0.142%
3B4f	NH3	21.3	65.5	6%	47%	48%	0.056%	0.072%	0.098%	0.034%	0.009%	0.035%
3B4gi	NH3	947.4	585.6	6%	83%	83%	0.885%	0.289%	0.873%	0.240%	0.080%	0.253%
3B4gii	NH3	210.3	520.8	6%	69%	69%	0.656%	0.519%	0.776%	0.359%	0.071%	0.366%
3B4giii	NH3	34.5	24.7	6%	78%	78%	0.035%	0.006%	0.037%	0.004%	0.003%	0.005%
3B4giv	NH3	122.2	81.1	6%	55%	56%	0.082%	0.029%	0.121%	0.016%	0.011%	0.019%
3B4h	NH3	14.6	42.3	6%	50%	50%	0.039%	0.045%	0.063%	0.023%	0.006%	0.023%
3Da1	NH3	4'258.3	2'812.5	5%	50%	50%	2.562%	1.027%	4.193%	0.513%	0.297%	0.593%
3Da2a	NH3	32'978.8	20'300.8	6%	22%	23%	8.525%	10.117%	30.268%	2.251%	2.757%	3.559%
3Da2b	NH3	1'169.4	-	6%	50%	50%	0.000%	1.433%	0.000%	0.717%	0.000%	0.717%
3Da2c	NH3	34.0	863.8	6%	50%	50%	0.790%	1.246%	1.288%	0.623%	0.117%	0.634%
3Da3	NH3	753.9	1'316.9	6%	38%	38%	0.909%	1.039%	1.963%	0.390%	0.179%	0.429%
5A	NH3	610.7	254.6	10%	50%	51%	0.235%	0.369%	0.380%	0.185%	0.054%	0.192%
5B1	NH3	175.1	327.6	100%	100%	141%	0.840%	0.274%	0.488%	0.274%	0.691%	0.743%
5B2	NH3	9.6	171.4	20%	75%	78%	0.241%	0.244%	0.256%	0.183%	0.072%	0.197%
5C1biv	NH3	5.7	14.3	20%	50%	54%	0.014%	0.014%	0.021%	0.007%	0.006%	0.009%
5C2	NH3	18.0	9.5	48%	25%	54%	0.009%	0.008%	0.014%	0.002%	0.010%	0.010%
5D1	NH3	91.7	123.4	1%	50%	50%	0.112%	0.071%	0.184%	0.036%	0.003%	0.036%
6A	NH3	977.8	1'005.5	30%	0%	30%	0.547%	0.300%	1.499%	0.000%	0.636%	0.636%
Total		**67'071**	**55'155**	**Level uncertainty:**			**13%**	**Trend uncertainty:**				**5%**

Table A - 18: Uncertainty analysis of PM2.5 emissions 1990 and 2017.

NFR	Pollutant	Emissions 1990	Emissions 2017	AD uncertainty 2017	EF uncertainty 2017	Combined uncertainty 2017	Combined uncertainty as % of total national 2017	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	749.6	75.7	10%	71%	72%	0.829%	1.656%	0.502%	1.176%	0.071%	1.178%
1A1b	PM2.5	47.7	8.9	1%	20%	20%	0.027%	0.078%	0.059%	0.016%	0.001%	0.016%
1A1c	PM2.5	4.6	13.9	0%	0%	0%	0.000%	0.079%	0.092%	0.000%	0.000%	0.000%
1A2a	PM2.5	14.8	3.2	2%	28%	28%	0.014%	0.022%	0.021%	0.006%	0.001%	0.006%
1A2b	PM2.5	19.7	1.2	2%	30%	30%	0.006%	0.049%	0.008%	0.015%	0.000%	0.015%
1A2c	PM2.5	40.8	11.4	2%	10%	10%	0.018%	0.042%	0.075%	0.004%	0.002%	0.005%
1A2d	PM2.5	149.6	0.5	2%	33%	33%	0.002%	0.428%	0.003%	0.141%	0.000%	0.141%
1A2e	PM2.5	25.7	1.4	2%	10%	10%	0.002%	0.065%	0.009%	0.006%	0.000%	0.006%
1A2f	PM2.5	437.6	44.4	2%	65%	65%	0.441%	0.965%	0.295%	0.628%	0.008%	0.628%
1A2gvii	PM2.5	728.9	404.1	1%	50%	50%	3.087%	0.581%	2.681%	0.290%	0.049%	0.294%
1A2gviii	PM2.5	495.0	327.0	2%	65%	65%	3.248%	0.743%	2.169%	0.483%	0.063%	0.487%
1A3ai(i)	PM2.5	92.4	20.0	1%	30%	30%	0.092%	0.133%	0.133%	0.040%	0.002%	0.040%
1A3aii(i)	PM2.5	22.7	2.6	1%	30%	30%	0.012%	0.048%	0.017%	0.014%	0.000%	0.014%
1A3bi	PM2.5	675.0	307.4	1%	57%	57%	2.692%	0.094%	2.039%	0.054%	0.037%	0.066%
1A3bii	PM2.5	317.2	105.6	1%	48%	48%	0.780%	0.213%	0.701%	0.103%	0.013%	0.104%
1A3biii	PM2.5	1'001.1	75.8	1%	27%	27%	0.313%	2.379%	0.503%	0.642%	0.009%	0.642%
1A3bvi	PM2.5	314.2	404.3	1%	50%	50%	3.088%	1.776%	2.682%	0.888%	0.049%	0.890%
1A3c	PM2.5	172.7	194.8	1%	50%	50%	1.488%	0.795%	1.292%	0.397%	0.024%	0.398%
1A3dii	PM2.5	59.1	34.2	1%	50%	50%	0.261%	0.057%	0.227%	0.028%	0.004%	0.029%
1A3ei	PM2.5	0.1	0.1	2%	27%	27%	0.000%	0.000%	0.001%	0.000%	0.000%	0.000%
1A4ai	PM2.5	426.1	492.8	2%	78%	78%	5.871%	2.040%	3.268%	1.592%	0.073%	1.593%
1A4bi	PM2.5	4'912.2	1'711.9	4%	76%	76%	19.895%	2.786%	11.355%	2.117%	0.597%	2.200%
1A4ci	PM2.5	528.3	207.7	21%	39%	44%	1.408%	0.144%	1.377%	0.056%	0.413%	0.417%
1A4cii	PM2.5	435.1	211.6	1%	80%	80%	2.586%	0.150%	1.404%	0.120%	0.026%	0.123%
1A5b	PM2.5	86.9	45.6	1%	50%	50%	0.349%	0.052%	0.303%	0.026%	0.006%	0.027%
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	164.0	2%	200%	200%	5.009%	0.395%	1.088%	0.790%	0.031%	0.790%
2A2	PM2.5	7.2	6.0	2%	500%	500%	0.455%	0.019%	0.039%	0.094%	0.001%	0.094%
2A5a	PM2.5	183.3	230.3	5%	500%	500%	17.591%	1.000%	1.528%	4.998%	0.108%	4.999%
2B5	PM2.5	43.7	29.3	2%	200%	200%	0.894%	0.068%	0.194%	0.136%	0.005%	0.137%
2B10a	PM2.5	7.9	0.2	2%	40%	40%	0.001%	0.022%	0.001%	0.009%	0.000%	0.009%
2C1	PM2.5	817.9	9.6	2%	125%	125%	0.183%	2.291%	0.064%	2.864%	0.002%	2.864%
2C3	PM2.5	78.3	-	5%	200%	200%	0.000%	0.226%	0.000%	0.451%	0.000%	0.451%
2C7a	PM2.5	5.2	0.6	5%	200%	200%	0.018%	0.011%	0.004%	0.023%	0.000%	0.023%
2C7c	PM2.5	1.7	1.4	5%	500%	500%	0.108%	0.005%	0.009%	0.023%	0.001%	0.023%
2D3c	PM2.5	4.0	3.6	20%	200%	201%	0.109%	0.012%	0.024%	0.024%	0.007%	0.025%
2D3i	PM2.5	12.0	-	30%	500%	501%	0.000%	0.035%	0.000%	0.173%	0.000%	0.173%
2G	PM2.5	512.8	444.7	25%	100%	103%	7.001%	1.472%	2.950%	1.472%	1.043%	1.804%
2H1	PM2.5	235.8	214.6	30%	200%	202%	6.628%	0.744%	1.423%	1.488%	0.604%	1.606%
2H2	PM2.5	188.8	182.8	10%	500%	500%	13.962%	0.668%	1.212%	3.342%	0.171%	3.347%
2H3	PM2.5	15.6	4.4	3%	200%	200%	0.133%	0.016%	0.029%	0.032%	0.001%	0.032%
2I	PM2.5	237.9	93.0	1%	500%	500%	7.100%	0.068%	0.617%	0.342%	0.009%	0.342%
3B1a	PM2.5	20.6	24.8	6%	300%	300%	1.136%	0.105%	0.164%	0.315%	0.015%	0.315%
3B1b	PM2.5	18.3	22.0	6%	300%	300%	1.008%	0.093%	0.146%	0.280%	0.013%	0.280%
3B2	PM2.5	0.8	0.8	6%	300%	300%	0.037%	0.003%	0.005%	0.009%	0.000%	0.009%
3B3	PM2.5	8.5	6.4	6%	300%	300%	0.292%	0.018%	0.042%	0.053%	0.004%	0.053%
3B4d	PM2.5	0.1	0.2	6%	300%	300%	0.008%	0.001%	0.001%	0.002%	0.000%	0.002%
3B4e	PM2.5	3.9	7.8	6%	300%	300%	0.356%	0.040%	0.052%	0.121%	0.005%	0.121%
3B4f	PM2.5	0.6	2.1	6%	300%	300%	0.095%	0.012%	0.014%	0.036%	0.001%	0.036%
3B4gi	PM2.5	9.2	9.5	6%	300%	300%	0.436%	0.037%	0.063%	0.110%	0.006%	0.110%
3B4gii	PM2.5	4.0	14.3	6%	300%	300%	0.655%	0.083%	0.095%	0.250%	0.009%	0.250%
3B4giii	PM2.5	1.9	1.5	6%	300%	300%	0.071%	0.005%	0.010%	0.014%	0.001%	0.014%
3B4giv	PM2.5	2.0	2.6	6%	300%	300%	0.117%	0.011%	0.017%	0.034%	0.002%	0.034%
3B4h	PM2.5	0.2	0.1	6%	300%	300%	0.005%	0.000%	0.001%	0.000%	0.000%	0.000%
3Dc	PM2.5	47.5	45.3	5%	200%	200%	1.384%	0.164%	0.300%	0.327%	0.021%	0.328%
5B2	PM2.5	NA	0.0	20%	100%	102%	0.001%	NA	NA	NA	NA	NA
5C1a	PM2.5	465.1	263.5	50%	30%	58%	2.347%	0.408%	1.748%	0.122%	1.236%	1.242%
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%	0.095%	0.000%	0.029%	0.000%	0.029%
5C1biv	PM2.5	14.3	4.0	20%	34%	39%	0.024%	0.015%	0.026%	0.005%	0.007%	0.009%
5C1bv	PM2.5	4.4	1.0	5%	33%	33%	0.005%	0.006%	0.007%	0.002%	0.000%	0.002%
5C2	PM2.5	84.7	44.6	48%	133%	141%	0.962%	0.051%	0.296%	0.068%	0.201%	0.212%
5E	PM2.5	1.4	1.5	20%	30%	36%	0.008%	0.006%	0.010%	0.002%	0.003%	0.003%
6A	PM2.5	5.8	5.1	30%	40%	50%	0.039%	0.017%	0.034%	0.007%	0.014%	0.016%
Total		**15'077**	**6'547**	**Level uncertainty:**			**34%**	**Trend uncertainty:**				**8%**

Table A - 19: Uncertainty analysis of PM10 emissions 1990 and 2017.

NFR	Pollutant	Emissions 1990	Emissions 2017	AD uncertainty 2017	EF uncertainty 2017	Combined uncertainty 2017	Combined uncertainty as % of total national 2017	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	1'009.9	76.3	10%	71%	72%	0.367%	2.300%	0.318%	1.633%	0.045%	1.634%
1A1b	PM10	47.7	8.9	1%	20%	20%	0.012%	0.086%	0.037%	0.017%	0.001%	0.017%
1A1c	PM10	4.9	14.6	0%	0%	0%	0.000%	0.048%	0.061%	0.000%	0.000%	0.000%
1A2a	PM10	20.5	3.6	2%	28%	28%	0.007%	0.038%	0.015%	0.011%	0.000%	0.011%
1A2b	PM10	28.5	1.3	2%	30%	30%	0.003%	0.069%	0.005%	0.021%	0.000%	0.021%
1A2c	PM10	40.8	11.4	2%	10%	10%	0.008%	0.058%	0.047%	0.006%	0.001%	0.006%
1A2d	PM10	166.6	0.5	2%	33%	33%	0.001%	0.430%	0.002%	0.142%	0.000%	0.142%
1A2e	PM10	25.7	1.4	2%	10%	10%	0.001%	0.061%	0.006%	0.006%	0.000%	0.006%
1A2f	PM10	832.6	82.2	2%	65%	65%	0.358%	1.816%	0.343%	1.181%	0.010%	1.181%
1A2gvii	PM10	2'173.2	2'318.2	1%	50%	50%	7.770%	4.024%	9.665%	2.012%	0.176%	2.020%
1A2gviii	PM10	502.5	339.0	2%	65%	65%	1.477%	0.110%	1.413%	0.071%	0.041%	0.082%
1A3ai(i)	PM10	102.7	20.0	1%	30%	30%	0.040%	0.183%	0.083%	0.055%	0.002%	0.055%
1A3aii(i)	PM10	25.2	2.6	1%	30%	30%	0.005%	0.055%	0.011%	0.016%	0.000%	0.016%
1A3bi	PM10	675.0	307.4	1%	57%	57%	1.181%	0.469%	1.281%	0.269%	0.023%	0.270%
1A3bii	PM10	317.2	105.6	1%	48%	48%	0.342%	0.382%	0.440%	0.185%	0.008%	0.185%
1A3biii	PM10	1'001.1	75.8	1%	27%	27%	0.137%	2.280%	0.316%	0.616%	0.006%	0.616%
1A3bvi	PM10	2'094.5	2'695.2	1%	50%	50%	9.034%	5.799%	11.237%	2.900%	0.205%	2.907%
1A3c	PM10	969.8	1'259.6	1%	50%	50%	4.222%	2.735%	5.252%	1.368%	0.096%	1.371%
1A3dii	PM10	59.1	34.2	1%	50%	50%	0.115%	0.011%	0.143%	0.005%	0.003%	0.006%
1A3ei	PM10	0.1	0.1	2%	27%	27%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
1A4ai	PM10	434.7	506.6	2%	78%	78%	2.648%	0.984%	2.112%	0.768%	0.047%	0.769%
1A4bi	PM10	5'016.7	1'752.9	4%	76%	76%	8.938%	5.693%	7.308%	4.326%	0.384%	4.343%
1A4ci	PM10	529.9	209.1	21%	39%	44%	0.622%	0.503%	0.872%	0.196%	0.262%	0.327%
1A4cii	PM10	511.2	272.2	1%	80%	80%	1.459%	0.191%	1.135%	0.153%	0.021%	0.154%
1A5b	PM10	286.5	262.9	1%	50%	50%	0.881%	0.353%	1.096%	0.176%	0.020%	0.178%
1B1a	PM10	1.6	0.6	30%	40%	50%	0.002%	0.002%	0.002%	0.001%	0.001%	0.001%
2A1	PM10	374.4	255.3	2%	200%	200%	3.421%	0.093%	1.064%	0.186%	0.030%	0.189%
2A2	PM10	14.4	11.9	2%	500%	500%	0.399%	0.012%	0.050%	0.061%	0.001%	0.061%
2A5a	PM10	366.5	460.6	5%	500%	500%	15.435%	0.970%	1.920%	4.848%	0.136%	4.850%
2B5	PM10	52.6	35.3	2%	200%	200%	0.473%	0.011%	0.147%	0.021%	0.004%	0.022%
2B10a	PM10	17.1	0.5	2%	40%	40%	0.001%	0.042%	0.002%	0.017%	0.000%	0.017%
2C1	PM10	1'485.5	15.0	2%	125%	125%	0.126%	3.788%	0.063%	4.735%	0.002%	4.735%
2C3	PM10	113.1	-	5%	200%	200%	0.000%	0.293%	0.000%	0.587%	0.000%	0.587%
2C7a	PM10	5.5	0.6	5%	200%	200%	0.008%	0.012%	0.003%	0.024%	0.000%	0.024%
2C7c	PM10	3.3	2.8	5%	500%	500%	0.093%	0.003%	0.012%	0.016%	0.001%	0.016%
2D3c	PM10	20.0	17.8	20%	200%	201%	0.240%	0.022%	0.074%	0.045%	0.021%	0.049%
2D3i	PM10	24.0	-	30%	500%	501%	0.000%	0.062%	0.000%	0.311%	0.000%	0.311%
2G	PM10	588.4	599.7	25%	100%	103%	4.142%	0.974%	2.500%	0.974%	0.884%	1.315%
2H1	PM10	243.8	221.3	30%	200%	202%	2.999%	0.290%	0.923%	0.581%	0.391%	0.700%
2H2	PM10	311.2	342.3	10%	500%	500%	11.470%	0.620%	1.427%	3.098%	0.202%	3.105%
2H3	PM10	15.6	4.4	3%	200%	200%	0.059%	0.022%	0.018%	0.045%	0.001%	0.045%
2I	PM10	951.4	371.9	1%	500%	500%	12.461%	0.917%	1.551%	4.586%	0.022%	4.586%
3B1a	PM10	84.5	101.5	6%	300%	300%	2.042%	0.204%	0.423%	0.613%	0.039%	0.614%
3B1b	PM10	74.8	90.2	6%	300%	300%	1.813%	0.182%	0.376%	0.545%	0.034%	0.546%
3B2	PM10	19.8	19.9	6%	300%	300%	0.400%	0.032%	0.083%	0.095%	0.008%	0.096%
3B3	PM10	188.2	142.1	6%	300%	300%	2.858%	0.104%	0.593%	0.313%	0.054%	0.318%
3B4d	PM10	3.4	4.4	6%	300%	300%	0.088%	0.009%	0.018%	0.028%	0.002%	0.028%
3B4e	PM10	6.2	12.2	6%	300%	300%	0.246%	0.035%	0.051%	0.105%	0.005%	0.105%
3B4f	PM10	0.9	3.3	6%	300%	300%	0.067%	0.011%	0.014%	0.034%	0.001%	0.034%
3B4gi	PM10	123.3	126.9	6%	300%	300%	2.553%	0.209%	0.529%	0.628%	0.048%	0.630%
3B4gii	PM10	40.4	143.0	6%	300%	300%	2.876%	0.492%	0.596%	1.475%	0.054%	1.476%
3B4giii	PM10	10.4	8.5	6%	300%	300%	0.171%	0.008%	0.035%	0.025%	0.003%	0.025%
3B4giv	PM10	18.5	24.7	6%	300%	300%	0.496%	0.055%	0.103%	0.164%	0.009%	0.165%
3B4h	PM10	0.5	0.8	6%	300%	300%	0.017%	0.002%	0.003%	0.007%	0.000%	0.007%
3Dc	PM10	1'054.0	1'008.8	5%	200%	200%	13.525%	1.471%	4.206%	2.943%	0.297%	2.958%
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	292.8	50%	50%	71%	1.387%	0.120%	1.221%	0.060%	0.863%	0.865%
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%	0.125%	0.000%	0.037%	0.000%	0.037%
5C1biv	PM10	20.0	5.7	20%	35%	40%	0.015%	0.028%	0.024%	0.010%	0.007%	0.012%
5C1bv	PM10	4.4	1.0	5%	33%	33%	0.002%	0.007%	0.004%	0.002%	0.000%	0.002%
5C2	PM10	93.1	48.9	48%	133%	141%	0.464%	0.037%	0.204%	0.050%	0.139%	0.147%
5E	PM10	2.8	3.0	20%	30%	36%	0.007%	0.005%	0.013%	0.002%	0.004%	0.004%
6A	PM10	206.3	182.4	30%	40%	50%	0.611%	0.225%	0.760%	0.090%	0.323%	0.335%
Total		**23'985**	**14'922**	**Level uncertainty:**			**32%**	**Trend uncertainty:**				**11%**

Table A - 20: Uncertainty analysis: Overview and data sources (legend see next page).

Code	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%	GHGI	19%	EMIS	32%	EMIS	22%	EMIS	20%	EMIS	71%	EMIS	71%	EMIS
1A1b	1%	GHGI	20%	EMIS	20%	EMIS	20%	EMIS	10%	EMIS	20%	EMIS	20%	EMIS
1A1c	-	GHGI	20%	B (EMEP)	20%	B (EMEP)	-	-	-	-	-	-	-	-
1A2a	2%	GHGI	27%	EMIS	18%	EMIS	15%	EMIS	10%	EMIS	28%	EMIS	28%	EMIS
1A2b	2%	GHGI	20%	EMIS	19%	EMIS	10%	EMIS	10%	EMIS	30%	EMIS	30%	EMIS
1A2c	2%	GHGI	10%	EMIS	10%	EMIS	11%	EMIS	10%	EMIS	10%	EMIS	10%	EMIS
1A2d	2%	GHGI	10%	EMIS	10%	EMIS	14%	EMIS	10%	EMIS	33%	EMIS	33%	EMIS
1A2e	2%	GHGI	10%	EMIS	10%	EMIS	12%	EMIS	10%	EMIS	10%	EMIS	10%	EMIS
1A2f	2%	GHGI	17%	EMIS	30%	EMIS	19%	EMIS	9%	EMIS	65%	EMIS	65%	EMIS
1A2gvii	1%	GHGI	13%	UBA	34%	UBA	10%	A (EMEP)	50%	France	50%	UBA/INFRAS	50%	UBA/INFRAS
1A2gviii	2%	NIR CH	17%	EMIS	30%	EMIS	19%	EMIS	9%	EMIS	65%	EMIS	65%	EMIS
1A3ai(i)	1%	GHGI	20%	B (EMEP)	50%	C (EMEP)	10%	A (EMEP)	-	-	30%	UBA/INFRAS	30%	UBA/INFRAS
1A3aii(i)	1%	GHGI	20%	B (EMEP)	50%	C (EMEP)	10%	A (EMEP)	-	-	30%	UBA/INFRAS	30%	UBA/INFRAS
1A3bi	1%	GHGI	38%	UBA	52%	UBA	10%	A (EMEP)	50%	France	57%	UBA/INFRAS	57%	UBA/INFRAS
1A3bii	1%	GHGI	32%	UBA	46%	UBA	10%	A (EMEP)	50%	France	48%	UBA/INFRAS	48%	UBA/INFRAS
1A3biii	1%	GHGI	18%	UBA	22%	UBA	10%	A (EMEP)	50%	France	27%	UBA/INFRAS	27%	UBA/INFRAS
1A3biv	1%	GHGI	36%	UBA	400%	UBA	10%	A (EMEP)	50%	France	54%	UBA/INFRAS	54%	UBA/INFRAS
1A3bv	1%	GHGI	-	-	40%	UBA	-	-	-	-	-	-	-	-
1A3bvi	1%	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%	GHGI	13%	UBA	34%	UBA	10%	A (EMEP)	50%	France	50%	UBA/INFRAS	50%	UBA/INFRAS
1A3dii	1%	GHGI	13%	UBA	34%	UBA	10%	A (EMEP)	50%	France	50%	UBA/INFRAS	50%	UBA/INFRAS
1A3ei	2%	GHGI	50%	C (EMEP)	50%	C (EMEP)	10%	A (EMEP)	50%	France	27%	UBA/INFRAS	27%	UBA/INFRAS
1A4ai	2%	GHGI	16%	EMIS	56%	EMIS	10%	EMIS	10%	EMIS	78%	EMIS	78%	EMIS
1A4aii	1%	GHGI	13%	UBA	75%	Sweden	10%	A (EMEP)	10%	EMIS	50%	UBA/INFRAS	50%	UBA/INFRAS
1A4bi	4%	GHGI	13%	EMIS	68%	EMIS	10%	EMIS	10%	EMIS	76%	EMIS	76%	EMIS
1A4bii	1%	GHGI	30%	EMIS	75%	Sweden	10%	A (EMEP)	10%	EMIS	50%	UBA/INFRAS	50%	UBA/INFRAS
1A4ci	21%	GHGI	30%	EMIS	75%	EMIS	18%	EMIS	10%	EMIS	39%	EMIS	39%	EMIS
1A4cii	1%	GHGI	13%	UBA	75%	Sweden	10%	A (EMEP)	50%	France	80%	EMIS	80%	EMIS
1A5b	1%	GHGI	13%	UBA	34%	UBA	10%	A (EMEP)	50%	France	50%	UBA/INFRAS	50%	UBA/INFRAS
1B1a	30%	D.O.EMEP	-	-	-	-	-	-	-	-	40%	EMIS	40%	EMIS
1B2ai	30%	-	-	-	50%	C (EMEP)	-	-	-	-	-	-	-	-
1B2aiv	30%	D.O.EMEP	-	-	47%	EMIS	47%	EMIS	-	-	-	-	-	-
1B2av	1%	D.O.EMEP	-	-	26%	EMIS	-	-	-	-	-	-	-	-
1B2b	22%	-	-	-	50%	C (EMEP)	-	-	-	-	-	-	-	-
1B2c	22%	EMIS	30%	EMIS	51%	EMIS	31%	EMIS	-	-	-	-	-	-
2A1	2%	NIR CH	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016	-	-	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016
2A2	2%	NIR CH	500%	EMEP/EEA 2016	500%	EMEP/EEA 2016	500%	EMEP/EEA 2016	-	-	500%	EMEP/EEA 2016	500%	EMEP/EEA 2016
2A5a	5%	EMIS	500%	EMEP/EEA 2016	500%	EMEP/EEA 2016	500%	EMEP/EEA 2016	-	-	500%	EMEP/EEA 2016	500%	EMEP/EEA 2016
2B1	2%	NIR CH	-	-	-	-	-	-	10%	EMEP/EEA 2016	-	-	-	-
2B2	2%	NIR CH	10%	EMEP/EEA 2016	-	-	-	-	10%	EMEP/EEA 2016	-	-	-	-
2B5	2%	NIR CH	-	-	-	-	20%	EMEP/EEA 2016	-	-	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016
2B10a	2%	NIR CH	-	-	40%	EMEP/EEA 2016	40%	EMEP/EEA 2016	40%	EMEP/EEA 2016	40%	EMEP/EEA 2016	40%	EMEP/EEA 2016
2C1	2%	NIR CH	50%	EMEP/EEA 2016	100%	EMEP/EEA 2016	100%	EMEP/EEA 2016	200%	EMEP/EEA 2016	125%	EMEP/EEA 2016	125%	EMEP/EEA 2016
2C3	5%	NIR CH	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016	0	-	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016
2C7a	5%	EMIS	-	-	200%	EMEP/EEA 2016	-	-	-	-	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016
2C7b	-	-	0	-	0	-	0	-	0	-	0	-	0	-
2C7c	5%	EMIS	100%	EMEP/EEA 2016	100%	EMEP/EEA 2016	100%	EMEP/EEA 2016	500%	EMEP/EEA 2016	500%	EMEP/EEA 2016	500%	EMEP/EEA 2016
2D3a	1%	EMIS	-	-	200%	EMEP/EEA 2016	-	-	-	-	-	-	-	-
2D3b	5%	EMIS	-	-	100%	EMEP/EEA 2016	-	-	-	-	-	-	-	-
2D3c	20%	EMIS	-	-	100%	EMEP/EEA 2016	-	-	-	-	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016
2D3d	30%	EMIS	-	-	40%	EMEP/EEA 2016	-	-	-	-	-	-	-	-
2D3e	40%	EMIS	-	-	100%	EMEP/EEA 2016	-	-	-	-	-	-	-	-
2D3f	20%	EMIS	-	-	100%	EMEP/EEA 2016	-	-	-	-	-	-	-	-
2D3g	30%	EMIS	-	-	150%	EMEP/EEA 2016	-	-	-	-	-	-	-	-
2D3h	15%	EMIS	-	-	100%	EMEP/EEA 2016	-	-	-	-	-	-	-	-
2D3i	30%	D.O.EMEP	-	-	180%	EMEP/EEA 2016	-	-	-	-	500%	EMEP/EEA 2016	500%	EMEP/EEA 2016
2G	25%	EMIS	100%	EMEP/EEA 2016	200%	EMEP/EEA 2016	100%	EMEP/EEA 2016	40%	EMEP/EEA 2016	100%	EMEP/EEA 2016	100%	EMEP/EEA 2016
2H1	30%	D.O.EMEP	-	-	200%	EMEP/EEA 2016	-	-	-	-	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016
2H2	10%	D.O.EMEP	-	-	100%	EMEP/EEA 2016	-	-	500%	EMEP/EEA 2016	500%	EMEP/EEA 2016	500%	EMEP/EEA 2016
2H3	3%	EMIS	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016	200%	EMEP/EEA 2016
2I	1%	EMIS	-	-	-	-	-	-	-	-	500%	EMEP/EEA 2016	500%	EMEP/EEA 2016
2L	25%	EMIS	-	-	-	-	-	-	100%	EMEP/EEA 2016	-	-	-	-
3B1a	6%	GHGI	50%	C (EMEP)	500%	EMEP/EEA 2016 (E)	-	-	38%	Infras 2017	300%	EMIS	300%	EMIS
3B1b	6%	GHGI	50%	C (EMEP)	500%	EMEP/EEA 2016 (E)	-	-	25%	Infras 2017	300%	EMIS	300%	EMIS
3B2	6%	GHGI	50%	C (EMEP)	500%	EMEP/EEA 2016 (E)	-	-	54%	Infras 2017	300%	EMIS	300%	EMIS
3B3	6%	GHGI	50%	C (EMEP)	500%	EMEP/EEA 2016 (E)	-	-	36%	Infras 2017	300%	EMIS	300%	EMIS
3B4d	6%	GHGI	50%	C (EMEP)	500%	EMEP/EEA 2016 (E)	-	-	57%	Infras 2017	300%	EMIS	300%	EMIS
3B4e	6%	GHGI	50%	C (EMEP)	500%	EMEP/EEA 2016 (E)	-	-	34%	Infras 2017	300%	EMIS	300%	EMIS
3B4f	6%	GHGI	50%	C (EMEP)	500%	EMEP/EEA 2016 (E)	-	-	47%	Infras 2017	300%	EMIS	300%	EMIS
3B4gi	6%	GHGI	50%	C (EMEP)	500%	EMEP/EEA 2016 (E)	-	-	83%	Infras 2017	300%	EMIS	300%	EMIS
3B4gii	6%	GHGI	50%	C (EMEP)	500%	EMEP/EEA 2016 (E)	-	-	69%	Infras 2017	300%	-	300%	-
3B4giii	6%	GHGI	50%	C (EMEP)	500%	EMEP/EEA 2016 (E)	-	-	78%	Infras 2017	300%	-	300%	-
3B4giv	6%	GHGI	50%	C (EMEP)	500%	EMEP/EEA 2016 (E)	-	-	55%	Infras 2017	300%	-	300%	-
3B4h	6%	GHGI	50%	C (EMEP)	500%	EMEP/EEA 2016 (E)	-	-	50%	Infras 2017	300%	-	300%	-
3Da1	5%	GHGI	100%	C (EMEP)	-	-	-	-	50%	Kupper 2012	-	-	-	-
3Da2a	6%	GHGI	50%	C (EMEP)	-	-	-	-	22%	Infras 2017	-	-	-	-
3Da2b	6%	GHGI	100%	C (EMEP)	-	-	-	-	50%	Kupper 2012	-	-	-	-
3Da2c	6%	GHGI	100%	C (EMEP)	-	-	-	-	50%	Kupper 2012	-	-	-	-
3Da3	6%	GHGI	100%	C (EMEP)	-	-	-	-	38%	Infras 2017	-	-	-	-
3Dc	5%	GHGI (LULUCF)	-	-	200%	EMEP/EEA 2016 (D)	-	-	-	-	200%	EMEP/EEA 2016 (D)	200%	EMEP/EEA 2016 (D)
5A	10%	NIR CH	50%	EMIS	50%	EMIS	40%	EMIS	50%	EMIS	25%	EMIS	30%	EMIS
5B1	100%	EMIS	-	-	100%	EMIS	-	-	100%	EMIS	-	-	-	-
5B2	20%	EMIS	100%	C (EMEP)	30%	EMIS	100%	EMIS	75%	EMIS	100%	EMIS	100%	EMIS
5C1a	50%	EMIS	40%	EMIS	50%	EMIS	40%	EMIS	-	-	30%	EMIS	50%	EMIS
5C1bi	30%	EMIS	30%	EMIS	30%	EMIS	30%	EMIS	-	-	30%	EMIS	30%	EMIS
5C1biii	30%	EMIS	30%	EMIS	30%	EMIS	30%	EMIS	-	-	30%	EMIS	30%	EMIS
5C1biv	20%	EMIS	50%	EMIS	20%	EMIS	30%	EMIS	50%	EMIS	34%	EMIS	35%	EMIS
5C1bv	5%	EMIS	30%	EMIS	30%	EMIS	-	-	-	-	33%	EMIS	33%	EMIS
5C2	48%	EMIS	133%	EMIS	133%	EMIS	117%	EMIS	25%	EMIS	133%	EMIS	133%	EMIS
5D1	1%	EMIS	10%	EMIS	27%	EMIS	37%	EMIS	50%	EMIS	-	-	-	-
5D2	10%	EMIS	10%	EMIS	20%	EMIS	20%	EMIS	-	-	-	-	-	-
5E	20%	EMIS	-	-	24%	EMIS	-	-	-	-	30%	EMIS	30%	EMIS
6A	30%	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 (2016) (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 2019); 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 or “NA”.

Kupper 2012: see References (chp. 12.1).

INFRAS 2017b: see References (chp. 12.1).

Annex 6 Summary information on condensables in PM

Table A - 21: Inclusion/exclusion of the condensable component from PM10 and PM2.5 emission factors

NFR	Source/sector name	PM emissions: the condensable component is		EF reference and comments
		included	excluded	
1	Energy		X	With the exception of the source categories listed below, no condensables are included in the reported PM emissions. For wood energy combustion condensable components are estimated but included in NMVOC emissions (see chapter 3.2.1.1.2).
1A4bi	Charcoal use Bonfire	X		The EF of particulate matter of these two source categories are based on default Tier-2 EF of the EMEP/EEA Guidebook 2013 (chp. 1A4, Table 3-14 (1A4bi open fireplaces burning wood)). According to the EMEP/EEA Guidebook 2016 (chp.1A4, Table 3-39), these EF values correspond to total particles which include both filterable and condensable PM.
2	IPPU		X	
3	Agriculture	NA	NA	
5	Waste		X	
6	Other		X	

Annex 7 Emission time series of main air pollutants and PM2.5 for 1980–2017 and 2020–2030

A7.1 Emission time series by pollutant and aggregated sectors

A7.1.1 NO_x emission time series

Table A - 22: NO_x emissions by sectors 1-6. The last column indicates the relative trend.

NOx	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1	158.2	157.6	156.4	156.6	158.3	158.6	155.5	151.9	146.7	140.4
2	1.6	1.6	1.6	1.6	1.6	1.4	1.2	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	0.4
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	166.9	166.3	165.0	165.2	166.8	166.7	163.3	159.3	153.9	147.1

NOx	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1	133.8	131.2	125.1	118.6	114.8	113.2	110.8	105.5	104.7	102.8
2	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.3	0.3
3	4.9	4.8	4.8	4.6	4.5	4.5	4.4	4.1	4.1	4.0
5	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sum	139.6	136.9	130.8	124.0	120.1	118.4	115.8	110.2	109.4	107.4

NOx	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1	100.3	97.7	92.3	89.6	87.6	86.2	82.5	79.0	76.0	71.8
2	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.4	0.3
3	4.0	4.0	3.9	3.9	3.8	3.9	3.9	3.9	3.9	3.8
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sum	104.9	102.3	96.9	94.1	92.1	90.6	87.0	83.5	80.5	76.2

NOx	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
1	70.8	67.1	66.8	67.1	63.6	61.6	60.1	58.4	-32
2	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	-4
3	4.0	3.8	3.8	3.8	3.9	3.8	3.8	3.9	0
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	14
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	15
Sum	75.4	71.6	71.3	71.5	68.1	66.0	64.5	62.8	-31

Table A - 23: NO_x emissions by sectors 1-6 (projection).

NOx	2020	2025	2030
	kt		
1	52.6	43.5	37.3
2	0.3	0.3	0.3
3	3.8	3.8	3.8
5	0.4	0.4	0.4
6	0.1	0.1	0.1
Sum	57.2	48.1	41.9

A7.1.2 NMVOC emission time series

Table A - 24: NMVOC emissions by sectors 1-6. The last column indicates the relative trend.

NMVOC total	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1	153.3	152.9	151.5	150.7	149.8	148.2	142.7	136.5	129.9	122.5
2	140.4	141.9	143.4	144.9	146.4	148.8	150.3	152.5	154.6	156.2
3	23.3	23.0	22.7	22.3	22.0	21.8	21.5	21.3	21.0	20.8
5	2.6	2.4	2.3	2.1	1.9	1.6	1.5	1.3	1.1	0.9
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sum	319.8	320.3	320.0	320.1	320.2	320.5	316.1	311.7	306.8	300.6

NMVOC total	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1	113.8	108.6	98.9	89.0	77.4	73.2	69.8	64.9	60.7	55.5
2	162.9	150.1	137.6	125.3	117.1	108.3	99.1	91.0	82.8	78.7
3	18.8	18.6	18.3	18.3	18.5	18.5	18.5	18.1	18.0	17.9
5	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Sum	296.4	278.3	255.8	233.5	213.9	200.9	188.4	174.9	162.4	153.0

NMVOC total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1	52.2	49.7	45.3	42.3	39.5	37.1	34.4	31.8	29.9	27.7
2	73.7	69.0	62.0	55.7	49.6	48.8	48.4	47.6	47.4	46.7
3	17.7	18.0	17.9	17.8	17.7	18.0	18.1	18.3	18.6	18.2
5	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.9	0.9	0.9
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Sum	144.5	137.7	126.3	116.7	107.7	104.8	101.9	98.7	96.9	93.8

NMVOC total	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
1	25.2	23.1	22.1	21.3	19.4	18.2	17.5	16.6	-55
2	46.5	45.9	45.5	44.4	42.9	42.4	41.1	42.0	-14
3	18.1	18.0	17.9	17.8	17.9	17.8	17.8	17.7	-1
5	1.0	1.0	1.1	1.1	1.2	1.3	1.3	1.4	81
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	16
Sum	91.0	88.2	86.9	84.9	81.6	79.8	77.9	77.9	-26

Table A - 25: NMVOC emissions by sectors 1-6 (projection).

NMVOC total	2020	2025	2030
	kt		
1	15.2	13.5	12.2
2	41.6	42.3	43.0
3	17.5	17.4	17.4
5	2.4	4.2	6.0
6	0.2	0.2	0.2
Sum	76.9	77.7	78.8

A7.1.3 SO_x emission time series

Table A - 26: SO_x emissions by sectors 1-6. The last column indicates the relative trend.

SO2	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1	110.9	98.0	86.8	80.4	77.4	70.7	65.2	60.2	52.9	43.4
2	2.8	2.8	2.7	2.6	2.5	2.3	2.2	2.0	1.8	1.6
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Sum	114.0	101.0	89.7	83.3	80.2	73.3	67.6	62.4	54.9	45.2

SO2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1	35.0	34.7	32.4	27.9	25.0	25.0	23.6	20.2	21.1	18.2
2	1.5	1.4	1.4	1.1	1.0	0.9	0.9	0.9	0.8	0.7
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Sum	36.7	36.3	34.0	29.2	26.1	26.0	24.5	21.2	22.0	19.1

SO2	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1	15.4	16.2	14.0	14.2	13.7	12.8	12.5	10.9	10.9	9.9
2	0.8	0.8	0.9	0.9	1.1	1.1	0.7	0.7	0.7	0.5
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Sum	16.3	17.1	14.9	15.1	14.9	13.9	13.3	11.6	11.7	10.4

SO2	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
1	9.7	7.8	7.9	7.5	6.8	5.1	4.6	4.5	-65
2	0.8	0.7	0.8	0.6	0.6	0.6	0.8	0.8	-22
3	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	33
6	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0
Sum	10.5	8.5	8.8	8.2	7.5	5.8	5.4	5.4	-61

Table A - 27: SO_x emissions by sectors 1-6 (projection).

SO2	2020	2025	2030
	kt		
1	4.2	3.9	4.0
2	0.7	0.7	0.7
3	NA	NA	NA
5	0.1	0.1	0.1
6	0.01	0.01	0.01
Sum	5.0	4.7	4.9

A7.1.4 NH_3 emission time series

Table A - 28: NH_3 emissions by sectors 1-6. The last column indicates the relative trend.

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	0.6	0.8	1.1	1.4
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	2.3	2.2	2.1	1.9	1.8	1.7	1.6	1.4	1.2
6	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sum	81.5	80.6	79.6	78.7	77.7	77.0	76.7	76.4	76.2	75.9

NH3	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1	1.7	2.0	2.3	2.5	2.6	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	63.1	61.9	60.9	59.9	59.5	58.4	57.7	55.2	54.5	52.8
5	0.9	0.9	0.9	0.9	0.8	0.8	0.9	0.9	0.9	0.9
6	1.0	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
Sum	67.0	66.0	65.3	64.5	64.2	63.4	63.0	60.7	60.2	58.8

NH3	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1	4.9	4.8	4.6	4.3	4.0	3.8	3.5	3.3	3.1	2.9
2	0.4	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.3
3	52.0	51.9	51.1	50.5	50.6	51.7	52.3	53.1	53.5	52.5
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
6	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.9	0.9	0.9
Sum	59.2	58.9	57.9	57.0	56.8	57.7	57.9	58.5	58.7	57.5

NH3	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
1	2.7	2.5	2.3	2.2	2.1	1.9	1.8	1.8	-54
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-49
3	52.7	52.1	51.8	51.3	51.9	51.5	51.3	51.2	-1
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	-3
6	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	15
Sum	57.4	56.6	56.2	55.5	56.0	55.4	55.2	55.1	-5

Table A - 29: NH_3 emissions by sectors 1-6 (projection).

NH3	2020	2025	2030
	kt		
1	1.6	1.6	1.5
2	0.2	0.1	0.1
3	50.7	50.5	50.5
5	1.1	1.5	1.8
6	1.0	1.0	1.0
Sum	54.6	54.7	55.0

A7.1.5 PM2.5 emission time series

Table A - 30: PM2.5 emissions by sectors 1-6. The last column indicates the relative trend.

PM2.5	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1	13.0	13.1	12.8	12.6	12.8	12.7	12.7	12.8	12.7	12.6
2	4.5	4.1	3.6	3.2	2.8	2.7	2.6	2.6	2.6	2.5
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	2.5	2.3	2.1	1.9	1.7	1.5	1.3	1.1	1.0	0.8
6	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Sum	20.0	19.5	18.6	17.8	17.4	17.0	16.8	16.6	16.3	16.1

PM2.5	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1	11.8	12.1	11.6	11.1	10.4	10.5	10.5	9.5	9.4	9.1
2	2.6	2.6	2.7	2.6	2.5	2.1	2.1	2.1	1.7	1.6
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4
6	0.006	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Sum	15.2	15.4	14.9	14.4	13.6	13.3	13.2	12.2	11.7	11.3

PM2.5	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1	8.5	8.5	7.8	7.7	7.5	7.4	7.2	6.6	6.5	6.2
2	1.6	1.5	1.6	1.5	1.6	1.5	1.5	1.6	1.6	1.5
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
6	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Sum	10.7	10.5	9.9	9.8	9.6	9.4	9.2	8.7	8.6	8.2

PM2.5	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
1	6.2	5.5	5.6	5.5	4.9	4.9	4.8	4.7	-36
2	1.5	1.5	1.5	1.5	1.4	1.4	1.3	1.4	-7
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	8
5	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	-17
6	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	35
Sum	8.2	7.5	7.6	7.5	6.8	6.7	6.6	6.6	-30

Table A - 31: PM2.5 emissions by sectors 1-6 (projection).

PM2.5	2020	2025	2030
	kt		
1	4.4	3.9	3.5
2	1.4	1.4	1.4
3	0.1	0.1	0.1
5	0.3	0.3	0.2
6	0.005	0.005	0.005
Sum	6.3	5.7	5.3

A7.1.6 BC emission time series

Table A - 32: BC emissions by sectors 1-6. The last column indicates the relative trend.

BC	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
1	4.85	4.91	4.94	4.98	5.05	5.10	5.21	5.32	5.43	5.53
2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
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	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Sum	5.03	5.08	5.10	5.12	5.17	5.21	5.31	5.41	5.50	5.59

BC	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1	5.06	5.24	4.96	4.79	4.42	4.44	4.47	4.01	3.93	3.78
2	0.01	0.01	0.01	0.01	0.01	0.004	0.004	0.004	0.003	0.003
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	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Sum	5.11	5.29	5.00	4.83	4.46	4.48	4.51	4.05	3.96	3.82

BC	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1	3.51	3.44	3.19	3.18	3.06	3.02	2.85	2.57	2.42	2.26
2	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002
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	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Sum	3.55	3.47	3.22	3.21	3.09	3.05	2.88	2.59	2.45	2.29

BC	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
1	2.19	1.95	1.94	1.75	1.55	1.54	1.44	1.39	-54
2	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	-47
3	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-17
6	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-8
Sum	2.22	1.98	1.97	1.78	1.58	1.57	1.46	1.41	-54

Table A - 33: BC emissions by sectors 1-6 (projection).

BC	2020	2025	2030
	kt		
1	1.20	0.88	0.65
2	0.001	0.001	0.001
3	NA	NA	NA
5	0.02	0.02	0.02
6	0.0001	0.0001	0.0001
Sum	1.22	0.90	0.67

A7.2 1 Energy

A7.2.1 1 Energy: NO_x

Table A - 34: NO_x emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2. The last column indicates the relative trend.

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	106.2	100.9	95.1	88.8
1A4	18.4	18.5	18.2	19.0	20.3	20.8	21.2	21.2	21.1	21.1
1A5	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9
1B2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Sum	158.2	157.6	156.4	156.6	158.3	158.6	155.5	151.9	146.7	140.4

NOx	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1A1	6.8	6.6	6.4	5.4	5.0	4.7	4.7	4.2	4.4	4.0
1A2	22.7	21.6	20.5	19.6	20.0	19.6	18.6	16.3	16.1	16.0
1A3	82.1	79.7	75.4	71.6	69.1	67.5	65.6	64.6	63.9	63.4
1A4	21.1	22.2	21.9	21.1	19.7	20.5	21.0	19.3	19.4	18.6
1A5	0.9	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7
1B2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Sum	133.8	131.2	125.1	118.6	114.8	113.2	110.8	105.5	104.7	102.8

NOx	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1A1	3.6	3.3	3.0	2.6	2.8	3.0	3.2	3.0	3.3	3.2
1A2	15.7	15.9	14.9	14.7	14.9	14.7	14.4	13.7	13.3	12.5
1A3	62.9	59.7	56.8	54.5	52.5	51.4	48.8	47.7	44.6	41.8
1A4	17.2	17.8	16.7	17.0	16.5	16.3	15.5	13.9	14.2	13.7
1A5	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.5
1B2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Sum	100.3	97.7	92.3	89.6	87.6	86.2	82.5	79.0	76.0	71.8

NOx	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
1A1	3.2	3.2	3.3	3.4	3.2	2.6	2.6	2.6	-11.9
1A2	12.4	11.6	11.1	10.8	10.2	9.6	9.4	9.2	-37.8
1A3	40.5	40.0	39.6	39.7	39.2	38.1	36.7	35.7	-30.4
1A4	14.0	11.8	12.3	12.6	10.4	10.8	11.0	10.4	-36.0
1A5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	-26.0
1B2	0.1	0.1	0.1	0.0	0.1	0.03	0.002	0.001	-99.2
Sum	70.8	67.1	66.8	67.1	63.6	61.6	60.1	58.4	-32.2

Table A - 35: NO_x emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 (projection).

NOx	2020	2025	2030
	kt		
1A1	3.5	5.0	6.4
1A2	8.2	7.6	7.3
1A3	31.1	22.5	16.0
1A4	9.3	8.1	7.1
1A5	0.4	0.4	0.4
1B2	0.002	0.001	0.001
Sum	52.6	43.5	37.3

A7.2.2 1 Energy: NMVOC

Table A - 36: NMVOC emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2. The last column indicates the relative trend.

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	0.6	0.5	0.5	0.4
1A2	2.2	2.2	2.1	2.1	2.1	2.1	2.2	2.2	2.3	2.3
1A3	123.3	122.2	121.0	119.6	118.1	116.5	109.5	101.9	93.8	85.2
1A4	13.5	13.8	13.7	13.9	14.4	14.6	15.0	15.4	15.7	16.2
1A5	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
1B2	13.7	14.0	14.0	14.3	14.4	14.2	15.3	16.3	17.5	18.3
Sum	153.3	152.9	151.5	150.7	149.8	148.2	142.7	136.5	129.9	122.5

NMVOC total	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1A1	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
1A2	2.3	2.3	2.3	2.3	2.3	2.4	2.3	2.3	2.3	2.2
1A3	76.1	69.3	60.5	53.5	47.6	44.0	40.5	37.4	34.8	32.5
1A4	15.1	15.7	15.1	14.7	13.7	13.9	14.1	13.0	12.9	12.5
1A5	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1B2	19.8	20.8	20.5	18.1	13.4	12.5	12.4	11.9	10.4	7.9
Sum	113.8	108.6	98.9	89.0	77.4	73.2	69.8	64.9	60.7	55.5

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	0.2	0.2	0.2	0.2
1A2	2.2	2.2	2.1	2.0	2.0	2.0	1.9	1.8	1.7	1.5
1A3	30.2	27.9	25.6	23.2	21.2	19.7	17.6	16.6	15.2	13.8
1A4	11.7	11.6	10.7	10.4	9.8	9.5	8.8	7.9	7.7	7.2
1A5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1B2	7.6	7.7	6.6	6.3	6.1	5.7	5.7	5.2	5.1	4.9
Sum	52.2	49.7	45.3	42.3	39.5	37.1	34.4	31.8	29.9	27.7

NMVOC total	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
1A1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-29
1A2	1.5	1.4	1.3	1.2	1.1	1.0	1.0	1.0	-50
1A3	12.8	11.9	11.0	10.3	9.6	9.1	8.8	8.3	-58
1A4	7.0	5.9	5.8	5.7	4.7	4.6	4.6	4.4	-53
1A5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-36
1B2	3.7	3.7	3.7	3.8	3.7	3.2	2.8	2.7	-53
Sum	25.2	23.1	22.1	21.3	19.4	18.2	17.5	16.6	-55

Table A - 37: NMVOC emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 (projection).

NMVOC total	2020	2025	2030
	kt		
1A1	0.2	0.2	0.2
1A2	0.9	0.8	0.8
1A3	7.4	6.5	5.9
1A4	4.1	3.7	3.3
1A5	0.1	0.1	0.1
1B2	2.8	2.7	2.6
Sum	15.2	13.5	12.2

A7.2.3 1 Energy: SO_x

Table A - 38: SO_x emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2. The last column indicates the relative trend.

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	4.8
1A2	49.5	40.4	34.3	29.6	26.7	22.4	22.1	23.0	21.4	17.6
1A3	6.8	6.5	6.2	5.9	5.5	5.1	4.8	4.5	4.1	3.8
1A4	46.2	42.8	38.2	36.8	37.2	35.4	30.8	25.6	20.8	16.5
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	80.4	77.4	70.7	65.2	60.2	52.9	43.4

SO2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
1A1	4.2	4.6	4.8	2.8	2.7	2.8	2.8	2.3	3.2	2.1
1A2	12.7	11.3	9.6	8.5	8.2	8.1	7.0	5.8	5.9	5.1
1A3	4.1	4.0	3.8	3.4	2.3	2.2	2.2	2.2	2.3	2.5
1A4	13.3	13.9	13.4	12.5	11.2	11.4	11.0	9.4	9.1	8.0
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	35.0	34.7	32.4	27.9	25.0	25.0	23.6	20.2	21.1	18.2

SO2	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
1A1	1.8	1.7	1.4	1.4	1.5	1.6	1.6	1.7	1.8	1.7
1A2	4.6	5.2	4.2	4.4	4.9	4.0	4.5	3.7	3.6	3.2
1A3	1.8	1.6	1.4	1.2	0.2	0.2	0.2	0.2	0.2	0.2
1A4	6.7	7.1	6.5	6.7	6.5	6.4	5.8	4.9	4.9	4.5
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	15.4	16.2	14.0	14.2	13.7	12.8	12.5	10.9	10.9	9.9

SO2	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
1A1	1.7	1.6	1.9	1.9	2.1	0.8	0.4	0.4	-76
1A2	2.9	2.5	2.5	2.3	2.2	2.1	2.1	2.3	-44
1A3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	20
1A4	4.5	3.2	3.1	2.8	1.9	1.7	1.6	1.4	-77
1A5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-10
1B2	0.3	0.3	0.2	0.3	0.3	0.2	0.1	0.1	-75
Sum	9.7	7.8	7.9	7.5	6.8	5.1	4.6	4.5	-65

Table A - 39: SO_x emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 (projection).

SO2	2020	2025	2030
	kt		
1A1	0.6	1.0	1.3
1A2	2.1	2.0	1.8
1A3	0.3	0.2	0.2
1A4	1.1	0.6	0.5
1A5	0.0	0.0	0.0
1B2	0.1	0.1	0.1
Sum	4.2	3.9	4.0

A7.2.4 1 Energy: NH_3

Table A - 40: NH_3 emissions from sector 1 Energy by source categories 1A1-1A5. The last column indicates the relative trend.

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	0.31	0.55	0.80	1.07
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	0.56	0.81	1.08	1.36

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	1.35	1.72	2.02	2.22	2.36	2.57	2.79	3.01	3.24	3.45
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	1.65	2.02	2.31	2.50	2.64	2.86	3.08	3.28	3.53	3.74

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	4.58	4.52	4.26	3.97	3.72	3.47	3.17	2.96	2.74	2.54
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	4.89	4.83	4.58	4.29	4.04	3.80	3.52	3.33	3.14	2.93

NH3	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
1A1	0.04	0.04	0.05	0.05	0.05	0.04	0.04	0.04	69
1A2	0.25	0.24	0.23	0.23	0.26	0.23	0.25	0.24	31
1A3	2.34	2.14	1.94	1.77	1.63	1.51	1.42	1.35	-61
1A4	0.13	0.11	0.12	0.13	0.11	0.12	0.13	0.13	6
1A5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5
Sum	2.75	2.53	2.34	2.17	2.05	1.90	1.83	1.77	-54

Table A - 41: NH_3 emissions from sector 1 Energy by source categories 1A1-1A5 (projection).

NH3	2020	2025	2030
	kt		
1A1	0.07	0.12	0.16
1A2	0.23	0.21	0.20
1A3	1.20	1.10	1.07
1A4	0.12	0.12	0.12
1A5	0.00	0.00	0.00
Sum	1.63	1.56	1.55

A7.2.5 1 Energy: PM2.5

Table A - 42: PM2.5 emissions from sector 1 Energy by source categories 1A1-1A5 and 1B1. The last column indicates the relative trend.

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	2.63	2.51	2.33	2.18	2.23	2.15	2.16	2.20	2.14	2.04
1A3	3.90	3.83	3.76	3.69	3.62	3.55	3.34	3.12	2.89	2.66
1A4	5.28	5.61	5.56	5.55	5.81	5.88	6.12	6.40	6.65	6.98
1A5	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09
1B1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	12.98	13.10	12.80	12.56	12.79	12.70	12.70	12.77	12.69	12.61

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	1.91	1.91	1.84	1.81	1.81	1.86	1.83	1.69	1.70	1.66
1A3	2.74	2.78	2.75	2.69	2.64	2.61	2.54	2.49	2.47	2.45
1A4	6.30	6.62	6.19	5.96	5.37	5.44	5.58	4.87	4.79	4.58
1A5	0.09	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06
1B1	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00005	0.00004	0.00004
Sum	11.84	12.13	11.56	11.11	10.43	10.50	10.49	9.54	9.44	9.10

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	1.60	1.62	1.48	1.50	1.46	1.42	1.37	1.26	1.20	1.06
1A3	2.43	2.31	2.21	2.17	2.12	2.12	2.08	2.00	1.84	1.72
1A4	4.14	4.21	3.87	3.89	3.73	3.71	3.52	3.19	3.29	3.22
1A5	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05
1B1	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Sum	8.54	8.46	7.80	7.75	7.51	7.44	7.15	6.64	6.54	6.21

PM2.5	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
1A1	0.16	0.16	0.19	0.18	0.19	0.11	0.09	0.10	-30
1A2	1.03	0.89	0.90	0.89	0.81	0.81	0.80	0.79	-44
1A3	1.63	1.59	1.55	1.36	1.32	1.29	1.17	1.17	-45
1A4	3.32	2.84	2.95	3.02	2.55	2.63	2.69	2.62	-29
1A5	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	-19
1B1	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-19
Sum	6.18	5.53	5.63	5.50	4.91	4.89	4.80	4.73	-36

Table A - 43: PM2.5 emissions from sector 1 Energy by source categories 1A1-1A5 and 1B1 (projection).

PM2.5	2020	2025	2030
	kt		
1A1	0.15	0.22	0.28
1A2	0.75	0.69	0.63
1A3	1.04	0.90	0.85
1A4	2.45	2.05	1.68
1A5	0.05	0.05	0.05
1B1	0.0001	0.0001	0.0001
Sum	4.43	3.90	3.48

A7.2.6 1 Energy: BC

Table A - 44: BC emissions from sector 1 Energy by source categories 1A1-1A5 and 1B1. The last column indicates the relative trend.

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	0.37	0.36	0.36	0.35	0.36	0.36	0.37	0.38	0.39	0.38
1A3	1.69	1.65	1.61	1.57	1.53	1.49	1.39	1.28	1.18	1.07
1A4	2.72	2.82	2.90	2.98	3.08	3.17	3.38	3.59	3.80	4.01
1A5	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
1B1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	4.85	4.91	4.94	4.98	5.05	5.10	5.21	5.32	5.43	5.53

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	0.38	0.39	0.39	0.39	0.40	0.41	0.40	0.39	0.39	0.38
1A3	1.11	1.14	1.13	1.12	1.12	1.13	1.11	1.10	1.10	1.10
1A4	3.51	3.66	3.38	3.23	2.87	2.87	2.92	2.50	2.41	2.28
1A5	0.03	0.02	0.02	0.02	0.02	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	5.06	5.24	4.96	4.79	4.42	4.44	4.47	4.01	3.93	3.78

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	0.37	0.36	0.33	0.32	0.31	0.29	0.26	0.22	0.19	0.15
1A3	1.11	1.06	1.03	1.03	1.03	1.05	1.05	0.99	0.88	0.80
1A4	2.01	2.00	1.81	1.81	1.70	1.66	1.53	1.34	1.34	1.29
1A5	0.01	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	3.51	3.44	3.19	3.18	3.06	3.02	2.85	2.57	2.42	2.26

BC	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
1A1	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-39
1A2	0.13	0.11	0.10	0.09	0.08	0.07	0.07	0.07	-77
1A3	0.74	0.73	0.70	0.50	0.51	0.50	0.40	0.40	-62
1A4	1.31	1.10	1.13	1.15	0.95	0.96	0.96	0.91	-45
1A5	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-65
1B1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-19
Sum	2.19	1.95	1.94	1.75	1.55	1.54	1.44	1.39	-54

Table A - 45: BC emissions from sector 1 Energy by source categories 1A1-1A5 and 1B1 (projection).

BC	2020	2025	2030
	kt		
1A1	0.01	0.01	0.01
1A2	0.05	0.03	0.02
1A3	0.29	0.17	0.12
1A4	0.85	0.66	0.50
1A5	0.00	0.00	0.00
1B1	0.00	0.00	0.00
Sum	1.20	0.88	0.65

A7.3 2 Industrial processes and product use

A7.3.1 2 Industrial processes and product use: NO_x

Table A - 46: NO_x emissions from sector 2 Industrial processes and product use by source categories 2A-2C, 2G and 2H. The last column indicates the relative trend.

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	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
2H	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Sum	1.62	1.61	1.60	1.58	1.57	1.36	1.17	0.98	0.80	0.64

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	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
2H	0.09	0.08	0.07	0.06	0.06	0.05	0.02	0.03	0.04	0.06
Sum	0.49	0.48	0.48	0.46	0.45	0.31	0.27	0.27	0.28	0.30

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	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.02	0.03
2H	0.07	0.07	0.12	0.14	0.13	0.03	0.05	0.04	0.05	0.07
Sum	0.33	0.35	0.40	0.43	0.42	0.30	0.34	0.33	0.36	0.31

NOx	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
2A	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-12
2B	0.07	0.07	0.07	0.04	0.06	0.03	0.05	0.05	-18
2C	0.17	0.19	0.18	0.17	0.19	0.18	0.18	0.18	4
2G	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-19
2H	0.08	0.10	0.08	0.08	0.07	0.07	0.02	0.03	-8
Sum	0.37	0.39	0.36	0.33	0.35	0.32	0.28	0.29	-4

Table A - 47: NO_x emissions from sector 2 Industrial processes and product use by source categories 2A-2C, 2G and 2H (projection).

NOx	2020	2025	2030
	kt		
2A	0.01	0.01	0.01
2B	0.05	0.05	0.05
2C	0.18	0.17	0.16
2G	0.02	0.02	0.02
2H	0.03	0.05	0.06
Sum	0.28	0.29	0.29

A7.3.2 2 Industrial processes and product use: NMVOC

Table A - 48: NMVOC emissions from sector 2 Industrial processes and product use by source categories 2A-2D, 2G and 2H. The last column indicates the relative trend.

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	0.19	0.20	0.21	0.23	0.24	0.25	0.26	0.73	0.88	0.92
2H	2.43	2.42	2.41	2.43	2.38	2.39	2.41	2.44	2.43	2.46
Sum	140.42	141.90	143.39	144.91	146.36	148.81	150.32	152.48	154.64	156.24

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	136.92	125.84	115.22	104.48	97.60	90.16	82.68	76.01	69.03	65.12
2G	21.49	19.98	18.50	17.10	15.82	14.57	13.19	11.79	10.66	10.38
2H	2.69	2.68	2.70	2.71	2.64	2.60	2.46	2.41	2.34	2.39
Sum	162.87	150.08	137.59	125.28	117.06	108.31	99.15	90.99	82.82	78.67

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	60.68	56.46	49.82	43.80	38.03	37.69	37.60	36.95	36.80	36.61
2G	9.84	9.46	9.12	8.77	8.52	8.20	7.81	7.64	7.47	7.28
2H	2.42	2.43	2.51	2.53	2.55	2.39	2.47	2.52	2.55	2.49
Sum	73.71	69.03	62.02	55.66	49.63	48.79	48.38	47.62	47.36	46.74

NMVOC total	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
2A	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	-12
2B	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.01	-55
2C	0.35	0.39	0.32	0.31	0.31	0.29	0.27	0.28	-39
2D	36.47	35.73	34.93	34.64	33.29	32.63	32.00	32.24	-14
2G	7.05	6.95	7.60	6.85	6.79	6.78	6.77	6.75	-18
2H	2.56	2.72	2.60	2.58	2.45	2.61	2.07	2.71	13
Sum	46.50	45.86	45.51	44.44	42.90	42.35	41.15	42.02	-14

Table A - 49: NMVOC emissions from sector 2 Industrial processes and product use by source categories 2A-2D, 2G and 2H (projection).

NMVOC total	2020	2025	2030
	kt		
2A	0.03	0.03	0.03
2B	0.02	0.02	0.02
2C	0.29	0.31	0.33
2D	31.98	32.49	32.98
2G	6.67	6.71	6.74
2H	2.61	2.75	2.88
Sum	41.60	42.31	42.98

A7.3.3 2 Industrial processes and product use: SO_2

Table A - 50: SO_2 emissions from sector 2 Industrial processes and product use by source categories 2A-2C and 2G-2H. The last column indicates the relative trend.

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	2016	2017	05-17
	kt								%
2A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-12
2B	0.76	0.66	0.74	0.56	0.59	0.62	0.73	0.81	17
2C	0.02	0.02	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	0.00	0.01	27
2H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-8
Sum	0.79	0.69	0.77	0.59	0.62	0.65	0.76	0.83	-22

Table A - 51: SO_2 emissions from sector 2 Industrial processes and product use by source categories 2A-2C and 2G-2H (projection).

SO2	2020	2025	2030
	kt		
2A	0.00	0.00	0.00
2B	0.68	0.68	0.68
2C	0.02	0.02	0.02
2G	0.01	0.01	0.01
2H	0.00	0.00	0.00
Sum	0.71	0.71	0.71

A7.3.4 2 Industrial processes and product use: NH_3

Table A - 52: NH_3 emissions from sector 2 Industrial processes and product use by source categories 2B, 2C, 2G, 2H and 2L. The last column indicates the relative trend.

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	0.16	0.16	0.16	0.16	0.16	0.17	0.18	0.19	0.20
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	0.20	0.20	0.19	0.21	0.20	0.18	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	0.32	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	0.24	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	0.27

NH3	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
2B	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	29
2C	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-16
2G	0.09	0.08	0.09	0.07	0.07	0.06	0.06	0.07	-72
2H	0.10	0.13	0.11	0.09	0.12	0.09	0.08	0.09	-2
2L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35
Sum	0.21	0.23	0.21	0.17	0.20	0.16	0.16	0.18	-50

Table A - 53: NH_3 emissions from sector 2 Industrial processes and product use by source categories 2B, 2C, 2G, 2H and 2L (projection).

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	0.08	0.07	0.05
2L	0.00	0.00	0.00
Sum	0.16	0.14	0.12

A7.3.5 2 Industrial processes and product use: PM2.5

Table A - 54: PM2.5 emissions from sector 2 Industrial processes and product use by source categories 2A-2D and 2G-2I. The last column indicates the rel. trend.

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	2.47	2.10	1.74	1.38	1.02	1.00	0.98	0.96	0.94	0.92
2D	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
2G	0.47	0.48	0.49	0.50	0.50	0.50	0.50	0.50	0.51	0.51
2H	0.83	0.76	0.69	0.63	0.56	0.47	0.44	0.42	0.41	0.39
2I	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Sum	4.24	3.82	3.40	2.99	2.57	2.44	2.40	2.36	2.34	2.31

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	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
2G	0.51	0.51	0.54	0.51	0.50	0.52	0.51	0.50	0.55	0.58
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	2.59	2.58	2.66	2.61	2.54	2.15	2.11	2.11	1.69	1.59

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	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2G	0.55	0.52	0.58	0.58	0.58	0.48	0.51	0.51	0.53	0.55
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	1.56	1.49	1.56	1.53	1.57	1.49	1.51	1.55	1.57	1.52

PM2.5	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
2A	0.44	0.44	0.42	0.43	0.42	0.39	0.40	0.40	-2
2B	0.04	0.03	0.04	0.03	0.03	0.03	0.03	0.03	-43
2C	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-79
2D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47
2G	0.49	0.50	0.52	0.54	0.45	0.42	0.40	0.44	-8
2H	0.44	0.45	0.42	0.40	0.43	0.41	0.39	0.40	-1
2I	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	13
Sum	1.51	1.53	1.50	1.50	1.44	1.36	1.33	1.38	-7

Table A - 55: PM2.5 emissions from sector 2 Industrial processes and product use by source categories 2A-2D and 2G-2I (projection).

PM2.5	**2020**	**2025**	**2030**
		kt	
2A	0.39	0.38	0.38
2B	0.03	0.03	0.03
2C	0.01	0.01	0.01
2D	0.00	0.00	0.00
2G	0.47	0.46	0.46
2H	0.41	0.43	0.45
2I	0.10	0.10	0.10
Sum	1.41	1.43	1.44

A7.3.6 2 Industrial processes and product use: BC

Table A - 56: BC emissions from sector 2 Industrial processes and product use by source categories 2A, 2C, 2D and 2G. The last column indicates the relative trend.

BC	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	t									
2A	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07
2C	9.22	7.94	6.67	5.40	4.12	4.15	4.16	4.19	4.20	4.22
2D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2G	1.91	1.95	1.98	2.02	2.00	1.96	1.96	1.97	1.96	1.98
Sum	11.19	9.95	8.72	7.48	6.19	6.16	6.19	6.22	6.24	6.27

BC	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	t									
2A	0.08	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05
2C	4.24	4.24	4.30	3.56	3.21	2.01	2.18	2.31	0.75	0.79
2D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2G	1.97	1.98	2.09	1.97	1.92	1.92	1.88	1.91	1.94	1.87
Sum	6.29	6.29	6.45	5.59	5.19	3.98	4.12	4.27	2.74	2.72

BC	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	t									
2A	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05
2C	0.77	0.78	0.86	0.94	0.96	0.96	0.28	0.03	0.03	0.02
2D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2G	1.87	1.83	1.84	1.85	1.81	1.62	1.68	1.59	1.62	1.66
Sum	2.69	2.67	2.75	2.84	2.82	2.64	2.01	1.68	1.70	1.74

BC	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kg								%
2A	0.06	0.06	0.05	0.05	0.06	0.05	0.05	0.05	-5.33
2C	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	-97.00
2D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.33
2G	1.51	1.44	1.54	1.48	1.29	1.25	1.30	1.30	-19.73
Sum	1.60	1.53	1.63	1.56	1.38	1.33	1.38	1.38	-47.47

Table A - 57: BC emissions from sector 2 Industrial processes and product use by source categories 2A, 2C, 2D and 2G (projection).

BC	2020	2025	2030
	kg		
2A	0.05	0.05	0.04
2C	0.03	0.03	0.03
2D	0.00	0.00	0.00
2G	1.29	1.26	1.24
Sum	1.37	1.34	1.31

A7.4 3 Agriculture

A7.4.1 3 Agriculture: NO_x

Table A - 58: NO_x emissions from Sector 3 Agriculture by source categories 3B and 3D. The last column indicates the relative trend.

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	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.1	1.1	1.1
3D	3.6	3.5	3.5	3.4	3.3	3.3	3.2	3.0	3.0	3.0
Sum	4.9	4.8	4.8	4.6	4.5	4.5	4.4	4.1	4.1	4.0

NOx	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
3B	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3D	2.9	3.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.8
Sum	4.0	4.0	3.9	3.9	3.8	3.9	3.9	3.9	3.9	3.8

NOx	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
3B	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-2
3D	2.9	2.8	2.8	2.8	2.9	2.8	2.8	2.9	1
Sum	4.0	3.8	3.8	3.8	3.9	3.8	3.8	3.9	0

Table A - 59: NO_x emissions from Sector 3 Agriculture by source categories 3B and 3D (projection).

NOx	2020	2025	2030
	kt		
3B	1.0	1.0	1.0
3D	2.8	2.8	2.8
Sum	3.8	3.8	3.8

A7.4.2 3 Agriculture: NMVOC

Table A - 60: NMVOC emissions from Sector 3 Agriculture by source category 3B and 3D. The last column indicates the relative trend.

NMVOC total	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
3B	21.3	20.9	20.6	20.2	19.9	19.7	19.4	19.1	18.9	18.6
3D	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.2	2.2
Sum	23.3	23.0	22.7	22.3	22.0	21.8	21.5	21.3	21.0	20.8

NMVOC total	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
3B	18.3	18.2	17.9	17.8	18.0	18.0	18.0	17.6	17.5	17.4
3D	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sum	18.8	18.6	18.3	18.3	18.5	18.5	18.5	18.1	18.0	17.9

NMVOC total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
3B	17.2	17.5	17.5	17.3	17.2	17.5	17.7	17.8	18.1	17.8
3D	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sum	17.7	18.0	17.9	17.8	17.7	18.0	18.1	18.3	18.6	18.2

NMVOC total	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
3B	17.6	17.5	17.5	17.4	17.5	17.3	17.3	17.3	-1.5
3D	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-2.4
Sum	18.1	18.0	17.9	17.8	17.9	17.8	17.8	17.7	-1.5

Table A - 61: NMVOC emissions from Sector 3 Agriculture by source category 3B and 3D (projection).

NMVOC total	2020	2025	2030
	kt		
3B	17.1	16.9	16.9
3D	0.5	0.5	0.5
Sum	17.5	17.4	17.4

A7.4.3 3 Agriculture: SO_x

There are no SO_x emissions from sector 3 Agriculture.

A7.4.4 3 Agriculture: NH_3

Table A - 62: NH_3 emissions from Sector 3 Agriculture by source categories 3B and 3D. The last column indicates the relative trend.

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	23.9	23.7	23.4	23.3	23.1	22.7	23.1	23.0	23.6	23.3
3D	39.2	38.2	37.5	36.6	36.4	35.7	34.6	32.2	30.9	29.5
Sum	63.1	61.9	60.9	59.9	59.5	58.4	57.7	55.2	54.5	52.8

NH3	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
3B	23.5	24.1	24.4	24.3	24.3	24.9	25.2	25.3	26.1	26.2
3D	28.5	27.8	26.6	26.2	26.3	26.8	27.1	27.8	27.5	26.3
Sum	52.0	51.9	51.1	50.5	50.6	51.7	52.3	53.1	53.5	52.5

NH3	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
3B	26.5	26.4	26.3	26.1	26.3	26.2	26.0	25.9	4
3D	26.2	25.7	25.5	25.2	25.6	25.3	25.3	25.3	-6
Sum	52.7	52.1	51.8	51.3	51.9	51.5	51.3	51.2	-1

Table A - 63: NH_3 emissions from Sector 3 Agriculture by source categories 3B and 3D (projection).

NH3	2020	2025	2030
	kt		
3B	25.7	25.7	25.7
3D	25.0	24.8	24.8
Sum	50.7	50.5	50.5

A7.4.5 3 Agriculture: PM2.5

Table A - 64: PM2.5 emissions from Sector 3 Agriculture by source category 3B and 3D. The last column indicates the relative trend.

PM2.5	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
3B	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
3D	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sum	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

PM2.5	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	kt									
3B	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
3D	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sum	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

PM2.5	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
3B	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
3D	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sum	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13

PM2.5	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
3B	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	14
3D	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	-3
Sum	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.14	8

Table A - 65: PM2.5 emissions from Sector 3 Agriculture by source category 3B and 3D (projection).

PM2.5	2020	2025	2030
	kt		
3B	0.09	0.09	0.09
3D	0.05	0.05	0.05
Sum	0.14	0.14	0.14

A7.5 5 Waste

A7.5.1 5 Waste: NO_x

Table A - 66: NO_x emissions from sector 5 Waste by source categories 5A-5D. The last column indicates the relative trend.

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	0.48	0.40	0.32	0.23	0.13
Sum	0.78	0.81	0.85	0.90	0.94	0.85	0.76	0.66	0.56	0.44

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	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
Sum	0.32	0.30	0.28	0.26	0.24	0.23	0.22	0.22	0.21	0.20

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	0.0010	0.0012	0.0013	0.0017
5C	0.17	0.16	0.15	0.15	0.16	0.15	0.15	0.15	0.15	0.15
5D	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Sum	0.18	0.17	0.16	0.17	0.17	0.16	0.16	0.16	0.16	0.16

NOx	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
5A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-59
5B	0.0025	0.0031	0.0041	0.0045	0.0046	0.0049	0.0053	0.0055	636
5C	0.15	0.15	0.15	0.16	0.16	0.17	0.17	0.17	13
5D	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	13
Sum	0.16	0.16	0.16	0.17	0.18	0.18	0.19	0.19	14

Table A - 67: NO_x emissions from sector 5 Waste by source categories 5A-5D (projection).

NOx	2020	2025	2030
	kt		
5A	0.00	0.00	0.00
5B	0.013	0.025	0.038
5C	0.14	0.14	0.13
5D	0.22	0.23	0.24
Sum	0.38	0.40	0.42

A7.5.2 5 Waste: NMVOC

Table A - 68: NMVOC emissions from sector 5 Waste by source categories 5A-5E. The last column indicates the relative trend.

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	0.04	0.05	0.06	0.07	0.08	0.09	0.11	0.12	0.13	0.14
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	2.60	2.43	2.25	2.06	1.86	1.64	1.46	1.28	1.10	0.92

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	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.26
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	0.74	0.74	0.75	0.73	0.71	0.70	0.70	0.70	0.70	0.75

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	0.28	0.29	0.30	0.30	0.30	0.32	0.36	0.42	0.46	0.48
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	0.77	0.76	0.77	0.75	0.75	0.75	0.81	0.86	0.90	0.90

NMVOC total	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
5A	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B	0.54	0.58	0.67	0.74	0.80	0.87	0.95	0.99	207
5C	0.36	0.34	0.34	0.34	0.33	0.33	0.32	0.31	-16
5D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13
5E	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0
Sum	0.95	0.99	1.08	1.14	1.19	1.26	1.33	1.36	81

Table A - 69: NMVOC emissions from sector 5 Waste by source categories 5A-5E (projection).

NMVOC total	2020	2025	2030
	kt		
5A	NA	NA	NA
5B	2.08	3.89	5.70
5C	0.27	0.25	0.23
5D	0.01	0.01	0.01
5E	0.06	0.06	0.06
Sum	2.42	4.21	6.00

A7.5.3 5 Waste: SO_x

Table A - 70: SO_x emissions from sector 5 Waste by source categories 5A-5D. The last column indicates the relative trend.

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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	0.23	0.23	0.23	0.23	0.23	0.22	0.22	0.21	0.20	0.19

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	0.00001	0.00001	0.00001	0.00002	0.00003	0.00004	0.00005	0.0001
5C	0.18	0.16	0.14	0.12	0.10	0.09	0.09	0.08	0.08	0.07
5D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	0.18	0.16	0.14	0.12	0.10	0.09	0.09	0.08	0.08	0.07

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	0.0002	0.0002	0.0002	0.0003
5C	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06
5D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06

SO2	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
5A	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B	0.0004	0.0005	0.0006	0.0007	0.0007	0.0007	0.0008	0.0008	636
5C	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.08	32
5D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13
Sum	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.08	33

Table A - 71: SO_x emissions from sector 5 Waste by source categories 5A-5D (projection).

SO2	2020	2025	2030
	kt		
5A	NA	NA	NA
5B	0.0020	0.0038	0.0057
5C	0.06	0.06	0.07
5D	0.02	0.03	0.03
Sum	0.09	0.09	0.10

A7.5.4 5 Waste: NH_3

Table A - 72: NH_3 emissions from sector 5 Waste by source categories 5A-5D. The last column indicates the relative trend.

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	0.07	0.08	0.09	0.10	0.11	0.12	0.14	0.15	0.16	0.17
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	2.34	2.26	2.17	2.06	1.94	1.84	1.71	1.56	1.39	1.20

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	0.18	0.20	0.22	0.23	0.25	0.27	0.29	0.30	0.31	0.34
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	0.91	0.86	0.87	0.85	0.83	0.85	0.86	0.86	0.86	0.88

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	0.37	0.37	0.38	0.38	0.37	0.37	0.38	0.39	0.39	0.39
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	0.91	0.93	0.94	0.92	0.93	0.93	0.93	0.92	0.91	0.89

NH3	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
5A	0.35	0.33	0.32	0.31	0.29	0.28	0.27	0.25	-40
5B	0.40	0.40	0.42	0.44	0.45	0.47	0.49	0.50	34
5C	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	10
5D	0.11	0.12	0.12	0.12	0.12	0.12	0.12	0.12	13
Sum	0.88	0.87	0.88	0.88	0.89	0.89	0.90	0.90	-2.7

Table A - 73: NH_3 emissions from sector 5 Waste by source categories 5A-5D (projection).

NH3	2020	2025	2030
	kt		
5A	0.21	0.17	0.14
5B	0.75	1.15	1.55
5C	0.02	0.02	0.02
5D	0.13	0.13	0.14
Sum	1.11	1.47	1.84

A7.5.5 5 Waste: PM2.5

Table A - 74: PM2.5 emissions from sector 5 Waste by source categories 5A-5C and 5E. The last column indicates the relative trend.

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	0.000000	0.000000	0.000001	0.000001	0.000002	0.000002	0.000003	0.000004
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	0.000004	0.000005	0.000006	0.000005	0.000006	0.000007	0.000009	0.000011	0.000012	0.000015
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	2016	2017	05-17
	kt								%
5A	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B	0.000023	0.000028	0.000037	0.000040	0.000041	0.000044	0.000047	0.000049	636
5C	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	-17
5E	0.002	0.002	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	0.3	0.3	-17

Table A - 75: PM2.5 emissions from sector 5 Waste by source categories 5A-5C and 5E (projection).

PM2.5	2020	2025	2030
	kt		
5A	NA	NA	NA
5B	0.2740	0.2538	0.2336
5C	0.3	0.3	0.2
5E	0.002	0.002	0.002
Sum	0.3	0.3	0.2

A7.5.6 5 Waste: BC

Table A - 76: BC emissions from sector 5 Waste by source categories 5A-5C. The last column indicates the relative trend.

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	2016	2017	05-17
	kt								%
5A	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	636
5C	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-17
Sum	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-17

Table A - 77: BC emissions from sector 5 Waste by source categories 5A-5C (projection).

BC	2020	2025	2030
	kt		
5A	NA	NA	NA
5B	0.00000	0.00001	0.00001
5C	0.020	0.019	0.017
Sum	0.020	0.019	0.017

A7.6 6 Other

A7.6.1 6 Other: NO_x

Table A - 78: NO_x emissions from sector 6 Other by source categories 6Ab-6Ad. The last column indicates the relative trend.

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	0.032	0.030	0.029	0.027	0.028	0.031	0.044	0.047	0.045	0.046
6Ac	0.050	0.050	0.050	0.047	0.044	0.044	0.042	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	0.099	0.097	0.095	0.090	0.087	0.090	0.102	0.099	0.095	0.100

NOx	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
6Ab	0.044	0.043	0.040	0.039	0.037	0.036	0.034	0.033	0.035	0.039
6Ac	0.038	0.041	0.040	0.038	0.039	0.038	0.037	0.039	0.037	0.034
6Ad	0.015	0.016	0.015	0.017	0.016	0.016	0.015	0.016	0.015	0.015
Sum	0.098	0.100	0.096	0.094	0.092	0.090	0.086	0.088	0.087	0.088

NOx	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
6Ab	0.042	0.048	0.056	0.054	0.053	0.054	0.052	0.051	42
6Ac	0.040	0.035	0.034	0.033	0.037	0.033	0.035	0.037	-1
6Ad	0.015	0.016	0.017	0.017	0.013	0.015	0.014	0.015	-8
Sum	0.097	0.099	0.106	0.104	0.104	0.102	0.101	0.103	15

Table A - 79: NO_x emissions from sector 6 Other by source categories 6Ab-6Ad (projection).

NOx	2020	2025	2030
	kt		
6Ab	0.051	0.053	0.053
6Ac	0.037	0.036	0.036
6Ad	0.015	0.015	0.015
Sum	0.103	0.104	0.104

A7.6.2 6 Other: NMVOC

Table A - 80: NMVOC emissions from sector 6 Other by source category 6Ab and 6Ad. The last column indicates the relative trend.

NMVOC total	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	kt									
6Ab	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
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									
6Ab	0.1057	0.1009	0.0958	0.0905	0.0916	0.0950	0.1004	0.1008	0.0948	0.0930
6Ad	0.1290	0.1269	0.1248	0.1227	0.1206	0.1185	0.1164	0.1145	0.1025	0.1137
Sum	0.2346	0.2277	0.2206	0.2131	0.2122	0.2135	0.2169	0.2153	0.1973	0.2067

NMVOC total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
6Ab	0.0884	0.0820	0.0768	0.0720	0.0662	0.0621	0.0599	0.0579	0.0580	0.0697
6Ad	0.1180	0.1260	0.1170	0.1279	0.1264	0.1230	0.1125	0.1254	0.1170	0.1136
Sum	0.2064	0.2081	0.1938	0.1999	0.1926	0.1851	0.1724	0.1833	0.1750	0.1833

NMVOC total	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
6Ab	0.0831	0.0919	0.1075	0.1055	0.1051	0.1045	0.1035	0.1028	66
6Ad	0.1109	0.1202	0.1261	0.1299	0.1018	0.1106	0.1078	0.1121	-9
Sum	0.1941	0.2121	0.2335	0.2354	0.2068	0.2151	0.2113	0.2149	16

Table A - 81: NMVOC emissions from sector 7 Other by source category 6Ab and 6Ad (projection).

NMVOC total	2020	2025	2030
	kt		
6Ab	0.1033	0.1065	0.1065
6Ad	0.1121	0.1121	0.1121
Sum	0.2154	0.2186	0.2186

A7.6.3 6 Other: SO_x

Table A - 82: SO_2 emissions from sector 6 Other by source category 6Ad. The last column indicates the relative trend.

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	0.0099	0.0098	0.0091	0.0099
Sum	0.0104	0.0103	0.0102	0.0101	0.0100	0.0099	0.0099	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	0.0110	0.0108	0.0102	0.0111	0.0105	0.0104
Sum	0.0102	0.0108	0.0103	0.0110	0.0110	0.0108	0.0102	0.0111	0.0105	0.0104

SO2	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
6Ad	0.0102	0.0109	0.0113	0.0116	0.0099	0.0106	0.0104	0.0108	0
Sum	0.0102	0.0109	0.0113	0.0116	0.0099	0.0106	0.0104	0.0108	0

Table A - 83: SO_2 emissions from sector 6 Other by source category 6Ad (projection).

SO2	2020	2025	2030
	kt		
6Ad	0.0108	0.0108	0.0108
Sum	0.0108	0.0108	0.0108

A7.6.4 6 Other: NH_3

Table A - 84: NH_3 emissions from sector 6 Other by source categories 6Aa-6Ac. The last column indicates the relative trend.

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	0.68	0.67	0.65	0.64	0.64	0.65	0.74	0.75	0.74	0.78
6Ac	0.18	0.16	0.15	0.14	0.14	0.14	0.13	0.10	0.10	0.10
Sum	0.98	0.94	0.93	0.90	0.90	0.92	1.00	0.98	0.96	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	0.77	0.72	0.72	0.70	0.66	0.64	0.62	0.61	0.61	0.63
6Ac	0.11	0.11	0.11	0.10	0.11	0.10	0.10	0.11	0.11	0.10
Sum	1.00	0.96	0.96	0.94	0.90	0.87	0.85	0.85	0.86	0.87

NH3	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
6Aa	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15	13
6Ab	0.65	0.70	0.76	0.76	0.76	0.77	0.75	0.74	16
6Ac	0.12	0.10	0.10	0.10	0.12	0.11	0.11	0.12	12
Sum	0.91	0.94	1.00	1.00	1.02	1.02	1.01	1.01	15

Table A - 85: NH_3 emissions from sector 6 Other by source categories 6Aa-6Ac (projection).

NH3	2020	2025	2030
	kt		
6Aa	0.15	0.16	0.17
6Ab	0.73	0.74	0.74
6Ac	0.12	0.11	0.11
Sum	1.00	1.02	1.02

A7.6.5 6 Other: PM2.5

Table A - 86: PM2.5 emissions from sector 6 Other by source categories 6Ab and 6Ad. The last column indicates the relative trend.

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	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
6Ad	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Sum	0.006	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

PM2.5	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	kt									
6Ab	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
6Ad	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Sum	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004

PM2.5	2010	2011	2012	2013	2014	2015	2016	2017	05-17
	kt								%
6Ab	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	83
6Ad	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	-8
Sum	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	35

Table A - 87: PM2.5 emissions from sector 6 Other by source categories 6Ab and 6Ad (projection).

PM2.5	2020	2025	2030
	kt		
6Ab	0.003	0.003	0.003
6Ad	0.002	0.002	0.002
Sum	0.005	0.005	0.005