# Switzerland's Informative Inventory Report 2025 (IIR)

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

Submission of March 2025
to the United Nations ECE Secretariat

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IIR_CHE_2025

# Table of contents

# Glossary

| | |
|---|---|
| AD | Activity data |
| Avenergy | Avenergy Suisse (Swiss Petroleum Association, formerly Erdöl-Vereinigung (EV)) |
| 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 |
| CCGT | Combined cycle gas turbine |
| 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 |
| CLRTAP | UNECE Convention on Long-Range Transboundary Air Pollution |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| CRT | Common Reporting Tables (used for the reporting under the UNFCCC) |
| DDPS | Federal Department of Defense, Civil Protection and Sport |
| DETEC | Department of the Environment, Transport, Energy and Communications |
| DIY | Do it youself markets |
| EF | Emission Factor |
| EMIS | Swiss Emission Information System |
| EMEP | European Monitoring and Evaluation Programme: 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), since 2019: Avenergy Suisse |
| ex | In combination with pollutant (PM2.5 ex, PM10 ex, TSP ex, BC ex or Cd ex)) exhaust fraction of this pollutant emissions |
| FAL | Swiss Federal Research Station for Agroecology and Agriculture (since 2013 Agroscope) |
| FCA | Federal Customs Administration, since 03.01.2022: Federal Office for Customs and Border Security (FOCBS) |
| FEDRO | Swiss Federal Roads Office |

| | |
|---|---|
| FOCA | Federal Office of Civil Aviation |
| FOEN | Federal Office for the Environment (former name SAEFL until 2005) |
| FOCBS | Federal Office for Customs and Border Security, formerly Federal Customs Administration (FCA) |
| FSKB | Fachverband der Schweizerischen Kies- und Betonindustrie |
| FSO | Federal Statistical Office (formerly SFSO) |
| fu | fuel used, principle for calculating activity data and the resulting emissions in the road transportation model (instead of the fuel sold principle) |
| 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 |
| IcdP | Indeno(1,2,3-cd)pyrene (CLRTAP: POP) |
| IIR | Informative Inventory Report (CLRTAP) |
| INFRAS | Research and consulting company, Zurich/Berne |
| IPCC | Intergovernmental Panel on Climate Change |
| IPPU | Industrial Processes and Product Use |
| ICAO | International Civil Aviation Organization |
| I-Teq | International Toxic Equivalent (unit of toxic equivalent factors for PCB’s, PCDDs, PCDFs for Human and Wildlife by WHO |
| IVZ | Swiss information system traffic admission (Informationssystem Verkehrszulassung IVZ) run by FEDRO, formerly MOFIS |
| kt | Kilo tonne (1000 tonnes) |
| L1, L2 | Key category according to level assessment with approach 1, approach 2 |
| LTO | Landing and 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 (since 2022: IVZ) |
| MSW | Municipal Solid Waste |
| NCV | Net Calorific Value |
| NFR | Nomenclature For Reporting |
| $NH_3$ | Ammonia |

| | |
|---|---|
| NID | National Inventory Document |
| 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, Included Elsewhere, Not Occuring, Not Relevant |
| nx | In combination with pollutant (PM2.5 nx, PM10 nx, TSP nx, BC nx or Cd nx)) non-exhaust fraction of this pollutant emissions |
| 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") |
| SCGT | Simple cycle gas turbine |
| SFOE | Swiss Federal Office of Energy |
| SFSO | Swiss Federal Statistical Office, now: Federal Statistical Office (FSO) |
| $SO_x$, $SO_2$ | Sulphur oxides, sulphur dioxide |
| SGWA | Swiss Gas and Water Industry Association |
| SPA | "Schwerpunktaktion", measurement project by the Federal Office for Customs and Border Security (FOCBS) to estimate the sulphur content for diesel oil, gasoline, gas oil Euro and Eco and residual fuel oil |
| swissmem | Swiss Mechanical and Electrical Engineering Industries (Schweizer Maschinen-, Elektro- und Metallindustrie) |
| T1, T2 | Key category according to trend assessment with approach 1, approach 2 |
| TAN | Total Ammonia Nitrogen |
| TFEIP | Task Force on Emission Inventory and Projections |
| TSP | Total Suspended Particulate matter |

| | |
|---|---|
| TSS | "Tankstellensurvey", measurement project by the Federal Office for Customs and Border Security (FOCBS) to estimate the sulphur content for diesel oil and gasoline |
| UNFCCC | United Nations Framework Convention on Climate Change |
| VKTS | Swiss supervising association of textile cleaning |
| VOC | Volatile Organic Compounds |
| VSG/SGIA | Swiss Gas Industry Association |
| VSLF | Swiss association for coating and paint applications |
| VSTB | Swiss association of grass drying plants |
| VTG | Swiss Armed Forces – Defence ("Die Gruppe Verteidigung") |
| WaM | Scenario "With additional Measures" |
| WM | Scenario "With Measures" |
| ZPK | Swiss association of pulp, paper and paperboard industry |

# Executive Summary

### 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 2023 for Estimating and Reporting Emission Data under the Convention on Long Range Transboundary Air Pollution (ECE 2023) and in the EMEP/EEA Air Pollutant Emission Inventory Guidebook, editions 2016, 2019 and 2023 (EMEP/EEA 2016, 2019, 2023).

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" (fu) 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 152 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 1990–2023 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: for the national total CLRTAP, so-called landing and take-off (LTO) emissions of domestic and international flights are taken into account while emissions of international and domestic cruise flights are reported under memo items only (see also chp. 3.1.6.1).

### Switzerland and CLRTAP

Switzerland is a Party to 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 1999 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 and entered into force on 7 October 2019. It includes newly also PM2.5 commitments. This amended protocol entered into force for Switzerland on 22 October 2019.

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 under the CLRTAP. 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 eighteenth 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), 2016 (UNECE 2016), 2020 (UNECE 2020a), 2022 (UNECE 2022a), 2023 (UNECE 2023a) and 2024 (UNECE 2024a). For the latest 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 is given in the chapters of the respective sectors and source categories.

**Key categories, uncertainties and completeness**

In order to identify the most relevant source categories, key category analyses were conducted according to approaches 1 and 2. For both approaches, level assessments were conducted for the years 2023 and 1990 and a trend assessment for 1990-2023. The key category analysis highlights that for the year 2023, Sector 1 Energy is responsible for the majority of emissions of $NO_x$, $SO_x$, PM2.5 and PM10. Sector 2 IPPU and Sector 3 Agriculture contribute most to NMVOC emissions. The large majority of $NH_3$ emissions are caused by livestock production within Sector 3 Agriculture.

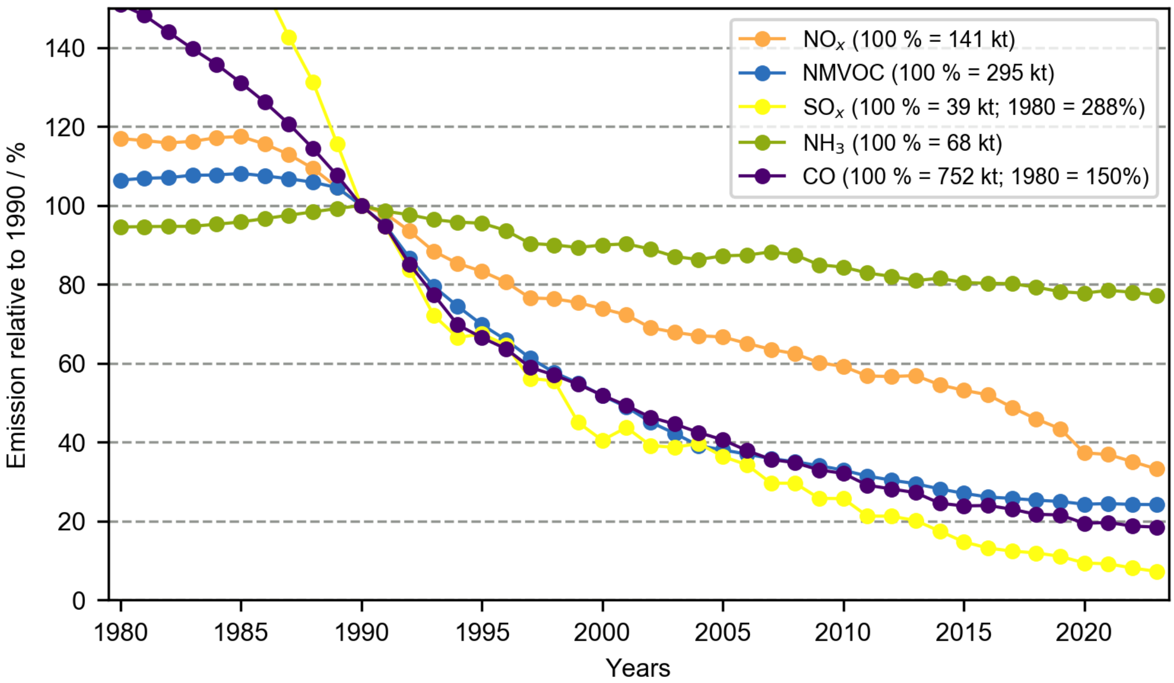
For the main pollutants ($NO_x$, NMVOC, $SO_x$, $NH_3$) as well as for PM2.5 and PM10, the uncertainty of the inventory, resulting from uncertainties from each category, is evaluated according to two methods: uncertainty propagation (approach 1) and Monte Carlo simulations (approach 2). In addition, a Tier 2 approach uncertainty estimation was conducted for agricultural $NH_3$ emissions in 2021. The uncertainty analysis has been carried out for level emissions for the years 1990 and 2023 and for the trend 1990-2023.

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 2022). It was certified by the Swiss Association for Quality and Management Systems in December 2007 and has been re-audited annually. A separate and formalized CLRTAP Inventory quality system is not foreseen. However, a centralised plausibility check for emissions was established that compares emissions of the previous and the latest submission.

## Emission trends 1980-2023




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 between 1990 and 2023. 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 show a smaller reduction mainly due to the decrease of animal numbers and changes in agricultural production techniques.

The drop of emissions in 2020/2021, especially visible for $NO_x$ and CO, is due to reduced traffic volumes during the COVID-19 pandemic.

Emission trends for PM2.5 (not included in ES Figure 1.1, see Figure 2-3) reveal a significant decline between 1980 and 2023 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.

## Characteristics of the sectors

- 1 Energy: the energy sector encompasses stationary and mobile fuel combustion activities and fugitive emissions from handling of fuels, such as losses in the gas network or refining and storage of gasoline and coal. Compared to the other sectors, fuel combustion activities are the main emission source of all air pollutants reported in the IIR except for $NH_3$, NMVOC, TSP and PCB. Within sector 1 Energy, source category 1A3 Transport is the predominant source of all main pollutants except for $SO_x$ and PM2.5, where 1A2 Manufacturing industries and construction and 1A4 Other sectors, respectively, are the most important sources. The emissions of all pollutants from the sector decreased compared to 1990. Note that regarding Pb emissions, sector 1 Energy was the dominant source in 1990 (mainly due to 1A3b Road transportation) but has become less relevant over time due to the fact that only unleaded gasoline is sold in Switzerland since 2000.

- 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 particulate matter (mainly PM2.5, but also PM10 and TSP), $SO_x$ as well as heavy metals (particularly Cd) 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 (until 2006). In source category 2K Consumption of POPs and heavy metals, considerable emissions of PCB are reported. Since 1990, the emissions of all pollutants decreased more or less continuously, although in the past few years, the decrease has been less pronounced for most of the pollutants.
- 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, $NO_x$, PM10 and TSP emissions. 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 in agriculture occurred between 1990 and 2004, followed by an increase until 2007 and then showed a slight but rather constant decrease again. Emissions of $NO_x$ reveal a decreasing trend since 1990 with slight fluctuations. NMVOC emissions mainly stem from 3B Manure management (silage feeding of cattle).
- 4 Land Use, Land-Use Change and Forestry (LULUCF): 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 under memo items in the official emission reporting templates and are described in chapter 7 Other and natural emissions.
- 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 (EMEP/EEA 2023), emissions from the combustion of waste-to-energy activities are therefore dealt within 1A Fuel combustion. Relevant pollutants within sector 5 Waste are NMVOC, PM2.5, heavy metals (especially Pb) and POPs. NMVOC emissions are mainly caused by 5B Biological treatment of solid waste. PM2.5, heavy metals, PCDD/PCDF and PAH emissions mainly originate from source category 5C waste incineration. Emissions in sector 5 Waste have declined since 1990, with the exception of NMVOC (increase).
- 6 Other: In this sector, mainly emissions from human and pet ammonia, private application of synthetic fertiliser as well as fire damages in buildings and in motor vehicles are reported. It is an important source of Pb, PCDD/PCDF, PAH and PCB, mainly due to 6A4 fire damage. Regarding the main pollutants, emissions from sector 6 Other are minor when compared to sectors 1 to 5. Overall, emissions are fluctuating without any significant trends.

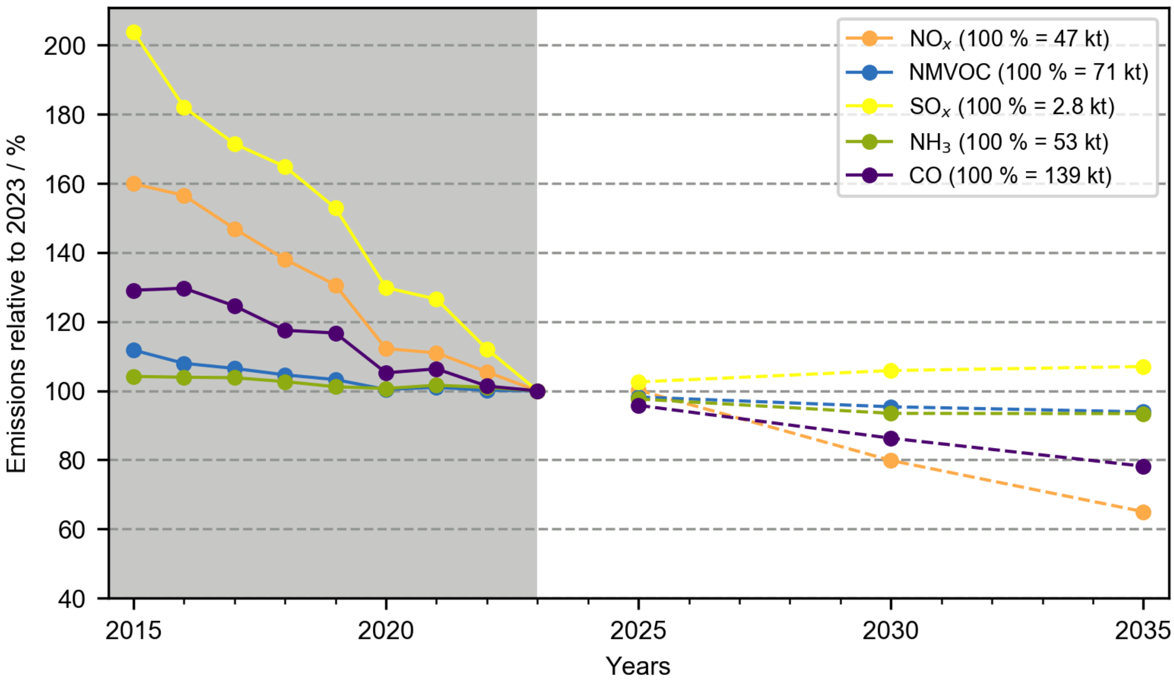
### Projections for emissions until 2035

The emission projections of air pollutants in Switzerland have been fully revised for the submission 2021 and a new “With Measures” (WM) scenario was elaborated.

The projected data for the energy consumption and resulting production quantities in industrial processes are mainly in accordance with the scenarios of the Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020).

For all activities depending on population size the latest perspectives for Switzerland’s inhabitants are integrated (SFSO 2020p), and for the agricultural sector an independent scenario was developed (Swiss Confederation 2017, FOAG 2011, Mack and Möhring 2021).

ES Figure 1.2 shows the past emissions from 2015-2023 and the projected emissions between 2025 and 2035 for main air pollutants under the WM scenario.




ES Figure 1.2 Relative trends for the total emissions from 2015-2023 (grey area) and the projected emissions between 2025 and 2035 for main pollutants and CO in the WM scenario. 100 % corresponds to levels of the latest reporting year.

According to the projections 2025-2035, the main pollutants will develop differently. Total $NO_x$ and CO emissions will continue to decrease significantly, while total emissions of NMVOC, $SO_x$ and $NH_3$ will remain at more or less constant levels.

For suspended particulate matter emissions, the smaller fractions of suspended particulate matter (PM2.5) and BC are expected to continue to decrease, whereas the larger fractions (PM10, TSP) are expected to remain at more or less constant levels because the ratio of the amount of non-exhaust particles to exhaust particles is considerably higher for PM10 and TSP than it is for PM2.5, and will be even higher in the future as the number of vehicles and mileage will increase.

Pb emissions are projected to slightly decrease between 2025 and 2035, whereas total Cd and Hg emissions are remaining about constant.

Total emissions of all persistent organic pollutants (POP) will decrease.

## Gothenburg Protocol

Under the CLRTAP, the 1999 Gothenburg Protocol requires that parties shall reduce and maintain the reduction in annual emission in accordance with national emission targets set for 2010. The following table shows the emission ceilings, the reported emissions for 2010 and the respective compliance. Accordingly, Switzerland is complient with the Gothenburg Protocol emission ceilings for all pollutants except for $NO_x$ in 2010. All emissions 2023 are in compliance with the emission ceilings 2010.

ES Table 1.1 Emission ceilings of the Gothenburg Protocol for 2010 and beyond compared to the reported emissions for 2010 and 2023 of the latest submission (2025).

| Pollutants | National emission ceilings for 2010 | Emissions 2010 (Subm. 2025) | Compliance with emission ceilings 2010 in 2010 | Emissions 2023 (Subm. 2025) | Compliance with emission ceilings 2010 in 2023 |
|---|---|---|---|---|---|
| | kt | kt | | kt | |
| $SO_x$ (as $SO_2$) | 26 | 10 | yes | 2.8 | yes |
| $NO_x$ (as $NO_2$) | 79 | 83 | no | 47 | yes |
| NMVOC | 144 | 97 | yes | 71 | yes |
| $NH_3$ | 63 | 58 | yes | 53 | yes |

The 2012 revised Gothenburg Protocol included emission reduction commitments for 2020 and beyond expressed as a percentage reduction from the 2005 emission level. On 22 October 2019, the amended protocol including the new reduction commitments for 2020, including newly PM2.5, has entered into force for Switzerland. ES Table 1.2 shows the emission reduction commitments for 2020 and the corresponding level of the emissions 2023. The emission reduction commitments 2020 are achieved for all pollutants.

ES Table 1.2 Reported emission reductions 2020 and 2023 versus level of 2005 and reduction commitments per 2020. The emission reduction commitments for 2020 are defined as reductions in percentages from 2005.

| Pollutant | Emission reduction commitments 2020 | Reduction achieved in 2020 | Compliance with reduction commitments 2020 in 2020 | Reduction achieved in 2023 | Compliance with reduction commitments 2020 in 2023 |
|---|---|---|---|---|---|
| | *%-reduction of 2005 level* | *%-reduction of 2005 level* | | *%-reduction of 2005 level* | |
| $SO_x$ (as $SO_2$) | 21% | 74% | yes | 80% | yes |
| $NO_x$ (as $NO_2$) | 41% | 44% | yes | 50% | yes |
| NMVOC | 30% | 36% | yes | 36% | yes |
| $NH_3$ | 8% | 11% | yes | 11% | yes |
| PM2.5 | 26% | 52% | yes | 55% | yes |

## Recalculations and improvements

In 2022, recalculations have a minor effect on the emission levels compared to previous submissions. The recalculations cause a lower emission level by 10.4 % for Cd. For $NO_x$, NMVOC, $SO_x$, PM2.5, CO and Pb, recalculations lead to a decrease of emissions in 2022 between 1 % and 3 %. For all other pollutants, the difference does not exceed 1 %.

Also in 1990, recalculations only have a minor effect on the emission levels compared to previous submissions. The recalculations cause a lower emission level by 2.2 % for Cd. For all other pollutants, the difference in emissions due to recalculations for 1990 does not exceed 1 %.

In the latest submission 2025, several improvements were conducted and a number of further planned improvements are identified. The following improvements had a relevant impact on the inventory in submission 2025:

- 1A: $NO_x$ and CO emission factors of boilers were updated based on a large number of air pollution control measurements of combustion installations (gas oil, natural gas) in several Swiss cantons.
- 2G: The emission factor for Cd was updated for source category 2G Consumption of tobacco products based on a country-specific estimation.

Switzerland prioritizes inventory improvements according to the key category analysis (KCA) and the uncertainty analysis where appropriate. The results of the uncertainty analysis are used to prioritize improvements through the results of the key category analysis, approach 2, in which source categories are sorted by decreasing order of contribution to the inventory uncertainty.

# 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 and its amendment 2012.
- The 1998 Aarhus Protocol on Persistent Organic Pollutants and its both amendments adopted in 2009.
- The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone and its amendment 2012 (national emission reduction commitments for 2020 for $SO_x$ (as $SO_2$), $NO_x$ (as $NO_2$), $NH_3$, NMVOC and for PM2.5).

According to the obligations of the CLRTAP, Switzerland is annually submitting its emission inventory (CLRTAP Inventory). For the present submission in March 2025, Switzerland provides for the eighteenth 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. Thereby, the relevant guidelines including the Guidelines for Reporting Emissions and Projections data under the Convention on Long-range Transboundary Air Pollution (ECE 2023, ECE 2023a), the EMEP/EEA guidebook (EMEP/EEA 2019 and EMEP/EEA 2023) and the 2006 IPCC Guidelines for National Greenhouse Gas Inventories as well as the 2019 Refinement (IPCC 2006, 2019) are also required to be considered.

Various QA/QC activities (see chp. 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 2025/(*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.

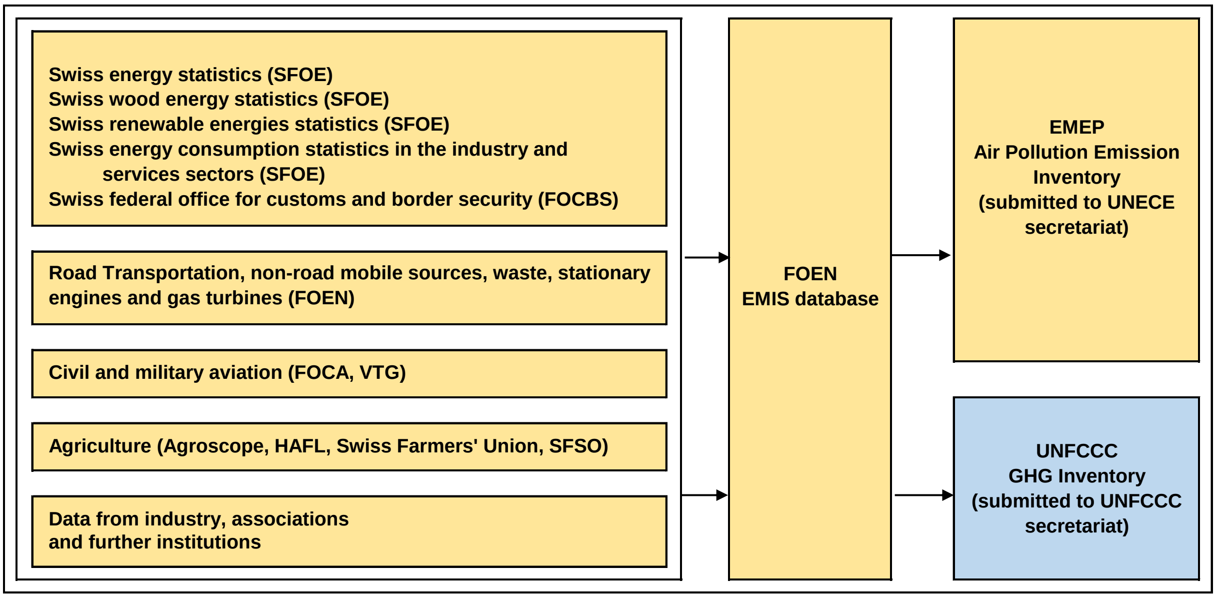



Figure 1-1 Data collection for EMIS database and CLRTAP air pollution emission inventory (GHG: Greenhouse Gas).

The preparation of the CLRTAP Inventory is 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 Document (NID, see FOEN 2025) 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 EMEP Centre on Emission Inventories and Projections (CEIP) and documented on the EMEP Website (UNECE 2024). Additionally, in-depth Stage 3 reviews took place in 2010, 2016, 2020, 2022, 2023 and 2024 documented in UNECE (2010, 2016, 2020a, 2022a, 2023a, 2024a). The recommendations of the latest Stage 1, 2 and 3 reviews were implemented in the latest 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.

## 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 2024 in chp. 8.2 (FOEN 2024b). Switzerland prioritises inventory improvements according to the key category analysis (KCA) and the uncertainty analysis where appropriate. The list shows the current state of realisation:

- *1A: The $NO_x$ and CO emission factors of boilers (gas oil, natural gas) were updated based on a large number of air pollution control measurements of combustion installations in several Swiss cantons. Source categories 1A1a, 1A2gviii, 1A4ai and 1A4bi are key categories for $NO_x$.*
  Current state: Done.
- *2D3 Other solvent use and 2G Other product use: A comprehensive update of all NMVOC emissions from solvent and product use is on-going. Several sub-categories within 2D3 as well as source category 2G are key categories for NMVOCs.*
  Current state: In progress.

Further additional improvements have been implemented for this submission 2025 as follows:

- 2G: The emission factor for Cd was updated for source category 2G Consumption of tobacco products based on a country-specific estimation. Source category 2G is a key category for Cd.
- 1A3: Adjustments were made to driving performance, mileage and energy consumption in the Handbook of Emission Factors for Road Transport (HBEFA, version 4.2. Additionally, new emission factors were adopted to the handbook. This leads to changes in activity data and emission factors in source category 1A3b Road transportation.
- 2H2: The NMVOC emission factor for bread production was updated based on a country-specific estimation. This leads to changes in NMVOC emissions in source category 2H2 Food and beverages industry. Source category 2H2 is a key category for NMVOCs.

### 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 Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution (ECE 2023).
- EMEP/EEA air pollutant emission inventory guidebook — version 2023 (EMEP/EEA 2023), 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 23 states:

*“For Parties for which emission ceilings or emission reduction commitments 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 or emission reduction commitments.”* (ECE 2023)

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 152 of the template because Switzerland’s compliance assessment refers to “fuel used” (fu) and not to “fuel sold”. Differences exclusively occur in sector 1A3b Road transportation (see Table 3-6 and description of system boundaries in chapter 3.1.6.1). 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. The KCA and the uncertainty analysis were carried out with emission values based on fuel used.

The methods used for the NFR sectors are given in the following Table 1-1. The classification follows the EMEP/EEA guidebook (EMEP/EEA 2023) 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. Default emission factors mainly stem from EMEP/EEA 2023. In Sector 1A Fuel Combustion source categories with a higher tier method are listed specifically. The methods described for sectors marked with a * apply only to the specific source category description.

| Sector | Source category | Method applied | Emission factors | Activity data |
|---|---|---|---|---|
| **1** | **Energy** | | | |
| 1A | Fuel Combustion activities<br>(excluding source categories marked with a * below) | T2 | CS, D | CS |
| 1A2gvii*<br>1A3a*<br>1A3c*<br>1A3d*<br>1A4aii*<br>1A4bii*<br>1A4cii*<br>1A5b* | Mobile combustion in manufacturing industries and construction<br>Civil Aviation<br>Railways<br>Domestic navigation<br>Commercial/Institutional: Mobile<br>Residential: Household and gardening (mobile)<br>Agriculture/Forestry/Fishing: Off-road vehicles and other machinery<br>Other (Military non-road) | T3 | CS, D | CS |
| 1A3b* | Road Transportation | T3 (exhaust pol.),<br>T2 (non-exhaust pol.) | CS, D | CS |
| 1B | Fugitive emissions from fuels | T1, T2, T3 | CS, D | CS |
| **2** | **Industrial processes and product use** | | | |
| 2A | Mineral products | T2 | CS, D | CS |
| 2B | Chemical industry | T2 | CS | CS |
| 2C | Metal production | T2 | CS, D | CS |
| 2D | Other solvent and product use | T1, T2 | CS, D | CS |
| 2G | Other product use | T2 | CS, D | CS |
| 2H | Other | T2 | CS | CS |
| 2I | Wood processing | T2 | CS | CS |
| 2K | Consumption of POPs and heavy metals | T2 | 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 | T2 | 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 2023).

EMIS maintains a database where emissions for various pollutants and greenhouse gases are calculated using emission factors and activity data according to the EMEP/EEA methodology, respectively IPCC Guidelines. Pollutants included are $NO_x$, NMVOC, $SO_x$, $NH_3$, particulate matter (PM2.5, PM10, TSP and BC), CO, priority heavy metals (Pb, Cd and Hg), POPs (PCDD/PCDF and PAHs), HCB and PCB, 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 various emission measurements, production data and emission factors from the industry, industry associations and research institutions and from Swiss statistics concerning population size, employment, waste and agriculture. Amongst others, these are 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.

As much as possible, all tables and figures in the IIR contain numeric values that are stored in and can be directly traced back to the EMIS database. All displayed units are (multiple of) existing units according to the international system of units. For all tables, by default two significant figures are represented for each value, independently of the uncertainty associated to the value. For a few tables representing trends, three significant figures are used to make the trend visible. In graphs, units for axis are represented following the guideline from the Bureau International des Poids et Mesures (BIPM 2019), i.e. the sign "/" is represented before the unit.

### 1.4.4 Data suppliers

Table 1-2 Primary and secondary data suppliers: 1–13 provide annual updates, 14–21 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/VTG | 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 | | | | | x | x | | | | |
| 13 | Avernergy Suisse / 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 | INFRAS | Model of stationary engines and gas turbines | x | x | x | x | | | | | | | |
| 20 | ecolot | Solvents and product use | | | | | | | x | | | | |
| 21 | Verenum | Wood energy, emission factor model | x | x | | x | | | | | | | |

## 1.5 Key categories

In order to identify the source categories which are the main contributors to the emissions of each pollutant ("level assessment"), or to the emission trend between the base year 1990 and the reporting year ("trend assessment"), and/or to the associated uncertainties, a Key Category Analysis (KCA) is performed according to the methodology described in the EMEP/EEA guidebook (EMEP/EEA 2023). Note that to compute the trend assessment, we use the formula from the 2019 Refinement to the 2006 IPCC Guidelines (IPCC 2019). The KCA can be performed based on two approaches: in approach 1, categories are set out in decreasing order of contribution to the inventory emissions or trend. In approach 2, this ranking is weighted by the uncertainty assigned to each category. Approach 1 therefore highlights categories which mostly contribute to emissions or to emission changes, while approach 2 identifies categories mostly contributing to the inventory uncertainty. A key category is prioritised within the inventory system because its estimate has a significant influence on the national total.

Note that for this submission, the key category analysis is performed based on the approach "fuels used", (in contrast to "fuels sold"; for differentiation of the two approaches see chapter 3.1.6.1). For approach 2 of the KCA, the emission uncertainty of each category is taken from the results of the Monte Carlo simulations (see details in chp. 1.7).

For the pollutants for which uncertainty estimates are available ($NO_x$, NMVOC, $SO_x$, $NH_3$, PM2.5 and PM10), key category analyses were conducted according to approach 1 and 2, for the base year, the reporting year and the trend. A KCA according to approach 1 was also conducted for TSP, BC, CO, Pb, Cd, Hg, PCDD/PCDF, PAHs, HCB and PCBs. All level and trend assessments were performed for all emission sources accounting for 80 % of the total national emissions (or total national trend).

### 1.5.1 Summary of KCA results, approaches 1 and 2

By comparison to the previous submission, the major sources of pollutants remain very similar:

- For $NO_x$, a large fraction of emissions for the year 2023 are caused by category 1A3 Transport. The three source categories 1A3bi Passenger cars, 1A3bii Light duty-vehicles and 1A3biii Heavy-duty vehicles and buses represents almost half of the inventory emissions. Each of these categories has a pronounced decreasing trend between 1990 and 2023 (see also chp. 2.3.1 and Annex A1.2).
- For NMVOCs, the major contributors are categories 2D3 Other solvent use and 3B1 Manure management.
- For $SO_x$, category 1A2f Non-metallic minerals represents about 45 % of emissions. Its trend for 1990-2023 is decreasing.
- Almost all $NH_3$ emissions originate from livestock production within Sector 3 Agriculture, particularly from 3Da2a Animal manure applied to soils and 3B Manure management.
- For PM2.5 the main source is category 1A4bi Residential: stationary plants, with approx. one third of emissions, followed by 1A3bvi Road transportation: automobile tyre and brake wear (15 %, note that this category contains only non-exhaust emissions). The trend 1990-2023 for category 1A3bvi is positive whereas it is negative for 1A4bi.
- The main source of PM10 emissions is category 1A3bvi Road transportation: automobile tyre and brake wear, representing 18 % of emissions, followed by categories 1A2gvii Mobile combustion in manufacturing industries and construction (17 %). As for PM2.5, the trend 1990-2023 for category 1A3bvi is positive.

Due to the absence of significantly large recalculations, there is no outstanding change in the list of key categories to report. The detailed results of the key category analysis, approaches 1 and 2, level and trend assessments, are reported in Table 1-3 to Table 1-11, where numeric values represent the percentage contributions to the assessment total, for each pollutant. In each table, the source categories are set out in order according to their NFR code.

## 1.5.2 KCA approach 1 results

### 1.5.2.1 Level key category analysis (approach 1)

The results of the key category analysis according to approach 1, level, are summarised in Table 1-3 for the year 1990 and in Table 1-4 for the year 2023 for $NO_x$, NMVOC, $SO_x$, $NH_3$, PM2.5 and PM10. See Table 1-5 and Table 1-6 for TSP, BC, CO, Pb, Cd, Hg, PCDD/PCDF, PAHs, HCB and PCBs.

Table 1-3 List of Switzerland's approach 1 level key categories for 1990, for the main pollutants, PM2.5 and PM10. Contributions are given in percentage of the total assessment per pollutant and depicted using a colour scale, a darker colour indicating a larger contribution. The bottom line reports the cumulative total over all key source categories per pollutant, which amounts to more than 80 % according to the KCA procedure. The column to the right reports the sum of contributions from all pollutants per category.

| NFR Code | Source category | Key categories approach 1: % level contribution to totals 1990 | | | | | | % sum of category |
|---|---|---|---|---|---|---|---|---|
| | | NOx | NMVOC | SOx | NH3 | PM2.5 | PM10 | |
| 1A1a | Public electricity and heat production | 4.5 | | 9.4 | | 2.9 | 2.9 | 20 |
| 1A2d | Stationary combustion in manufacturing industries and construction: pulp paper and print | | | 8.3 | | | | 8.3 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | 7.5 | | 9.0 | | | 2.3 | 19 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | 4.5 | | | | 2.7 | 6.0 | 13 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | | | 9.0 | | 3.2 | 2.5 | 15 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | 31 | 19 | 4.1 | | | | 54 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | 4.4 | | | | | | 4.4 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | 21 | | 4.7 | | 5.8 | 4.3 | 36 |
| 1A3bv(fu) | Road transportation: gasoline evaporation (fuel used) | | 5.8 | | | | | 5.8 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | | | | | 2.5 | 5.6 | 8.1 |
| 1A3c | Railways | | | | | | 2.7 | 2.7 |
| 1A4ai | Commercial/institutional: stationary | | | 9.9 | | 5.0 | 3.9 | 19 |
| 1A4bi | Residential: stationary plants | 8.3 | 3.4 | 26 | | 53 | 42 | 134 |
| 1A4ci | Agriculture/forestry/fishing: stationary | | | | | 2.6 | | 2.6 |
| 1B2av | Distribution of oil products | | 6.5 | | | | | 6.5 |
| 2C1 | Iron and steel production | | | | | 3.0 | 4.1 | 7.1 |
| 2D3a | Domestic solvent use including fungicides | | 3.0 | | | | | 3.0 |
| 2D3d | Coating applications | | 14 | | | | | 14 |
| 2D3e | Degreasing | | 4.0 | | | | | 4.0 |
| 2D3g | Chemical products | | 9.3 | | | | | 9.3 |
| 2D3h | Printing | | 6.9 | | | | | 6.9 |
| 2G | Other product use | | 7.6 | | | | | 7.6 |
| 2I | Wood processing | | | | | | 2.4 | 2.4 |
| 3B1a | Manure management - Dairy cattle | | 2.2 | | 14 | | | 16 |
| 3B1b | Manure management - Non-dairy cattle | | | | 7.6 | | | 7.6 |
| 3B3 | Manure management - Swine | | | | 10 | | | 10 |
| 3Da2a | Animal manure applied to soils | | | | 50 | | | 50 |
| 3De | Cultivated crops | | | | | | 2.9 | 2.9 |
| Total contribution from key categories, % | | 81 | 81 | 81 | 82 | 81 | 81 | |

Table 1-4 List of Switzerland's approach 1 level key categories 2023, for the main pollutants, PM2.5 and PM10. Contributions are given in percentage of the total assessment per pollutant and depicted using a colour scale, a darker colour indicating a larger contribution. The bottom line reports the cumulative total over all key source categories per pollutant, which amounts to more than 80 % according to the KCA procedure. The column to the right reports the sum of contributions from all pollutants per category.

| NFR Code | Source category | Key categories approach 1: % level contribution to totals 2023 | | | | | | % sum of |
|---|---|---|---|---|---|---|---|---|
| | | NOx | NMVOC | SOx | NH3 | PM2.5 | PM10 | category |
| 1A1a | Public electricity and heat production | 4.8 | | 9.0 | | | | 14 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | 6.0 | | 46 | | | | 52 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | | | | | 6.2 | 17 | 23 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | 3.5 | | 9.2 | | 3.0 | | 16 |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | 4.2 | | 4.9 | | | | 9.1 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | 32 | 5.1 | | | | | 37 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | 7.5 | | | | | | 7.5 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | 6.5 | | | | | | 6.5 |
| 1A3bv(fu) | Road transportation: gasoline evaporation (fuel used) | | 2.5 | | | | | 2.5 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | | | | | 15 | 19 | 34 |
| 1A3c | Railways | | | | | 3.7 | 11 | 15 |
| 1A4ai | Commercial/institutional: stationary | 6.1 | | | | 6.9 | 3.2 | 16 |
| 1A4bi | Residential: stationary plants | 7.4 | 3.3 | 7.3 | | 30 | 14 | 62 |
| 1A4ci | Agriculture/forestry/fishing: stationary | | | | | 3.3 | | 3.3 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | 3.4 | | | | | | 3.4 |
| 1A5b | Other mobile (including military land-based and recreational boats) | | | | | | 1.9 | 1.9 |
| 1B2av | Distribution of oil products | | 2.8 | | | | | 2.8 |
| 2A5a | Quarrying and mining of minerals other than coal | | | | | | 2.5 | 2.5 |
| 2B5 | Carbide production | | | 7.0 | | | | 7.0 |
| 2D3a | Domestic solvent use including fungicides | | 9.1 | | | | | 9.1 |
| 2D3b | Road paving with asphalt | | 3.8 | | | | | 3.8 |
| 2D3d | Coating applications | | 12 | | | | | 12 |
| 2D3e | Degreasing | | 2.2 | | | | | 2.2 |
| 2D3g | Chemical products | | 4.5 | | | | | 4.5 |
| 2D3h | Printing | | 5.1 | | | | | 5.1 |
| 2D3i | Other solvent use | | 2.7 | | | | | 2.7 |
| 2G | Other product use | | 8.9 | | | 5.3 | 2.8 | 17 |
| 2H1 | Pulp and paper industry | | | | | 2.4 | | 2.4 |
| 2H2 | Food and beverages industry | | | | | 2.7 | 2.2 | 4.9 |
| 3B1a | Manure management - Dairy cattle | | 9.2 | | 19 | | | 28 |
| 3B1b | Manure management - Non-dairy cattle | | 10 | | 14 | | | 24 |
| 3B3 | Manure management - Swine | | | | 9.0 | | | 9.0 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | | | | 4.3 | | | 4.3 |
| 3Da2a | Animal manure applied to soils | | | | 38 | | | 38 |
| 3De | Cultivated crops | | | | | | 7.1 | 7.1 |
| 5C1a | Municipal waste incineration | | | | | 3.5 | 1.7 | 5.3 |
| Total contribution from key categories, % | | 82 | 81 | 83 | 84 | 82 | 81 | |

Table 1-5 List of Switzerland's approach 1 level key categories 1990, for TSP, BC, CO, priority heavy metals, PCDD/PCDF, PAHs total, HCB and PCBs. Contributions are given in percentage of the total assessment per pollutant and depicted using a colour scale, a darker colour indicating a larger contribution. The bottom line reports the cumulative total over all key source categories per pollutant, which amounts to more than 80 % according to the KCA procedure. The column to the right reports the sum of contributions from all pollutants per category.

| NFR Code | Source category | Key categories approach 1: % level contribution to totals 1990 | | | | | | | | | | % sum of category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TSP | BC | CO | Pb | Cd | Hg | PCDD/PCDF | PAHs total | HCB | PCB | |
| 1A1a | Public electricity and heat production | 1.9 | | | 8.4 | 55 | 62 | 68 | | | | 195 |
| 1A2b | Stationary combustion in manufacturing industries and construction: non-ferrous metals | | | | | | | | | 100 | | 100 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | 2.2 | | | | 21 | | | | | | 23 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | 5.4 | 4.5 | | | | | | | | | 9.8 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | | 4.2 | 56 | 60 | | | | | | | 120 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | | | 9.6 | | | | | | | | 9.6 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | 2.8 | 14 | | | | | | | | | 17 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | 3.6 | | | | | | | | | | 3.6 |
| 1A3c | Railways | 2.3 | | | | | | | | | | 2.3 |
| 1A4ai | Commercial/institutional: stationary | 2.7 | 5.2 | | | | | | | | | 7.9 |
| 1A4bi | Residential: stationary plants | 29 | 56 | 15 | | | | 9.2 | 71 | | | 180 |
| 2B10a | Chemical industry: other | | | | | | 6.1 | | | | | 6.1 |
| 2C1 | Iron and steel production | 4.8 | | | 17 | 14 | 18 | 6.5 | | | | 60 |
| 2C3 | Aluminium production | | | | | | | | 12 | | | 12 |
| 2I | Wood processing | 7.7 | | | | | | | | | | 7.7 |
| 2K | Consumption of POPs and heavy metals (e.g. electrical and scientific equipment) | | | | | | | | | | 65 | 65 |
| 3De | Cultivated crops | 19 | | | | | | | | | | 19 |
| 5E | Other waste | | | | | | | | | | 9.2 | 9.2 |
| 6A | Other sources | | | | | | | | | | 12 | 12 |
| Total contribution from key categories, % | | 81 | 84 | 81 | 85 | 90 | 86 | 83 | 83 | 100 | 87 | |

Table 1-6 List of Switzerland's approach 1 level key categories 2023, for TSP, BC, CO, priority heavy metals, PCDD/PCDF, PAHs total, HCB and PCBs. Contributions are given in percentage of the total assessment per pollutant and depicted using a colour scale, a darker colour indicating a larger contribution. The bottom line reports the cumulative total over all key source categories per pollutant, which amounts to more than 80 % according to the KCA procedure. The column to the right reports the sum of contributions from all pollutants per category.

| NFR Code | Source category | Key categories approach 1: % level contribution to totals 2023 | | | | | | | | | | % sum of category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TSP | BC | CO | Pb | Cd | Hg | PCDD/PCDF | PAHs total | HCB | PCB | |
| 1A1a | Public electricity and heat production | | | | 22 | 37 | 52 | 8.1 | | 54 | | 174 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | | | 5.9 | | 6.2 | 10 | | | | | 22 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | 13 | | | | 4.7 | | | | | | 17 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | | | | 7.5 | | 5.0 | | | | | 12 |
| 1A3aii(i) | Civil aviation (domestic cruise) | | | | 8.5 | | | | | | | 8.5 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | | | 33 | | | | | 8.9 | | | 42 |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | | | 3.5 | | | | | | | | 3.5 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | 9.3 | 12 | | | 23 | | | | | | 43 |
| 1A3c | Railways | 7.2 | | | | | | | | | | 7.2 |
| 1A3dii | National navigation (shipping) | | | 3.6 | | | | | | | | 3.6 |
| 1A4ai | Commercial/institutional: stationary | 1.7 | 9.1 | 4.5 | | | | 9.5 | 11 | 11 | | 46 |
| 1A4aii | Commercial/institutional: mobile | | | 4.7 | | | | | | | | 4.7 |
| 1A4bi | Residential: stationary plants | 7.3 | 50 | 17 | 4.4 | 6.2 | 8.3 | 34 | 57 | 25 | | 210 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | | 9.3 | 8.8 | | | | | | | | 18 |
| 2A5a | Quarrying and mining of minerals other than coal | 3.0 | | | | | | | | | | 3.0 |
| 2C1 | Iron and steel production | | | | | | 6.7 | | | | | 6.7 |
| 2G | Other product use | | | | | 6.5 | | | | | | 6.5 |
| 2K | Consumption of POPs and heavy metals (e.g. electrical and scientific equipment) | | | | | | | | | | 90 | 90 |
| 3B3 | Manure management - Swine | 2.2 | | | | | | | | | | 2.2 |
| 3B4gi | Manure management - Laying hens | 2.6 | | | | | | | | | | 2.6 |
| 3De | Cultivated crops | 36 | | | | | | | | | | 36 |
| 5C1a | Municipal waste incineration | | | | 20 | | | 20 | | | | 40 |
| 5C2 | Open burning of waste | | | | | | | | 8.1 | | | 8.1 |
| 6A | Other sources | | | | 22 | | | 8.1 | | | | 30 |
| Total contribution from key categories, % | | 81 | 80 | 81 | 84 | 84 | 82 | 80 | 85 | 89 | 90 | |

### 1.5.2.2 Trend key category analysis (approach 1)

The results of the KCA according to approach 1, trend, for 1990-2023 are summarised in Table 1-7 and Table 1-8.

Table 1-7 List of Switzerland's approach 1 key categories for the trend 1990-2023, for the main pollutants, PM2.5 and PM10. Contributions are given in percentage of the total assessment per pollutant and depicted using a colour scale, a darker colour indicating a larger contribution. The bottom line reports the cumulative total over all key source categories per pollutant, which amounts to more than 80 % according to the KCA procedure. The column to the right reports the sum of contributions from all pollutants per category.

| NFR Code | Source category | Key categories approach 1: % contribution to trend 1990 - 2023 | | | | | | % sum of category |
|---|---|---|---|---|---|---|---|---|
| | | NOx | NMVOC | SOx | NH3 | PM2.5 | PM10 | |
| 1A1a | Public electricity and heat production | | | | | 2.8 | 2.7 | 5.5 |
| 1A2d | Stationary combustion in manufacturing industries and construction: pulp paper and print | | | 8.0 | | | | 8.0 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | 3.7 | | 36 | | | 1.9 | 41 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | 3.1 | | | | 4.6 | 11 | 19 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | 4.9 | | | | | | 4.9 |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | 8.5 | | 4.4 | | | | 13 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | 2.6 | 19 | | | | | 22 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | 7.8 | | | | | | 7.8 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | 37 | | 4.2 | | 6.9 | 4.3 | 52 |
| 1A3bv(fu) | Road transportation: gasoline evaporation (fuel used) | | 4.6 | | | | | 4.6 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | | | | | 17 | 14 | 31 |
| 1A3c | Railways | | | | | 4.1 | 8.6 | 13 |
| 1A3dii | National navigation (shipping) | 3.0 | | | | | | 3.0 |
| 1A4ai | Commercial/institutional: stationary | 6.1 | | 6.7 | | 2.5 | | 15 |
| 1A4bi | Residential: stationary plants | | | 18 | | 31 | 30 | 80 |
| 1B2av | Distribution of oil products | | 5.0 | | | | | 5.0 |
| 2B5 | Carbide production | | | 5.2 | | | | 5.2 |
| 2C1 | Iron and steel production | | | | | 3.8 | 4.2 | 8.1 |
| 2D3a | Domestic solvent use including fungicides | | 8.4 | | | | | 8.4 |
| 2D3b | Road paving with asphalt | | 2.9 | | | | | 2.9 |
| 2D3d | Coating applications | | 3.0 | | | | | 3.0 |
| 2D3e | Degreasing | | 2.5 | | | | | 2.5 |
| 2D3g | Chemical products | | 6.7 | | | | | 6.7 |
| 2D3h | Printing | | 2.5 | | | | | 2.5 |
| 2G | Other product use | | | | | 4.5 | | 4.5 |
| 2H2 | Food and beverages industry | | 2.1 | | | 2.6 | | 4.7 |
| 3B1a | Manure management - Dairy cattle | | 9.7 | | 15 | | | 25 |
| 3B1b | Manure management - Non-dairy cattle | | 12 | | 16 | | | 28 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | | | | 5.3 | | | 5.3 |
| 3Da2a | Animal manure applied to soils | 4.1 | | | 33 | | | 37 |
| 3Da2b | Sewage sludge applied to soils | | | | 4.6 | | | 4.6 |
| 3Da2c | Other organic fertilisers applied to soils (including compost) | | | | 5.1 | | | 5.1 |
| 3Da3 | Urine and dung deposited by grazing animals | | | | 4.2 | | | 4.2 |
| 3De | Cultivated crops | | | | | | 4.5 | 4.5 |
| 5B2 | Biological treatment of waste - Anaerobic digestion at biogas facilities | | 2.2 | | | | | 2.2 |
| Total contribution from key categories, % | | 81 | 81 | 83 | 83 | 80 | 81 | |

Table 1-8 List of Switzerland's approach 1 key categories for the trend 1990-2023, for TSP, BC, CO, priority heavy metals, PCDD/PCDF, PAHs total, HCB and PCBs. Contributions are given in percentage of the total assessment per pollutant and depicted using a colour scale, a darker colour indicating a larger contribution. The bottom line reports the cumulative total over all key source categories per pollutant, which amounts to more than 80 % according to the KCA procedure. The column to the right reports the sum of contributions from all pollutants per category.

| NFR Code | Source category | Key categories approach 1: % contribution to trend 1990 - 2023 | | | | | | | | | | % sum of category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TSP | BC | CO | Pb | Cd | Hg | PCDD/ PCDF | PAHs total | HCB | PCB | |
| 1A1a | Public electricity and heat production | | | | 8.6 | 19 | 16 | 41 | | 27 | 14 | 126 |
| 1A2b | Stationary combustion in manufacturing industries and construction: non-ferrous metals | | | | | | | | | 50 | | 50 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | 2.2 | | 6.6 | | 16 | 11 | | | | | 35 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | 8.2 | 5.1 | | | 4.6 | | | | | | 18 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | | | | | | 7.7 | | | | | 7.7 |
| 1A3aii(i) | Civil aviation (domestic cruise) | | | | 5.0 | | | | | | | 5.0 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | | | 37 | 37 | | | | 15 | | | 89 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | | | 11 | | | | | | | | 11 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | 3.1 | 25 | | | | | | | | | 28 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | 6.4 | 21 | | | 22 | | | | | | 50 |
| 1A3c | Railways | 5.6 | | | | | | | | | | 5.6 |
| 1A4ai | Commercial/institutional: stationary | | 8.1 | 4.7 | | | 7.7 | 5.8 | 8.8 | | | 35 |
| 1A4aii | Commercial/institutional: mobile | | | 6.6 | | | | | | | | 6.6 |
| 1A4bi | Residential: stationary plants | 24 | 13 | 3.7 | | | 12 | 17 | 26 | 12 | | 109 |
| 1A4bii | Residential: household and gardening (mobile) | | | 3.8 | | | | | | | | 3.8 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | | 11 | 8.1 | | | | | | | | 19 |
| 2B10a | Chemical industry: other | | | | | | 9.9 | | | | | 9.9 |
| 2C1 | Iron and steel production | 5.4 | | | 9.1 | 14 | 18 | | | | | 46 |
| 2C3 | Aluminium production | | | | | | | | 23 | | | 23 |
| 2G | Other product use | | | | | 5.9 | | | | | | 5.9 |
| 2I | Wood processing | 6.8 | | | | | | | | | | 6.8 |
| 2K | Consumption of POPs and heavy metals (e.g. electrical and scientific equipment) | | | | | | | | | | 50 | 50 |
| 3De | Cultivated crops | 19 | | | | | | | | | | 19 |
| 5C1a | Municipal waste incineration | | | | 12 | | | 12 | | | | 24 |
| 5C2 | Open burning of waste | | | | | | | | 8.8 | | | 8.8 |
| 5E | Other waste | | | | | | | | | | 18 | 18 |
| 6A | Other sources | | | | 12 | | | 5.0 | | | | 17 |
| Total contribution from key categories, % | | 81 | 84 | 82 | 83 | 81 | 81 | 81 | 82 | 89 | 82 | |

## 1.5.3 KCA approach 2 results

### 1.5.3.1 Level key category analysis (approach 2)

The results of the KCA according to approach 2, level assessment, are summarised in Table 1-9 for the year 1990 and in Table 1-10 for the year 2023.

Table 1-9 List of Switzerland's approach 2 level key categories 1990, for the main pollutants, PM2.5 and PM10.Contributions are given in percentage of the total assessment per pollutant and depicted using a colour scale, a darker colour indicating a larger contribution. The bottom line reports the cumulative total over all key source categories per pollutant, which amounts to more than 80 % according to the KCA procedure. The column to the right reports the sum of contributions from all pollutants per category.

| NFR Code | Source category | Key categories approach 2: % level contribution to totals 1990 | | | | | | % sum of category |
|---|---|---|---|---|---|---|---|---|
| | | NOx | NMVOC | SOx | NH3 | PM2.5 | PM10 | |
| 1A1a | Public electricity and heat production | 3.7 | | 13 | | 2.7 | 2.5 | 21 |
| 1A2d | Stationary combustion in manufacturing industries and construction: pulp paper and print | | | 6.5 | | | | 6.5 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | 4.9 | | 9.6 | | | | 14 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | | | | | | 3.6 | 3.6 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | | | 9.6 | | 2.8 | 2.0 | 14 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | 45 | 14 | | | | | 59 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | 5.4 | | | | | | 5.4 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | 14 | | 2.6 | | 2.1 | | 19 |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | | 6.8 | | | | | 6.8 |
| 1A3bv(fu) | Road transportation: gasoline evaporation (fuel used) | | 3.3 | | | | | 3.3 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | | | | | | 3.4 | 3.4 |
| 1A4ai | Commercial/institutional: stationary | | | 5.6 | | 5.1 | 3.7 | 14 |
| 1A4bi | Residential: stationary plants | 4.2 | 3.3 | 16 | | 54 | 38 | 115 |
| 1B2aiv | Fugitive emissions oil: refining / storage | | | 3.3 | | | | 3.3 |
| 1B2av | Distribution of oil products | | 3.7 | | | | | 3.7 |
| 2A1 | Cement production | | | | | 1.8 | 1.9 | 3.6 |
| 2A5a | Quarrying and mining of minerals other than coal | | | | | | 2.7 | 2.7 |
| 2C1 | Iron and steel production | | | | | 4.4 | 5.4 | 9.7 |
| 2C3 | Aluminium production | | | 15 | | | | 15 |
| 2D3d | Coating applications | | 8.8 | | | | | 8.8 |
| 2D3e | Degreasing | | 3.6 | | | | | 3.6 |
| 2D3g | Chemical products | | 13 | | | | | 13 |
| 2D3h | Printing | | 4.4 | | | | | 4.4 |
| 2D3i | Other solvent use | | 3.8 | | | | | 3.8 |
| 2G | Other product use | | 17 | | | 2.4 | 1.8 | 21 |
| 2H2 | Food and beverages industry | | | | | 2.5 | 2.8 | 5.3 |
| 2I | Wood processing | | | | | 2.9 | 7.8 | 11 |
| 3B1a | Manure management - Dairy cattle | | | | 12 | | | 12 |
| 3B1b | Manure management - Non-dairy cattle | | | | 6.4 | | | 6.4 |
| 3B3 | Manure management - Swine | | | | 13 | | | 13 |
| 3B4gi | Manure management - Laying hens | | | | 3.6 | | | 3.6 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | 3.3 | | | 9.5 | | | 13 |
| 3Da2a | Animal manure applied to soils | | | | 34 | | | 34 |
| 3De | Cultivated crops | | | | | | 5.3 | 5.3 |
| 6A | Other sources | | | | 4.0 | | | 4.0 |
| Total contribution from key categories, % | | 81 | 81 | 81 | 82 | 80 | 81 | |

Table 1-10 List of Switzerland's approach 2 level key categories 2023, for the main pollutants, PM2.5 and PM10. Contributions are given in percentage of the total assessment per pollutant and depicted using a colour scale, a darker colour indicating a larger contribution. The bottom line reports the cumulative total over all key source categories per pollutant, which amounts to more than 80 % according to the KCA procedure. The column to the right reports the sum of contributions from all pollutants per category.

| NFR Code | Source category | Key categories approach 2: % level contribution to totals 2023 | | | | | | % sum of |
|---|---|---|---|---|---|---|---|---|
| | | NOx | NMVOC | SOx | NH3 | PM2.5 | PM10 | category |
| 1A1a | Public electricity and heat production | 3.6 | | 11 | | | | 15 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | 3.6 | | 45 | | | | 49 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | | | | | 3.7 | 9.4 | 13 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | | | 9.1 | | 2.3 | | 11 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | 42 | 3.4 | | | | | 46 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | 8.3 | | | | | | 8.3 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | 4.0 | | | | | | 4.0 |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | | 3.7 | | | | | 3.7 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | | | | | 9.2 | 10 | 20 |
| 1A3c | Railways | | | | | | 6.0 | 6.0 |
| 1A4ai | Commercial/institutional: stationary | 3.3 | | | | 6.4 | 2.8 | 13 |
| 1A4bi | Residential: stationary plants | 3.4 | 2.9 | 4.0 | | 27 | 12 | 49 |
| 1A4ci | Agriculture/forestry/fishing: stationary | | | 2.6 | | | | 2.6 |
| 2A1 | Cement production | | | | | 4.2 | 2.7 | 6.8 |
| 2A5a | Quarrying and mining of minerals other than coal | | | | | 5.1 | 7.5 | 13 |
| 2B5 | Carbide production | | | 7.3 | | | | 7.3 |
| 2B10a | Chemical industry: other | | | 2.9 | | | | 2.9 |
| 2D3a | Domestic solvent use including fungicides | | 5.9 | | | | | 5.9 |
| 2D3b | Road paving with asphalt | | 4.5 | | | | | 4.5 |
| 2D3d | Coating applications | | 6.7 | | | | | 6.7 |
| 2D3g | Chemical products | | 5.5 | | | | | 5.5 |
| 2D3h | Printing | | 2.9 | | | | | 2.9 |
| 2D3i | Other solvent use | | 5.0 | | | | | 5.0 |
| 2G | Other product use | | 18 | | | 5.9 | 3.0 | 26 |
| 2H1 | Pulp and paper industry | | | | | 4.4 | | 4.4 |
| 2H2 | Food and beverages industry | | 2.4 | | | 8.7 | 6.7 | 18 |
| 2I | Wood processing | | | | | 2.5 | 4.1 | 6.5 |
| 3B1a | Manure management - Dairy cattle | | 7.2 | | 16 | | | 24 |
| 3B1b | Manure management - Non-dairy cattle | | 9.5 | | 11 | | | 20 |
| 3B3 | Manure management - Swine | | | | 10 | | | 10 |
| 3B4gi | Manure management - Laying hens | | | | | | 2.5 | 2.5 |
| 3B4gii | Manure management - Broilers | | 3.2 | | 3.2 | | 3.4 | 9.8 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | 4.5 | | | 6.1 | | | 11 |
| 3Da2a | Animal manure applied to soils | 5.4 | | | 24 | | | 29 |
| 3Da3 | Urine and dung deposited by grazing animals | 3.1 | | | 4.8 | | | 7.9 |
| 3De | Cultivated crops | | | | | | 12 | 12 |
| 5C1a | Municipal waste incineration | | | | | 2.5 | | 2.5 |
| 6A | Other sources | | | | 5.6 | | | 5.6 |
| Total contribution from key categories, % | | 82 | 81 | 82 | 82 | 82 | 82 | |

### 1.5.3.2 Trend key category analysis (approach 2)

The results of the KCA according to approach 2, trend assessment, for 1990-2023 are summarised in Table 1-11.

Table 1-11 List of Switzerland's approach 2 key categories for the trend 1990-2023, for the main pollutants, PM2.5 and PM10. Contributions are given in percentage of the total assessment per pollutant and depicted using a colour scale, a darker colour indicating a larger contribution. The bottom line reports the cumulative total over all key source categories per pollutant, which amounts to more than 80 % according to the KCA procedure. The column to the right reports the sum of contributions from all pollutants per category.

| NFR Code | Source category | Key categories approach 2: % contribution to trend 1990 - 2023 | | | | | | % sum of |
|---|---|---|---|---|---|---|---|---|
| | | NOx | NMVOC | SOx | NH3 | PM2.5 | PM10 | category |
| 1A1a | Public electricity and heat production | | | | | 2.5 | 2.3 | 4.9 |
| 1A2d | Stationary combustion in manufacturing industries and construction: pulp paper and print | | | 7.1 | | | | 7.1 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | 2.5 | | 43 | | | | 46 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | | | | | 2.9 | 7.0 | 9.8 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | 3.4 | | | | | | 3.4 |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | 6.7 | | 2.8 | | | | 9.5 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | 3.9 | 14 | | | | | 18 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | 9.9 | | | | | | 9.9 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | 26 | | 2.7 | | | | 29 |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | | 3.9 | | | | | 3.9 |
| 1A3bv(fu) | Road transportation: gasoline evaporation (fuel used) | | 2.7 | | | | | 2.7 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | | | | | 11 | 8.3 | 19 |
| 1A3c | Railways | | | | | 2.6 | 5.2 | 7.8 |
| 1A4ai | Commercial/institutional: stationary | 3.9 | | 4.3 | | | | 8.2 |
| 1A4bi | Residential: stationary plants | | | 12 | | 30 | 27 | 70 |
| 1B2av | Distribution of oil products | | 2.9 | | | | | 2.9 |
| 1B2c | Venting and flaring (oil gas combined oil and gas) | 2.3 | | | | | | 2.3 |
| 2A1 | Cement production | | | | | 3.5 | | 3.5 |
| 2A5a | Quarrying and mining of minerals other than coal | | | | | 5.4 | 5.7 | 11 |
| 2B5 | Carbide production | | | 6.6 | | | | 6.6 |
| 2B10a | Chemical industry: other | | | 2.4 | | | | 2.4 |
| 2C1 | Iron and steel production | | | | | 5.2 | 5.6 | 11 |
| 2D3a | Domestic solvent use including fungicides | | 6.1 | | | | | 6.1 |
| 2D3b | Road paving with asphalt | | 3.9 | | | | | 3.9 |
| 2D3e | Degreasing | | 2.3 | | | | | 2.3 |
| 2D3g | Chemical products | | 9.3 | | | | | 9.3 |
| 2D3i | Other solvent use | | 2.5 | | | | | 2.5 |
| 2G | Other product use | | 3.9 | | | 5.2 | | 9.1 |
| 2H1 | Pulp and paper industry | | | | | 3.9 | | 3.9 |
| 2H2 | Food and beverages industry | | 2.8 | | | 8.9 | 4.7 | 16 |
| 2I | Wood processing | | | | | | 3.6 | 3.6 |
| 3B1a | Manure management - Dairy cattle | | 8.5 | | 12 | | | 21 |
| 3B1b | Manure management - Non-dairy cattle | | 12 | | 13 | | | 25 |
| 3B3 | Manure management - Swine | | | | 3.7 | | | 3.7 |
| 3B4gi | Manure management - Laying hens | | 2.2 | | | | | 2.2 |
| 3B4gii | Manure management - Broilers | | 4.5 | | 5.5 | | 3.5 | 13 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | 4.5 | | | 7.4 | | | 12 |
| 3Da2a | Animal manure applied to soils | 8.2 | | | 20 | | | 29 |
| 3Da2c | Other organic fertilisers applied to soils (including compost) | 2.6 | | | 7.8 | | | 10 |
| 3Da3 | Urine and dung deposited by grazing animals | 7.2 | | | 7.4 | | | 15 |
| 3De | Cultivated crops | | | | | | 8.2 | 8.2 |
| 6A | Other sources | | | | 4.8 | | | 4.8 |
| Total contribution from key categories, % | | 81 | 82 | 82 | 82 | 81 | 82 | |

## 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. The latest audit according to ISO 9001:2015 was on 27th June 2024 and the current certificate is valid until 2025 (Swiss Safety Center 2022). The QMS is designed to comply with the UNFCCC reporting guidelines (UNFCCC 2019, 2022a) 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 requirements as ensured for GHG also hold for air pollutants. The quality manual (FOEN 2025a) contains all relevant information regarding the QMS. It is updated annually and made available to everyone contributing to the GHG inventory.

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 routine checks implemented in the database 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 latest 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 twice 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, NMVOC and $SO_x$)
- Selective checks of emission factors of the inventory. For example, for submission 2025 a general comparison of emission factors with the newly published EMEP/EEA guidebook (EMEP/EEA 2023) has been conducted. In some source categories (e.g. 1A3b road transportation or 3D Crop production and agricultural soils) emission factors from guidebook version 2019 (EMEP/EEA 2019) are still used. The emission factors are progressively updated through methodological updates.
- Every year specific projects are implemented to improve the inventory in particular sections.

In addition to the QA/QC measures mentioned above, Switzerland regularly performs verification checks with data outside of the air pollutant inventory:

- The air pollutant inventory is intertwined with the GHG inventory, so any verification checks regarding precursor emissions or activity data in the GHG inventory are also applied to the air pollutant inventory.
- Switzerland systematically compares the emission factors with other European countries, especially if new emission factors are introduced to the inventory or if the accuracy of an emission factor or of a data source is questioned in an internal or external review process.
- Switzerland carries out sector-specific verification processes for individual source categories or processes.
- Switzerland regularly compares the emissions from the air pollutant inventory with the results of the national ambient concentration modelling “PolluMap” ($NO_2$, PM2.5 and PM10).

The continuous improvement of the inventory is in particular addressing recommendations and encouragements from the latest stage 3 review of Switzerland’s emission inventory (UNECE 2024a). Switzerland prioritizes inventory improvements based on the findings from the stage 3 reviews and according to the key category analysis (KCA) and the uncertainty analysis, where appropriate.

## 1.7 General uncertainty evaluation

### 1.7.1 Data sources and data used

The uncertainty analysis is conducted using activity data and emission factors at the same level of aggregation as used for the NFR reporting tables (classification according to EMEP/EEA 2023). As for the key category analysis, emissions based on fuel used are considered.

Several sources of uncertainties are listed below. Uncertainty values for activity data and emission factors were updated where appropriate.

- Uncertainties of activity data are taken from the uncertainty analysis of Switzerland’s GHG Inventory (FOEN 2024).

- Uncertainties for the emission factors and emissions of mobile sources are from the study IFEU/INFRAS (2010), 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 the EMEP/EEA guidebook (EMEP/EEA 2023, part A, chp. 5, Table 2-2).
- To estimate the uncertainties associated with $NH_3$ emissions from sector 3 Agriculture, a model essentially based on the nitrogen-flow model AGRAMMON was previously developed by INFRAS (2015c, 2017b). Since then, the AGRAMMON model has been revised and in addition, a new survey on production techniques in Swiss agriculture has been performed in 2019. Based on these updates, INFRAS made a new uncertainty analysis for the year 2019 (INFRAS 2021). The new uncertainty estimate for ammonia emissions from Swiss agriculture is 12.6 %, which is slightly lower than the 13.6 % estimated in the previous study. Numeric values can be found in Annex A5.1.
- Detailed numeric values and references for the uncertainties are reported in Annex 5.

### 1.7.2 Methodology

The uncertainty aggregation for the main pollutants and particulate matter is carried out for the latest submission according to approach 1 (uncertainty propagation) and approach 2 (Monte Carlo simulations).

Input uncertainty values for activity data and emission factors at the same aggregation level as required for the key category analysis are used for the computation. For the main pollutants, PM2.5 and PM10, a total of 127 categories were considered, as in the NFR tables used to report emissions.

Uncertainties are assessed in accordance with the EMEP/EEA guidebook (EMEP/EEA 2023: Part A, chapter 5) and with the 2006 IPCC Guidelines (IPCC 2006), and, where applicable, the 2019 Refinement to the 2006 IPCC Guidelines (IPCC 2019). The Monte Carlo simulations follow the recommendations by JCGM (2008, Supplement 1).

The following assumptions were applied to both approaches:

- Full correlation or no correlation can be set between the base year and the reporting year for the same input variable.
- The following statistical distributions can be used: normal, triangular, gamma. If a variable cannot physically have negative values and has an uncertainty > 100 %, a gamma distribution is preferred in order to not generate negative values during Monte Carlo simulations. This is particularly relevant for emission factors.
- Asymmetric distribution: in approach 1, this is taken into account by computing the uncertainty propagation separately for each side of the mean. In approach 2, each distribution can be simulated, and asymmetric distributions are not an issue.

The following factors are not accounted for:

- Partial correlation between the base year and the reporting year for the same input variable.
- Correlations between categories (for different input variables).

For both approaches, all uncertainty results represent a 95 % confidence interval. For a symmetrical distribution, this interval is centred on the mean. For non-symmetrical distributions obtained by Monte Carlo simulations, the reported uncertainties represent the narrowest 95 % interval, in agreement with JCGM (2008, S1). Uncertainties are given for the lower range (from the lower edge to the mean) and the upper range (from the mean to the upper edge), expressed as a percentage of the mean.

#### 1.7.2.1 Aggregation of uncertainties using approach 1: uncertainty propagation

The uncertainty propagation is computed using the open source software Python (version 3.6.1, https://www.python.org/), in which the equations given in the guidelines are programmed. Results of approach 1 for the reporting year and for the trend for each considered pollutant are summarised in Table 1-12.

#### 1.7.2.2 Aggregation of uncertainties using approach 2: Monte Carlo simulations

The Monte Carlo simulations were performed for the base year 1990, the reporting year 2023 and the trend at the aggregation level required for the KCA. All input variables can be found in Annex 5. Results for each pollutant are summarised in Table 1-12.

The main strategy in Monte Carlo analysis is to simulate a probability distribution for each input variable (distribution type, mean and standard deviation) and propagate these probability distributions to the final value of the model, in order to obtain a realistic uncertainty envelope for the final quantity. In practice, this is achieved by generating a large set of random numbers for each input quantity according to its distribution probability and by computing the intermediate (if any) and final values according to the equations of the model. The strength of this method is to propagate uncertainties accurately even if the equations of the model are non-linear and even if the final uncertainty envelope is non-symmetric. Another advantage is that a distribution is produced to represent the final quantity, while this information is not available from approach 1.

In our settings, each input quantity is an activity data associated with an emission factor or if applicable a direct emission. The final quantity is the emission at the inventory level and the mathematical model is the sum of emissions from each process.

**Modelling framework**

The Monte Carlo simulations are programmed using the open-source software Python (version 3.6.1, https://www.python.org/). Python is run through the Anaconda installation (https://www.anaconda.com/, version 4.4.0 (64 bit)) on a Windows PC.

To generate random numbers corresponding to the selected distributions, mean and variances, the Python function `random` is used. In practice, for each input emission factor and activity data (or direct emission, if applicable), random numbers are generated according to the input parameters. The final uncertainty envelope is obtained by computing the emissions as the product of activity data and emission factors and by then adding up all emissions. Intermediate sums can also be obtained, for example the sum for a given sector.

For each input quantity, 500’000 random values were generated resulting in equal numbers of values for the base year, the reporting year and the trend.

The average offset between the obtained mean for each process and the input mean is less than 0.1 % for each pollutant. This reflects the uncertainty introduced by the Monte Carlo method itself. This computational uncertainty remains small compared to the uncertainty introduced by activity data and emission factors.

### Correlation

If two variables representing the base year (BY) and the reporting year (RY) for the same process are fully correlated, a random number is generated for the base year only, written $BY_{random}$. The random value for the reporting year $RY_{random}$ is then computed as:

$RY_{random} = BY_{random} * RY_{input, mean}/BY_{input, mean}$,

where $RY_{input, mean}$ and $BY_{input, mean}$ are the input mean values for the variables in the reporting year and the base year, respectively.

This method implicitly assumes that the uncertainty for the base year and the reporting year, expressed in percentage of the mean value, stays the same.

No correlation between activity data (or emission factors) resulting from different processes for the same year is programmed.

### Sensitivity analysis

The sensitivity analysis investigates how sensitive the total emission is to each input emission. This analysis was conducted for the base year and the reporting year.

The sensitivity of a total value (total base year emission, total reporting year emission) to the variability of input quantities is computed as the correlation coefficient between total and input values, using in Python the function `corrcoef` from the `numpy` package. Each sensitivity value is computed on 500'000 pairs of points.

The sensitivity therefore has a value between -1 and +1, where a negative value indicates a negative correlation, and a positive value a positive correlation. For emissions, since the total values are a sum of input values, we expect only positive correlations.

Intuitively, the variability in the total value will be very sensitive to a process with also a high variability, compared to other processes with a smaller variability. In other words, the inventory total is expected to be mostly sensitive to processes with a high uncertainty (expressed in absolute values or in the same unit as the emissions).

### Source code availability

The Python source code is available on the Github public platform with the repository name <inventory_uncertainty_UNFCCC_CLRTAP>.

## 1.7.3 Results of approach 1 and 2 uncertainty evaluation

Table 1-12 shows the results of the uncertainty evaluation using approaches 1 and 2 for the base year, the reporting year and the trend. Due to the availability of uncertainty data, the analysis was restricted to the main pollutants ($NO_x$, NMVOC, $SO_x$, $NH_3$) as well as PM2.5 and PM10. The total emissions in the base year and the reporting year as well as the emission trends 1990-2023 of these pollutants are also shown in Table 1-12. Since emission factors are generally the major sources of uncertainty (compared to activity data) and since they are considered correlated across years this may result in smaller uncertainties for the trends than for the emission levels.

Table 1-12 For each pollutant, emission levels for 1990 and 2023, trend and associated relative uncertainties obtained from the uncertainty propagation (approach 1) and from Monte Carlo simulations (approach 2), for the main pollutants, PM2.5 and PM10. Note that the trend and its associated uncertainties are expressed in the same unit, in percent. As an example, for a trend of -10 % with uncertainties of 2 %, the trend is comprised between -12 % and -8 %.

| Pollutant | Emissions 1990 | | | Emissions 2023 | | | Trend 1990-2023 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Value t | U(-)% | U(+)% | Value t | U(-)% | U(+)% | Value % | U(-)% | U(+)% |
| Uncertainty propagation (approach 1) | | | | | | | | | |
| NOx | 140'708 | 13 | 13 | 46'742 | 13 | 13 | -66.8 | 1.1 | 1.1 |
| NMVOC | 294'961 | 17 | 30 | 71'290 | 17 | 31 | -75.8 | 3.5 | 4.2 |
| SOx | 39'182 | 5.1 | 6.9 | 2'829 | 9.4 | 9.4 | -92.8 | 0.56 | 0.56 |
| NH3 | 68'492 | 13 | 13 | 52'895 | 12 | 12 | -22.8 | 4.6 | 4.6 |
| PM2.5 | 27'172 | 41 | 42 | 6'224 | 26 | 36 | -77.1 | 4.7 | 6.3 |
| PM10 | 36'471 | 33 | 40 | 14'078 | 20 | 39 | -61.4 | 9.4 | 13 |
| Monte Carlo simulations (approach 2) | | | | | | | | | |
| NOx | 140'708 | 13 | 13 | 46'742 | 13 | 13 | -66.8 | 1.1 | 1.2 |
| NMVOC | 294'961 | 22 | 25 | 71'290 | 23 | 25 | -75.8 | 3.8 | 3.9 |
| SOx | 39'182 | 5.8 | 6.1 | 2'829 | 9.5 | 9.4 | -92.8 | 0.62 | 0.62 |
| NH3 | 68'492 | 13 | 13 | 52'895 | 12 | 12 | -22.8 | 4.8 | 4.9 |
| PM2.5 | 27'172 | 42 | 41 | 6'224 | 31 | 31 | -77.1 | 5.1 | 6.3 |
| PM10 | 36'471 | 36 | 37 | 14'078 | 28 | 31 | -61.4 | 10 | 12 |

In general, uncertainties resulting from approaches 1 and 2 are in concordance, especially for the upper range uncertainty. For the lower range uncertainty, approach 1 may result in a smaller estimate in cases where the inventory probability distribution is asymmetric. We therefore recommend taking into consideration the uncertainty estimate provided by approach 2 (Monte Carlo simulations).

The level and trend uncertainty estimations for the latest submission remained similar for all pollutants compared to the values of the previous submission.

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

For the other air pollutants such as heavy metals, the uncertainties are assumed to be in the range of 50 % to 100 %. For POPs, uncertainties might be even higher.

The Monte Carlo simulations provide data to conduct a sensitivity analysis between emissions from each category and the inventory (total) emission for $NO_x$, NMVOC, $NH_3$, $SO_x$, PM2.5 and PM10. This analysis quantifies the influence of a change in the emission of a given category on the inventory total. The results of the sensitivity analysis for the base year and the reporting year are shown in Annex A5.3.2. The processes ranked in descending order of importance according to the sensitivity analysis follow almost the same order as the processes ranked according to approach 2 of the key category analysis. Both methods highlight categories with large uncertainties, expressed in absolute values. The sensitivity analysis therefore confirms the results obtained by approach 2 of the KCA.

## 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 guidebook (EMEP/EEA 2023), the Swiss CLRTAP Inventory is complete.

### 1.8.1 Sources not estimated (NE)

Emissions of additional (non-priority) heavy metals in all sectors are not estimated. There are no large sources of non-priority heavy metals in Switzerland. For the most important processes (e.g. wood waste furnaces, waste incineration plants, steelworks), measured emissions values for non-priority heavy metals are not available. Due to limited resources, the focus lies on priority heavy metals in Switzerland's inventory.

In few other source categories, specific pollutants were "not estimated" (NE). For further details, 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 do not exist, and specific emissions are reported as "not occurring (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. These are reported as "not applicable (NA)".

# 2 Emission trends 1980-2023

**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” (fu), 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 generally decreasing in the period 1980-2023 (see Table 2-1). Only the emissions of non-exhaust particulate matter (PM2.5, PM10, TSPs, BC) are increasing. Note that there is a methodological difference 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 | 1990 | 2005 | 2023 | 1980–2023 | 1990–2023 | 2005–2023 |
|---|---|---|---|---|---|---|---|---|
| $NO_x$ | kt | 165 | 141 | 94 | 47 | -72% | -67% | -50% |
| NMVOC | kt | 314 | 295 | 112 | 71 | -77% | -76% | -36% |
| $SO_2$ | kt | 113 | 39 | 14 | 2.8 | -97% | -93% | -80% |
| $NH_3$ | kt | 65 | 68 | 60 | 53 | -18% | -23% | -11% |
| PM2.5 total | kt | 26 | 27 | 14 | 6.2 | -76% | -77% | -55% |
| PM2.5 exhaust | kt | 24 | 25 | 12 | 3.9 | -84% | -84% | -67% |
| PM2.5 non-exhaust | kt | 2.2 | 2.4 | 2.2 | 2.3 | 5% | -1% | 7% |
| PM10 total | kt | 36 | 36 | 21 | 14 | -61% | -61% | -34% |
| PM10 exhaust | kt | 27 | 27 | 13 | 4.3 | -84% | -84% | -66% |
| PM10 non-exhaust | kt | 9.4 | 9.4 | 8.9 | 9.8 | 4% | 4% | 10% |
| TSP total | kt | 61 | 56 | 36 | 28 | -54% | -50% | -21% |
| TSP exhaust | kt | 33 | 30 | 13 | 4.6 | -86% | -84% | -65% |
| TSP non-exhaust | kt | 28 | 27 | 22 | 23 | -15% | -12% | 5% |
| BC total | kt | 4.9 | 5.7 | 3.5 | 0.83 | -83% | -85% | -77% |
| BC exhaust | kt | 4.9 | 5.7 | 3.5 | 0.73 | -85% | -87% | -79% |
| BC non-exhaust | kt | 0.026 | 0.071 | 0.078 | 0.097 | 276% | 38% | 25% |
| CO | kt | 1'135 | 752 | 305 | 139 | -88% | -82% | -54% |
| Pb | t | 1'326 | 355 | 18 | 7.8 | -99% | -98% | -57% |
| Cd | t | 5.2 | 3.2 | 0.48 | 0.41 | -92% | -87% | -16% |
| Hg | t | 7.5 | 6.3 | 0.73 | 0.56 | -93% | -91% | -23% |
| PCDD/PCDF | g I-Teq | 443 | 192 | 31 | 12 | -97% | -94% | -61% |
| BaP | t | 2.3 | 2.3 | 1.4 | 0.70 | -70% | -70% | -51% |
| BbF | t | 2.6 | 2.6 | 1.6 | 0.75 | -71% | -71% | -53% |
| BkF | t | 1.6 | 1.7 | 1.0 | 0.47 | -70% | -72% | -54% |
| IcdP | t | 1.2 | 1.4 | 0.82 | 0.42 | -65% | -70% | -49% |
| PAH tot | t | 7.6 | 8.0 | 4.9 | 2.3 | -69% | -71% | -52% |
| HCB | kg | 97 | 173 | 0.44 | 0.34 | -100% | -100% | -23% |
| PCB | t | 3.6 | 2.3 | 1.3 | 0.31 | -91% | -87% | -76% |

### 2.1.2 Legal basis for the implementation of reduction measures

The mainly 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 and is still currently applicable (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), including the 1985 Sulphur Protocol (ratified in 1987), the 1988 $NO_x$ Protocol (ratified in 1990), the 1991 VOC Protocol (ratified in 1994), the 1994 Sulphur Protocol (ratified in 1998), the 1998 POP Protocol and 1998 Heavy Metals Protocol (both ratified in 2000) as well as the 1999 (2012) Gothenburg Protocol (ratified in 2005), and the revised 2012 Gothenburg Protocol (ratified in 2019).

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.

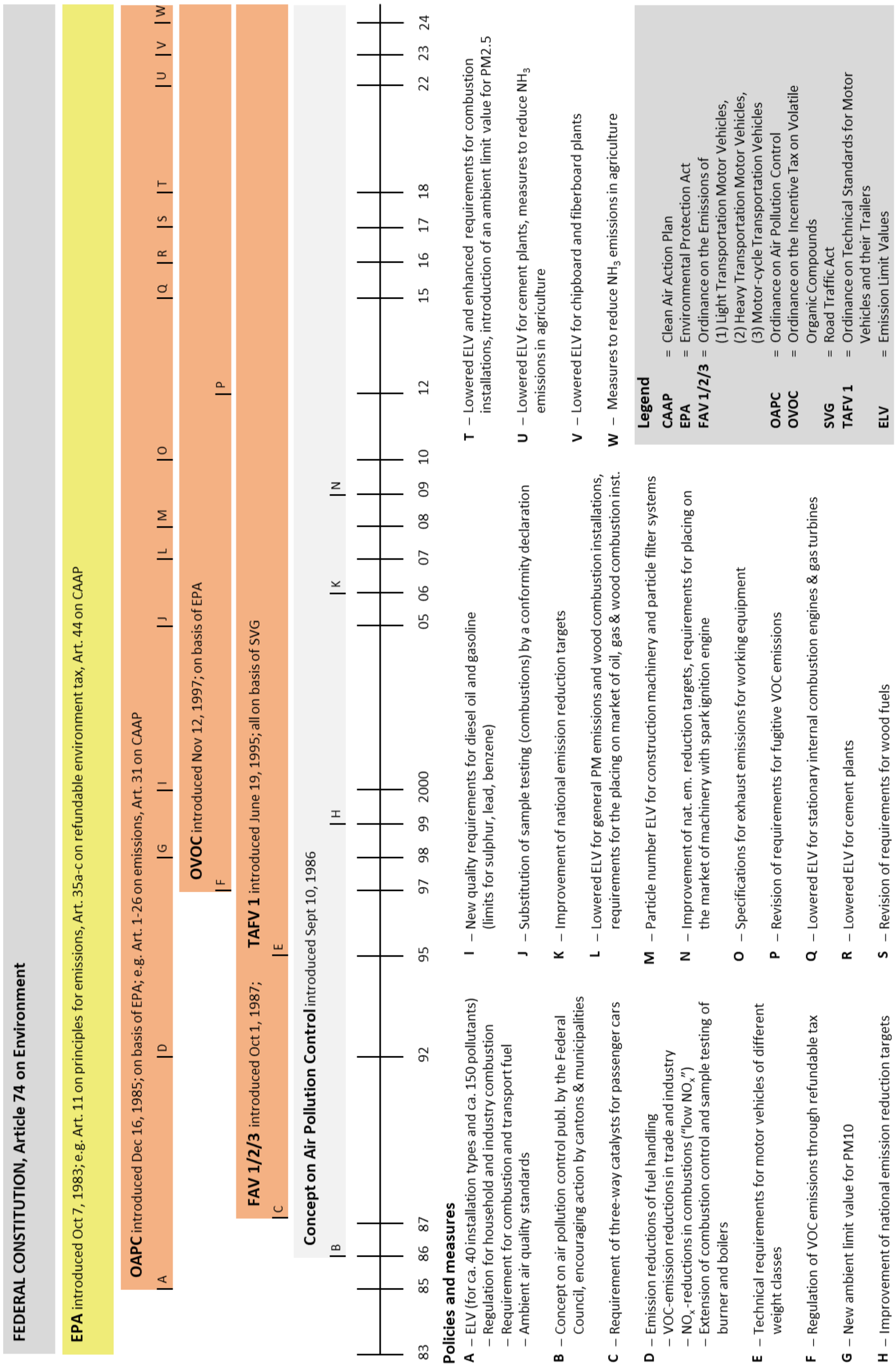



Figure 2-1 Overview of the OAPC Revisions in Switzerland. The Concept on Air Pollution Control is also referred to as the Air Pollution Control Strategy.

For further information on legislation on the abatement of air pollution, see https://www.bafu.admin.ch/bafu/en/home/topics/air/law.html [29.01.2025].

# 2.2 Overall trends of total emissions

## 2.2.1 Main air pollutants and CO

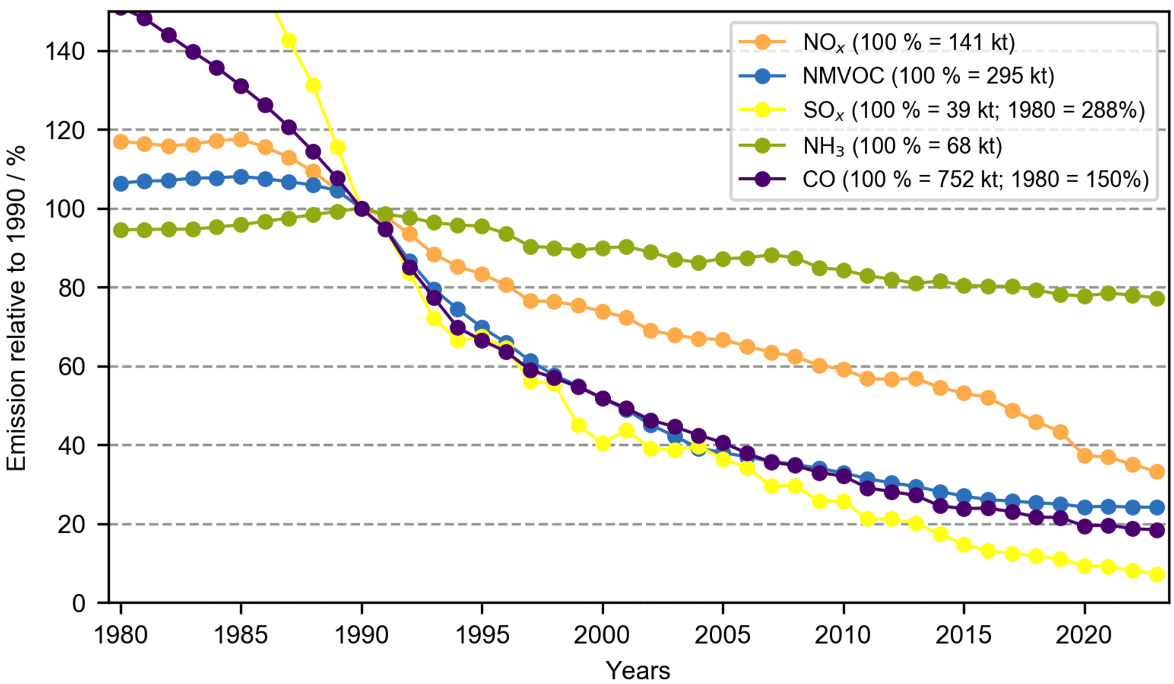
Emission trends of the main air pollutants and CO show a decline over the past 40 years as a result of the strict air pollution control policy and the implementation of a large number of emission reduction measures (see Figure 2-2 and Table 2-2).

Overall, the most effective reduction measures were the abatement of exhaust emissions from road vehicles and stationary installations and the incentive taxes on VOC (since 2000) and on fossil combustible fuels (since 2008). The latter measure was (jointly) responsible for the significant shift in the fuel mix of standard fossil fuels in industry from solid and liquid fuels to natural gas and the strong reduction of the use of residual fuel oil. As a result, $NO_x$, NMVOC and CO emissions clearly declined between 1980 and 2023.

In addition, the legal restrictions of the sulphur content in liquid fuels and the switch from gas oil to natural gas in residential heating are important for the significant decrease in $SO_x$ emissions observed. The lowering of the sulphur content in liquid fuels is shown inTable 3-29. Annual fluctuations of $SO_x$ emissions occur mainly due to annual variations of heating degree days, which affects the consumption of gas oil.

The reduction of $NH_3$ emissions since 1980 is not as pronounced as for the other pollutants mentioned above. $NH_3$ emissions are influenced by changes in the number of livestock (and thus N excretions), 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). Between 1990 and 2020, the amount of N excreted by livestock decreased by 17 % (Kupper et al. 2022), which had a corresponding effect on $NO_x$ and $NH_3$ emissions from agriculture (see chapters 5.1.1 and 5.1.3).

In the year 2020, a drop of $NO_x$ emissions happened mainly due to the COVID-19 pandemic measures and the resulting reduction of traffic in Switzerland. The reduced traffic volumes affected all pollutants which are emitted by a large share from the source category 1A3 Transport (in particular 1A3b Road transportation).




Emission trends 1980-2023: Overall trends of total emissions - Main air pollutants and CO

Figure 2-2 Relative trends for the total emissions of main air pollutants and CO in Switzerland 1980–2023 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 | NOx | NMVOC | SOx | NH3 | CO |
|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt |
| 1980 | 165 | 314 | 113 | 65 | 1'135 |
| 1985 | 165 | 319 | 68 | 66 | 985 |
| 1990 | 141 | 295 | 39 | 68 | 752 |
| 1995 | 117 | 206 | 26 | 65 | 500 |
| 2000 | 104 | 153 | 16 | 62 | 390 |
| 2005 | 94 | 112 | 14 | 60 | 305 |
| 2010 | 83 | 97 | 10 | 58 | 241 |
| 2014 | 77 | 83 | 6.8 | 56 | 184 |
| 2015 | 75 | 80 | 5.8 | 55 | 179 |
| 2016 | 73 | 77 | 5.2 | 55 | 180 |
| 2017 | 69 | 76 | 4.9 | 55 | 173 |
| 2018 | 65 | 75 | 4.7 | 54 | 163 |
| 2019 | 61 | 74 | 4.3 | 54 | 162 |
| 2020 | 52 | 72 | 3.7 | 53 | 146 |
| 2021 | 52 | 72 | 3.6 | 54 | 148 |
| 2022 | 49 | 71 | 3.2 | 53 | 141 |
| 2023 | 47 | 71 | 2.8 | 53 | 139 |
| 2023 vs 2005 (%) | -50 | -36 | -80 | -11 | -55 |

### 2.2.2 Suspended particulate matter

Emissions for suspended particulate matter (PM2.5, PM10, TSP and BC) show a significant decline since 1990 (see Figure 2-3 and Table 2-3). This decline can be mainly attributed to a reduction of exhaust particulate matter emissions (see Figure 2-4 and Table 2-4). The following measures were important for the reductions:

- 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 a revision of the Ordinance of Air Pollution Control (OAPC) in 2007 and in 2018 with more stringent emission limit values for general dust emissions and total solids 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. With the OAPC revision in 2018, the particle number emission limit value became mandatory for new machines in all sectors in accordance with new EU regulations. It aims at reducing the fine fraction of particulate matter (PM2.5) and soot (see also Figure 2-1).

In contrast to exhaust particulate matter emissions, non-exhaust emissions show an increasing trend since about 2003 (see Figure 2-5, Table 2-5). This increase is mainly due to growing activity data (annual mileage and machine hours) of mobile sources, and in absolute terms it is more distinctive for TSP and PM10 than for PM2.5 (see chp. 2.4.4). Since annual mileage dropped in 2020 and 2021 due to the COVID-19 pandemic measures, non-exhaust particulate matter emissions have decreased in 2020 and 2021 compared to 2019 as well (see Figure 2-5).

Note that in the years 1980 to 1990, BC exhaust emissions increased due to a large increase in the consumption of wood energy mainly in households (1A4bi), and to a lower extent also in the commercial sector (1A4ai) and in agriculture and forestry (1A4ci).

Condensable fractions are included in TSP, PM10 and PM2.5 emissions of wood energy combustion (1A1a, 1A2gviii, 1A4ai/bi/ci; see respective sections in chp. 3.2.1.1.2), road transportation (1A3b), non-road vehicles and machinery (1A2gvii, 1A3c/d, 1A4aii/bii/cii and 1A5b), bonfires (1A4bi) and charcoal use (1A4bi).

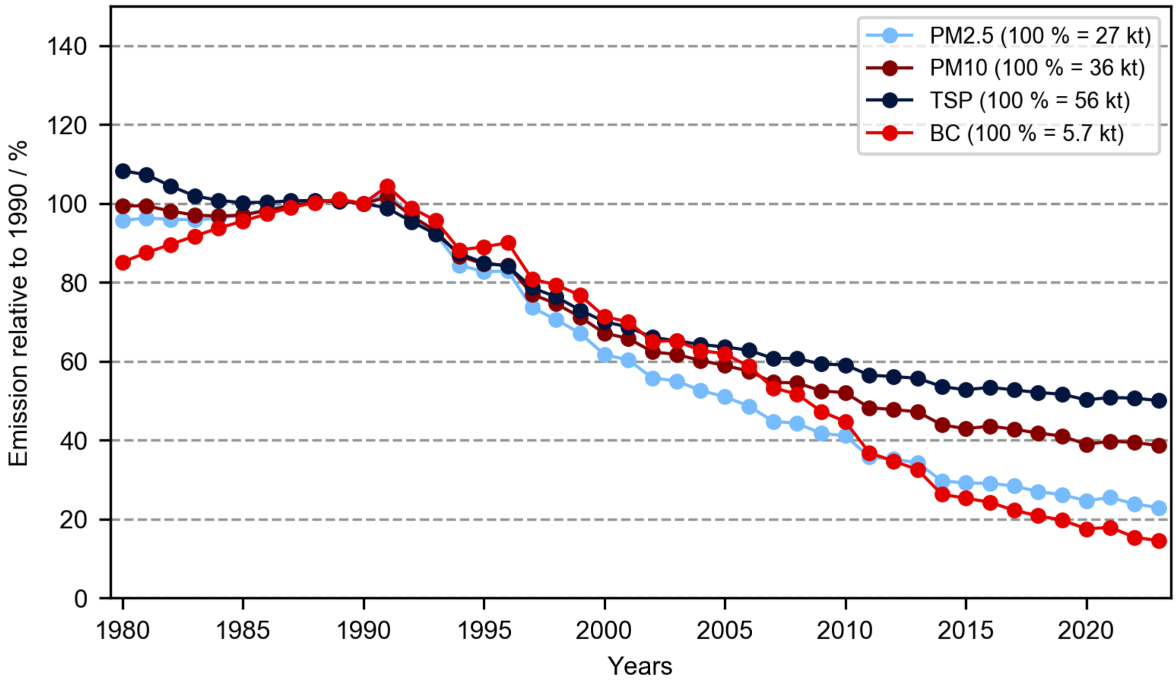



Figure 2-3 Total emissions of suspended particulate matter TSP, PM10, PM2.5 and BC in Switzerland 1980–2023 (in percentage of 1990). Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

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 | 26 | 36 | 61 | 4.9 |
| 1985 | 26 | 35 | 56 | 5.5 |
| 1990 | 27 | 36 | 56 | 5.7 |
| 1995 | 22 | 31 | 48 | 5.1 |
| 2000 | 17 | 24 | 39 | 4.1 |
| 2005 | 14 | 21 | 36 | 3.5 |
| 2010 | 11 | 19 | 33 | 2.6 |
| 2014 | 8.1 | 16 | 30 | 1.5 |
| 2015 | 7.9 | 16 | 30 | 1.4 |
| 2016 | 7.9 | 16 | 30 | 1.4 |
| 2017 | 7.7 | 16 | 30 | 1.3 |
| 2018 | 7.3 | 15 | 29 | 1.2 |
| 2019 | 7.1 | 15 | 29 | 1.1 |
| 2020 | 6.7 | 14 | 28 | 1.0 |
| 2021 | 6.9 | 14 | 29 | 1.0 |
| 2022 | 6.5 | 14 | 28 | 0.88 |
| 2023 | 6.2 | 14 | 28 | 0.83 |
| 2023 vs 2005 (%) | -55 | -34 | -21 | -77 |

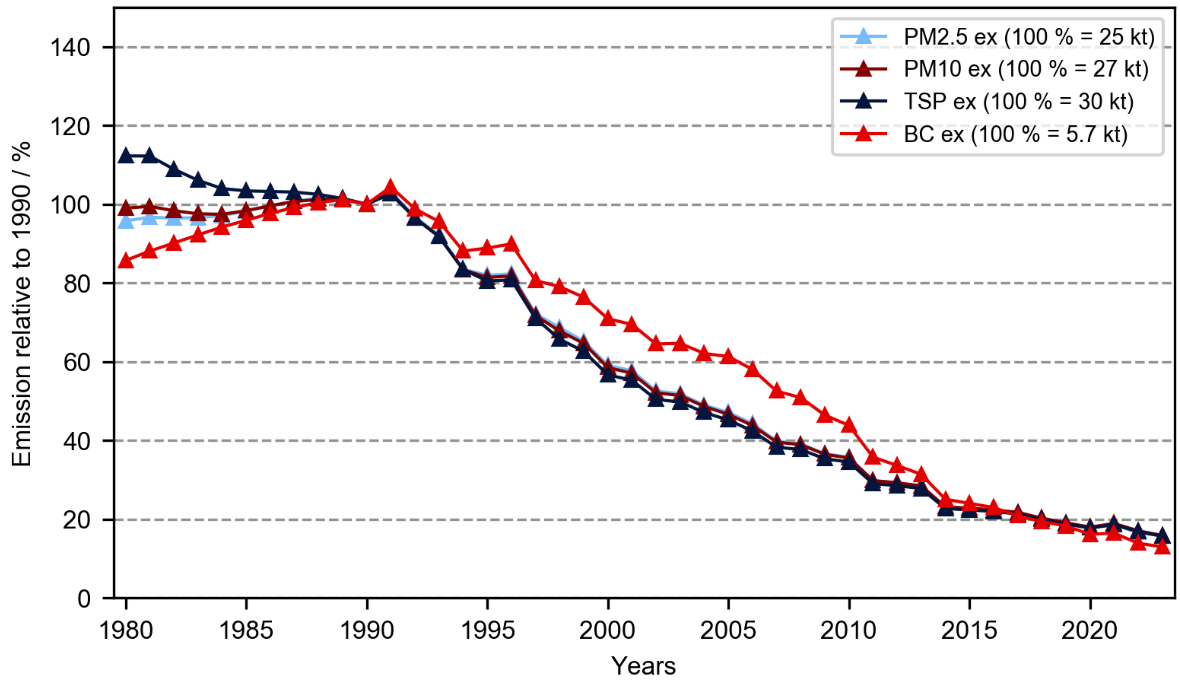



Figure 2-4 Exhaust emissions of suspended particulate matter TSP, PM10, PM2.5 and BC in Switzerland 1980–2023 (in percentage of 1990). Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

Table 2-4 Exhaust 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 ex | PM10 ex | TSP ex | BC ex |
|---|---|---|---|---|
| | kt | kt | kt | kt |
| 1980 | 24 | 27 | 33 | 4.9 |
| 1985 | 24 | 27 | 31 | 5.4 |
| 1990 | 25 | 27 | 30 | 5.7 |
| 1995 | 20 | 22 | 24 | 5.0 |
| 2000 | 15 | 16 | 17 | 4.0 |
| 2005 | 12 | 13 | 13 | 3.5 |
| 2010 | 8.9 | 9.6 | 10 | 2.5 |
| 2014 | 5.7 | 6.3 | 6.7 | 1.4 |
| 2015 | 5.6 | 6.2 | 6.6 | 1.4 |
| 2016 | 5.5 | 6.1 | 6.5 | 1.3 |
| 2017 | 5.3 | 5.9 | 6.3 | 1.2 |
| 2018 | 4.9 | 5.5 | 5.9 | 1.1 |
| 2019 | 4.7 | 5.2 | 5.5 | 1.0 |
| 2020 | 4.4 | 4.9 | 5.2 | 0.91 |
| 2021 | 4.6 | 5.1 | 5.5 | 0.93 |
| 2022 | 4.1 | 4.6 | 5.0 | 0.78 |
| 2023 | 3.9 | 4.3 | 4.6 | 0.73 |
| 2023 vs 2005 (%) | -67 | -66 | -65 | -79 |

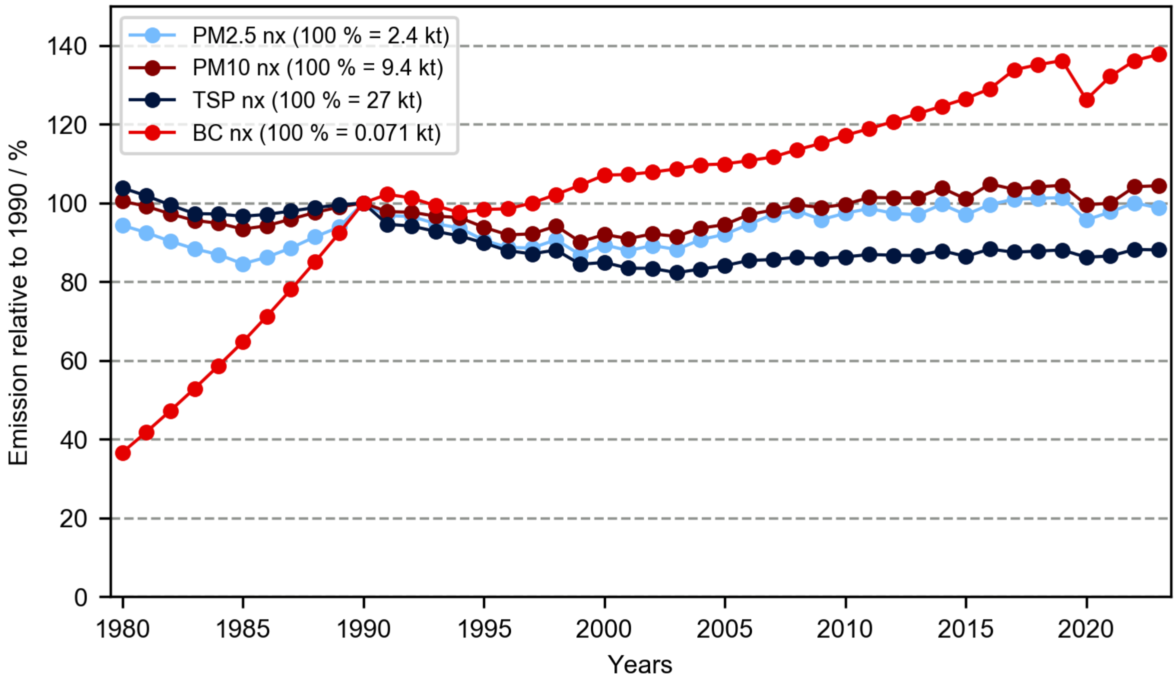



Figure 2-5 Non-exhaust emissions of suspended particulate matter TSP, PM10, PM2.5 and BC in Switzerland 1980–2023 (in percentage of 1990). Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

Table 2-5 Non-exhaust 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 nx | PM10 nx | TSP nx | BC nx |
|---|---|---|---|---|
| | kt | kt | kt | kt |
| 1980 | 2.2 | 9.4 | 28 | 0.026 |
| 1985 | 2.0 | 8.8 | 26 | 0.046 |
| 1990 | 2.4 | 9.4 | 27 | 0.071 |
| 1995 | 2.1 | 8.8 | 24 | 0.069 |
| 2000 | 2.1 | 8.6 | 23 | 0.076 |
| 2005 | 2.2 | 8.9 | 22 | 0.078 |
| 2010 | 2.3 | 9.3 | 23 | 0.083 |
| 2014 | 2.3 | 9.7 | 23 | 0.088 |
| 2015 | 2.3 | 9.5 | 23 | 0.089 |
| 2016 | 2.3 | 9.8 | 23 | 0.091 |
| 2017 | 2.4 | 9.7 | 23 | 0.095 |
| 2018 | 2.4 | 9.8 | 23 | 0.095 |
| 2019 | 2.4 | 9.8 | 23 | 0.096 |
| 2020 | 2.3 | 9.3 | 23 | 0.089 |
| 2021 | 2.3 | 9.4 | 23 | 0.093 |
| 2022 | 2.4 | 9.8 | 23 | 0.096 |
| 2023 | 2.3 | 9.8 | 23 | 0.097 |
| 2023 vs 2005 (%) | 7.3 | 10 | 4.8 | 25 |

## 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 2-6 and Table 2-6). 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, the decreasing trend of heavy metals emissions is less pronounced.

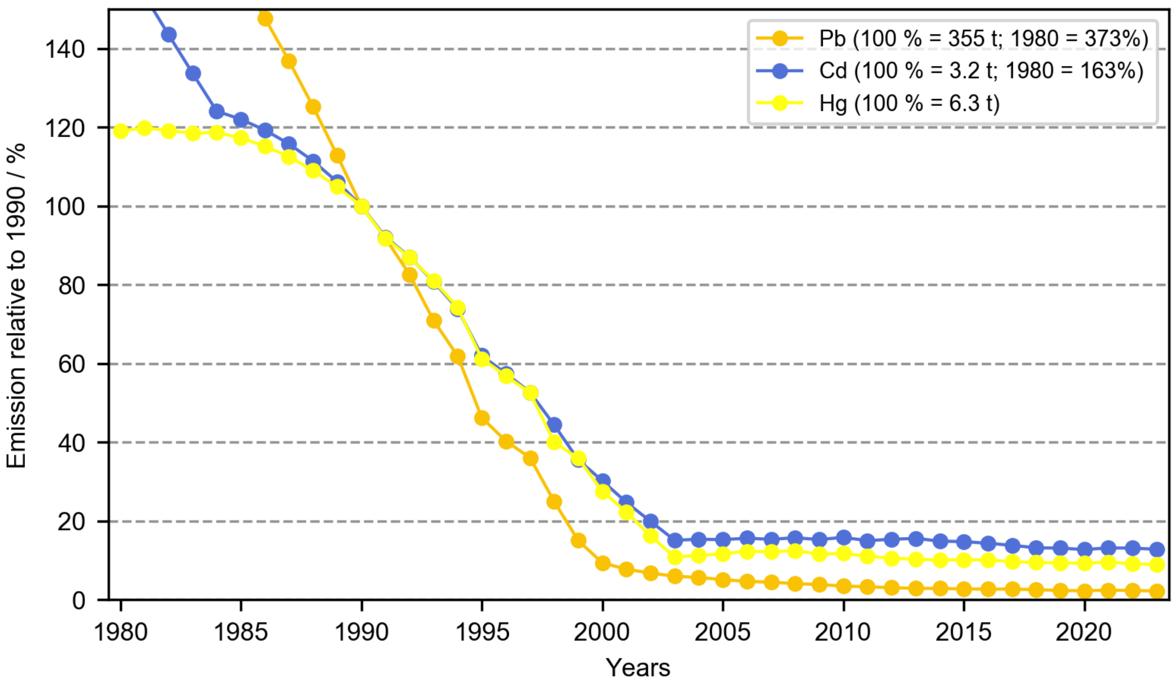


Figure 2-6 Emissions of priority heavy metals in Switzerland 1980–2023 (in percentage of 1990). Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

Table 2-6 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 | 1'326 | 5.2 | 7.5 |
| 1985 | 559 | 3.9 | 7.4 |
| 1990 | 355 | 3.2 | 6.3 |
| 1995 | 164 | 2.0 | 3.9 |
| 2000 | 33 | 0.96 | 1.7 |
| 2005 | 18 | 0.48 | 0.73 |
| 2010 | 12 | 0.50 | 0.74 |
| 2014 | 10 | 0.47 | 0.63 |
| 2015 | 9.6 | 0.47 | 0.64 |
| 2016 | 9.4 | 0.46 | 0.64 |
| 2017 | 9.5 | 0.44 | 0.61 |
| 2018 | 9.0 | 0.42 | 0.59 |
| 2019 | 8.2 | 0.42 | 0.59 |
| 2020 | 8.0 | 0.41 | 0.58 |
| 2021 | 8.5 | 0.42 | 0.60 |
| 2022 | 8.2 | 0.42 | 0.57 |
| 2023 | 7.8 | 0.41 | 0.56 |
| 2023 vs 2005 (%) | -57 | -16 | -23 |

### 2.2.4 Persistent organic pollutants (POPs)

The emissions of persistent organic pollutants have generally declined since 1980 (see Figure 2-7 and Table 2-7).

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

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 more than half in manually operated furnaces and increased by about a factor of eight in automatic combustion installations since 1990.

HCB emissions are strongly influenced by activity data of the secondary aluminium production. The trend shown in Figure 2-7 is primarily a reflection of the activity of the single plant for secondary aluminium production in Switzerland which ceased in 1993. Since then, total HCB emissions remain on a generally low level with a slight further decrease. 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 (heating degree days).

With the exception of a sudden sharp increase in 1999, PCB emissions decreased continuously since 1980. Although the use of PCBs in anti-corrosive paints and joint sealants (so-called open applications) is prohibited since 1972, they are the predominant PCB emission sources for most of the time. In 1986, a total ban was placed on any form of PCB use in Switzerland. Between 1975 and 1985 and around 2000, burning of PCB contaminated waste oil in outdoor fires (ceased in 1999) and shredding of electronic waste containing PCBs in small capacitors, respectively, were the dominant PCB sources. The latter was also the cause for the sudden sharp emission increase in 1999. Mainly in the seventies and eighties, accidental release by fire, small and large capacitors and waste incineration were important emission sources as well.

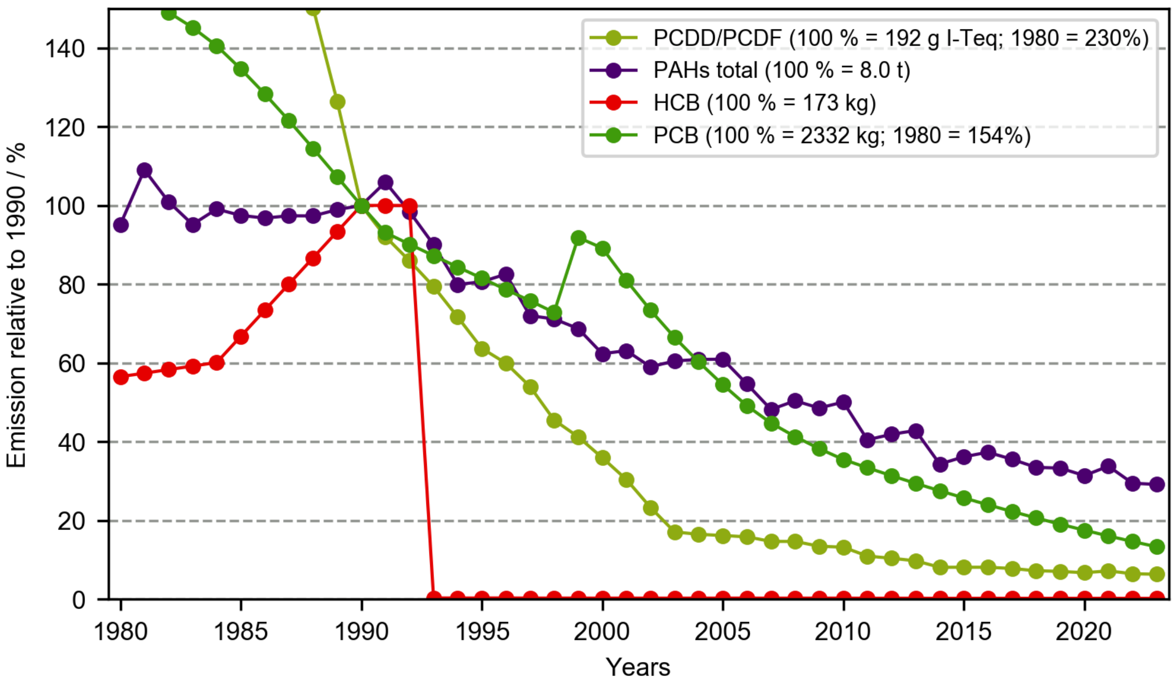



Figure 2-7 Emissions of POPs Annex III[1]: PAH – as the sum of benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene – PCDD/PCDF, HCB and PCB in Switzerland 1980–2023. Note that values for PCDD/PCDF before 1989 are not displayed here but illustrated in the table below. Potential discrepancies between the values before 1990 and those afterwards result from higher data availability after 1990.

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

Table 2-7 Total emissions of POPs Annex III (see footnote 1, p. 54). 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 | PAHs total | HCB | PCB |
|---|---|---|---|---|---|---|---|---|
| | g I-Teq | t | t | t | t | t | kg | kg |
| 1980 | 443 | 2.3 | 2.6 | 1.6 | 1.2 | 7.6 | 97 | 3'607 |
| 1985 | 397 | 2.3 | 2.6 | 1.6 | 1.3 | 7.8 | 115 | 3'140 |
| 1990 | 192 | 2.3 | 2.6 | 1.7 | 1.4 | 8.0 | 173 | 2'332 |
| 1995 | 123 | 2.0 | 2.1 | 1.3 | 1.2 | 6.5 | 0.49 | 1'901 |
| 2000 | 69 | 1.5 | 1.6 | 1.1 | 0.87 | 5.0 | 0.43 | 2'079 |
| 2005 | 31 | 1.4 | 1.6 | 1.0 | 0.82 | 4.9 | 0.44 | 1'270 |
| 2010 | 25 | 1.3 | 1.3 | 0.77 | 0.71 | 4.0 | 0.45 | 827 |
| 2014 | 16 | 0.84 | 0.89 | 0.55 | 0.49 | 2.8 | 0.35 | 642 |
| 2015 | 16 | 0.89 | 0.94 | 0.57 | 0.51 | 2.9 | 0.36 | 600 |
| 2016 | 16 | 0.91 | 0.96 | 0.59 | 0.53 | 3.0 | 0.38 | 559 |
| 2017 | 15 | 0.86 | 0.91 | 0.57 | 0.51 | 2.9 | 0.37 | 519 |
| 2018 | 14 | 0.81 | 0.86 | 0.54 | 0.48 | 2.7 | 0.36 | 481 |
| 2019 | 14 | 0.81 | 0.86 | 0.54 | 0.48 | 2.7 | 0.36 | 444 |
| 2020 | 13 | 0.76 | 0.81 | 0.51 | 0.45 | 2.5 | 0.35 | 408 |
| 2021 | 14 | 0.82 | 0.87 | 0.54 | 0.48 | 2.7 | 0.37 | 374 |
| 2022 | 12 | 0.71 | 0.76 | 0.48 | 0.42 | 2.4 | 0.34 | 341 |
| 2023 | 12 | 0.70 | 0.75 | 0.47 | 0.42 | 2.3 | 0.34 | 310 |
| 2023 vs 2005 (%) | -61 | -51 | -53 | -54 | -49 | -52 | -23 | -76 |

## 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 2-8 and Figure 2-8. Overall, $NO_x$ emissions in Switzerland constantly declined between 1990 and 2023.

The decline has mainly occurred due to emission reductions in the energy sector. Within the energy sector, in particular categories 1A3 Transport, 1A4 Other sectors and 1A2 Manufacturing industries are relevant for $NO_x$ emissions in 2023. The decrease of $NO_x$ emissions in sector 1 Energy was primarily due to the abatement of exhaust emissions from road vehicles (in category 1A3 Transport) and from production of process heat in manufacturing industries (1A2) and in residential, commercial and institutional heating (1A4).

- The reductions in 1A3b Road transportation 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 for 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 due to emission standards has not been as pronounced as expected in the years before 2015 because of an increasing share of diesel-powered passenger cars and higher emission factor than expected (the “dieselgate” scandal[2], detected in the year 2015).

- In the years 2020 and 2021, the COVID-19 pandemic led to measures that resulted in a massive reduction in transport activities (1A3). The lower traffic volume led to a strong decrease in $NO_x$ emissions from 1A3b Road transportation and a sharp drop in emissions from 1A3a Aviation, especially international aviation. However, the share of $NO_x$ emissions from 1A3a Aviation in 1A3 Transport is smaller than that from 1A3b Road transportation, in particular due to the system boundaries (only LTO emissions from air traffic are taken into account in the national total, see chapter 3.1.6.1).
- The reductions in 1A2 Manufacturing industries and construction 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 effects resulted in an increase of the total heated area. On the other hand, higher standards were specified for insulation and for combustion equipment efficiency for new or renovated buildings including low-$NO_x$ standards. Furthermore, a substantial substitution of gas oil by natural gas under 1A4 Other sectors resulted in further reductions of $NO_x$ emissions (i.e. natural gas consumption increased by half from 1990 to 2023). These emission reductions compensate for the expected increase in emissions due to higher demand for heating energy as a result of more heating surface, and lead to a total reduction of $NO_x$ emissions under category 1A4 Other sectors.

$NO_x$ emissions from Agriculture decrease on a rather low absolute emission level. This was mainly due to a reduction and thus N excretions of livestock (-17 % between 1990 and 2020) and a strong decrease of N fertiliser use (-38 % N applied between 1990 and 2020) due to nutrient balance restrictions (Kupper et al. 2022).

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

| NOx emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt | kt | % | % |
| 1(fu) Energy | 135 | 89 | 79 | 43 | -56 | -46 | -52 | 92 |
| 1A(fu) Combustion | 135 | 89 | 79 | 43 | -56 | -46 | -52 | 92 |
| 1A1 Energy industries | 6.8 | 3.0 | 3.1 | 2.6 | -3.7 | -0.36 | -12 | 5.6 |
| 1A2 Manufacturing industries and construction | 23 | 14 | 12 | 6.5 | -10 | -7.9 | -55 | 14 |
| 1A3(fu) Transport | 83 | 54 | 48 | 25 | -35 | -29 | -54 | 53 |
| 1A4 Other sectors | 22 | 17 | 15 | 8.3 | -6.7 | -8.3 | -50 | 18 |
| 1A5 Other | 0.88 | 0.60 | 0.54 | 0.40 | -0.34 | -0.20 | -34 | 0.85 |
| 1B Fugitive emissions from fuels | 0.21 | 0.29 | 0.11 | 0.00057 | -0.098 | -0.28 | -100 | 0.0012 |
| 2 Industrial processes and product use | 0.52 | 0.34 | 0.40 | 0.20 | -0.11 | -0.14 | -41 | 0.43 |
| 3 Agriculture | 5.0 | 3.8 | 4.0 | 3.5 | -0.97 | -0.35 | -9.2 | 7.5 |
| 5 Waste | 0.29 | 0.16 | 0.15 | 0.12 | -0.14 | -0.035 | -22 | 0.27 |
| 6 Other sources | 0.092 | 0.097 | 0.100 | 0.085 | 0.0079 | -0.012 | -12 | 0.18 |
| National total for compliance | 141 | 94 | 83 | 47 | -57 | -47 | -50 | 100 |
| Gothenburg Protocol, target emission ceiling 2010 | | | 79 | | | | | |
| Gothenburg Protocol revised, target emission reduction 2005-2020 | | | | | | | -41 | |

[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 [29.01.2025]

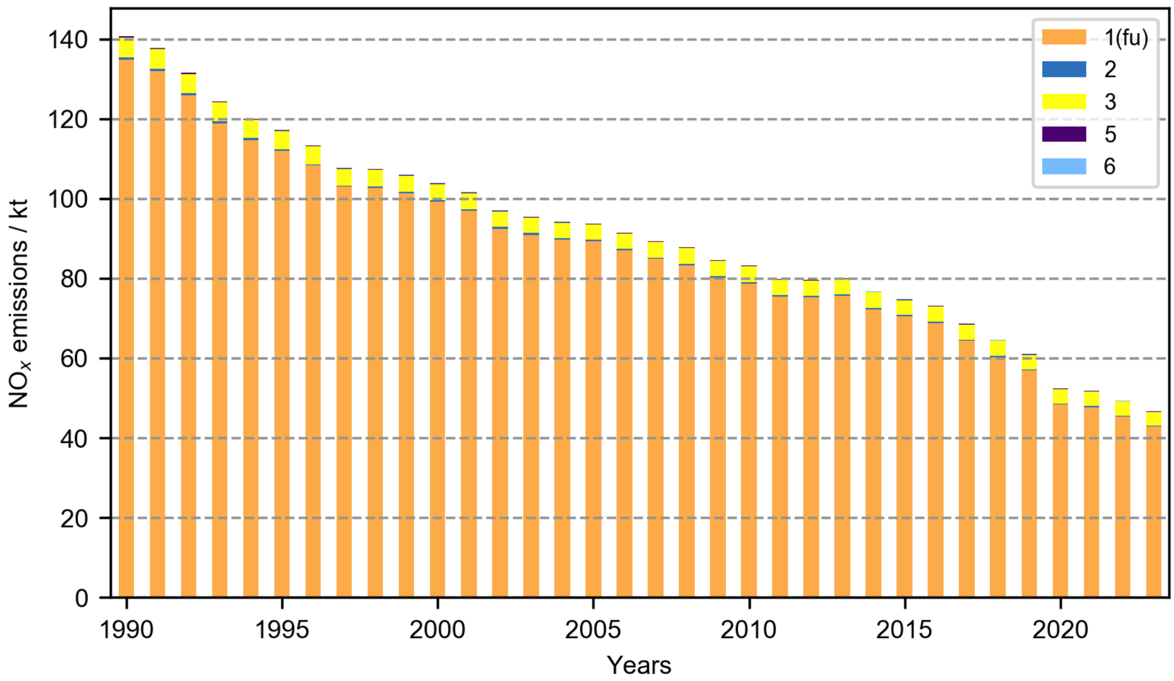



Figure 2-8 Trend of $NO_x$ emissions (kt) in Switzerland by sector ((fu) means fuel used approach).

### 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 2-9 and Figure 2-9. The NMVOC emissions have decreased in the time span 1990-2023.

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 1990-2004 than from 2004 onwards. The reduction of 1990-2004 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 paint application (2001-2004) which is partly due to substitution of conventional paints by powder coatings.
  Despite population growth and the associated increase in product use (e.g. cosmetics, toiletries, cleaning agents and care products), the general trend of NMVOC emissions from sector 2 IPPU was still decreasing from 2004-2016 (and rather constant values afterwards). This was mainly a result of reduced emissions caused by the ordinance on the VOC incentive tax (enactment of the tax in 2000 and revision in 2012).
- In sector 1 Energy, the emission reduction was mainly influenced from category 1A3b Road transportation, in particular 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 2023, which leads to a decrease of NMVOC emissions. In 2020 and 2021, the COVID-19 pandemic led to a reduction of NMVOC emissions from road transportation due to reduced traffic volumes.
  The measures against the pandemic also led to a sharp drop in emissions from 1A3a Aviation in 2020 and 2021, especially international aviation. However, the share of NMVOC emissions from 1A3a Aviation in 1A3 Transport is smaller than that from 1A3b

Road transportation, in particular due to the different fuel types (most NMVOC emissions stem from gasoline engines and the system boundaries (only LTO emissions from air traffic are taken into account in the national total, see chapter 3.1.6.1).

- NMVOC emissions of source category 1A4 Other sectors declined in the same period as well due to technical improvements of wood combustion installations and a reduction in the number and energy consumption of emission intensive types of log wood furnaces.

NMVOC emissions from sector 3 Agriculture show a significant increase between 2000 and 2008 and have remained at about constant level since 2014. They depend on the number of livestock, in particular, the number of cattle receiving silage feeding. Thus, the emission increase is mainly due to the increase in non-dairy cattle which predominately are fed by silage.

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

| NMVOC emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt | kt | % | % |
| 1(fu) Energy | 130 | 44 | 31 | 15 | -99 | -29 | -65 | 21 |
| 1A(fu) Combustion | 109 | 37 | 26 | 13 | -83 | -24 | -65 | 18 |
| 1A1 Energy industries | 0.33 | 0.32 | 0.26 | 0.20 | -0.067 | -0.12 | -39 | 0.28 |
| 1A2 Manufacturing industries and construction | 2.4 | 2.1 | 1.6 | 0.85 | -0.78 | -1.2 | -59 | 1.2 |
| 1A3(fu) Transport | 89 | 23 | 15 | 7.0 | -74 | -16 | -69 | 9.9 |
| 1A4 Other sectors | 17 | 12 | 9.3 | 4.7 | -8.2 | -6.9 | -60 | 6.6 |
| 1A5 Other | 0.16 | 0.11 | 0.090 | 0.064 | -0.070 | -0.045 | -42 | 0.090 |
| 1B Fugitive emissions from fuels | 21 | 7.2 | 5.2 | 2.4 | -16 | -4.8 | -67 | 3.4 |
| 2 Industrial processes and product use | 149 | 51 | 47 | 36 | -102 | -15 | -29 | 51 |
| 3 Agriculture | 14 | 16 | 17 | 18 | 2.8 | 2.0 | 12 | 25 |
| 5 Waste | 1.1 | 1.0 | 1.2 | 1.8 | 0.049 | 0.75 | 73 | 2.5 |
| 6 Other sources | 0.20 | 0.20 | 0.18 | 0.17 | -0.024 | -0.037 | -18 | 0.23 |
| National total for compliance | 295 | 112 | 97 | 71 | -198 | -41 | -36 | 100 |
| Gothenburg Protocol, target emission ceiling 2010 | | | 144 | | | | | |
| Gothenburg Protocol revised, target emission reduction 2005-2020 | | | | | | | -30 | |

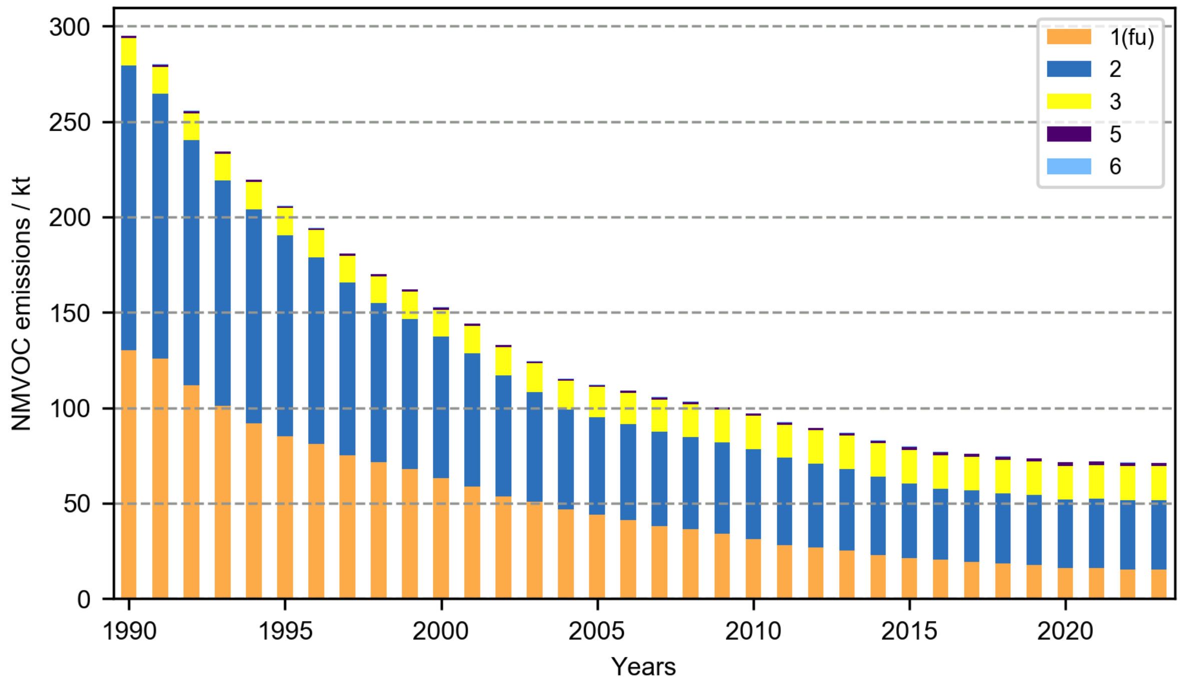



Figure 2-9 Trend of NMVOC emissions (kt) in Switzerland by sector ((fu) means fuel used approach).

### 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 2-10 and Figure 2-10. $SO_x$ emissions show a decreasing trend with some fluctuations between 1990 and 2023.

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

- First, the Ordinance on Air Pollution Control (Swiss Confederation 1985) introduced a limitation of the sulphur content in liquid fuels, with further stepwise lowering in 1991, 2000, 2005, 2008 and 2009 for liquid fuels (Table 3-28). These stringent measures resulted in a significant decrease of the sulphur oxide emissions from fuel combustion under 1A3 Transport and 1A4 Other sectors (gas oil, diesel oil and gasoline, see Table 3-28).
- 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 Other sectors resulted in further reductions of sulphur emissions (natural gas consumption increased by half from 1990 to 2023).
- 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).

In addition, $SO_x$ emissions from 2C Metal production declined between 1990 and 2007, mainly following the decrease in aluminium production volume, which was ceased in 2006. $SO_x$ emissions of sector 2B Chemical industry show no clear trend in the period 1990–2023. They stem predominately from the sulphur content of the raw materials of the graphite and silicon carbide production (petroleum coke and other bituminous coal) and reflect, thus, the production volumes.

Table 2-10 $SO_x$ emissions, trends and share per sector as well as the emission ceiling for 2010 from the Gothenburg Protocol (national total for compliance; fuel used).

| SOx emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt | kt | % | % |
| 1(fu) Energy | 37 | 13 | 9.2 | 2.5 | -28 | -11 | -81 | 90 |
| 1A(fu) Combustion | 37 | 13 | 9.0 | 2.5 | -28 | -10 | -80 | 89 |
| 1A1 Energy industries | 4.3 | 1.6 | 1.7 | 0.31 | -2.6 | -1.3 | -81 | 11 |
| 1A2 Manufacturing industries and construction | 13 | 4.2 | 2.9 | 1.6 | -10 | -2.5 | -61 | 58 |
| 1A3(fu) Transport | 4.0 | 0.18 | 0.20 | 0.19 | -3.8 | 0.010 | 5.6 | 6.8 |
| 1A4 Other sectors | 15 | 6.6 | 4.1 | 0.34 | -11 | -6.3 | -95 | 12 |
| 1A5 Other | 0.078 | 0.037 | 0.037 | 0.033 | -0.041 | -0.0044 | -12 | 1.2 |
| 1B Fugitive emissions from fuels | 0.72 | 0.51 | 0.22 | 0.015 | -0.50 | -0.50 | -97 | 0.54 |
| 2 Industrial processes and product use | 1.6 | 1.0 | 0.80 | 0.26 | -0.84 | -0.78 | -75 | 9.0 |
| 3 Agriculture | NA | NA | NA | NA | - | - | - | - |
| 5 Waste | 0.16 | 0.063 | 0.063 | 0.030 | -0.10 | -0.033 | -52 | 1.1 |
| 6 Other sources | 0.0092 | 0.0094 | 0.0074 | 0.0072 | -0.0017 | -0.0022 | -23 | 0.25 |
| National total for compliance | 39 | 14 | 10 | 2.8 | -29 | -11 | -80 | 100 |
| Gothenburg Protocol, target emission ceiling 2010 | | | 26 | | | | | |
| Gothenburg Protocol revised, target emission reduction 2005-2020 | | | | | | | -21 | |

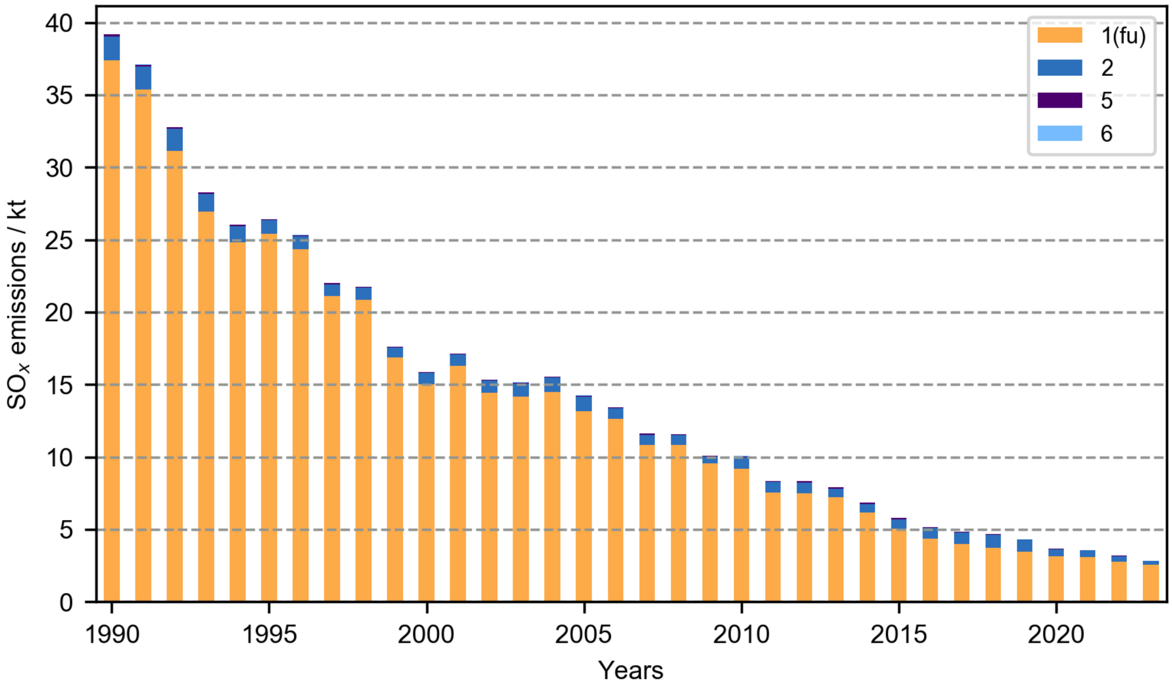



Figure 2-10 Trend of $SO_x$ emissions (kt) in Switzerland by sector ($SO_x$ as sum of $SO_2$ and $SO_3$, expressed as $SO_2$ equivalents) ((fu) means fuel used approach).

### 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 2-11 and Figure 2-11. $NH_3$ emissions show a decreasing trend between 1990 and 2023.

Emission reductions (with fluctuations) occurred mainly in source category 3D Crop production and agricultural soils, especially in 3Da2a Animal manure applied to soils, while emissions from source category 3B Manure management slightly increased. In 2023, both categories are about equally important. Agricultural ammonia emissions decreased between 1990 and 2004, followed by a slight increase until 2007 and another decrease since then. This non-monotonic trend results from a combination of changes in animal numbers, introduction of nutrient balance regulations for nitrogen, introduction of new housing systems and more grazing due to developments in animal welfare regulations, increase of animal productivity, changes in production techniques and a considerable decrease of N fertiliser use due to nutrient balance restrictions (Kupper et al. 2015, 2018, 2022). Between 1990 and 2020, N excretions from livestock decreased by 17 % and N excretions of livestock going into the manure stream even by 27 % (Kupper et al. 2022). A further reason for the downward trend of agricultural $NH_3$ emissions is the growing importance of grazing due to animal welfare incentives. The share of soluble N (TAN) of excretions of livestock going to grazing increased from 8 % in 1990 to 17 % in 2020 (Kupper et al. 2022).

Table 2-11 $NH_3$ emissions, trends and share per sector as well as the emission ceiling for 2010 from the Gothenburg Protocol (national total for compliance; fuel used).

| NH3 emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt | kt | % | % |
| 1(fu) Energy | 1.7 | 3.9 | 2.7 | 1.3 | 1.1 | -2.6 | -68 | 2.4 |
| 1A(fu) Combustion | 1.7 | 3.9 | 2.7 | 1.3 | 1.1 | -2.6 | -68 | 2.4 |
| 1A1 Energy industries | 0.0049 | 0.029 | 0.036 | 0.042 | 0.032 | 0.014 | 47 | 0.080 |
| 1A2 Manufacturing industries and construction | 0.17 | 0.19 | 0.24 | 0.21 | 0.077 | 0.015 | 7.5 | 0.40 |
| 1A3(fu) Transport | 1.3 | 3.5 | 2.3 | 0.90 | 0.99 | -2.6 | -74 | 1.7 |
| 1A4 Other sectors | 0.18 | 0.14 | 0.14 | 0.10 | -0.038 | -0.042 | -29 | 0.19 |
| 1A5 Other | 0.000037 | 0.000039 | 0.000042 | 0.000041 | 0.000005 | 0.000001 | 3.3 | 0.000077 |
| 1B Fugitive emissions from fuels | NA | NA | NA | NA | - | - | - | - |
| 2 Industrial processes and product use | 0.37 | 0.35 | 0.21 | 0.13 | -0.16 | -0.22 | -63 | 0.25 |
| 3 Agriculture | 65 | 54 | 53 | 50 | -12 | -4.0 | -7.5 | 94 |
| 5 Waste | 0.91 | 0.93 | 0.89 | 0.86 | -0.020 | -0.064 | -6.9 | 1.6 |
| 6 Other sources | 0.85 | 0.88 | 0.92 | 0.97 | 0.073 | 0.095 | 11 | 1.8 |
| National total for compliance | 68 | 60 | 58 | 53 | -11 | -6.8 | -11 | 100 |
| Gothenburg Protocol, target emission ceiling 2010 | | | 63 | | | | | |
| Gothenburg Protocol revised, target emission reduction 2005-2020 | | | | | | | -8.0 | |

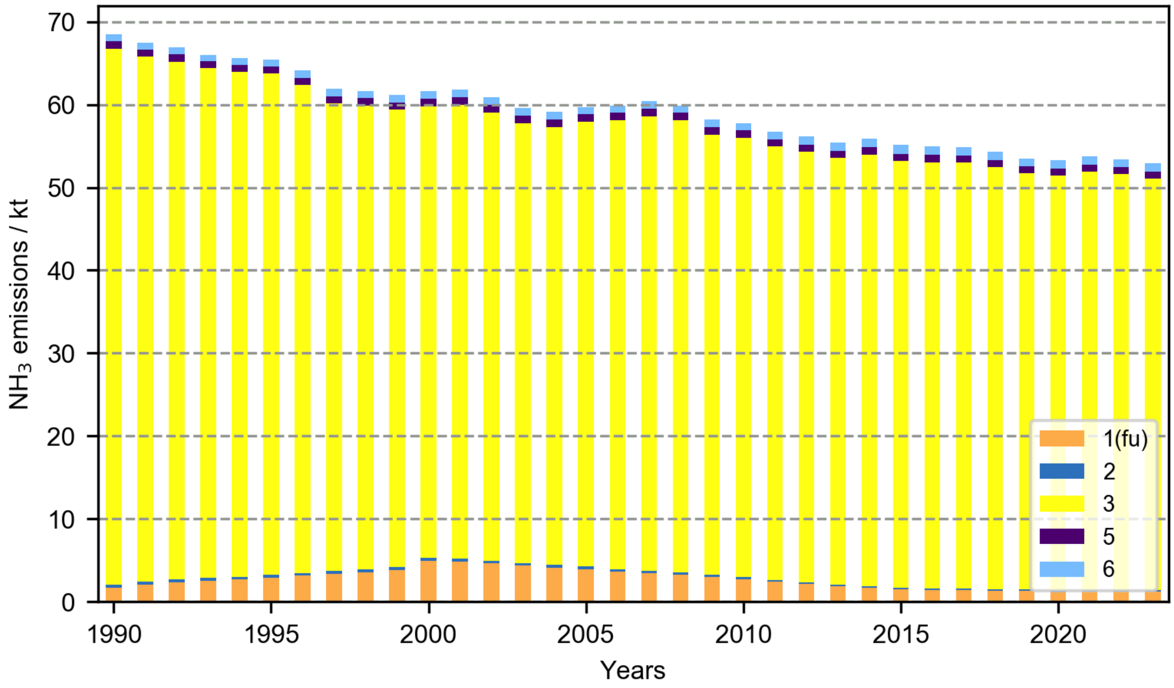



Figure 2-11 Trend of $NH_3$ emissions (kt) in Switzerland by sector. ((fu) means fuel used approach).

## 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. For TSP, due to the considerable emission reductions in sector 1 Energy, the emissions from sector 3 Agriculture have gained in importance and have been of comparable size in recent years.

Particulate matter emissions per sector are given in Table 2-12 and Figure 2-12 for PM2.5, in Table 2-13 for PM10, in Table 2-14 to Table 2-16 and Figure 2-13 for TSP and in Table 2-17 for BC. Total particulate matter emissions generally 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.

In the sector 1 Energy, the decline can be mainly attributed to a reduction of exhaust particulate matter emissions:

- The large reduction of exhaust particulate matter emissions is primarily due to the development of emissions from wood combustion, especially in single-room furnaces and building heating systems (1A4). The reduction was achieved through technological improvements of the combustion installations and a reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves). In addition, wood energy consumption in manually operated furnaces decreased by more than half since 1990. Furthermore, the revision of the Ordinance of Air Pollution (Swiss Confederation 1985) in 2007 introduced more stringent emission limits (2007, 2008 and 2012) for mainly automatic wood combustion installations, which also led to a reduction in emissions from these installations (mainly in 1A1 and 1A2), although their wood energy consumption increased by about a factor of eight since 1990.
- A further reduction of exhaust emissions under 1A3 Transport was caused by the abatement of exhaust emissions from road vehicles. Throughout the years, a continuous reduction of these emissions has been achieved with the stepwise adoption of the Euro standards. New diesel cars must be equipped with diesel particle filters.
- Under category 1A2 Manufacturing industries and construction, a reduction of exhaust emissions resulted from technological improvements in construction machineries (an installation of particle filters for new construction machineries with diesel engines is required by the Ordinance on Air Pollution Control (OAPC) since 2009) and from a fuel switch in stationary combustion (i.e. from coal, residual fuel oil and gas oil to natural gas).
- There is an underlying increasing in non-exhaust particulate matter emissions from growing activity data (annual mileage and machine hours) of mobile sources 1A3 Transport and 1A2gvii Mobile combustion in manufacturing industries and construction which affects larger particle emissions (TSP and PM10) more than PM2.5. This is due to a larger share of non-exhaust emissions with a particle diameter of 10 micrometres and larger. Therefore, the overall decreasing trend in TSP emissions is less pronounced as compared to the decrease in PM2.5 emissions. Note: In 2020 and 2021, despite this underlying increasing trend, the measures against the COVID-19 pandemic led to a reduction of non-exhaust PM10 emissions from road transportation due to reduced traffic volumes.

In sector 2 IPPU, particulate matter emissions strongly decrease in the period 1990-2001 and fluctuate only slightly since then. In 1990, the source categories 2A Mineral products (PM2.5, PM10, TSP), 2C Metal production (PM2.5, PM10, TSP), 2G Other product use (PM2.5), 2H Other (PM2.5) and 2I Wood processing (PM10, TSP) contributed the most to the particulate matter emissions. After 1999, IPPU emissions (e.g. from cement production, gravel plants and use of fireworks and tobacco, wood processing) became a smaller source of total particulate matter emissions. The following measures contribute to the decreasing trend:

- Significant emission reductions up to 1999 occurred in category 2C1 Iron and steel production in two steps. In 1995, two steel production sites were closed 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.
- For TSP emissions, also the emission reduction in 2I Wood processing between 1990 and 2003 was relevant. On the one hand, this was achieved by refurbishments due to the enforcement of the OAPC (Swiss Confederation 1985), but also by the area-wide introduction of filter systems due to occupational safety regulations (carcinogenic effect of beech wood dust).

## 2.4.2 Trends for PM2.5

Switzerland's emissions of PM2.5 per sector are given in Table 2-12 and Figure 2-12. For explanations regarding the trends, see chp. 2.4.1 for features commonly holding for all particulate matter emissions.

Table 2-12 PM2.5 emissions, trends and share per sector (national total for compliance; fuel used).

| PM2.5 emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt | kt | % | % |
| 1(fu) Energy | 24 | 12 | 9.3 | 4.8 | -15 | -7.2 | -60 | 77 |
| 1A(fu) Combustion | 24 | 12 | 9.3 | 4.8 | -15 | -7.2 | -60 | 77 |
| 1A1 Energy industries | 0.83 | 0.19 | 0.20 | 0.061 | -0.64 | -0.13 | -69 | 0.98 |
| 1A2 Manufacturing industries and construction | 2.3 | 1.7 | 1.2 | 0.62 | -1.1 | -1.1 | -63 | 10.0 |
| 1A3(fu) Transport | 3.7 | 2.8 | 2.3 | 1.5 | -1.5 | -1.4 | -48 | 24 |
| 1A4 Other sectors | 17 | 7.2 | 5.6 | 2.6 | -11 | -4.6 | -64 | 42 |
| 1A5 Other | 0.087 | 0.057 | 0.050 | 0.045 | -0.037 | -0.012 | -21 | 0.72 |
| 1B Fugitive emissions from fuels | 0.00060 | 0.00066 | 0.00031 | 0.000039 | -0.00029 | -0.00062 | -94 | 0.00063 |
| 2 Industrial processes and product use | 2.5 | 1.3 | 1.4 | 0.99 | -1.1 | -0.35 | -26 | 16 |
| 3 Agriculture | 0.12 | 0.13 | 0.13 | 0.15 | 0.013 | 0.017 | 13 | 2.3 |
| 5 Waste | 0.57 | 0.38 | 0.36 | 0.27 | -0.20 | -0.11 | -28 | 4.3 |
| 6 Other sources | 0.0044 | 0.0043 | 0.0044 | 0.0047 | 0.000007 | 0.00038 | 8.8 | 0.075 |
| National total for compliance | 27 | 14 | 11 | 6.2 | -16 | -7.6 | -55 | 100 |
| Gothenburg Protocol, target emission ceiling 2010 | | | - | | | | | |
| Gothenburg Protocol revised, target emission reduction 2005-2020 | | | | | | | -26 | |

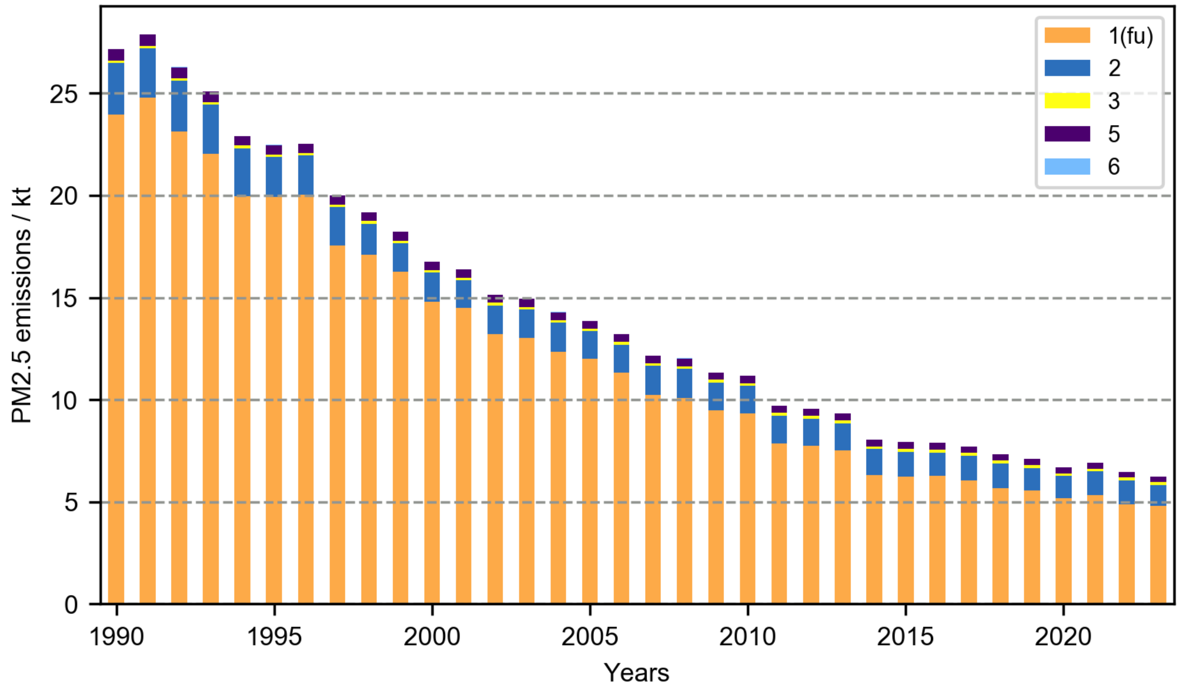



Figure 2-12 Trend of PM2.5 emissions (kt) in Switzerland by sector ((fu) means fuel used approach).

## 2.4.3 Trends for PM10

Switzerland's emissions of PM10 per sector are given in Table 2-13. For explanations regarding the trends, see chp. 2.4.1 for features commonly holding for all particulate matter emissions.

Table 2-13 PM10 emissions, trends and share per sector (national total for compliance; fuel used).

| PM10 emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt | kt | % | % |
| 1(fu) Energy | 29 | 17 | 14 | 10 | -15 | -6.8 | -40 | 72 |
| 1A(fu) Combustion | 29 | 17 | 14 | 10 | -15 | -6.8 | -40 | 72 |
| 1A1 Energy industries | 1.1 | 0.20 | 0.20 | 0.062 | -0.90 | -0.14 | -69 | 0.44 |
| 1A2 Manufacturing industries and construction | 4.2 | 3.6 | 3.1 | 2.6 | -1.1 | -0.93 | -26 | 19 |
| 1A3(fu) Transport | 5.9 | 5.3 | 4.9 | 4.4 | -0.97 | -0.89 | -17 | 31 |
| 1A4 Other sectors | 18 | 7.7 | 6.0 | 2.8 | -12 | -4.9 | -64 | 20 |
| 1A5 Other | 0.29 | 0.27 | 0.27 | 0.26 | -0.018 | -0.0041 | -1.5 | 1.9 |
| 1B Fugitive emissions from fuels | 0.0020 | 0.0013 | 0.00098 | 0.00038 | -0.0011 | -0.00091 | -71 | 0.0027 |
| 2 Industrial processes and product use | 4.5 | 2.2 | 2.3 | 1.7 | -2.2 | -0.47 | -22 | 12 |
| 3 Agriculture | 1.7 | 1.7 | 1.7 | 1.8 | 0.015 | 0.12 | 7.3 | 13 |
| 5 Waste | 0.64 | 0.42 | 0.41 | 0.30 | -0.24 | -0.12 | -28 | 2.1 |
| 6 Other sources | 0.23 | 0.21 | 0.14 | 0.11 | -0.086 | -0.10 | -47 | 0.80 |
| National total for compliance | 36 | 21 | 19 | 14 | -18 | -7.4 | -34 | 100 |

### 2.4.4 Trends for TSP

Switzerland’s emissions of TSP per sector are given in Table 2-14 to Table 2-16 and Figure 2-13. In addition to the features commonly holding for all particulate matter emissions mentioned in chp. 2.4.1, the contribution of sector 3 Agriculture to non-exhaust TSP emissions is significant (see Table 2-16). Its dominant emission sources are soil cultivation and crop harvesting reported in 3De Cultivated crops. These emissions remained on a rather constant level since 1990 and account for a high share of TSP emissions. In recent years, the TSP emission shares of the sectors 1 Energy and 3 Agriculture are of comparable size. In comparison, non-exhaust PM10 and PM2.5 emissions from the agriculture sector contribute less. Accordingly, the (relative) decreasing trend of TSP is less pronounced than the ones of PM10 and PM2.5.

Table 2-14 Total TSP emissions (sum of exhaust and non-exhaust), trends and share per sector (national total for compliance; fuel used).

| TSP emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt | kt | % | % |
| 1(fu) Energy | 32 | 19 | 16 | 12 | -16 | -6.9 | -36 | 43 |
| 1A(fu) Combustion | 32 | 19 | 16 | 12 | -16 | -6.9 | -36 | 43 |
| 1A1 Energy industries | 1.1 | 0.22 | 0.22 | 0.065 | -0.90 | -0.15 | -70 | 0.23 |
| 1A2 Manufacturing industries and construction | 5.5 | 4.7 | 4.2 | 3.8 | -1.3 | -0.82 | -18 | 14 |
| 1A3(fu) Transport | 6.2 | 5.7 | 5.3 | 4.9 | -0.87 | -0.77 | -14 | 17 |
| 1A4 Other sectors | 19 | 8.1 | 6.3 | 2.9 | -13 | -5.1 | -64 | 10 |
| 1A5 Other | 0.40 | 0.39 | 0.40 | 0.39 | -0.0054 | 0.00074 | 0.19 | 1.4 |
| 1B Fugitive emissions from fuels | 0.0045 | 0.0023 | 0.0021 | 0.00095 | -0.0024 | -0.0014 | -59 | 0.0034 |
| 2 Industrial processes and product use | 9.9 | 3.4 | 3.4 | 2.8 | -6.5 | -0.57 | -17 | 9.9 |
| 3 Agriculture | 13 | 13 | 13 | 13 | -0.33 | 0.073 | 0.58 | 45 |
| 5 Waste | 0.79 | 0.51 | 0.49 | 0.37 | -0.29 | -0.14 | -28 | 1.3 |
| 6 Other sources | 0.31 | 0.31 | 0.23 | 0.20 | -0.083 | -0.11 | -34 | 0.72 |
| National total for compliance | 56 | 36 | 33 | 28 | -23 | -7.6 | -21 | 100 |

Table 2-15 Exhaust TSP emissions, trends and share per sector (national total for compliance; fuel used).

| TSP ex emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt | kt | % | % |
| 1(fu) Energy | 26 | 12 | 8.7 | 3.5 | -17 | -8.2 | -70 | 76 |
| 1A(fu) Combustion | 26 | 12 | 8.7 | 3.5 | -17 | -8.2 | -70 | 76 |
| 1A1 Energy industries | 1.1 | 0.22 | 0.22 | 0.065 | -0.90 | -0.15 | -70 | 1.4 |
| 1A2 Manufacturing industries and construction | 2.9 | 1.6 | 1.0 | 0.33 | -1.9 | -1.3 | -80 | 7.0 |
| 1A3(fu) Transport | 2.9 | 1.9 | 1.3 | 0.28 | -1.7 | -1.6 | -85 | 6.0 |
| 1A4 Other sectors | 19 | 8.0 | 6.2 | 2.8 | -13 | -5.1 | -64 | 61 |
| 1A5 Other | 0.057 | 0.020 | 0.012 | 0.0066 | -0.044 | -0.014 | -67 | 0.14 |
| 1B Fugitive emissions from fuels | 0.00044 | 0.00059 | 0.00024 | 0.000001 | -0.00021 | -0.00059 | -100 | 0.000025 |
| 2 Industrial processes and product use | 2.6 | 0.83 | 0.81 | 0.57 | -1.8 | -0.27 | -32 | 12 |
| 3 Agriculture | NA | NA | NA | NA | - | - | - | - |
| 5 Waste | 0.78 | 0.50 | 0.49 | 0.36 | -0.29 | -0.14 | -28 | 7.8 |
| 6 Other sources | 0.30 | 0.29 | 0.21 | 0.18 | -0.096 | -0.11 | -38 | 3.9 |
| National total for compliance | 30 | 13 | 10 | 4.6 | -19 | -8.7 | -65 | 100 |

Table 2-16 Non-exhaust TSP emissions, trends and share per sector (national total for compliance; fuel used).

| TSP nx emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt | kt | % | % |
| 1(fu) Energy | 6.4 | 7.3 | 7.8 | 8.6 | 1.4 | 1.3 | 18 | 37 |
| 1A(fu) Combustion | 6.4 | 7.3 | 7.8 | 8.6 | 1.4 | 1.3 | 18 | 37 |
| 1A1 Energy industries | NA | NA | NA | NA | - | - | - | - |
| 1A2 Manufacturing industries and construction | 2.6 | 3.0 | 3.2 | 3.5 | 0.61 | 0.45 | 15 | 15 |
| 1A3(fu) Transport | 3.3 | 3.8 | 4.1 | 4.6 | 0.78 | 0.84 | 22 | 20 |
| 1A4 Other sectors | 0.13 | 0.12 | 0.11 | 0.10 | -0.021 | -0.018 | -15 | 0.44 |
| 1A5 Other | 0.34 | 0.37 | 0.38 | 0.38 | 0.039 | 0.015 | 3.9 | 1.6 |
| 1B Fugitive emissions from fuels | 0.0040 | 0.0017 | 0.0019 | 0.00095 | -0.0022 | -0.00080 | -46 | 0.0040 |
| 2 Industrial processes and product use | 7.4 | 2.5 | 2.6 | 2.2 | -4.7 | -0.30 | -12 | 9.5 |
| 3 Agriculture | 13 | 13 | 13 | 13 | -0.33 | 0.073 | 0.58 | 54 |
| 5 Waste | 0.0034 | 0.0036 | 0.0036 | 0.0036 | 0.00024 | 0.000000 | 0.000 | 0.015 |
| 6 Other sources | 0.0072 | 0.017 | 0.020 | 0.022 | 0.013 | 0.0045 | 26 | 0.093 |
| National total for compliance | 27 | 22 | 23 | 23 | -3.6 | 1.1 | 4.8 | 100 |

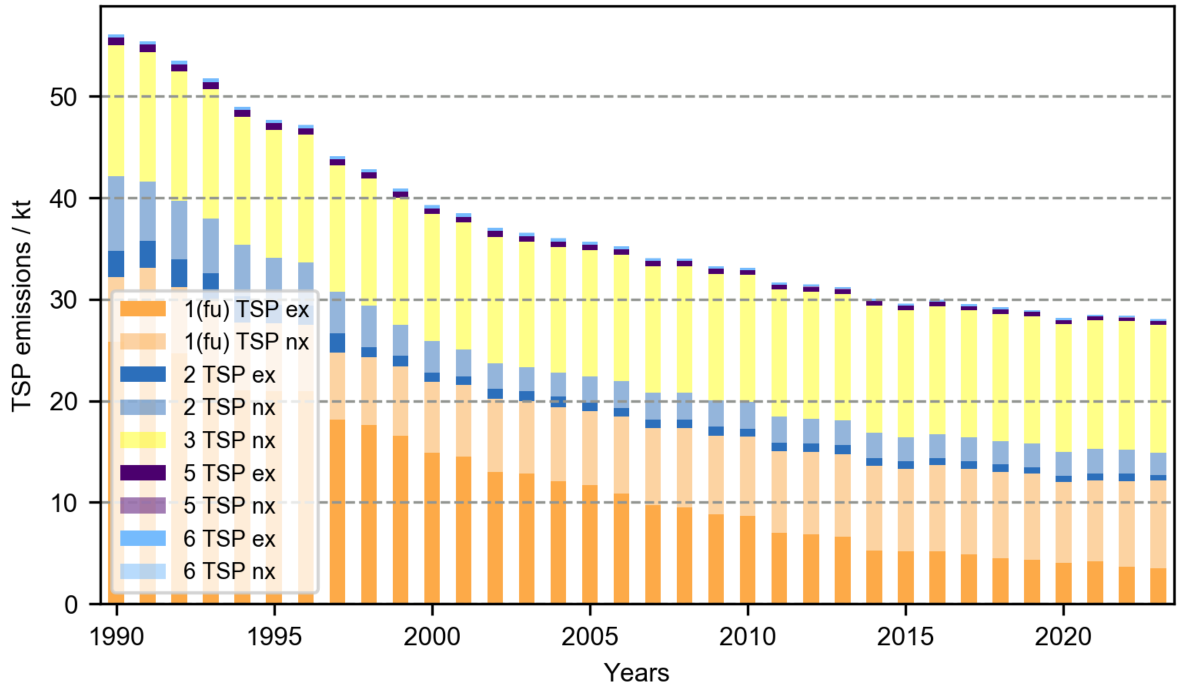



Figure 2-13 Trend of TSP emissions (kt) in Switzerland for sectors 1-6 split in exhaust (ex) and non-exhaust (nx) fraction. Non-exhaust emissions cross-hatched ((fu) means fuel used approach).

### 2.4.5 Trends for BC

Switzerland's emissions of BC mainly stem from sector 1 Energy, especially from stationary combustion in category 1A4bi Residential. The trend of BC emissions per sector is given in Table 2-17. BC emissions have decreased throughout the time period 1990-2023.

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

| BC emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt | kt | % | % |
| 1(fu) Energy | 5.7 | 3.5 | 2.5 | 0.81 | -3.1 | -2.7 | -77 | 98 |
| 1A(fu) Combustion | 5.7 | 3.5 | 2.5 | 0.81 | -3.1 | -2.7 | -77 | 97 |
| 1A1 Energy industries | 0.038 | 0.016 | 0.016 | 0.0072 | -0.022 | -0.0086 | -54 | 0.87 |
| 1A2 Manufacturing industries and construction | 0.42 | 0.32 | 0.14 | 0.030 | -0.28 | -0.29 | -91 | 3.6 |
| 1A3(fu) Transport | 1.4 | 1.2 | 0.86 | 0.19 | -0.52 | -1.1 | -85 | 23 |
| 1A4 Other sectors | 3.8 | 1.9 | 1.5 | 0.58 | -2.3 | -1.3 | -70 | 70 |
| 1A5 Other | 0.026 | 0.0099 | 0.0058 | 0.0032 | -0.020 | -0.0067 | -67 | 0.39 |
| 1B Fugitive emissions from fuels | 0.00020 | 0.00018 | 0.00010 | 0.000023 | -0.00010 | -0.00016 | -88 | 0.0028 |
| 2 Industrial processes and product use | 0.0063 | 0.0026 | 0.0016 | 0.0012 | -0.0047 | -0.0014 | -54 | 0.15 |
| 3 Agriculture | NA | NA | NA | NA | - | - | - | - |
| 5 Waste | 0.040 | 0.027 | 0.026 | 0.019 | -0.014 | -0.0072 | -27 | 2.3 |
| 6 Other sources | 0.00016 | 0.00015 | 0.000099 | 0.000078 | -0.000063 | -0.000070 | -47 | 0.0094 |
| National total for compliance | 5.7 | 3.5 | 2.6 | 0.83 | -3.2 | -2.7 | -77 | 100 |

# 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 2-18. The CO emissions have decreased between 1990 and 2023.

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). In 2020 and 2021, the COVID-19 pandemic led to a strong reduction of CO emissions from road transportation due to reduced traffic volumes.
- 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 more than half.

Table 2-18 CO emissions, trends and share per sector (national total for compliance; fuel used).

| CO emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt | kt | % | % |
| 1(fu) Energy | 737 | 294 | 232 | 133 | -506 | -162 | -55 | 96 |
| 1A(fu) Combustion | 737 | 294 | 232 | 133 | -506 | -162 | -55 | 96 |
| 1A1 Energy industries | 1.2 | 1.1 | 1.0 | 0.66 | -0.19 | -0.42 | -39 | 0.47 |
| 1A2 Manufacturing industries and construction | 27 | 21 | 20 | 14 | -7.2 | -6.5 | -31 | 10 |
| 1A3(fu) Transport | 546 | 165 | 118 | 63 | -428 | -102 | -62 | 45 |
| 1A4 Other sectors | 162 | 106 | 92 | 54 | -70 | -53 | -49 | 39 |
| 1A5 Other | 1.2 | 0.92 | 0.87 | 0.76 | -0.34 | -0.16 | -17 | 0.55 |
| 1B Fugitive emissions from fuels | 0.048 | 0.063 | 0.025 | 0.00014 | -0.022 | -0.063 | -100 | 0.00010 |
| 2 Industrial processes and product use | 11 | 8.1 | 7.2 | 4.4 | -3.9 | -3.7 | -46 | 3.2 |
| 3 Agriculture | NA | NA | NA | NA | - | - | - | - |
| 5 Waste | 2.6 | 1.8 | 1.7 | 1.4 | -0.83 | -0.48 | -26 | 0.99 |
| 6 Other sources | 0.93 | 0.86 | 0.57 | 0.46 | -0.35 | -0.40 | -47 | 0.33 |
| National total for compliance | 752 | 305 | 241 | 139 | -511 | -166 | -55 | 100 |

# 2.6 Trends of priority heavy metals per pollutant

## 2.6.1 Lead (Pb)

Switzerland's emissions of Pb mainly stem from sector 1 Energy. Due to significant reductions of Pb emissions in sector 1 Energy, also sectors 6 Other and 5 Waste contribute significantly to emission since 2000 and 2010, respectively. The trend of Pb emissions per sector is given in Table 2-19. 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 1A3b Road transportation) 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 in 1995 and the installation of new filters in the electric arc furnaces of the remaining secondary steel production plants in 1998/1999.
- 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 by improving the already installed technology.

Since 2000, the emissions further decrease on a lower level. The main reductions in this time period were achieved in the sectors, 1 Energy, 6 Other and 2 IPPU:

- In sector 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 1A3b Road transportation due to a higher share of diesel oil in comparison to gasoline (diesel oil has a much lower lead content than gasoline).
- The Pb emissions in sector 6 Other originate from fire damages (6Ad) and their reduction is mainly caused by a decrease in the number of building fires per year.
- In sector 2 IPPU, the ban of Pb in fireworks (2G) in 2003 lead to Pb emission reductions.

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

| Pb emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | t | t | t | t | t | t | % | % |
| 1(fu) Energy | 275 | 6.7 | 5.4 | 4.0 | -270 | -2.7 | -40 | 52 |
| 1A(fu) Combustion | 272 | 6.7 | 5.4 | 4.0 | -266 | -2.7 | -40 | 52 |
| 1A1 Energy industries | 30 | 1.9 | 1.8 | 1.7 | -28 | -0.22 | -11 | 22 |
| 1A2 Manufacturing industries and construction | 6.3 | 2.7 | 1.8 | 0.89 | -4.5 | -1.8 | -67 | 11 |
| 1A3(fu) Transport | 232 | 1.2 | 1.0 | 0.84 | -231 | -0.36 | -30 | 11 |
| 1A4 Other sectors | 3.8 | 0.94 | 0.90 | 0.57 | -2.9 | -0.37 | -39 | 7.3 |
| 1A5 Other | 0.033 | 0.00023 | 0.00024 | 0.00024 | -0.032 | 0.000011 | 4.8 | 0.0031 |
| 1B Fugitive emissions from fuels | 3.5 | 0.0011 | 0.00043 | 0.000002 | -3.5 | -0.0011 | -100 | 0.000027 |
| 2 Industrial processes and product use | 67 | 2.1 | 0.70 | 0.51 | -66 | -1.6 | -76 | 6.5 |
| 3 Agriculture | NA | NA | NA | NA | - | - | - | - |
| 5 Waste | 4.3 | 2.3 | 2.3 | 1.6 | -2.0 | -0.74 | -32 | 20 |
| 6 Other sources | 7.6 | 6.8 | 3.8 | 1.7 | -3.8 | -5.1 | -75 | 22 |
| National total for compliance | 355 | 18 | 12 | 7.8 | -342 | -10 | -57 | 100 |

## 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 2-20. Cd emissions showed a decreasing trend between 1990 and 2003 and remained about constant since then until 2013. After that, emissions slightly decrease.

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

- By equipping municipal solid waste incineration plants with flue gas treatment or by improving the already installed technologies, a significant reduction has been achieved in the period 1990–2003 under category 1A1a Public electricity and heat production.
- 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 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 in 1995 and the installation of new filters in the electric arc furnaces of the remaining secondary steel production plants in 1998/1999.

The slight decrease since 2013 is mainly due to continuous technical improvement in municipal solid waste incineration plants (source category 1A1a Public electricity and heat production), but also in sewage sludge incineration plants (source category 5C1).

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

| Cd emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | t | t | t | t | t | t | % | % |
| 1(fu) Energy | 2.6 | 0.43 | 0.44 | 0.37 | -2.2 | -0.063 | -15 | 90 |
| 1A(fu) Combustion | 2.6 | 0.43 | 0.44 | 0.37 | -2.2 | -0.062 | -14 | 90 |
| 1A1 Energy industries | 1.8 | 0.18 | 0.20 | 0.15 | -1.6 | -0.026 | -15 | 37 |
| 1A2 Manufacturing industries and construction | 0.74 | 0.10 | 0.091 | 0.066 | -0.65 | -0.037 | -36 | 16 |
| 1A3(fu) Transport | 0.069 | 0.077 | 0.083 | 0.096 | 0.013 | 0.019 | 24 | 24 |
| 1A4 Other sectors | 0.084 | 0.068 | 0.068 | 0.051 | -0.017 | -0.017 | -25 | 12 |
| 1A5 Other | 0.00048 | 0.00051 | 0.00054 | 0.00053 | 0.000058 | 0.000015 | 2.9 | 0.13 |
| 1B Fugitive emissions from fuels | 0.0011 | 0.0015 | 0.00058 | 0.000003 | -0.00056 | -0.0015 | -100 | 0.00071 |
| 2 Industrial processes and product use | 0.49 | 0.033 | 0.032 | 0.031 | -0.45 | -0.0022 | -6.6 | 7.6 |
| 3 Agriculture | NA | NA | NA | NA | - | - | - | - |
| 5 Waste | 0.046 | 0.021 | 0.027 | 0.0088 | -0.020 | -0.012 | -57 | 2.2 |
| 6 Other sources | 0.0023 | 0.0023 | 0.0017 | 0.0016 | -0.00054 | -0.00065 | -29 | 0.40 |
| National total for compliance | 3.2 | 0.48 | 0.50 | 0.41 | -2.7 | -0.078 | -16 | 100 |

### 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 2-21. Hg emissions showed a decreasing trend between 1990 and 2003 and from then on, a further 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 Energy industries has been achieved in the period 1990–2003 by equipping municipal solid waste incineration plants with flue gas treatment or by improving the already installed technology.
- The closing down of two steel production sites in 1995 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 mainly due to continuous technical improvements in waste and special waste incineration plants (1A1a) as well as crematoria (5C1).

Table 2-21 Hg emissions, trends and share per sector (national total for compliance; fuel used).

| Hg emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | t | t | t | t | t | t | % | % |
| 1(fu) Energy | 4.3 | 0.59 | 0.59 | 0.49 | -3.7 | -0.096 | -16 | 88 |
| 1A(fu) Combustion | 4.3 | 0.59 | 0.59 | 0.49 | -3.7 | -0.095 | -16 | 88 |
| 1A1 Energy industries | 3.9 | 0.34 | 0.32 | 0.29 | -3.6 | -0.049 | -14 | 52 |
| 1A2 Manufacturing industries and construction | 0.25 | 0.12 | 0.14 | 0.088 | -0.11 | -0.034 | -28 | 16 |
| 1A3(fu) Transport | 0.034 | 0.037 | 0.037 | 0.032 | 0.0026 | -0.0049 | -13 | 5.7 |
| 1A4 Other sectors | 0.089 | 0.086 | 0.094 | 0.078 | 0.0048 | -0.0079 | -9.2 | 14 |
| 1A5 Other | 0.000027 | 0.000028 | 0.000030 | 0.000029 | 0.000003 | 0.000001 | 2.4 | 0.0052 |
| 1B Fugitive emissions from fuels | 0.00020 | 0.00025 | 0.000098 | 0.000000 | -0.000098 | -0.00025 | -100 | 0.000087 |
| 2 Industrial processes and product use | 1.5 | 0.067 | 0.066 | 0.040 | -1.4 | -0.027 | -41 | 7.1 |
| 3 Agriculture | NA | NA | NA | NA | - | - | - | - |
| 5 Waste | 0.52 | 0.077 | 0.081 | 0.029 | -0.44 | -0.048 | -62 | 5.2 |
| 6 Other sources | 0.0011 | 0.0011 | 0.00080 | 0.00073 | -0.00029 | -0.00034 | -32 | 0.13 |
| National total for compliance | 6.3 | 0.73 | 0.74 | 0.56 | -5.6 | -0.17 | -23 | 100 |

## 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 2-22. PCDD/PCDF emissions were significantly reduced between 1990 and 2003. From then on, the decrease continues on a lower level. Due to the significant reductions in PCDD/PCDF emissions, particularly in sector 1 Energy, sector 5 Waste has also become an important PCDD/PCDF emission source.

The significant decrease between 1990 and 2003 was mainly achieved in category 1A1a Public electricity and heat production by retrofitting municipal solid waste incineration plants with flue gas treatment or by improving the already installed technology. Further reductions between 1990 and 2003 were achieved in source categories 2C1 Iron and steel production (i.e. closing down of two production sites in 1995 and installation of new filters in the electric arc furnaces of the remaining two secondary steel production plants in 1998/1999) and 5C1 Waste incineration (i.e. a continuous reduction of clinical waste incinerated at the hospital sites themselves which ceased in 2002 completely).

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 in manually operated furnaces decreased by more than half).

Since 2003, the slightly decreasing trend is mainly shaped through reductions in categories 1A4bi Residential: Stationary and 1A1a Public electricity and heat production (mainly due to further technical improvements in municipal solid waste incineration plants).

Table 2-22 PCDD/PCDF emissions, trends and share per sector (national total for compliance; fuel used).

| PCDD/ PCDF emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | g I-Teq | g I-Teq | g I-Teq | g I-Teq | g I-Teq | g I-Teq | % | % |
| 1(fu) Energy | 161 | 23 | 19 | 7.7 | -142 | -15 | -67 | 64 |
| 1A(fu) Combustion | 161 | 23 | 19 | 7.7 | -142 | -15 | -67 | 64 |
| 1A1 Energy industries | 130 | 5.2 | 3.4 | 0.99 | -127 | -4.3 | -81 | 8.1 |
| 1A2 Manufacturing industries and construction | 8.4 | 2.8 | 2.1 | 0.90 | -6.3 | -1.9 | -68 | 7.4 |
| 1A3(fu) Transport | 1.6 | 1.7 | 1.7 | 0.43 | 0.076 | -1.3 | -75 | 3.6 |
| 1A4 Other sectors | 20 | 13 | 12 | 5.4 | -8.3 | -8.0 | -60 | 45 |
| 1A5 Other | 0.00036 | 0.00038 | 0.00040 | 0.00039 | 0.000040 | 0.000009 | 2.4 | 0.0032 |
| 1B Fugitive emissions from fuels | 0.000006 | NA | NA | NA | -0.000006 | - | - | - |
| 2 Industrial processes and product use | 17 | 2.1 | 1.2 | 0.69 | -16 | -1.4 | -67 | 5.7 |
| 3 Agriculture | NA | NA | NA | NA | - | - | - | - |
| 5 Waste | 13 | 4.3 | 4.0 | 2.7 | -9.1 | -1.5 | -36 | 22 |
| 6 Other sources | 1.6 | 1.6 | 1.1 | 0.99 | -0.51 | -0.58 | -37 | 8.1 |
| National total for compliance | 192 | 31 | 25 | 12 | -167 | -19 | -61 | 100 |

### 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 2-23. PAH emissions have been reduced continuously between 1990 and 2023, except for 1A3b Road transportation, where PAH emissions increased in parallel with the increase of traffic volumes (except for 2020/2021, where traffic volumes shrank due to the COVID-19 pandemic).

The PAH emissions are dominated by wood energy combustion in single-room furnaces and building heating installations. Their reduction has mainly been achieved in the dominant source category 1A4 Other sectors through technological improvements of wood furnaces and a reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves) as well as a decrease of wood energy consumption by more than half in manually operated furnaces. The superimposed fluctuations in the emission trend reflect the climate variabilities (i.e. warmer or colder winters).

Table 2-23 PAH emissions, trends and share per sector (national total for compliance; fuel used).

| PAHs total emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | t | t | t | t | t | t | % | % |
| 1(fu) Energy | 6.7 | 4.1 | 3.7 | 2.0 | -3.0 | -2.1 | -50 | 86 |
| 1A(fu) Combustion | 6.7 | 4.1 | 3.7 | 2.0 | -3.0 | -2.1 | -50 | 86 |
| 1A1 Energy industries | 0.0076 | 0.0085 | 0.011 | 0.0098 | 0.0030 | 0.0013 | 15 | 0.42 |
| 1A2 Manufacturing industries and construction | 0.23 | 0.18 | 0.16 | 0.095 | -0.075 | -0.083 | -47 | 4.1 |
| 1A3(fu) Transport | 0.15 | 0.17 | 0.21 | 0.29 | 0.061 | 0.12 | 73 | 12 |
| 1A4 Other sectors | 6.3 | 3.7 | 3.3 | 1.6 | -3.0 | -2.1 | -56 | 70 |
| 1A5 Other | 0.00071 | 0.00073 | 0.00076 | 0.00068 | 0.000051 | -0.000053 | -7.2 | 0.029 |
| 1B Fugitive emissions from fuels | 0.000002 | 0.000002 | 0.000001 | 0.000000 | -0.000001 | -0.000002 | -100 | 0.000000 |
| 2 Industrial processes and product use | 0.96 | 0.51 | 0.023 | 0.019 | -0.94 | -0.49 | -96 | 0.80 |
| 3 Agriculture | NA | NA | NA | NA | - | - | - | - |
| 5 Waste | 0.28 | 0.23 | 0.21 | 0.19 | -0.075 | -0.037 | -16 | 8.1 |
| 6 Other sources | 0.065 | 0.086 | 0.092 | 0.11 | 0.027 | 0.024 | 28 | 4.7 |
| National total for compliance | 8.0 | 4.9 | 4.0 | 2.3 | -4.0 | -2.6 | -52 | 100 |

### 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 2-24. HCB emissions have significantly dropped in 1993 and then slightly decreased until 2023.

The decrease of HCB emissions in 1993 occurred in category 1A2b Non-ferrous metals due to the shutdown of the single secondary aluminium production plant. Since then, emissions continue to slightly decrease, in particular in category 1A4 Other sectors 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 more than half). In contrast, the amount of municipal solid waste incinerated has increased (1A1a Public electricity and heat production), which leads to an increase in HCB emissions in this source category.

Table 2-24 HCB emissions, trends and share per sector (national total for compliance; fuel used).

| HCB emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kg | kg | kg | kg | kg | kg | % | % |
| 1(fu) Energy | 173 | 0.44 | 0.45 | 0.34 | -172 | -0.10 | -23 | 100 |
| 1A(fu) Combustion | 173 | 0.44 | 0.45 | 0.34 | -172 | -0.10 | -23 | 100 |
| 1A1 Energy industries | 0.11 | 0.15 | 0.17 | 0.18 | 0.060 | 0.031 | 21 | 54 |
| 1A2 Manufacturing industries and construction | 172 | 0.051 | 0.051 | 0.033 | -172 | -0.018 | -35 | 9.8 |
| 1A3(fu) Transport | NE | NE | NE | NE | - | - | - | - |
| 1A4 Other sectors | 0.38 | 0.24 | 0.22 | 0.12 | -0.16 | -0.12 | -49 | 36 |
| 1A5 Other | NE | NE | NE | NE | - | - | - | - |
| 1B Fugitive emissions from fuels | NA | NA | NA | NA | - | - | - | - |
| 2 Industrial processes and product use | NA | NA | NA | NA | - | - | - | - |
| 3 Agriculture | NA | NA | NA | NA | - | - | - | - |
| 5 Waste | NA | NA | NA | NA | - | - | - | - |
| 6 Other sources | NA | NA | NA | NA | - | - | - | - |
| National total for compliance | 173 | 0.44 | 0.45 | 0.34 | -172 | -0.10 | -23 | 100 |

## 2.7.4 PCBs

Switzerland’s emissions of PCBs mainly stem from sector 2 IPPU, i.e. from source category 2K Usage of PCBs. To a lesser extent, also sectors 5 Waste and 6 Other contribute to PCB emissions. The trend of PCB emissions per sector is shown in Table 2-25. PCB emissions have decreased continuously between 1990 and 2023 except for a sudden sharp increase in 1999.

PCBs were used in Switzerland in transformers, large and small capacitors, anti-corrosive paints and joint sealants between 1946 and 1986, before a total ban was placed on any form of PCB use. The use in so-called open applications, i.e. anti-corrosive paints and joint sealants, was already forbidden in 1972. The emissions from source category 2K Usage of PCBs are dominated by the two open applications and are decreasing since 1975, while still remaining the major source until now (see also Table 1-6 and Figure A - 2).

At the end of the PCB containing products' life cycle, they are disposed of. Some of them undergo priorly a treatment process. Shredding of electronic waste containing PCBs in small capacitors (5E) is the dominant emission source in sector 5 Waste from 1990 onwards and is the cause for the sudden sharp increase in 1999. As a consequence of the legal ban of disposal of combustible waste in landfills a sharp increase in shredding of small capacitors occurred in 1999 although they should have been treated as special waste from 1998 onwards. Between 1999 and 2002, shredding was even the largest emission source of all. Before 1990, 5C1bii Open burning, i. e. burning of PCB contaminated waste oil in outdoor fires (ceased in 1999) dominated the emissions from 5 Waste.

From all PCB usages, PCBs can also be accidentally released by fire or by spilling to soil. Accidental release by fire is dominating the emissions from sector 6 Other which has decreased continuously since 1980.

PCB emissions from 1A1a Municipal solid waste incineration were of somewhat lower importance reaching a maximum in the early 1980s. From 1998 onwards, all PCB containing waste has to be incinerated in special waste incineration plants only.

PCB emissions arise also from combustion of solid and liquid fuels. Like PCDD/PCDF, PCBs are synthesized in the combustion process as by-products involving chloride and organic carbon or are due to incomplete combustion of PCB impurities in the fuel. Please note that these emissions are orders of magnitude smaller than the emissions from former use and subsequent disposal of PCBs.

Table 2-25 PCB emissions, trends and share per sector (national total for compliance; fuel used).

| PCB emissions | 1990 | 2005 | 2010 | 2023 | 1990-2010 | 2005-2023 | 2005-2023 | share in 2023 |
|---|---|---|---|---|---|---|---|---|
| | kg | kg | kg | kg | kg | kg | % | % |
| 1(fu) Energy | 165 | 1.4 | 0.55 | 0.36 | -164 | -1.1 | -75 | 0.11 |
| 1A(fu) Combustion | 165 | 1.4 | 0.55 | 0.36 | -164 | -1.1 | -75 | 0.11 |
| 1A1 Energy industries | 164 | 1.1 | 0.18 | 0.061 | -164 | -1.0 | -94 | 0.020 |
| 1A2 Manufacturing industries and construction | 0.50 | 0.35 | 0.38 | 0.29 | -0.12 | -0.061 | -17 | 0.095 |
| 1A3(fu) Transport | 0.00037 | 0.00037 | 0.00034 | 0.000088 | -0.000027 | -0.00028 | -76 | 0.000029 |
| 1A4 Other sectors | 0.0022 | 0.0015 | 0.0013 | 0.00069 | -0.00093 | -0.00080 | -54 | 0.00022 |
| 1A5 Other | NE | NE | NE | NE | - | - | - | - |
| 1B Fugitive emissions from fuels | NA | NA | NA | NA | - | - | - | - |
| 2 Industrial processes and product use | 1'537 | 922 | 708 | 279 | -829 | -643 | -70 | 90 |
| 3 Agriculture | NA | NA | NA | NA | - | - | - | - |
| 5 Waste | 347 | 254 | 56 | 5.1 | -291 | -249 | -98 | 1.6 |
| 6 Other sources | 282 | 93 | 62 | 25 | -220 | -68 | -73 | 8.2 |
| National total for compliance | 2'332 | 1'270 | 827 | 310 | -1'505 | -960 | -76 | 100 |

# 2.8 Compliance with the Gothenburg Protocol

## 2.8.1 Emission ceilings 2010

Under the CLRTAP, the 1999 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 2-26 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 except for $NO_x$ in 2010. All emissions 2023 are in compliance with the emission ceilings for 2010.

Table 2-26 Emission ceilings of the Gothenburg Protocol for 2010 and beyond compared to the reported emissions for 2010 and 2023 of the latest submission (2025).

| Pollutants | National emission ceilings for 2010 | Emissions 2010 (Subm. 2025) | Compliance with emission ceilings 2010 in 2010 | Emissions 2023 (Subm. 2025) | Compliance with emission ceilings 2010 in 2023 |
|---|---|---|---|---|---|
| | kt | kt | | kt | |
| $SO_x$ (as $SO_2$) | 26 | 10 | yes | 2.8 | yes |
| $NO_x$ (as $NO_2$) | 79 | 83 | no | 47 | yes |
| NMVOC | 144 | 97 | yes | 71 | yes |
| $NH_3$ | 63 | 58 | yes | 53 | 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. On 7 October 2019, the amended protocol including the new reduction commitments for 2020 has entered into force.

Table 2-27 shows the emission reduction commitments of the amended Gothenburg protocol and the corresponding emissions in 2023. The emission reduction commitments 2020 are achieved for all the pollutants ($SO_x$, $NO_x$, NMVOC, $NH_3$ and PM2.5).

Table 2-27 Reported emission reductions in 2020 and 2023 versus level of 2005 and reduction commitments per 2020. The Emission commitments 2020 are defined as reductions in percentages from 2005.

| **Pollutant** | **Emission reduction commitments 2020** | **Reduction achieved in 2020** | **Compliance with reduction commitments 2020 in 2020** | **Reduction achieved in 2023** | **Compliance with reduction commitments 2020 in 2023** |
|---|---|---|---|---|---|
| | *%-reduction of 2005 level* | *%-reduction of 2005 level* | | *%-reduction of 2005 level* | |
| $SO_x$ (as $SO_2$) | 21% | 74% | yes | 80% | yes |
| $NO_x$ (as $NO_2$) | 41% | 44% | yes | 50% | yes |
| NMVOC | 30% | 36% | yes | 36% | yes |
| $NH_3$ | 8% | 11% | yes | 11% | yes |
| PM2.5 | 26% | 52% | yes | 55% | yes |

# 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, PM2.5 and $SO_x$ 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 of 1A3 Transport since 1990 was reached in the year 2015, afterwards the share decreases. Emissions from 1A2 Manufacturing industries and construction and 1A4 Other sectors (commercial/institutional, residential, agriculture/forestry/fishing) are also contributing a noticeable amount. 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. Various measures led to a total $NO_x$ reduction between 1990 and 2023:

- The reductions in 1A3b Road transportation 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 for 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 due to emission standards has not been as pronounced as expected in the years before 2015 because of an increasing share of diesel-powered passenger cars and higher emission factor than expected (the “dieselgate” scandal[3], detected in the year 2015).
- In the years 2020 and 2021, the COVID-19 pandemic led to measures that resulted in a massive reduction in transport activities (1A3). The lower traffic volume led to a strong decrease in $NO_x$ emissions from 1A3b Road transportation and a sharp drop in emissions from 1A3a Aviation, especially international aviation. However, the share of $NO_x$ emissions from 1A3a Aviation in 1A3 Transport is smaller than that from 1A3b Road transportation, in particular due to the system boundaries (only LTO emissions from air traffic are taken into account in the national total, see chapter 3.1.6.1).
- The reductions in 1A2 Manufacturing industries and construction 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. On contrary, higher standards were specified for insulation and for

[4] https://www.bafu.admin.ch/bafu/en/home/topics/air/state/non-road-datenbank.html [06.02.2025]

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 Other sectors resulted in further reductions of $NO_x$ emissions (i.e. natural gas consumption increased by half from 1990 to 2023). These two effects compensated for the additional heated area, and lead to a reduction of $NO_x$ emissions under category 1A4 Other sectors.

Emissions from 1A1 Energy industries are minor with a decreasing trend until 2015 and a slight increase in the recent years due to increasing use of wood waste. 1A5 Other (Military) and 1B Fugitive emissions are negligible. minor.

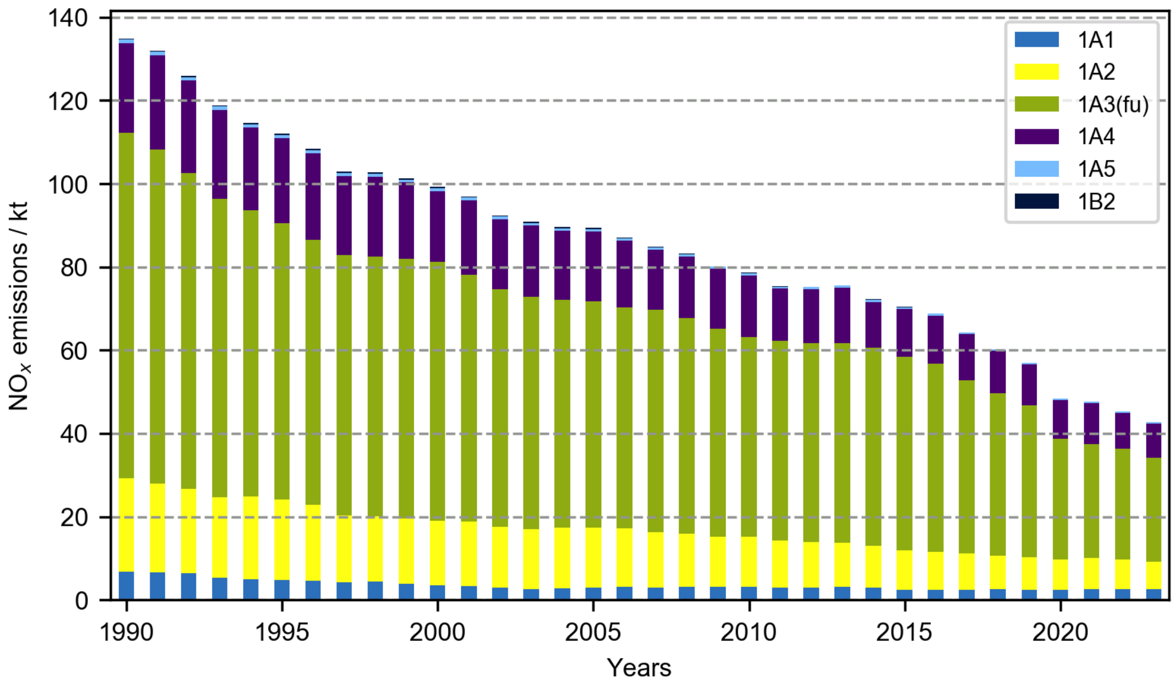



Figure 3-1 Switzerland's $NO_x$ emissions from the energy sector by source categories 1A1-1A5 and 1B2 between 1990 and 2023 ((fu) means fuel used approach). The corresponding data can be found in Table 3-1.

Table 3-1 $NO_x$ emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 ((fu) means fuel used approach). The last column in the third part of the table indicates the relative trend.

| NOx | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 1A1 | kt | 6.8 | 4.7 | 3.5 | 3.0 | 3.1 |
| 1A2 | kt | 23 | 19 | 15 | 14 | 12 |
| 1A3(fu) | kt | 83 | 66 | 62 | 54 | 48 |
| 1A4 | kt | 22 | 20 | 17 | 17 | 15 |
| 1A5 | kt | 0.88 | 0.71 | 0.67 | 0.60 | 0.54 |
| 1B1 | kt | NA | NA | NA | NA | NA |
| 1B2 | kt | 0.21 | 0.31 | 0.31 | 0.29 | 0.11 |
| Sum | kt | 135 | 112 | 99 | 89 | 79 |

| NOx | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 1A1 | kt | 3.0 | 2.5 | 2.5 | 2.5 | 2.5 |
| 1A2 | kt | 10 | 9.4 | 9.1 | 8.7 | 8.1 |
| 1A3(fu) | kt | 47 | 47 | 45 | 42 | 39 |
| 1A4 | kt | 11 | 11 | 12 | 11 | 10 |
| 1A5 | kt | 0.51 | 0.49 | 0.49 | 0.45 | 0.43 |
| 1B1 | kt | NA | NA | NA | NA | NA |
| 1B2 | kt | 0.088 | 0.050 | 0.0031 | 0.0024 | 0.0024 |
| Sum | kt | 72 | 70 | 69 | 64 | 60 |

| NOx | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 1A1 | kt | 2.5 | 2.5 | 2.5 | 2.5 | 2.6 | -12 |
| 1A2 | kt | 7.8 | 7.3 | 7.5 | 7.1 | 6.5 | -55 |
| 1A3(fu) | kt | 36 | 29 | 27 | 27 | 25 | -54 |
| 1A4 | kt | 9.9 | 9.2 | 9.9 | 8.5 | 8.3 | -50 |
| 1A5 | kt | 0.39 | 0.40 | 0.38 | 0.40 | 0.40 | -34 |
| 1B1 | kt | NA | NA | NA | NA | NA | - |
| 1B2 | kt | 0.0016 | 0.0018 | 0.0013 | 0.00059 | 0.00057 | -100 |
| Sum | kt | 57 | 48 | 48 | 45 | 43 | -52 |

### 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 2023. Due to the decrease of NMVOC emissions from 1A3 Transport, the relative importance of NMVOC emissions from 1A4 Other sectors is increasing.

- In sector 1 Energy, the emission reduction was mainly influenced from category 1A3b Road transportation, in particular 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 2023, which leads to a decrease of NMVOC emissions. In 2020 and 2021, the COVID-19 pandemic led to a reduction of NMVOC emissions from road transportation due to reduced traffic volumes.
  The measures against the pandemic also led to a sharp drop in emissions from 1A3a Aviation in 2020 and 2021, especially international aviation. However, the share of NMVOC emissions from 1A3a Aviation in 1A3 Transport is smaller than that from 1A3b Road transportation, in particular due to the different fuel types (most NMVOC emissions stem from gasoline engines and the system boundaries (only LTO emissions from air traffic are taken into account in the national total, see chapter 3.1.6.1).
- NMVOC emissions of source category 1A4 Other sectors declined in the same period as well due to technical improvements of wood combustion installations and a reduction in the number and energy consumption of emission intensive types of log wood furnaces.

- The decline of NMVOC emissions in 1B2 Fugitive emissions from oil and gas is due to technical improvement to reduce fugitive emissions caused by distribution and storage of gasoline.

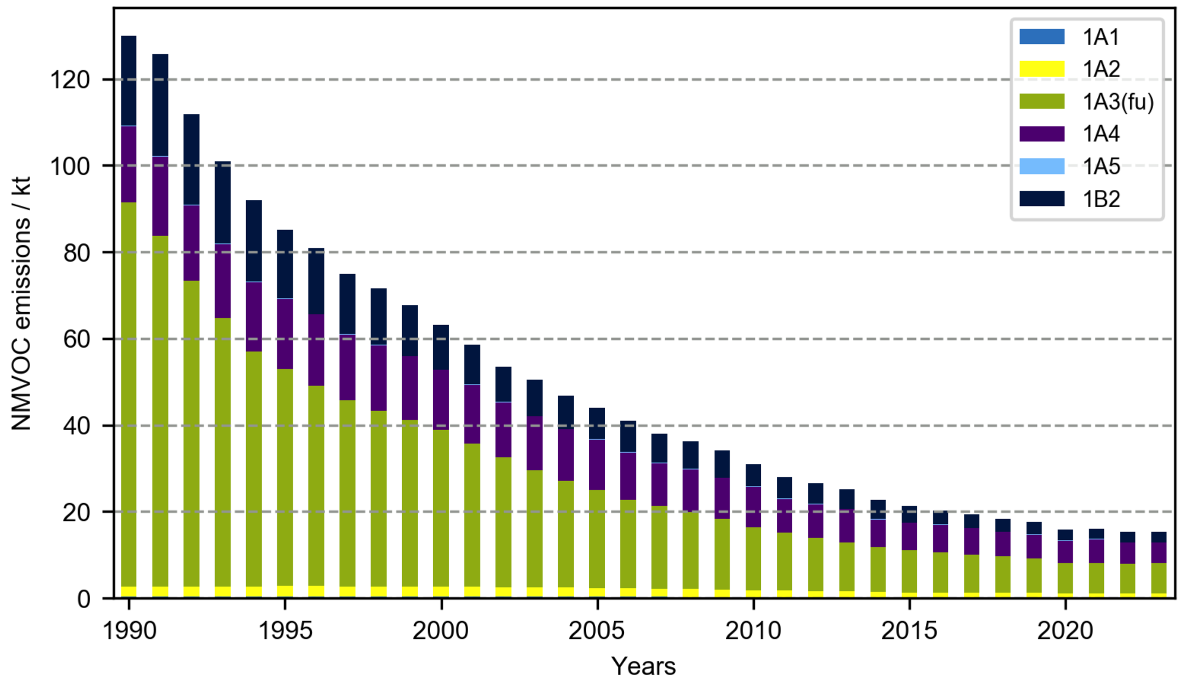



Figure 3-2 Switzerland's NMVOC emissions from the energy sector by source categories 1A1-1A5 and 1B2 between 1990 and 2023 ((fu) means fuel used approach). The corresponding data can be found in Table 3-2.

Table 3-2 NMVOC emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 ((fu) means fuel used approach). The last column in the third part of the table indicates the relative trend.

| NMVOC | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 1A1 | kt | 0.33 | 0.33 | 0.35 | 0.32 | 0.26 |
| 1A2 | kt | 2.4 | 2.4 | 2.3 | 2.1 | 1.6 |
| 1A3(fu) | kt | 89 | 50 | 36 | 23 | 15 |
| 1A4 | kt | 17 | 16 | 14 | 12 | 9.3 |
| 1A5 | kt | 0.16 | 0.14 | 0.13 | 0.11 | 0.090 |
| 1B1 | kt | NA | NA | NA | NA | NA |
| 1B2 | kt | 21 | 16 | 10 | 7.2 | 5.2 |
| Sum | kt | 130 | 85 | 63 | 44 | 31 |

| NMVOC | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 1A1 | kt | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| 1A2 | kt | 1.2 | 1.1 | 1.1 | 1.1 | 1.0 |
| 1A3(fu) | kt | 10 | 9.7 | 9.2 | 8.8 | 8.4 |
| 1A4 | kt | 6.3 | 6.3 | 6.4 | 6.1 | 5.7 |
| 1A5 | kt | 0.079 | 0.075 | 0.076 | 0.070 | 0.068 |
| 1B1 | kt | NA | NA | NA | NA | NA |
| 1B2 | kt | 4.4 | 3.8 | 3.3 | 3.1 | 3.0 |
| Sum | kt | 23 | 21 | 20 | 19 | 18 |

| NMVOC | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 1A1 | kt | 0.21 | 0.21 | 0.20 | 0.20 | 0.20 | -39 |
| 1A2 | kt | 0.98 | 0.92 | 0.93 | 0.90 | 0.85 | -59 |
| 1A3(fu) | kt | 8.0 | 6.9 | 7.0 | 6.9 | 7.0 | -69 |
| 1A4 | kt | 5.5 | 5.2 | 5.5 | 4.8 | 4.7 | -60 |
| 1A5 | kt | 0.062 | 0.063 | 0.061 | 0.064 | 0.064 | -42 |
| 1B1 | kt | NA | NA | NA | NA | NA | - |
| 1B2 | kt | 2.8 | 2.5 | 2.4 | 2.4 | 2.4 | -67 |
| Sum | kt | 18 | 16 | 16 | 15 | 15 | -65 |

### 3.1.3 Overview and trend for $SO_x$

Figure 3-3 depicts the $SO_x$ emissions in energy related sectors since 1990. In 2023, the main contribution from the sector 1 Energy are $SO_x$ emissions from source category 1A2 Manufacturing industries and construction. Other relevant sources are categories 1A1 Energy industries, 1A3 Transport and 1A4 Other sectors. $SO_x$ emissions from the other source categories (1A5 and 1B2) are negligible in the meantime. Overall, there is a decreasing trend since 1990, which is more pronounced between 1990 and 2000. The time series also show some year-to-year fluctuations. These fluctuations are mainly due to annual variations in the number of heating degree days, which causes fluctuations in the $SO_x$ emissions from fossil fuel-based heating systems in sector 1A4 Other sectors.

- First, the Ordinance on Air Pollution Control (Swiss Confederation 1985) introduced a limitation of the sulphur content in fuels, with further stepwise lowering in 1991, 2000, 2005, 2008 and 2009 for liquid fuels (Table 3-28). These stringent measures resulted in a significant decrease of the sulphur oxide emissions from fuel combustion under 1A3 Transport and 1A4 Other sectors (gas oil, diesel oil and gasoline, see Table 3-28).
- 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 Other sectors resulted in further reductions of sulphur emissions (natural gas consumption increased by half from 1990 to 2023).
- 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).

Additionally, emissions of 1A1 are decreasing caused by substitution of emission intensive fuels (e.g. no more consumption of residual fuel oil since 2011 and no more bituminous coal since 2000) and by the closing of a refinery plant in 2015. The $SO_x$ emissions from 1B2 Fugitive emissions from oil and gas are due to Claus units and flaring in refineries. The decrease between 1990 and 1995 can be explained by the retrofitting of the clause units due to the enactment of the Ordinance on Air Pollution Control in 1985. Further, the emission factors from clause units and flaring decreased over time.

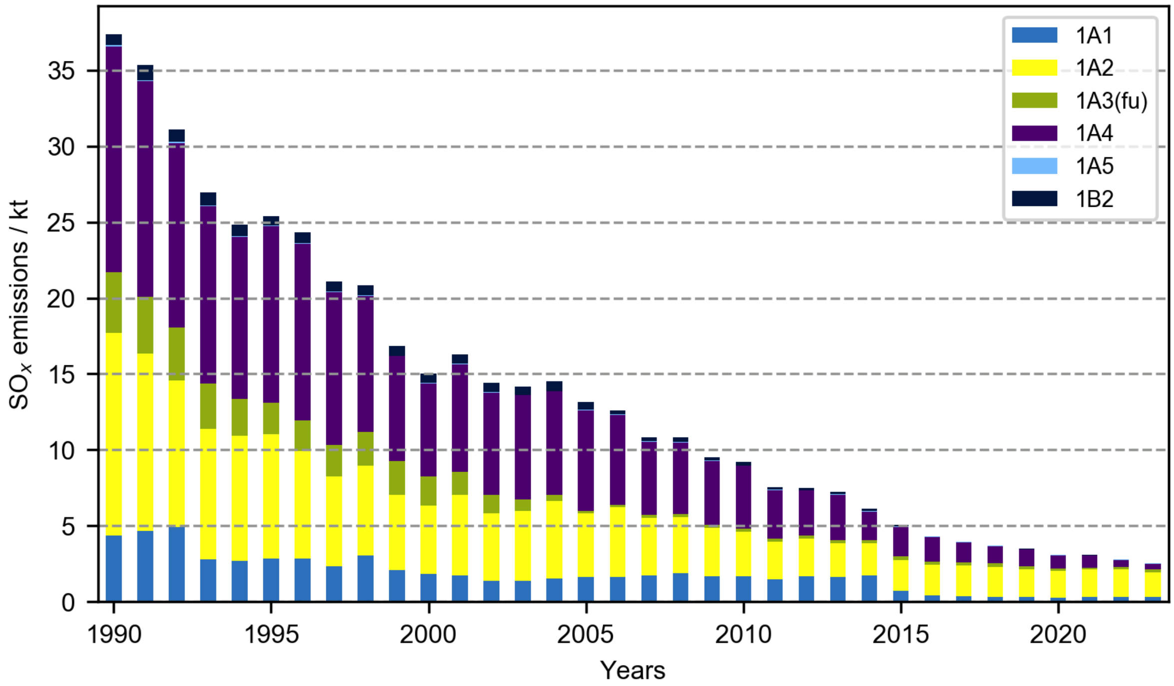



Figure 3-3 Switzerland's $SO_x$ emissions from the energy sector by source category 1A1-1A5 and 1B2 between 1990 and 2023 ((fu) means fuel used approach). The corresponding data can be found in Table 3-3.

Table 3-3 $SO_x$ emissions from sector 1 Energy by source categories 1A1-1A5 and 1B2 ((fu) means fuel used approach). The last column in the third part of the table indicates the relative trend.

| SOx | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 1A1 | kt | 4.3 | 2.8 | 1.8 | 1.6 | 1.7 |
| 1A2 | kt | 13 | 8.2 | 4.5 | 4.2 | 2.9 |
| 1A3(fu) | kt | 4.0 | 2.1 | 1.9 | 0.18 | 0.20 |
| 1A4 | kt | 15 | 12 | 6.1 | 6.6 | 4.1 |
| 1A5 | kt | 0.078 | 0.049 | 0.045 | 0.037 | 0.037 |
| 1B1 | kt | NA | NA | NA | NA | NA |
| 1B2 | kt | 0.72 | 0.63 | 0.59 | 0.51 | 0.22 |
| Sum | kt | 37 | 25 | 15 | 13 | 9.2 |

| SOx | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 1A1 | kt | 1.7 | 0.73 | 0.39 | 0.39 | 0.31 |
| 1A2 | kt | 2.1 | 2.0 | 2.0 | 2.0 | 2.0 |
| 1A3(fu) | kt | 0.21 | 0.22 | 0.22 | 0.22 | 0.23 |
| 1A4 | kt | 1.9 | 1.9 | 1.6 | 1.3 | 1.1 |
| 1A5 | kt | 0.037 | 0.036 | 0.038 | 0.034 | 0.034 |
| 1B1 | kt | NA | NA | NA | NA | NA |
| 1B2 | kt | 0.16 | 0.085 | 0.019 | 0.018 | 0.019 |
| Sum | kt | 6.1 | 5.0 | 4.3 | 4.0 | 3.7 |

| SOx | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 1A1 | kt | 0.29 | 0.29 | 0.33 | 0.30 | 0.31 | -81 |
| 1A2 | kt | 1.8 | 1.8 | 1.8 | 1.8 | 1.6 | -61 |
| 1A3(fu) | kt | 0.23 | 0.11 | 0.12 | 0.17 | 0.19 | 5.6 |
| 1A4 | kt | 1.1 | 0.90 | 0.80 | 0.43 | 0.34 | -95 |
| 1A5 | kt | 0.030 | 0.031 | 0.030 | 0.033 | 0.033 | -12 |
| 1B1 | kt | NA | NA | NA | NA | NA | - |
| 1B2 | kt | 0.016 | 0.017 | 0.014 | 0.016 | 0.015 | -97 |
| Sum | kt | 3.5 | 3.1 | 3.1 | 2.8 | 2.5 | -81 |

### 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, there are no source categories from the energy sector that are key categories for $NH_3$. For all years, the main contributor among categories of sector 1 Energy is 1A3 Transport. 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 in combination with three-way catalytic converters: 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 due to technological improvements in three-way catalytic converters.

In 2020, the COVID-19 pandemic led to measures that resulted in a massive reduction in traffic. The lower traffic volume led to a small but visible decrease in $NH_3$ emissions from 1A3b Road transportation.

Emissions from the other source categories are comparably small. The $NH_3$ emissions in 1A2 Manufacturing industries and construction are mainly due to source category 1A2f Manufacturing industries and construction: Non-metallic minerals (especially cement and rock wool production). $NH_3$ emissions in 1A4 Other sectors stem mainly from residential wood combustions.

There are no $NH_3$ emissions from source category 1B Fugitive emissions from fuels.

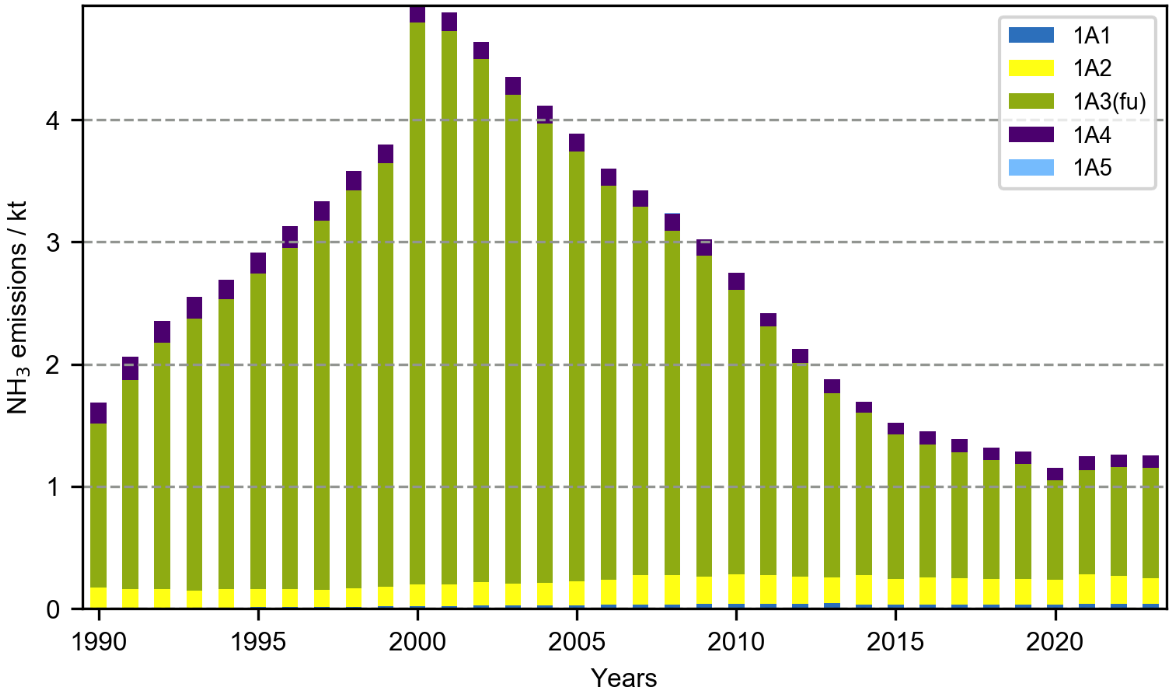



Figure 3-4 Switzerland's $NH_3$ emissions from the energy sector by source category 1A1-1A5 between 1990 and 2023 ((fu) means fuel used approach). There are no emissions from 1B. The corresponding data can be found in Table 3-4.

Table 3-4 $NH_3$ emissions from sector 1 Energy by source categories 1A1-1A5 ((fu) means fuel used approach). The last column in the third part of the table indicates the relative trend.

| NH3 | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 1A1 | kt | 0.0049 | 0.011 | 0.021 | 0.029 | 0.036 |
| 1A2 | kt | 0.17 | 0.15 | 0.18 | 0.19 | 0.24 |
| 1A3(fu) | kt | 1.3 | 2.6 | 4.6 | 3.5 | 2.3 |
| 1A4 | kt | 0.18 | 0.17 | 0.14 | 0.14 | 0.14 |
| 1A5 | kt | 0.000037 | 0.000038 | 0.000039 | 0.000039 | 0.000042 |
| 1B1 | kt | NA | NA | NA | NA | NA |
| 1B2 | kt | NA | NA | NA | NA | NA |
| Sum | kt | 1.7 | 2.9 | 4.9 | 3.9 | 2.7 |

| NH3 | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 1A1 | kt | 0.034 | 0.032 | 0.032 | 0.034 | 0.033 |
| 1A2 | kt | 0.24 | 0.21 | 0.23 | 0.22 | 0.21 |
| 1A3(fu) | kt | 1.3 | 1.2 | 1.1 | 1.0 | 0.98 |
| 1A4 | kt | 0.090 | 0.098 | 0.11 | 0.10 | 0.10 |
| 1A5 | kt | 0.000041 | 0.000041 | 0.000041 | 0.000041 | 0.000041 |
| 1B1 | kt | NA | NA | NA | NA | NA |
| 1B2 | kt | NA | NA | NA | NA | NA |
| Sum | kt | 1.7 | 1.5 | 1.4 | 1.4 | 1.3 |

| NH3 | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 1A1 | kt | 0.033 | 0.034 | 0.037 | 0.037 | 0.042 | 47 |
| 1A2 | kt | 0.21 | 0.20 | 0.24 | 0.23 | 0.21 | 7.5 |
| 1A3(fu) | kt | 0.94 | 0.81 | 0.85 | 0.89 | 0.90 | -74 |
| 1A4 | kt | 0.10 | 0.10 | 0.11 | 0.10 | 0.10 | -29 |
| 1A5 | kt | 0.000041 | 0.000041 | 0.000041 | 0.000041 | 0.000041 | 3.3 |
| 1B1 | kt | NA | NA | NA | NA | NA | - |
| 1B2 | kt | NA | NA | NA | NA | NA | - |
| Sum | kt | 1.3 | 1.2 | 1.2 | 1.3 | 1.3 | -68 |

### 3.1.5 Overview and trend for PM2.5

Figure 3-5 depicts the PM2.5 emissions in energy related sectors since 1990. The main contributor is source category 1A4 Other sectors, followed by 1A3 Transport and 1A2 Manufacturing industries and construction. Within source category 1A4 Other sectors, mainly wood combustion in small and mid-sized wood furnaces contribute to PM2.5 emissions. Overall emissions declined since 1990. The following effects mainly attributed to the reduction of particulate matter emissions:

- The large reduction of exhaust particulate matter emissions is primarily due to the development of emissions from wood combustion, especially in single-room furnaces and building heating systems (1A4; not only filterable fractions, but also condensable fractions which are particularly relevant for single-room furnaces and building heating). The reduction was achieved through technological improvements of the combustion installations and a reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves). In addition, wood energy consumption in manually operated furnaces decreased by more than half since 1990. Furthermore, the revision of the Ordinance of Air Pollution (Swiss Confederation 1985) in 2007 introduced more stringent emission limits (2007, 2008 and 2012) for mainly automatic wood combustion installations, which also led to a reduction in emissions from these installations (mainly in 1A1 and 1A2), although their wood energy consumption increased by about a factor of eight since 1990.
- A further reduction of exhaust emissions under 1A3 Transport was caused by the abatement of exhaust emissions from road vehicles. Throughout the years, a continuous

reduction of these emissions has been achieved with the stepwise adoption of the Euro standards. New diesel cars must be equipped with diesel particle filters.

- Under category 1A2 Manufacturing industries and construction, a reduction of exhaust emissions resulted from technological improvements in construction machineries (an installation of particle filters for new construction machineries with diesel engines is required by the Ordinance on Air Pollution Control (OAPC) since 2009) and from a fuel switch in stationary combustion (i.e. from coal, residual fuel oil and gas oil to natural gas).
- There is an underlying increasing in non-exhaust particulate matter emissions from growing activity data (annual mileage and machine hours) of mobile sources 1A3 Transport and 1A2gvii Mobile combustion in manufacturing industries and construction which affects larger particle emissions (TSP and PM10) more than PM2.5 (see Table 2-16 and Figure 2-13). This is due to a larger share of non-exhaust emissions with a particle diameter of 10 micrometres and larger. Therefore, the overall decreasing trend in TSP emissions is less pronounced as compared to the decrease in PM2.5 emissions. Note: In 2020 and 2021, despite this underlying increasing trend, the measures against the COVID-19 pandemic led to a reduction of non-exhaust PM10 emissions from road transportation due to reduced traffic volumes.

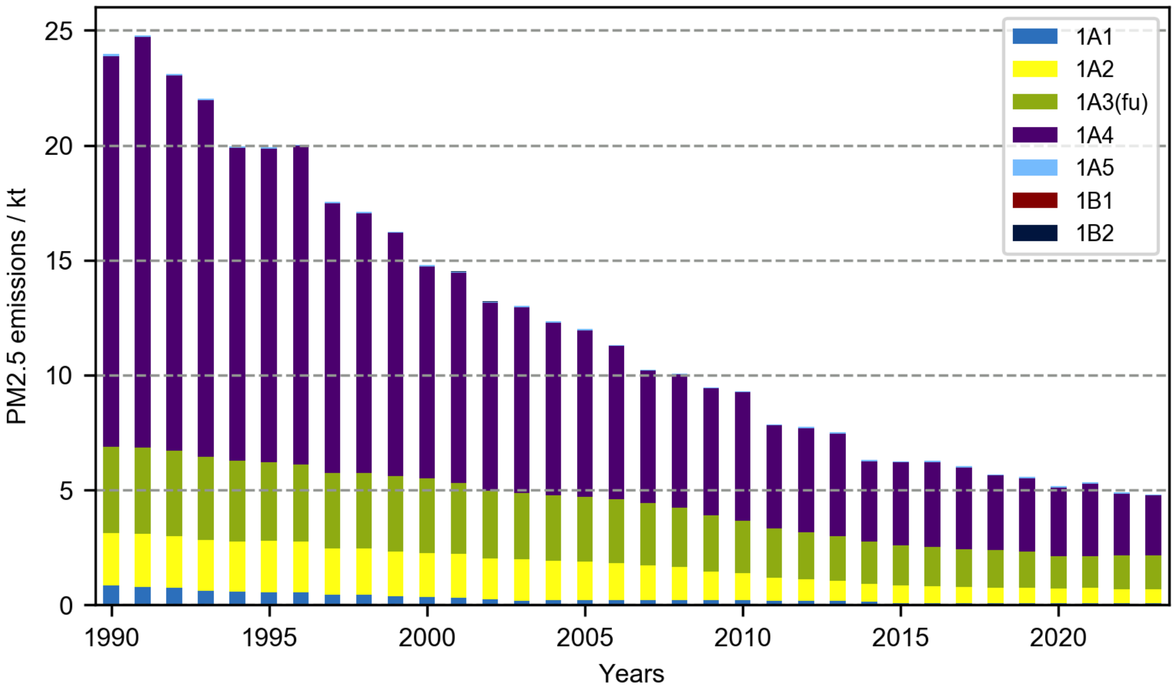



Figure 3-5 Switzerland's PM2.5 emissions from the energy sector by source categories 1A1-1A5 and 1B1 between 1990 and 2023 ((fu) means fuel used approach). The corresponding data can be found in Table 3-5.

Table 3-5 PM2.5 emissions from sector 1 Energy by source categories 1A1-1A5 and 1B1-1B2 ((fu) means fuel used approach). The last column in the third part of the table indicates the relative trend.

| PM2.5 | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 1A1 | kt | 0.83 | 0.55 | 0.35 | 0.19 | 0.20 |
| 1A2 | kt | 2.3 | 2.2 | 1.9 | 1.7 | 1.2 |
| 1A3(fu) | kt | 3.7 | 3.4 | 3.3 | 2.8 | 2.3 |
| 1A4 | kt | 17 | 14 | 9.2 | 7.2 | 5.6 |
| 1A5 | kt | 0.087 | 0.063 | 0.062 | 0.057 | 0.050 |
| 1B1 | kt | 0.00016 | 0.000086 | 0.000063 | 0.000070 | 0.000074 |
| 1B2 | kt | 0.00044 | 0.00065 | 0.00065 | 0.00059 | 0.00024 |
| Sum | kt | 24 | 20 | 15 | 12 | 9.3 |

| PM2.5 | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 1A1 | kt | 0.15 | 0.089 | 0.069 | 0.069 | 0.065 |
| 1A2 | kt | 0.75 | 0.75 | 0.73 | 0.71 | 0.69 |
| 1A3(fu) | kt | 1.9 | 1.7 | 1.7 | 1.6 | 1.6 |
| 1A4 | kt | 3.5 | 3.6 | 3.7 | 3.6 | 3.3 |
| 1A5 | kt | 0.047 | 0.046 | 0.046 | 0.046 | 0.045 |
| 1B1 | kt | 0.000070 | 0.000064 | 0.000059 | 0.000057 | 0.000053 |
| 1B2 | kt | 0.00018 | 0.00010 | 0.000006 | 0.000005 | 0.000005 |
| Sum | kt | 6.3 | 6.2 | 6.3 | 6.0 | 5.7 |

| PM2.5 | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 1A1 | kt | 0.067 | 0.062 | 0.065 | 0.060 | 0.061 | -69 |
| 1A2 | kt | 0.67 | 0.65 | 0.67 | 0.63 | 0.62 | -63 |
| 1A3(fu) | kt | 1.6 | 1.4 | 1.4 | 1.5 | 1.5 | -48 |
| 1A4 | kt | 3.2 | 3.0 | 3.1 | 2.7 | 2.6 | -64 |
| 1A5 | kt | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | -21 |
| 1B1 | kt | 0.000047 | 0.000046 | 0.000046 | 0.000048 | 0.000038 | -46 |
| 1B2 | kt | 0.000003 | 0.000004 | 0.000003 | 0.000001 | 0.000001 | -100 |
| Sum | kt | 5.6 | 5.2 | 5.3 | 4.9 | 4.8 | -60 |

## 3.1.6 General method and disaggregation of energy consumption

### 3.1.6.1 System boundaries: Differences between CLRTAP and UNFCCC reporting

Switzerland uses the same data base for the Swiss greenhouse gas inventory as for the Swiss air pollution inventory and 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.

*Fuel used or fuel sold approach in 1A3b Road transportation*

There are two different approaches for calculating emissions in source category 1A3b Road transportation. One is the fuel used approach, which is based on the road transportation model, that calculates the fuel consumption using kilometres driven per vehicle category in the Swiss territory as described in chapter 3.2.6. The other one is the fuel sold approach, which bases on the total amount of fuel sold as reported in the Swiss energy statistics. The difference between the calculated fuel consumption of diesel oil, gasoline, biodiesel, bioethanol and natural gas in the road transportation model and the Swiss energy statistics is called “statistical difference and fuel tourism”. “Fuel tourism” refers to the amount of fuel sold in Switzerland but consumed abroad or vice versa. To calculate the emissions for the fuel sold approach, this difference in fuel consumption per fuel type is distributed proportionally across each vehicle category, whereby the activity data in GJ, driven kilometres and the number of vehicles is adjusted proportionally in each category.

As Switzerland is a small country, the difference between these two approaches amounts to several percent, with considerable variation from year to year due to fluctuating fuel price differences between Switzerland and its neighboring countries.

*Only domestic flights or only LTO cycles in 1A3a Aviation (civil)*

Another difference concerns emissions from 1A3a Aviation: International flights are flights from a Swiss airport to a destination abroad. International flights with landing in Switzerland are not accounted because they bought their fuel at the departure airport abroad. Domestic flights are flights with departure and destination in Switzerland. For the GHG inventory only emissions from domestic flights are accounted, while emissions from international flights are reported as aviation bunker, i.e. as a memo item (1D1 International aviation). For the reporting of air pollutants under the CLRTAP, landing and takeoff (LTO) cycle emissions of domestic and international flights are accounted for, while emissions of domestic and international cruise flights are reported as memo items only (see Table 3-6). Note that emissions from overflights without landing in Switzerland are not considered in either approach.

*National totals for compliance with emission ceilings*

Under the UNFCCC, there is no difference between the reported national total and the national total for assessing compliance as it is based on fuel sold within the national territory. Under the CLRTAP, the national total is based on fuel sold but for assessing compliance it is based on fuel used (fu) in 1A3b Road transportation within the Swiss boundaries.

Table 3-6 Accounting rules for emissions from 1A3a Aviation and 1A3b Road transportation for CLRTAP and UNFCCC.

| Differences between reporting under CLRTAP and UNFCCC concerning the accounting to the national total | | | CLRTAP / NFR tables | | | UNFCCC / CRT tables | |
|---|---|---|---|---|---|---|---|
| | | | accounted to | | | | |
| | | | National total | National total for compliance | Separated information / Memo items | National total | Bunker (1D) |
| 1A3b - Road transportation | 1A3bi–v (fu) Fuel used - approach | Based on statistics of driven km and vehicle categories | No | Yes | Yes | No | No |
| | 1A3bi-v Fuels sold - approach | The activity data of the fuel used-approach are adapted to reflect the total of fuel sold as reported in statistics. | Yes | No | No | Yes | No |
| 1A3a - Aviation | Civil and 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 |
| | | Fuel Dumping | No | No | Yes | No | Yes |
| | | Overflights | No | No | No | No | No |

Emissions generated by road transportation considering fuel used in Switzerland as modelled in the road transportation model described in chp. 3.2.6.2.2 are reported in lines 143-149 in the NFR tables. Emissions generated by road transportation considering the amount of fuel sold in Switzerland are reported in lines 27-33 in the NFR tables.

The following memo items are reported for Switzerland in lines 157-164 in the NFR tables:

- 1A3ai(ii) International aviation cruise (civil) Emission modelling see chp. 3.2.6.2
- 1A3aii(ii) Domestic aviation cruise (civil) Emission modelling see chp. 3.2.6.2
- 1A3di(i) International maritime navigation Emission modelling see chp. 3.2.6.2
- 11B Forest fires Emission modelling see chp. 7.3
- 11C Other natural emissions Emission modelling see chp. 7.4

Recalculations concerning emission estimates of source categories in 1A3 are described in chp. 3.2.6.3, recalculations for 11B in chp. 7.3.3 and for 11C in chp. 7.4.3.

Net calorific values (NCV)

Table 3-7 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.

Table 3-7 Net calorific values (NCVs) of various fuels. Where values for two years are indicated, the NCV is interpolated between these two years and constant NCVs are used before the first and after the second year (corresponding to the two indicated values). For the NCV of wood, a range covering all facility categories and years is provided. For the NCVs of natural gas and biogas see Table 3-8.

| Fuel | Year | | NCV | Unit | Data sources |
|---|---|---|---|---|---|
| | | | **Fossil fuel** | | |
| Gasoline | until | 1998 | 42.5 | GJ/t | EMPA (1999) |
| | from | 2013 | 42.6 | GJ/t | SFOE/FOEN (2014) |
| Jet kerosene | until | 1998 | 43.0 | GJ/t | EMPA (1999) |
| | from | 2013 | 43.2 | GJ/t | SFOE/FOEN (2014) |
| Diesel oil | until | 1998 | 42.8 | GJ/t | EMPA (1999) |
| | from | 2013 | 43.0 | GJ/t | SFOE/FOEN (2014) |
| Gas oil | until | 1998 | 42.6 | GJ/t | EMPA (1999) |
| | from | 2013 | 42.9 | GJ/t | SFOE/FOEN (2014) |
| Residual fuel oil | from | 1990 | 41.2 | GJ/t | EMPA (1999) |
| Liquefied petroleum gas | from | 1990 | 46.0 | GJ/t | SFOE (2024) |
| Petroleum coke | until | 1998 | 35.0 | GJ/t | SFOE (2024) |
| | from | 2010 | 31.8 | GJ/t | SFOE (2024) |
| Other bituminous coal | until | 1998 | 28.052 | GJ/t | SFOE (2024) |
| | from | 2010 | 25.5 | GJ/t | SFOE (2024) |
| Lignite | until | 1998 | 20.097 | GJ/t | SFOE (2024) |
| | from | 2010 | 23.6 | GJ/t | SFOE (2024) |
| | | | **Biofuel** | | |
| Biodiesel | from | 1990 | 32.7 | GJ/m3 | SFOE (2024) |
| Bioethanol | from | 1990 | 21.1 | GJ/m3 | SFOE (2024) |
| Wood | from | 1990 | 8.6-14.6 | GJ/t | SFOE (2024b) |

*Gasoline, jet kerosene, diesel oil and gas oil*

For gasoline, jet kerosene, diesel oil and gas oil, NCV for 1998 and 2013 are based on national measurement campaigns and are the same as used by the Swiss Federal Office of Energy (SFOE 2024). A first campaign was conducted by the Swiss Federal Laboratories for Materials Science and Technology (EMPA) in 1998 (EMPA 1999). Since earlier 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 refineries operating at that time in Switzerland) 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 2024), is assumed to be constant over the entire reporting period.

*Liquefied petroleum gas*

The NCV of liquefied petroleum gas is the same as used by the Swiss Federal Office of Energy (SFOE 2024) and is – as in the Swiss overall energy statistics – constant over the entire reporting period. It is assumed that liquefied petroleum gas is a mixture of propane and butane in equal proportions.

*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 2024). For these fuels, the Swiss overall energy statistics contains NCVs for the years 1998 and 2010. Values in between are interpolated, with values before the first and after the last year of available data 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 3-8) and also the $CO_2$ emission factor used in the GHG inventory 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 (2024). 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 (2024i). The NCV of biogas is assumed to be equal to the NCV of natural gas since the raw biogas is treated to fulfil the same quality level including its energetic properties as natural gas.

Table 3-8 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, the latest report is SGWA (2024). Spreadsheet to determine national averages: FOEN 2024i.

| Year | NCV of natural gas and biogas [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 | 47.4 |
| 2018 | 47.6 |
| 2019 | 47.5 |
| 2020 | 47.6 |
| 2021 | 48.2 |
| 2022 | 48.0 |
| 2023 | 48.4 |

*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 2024b).

Table 3-7 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 2024) and are – as in the Swiss overall energy statistics – constant over the entire reporting period.

### 3.1.6.2 Swiss energy model and final Swiss energy consumption

#### *3.1.6.2.1 Swiss overall energy statistics*

The fundamental data on final energy consumption is provided by the Swiss overall energy statistics (SFOE 2024). 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. To calculate the correct Swiss fuel consumption, Liechtenstein's liquid fossil fuel consumption, given by Liechtenstein's energy statistics (OS 2024), 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 2024). 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 Avenergy Suisse (formerly Swiss petroleum association, EV) for data on import, export, sales, stocks of oil products and for processing of crude oil in refineries.
- Annual import data for natural gas from the Swiss gas industry association (VSG).
- Annual import data for petroleum products and coal from the Federal Office for Customs and Border Security (FOCBS).
- Data provided by industry associations (GVS, SGWA, Cemsuisse, VSG, VSTB, etc.).
- Swiss electricity statistics (SFOE 2024g).
- Swiss renewable energies statistics (SFOE 2024a).
- Swiss wood energy statistics (SFOE 2024b).
- Swiss statistics on combined heat and power generation (SFOE 2024c).

As can be seen in Figure 3-6, fossil fuels amount to slightly less 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.

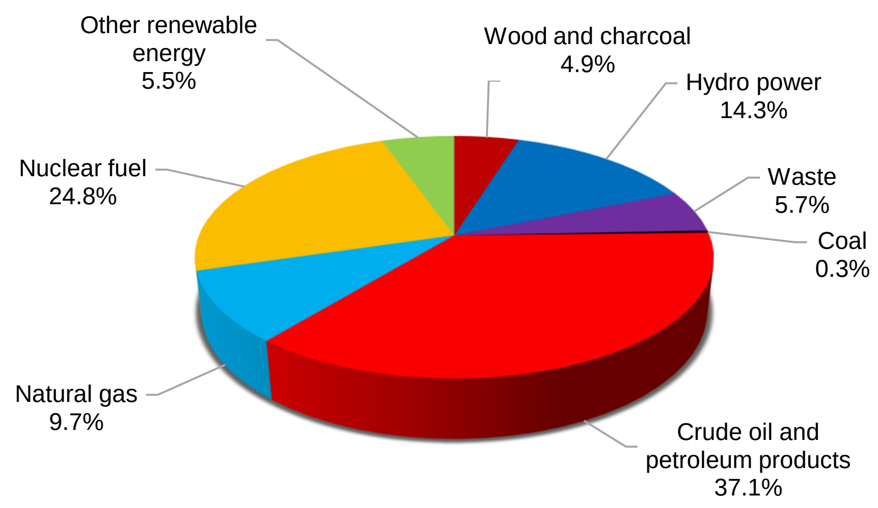



Figure 3-6 Switzerland’s primary energy consumption in 2023 by fuel type (see corresponding data and additional information on energy consumption over time in SFOE 2024).

Table 3-9 shows primary energy consumption excluding nuclear fuel and hydro power. On the one hand, the combined effect of decreasing consumption of gasoline and increasing consumption of jet kerosene and diesel oil led to an increasing trend until about 2010 and a stabilization thereafter in the transport sector. On the other hand, consumption in the residential and industry sector (mainly gas oil) substantially decreased. Overall, liquid fossil fuel consumption changed only little between 1990 and about 2010 but started to decrease thereafter. Natural gas consumption increased since 1990, compensating to some extent the decreasing use of gas oil and residual fuel oil in the various sectors. Due to the restrictions related to the COVID-19 pandemic the years 2020 and 2021 are exceptional, with lower fossil fuel consumption than in the years before. Particularly, in the transport sector the consumption of gasoline, jet kerosene and diesel oil, does not reach the level of 2019 anymore. Compared to 2021, total fuel consumption declined in 2022. In particular gas oil and natural gas consumption was lower compared to the previous years due to the warm winter and energy saving measures in response to the looming energy shortage. In 2023 total fuel consumption was on a similar level as in 2022.

Table 3-9 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 gasoline, diesel and biofuels consumption from fuel tourism, as well as all jet kerosene sold for domestic and international aviation. Natural gas and gasoline losses due to fugitive emissions (reported in sector 1B) are not included.

| Year | **Gasoline** | **Jet kerosene** used for LTO | **Jet kerosene** used for cruise (memo item) | **Diesel oil** (incl. fossil fraction of biodiesel) | **Diesel oil** used for intern. Navigation (memo item) | **Gas oil** | **Residual fuel oil** | **Refinery gas & Liquefied petroleum gas** | **Petroleum coke** | **Solid fuels** | **Gaseous fuels** excl. losses | **Other fossil fuels** | **Biomass** (incl. Bio fuels) | **National Total** as reported in NFR tables | **Total** incl. memo items |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TJ | TJ | TJ | TJ | TJ | TJ | TJ | TJ | TJ | TJ | TJ | TJ | TJ | TJ | TJ |
| 1990 | 155'703 | 8'059 | 40'008 | 46'736 | 821 | 218'510 | 23'342 | 8'890 | 1'400 | 14'901 | 68'426 | 19'074 | 46'826 | 611'865 | 652'695 |
| 1991 | 162'063 | 7'640 | 38'922 | 47'417 | 737 | 238'602 | 23'590 | 12'437 | 980 | 12'162 | 76'724 | 18'503 | 48'827 | 648'945 | 688'604 |
| 1992 | 168'037 | 7'803 | 41'297 | 45'926 | 780 | 236'809 | 24'170 | 11'492 | 315 | 8'758 | 80'627 | 18'935 | 47'749 | 650'620 | 692'697 |
| 1993 | 155'808 | 7'861 | 42'915 | 44'197 | 781 | 225'920 | 17'165 | 12'388 | 1'120 | 7'442 | 84'574 | 19'041 | 48'092 | 623'607 | 667'302 |
| 1994 | 155'797 | 7'911 | 44'198 | 46'924 | 824 | 207'141 | 17'860 | 13'455 | 1'470 | 7'632 | 83'402 | 19'051 | 46'054 | 606'696 | 651'719 |
| 1995 | 151'094 | 7'987 | 46'960 | 47'865 | 739 | 217'523 | 17'278 | 12'756 | 1'260 | 7'962 | 91'942 | 19'586 | 48'095 | 623'347 | 671'046 |
| 1996 | 155'033 | 8'017 | 48'736 | 44'946 | 651 | 226'289 | 15'097 | 13'939 | 1'015 | 5'456 | 99'530 | 20'430 | 51'683 | 641'436 | 690'823 |
| 1997 | 161'031 | 8'320 | 50'454 | 46'731 | 657 | 212'223 | 12'581 | 14'236 | 280 | 4'590 | 96'083 | 21'501 | 48'540 | 626'116 | 677'227 |
| 1998 | 162'315 | 8'540 | 52'728 | 48'684 | 528 | 222'407 | 15'882 | 15'259 | 455 | 3'960 | 98'890 | 23'575 | 50'160 | 650'128 | 703'384 |
| 1999 | 167'815 | 8'762 | 56'482 | 51'629 | 558 | 212'349 | 11'058 | 15'805 | 521 | 4'105 | 102'415 | 24'197 | 50'918 | 649'575 | 706'615 |
| 2000 | 168'009 | 9'074 | 58'987 | 55'149 | 531 | 196'137 | 7'923 | 13'649 | 551 | 6'120 | 101'800 | 26'288 | 50'603 | 635'304 | 694'822 |
| 2001 | 163'442 | 8'598 | 55'610 | 56'266 | 447 | 213'089 | 9'942 | 14'069 | 410 | 6'233 | 105'966 | 26'775 | 53'894 | 658'684 | 714'741 |
| 2002 | 160'276 | 8'128 | 51'278 | 58'392 | 333 | 196'655 | 6'446 | 15'584 | 679 | 5'565 | 104'007 | 27'624 | 53'436 | 636'793 | 688'404 |
| 2003 | 159'512 | 7'327 | 46'110 | 61'812 | 443 | 208'040 | 7'061 | 13'642 | 202 | 5'663 | 109'957 | 27'369 | 56'020 | 656'605 | 703'158 |
| 2004 | 156'708 | 6'886 | 43'555 | 66'453 | 446 | 203'370 | 7'561 | 16'429 | 1'819 | 5'420 | 113'459 | 28'495 | 56'993 | 663'593 | 707'594 |
| 2005 | 151'966 | 7'020 | 44'081 | 72'583 | 493 | 205'729 | 5'805 | 16'432 | 2'906 | 5'940 | 116'493 | 28'833 | 59'152 | 672'859 | 717'433 |
| 2006 | 147'344 | 7'291 | 46'280 | 78'621 | 457 | 195'926 | 6'419 | 18'578 | 3'324 | 6'467 | 113'264 | 30'837 | 62'265 | 670'337 | 717'074 |
| 2007 | 145'923 | 7'538 | 49'627 | 84'437 | 465 | 171'313 | 5'179 | 15'587 | 2'730 | 7'196 | 110'252 | 29'617 | 61'312 | 641'084 | 691'176 |
| 2008 | 142'713 | 7'773 | 53'378 | 92'690 | 473 | 178'833 | 4'581 | 16'288 | 3'616 | 6'562 | 117'451 | 30'394 | 65'500 | 666'401 | 720'252 |
| 2009 | 138'883 | 7'496 | 51'169 | 94'156 | 425 | 173'219 | 3'530 | 16'301 | 3'254 | 6'193 | 112'674 | 29'314 | 65'671 | 650'690 | 702'285 |
| 2010 | 133'953 | 7'699 | 53'921 | 97'792 | 471 | 182'295 | 2'967 | 15'463 | 3'498 | 6'208 | 125'846 | 30'612 | 70'573 | 676'906 | 731'297 |
| 2011 | 128'775 | 7'970 | 57'726 | 100'466 | 428 | 143'760 | 2'292 | 14'856 | 2'957 | 5'792 | 111'617 | 30'320 | 66'243 | 615'050 | 673'204 |
| 2012 | 124'229 | 8'258 | 59'048 | 106'633 | 385 | 154'448 | 2'780 | 12'247 | 3'148 | 5'269 | 122'398 | 30'648 | 72'135 | 642'194 | 701'627 |
| 2013 | 118'572 | 8'243 | 59'825 | 111'502 | 342 | 162'532 | 1'959 | 15'053 | 2'735 | 5'567 | 128'912 | 30'403 | 75'741 | 661'218 | 721'385 |
| 2014 | 113'820 | 8'282 | 60'259 | 114'422 | 299 | 122'694 | 1'581 | 14'473 | 3'148 | 5'704 | 111'660 | 30'894 | 70'012 | 596'689 | 657'247 |
| 2015 | 105'540 | 8'414 | 62'374 | 112'888 | 342 | 129'349 | 862 | 9'822 | 1'145 | 5'205 | 119'314 | 31'838 | 73'282 | 597'658 | 660'374 |
| 2016 | 102'250 | 8'577 | 65'584 | 114'206 | 299 | 132'325 | 378 | 9'136 | 890 | 4'795 | 125'355 | 33'449 | 79'370 | 610'733 | 676'615 |
| 2017 | 99'112 | 8'581 | 67'352 | 113'952 | 256 | 123'726 | 350 | 8'770 | 763 | 4'609 | 125'602 | 33'289 | 82'597 | 601'351 | 668'959 |
| 2018 | 97'545 | 8'756 | 71'494 | 115'559 | 200 | 111'225 | 87 | 8'890 | 781 | 4'285 | 118'931 | 34'610 | 82'284 | 582'953 | 654'647 |
| 2019 | 96'748 | 8'587 | 72'482 | 115'638 | 197 | 108'625 | 111 | 8'108 | 777 | 3'842 | 121'941 | 35'264 | 84'682 | 584'324 | 657'003 |
| 2020 | 85'681 | 3'930 | 26'685 | 109'594 | 189 | 97'246 | 76 | 7'627 | 700 | 3'696 | 118'835 | 35'204 | 83'777 | 546'365 | 573'240 |
| 2021 | 87'541 | 4'203 | 29'756 | 110'738 | 228 | 107'991 | 139 | 7'522 | 604 | 3'726 | 129'419 | 34'707 | 90'591 | 577'181 | 607'166 |
| 2022 | 85'025 | 6'779 | 53'086 | 110'588 | 207 | 86'970 | 0 | 9'604 | 731 | 3'880 | 106'398 | 35'284 | 84'659 | 529'920 | 583'212 |
| 2023 | 87'805 | 7'584 | 63'617 | 108'357 | 200 | 84'286 | 41 | 9'024 | 763 | 3'065 | 98'606 | 34'597 | 87'069 | 521'198 | 585'015 |

#### *3.1.6.2.2 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 2024). 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 2024), the Swiss renewable energy statistics (SFOE 2024a), the energy consumption statistics in the industry and services sectors (SFOE 2024d), as well as additional information from the industry. As wood energy consumption is not based on the Swiss overall energy statistics but directly on the figures from the Swiss wood energy statistics (SFOE2024b), its activity data are derived in a separate but analogous model.

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 3-7 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 model of stationary engines and gas turbines. 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 3.1.6.2.3, the resulting sectoral disaggregation is shown separately for each fuel type (including the disaggregation of the separate model for wood energy combustion).

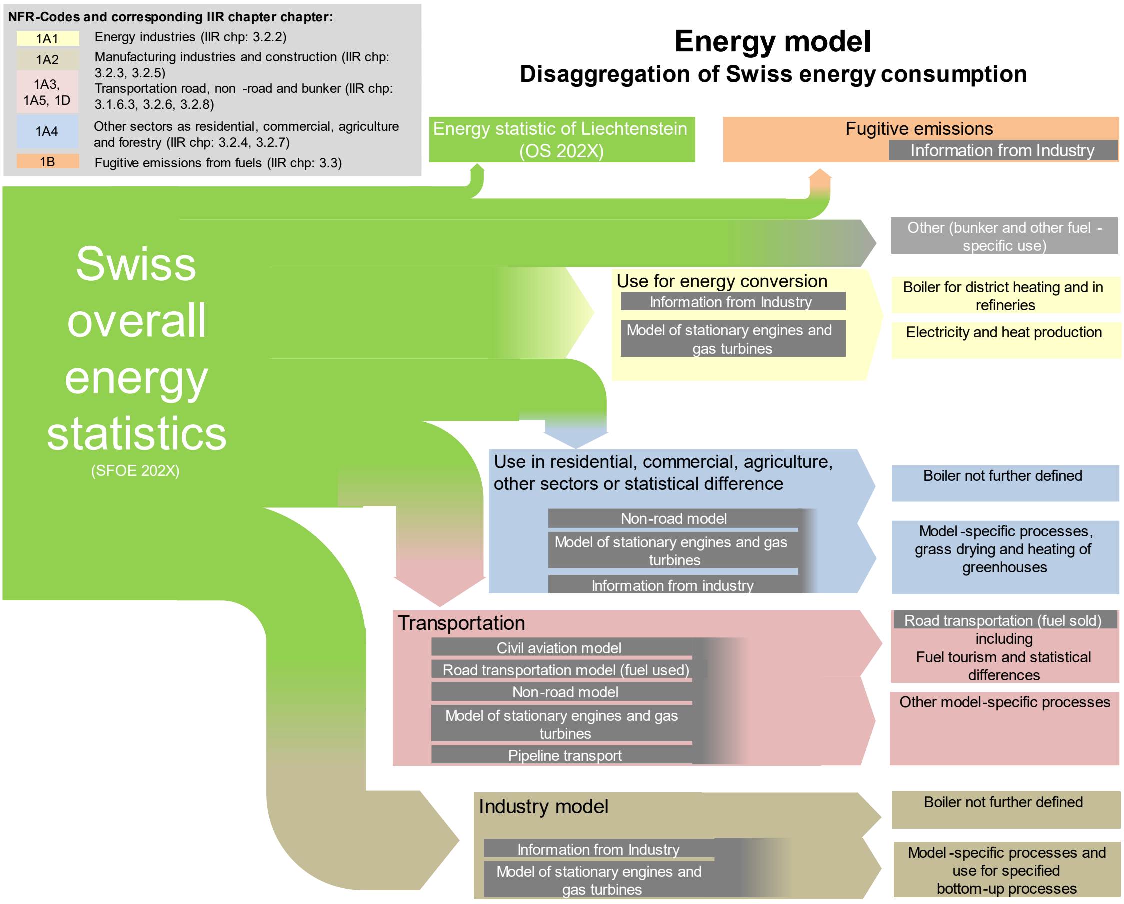



Figure 3-7 Overview of Switzerland's energy model. In the abbreviations SFOE 202X and OS 202X the "X" refers to the latest edition of the respective statistics.

**Industry model** (Details are given in chp. 3.2.3.2)

The industry model disaggregates the total fuel consumption in the industry sector (SFOE 2024) by source category and fuel type. It is based on the following two pillars. First, the energy consumption statistics in the industry and services sectors (SFOE 2024d) provide a comprehensive annual survey of fuel consumptions for all years since 1999 or 2002 (depending on the fuel type). These statistics are consistently extended back to 1990 based on a bottom-up industry model (Prognos 2013). Second, further disaggregation is 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.

**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.

**Model of stationary engines and gas turbines**

(Details are given in chp. 3.2.1.1.2)

The model of stationary engines and gas turbines in 1A Fuel combustion activities is based on an inventory of installed capacities, technologies and operating hours of engines and gas turbines throughout Switzerland (INFRAS 2022a). The inventory is based on a survey with the cantonal authorities, information from websites and annual reports from industry, as well as from direct enquiries with the operators. The fuel consumption per engine and turbine type was derived from the inventory and the emissions are calculated using corresponding emission factors from different references.

**Model for wood energy combustion**

(Details are given in chp. 3.2.1.1.3)

Based on the Swiss wood energy statistics (SFOE 2024b), 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.

### 3.1.6.2.3 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 2024) into the relevant source categories 1A1-1A5 (Figure 3-8). For each fuel type, the disaggregation process of the energy model as shown schematically in Figure 3-7, the interaction between the different sub-models and additional data sources are visualized separately in Figure 3-9 to Figure 3-18.

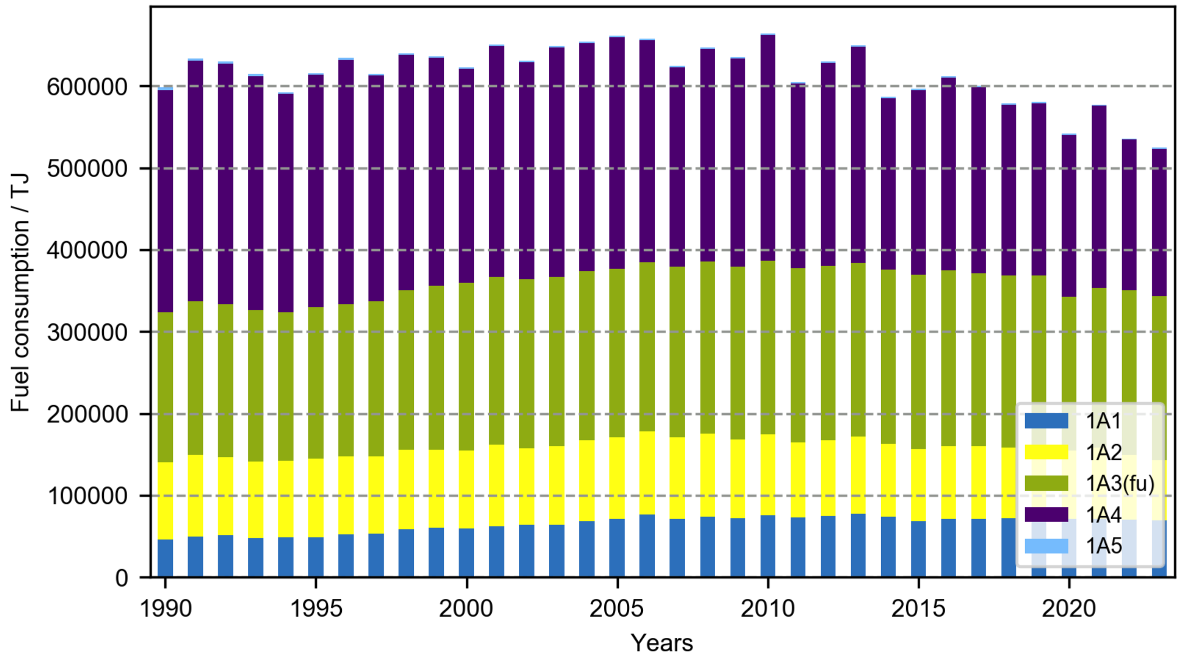



Figure 3-8 Switzerland's energy consumption in the source categories 1A1–1A5 based on the Swiss energy model ("fu" means fuel used approach). Since 1990 population has increased by about one third, industrial production by about three quarters and the motor vehicle fleet by almost three quarters (SFOE 2024, table 43a)

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. 3.1.6.2.2. In addition, the following assignments are considered as well:

- For source category 1A4ci Other sectors – Agriculture/forestry/fishing, specific bottom-up industry information is available for grass drying and the heating of greenhouses. The fuel consumption for grass drying is determined by the Swiss association of grass drying plants (VSTB). Further, based on annual energy consumption data from the Energy Agency of the Swiss Private Sector (EnAW) regarding agricultural greenhouses exempt from the $CO_2$ levy, total energy consumption of all greenhouses within Switzerland is extrapolated. The respective fuel consumption for grass drying and greenhouses is subtracted from the total fuel consumption of commercial, agriculture and statistical differences (see Figure 3-7).
- 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 1A3bi-iii Road transportation.

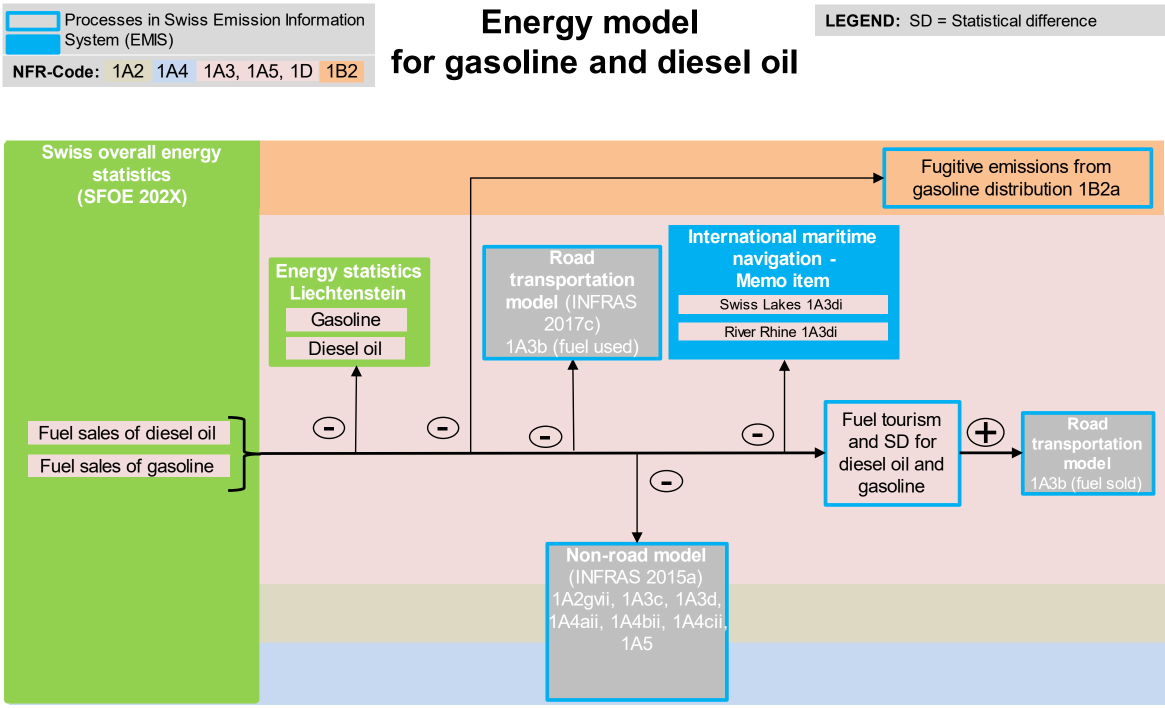



Figure 3-9 Schematic disaggregation of 1A Fuel consumption for gasoline and diesel oil. Marine bunker fuel consumption is based on the national customs statistics (see chapter 3.1.6.1 on memo items)

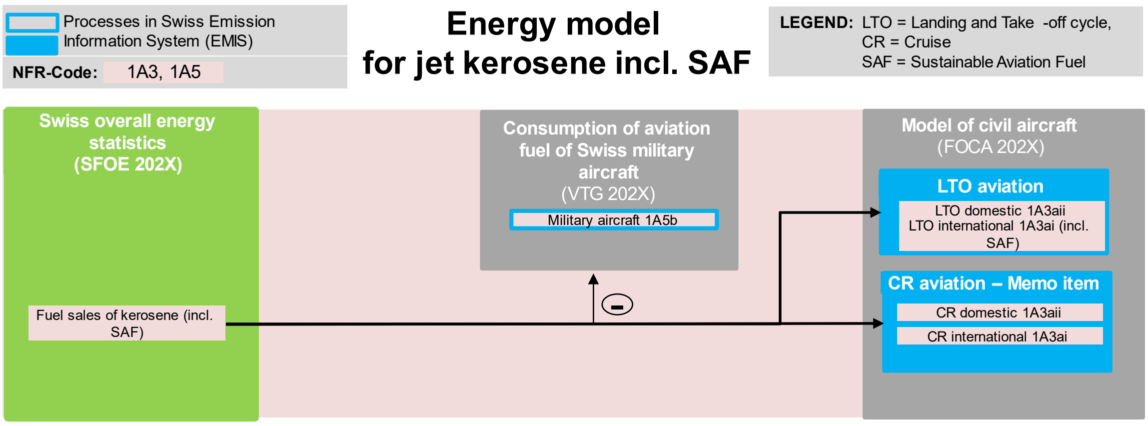



Figure 3-10 Schematic disaggregation of 1A Fuel consumption for jet kerosene. Fuel consumption for military aircraft is provided by the Swiss Air Force (part of the Swiss Armed Forces, VTG). The differentiation between domestic and international aviation as well as between CR and LTO is provided by the civil aviation model (see chp. 3.2.6.2.1)

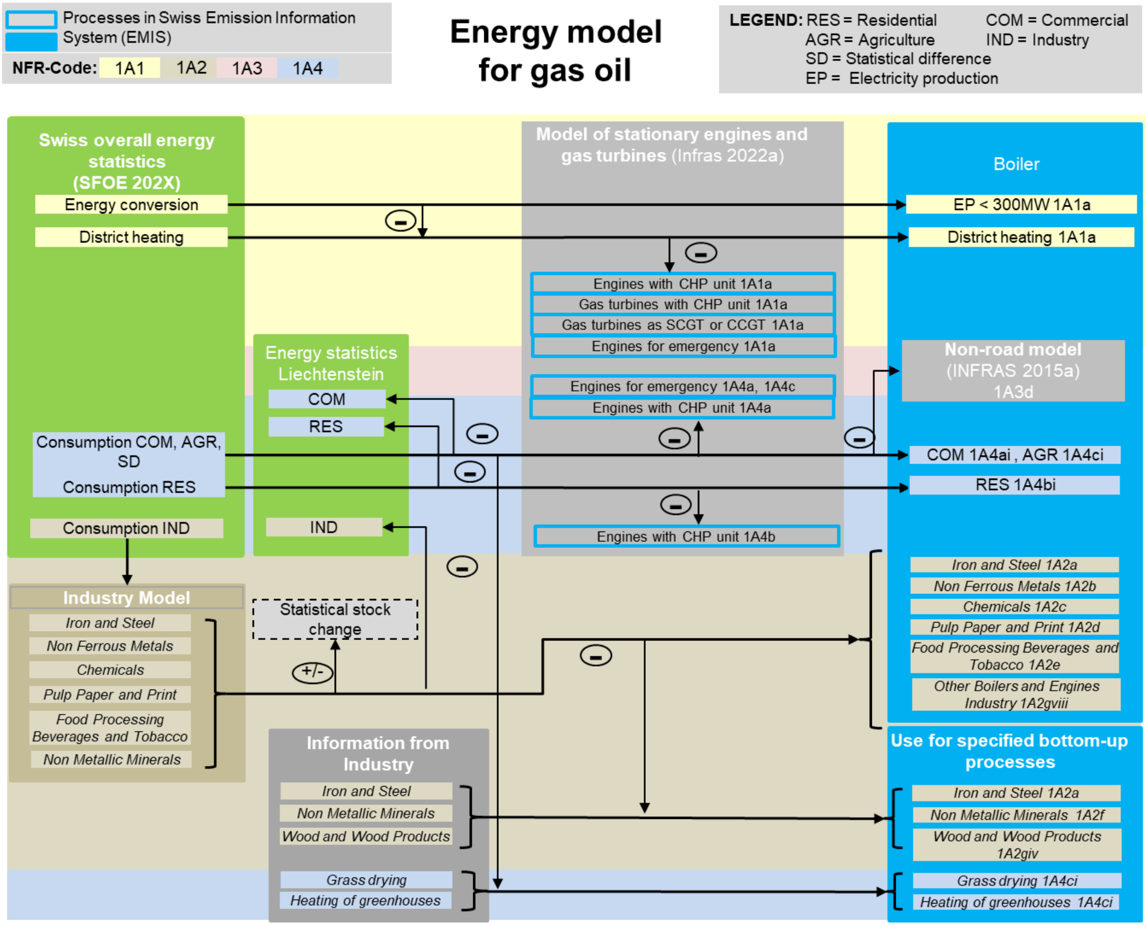



Figure 3-11 Schematic disaggregation of 1A Fuel consumption for gas oil. The Swiss overall energy statistics provide gas oil use for energy conversion and the amount thereof being used for district heating. Based on this information, gas oil use is split into 1A1ai Electricity generation and 1A1aiii Heat plants. According to the non-road model, a small amount of gas oil is consumed in source category 1A3d navigation (steam-powered vessels).

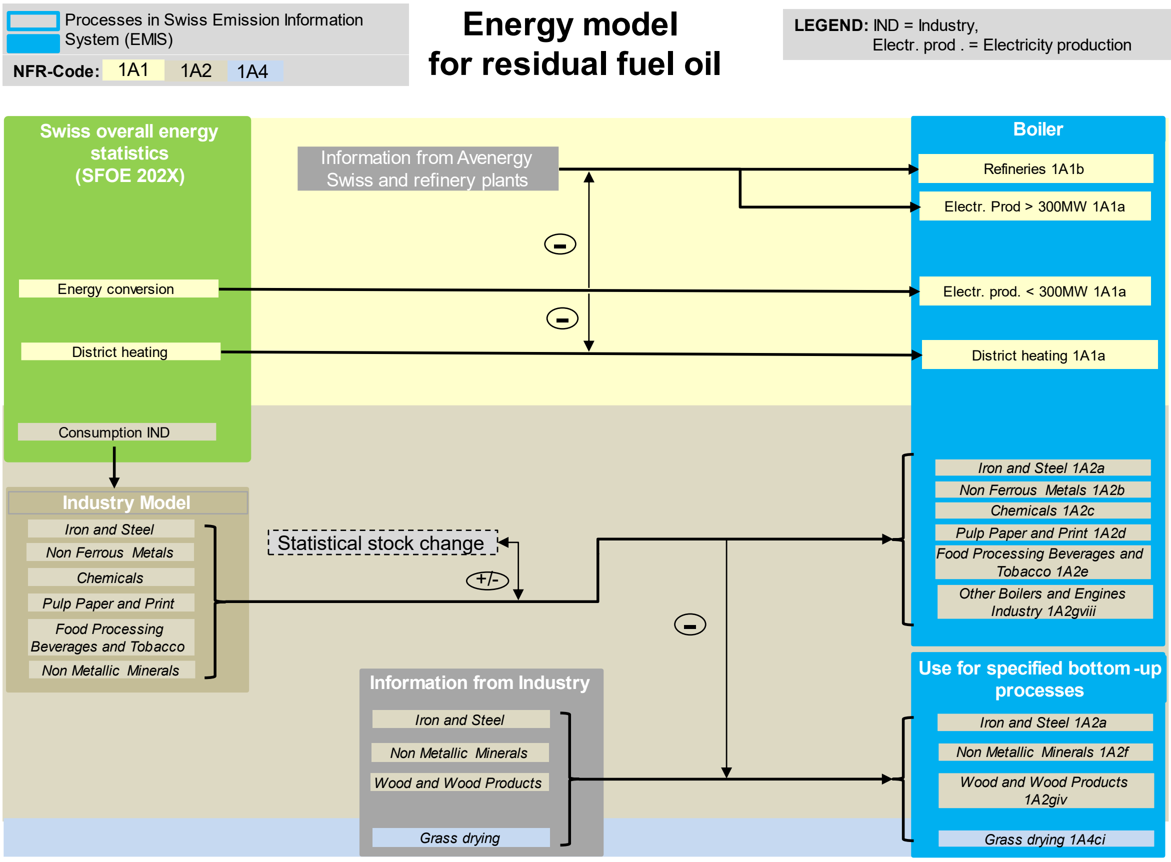



Figure 3-12 Schematic disaggregation of 1A Fuel consumption for residual fuel oil. The Swiss overall energy statistics report residual fuel oil use in energy conversion and the amount thereof consumed in electricity production (one single fossil fuel power station, operational from 1985 to 1994), district 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.

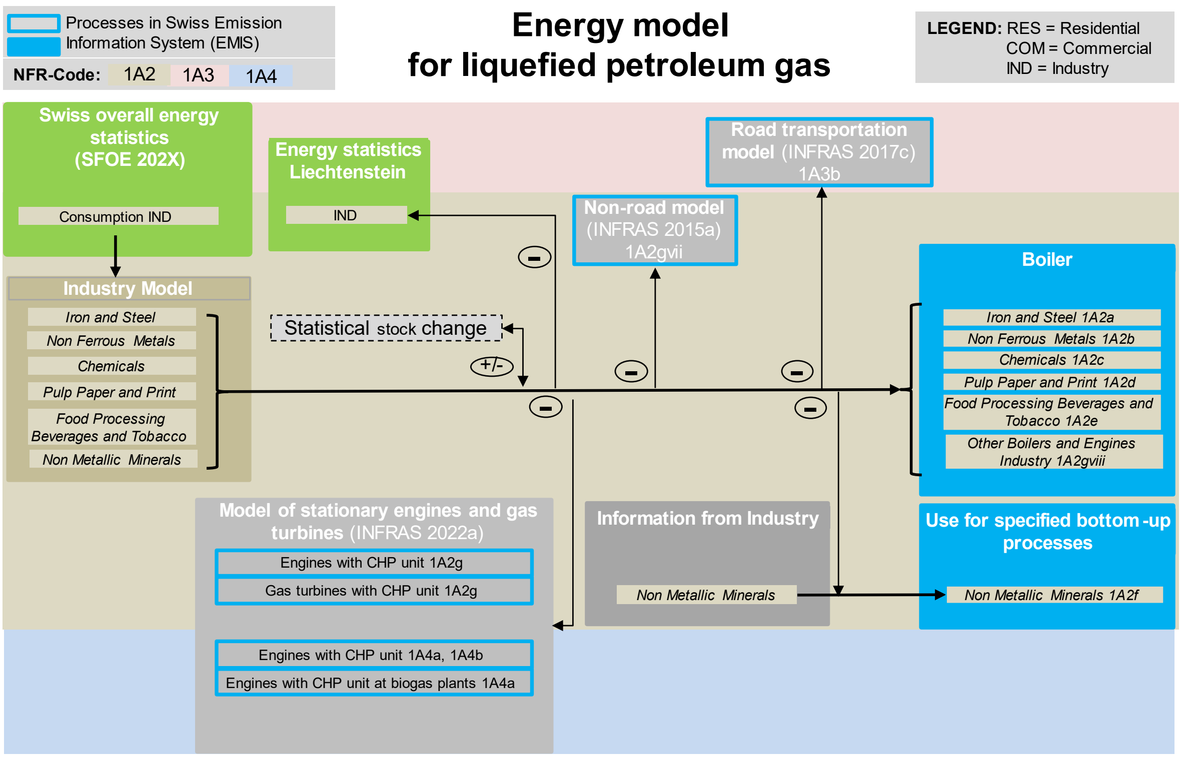



Figure 3-13 Schematic disaggregation of 1A Fuel consumption for liquefied petroleum gas.

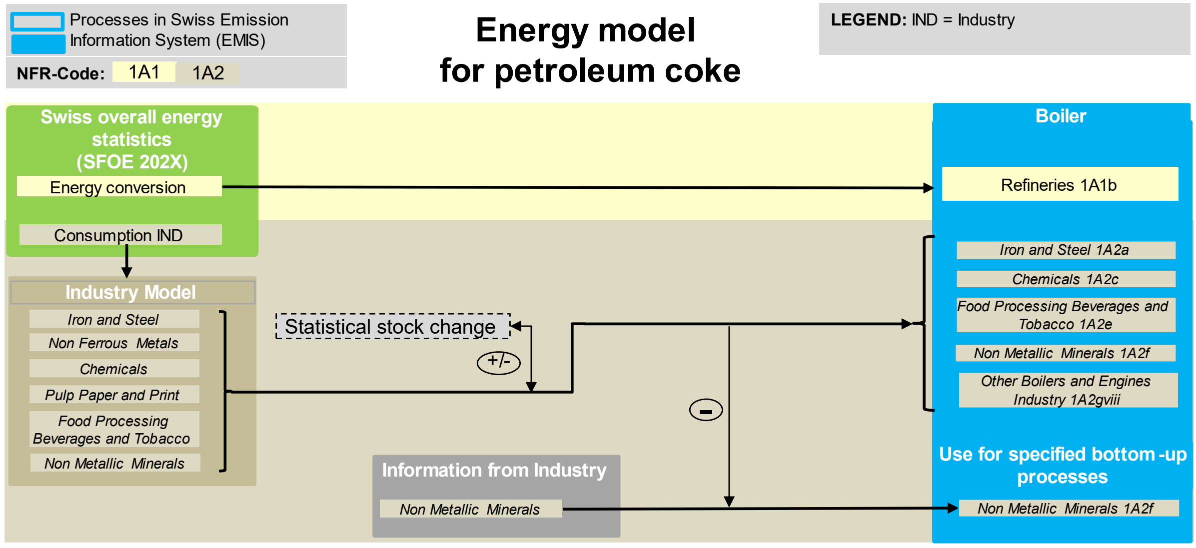



Figure 3-14 Schematic disaggregation of 1A Fuel consumption for petroleum coke.

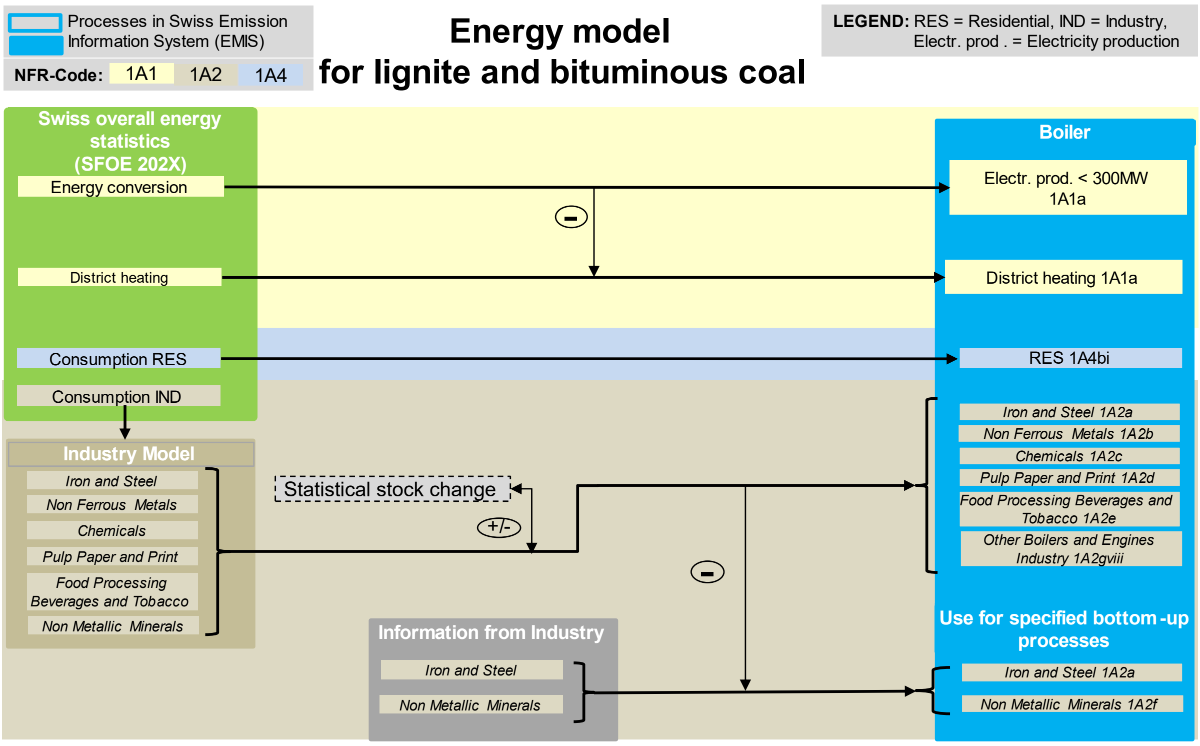



Figure 3-15 Schematic disaggregation of 1A Fuel consumption for lignite and bituminous coal. The Swiss overall energy statistics provide bituminous coal use for energy conversion and the amount thereof being used for district heating. Based on this information, use of bituminous coal in energy industries is split into 1A1ai Electricity generation and 1A1aiii Heat plants up to 1995. Coal consumption for public electricity and heat production ceased thereafter.

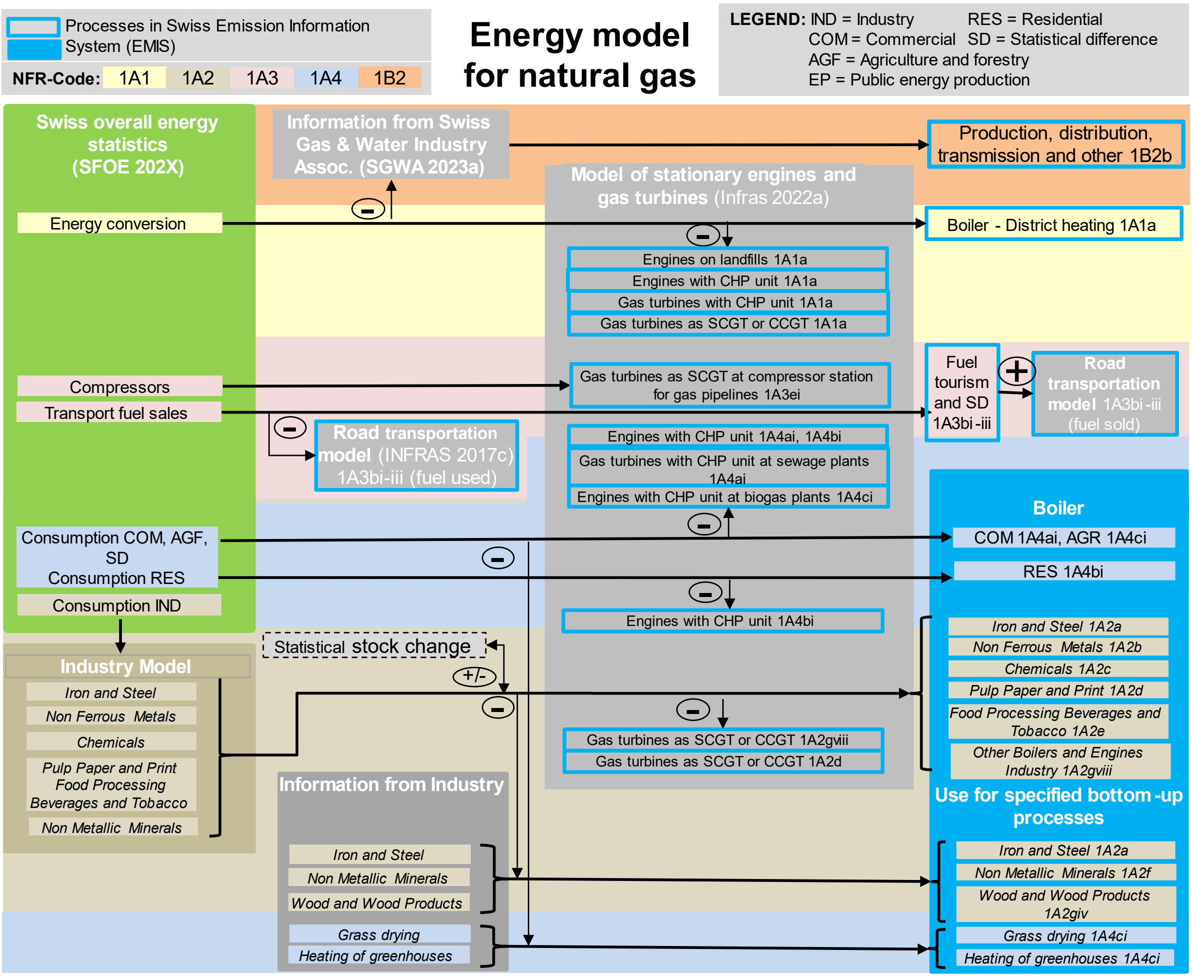



Figure 3-16 Schematic disaggregation of 1A Fuel consumption (and 1B Fugitive emissions from fuels) for natural gas. The Swiss overall energy statistics (SFOE 2024) provide gas use in the transformation sector (energy conversion and distribution losses). Distribution losses as estimated by the Swiss Gas 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.

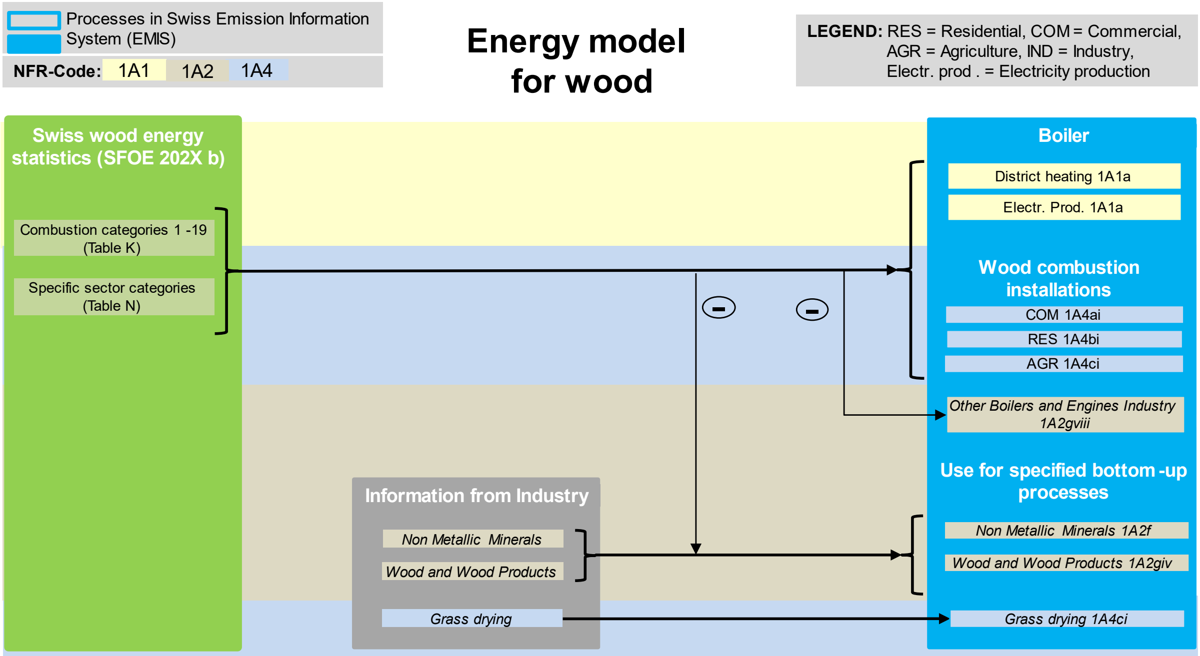



Figure 3-17 Schematic disaggregation of 1A Fuel consumption for wood. For a detailed description of the Energy model for wood combustion, see chapter 3.2.1.1.2.

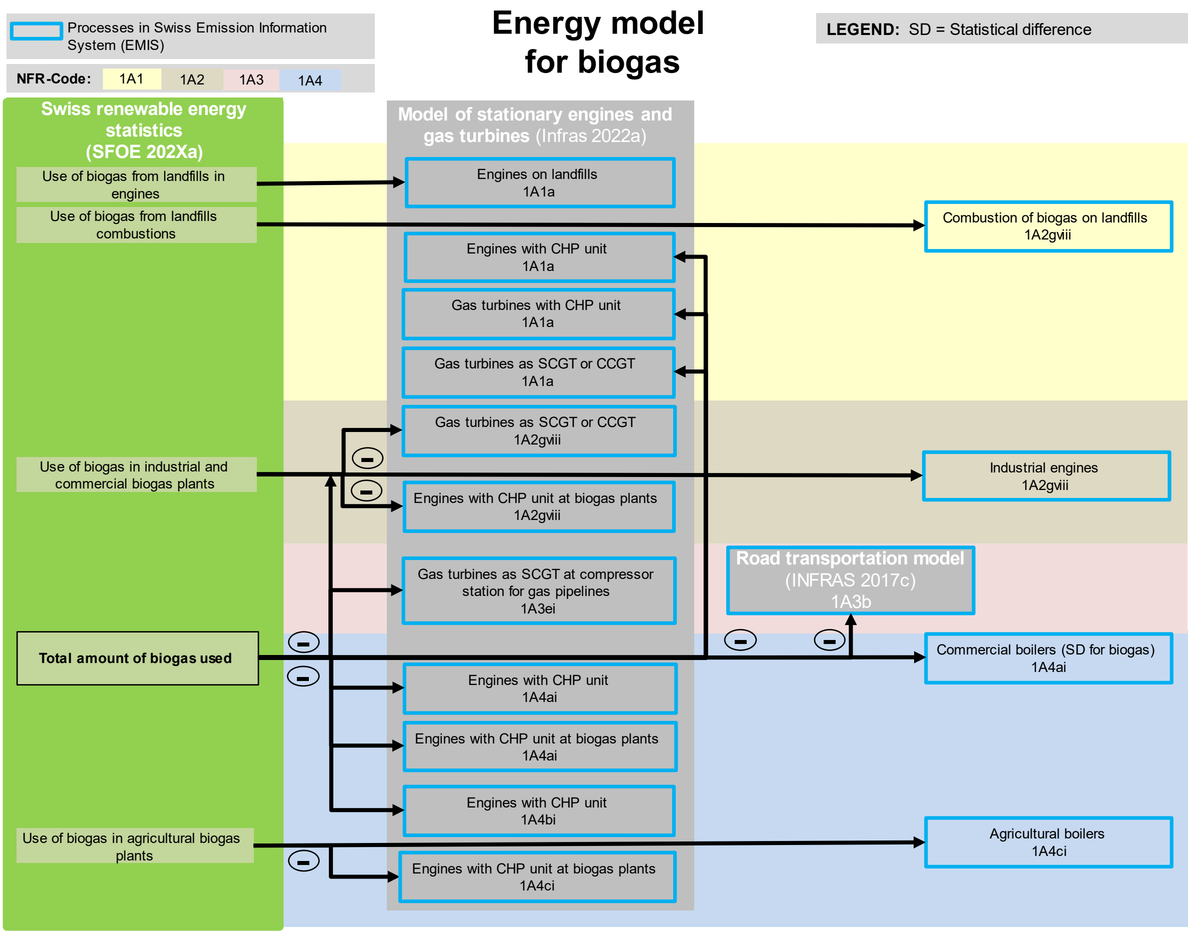



Figure 3-18 Schematic disaggregation of 1A Fuel consumption for biogas.

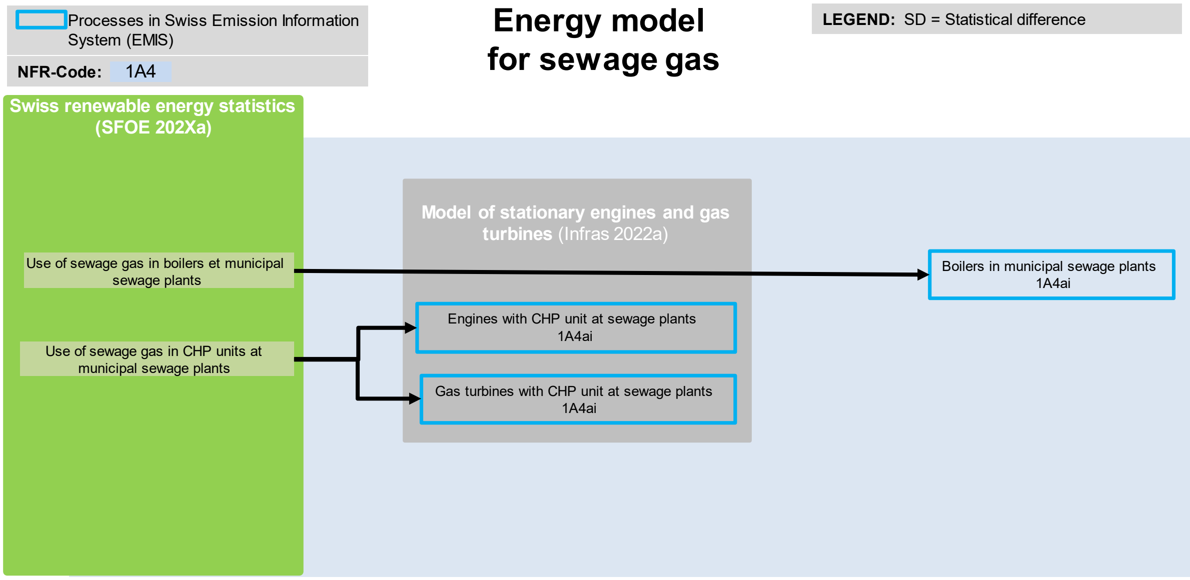



Figure 3-19 Schematic disaggregation of 1A Fuel consumption for sewage gas.

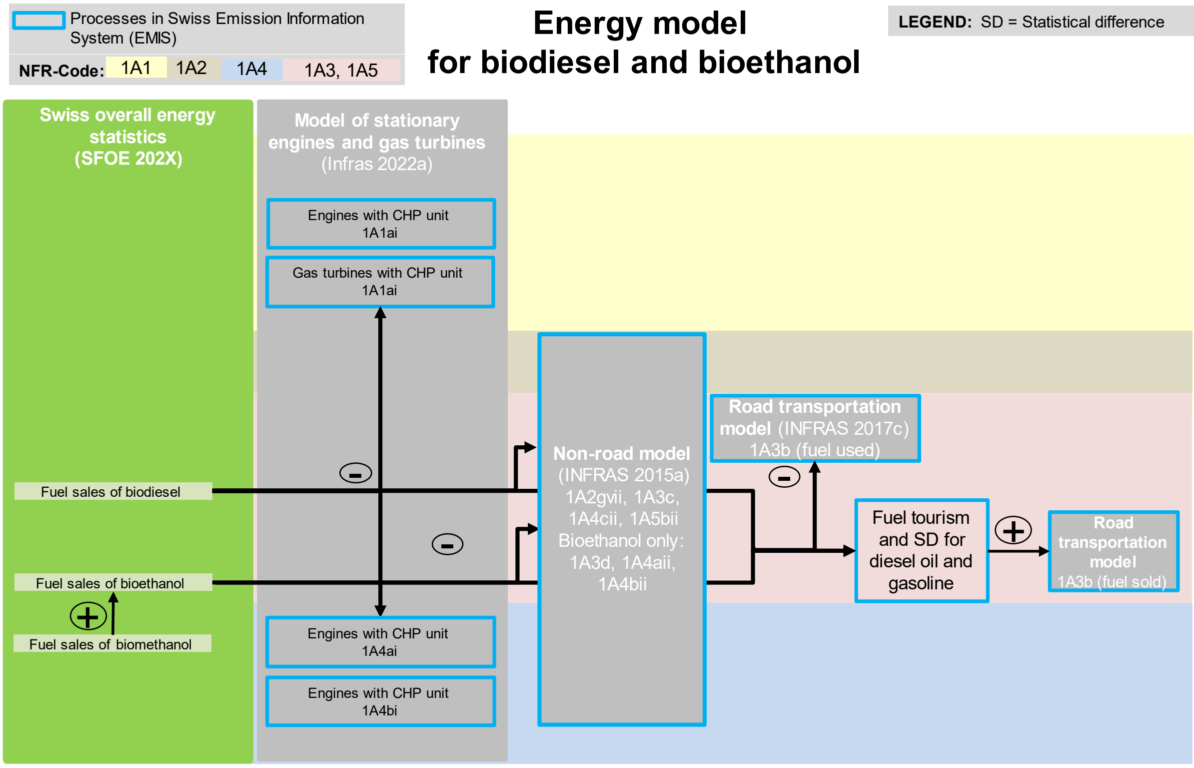



Figure 3-20 Schematic disaggregation of 1A Fuel consumption for biodiesel and bioethanol.

### Statistical stock change

In a few years the quantity of a fuel sold in a year according to total energy statistics may be smaller (or larger) than the quantity effectively used in the same year as reported from bottom-up data. The reason for such deviations is due to further stocks which are not taken into consideration at the level of the Swiss energy statistics and are managed at the individual plant level. Some plants manage their own intermediate fuel stocks, which they may carry over for use in later years. To mitigate the difference between less fuel sold (according to the total energy statistics) than fuel used (according to bottom-up information) in one year, so-called “stock shifts” are assumed in the energy model. Stockpiling can only be performed in the years in which more fuel was sold according to total energy statistics than was used based on bottom-up information. Stock which was accumulated in such years can be used in later years to level out the deviations between the total energy statistics and bottom-up data. Currently, stocks are formed in different years for residual fuel oil, petroleum coke and other bituminous coal:

- For residual fuel oil stock was build up in the years 2008-2010, 2014, 2015 and used in the years 2011, 2012, 2016-2021.
- For petroleum coke stock was build up in the years 2007, 2018 and used in the years 2008, 2019.
- For other bituminous coal stock was build up in the years 1991, 1996, 2003, 2005-2007 and used in the years 1993, 1994, 1998-2001, 2011, 2012.

## 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 3-10), the air pollutant emissions are calculated by a Tier 3 method based on the corresponding decision trees given in EMEP/EEA guidebook (EMEP/EEA 2023). 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 3-10 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:

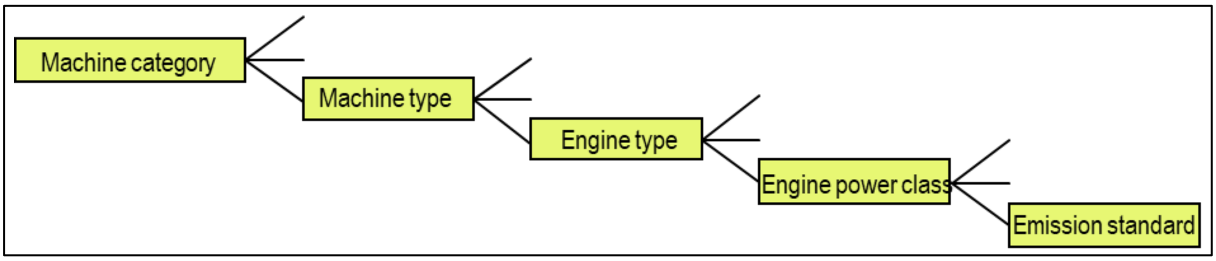



Figure 3-21 Each non-road vehicle is classified by its engine-power class, engine type, machine type, machine category, and emission standard.

The emission modelling is based on activity data and emission factors by means of the following equation, which is implemented at the most disaggregated level (Figure 3-21):

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

with

| | | |
|---|---|---|
| $Em$ | = | emission by engine type, pollutant or GHG (in g/a) |
| $N$ | = | number of vehicles (--) |
| $H$ | = | number of operation hours per year (h/a) |
| $P$ | = | engine power output (kW) |
| $\lambda$ | = | effective load factor (--) |
| $\varepsilon$ | = | 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 $\varepsilon$ 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 from 1980 to 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. $SO_x$ is country-specific, see Table 3-28. For other air pollutants, the main data sources are USEPA (2010), IFEU (2010), EMEP/EEA (2019) and Integer (2013). In general, the following sources are used for the emission factors (if not stated differently in the respective chapters 3.2.5.2, 3.2.6.2, 3.2.7.2 or 3.2.8.2):

- Emission factors for $NO_x$, VOC/$CH_4$, CO and exhaust particulate matter (PM) are generally given in FOEN (2015j) and INFRAS (2015a). BC exhaust emission factors stem from Neosys (2013). Considering the measuring procedure and the maximum temperature of 52°C, it can be assumed that PM condensable are also included in the measurements. The installed technology also plays a role in this context (petrol engines with/without catalytic converter, diesel engines with/without particulate filter, etc.).
- Non-exhaust particulate matter (PM) and non-exhaust BC emission factors are based on Carbotech (2000), with some modifications by BUWAL (2001). It should be noted that "PM" in BUWAL (2001) corresponds to total PM, including particles larger than 10 µm. For all non-road mobile machinery sources except rail abrasion, PM10 amounts to 67 % of total PM according to in BUWAL (2001). For rail abrasion, PM10 amounts to 90 % to 100 % of total PM according to in BUWAL (2001). The corresponding factors have been applied in PM10 emission calculation.
- NMVOC is not modelled bottom-up; the NMVOC emissions are calculated as the difference of VOC and $CH_4$ emissions given in FOEN (2015j) and INFRAS (2015a).
- $SO_x$ emission factors are based upon the sulphur content of fuels (see chp. 3.2.1.2). These are country- and fuel-specific, see implied emission factors in Table 3-28 (column diesel oil, gasoline, natural gas) and in specific tables in the non-road chapters.
- Emission factors for $NH_3$, priority heavy metals and POPs are generally taken from the EMEP/EEA guidebook (EMEP/EEA 2019). Pb emission factors are estimated based on the Pb content of fuels (according to EMEP/EEA 2023). PCDD/PCDF emissions are taken from Rentz et al. (2008).

Note that all emission factors (in kg/hr) of $NO_x$, NMVOC, PM (exhaust only; PM2.5 assumed equal to PM10 for combustion particles) and CO can be visualised and downloaded (tables in CSV format) by a query from the online non-road database INFRAS (2015a)[4]. For a detailed description of emission factors and their origin, see tables in the Annex 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.

## 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 (IVZ, formerly MOFIS) run by 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

[4] https://www.bafu.admin.ch/bafu/en/home/topics/air/state/non-road-datenbank.html [06.02.2025]

- 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. Details are documented in FOEN (2015j). All activity data (vehicle stocks, operating hours, consumption factors) can be downloaded by query from the online non-road database INFRAS (2015a), which is the data pool of FOEN (2015j). They can be queried by vehicle type, fuel type, power class and emission standard either at aggregated or disaggregated levels.

In Annex A2.1.2 (Table A - 13) the stock numbers and the operating hours of non-road vehicles are summarised for each non-road category.

For the greenhouse gas inventory under UNFCCC the fossil carbon fraction of biodiesel is estimated based on the method described in Sebos (2022). While all carbon in HVO (Hydrotreated Vegetable Oil) is of biogenic origin, FAME (Fatty Acid Methyl Esters) contains a fossil fraction due to the use of methanol from fossil sources in its production. The shares of FAME and HVO in biodiesel are available from the Swiss overall energy statistics (SFOE 2024). The fossil fraction of FAME depends on the feedstock it is derived from (e.g. rapeseed, soy, palm oil); since the feedstock shares are not captured in the Swiss energy statistics, they are based on European average values from HBEFA 4.1. The resulting overall fossil fraction of biodiesel varies over time – around 4.0 to 5.4 % of total biodiesel are reported under “fossil liquid fuels” as “biodiesel fossil”. For technical reasons in our database, there is a split of the whole biodiesel amount in fossil and biogenic biodiesel and not only for the carbon fraction and $CO_2$.

#### *3.2.1.1.2 Model of stationary engines and gas turbines*

**Choice of method**

The emissions from stationary engines and gas turbines in 1A Fuel combustion activities are calculated by a Tier 2 method based on chapter 1A1 Energy industries in the EMEP/EEA guidebook (EMEP/EEA 2023).

**Methodology**

The model for calculating emissions from stationary engines and gas turbines underwent an extensive revision during the years 2021 to 2022 and were finally implemented for the data submission 2024. To calculate the final fuel consumption for each category of stationary engines and gas turbines an inventory of power output values, distribution of exhaust gas technologies, average load factors and operating hours was elaborated. For large installations including engines and gas turbines with combined heat and power generation (CHP) along with gas turbines in simple cycle (SCGT) and combined cycle (CCGT) configuration, the available information was compiled individually for each unit. Most of the information was obtained from the cantonal air pollution control authorities, from publicly accessible websites and annual reports from industry, as well as from direct enquiries to the operators. Further details and results are documented in INFRAS (2022a). Emissions are calculated using the resulting fuel consumption for each category of stationary engines and gas turbines within 1A – Fuel consumption activities and multiplied with the respective emission factors.

**Emission factors**

Emission factors are taken from various sources based on measurements, modelling and literature and described in INFRAS (2022a). $SO_x$ is country-specific, see chp. 3.2.1.2, Table 3-30. For other air pollutants, the main data sources are EMEP/EEA (2023), UBA (2020), Norwegian Environment Agency (2020), Ecoinvent (2021), Ebertsch 2021 and Aschmann et al. (2019). The following sources are used for the emission factors of stationary engines and gas turbines, depending on the fuel used:

- Emission factors for $NO_x$ and CO are primarily based on measurements and given in INFRAS 2022a. Exhaust particulate matter (PM) including TSP, PM10 and PM2.5 as well as BC exhaust emission factors stem from tables 3-29, 3-30 and 3-31 (Tier 2) of chapter 1A4 Small combustion of the EMEP/EEA guidebook (EMEP/EEA 2023). Considering the measuring procedure and the recommended sample temperature of 160°C, it can be assumed that PM condensable are not included in the measurements.
- NMVOC emissions are calculated as the difference of VOC and $CH_4$ emissions given in INFRAS (2022a).
- VOC emission factors stem from tables 3-28, 3-29, 3-30 and 3-31 (Tier 2) of chapter 1A4 Small combustion of the EMEP/EEA guidebook (EMEP/EEA 2023).
- $CH_4$ emission factors originate from table 87 of the National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2018, UBA (2020).
- $SO_x$ emission factors are based upon the sulphur content of fuels (see chp. 3.2.1.2). These are country- and fuel-specific, see implied emission factors in Table 3-30 (column diesel oil, gas oil, natural gas) and in specific tables below.
- Emission factors for $NH_3$ are generally taken from Ecoinvent (2021) and the Norwegian Environment Agency (2020) for all categories, except for installations with SCR catalysts, where the corresponding limit values were taken as defined in the Federal Ordinance on Air Pollution Control OAPC (Swiss Confederation 1985).
- Emission factors for priority heavy metals, PCDD/PCDF, PAHs as well as HCB and PCB stem from tables 3-28, 3-29, 3-30 and 3-31 (Tier 2) of chapter 1A4 Small combustion of the EMEP/EEA guidebook (EMEP/EEA 2019).

Table 3-11 Emission factors of engines and gas turbines in 1A1 Energy industries.

| 1A1 Energy industries (Engines and gas turbines) | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| 1A1a Gas turbines as SCGT or CCGT | Gas oil | GJ | 83 | 0.18 | 0.84 | 0.10 | 9.5 | 9.5 | 9.5 | 0.32 | 2.6 |
| 1A1a Gas turbines as SCGT or CCGT | Natural gas | GJ | 29 | 1.6 | 0.23 | NA | 0.20 | 0.20 | 0.20 | 0.00050 | 14 |
| 1A1a Gas turbines as SCGT or CCGT | Biogas | GJ | 48 | 1.6 | 0.50 | NA | 0.20 | 0.20 | 0.20 | 0.00050 | 14 |
| 1A1a Gas turbines with CHP unit | Gas oil | GJ | 83 | 0.18 | 0.84 | 0.10 | 9.5 | 9.5 | 9.5 | 0.32 | 2.6 |
| 1A1a Gas turbines with CHP unit | Natural gas | GJ | 32 | 1.6 | 0.23 | NA | 0.23 | 0.23 | 0.23 | 0.00050 | 9.8 |
| 1A1a Gas turbines with CHP unit | Biodiesel fossil | GJ | 83 | 0.18 | 0.30 | 0.10 | 9.5 | 9.5 | 9.5 | 0.32 | 2.6 |
| 1A1a Gas turbines with CHP unit | Biodiesel biogenic | GJ | 83 | 0.18 | 0.30 | 0.10 | 9.5 | 9.5 | 9.5 | 0.32 | 2.6 |
| 1A1a Gas turbines with CHP unit | Biogas | GJ | 48 | 1.6 | 0.50 | NA | 0.23 | 0.23 | 0.23 | 0.00050 | 9.8 |
| 1A1a Engines with CHP unit | Gas oil | GJ | 137 | 50 | 0.84 | 8.9 | 30 | 30 | 30 | 2.3 | 136 |
| 1A1a Engines with CHP unit | Natural gas | GJ | 71 | 89 | 0.23 | 2.5 | 2.0 | 2.0 | 2.0 | 0.0041 | 54 |
| 1A1a Engines with CHP unit | Biodiesel fossil | GJ | 407 | 50 | 0.30 | 3.5 | 30 | 30 | 30 | 2.3 | 132 |
| 1A1a Engines with CHP unit | Biodiesel biogenic | GJ | 407 | 50 | 0.30 | 3.5 | 30 | 30 | 30 | 2.3 | 132 |
| 1A1a Engines with CHP unit | Biogas | GJ | 96 | 89 | 0.50 | 2.5 | 2.0 | 2.0 | 2.0 | 0.0041 | 86 |
| 1A1a Engines used as emergency generators | Gas oil | GJ | 942 | 50 | 0.84 | 0.10 | 26 | 26 | 26 | 2.3 | 137 |
| 1A1a Engines on landfills | Natural gas | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A1a Engines on landfills | Biogas | GJ | 98 | 89 | 0.50 | 3.1 | 2.0 | 2.0 | 2.0 | 0.0039 | 125 |
| 1A1b Gas turbines as SCGT at refineries | Refinery gas | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO |

| 1A1 Energy industries (Engines and gas turbines) | | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| 1A1a Gas turbines as SCGT or CCGT | Gas oil | GJ | 0.012 | 0.0010 | 0.12 | 1.8 | NA | NA | NA | NA | NA | NA |
| 1A1a Gas turbines as SCGT or CCGT | Natural gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| 1A1a Gas turbines as SCGT or CCGT | Biogas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| 1A1a Gas turbines with CHP unit | Gas oil | GJ | 0.012 | 0.0010 | 0.12 | 1.8 | NA | NA | NA | NA | NA | NA |
| 1A1a Gas turbines with CHP unit | Natural gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| 1A1a Gas turbines with CHP unit | Biodiesel fossil | GJ | 0.012 | 0.0010 | 0.12 | 1.8 | NA | NA | NA | NA | NA | NA |
| 1A1a Gas turbines with CHP unit | Biodiesel biogenic | GJ | 0.012 | 0.0010 | 0.12 | 1.8 | NA | NA | NA | NA | NA | NA |
| 1A1a Gas turbines with CHP unit | Biogas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| 1A1a Engines with CHP unit | Gas oil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A1a Engines with CHP unit | Natural gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| 1A1a Engines with CHP unit | Biodiesel fossil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A1a Engines with CHP unit | Biodiesel biogenic | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A1a Engines with CHP unit | Biogas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| 1A1a Engines used as emergency generators | Gas oil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A1a Engines on landfills | Natural gas | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A1a Engines on landfills | Biogas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| 1A1b Gas turbines as SCGT at refineries | Refinery gas | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

Table 3-12 Emission factors of engines and gas turbines in 1A2 Manufacturing industry and construction.

| 1A2 Manufacturing industries and construction (Engines and gas turbines) | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| 1A2d Gas turbines as SCGT or CCGT | Natural gas | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A2gviii Gas turbines as SCGT or CCGT | Natural gas | GJ | 85 | 1.6 | 0.23 | NA | 0.20 | 0.20 | 0.20 | 0.00050 | 11 |
| 1A2gviii Gas turbines as SCGT or CCGT | Biogas | GJ | 48 | 1.6 | 0.50 | NA | 0.20 | 0.20 | 0.20 | 0.00050 | 11 |
| 1A2gviii Gas turbines with CHP unit | Liquefied petroleum gas | GJ | 48 | 1.6 | 0.50 | NA | 0.20 | 0.20 | 0.20 | 0.00050 | 4.8 |
| 1A2gviii Engines with CHP unit | Liquefied petroleum gas | GJ | 135 | 89 | 0.50 | NA | 2.0 | 2.0 | 2.0 | 0.0050 | 56 |
| 1A2gviii Engines with CHP unit at biogas plants | Biogas | GJ | 99 | 89 | 0.50 | 3.8 | 2.0 | 2.0 | 2.0 | 0.0039 | 132 |

| 1A2 Manufacturing industries and construction (Engines and gas turbines) | | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| 1A2d Gas turbines as SCGT or CCGT | Natural gas | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A2gviii Gas turbines as SCGT or CCGT | Natural gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| 1A2gviii Gas turbines as SCGT or CCGT | Biogas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| 1A2gviii Gas turbines with CHP unit | Liquefied petroleum gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| 1A2gviii Engines with CHP unit | Liquefied petroleum gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0013 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| 1A2gviii Engines with CHP unit at biogas plants | Biogas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |

Table 3-13 Emission factors of engines and gas turbines in 1A3 Transport.

| 1A3(fu) Transport (Engines and gas turbines) | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| 1A3ei Gas turbines at compressor stations for gas pipelines | Natural gas | GJ | 30 | 1.6 | 0.23 | NA | 0.20 | 0.20 | 0.20 | 0.00050 | 11 |
| 1A3ei Gas turbines at compressor stations for gas pipelines | Biogas | GJ | 48 | 1.6 | 0.50 | NA | 0.20 | 0.20 | 0.20 | 0.00050 | 11 |

| 1A3(fu) Transport (Engines and gas turbines) | | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| 1A3ei Gas turbines at compressor stations for gas pipelines | Natural gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| 1A3ei Gas turbines at compressor stations for gas pipelines | Biogas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |

Table 3-14 Emission factors of engines and gas turbines in 1A4ai Other sectors: commercial/institutional.

| 1A4ai Commercial/Institutional Stationary (Engines and gas turbines) | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| 1A4ai Engines with CHP unit | Gas oil | GJ | 137 | 50 | 0.84 | 8.9 | 30 | 30 | 30 | 2.3 | 136 |
| 1A4ai Engines with CHP unit | Liquefied petroleum gas | GJ | 135 | 89 | 0.50 | NA | 2.0 | 2.0 | 2.0 | 0.0050 | 56 |
| 1A4ai Engines with CHP unit | Natural gas | GJ | 71 | 89 | 0.23 | 2.5 | 2.0 | 2.0 | 2.0 | 0.0041 | 54 |
| 1A4ai Engines with CHP unit | Biodiesel fossil | GJ | 407 | 50 | 0.30 | 3.5 | 30 | 30 | 30 | 2.3 | 132 |
| 1A4ai Engines with CHP unit | Biodiesel biogenic | GJ | 407 | 50 | 0.30 | 3.5 | 30 | 30 | 30 | 2.3 | 132 |
| 1A4ai Engines with CHP unit | Biogas | GJ | 96 | 89 | 0.50 | 2.5 | 2.0 | 2.0 | 2.0 | 0.0041 | 86 |
| 1A4ai Engines with CHP unit at biogas plants | Liquefied petroleum gas | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A4ai Engines with CHP unit at biogas plants | Biodiesel fossil | GJ | 157 | 50 | 0.30 | 8.7 | 30 | 30 | 30 | 2.3 | 136 |
| 1A4ai Engines with CHP unit at biogas plants | Biodiesel biogenic | GJ | 157 | 50 | 0.30 | 8.7 | 30 | 30 | 30 | 2.3 | 136 |
| 1A4ai Engines with CHP unit at biogas plants | Biogas | GJ | 99 | 89 | 0.50 | 3.8 | 2.0 | 2.0 | 2.0 | 0.0039 | 132 |
| 1A4ai Engines used as emergency generators | Gas oil | GJ | 909 | 50 | 0.84 | 0.47 | 14 | 14 | 14 | 2.3 | 137 |
| 1A4ai Gas turbines at sewage plants | Natural gas | GJ | 53 | 1.6 | 0.23 | NA | 0.20 | 0.20 | 0.20 | 0.00050 | 25 |
| 1A4ai Gas turbines at sewage plants | Sewage gas | GJ | 48 | 1.6 | 0.50 | NA | 0.23 | 0.23 | 0.23 | 0.00050 | 10.0 |
| 1A4ai Engines with CHP unit at sewage plants | Natural gas | GJ | 310 | 89 | 0.23 | NA | 2.0 | 2.0 | 2.0 | 0.0050 | 76 |
| 1A4ai Engines with CHP unit at sewage plants | Sewage gas | GJ | 101 | 89 | 0.50 | 2.0 | 2.0 | 2.0 | 2.0 | 0.0042 | 141 |

| 1A4ai Commercial/Institutional Stationary (Engines and gas turbines) | | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| 1A4ai Engines with CHP unit | Gas oil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A4ai Engines with CHP unit | Liquefied petroleum gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0013 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| 1A4ai Engines with CHP unit | Natural gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| 1A4ai Engines with CHP unit | Biodiesel fossil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A4ai Engines with CHP unit | Biodiesel biogenic | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A4ai Engines with CHP unit | Biogas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| 1A4ai Engines with CHP unit at biogas plants | Liquefied petroleum gas | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A4ai Engines with CHP unit at biogas plants | Biodiesel fossil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A4ai Engines with CHP unit at biogas plants | Biodiesel biogenic | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A4ai Engines with CHP unit at biogas plants | Biogas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| 1A4ai Engines used as emergency generators | Gas oil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A4ai Gas turbines at sewage plants | Natural gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| 1A4ai Gas turbines at sewage plants | Sewage gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| 1A4ai Engines with CHP unit at sewage plants | Natural gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| 1A4ai Engines with CHP unit at sewage plants | Sewage gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |

Table 3-15 Emission factors of engines and gas turbines in 1A4bi Other sectors: residential.

| 1A4bi Residential Stationary (Engines and gas turbines) | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| 1A4bi Engines with CHP unit | Gas oil | GJ | 137 | 50 | 0.84 | 8.9 | 30 | 30 | 30 | 2.3 | 136 |
| 1A4bi Engines with CHP unit | Liquefied petroleum gas | GJ | 135 | 89 | 0.50 | NA | 2.0 | 2.0 | 2.0 | 0.0050 | 56 |
| 1A4bi Engines with CHP unit | Natural gas | GJ | 71 | 89 | 0.23 | 2.5 | 2.0 | 2.0 | 2.0 | 0.0041 | 54 |
| 1A4bi Engines with CHP unit | Biodiesel fossil | GJ | 407 | 50 | 0.30 | 3.5 | 30 | 30 | 30 | 2.3 | 132 |
| 1A4bi Engines with CHP unit | Biodiesel biogenic | GJ | 407 | 50 | 0.30 | 3.5 | 30 | 30 | 30 | 2.3 | 132 |
| 1A4bi Engines with CHP unit | Biogas | GJ | 96 | 89 | 0.50 | 2.5 | 2.0 | 2.0 | 2.0 | 0.0041 | 86 |

| 1A4bi Residential Stationary (Engines and gas turbines) | | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| 1A4bi Engines with CHP unit | Gas oil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A4bi Engines with CHP unit | Liquefied petroleum gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0013 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| 1A4bi Engines with CHP unit | Natural gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| 1A4bi Engines with CHP unit | Biodiesel fossil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A4bi Engines with CHP unit | Biodiesel biogenic | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A4bi Engines with CHP unit | Biogas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |

Table 3-16 Emission factors of engines and gas turbines in 1A4ci Other sectors: agriculture/forestry/fishing.

| 1A4ci Agriculture/Forestry/Fishing Stationary (Engines and gas turbines) | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| 1A4ci Engines used as emergency generators | Gas oil | GJ | 942 | 50 | 0.84 | 0.10 | 27 | 27 | 27 | 2.3 | 137 |
| 1A4ci Engines with CHP unit at biogas plants | Natural gas | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A4ci Engines with CHP unit at biogas plants | Biogas | GJ | 97 | 89 | 0.50 | 3.2 | 2.0 | 2.0 | 2.0 | 0.0038 | 108 |

| 1A4ci Agriculture/Forestry/Fishing Stationary (Engines and gas turbines) | | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| 1A4ci Engines used as emergency generators | Gas oil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| 1A4ci Engines with CHP unit at biogas plants | Natural gas | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A4ci Engines with CHP unit at biogas plants | Biogas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |

### Activity data

Activity data were collected by surveys among the cantonal air pollution control authorities. For engines used as emergency generators, their proof of gas oil use, which is deposited with the Federal Office for Customs and Border Security (FOCBS), were the most important source of data. Furthermore, the statistics by the SFOE about the thermal electricity production including combined heat and power generation (CHP) in Switzerland (SFOE 2021c) served as the basis for activity data modelling. For large installations including engines as well as simple cycle gas turbines (SCGT) and combined cycle gas turbines (CCGT), the websites and annual reports of the operators provided informative information on technical data, operating hours or fuel consumption. From these data sources, all necessary information like modelling of the quantity of installations, annual operating hours, load factors and rated thermal input were derived. Details are documented in INFRAS (2022a).

The activity data of engines using landfill gas in 1A1a Public electricity and heat production, engines using biogas in 1A2gviii Other - Manufacturing industries, 1A4ai Other – Commercial/institutional and 1A4ci Other – Agriculture/forestry /fishing, as well as gas turbines at the compressor station in 1A3ei Pipeline transport using natural gas are updated annually with newest available information concerning fuel consumption from SFOE 2024a and SFOE 2024, respectively.

For the greenhouse gas inventory under UNFCCC the fossil carbon fraction of biodiesel is estimated based on the method described in Sebos (2022). While all carbon in HVO (Hydrotreated Vegetable Oil) is of biogenic origin, FAME (Fatty Acid Methyl Esters) contains a fossil fraction due to the use of methanol from fossil sources in its production. The shares of FAME and HVO in biodiesel are available from the Swiss overall energy statistics (SFOE 2024). The fossil fraction of FAME depends on the feedstock it is derived from (e.g. rapeseed, soy, palm oil); since the feedstock shares are not captured in the Swiss energy statistics, they are based on European average values from HBEFA 4.1. The resulting overall fossil fraction of biodiesel varies over time – around 4.0 to 5.4 % of total biodiesel are reported under “fossil liquid fuels” as “biodiesel fossil”. For technical reasons in our database, there is a split of the whole biodiesel amount in fossil and biogenic biodiesel and not only for the carbon fraction and $CO_2$.

Natural gas also includes the consumed amount of liquefied natural gas (LNG) as supplied by the Swiss overall energy statistics (SFOE 2024).

Table 3-17 Activity data of engines and gas turbines in 1A1 Energy industries.

| 1A1 Energy industries (Engines and gas turbines) | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 421 | 1'907 | 4'851 | 4'647 | 5'088 | 3'621 | 3'213 | 4'709 | 3'748 | 3'643 | 3'649 | 3'566 | 3'668 | 3'834 | 3'846 |
| 1A1a Gas turbines as SCGT or CCGT | Gas oil | TJ | 24 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 7.2 | 7.4 | 7.7 | 7.8 |
| 1A1a Gas turbines as SCGT or CCGT | Natural gas | TJ | 3.5 | 779 | 840 | 1'110 | 2'410 | 1'082 | 2'306 | 4'154 | 3'245 | 3'208 | 3'260 | 3'208 | 3'192 | 3'331 | 3'337 |
| 1A1a Gas turbines as SCGT or CCGT | Biogas | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 110 | 121 | 130 |
| 1A1a Gas turbines with CHP unit | Gas oil | TJ | 6.7 | 3.6 | NO | 8.1 | 3.6 | 0.69 | 0.59 | 0.29 | 0.20 | 0.12 | 0.16 | 0.16 | 0.16 | 0.16 | 0.15 |
| 1A1a Gas turbines with CHP unit | Natural gas | TJ | 66 | 31 | NO | 39 | 42 | 13 | 12 | 6.5 | 3.5 | 3.2 | 2.8 | 2.7 | 2.8 | 2.9 | 2.9 |
| 1A1a Gas turbines with CHP unit | Biodiesel fossil | TJ | NO | NO | NO | 0.0049 | 0.028 | 0.012 | 0.010 | 0.0048 | 0.0028 | 0.0024 | 0.0025 | 0.0026 | 0.0029 | 0.0030 | 0.0029 |
| 1A1a Gas turbines with CHP unit | Biodiesel biogenic | TJ | NO | NO | NO | 0.096 | 0.61 | 0.21 | 0.18 | 0.100 | 0.062 | 0.055 | 0.054 | 0.053 | 0.053 | 0.054 | 0.053 |
| 1A1a Gas turbines with CHP unit | Biogas | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 0.089 | 0.096 | 0.11 | 0.11 |
| 1A1a Engines with CHP unit | Gas oil | TJ | 7.5 | 47 | 179 | 167 | 55 | 27 | 25 | 21 | 24 | 14 | 18 | 18 | 18 | 18 | 17 |
| 1A1a Engines with CHP unit | Natural gas | TJ | 73 | 405 | 655 | 799 | 661 | 532 | 513 | 473 | 426 | 370 | 319 | 307 | 315 | 327 | 325 |
| 1A1a Engines with CHP unit | Biodiesel fossil | TJ | NO | NO | NO | 0.10 | 0.44 | 0.46 | 0.42 | 0.35 | 0.35 | 0.28 | 0.28 | 0.29 | 0.32 | 0.34 | 0.33 |
| 1A1a Engines with CHP unit | Biodiesel biogenic | TJ | NO | NO | NO | 2.0 | 9.5 | 8.4 | 7.5 | 7.3 | 7.6 | 6.4 | 6.1 | 6.0 | 6.0 | 6.1 | 5.9 |
| 1A1a Engines with CHP unit | Biogas | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 10 | 11 | 12 | 13 |
| 1A1a Engines used as emergency generators | Gas oil | TJ | 1.4 | 1.4 | 1.5 | 1.5 | 1.6 | 1.7 | 1.7 | 1.7 | 1.7 | 1.8 | 1.8 | 1.7 | 1.8 | 1.8 | 1.8 |
| 1A1a Engines on landfills | Natural gas | TJ | NO | NO | NO | 14 | 14 | 11 | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A1a Engines on landfills | Biogas | TJ | 238 | 609 | 568 | 204 | 49 | 31 | 21 | 12 | 6.5 | 6.0 | 8.4 | 4.0 | 4.0 | 5.0 | 4.4 |
| 1A1b Gas turbines as SCGT at refineries | Refinery gas | TJ | NO | NO | 2'575 | 2'270 | 1'808 | 1'879 | 293 | NO | NO | NO | NO | NO | NO | NO | NO |

Table 3-18 Activity data of engines and gas turbines in 1A2 Manufacturing industry and construction.

| 1A2 Manufacturing industries and construction (Engines and gas turbines) | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 655 | 1'775 | 2'585 | 1'723 | 2'010 | 1'156 | 1'111 | 451 | 415 | 353 | 354 | 346 | 363 | 398 | 372 |
| 1A2d Gas turbines as SCGT or CCGT | Natural gas | TJ | NO | 955 | 1'616 | 490 | 422 | 608 | 682 | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A2gviii Gas turbines as SCGT or CCGT | Natural gas | TJ | 613 | 721 | 810 | 1'073 | 1'355 | 238 | 145 | 145 | 145 | 145 | 145 | 145 | 144 | 150 | 151 |
| 1A2gviii Gas turbines as SCGT or CCGT | Biogas | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 5.0 | 5.5 | 5.9 |
| 1A2gviii Gas turbines with CHP unit | Liquefied petroleum gas | TJ | 0.68 | 0.87 | NO | 1.5 | 2.3 | 0.79 | 0.66 | 0.54 | 0.12 | 0.081 | 0.066 | 0.064 | 0.063 | 0.064 | 0.064 |
| 1A2gviii Engines with CHP unit | Liquefied petroleum gas | TJ | 0.75 | 11 | 33 | 30 | 35 | 31 | 28 | 39 | 14 | 9.4 | 7.4 | 7.3 | 7.3 | 7.5 | 7.3 |
| 1A2gviii Engines with CHP unit at biogas plants | Biogas | TJ | 41 | 87 | 126 | 128 | 195 | 278 | 256 | 267 | 256 | 199 | 201 | 194 | 206 | 235 | 208 |

Table 3-19 Activity data of engines and gas turbines in 1A3 Transport.

| 1A3(fu) Transport (Engines and gas turbines) | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 560 | 310 | 340 | 1'070 | 830 | 830 | 760 | 340 | 470 | 490 | 600 | 540 | 138 | 420 | 192 |
| 1A3ei Gas turbines at compressor stations for gas pipelines | Natural gas | TJ | 560 | 310 | 340 | 1'070 | 830 | 830 | 760 | 340 | 470 | 490 | 600 | 540 | 120 | 400 | 170 |
| 1A3ei Gas turbines at compressor stations for gas pipelines | Biogas | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 18 | 20 | 22 |

Table 3-20 Activity data of engines and gas turbines in 1A4a Other sectors: commercial/institutional.

| 1A4ai Commercial/Institutional Stationary (Engines and gas turbines) | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 1'572 | 2'973 | 4'524 | 5'062 | 4'603 |
| 1A4ai Engines with CHP unit | Gas oil | TJ | 44 | 171 | 580 | 539 | 178 |
| 1A4ai Engines with CHP unit | Liquefied petroleum gas | TJ | 2.4 | 36 | 103 | 95 | 109 |
| 1A4ai Engines with CHP unit | Natural gas | TJ | 355 | 1'407 | 2'169 | 2'596 | 2'089 |
| 1A4ai Engines with CHP unit | Biodiesel fossil | TJ | NO | NO | NO | 0.32 | 1.4 |
| 1A4ai Engines with CHP unit | Biodiesel biogenic | TJ | NO | NO | NO | 6.2 | 30 |
| 1A4ai Engines with CHP unit | Biogas | TJ | NO | NO | NO | NO | NO |
| 1A4ai Engines with CHP unit at biogas plants | Liquefied petroleum gas | TJ | NO | 2.9 | 5.6 | NO | NO |
| 1A4ai Engines with CHP unit at biogas plants | Biodiesel fossil | TJ | NO | NO | 1.3 | 0.068 | 1.1 |
| 1A4ai Engines with CHP unit at biogas plants | Biodiesel biogenic | TJ | NO | NO | 25 | 1.3 | 24 |
| 1A4ai Engines with CHP unit at biogas plants | Biogas | TJ | NO | 29 | 82 | 143 | 394 |
| 1A4ai Engines used as emergency generators | Gas oil | TJ | 383 | 383 | 391 | 396 | 405 |
| 1A4ai Gas turbines at sewage plants | Natural gas | TJ | NO | 0.23 | 0.073 | NO | 0.019 |
| 1A4ai Gas turbines at sewage plants | Sewage gas | TJ | 179 | 169 | 66 | NO | 18 |
| 1A4ai Engines with CHP unit at sewage plants | Natural gas | TJ | NO | 1.0 | 1.2 | 1.4 | 1.4 |
| 1A4ai Engines with CHP unit at sewage plants | Sewage gas | TJ | 610 | 775 | 1'100 | 1'284 | 1'351 |

| 1A4ai Commercial/Institutional Stationary (Engines and gas turbines) | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 4'349 | 4'260 | 4'181 | 4'008 | 3'813 | 3'643 | 3'639 | 3'648 | 3'751 | 3'741 |
| 1A4ai Engines with CHP unit | Gas oil | TJ | 88 | 77 | 66 | 76 | 44 | 57 | 55 | 55 | 56 | 54 |
| 1A4ai Engines with CHP unit | Liquefied petroleum gas | TJ | 97 | 87 | 121 | 44 | 29 | 23 | 23 | 23 | 23 | 23 |
| 1A4ai Engines with CHP unit | Natural gas | TJ | 1'668 | 1'596 | 1'469 | 1'325 | 1'151 | 991 | 956 | 979 | 1'018 | 1'010 |
| 1A4ai Engines with CHP unit | Biodiesel fossil | TJ | 1.4 | 1.3 | 1.1 | 1.1 | 0.88 | 0.88 | 0.91 | 1.0 | 1.1 | 1.0 |
| 1A4ai Engines with CHP unit | Biodiesel biogenic | TJ | 26 | 23 | 23 | 24 | 20 | 19 | 19 | 19 | 19 | 18 |
| 1A4ai Engines with CHP unit | Biogas | TJ | NO | NO | NO | NO | NO | NO | 31 | 34 | 37 | 39 |
| 1A4ai Engines with CHP unit at biogas plants | Liquefied petroleum gas | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A4ai Engines with CHP unit at biogas plants | Biodiesel fossil | TJ | 1.2 | 1.3 | 1.2 | 0.88 | 1.0 | 0.75 | 0.78 | 0.84 | 0.85 | 0.83 |
| 1A4ai Engines with CHP unit at biogas plants | Biodiesel biogenic | TJ | 22 | 23 | 24 | 19 | 23 | 16 | 16 | 16 | 15 | 15 |
| 1A4ai Engines with CHP unit at biogas plants | Biogas | TJ | 701 | 738 | 780 | 807 | 818 | 813 | 807 | 787 | 897 | 908 |
| 1A4ai Engines used as emergency generators | Gas oil | TJ | 412 | 413 | 415 | 417 | 420 | 421 | 413 | 411 | 409 | 405 |
| 1A4ai Gas turbines at sewage plants | Natural gas | TJ | 0.027 | 0.029 | 0.25 | 0.23 | 0.24 | 0.23 | 0.21 | 0.20 | 0.20 | 0.19 |
| 1A4ai Gas turbines at sewage plants | Sewage gas | TJ | 25 | 25 | 26 | 26 | 34 | 33 | 34 | 34 | 33 | 32 |
| 1A4ai Engines with CHP unit at sewage plants | Natural gas | TJ | 1.4 | 1.5 | 12 | 11 | 8.8 | 8.6 | 8.0 | 7.7 | 7.4 | 7.2 |
| 1A4ai Engines with CHP unit at sewage plants | Sewage gas | TJ | 1'306 | 1'274 | 1'241 | 1'257 | 1'264 | 1'259 | 1'276 | 1'282 | 1'235 | 1'227 |

Table 3-21 Activity data of engines and gas turbines in 1A4b Other sectors: residential.

| 1A4bi Residential Stationary (Engines and gas turbines) | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 45 | 179 | 317 | 360 | 267 |
| 1A4bi Engines with CHP unit | Gas oil | TJ | 4.9 | 19 | 64 | 60 | 20 |
| 1A4bi Engines with CHP unit | Liquefied petroleum gas | TJ | 0.26 | 4.0 | 11 | 11 | 12 |
| 1A4bi Engines with CHP unit | Natural gas | TJ | 39 | 156 | 241 | 288 | 232 |
| 1A4bi Engines with CHP unit | Biodiesel fossil | TJ | NO | NO | NO | 0.035 | 0.15 |
| 1A4bi Engines with CHP unit | Biodiesel biogenic | TJ | NO | NO | NO | 0.69 | 3.3 |
| 1A4bi Engines with CHP unit | Biogas | TJ | NO | NO | NO | NO | NO |

| 1A4bi Residential Stationary (Engines and gas turbines) | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 209 | 198 | 187 | 163 | 138 | 121 | 121 | 123 | 128 | 127 |
| 1A4bi Engines with CHP unit | Gas oil | TJ | 9.7 | 8.5 | 7.4 | 8.4 | 4.8 | 6.4 | 6.2 | 6.1 | 6.2 | 6.0 |
| 1A4bi Engines with CHP unit | Liquefied petroleum gas | TJ | 11 | 9.6 | 14 | 4.9 | 3.3 | 2.6 | 2.5 | 2.5 | 2.6 | 2.5 |
| 1A4bi Engines with CHP unit | Natural gas | TJ | 185 | 177 | 163 | 147 | 128 | 110 | 106 | 109 | 113 | 112 |
| 1A4bi Engines with CHP unit | Biodiesel fossil | TJ | 0.16 | 0.15 | 0.12 | 0.12 | 0.097 | 0.098 | 0.10 | 0.11 | 0.12 | 0.11 |
| 1A4bi Engines with CHP unit | Biodiesel biogenic | TJ | 2.9 | 2.6 | 2.5 | 2.6 | 2.2 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| 1A4bi Engines with CHP unit | Biogas | TJ | NO | NO | NO | NO | NO | NO | 3.5 | 3.7 | 4.1 | 4.4 |

Table 3-22 Activity data of engines and gas turbines in 1A4c Other sectors: agriculture/forestry/fishing.

| 1A4ci Agriculture/Forestry/Fishing Stationary (Engines and gas turbines) | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 64 | 53 | 67 | 133 | 499 |
| 1A4ci Engines used as emergency generators | Gas oil | TJ | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| 1A4ci Engines with CHP unit at biogas plants | Natural gas | TJ | 2.7 | 1.3 | 2.5 | 2.3 | NO |
| 1A4ci Engines with CHP unit at biogas plants | Biogas | TJ | 59 | 49 | 62 | 128 | 497 |

| 1A4ci Agriculture/Forestry/Fishing Stationary (Engines and gas turbines) | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 930 | 1'043 | 1'194 | 1'274 | 1'405 | 1'614 | 1'764 | 1'911 | 1'948 | 2'005 |
| 1A4ci Engines used as emergency generators | Gas oil | TJ | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| 1A4ci Engines with CHP unit at biogas plants | Natural gas | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A4ci Engines with CHP unit at biogas plants | Biogas | TJ | 928 | 1'041 | 1'192 | 1'272 | 1'403 | 1'612 | 1'762 | 1'909 | 1'946 | 2'003 |

### *3.2.1.1.3 Model for wood energy 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 the EMEP/EEA guidebook (EMEP/EEA 2023).

## Methodology

The Swiss wood energy statistics (SFOE 2024b) distinguish 24 wood combustion installation types (exclusive municipal solid waste plants) that are fired with logwood, pellets, chips or so-called renewable waste from wood products and provide both the annual wood consumption for the individual categories of combustion installation types (table 4.1, categories 1-19) and the allocations of the installation types to the sectoral consumer categories (table 6.1, 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 3-23) to the source categories 1A1a Public Electricity and Heat Production, 1A2gviii Other, 1A4ai Commercial/Institutional, 1A4bi Residential and 1A4ci Agriculture/Forestry/Fishing. Installation types of the wood energy statistics with the same emission behaviour are grouped into one category in Table 3-23.

The combustion of any household waste in wood-burning fireplaces and stoves is prohibited in Switzerland since 1992 (Ordinance on Air Pollution Control, Swiss Confederation 1985). Emissions from illegal domestic incineration of municipal solid waste are reported in source category 5C1a Municipal waste incineration (see chp. 6.4.2)

Table 3-23 Assignment of the categories of wood combustion installations from the Swiss wood energy statistics (SFOE 2024b) to the categories of the emission factor model (Zotter and Nussbaumer 2022).

| Categories of wood combustion installations | | |
|---|---|---|
| Swiss wood energy statistics | | Emission factor model |
| 1 | Open fireplaces | Open fireplaces |
| 2 | Closed fireplaces | Closed fireplaces, log wood stoves |
| 3 | Log wood stoves | |
| 4a | Heating stoves (living area) | |
| 4b | Pellet stoves | Pellet stoves |
| 5 | Tiled stoves | Closed fireplaces, log wood stoves |
| 6 | Log wood hearths | Log wood hearths |
| 7 | Central heating hearths | |
| 8 | Log wood boilers <50 kW | Log wood boilers |
| 9 | Log wood boilers >50 kW | |
| 10 | Log wood dual chamber boilers | Log wood dual chamber boilers |
| 11a | Automatic chip boilers < 50 kW | Automatic chip boilers < 50 kW |
| 11b | Automatic pellet boilers < 50 kW | Automatic pellet boilers < 50 kW |
| 12a | Automatic chip boilers 50–300 kW w/o wood processing companies | Automatic chip boilers 50–300 kW w/o wood processing companies |
| 12b | Automatic pellet boilers 50–300 kW | Automatic pellet boilers 50–300 kW |
| 13 | Automatic chip boilers 50–300 kW within wood processing companies | Automatic chip boilers 50–300 kW within wood processing companies |
| 14a | Automatic chip boilers 300–500 kW w/o wood processing companies | Automatic chip boilers 300–500 kW w/o wood processing companies |
| 14b | Automatic pellet boilers 300–500 kW | Automatic pellet boilers 300–500 kW |
| 15 | Automatic chip boilers 300–500 kW within wood processing companies | Automatic chip boilers 300–500 kW within wood processing companies |
| 16a | Automatic chip boilers > 500 kW w/o wood processing companies | Automatic chip boilers > 500 kW w/o wood processing companies |
| 16b | Automatic pellet boilers > 500 kW | Automatic pellet boilers > 500 kW |
| 17 | Automatic chip boilers > 500 kW within wood processing companies | Automatic chip boilers > 500 kW within wood processing companies |
| 18 | Combined chip heat and power plants | Combined chip heat and power plants |
| 19 | Plants for renewable waste from wood products | Plants for renewable waste from wood products |

## Emission factors

All emission factors are based on a country-specific emission factor model for wood energy that has been completely revised for the entire time series (including projections) by Zotter and Nussbaumer (2022). Emission factor values are modelled for the years 1990, 2008, 2014, 2020 and 2035, i.e. 2008 and 2014 being the update years of the previous models. Years in between are linearly interpolated.

The model is based on a large number of air pollution control measurements, laboratory and field measurements, literature data (e.g. beReal, emission factors in the Nordic countries) and the EMEP/EEA guidebook (EMEP/EEA 2019) and takes into account both various technology standards of combustion installations and operating influences.

For single-room furnaces, i.e. open/closed fireplaces and log wood stoves (categories 1-4a, 5) the emission factors of $NO_x$, VOC, PM exhaust (filterable fraction) and CO are modelled based on literature emission data covering the entire combustion process including the start-up phase and burn-out. A distinction was made between furnaces of conventional and modern technology. In a first step, average emission factors were derived under optimal operating conditions. Optimal operation means that no wet wood is used, the wood is lit from above and the combustion process is not negatively influenced by non-optimal operation. However, in order to be able to represent the emissions as realistically as possible, user impacts such as lighting from below, lighting with newspaper, using wet wood, overloading the combustion chamber as well as reducing the air supply were taken into account by factors. Also based on literature data, factors for the ratio of the emission factors of each disadvantageous operation mode compared to optimal operation were determined. As no literature data on the shares of the respective (disadvantageous) operating modes could be found they were estimated. Shares of 35 % optimal operation, 25 % lighting from below, 10 % lighting with newspaper, 10 % wet wood, 10 % overloaded combustion chamber and 10 % reduced air supply were assumed for a representative mean furnace operation in 2020. By varying these operation shares (user impacts) and the shares of furnace technology (conventional, modern), the emission factors for the past (1990, 2008, 2014) and the future (2035) were modelled as well. As there is no information on the technology of the appliances in the Swiss wood energy statistics (SFOE 2024b), assumptions had to be made. Only a classification into so-called conventional and modern furnaces was made. Conventional includes furnaces with single-stage combustion and those described as old in the literature, while modern comprises multi-stage furnaces and those designated as new or with the eco-label. Assumptions on technology distribution were made for three commissioning periods (1990-1998: 100 % conventional, 1999-2008. 50 % conventional/50 % modern, 2009-2019: 25 % conventional/75 % modern) yielding a fleet of 56 % conventional and 44 % modern single-room furnaces in 2020. Compared to other countries (Austria, Denmark, Germany, Norway and Sweden) with values in the range of 20 % to 50 % this share of conventional furnaces is rather high.

For log boilers (<50 kW, >50 kW, categories 8-9), limited literature data were available for the derivation of emission factors. Only studies that reflect real operation as far as possible were considered, i.e. that cover the entire combustion process or large parts of it (at least including start or burn-out), and for which data on full and partial load were available. It was also not possible to differentiate between different technologies (conventional, modern).

For automatic boilers >50 kW (categories 12-17), combined heat and power plants (category 18) and plants for renewable waste from wood products (category 19), the emission factors of $NO_x$, VOC, PM exhaust and CO are derived based on the factors of the different operating phases (start, stop, full load, partial load and stand-by) and their effective combustion heat output, taking into account typical shares of the respective phases.

Besides the emission factors for PM exhaust, those for PM condensable were also derived, see Table 3-25. The condensable PM fractions were estimated using the ratio of PM (total particles)/PM exhaust based on literature data, including measurements by Zotter and Nussbaumer (2022) on some installation types relevant for Switzerland. The model differentiates between manually operated single room stoves / central heating boilers and (larger) automatic combustion installations, see Table 3-26. The latest submission of Switzerland's air pollution emission inventory now also includes the emissions of PM condensable.

A mean constant NMVOC to VOC ratio over time of 0.7 is used for all combustion installation types, based on literature emission data for single-room furnaces and central heating systems of different technology, operating conditions and phases. The shares of PM2.5 in TSP and PM10 in TSP are assumed to be 90 % and 95 %, respectively, for all installation types and the entire time series.

For the temporal development of the emission factors of the priority heavy metals Pb and Cd the same relative development was assumed as for PM and for those of the POPs (PCDD/PCDF, PAHs, HCB and PCBs) as for CO. The emission factors of Hg were assumed to be constant over the entire period.

Table 3-24 Emission factors 2023 of pollutants due to wood combustion from source categories 1A1-1A4 (“w/o wood proc. companies.” stands for “without wood processing companies”). PM2.5, PM10 and TSP correspond to PM total particles, which include both the exhaust (filterable) and condensable fractions.

| 1A Combustion (Wood combustion) | Unit of activity data | NOx | NMVOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Open fireplaces | GJ wood | 80 | 251 | 10 | 4.8 | 173 | 182 | 192 | 58 | 2'900 |
| Closed fireplaces | GJ wood | 85 | 229 | 10 | 4.8 | 146 | 155 | 162 | 52 | 2'680 |
| Log wood stoves | GJ wood | 85 | 229 | 10 | 4.8 | 146 | 155 | 162 | 52 | 2'680 |
| Heating stoves (living area) | GJ wood | 85 | 229 | 10 | 4.8 | 146 | 155 | 162 | 52 | 2'680 |
| Pellet stoves | GJ wood | 85 | 13 | 10 | 1.9 | 65 | 68 | 72 | 13 | 372 |
| Tiled stoves | GJ wood | 85 | 229 | 10 | 4.8 | 146 | 155 | 162 | 52 | 2'680 |
| Log wood hearths | GJ wood | 70 | 325 | 10 | 4.8 | 342 | 361 | 380 | 122 | 3'840 |
| Central heating hearths | GJ wood | 70 | 325 | 10 | 4.8 | 342 | 361 | 380 | 122 | 3'840 |
| Log wood boilers <50 kW | GJ wood | 100 | 64 | 10 | 1.9 | 97 | 103 | 108 | 15 | 1'580 |
| Log wood boilers >50 kW | GJ wood | 100 | 64 | 10 | 1.9 | 97 | 103 | 108 | 15 | 1'580 |
| Log wood dual chamber boilers | GJ wood | 70 | 336 | 10 | 4.8 | 342 | 361 | 380 | 130 | 4'000 |
| Automatic chip boilers < 50 kW | GJ wood | 120 | 38 | 10 | 1.9 | 151 | 160 | 168 | 16 | 840 |
| Automatic pellet boilers < 50 kW | GJ wood | 70 | 12 | 10 | 1.9 | 29 | 31 | 32 | 6.6 | 306 |
| Automatic chip boilers 50-300 kW w/o wood proc. companies | GJ wood | 128 | 19 | 3.0 | 1.9 | 51 | 55 | 57 | 2.6 | 424 |
| Automatic pellet boilers 50-300 kW | GJ wood | 75 | 6.8 | 3.0 | 1.9 | 28 | 30 | 31 | 0.98 | 158 |
| Automatic chip boilers 50-300 kW within wood proc. companies | GJ wood | 138 | 19 | 3.0 | 1.9 | 52 | 56 | 58 | 2.6 | 434 |
| Automatic chip boilers 300-500 kW w/o wood proc. companies | GJ wood | 128 | 19 | 3.0 | 1.9 | 51 | 55 | 57 | 2.6 | 424 |
| Automatic pellet boilers 300-500 kW | GJ wood | 75 | 6.8 | 3.0 | 1.9 | 28 | 30 | 31 | 0.98 | 158 |
| Automatic chip boilers 300-500 kW within wood proc. companies | GJ wood | 138 | 19 | 3.0 | 1.9 | 52 | 56 | 58 | 2.6 | 434 |
| Automatic chip boilers > 500 kW w/o wood proc. companies | GJ wood | 118 | 6.6 | 3.0 | 2.0 | 9.0 | 9.9 | 9.9 | 0.18 | 132 |
| Automatic pellet boilers > 500 kW | GJ wood | 72 | 2.0 | 3.0 | 2.0 | 5.1 | 5.1 | 5.1 | 0.10 | 48 |
| Automatic chip boilers > 500 kW within wood proc. companies | GJ wood | 118 | 6.8 | 3.0 | 2.0 | 19 | 20 | 21 | 0.44 | 144 |
| Combined chip heat and power plants | GJ wood | 39 | 0.28 | 1.0 | 2.0 | 0.33 | 0.33 | 0.33 | 0.0030 | 9.2 |
| Plants for renewable waste from wood products | GJ wood waste | 128 | 1.1 | 19 | 5.0 | 1.4 | 1.4 | 1.5 | 0.030 | 56 |

| 1A Combustion (Wood combustion) | Unit of activity data | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| Open fireplaces | GJ wood | 19 | 1.0 | 2.0 | 480 | 48 | 48 | 28 | 28 | 4'800 | 58 |
| Closed fireplaces | GJ wood | 19 | 1.0 | 2.0 | 480 | 48 | 48 | 28 | 28 | 4'800 | 58 |
| Log wood stoves | GJ wood | 19 | 1.0 | 2.0 | 480 | 48 | 48 | 28 | 28 | 4'800 | 58 |
| Heating stoves (living area) | GJ wood | 19 | 1.0 | 2.0 | 480 | 48 | 48 | 28 | 28 | 4'800 | 58 |
| Pellet stoves | GJ wood | 19 | 1.0 | 2.0 | 48 | 9.4 | 9.4 | 3.8 | 3.8 | 4'800 | 10 |
| Tiled stoves | GJ wood | 19 | 1.0 | 2.0 | 480 | 48 | 48 | 28 | 28 | 4'800 | 58 |
| Log wood hearths | GJ wood | 19 | 1.0 | 2.0 | 480 | 48 | 48 | 28 | 28 | 4'800 | 58 |
| Central heating hearths | GJ wood | 19 | 1.0 | 2.0 | 480 | 48 | 48 | 28 | 28 | 4'800 | 58 |
| Log wood boilers <50 kW | GJ wood | 19 | 1.0 | 2.0 | 240 | 28 | 28 | 14 | 14 | 4'800 | 18 |
| Log wood boilers >50 kW | GJ wood | 19 | 1.0 | 2.0 | 240 | 28 | 28 | 14 | 14 | 4'800 | 18 |
| Log wood dual chamber boilers | GJ wood | 20 | 1.0 | 2.0 | 500 | 100 | 100 | 60 | 60 | 5'000 | 60 |
| Automatic chip boilers < 50 kW | GJ wood | 19 | 1.0 | 2.0 | 94 | 9.4 | 9.4 | 3.8 | 3.8 | 4'800 | 18 |
| Automatic pellet boilers < 50 kW | GJ wood | 19 | 1.0 | 2.0 | 46 | 9.4 | 9.4 | 3.8 | 3.8 | 4'800 | 10 |
| Automatic chip boilers 50-300 kW w/o wood proc. companies | GJ wood | 13 | 1.0 | 2.0 | 48 | 4.6 | 4.6 | 2.4 | 2.4 | 4'600 | 10 |
| Automatic pellet boilers 50-300 kW | GJ wood | 13 | 1.0 | 2.0 | 48 | 4.6 | 4.6 | 2.4 | 2.4 | 4'600 | 10 |
| Automatic chip boilers 50-300 kW within wood proc. companies | GJ wood | 13 | 1.0 | 2.0 | 96 | 4.6 | 4.6 | 2.4 | 2.4 | 4'600 | 10 |
| Automatic chip boilers 300-500 kW w/o wood proc. companies | GJ wood | 9.0 | 1.0 | 2.0 | 48 | 0.94 | 0.94 | 0.94 | 0.94 | 4'600 | 10 |
| Automatic pellet boilers 300-500 kW | GJ wood | 9.0 | 1.0 | 2.0 | 48 | 0.94 | 0.94 | 0.94 | 0.94 | 4'600 | 10 |
| Automatic chip boilers 300-500 kW within wood proc. companies | GJ wood | 9.0 | 1.0 | 2.0 | 96 | 0.94 | 0.94 | 0.94 | 0.94 | 4'600 | 10 |
| Automatic chip boilers > 500 kW w/o wood proc. companies | GJ wood | 9.0 | 1.0 | 2.0 | 48 | 0.94 | 0.94 | 0.94 | 0.94 | 940 | 10 |
| Automatic pellet boilers > 500 kW | GJ wood | 9.0 | 1.0 | 2.0 | 48 | 0.94 | 0.94 | 0.94 | 0.94 | 940 | 10 |
| Automatic chip boilers > 500 kW within wood proc. companies | GJ wood | 9.0 | 1.0 | 2.0 | 96 | 0.94 | 0.94 | 0.94 | 0.94 | 940 | 10 |
| Combined chip heat and power plants | GJ wood | 9.0 | 1.0 | 2.0 | 10 | 0.092 | 0.092 | 0.092 | 0.092 | 940 | 10 |
| Plants for renewable waste from wood products | GJ wood waste | 100 | 2.0 | 2.0 | 46 | 0.94 | 0.94 | 0.94 | 0.94 | 940 | 10 |

Table 3-25 Emission factors 2023 of PM exhaust (filterable) and PM condensable due to wood combustion from source categories 1A1-1A4 (“w/o wood proc. companies.” stands for “without wood processing companies”).

| 1A Combustion (Wood combustion) | Unit of activity data | PM2.5 ex | PM2.5 cond | PM10 ex | PM10 cond | TSP ex | TSP cond |
|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... |
| Open fireplaces | GJ wood | 86 | 86 | 91 | 91 | 96 | 96 |
| Closed fireplaces | GJ wood | 76 | 70 | 80 | 75 | 84 | 78 |
| Log wood stoves | GJ wood | 76 | 70 | 80 | 75 | 84 | 78 |
| Heating stoves (living area) | GJ wood | 76 | 70 | 80 | 75 | 84 | 78 |
| Pellet stoves | GJ wood | 34 | 30 | 36 | 32 | 38 | 34 |
| Tiled stoves | GJ wood | 76 | 70 | 80 | 75 | 84 | 78 |
| Log wood hearths | GJ wood | 171 | 171 | 181 | 181 | 190 | 190 |
| Central heating hearths | GJ wood | 171 | 171 | 181 | 181 | 190 | 190 |
| Log wood boilers <50 kW | GJ wood | 50 | 47 | 53 | 49 | 56 | 52 |
| Log wood boilers >50 kW | GJ wood | 50 | 47 | 53 | 49 | 56 | 52 |
| Log wood dual chamber boilers | GJ wood | 180 | 162 | 190 | 171 | 200 | 180 |
| Automatic chip boilers < 50 kW | GJ wood | 79 | 72 | 84 | 76 | 88 | 80 |
| Automatic pellet boilers < 50 kW | GJ wood | 26 | 2.8 | 28 | 2.8 | 29 | 2.9 |
| Automatic chip boilers 50-300 kW w/o wood proc. companies | GJ wood | 47 | 4.4 | 49 | 5.2 | 52 | 5.2 |
| Automatic pellet boilers 50-300 kW | GJ wood | 25 | 2.8 | 27 | 2.8 | 28 | 2.8 |
| Automatic chip boilers 50-300 kW within wood proc. companies | GJ wood | 48 | 4.4 | 50 | 5.2 | 53 | 5.3 |
| Automatic chip boilers 300-500 kW w/o wood proc. companies | GJ wood | 47 | 4.4 | 49 | 5.2 | 52 | 5.2 |
| Automatic pellet boilers 300-500 kW | GJ wood | 25 | 2.8 | 27 | 2.8 | 28 | 2.8 |
| Automatic chip boilers 300-500 kW within wood proc. companies | GJ wood | 48 | 4.4 | 50 | 5.2 | 53 | 5.3 |
| Automatic chip boilers > 500 kW w/o wood proc. companies | GJ wood | 8.2 | 0.82 | 9.0 | 0.90 | 9.0 | 0.90 |
| Automatic pellet boilers > 500 kW | GJ wood | 4.6 | 0.46 | 4.6 | 0.46 | 4.6 | 0.46 |
| Automatic chip boilers > 500 kW within wood proc. companies | GJ wood | 16 | 2.6 | 17 | 2.6 | 18 | 2.6 |
| Combined chip heat and power plants | GJ wood | 0.30 | 0.030 | 0.30 | 0.030 | 0.30 | 0.030 |
| Plants for renewable waste from wood products | GJ wood waste | 1.3 | 0.13 | 1.3 | 0.13 | 1.4 | 0.14 |

Table 3-26 Ratios of PM(total particles)/PMexhaust for wood combustion installations (model values, Zotter and Nussbaumer (2022))

<table>
<tr><th rowspan="2">1A Wood combustion</th><th>1990</th><th>2008</th><th>2014</th><th>2020</th><th>2035</th></tr>
<tr><th colspan="5">PM(total particles)/PMexhaust</th></tr>
<tr><td>Open fireplaces</td><td rowspan="7">3</td><td rowspan="7" colspan="3">2</td><td>2</td></tr>
<tr><td>Closed fireplaces, log wood stoves</td><td>1.5</td></tr>
<tr><td>Pellet stoves</td><td>1.3</td></tr>
<tr><td>Log wood hearths</td><td>2</td></tr>
<tr><td>Log wood boilers</td><td>1.5</td></tr>
<tr><td>Log wood dual chamber boilers</td><td>2</td></tr>
<tr><td>Automatic chip boilers < 50 kW</td><td>1.5</td></tr>
<tr><td>Automatic pellet boilers < 50 kW</td><td rowspan="12">1.5</td><td rowspan="12" colspan="4">1.1</td></tr>
<tr><td>Automatic chip boilers 50–300 kW w/o wood proc. companies</td></tr>
<tr><td>Automatic pellet boilers 50–300 kW</td></tr>
<tr><td>Automatic chip boilers 50–300 kW within wood proc. companies</td></tr>
<tr><td>Automatic chip boilers 300–500 kW w/o wood proc. companies</td></tr>
<tr><td>Automatic pellet boilers 300–500 kW</td></tr>
<tr><td>Automatic chip boilers 300–500 kW within wood proc. companies</td></tr>
<tr><td>Automatic chip boilers > 500 kW w/o wood proc. companies</td></tr>
<tr><td>Automatic pellet boilers > 500 kW</td></tr>
<tr><td>Automatic chip boilers > 500 kW within wood proc. companies</td></tr>
<tr><td>Combined chip heat and power plants</td></tr>
<tr><td>Plants for renewable waste from wood products</td></tr>
</table>

### Activity data

Categories of wood combustion installations and their respective wood energy consumption (see Table 3-27) are based on the Swiss wood energy statistics (SFOE 2024b, table 4.1) as well as the disaggregation into the individual source categories 1A1a Public electricity and heat production, 1A2gviii Manufacturing industries: Other, 1A4ai Commercia/Institutional, 1A4bi Residential and 1A4ci Agriculture/Forestry/Fishing (SFOE 2024b, table 6.1).

In the statistics, the wood energy consumption of single-room furnaces and central heating systems (fireplaces, stoves and boilers <50 kW, categories 1-11b) is not based on sales figures (and estimated amounts of collected wood) but modelled based on the stock of appliances of the individual installation types and their average type-specific wood consumption. The number of new appliances that are annually commissioned are collected based on sales statistics of the associations of manufacturers and importers of wood furnaces and large DIY markets. The stock of appliances is calculated based on the annual number of new appliances commissioned and their respective average service life assuming that they are all decommissioned when they reach the average service life. The average service life is installation type-specific and varies between 15 years for pellets stoves and automatic boilers and 30 years for tiled stoves. The installation-specific wood consumption is derived from the average rated thermal input and the average number of operating hours, also taking into account whether the installations are operated only to a small extent or not at all since the main heating of the building is provided by another heating system (e.g. gas oil, natural gas). The wood energy consumption of automatic boilers >50 kW (categories 12-17) is based on the actual number of these boilers, which is updated annually based on information from the cantons and manufacturing companies, and their installed capacities. The fuel consumption of combined heat and power plants (category 18) and plants for renewable waste from wood products (category 19) are collected individually due to their small number and large outputs.

As additional data source, specific bottom-up information from the industry is 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 2025/1A 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 3-17):

- 1A2: The wood energy consumption of 1A2f Brick and tile production (2000-2012) was subtracted from the activity data of 1A2gviii Automatic chip boiler >500 kW without wood processing companies, while that of wood waste in 1A2f Cement production (1994-1997 and from 2009 onwards) and 1A2gviii Fibreboard is subtracted from the activity data of 1A2gviii Plants for renewable waste from wood products.
- 1A4: 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 3-27 Wood energy consumption in 1A Fuel combustion (“w/o wood proc. companies.” stands for “without wood processing companies”).

| 1A Combustion (Wood combustion) | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 28'219 | 29'649 | 27'426 | 31'413 | 40'135 |
| Open fireplaces | TJ wood | 226 | 270 | 195 | 181 | 124 |
| Closed fireplaces | TJ wood | 258 | 545 | 766 | 953 | 1'211 |
| Log wood stoves | TJ wood | 1'144 | 1'769 | 2'148 | 2'789 | 3'879 |
| Heating stoves (living area) | TJ wood | 1'830 | 1'552 | 1'012 | 584 | 254 |
| Pellet stoves | TJ wood | NO | NO | 7.0 | 48 | 151 |
| Tiled stoves | TJ wood | 4'041 | 3'300 | 2'561 | 2'710 | 3'175 |
| Log wood hearths | TJ wood | 3'877 | 2'840 | 1'611 | 1'427 | 854 |
| Central heating hearths | TJ wood | 4'643 | 4'177 | 3'126 | 2'593 | 1'494 |
| Log wood boilers <50 kW | TJ wood | 5'219 | 5'391 | 4'861 | 4'995 | 4'488 |
| Log wood boilers >50 kW | TJ wood | 88 | 173 | 244 | 362 | 421 |
| Log wood dual chamber boilers | TJ wood | 1'964 | 1'777 | 977 | 480 | 273 |
| Automatic chip boilers < 50 kW | TJ wood | 239 | 433 | 550 | 753 | 1'008 |
| Automatic pellet boilers < 50 kW | TJ wood | NO | NO | 56 | 804 | 2'106 |
| Automatic chip boilers 50-300 kW w/o wood proc. companies | TJ wood | 464 | 858 | 1'161 | 1'862 | 2'735 |
| Automatic pellet boilers 50-300 kW | TJ wood | NO | NO | 3.0 | 114 | 601 |
| Automatic chip boilers 50-300 kW within wood proc. companies | TJ wood | 895 | 1'186 | 1'216 | 1'365 | 1'533 |
| Automatic chip boilers 300-500 kW w/o wood proc. companies | TJ wood | 237 | 521 | 713 | 1'000 | 1'503 |
| Automatic pellet boilers 300-500 kW | TJ wood | NO | NO | NO | 19 | 195 |
| Automatic chip boilers 300-500 kW within wood proc. companies | TJ wood | 412 | 570 | 588 | 632 | 674 |
| Automatic chip boilers > 500 kW w/o wood proc. companies | TJ wood | 314 | 1'096 | 1'732 | 2'400 | 4'483 |
| Automatic pellet boilers > 500 kW | TJ wood | NO | NO | NO | 9.0 | 186 |
| Automatic chip boilers > 500 kW within wood proc. companies | TJ wood | 1'389 | 2'128 | 2'368 | 2'768 | 2'960 |
| Combined chip heat and power plants | TJ wood | NO | 3.0 | 186 | 127 | 2'756 |
| Plants for renewable waste from wood products | TJ wood waste | 979 | 1'060 | 1'345 | 2'439 | 3'070 |

| 1A Combustion (Wood combustion) | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 37'314 | 38'920 | 42'573 | 43'570 | 41'149 | 43'332 | 42'660 | 49'787 | 44'915 | 46'931 |
| Open fireplaces | TJ wood | 62 | 64 | 68 | 67 | 62 | 62 | 58 | 59 | 42 | 40 |
| Closed fireplaces | TJ wood | 887 | 933 | 941 | 865 | 759 | 735 | 649 | 721 | 582 | 569 |
| Log wood stoves | TJ wood | 3'094 | 3'370 | 3'572 | 3'429 | 3'131 | 3'103 | 2'829 | 3'170 | 2'594 | 2'551 |
| Heating stoves (living area) | TJ wood | 120 | 113 | 103 | 81 | 74 | 74 | 64 | 74 | 67 | 72 |
| Pellet stoves | TJ wood | 159 | 181 | 199 | 196 | 186 | 187 | 175 | 198 | 166 | 170 |
| Tiled stoves | TJ wood | 2'723 | 3'030 | 3'246 | 3'165 | 2'962 | 3'031 | 2'833 | 3'315 | 2'813 | 2'918 |
| Log wood hearths | TJ wood | 517 | 533 | 520 | 468 | 408 | 392 | 344 | 383 | 316 | 293 |
| Central heating hearths | TJ wood | 461 | 473 | 472 | 432 | 384 | 371 | 331 | 365 | 301 | 296 |
| Log wood boilers <50 kW | TJ wood | 2'499 | 2'637 | 2'695 | 2'532 | 2'300 | 2'306 | 2'060 | 2'253 | 1'823 | 1'822 |
| Log wood boilers >50 kW | TJ wood | 321 | 333 | 337 | 320 | 297 | 290 | 260 | 270 | 216 | 213 |
| Log wood dual chamber boilers | TJ wood | 125 | 119 | 112 | 88 | 67 | 57 | 42 | 38 | 27 | 21 |
| Automatic chip boilers < 50 kW | TJ wood | 739 | 786 | 798 | 742 | 667 | 644 | 559 | 582 | 455 | 450 |
| Automatic pellet boilers < 50 kW | TJ wood | 2'099 | 2'376 | 2'610 | 2'619 | 2'538 | 2'676 | 2'489 | 2'909 | 2'719 | 2'825 |
| Automatic chip boilers 50-300 kW w/o wood proc. companies | TJ wood | 2'645 | 3'032 | 3'350 | 3'372 | 3'252 | 3'375 | 3'237 | 3'836 | 3'305 | 3'456 |
| Automatic pellet boilers 50-300 kW | TJ wood | 857 | 1'091 | 1'310 | 1'451 | 1'498 | 1'644 | 1'676 | 2'136 | 1'971 | 2'127 |
| Automatic chip boilers 50-300 kW within wood proc. companies | TJ wood | 1'282 | 1'400 | 1'489 | 1'486 | 1'426 | 1'421 | 1'370 | 1'530 | 1'333 | 1'379 |
| Automatic chip boilers 300-500 kW w/o wood proc. companies | TJ wood | 1'436 | 1'644 | 1'816 | 1'820 | 1'742 | 1'818 | 1'746 | 2'039 | 1'759 | 1'853 |
| Automatic pellet boilers 300-500 kW | TJ wood | 239 | 279 | 337 | 355 | 352 | 365 | 352 | 449 | 391 | 419 |
| Automatic chip boilers 300-500 kW within wood proc. companies | TJ wood | 570 | 600 | 632 | 623 | 617 | 589 | 569 | 623 | 540 | 558 |
| Automatic chip boilers > 500 kW w/o wood proc. companies | TJ wood | 5'015 | 5'843 | 6'575 | 6'778 | 6'525 | 6'927 | 7'032 | 8'312 | 7'134 | 7'638 |
| Automatic pellet boilers > 500 kW | TJ wood | 281 | 317 | 364 | 362 | 346 | 370 | 373 | 445 | 398 | 428 |
| Automatic chip boilers > 500 kW within wood proc. companies | TJ wood | 2'407 | 2'568 | 2'653 | 2'546 | 2'397 | 2'460 | 2'387 | 2'632 | 2'293 | 2'413 |
| Combined chip heat and power plants | TJ wood | 5'325 | 3'830 | 3'970 | 4'887 | 4'696 | 5'921 | 6'319 | 6'795 | 7'294 | 7'727 |
| Plants for renewable waste from wood products | TJ wood waste | 3'450 | 3'367 | 4'404 | 4'887 | 4'463 | 4'513 | 4'906 | 6'653 | 6'375 | 6'692 |

### 3.2.1.2 Country-specific and fuel-specific default emission factors for 1A Fuel combustion

#### Methodology

For fossil standard fuels in source category 1A Fuel combustion, we use country-specific and fuel-specific default emission factors, whose values are applicable to several source categories, for $SO_2$ only. This is appropriate for $SO_2$ because in many cases, the amount of $SO_2$ emitted per amount of fuel burned directly depends on the sulphur content of the fuel. For a given fuel, the sulphur content for the whole country is considered homogenous. For other pollutants, the emission factors depend on the combustion process as well and are reported in their specific chapters.

The country-specific default emission factors for $SO_2$ are estimated as follow:

- Where available, we use sulphur content measured annually in fuels in Switzerland, usually expressed as a mass of sulphur per mass of fuel. For liquid fuels, due to yearly fluctuating average values probably caused by a low number of samples per year, we use as annual sulphur content the average value from all samples available from the given year as well as the previous and subsequent year. In case no data are available for a given year, we use a linear interpolation between existing 3-year-average data points. An overview of the available measured data is presented in Table 3-29. These data are available for diesel oil, gasoline, gas oil and residual fuel oil.

- In case no measurement is available, we assume that the legal emission limits are respected and use these legal limits as emission factors. An overview of applicable maximal emission limits as defined in the Federal Ordinance on Air Pollution Control OAPC (Swiss Confederation 1985) is given in Table 3-28. This approach is used in particular for bituminous coal and lignite.

The $SO_2$ emission factor expressed as mass per energy amount of a given fuel *i* is computed as:

$$EF_{SO_2,i} = \frac{M_{SO_2}}{M_S} * \frac{C_{S,i}}{NCV_i}$$

Where:

$EF_{SO2,i}$ is the emission factor for $SO_2$ for a given fuel *i* (g/GJ)

$M_{SO2}$ is the molar mass of $SO_2$ (g/mol)

$M_S$ is the molar mass of sulphur (g/mol)

$C_{S,i}$ is the measured sulphur content of the given fuel *i* if applicable, otherwise the maximum legal limit for sulphur content (g/t)

$NCV_i$ is the net calorific value for the given fuel *i* (GJ/t)

The obtained country-specific and fuel-specific $SO_2$ emission factors are reported in Table 3-30.

**Ongoing measurement surveys**

“Schwerpunktaktion, SPA”: The data produced by the Federal Office for Customs and Border Security (FOCBS) through its measurement project “Schwerpunktaktion Brenn und Treibstoffe” (“SPA”) are used from 2004 onwards. This project aims at estimating the sulphur content for diesel oil, gasoline, gas oil Euro and Eco and residual fuel oil.

“Tankstellensurvey, TSS”: For diesel oil and gasoline, the measurement project “Tankstellensurvey” (“TSS”), piloted by the FOEN, started in 2009 and is conducted annually. Samples are taken from a representative set of fueling stations in Switzerland and analysed for sulphur content.

**Details per fuel type**

**Gas oil, heating gas**: 2006 saw the introduction to the market of low-sulphur eco-grade gas oil with a maximum legal sulphur limit of 50 g/t. From 2009 onwards, FOCBS measurements (“SPA” campaign) include both standard Euro- and eco-grade gas oil. For eco-grade gas oil for the years before 2009, values are assumed equal to those from 2009. For each year, the sulphur content for the sum of gas oil is the measured sulphur content for each grade, weighted by the respective total annual fuel consumption. From 2014 onwards, the detailed annual fuel consumption for the two grades is available from the activity report of Carbura (latest report: Carbura 2023b). The fraction of used eco-grade is interpolated linearly between 2006 and 2013. Measurements from both the SPA (from 2004 onwards) and the TSS (from 2009 onwards) campaigns are used. Before 2004, we use data as published in SAEFL (2000).

The emission factor for heating gas (used as fuel in source category 1A2c Chemicals) is assumed equal to the one for gas oil.

**Diesel oil, Biodiesel**: Measurements from both the SPA (from 2004 onwards) and the TSS (from 2009 onwards) campaigns are used. Before 1994, data are assumed equal to the measured values for Gas oil (Euro grade). Between 1994 and 2004, data are used as published in SAEFL 2000.

The emission factor for biodiesel is assumed equal to the one for diesel oil.

**Gasoline, Bioethanol**: Measurements from both the SPA (from 2004 onwards) and the TSS (from 2009 onwards) campaigns are used. Due to the absence of data for 1990-2000 included, the sulphur content in gasoline is assumed to be 10% less than the legal maximum limit of 200 g/t, producing a value of 180 g/t. Values are linearly interpolated between 2000 and 2004.

The emission factor for bioethanol is assumed equal to the one for gasoline.

**Residual fuel oil, Gasolio**: Measurements from the SPA campaign are used from 2004 onwards. For previous years, we use data as published in SAEFL (2000).

The emission factor for gasolio (used as fuel in source category 1A2c Chemicals) is assumed equal to the one for residual fuel oil.

**Liquefied petroleum gas**: No data is available for liquefied petroleum gas. We assume that the sulphur content is near the legal limit of 190 g/t for natural gas and therefore use a value of 0.5 g/GJ.

**Natural gas:** For natural gas for 2003, 2006, 2009 and then annually from 2011 onwards, we use the measured sulphur content as published by the SGWA (latest report: SGWA 2024). We use the annual data without averaging over 3 years because fluctuations between years are likely caused by different field origins of the natural gas. We also use a linear interpolation in case of missing data. For all years before 2003, we assume that the sulphur content in natural gas is near the legal limit of 190 g/t and therefore use a value of 0.5 g/GJ.

**Gaseous fuels of biogenic origin:** For biogas, sewage gas and landfill gas, no data are available. We assume that the sulphur content is near the legal limit of 190 g/t and therefore use a value of 0.5 g/GJ.

**Other bituminous coal:** There are no measured data and we assume that the sulphur content is 20% below the legal limit. 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 g $SO_2$/GJ) shown in Table 3-28 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 g $SO_2$/GJ).

**Lignite**: There are no measured data and we assume that the sulphur content is 10% below the legal limit, which is the same as for bituminous coal.

**Jet kerosene**: There is no default, country-specific emission factor for $SO_2$ for jet kerosene. Category-specific emission factors are reported in their respective chapters.

Table 3-28 Legal limits for sulphur content per fuel type.

| Maximum legal limit of sulphur content | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fuel | Diesel oil | Gasoline | Gas oil (Euro extra-light) | Gas oil (eco extra-light) | Natural gas | Res. fuel oil Class A | Res. fuel oil Class B | Coal, thermal input < 1MW | Coal, thermal input > 1MW |
| Ref. OAPC 2022 | OAPC Annex 5 §6 | OAPC Annex 5 §5 | OAPC Annex 5 §11bis a | OAPC Annex 5 §11bis b | OAPC Annex 5 §42 | OAPC Annex 3, §421, lit.2 | OAPC Annex 5 §11bis c | OAPC Annex 3 §513 | OAPC Annex 5 §2 |
| Unit | g/t | g/t | g/t | g/t | g/t | g/t | g/t | g/t | g/t |
| 1990 | 2'000 | 200 | 2'000 | NO | 190 | 15'000 | 28'000 | 10'000 | 30'000 |
| 1991 | 2'000 | 200 | 2'000 | NO | 190 | 10'000 | 28'000 | 10'000 | 30'000 |
| 1992 | 2'000 | 200 | 2'000 | NO | 190 | 10'000 | 28'000 | 10'000 | 30'000 |
| 1993 | 2'000 | 200 | 2'000 | NO | 190 | 10'000 | 28'000 | 10'000 | 30'000 |
| 1994 | 2'000 | 200 | 2'000 | NO | 190 | 10'000 | 28'000 | 10'000 | 30'000 |
| 2000 | 350 | 150 | 2'000 | NO | 190 | 10'000 | 28'000 | 10'000 | 30'000 |
| 2005 | 50 | 50 | 2'000 | NO | 190 | 10'000 | 28'000 | 10'000 | 30'000 |
| 2008 | 50 | 50 | 2'000 | NO | 190 | 10'000 | 28'000 | 10'000 | 30'000 |
| 2009 | 10 | 10 | 1'000 | NO | 190 | 10'000 | 28'000 | 10'000 | 30'000 |
| 2018 | 10 | 10 | 1'000 | 50 | 190 | 10'000 | 28'000 | 10'000 | 30'000 |
| 2023 | 10 | 10 | 1'000 | 50 | 190 | 10'000 | 28'000 | 10'000 | 30'000 |

Table 3-29 Measured sulphur content per fuel type.

| | Measured sulphur content in fuels | | | | |
|---|---|---|---|---|---|
| Fuel | Diesel oil | Gasoline | Gas oil (Euro) | Gas oil (Eco) | Res. fuel oil Class A |
| Unit | g/t | g/t | g/t | g/t | g/t |
| 1990 | NE | NE | 1'600 | NO | 9'747 |
| 1991 | NE | NE | 1'300 | NO | 8'900 |
| 1992 | NE | NE | 1'200 | NO | 8'600 |
| 1993 | NE | NE | 1'000 | NO | 8'700 |
| 1994 | 434 | NE | 1'350 | NO | 7'710 |
| 1995 | 341 | NE | 1'170 | NO | 7'770 |
| 1996 | 372 | NE | 1'160 | NO | 7'770 |
| 1997 | 353 | NE | 1'250 | NO | 7'000 |
| 1998 | 402 | NE | 926 | NO | 8'300 |
| 1999 | 443 | NE | 650 | NO | 6'200 |
| 2000 | 272 | NE | 680 | NO | 6'600 |
| 2001 | 250 | NE | 830 | NO | 8'200 |
| 2002 | 235 | NE | 798 | NO | 8'200 |
| 2003 | 200 | NE | NE | NO | 7'900 |
| 2004 | 5.2 | 3.8 | 730 | NO | 7'600 |
| 2005 | 6.4 | 5.6 | 808 | NO | 7'800 |
| 2006 | NE | NE | NE | NE | NE |
| 2007 | NE | NE | NE | NE | NE |
| 2008 | NE | NE | NE | NE | NE |
| 2009 | 7.6 | 5.3 | 641 | 25 | 9'217 |
| 2010 | 6.7 | 4.3 | 631 | 34 | 8'825 |
| 2011 | 6.6 | 4.7 | 531 | 21 | 8'967 |
| 2012 | 6.5 | 4.8 | 672 | 26 | 9'100 |
| 2013 | 7.1 | 4.5 | 308 | 25 | 8'967 |
| 2014 | 6.8 | 4.4 | 502 | 27 | 7'800 |
| 2015 | 7.7 | 4.2 | 516 | 14 | 8'233 |
| 2016 | 7.0 | 4.2 | 246 | 10 | 8'450 |
| 2017 | 7.7 | 5.0 | 248 | 19 | 9'833 |
| 2018 | 7.5 | 5.2 | 486 | 5 | 9'133 |
| 2019 | NE | NE | NE | NE | NE |
| 2020 | 6.2 | NE | 319 | 18 | 5'533 |
| 2021 | 7.1 | NE | 337 | 19 | 5'600 |
| 2022 | 6.6 | 4.8 | 551 | 17 | 6'567 |
| 2023 | 6.4 | 3.7 | NE | 14 | 5'500 |

Table 3-30 Country-specific and fuel-specific default emissions factors for $SO_x$ used within source category 1A Fuel combustion activities, 1990-2023.

| SOx emission factors | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| Fuel combustion | Gasoline | g/GJ | 8.46 | 8.46 | 6.80 | 0.233 | 0.219 |
| Fuel combustion | Diesel oil | g/GJ | 69.1 | 17.8 | 15.0 | 0.280 | 0.319 |
| Fuel combustion | Gas oil | g/GJ | 72.4 | 57.5 | 33.7 | 34.6 | 23.0 |
| Fuel combustion | Residual fuel oil | g/GJ | 466 | 376 | 339 | 381 | 438 |
| Fuel combustion | Liquefied petroleum gas | g/GJ | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 |
| Fuel combustion: Boilers manufacturing industry | Other bituminous coal | g/GJ | 500 | 500 | 500 | 500 | 500 |
| Fuel combustion: Boilers residential | Other bituminous coal | g/GJ | 350 | 350 | 350 | 350 | 350 |
| Fuel combustion | Lignite | g/GJ | 500 | 500 | 500 | 500 | 500 |
| Fuel combustion | Natural gas | g/GJ | 0.500 | 0.500 | 0.500 | 0.451 | 0.425 |
| Fuel combustion | Biodiesel biogenic | g/GJ | 69.1 | 17.8 | 15.0 | 0.280 | 0.319 |
| Fuel combustion | Bioethanol | g/GJ | 8.46 | 8.46 | 6.80 | 0.233 | 0.219 |
| Fuel combustion | Biogas | g/GJ | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 |
| Fuel combustion | Sewage gas | g/GJ | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 |

| SOx emission factors | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fuel combustion | Gasoline | g/GJ | 0.205 | 0.200 | 0.209 | 0.218 | 0.236 | 0.240 | 0.217 | 0.222 | 0.190 | 0.194 |
| Fuel combustion | Diesel oil | g/GJ | 0.335 | 0.333 | 0.347 | 0.342 | 0.333 | 0.325 | 0.316 | 0.307 | 0.309 | 0.305 |
| Fuel combustion | Gas oil | g/GJ | 14.2 | 13.8 | 10.6 | 8.85 | 8.38 | 7.84 | 6.79 | 4.88 | 1.94 | 0.841 |
| Fuel combustion | Residual fuel oil | g/GJ | 416 | 396 | 448 | 453 | 460 | 356 | 269 | 290 | 290 | 283 |
| Fuel combustion | Liquefied petroleum gas | g/GJ | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 |
| Fuel combustion: Boilers manufacturing industry | Other bituminous coal | g/GJ | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 |
| Fuel combustion: Boilers residential | Other bituminous coal | g/GJ | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 |
| Fuel combustion | Lignite | g/GJ | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 |
| Fuel combustion | Natural gas | g/GJ | 0.440 | 0.434 | 0.432 | 0.377 | 0.379 | 0.129 | 0.155 | 0.0393 | 0.175 | 0.231 |
| Fuel combustion | Biodiesel biogenic | g/GJ | 0.335 | 0.333 | 0.347 | 0.342 | 0.333 | 0.325 | 0.316 | 0.307 | 0.309 | 0.305 |
| Fuel combustion | Bioethanol | g/GJ | 0.205 | 0.200 | 0.209 | 0.218 | 0.236 | 0.240 | 0.217 | 0.222 | 0.190 | 0.194 |
| Fuel combustion | Biogas | g/GJ | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 |
| Fuel combustion | Sewage gas | g/GJ | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 |

## 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 3-31 Specification of source category 1A1 Energy industries.

| 1A1 | Source category | Specification |
|---|---|---|
| 1A1a | Public electricity and heat production | Main sources are waste incineration plants with heat and power generation (Other fossil and biogenic fuels) and public district heating systems including boilers, and boilers with combined heat and power generation not further defined, as well as engines and gas turbines with fossil fuels and biogas, and engines on landfill sites or emergency generators.<br>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.<br>Use of refinery gas in gas turbines with SCGT at refineries. |
| 1A1c | Manufacture of solid fuels and other energy industries | Emissions from charcoal production |

Table 3-32 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 1A1, Energy Industries.

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 1A1a | Public electricity and heat production | NOx | L1, L2 |
| 1A1a | Public electricity and heat production | SOx | L1, L2 |
| 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 Energy industries, 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 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 1A1a Public electricity and heat production are estimated using a Tier 2 method, see decision tree in chapter 1A1 Energy industries in EMEP/EEA guidebook (EMEP/EEA 2023).

### 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 municipal solid waste incinerated. They are all country-specific and based on extensive and repeated emission control measurements according to the Ordinance on Air Pollution Control on municipal solid waste incineration and special waste incineration plants (TBF 2005, TBF 2015, TBF 2021) as well as on expert estimates. The sources are documented in the EMIS database (EMIS 2025/1A1a Kehrichtverbrennungsanlagen and EMIS 2025/1A1a Sonderabfallverbrennungs-anlagen). 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. The PCB emission factors from municipal solid waste and special waste incineration are based on the mass flow and emission model of former use and disposal of PCBs in Switzerland (Glüge et al. 2017), see Annex A2.2.

Until 2003 the same emission factors have been applied for special waste and municipal solid waste incineration plants (TBF 2005). The emission factors have been reevaluated and revised for the two types of installations separately for the years 2013 and 2018 (TBF 2015, TBF 2021). In general, emission factors for sewage sludge incineration plants are considerably higher compared to those for municipal solid waste incineration plants. Regardless, special waste incineration plants meet equal Ordinance on Air Pollution Control emission limit values as municipal solid waste incineration plants.

Table 3-33 Implied emission factors for 1A1a Public electricity and heat production of energy industries for Other fuels (municipal solid waste and special waste) in 2023.

| 1A1a Public electricity and heat production | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex |
|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Waste | t | 376 | 28 | 52 | 4.6 | 8.2 | 8.2 | 8.2 | 0.074 |
| Hazardous waste | t | 745 | 150 | 24 | 16 | 33 | 33 | 33 | 0.30 |
| PCB | g | NA | NA | NA | NA | NA | NA | NA | NA |

| 1A1a Public electricity and heat production | Unit | CO | Pb | Cd | Hg | PCDD/ PCDF | HCB | PCB |
|---|---|---|---|---|---|---|---|---|
| | | g/... | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... |
| Waste | t | 72 | 300 | 30 | 69 | 200 | 0.045 | NA |
| Hazardous waste | t | 229 | 1'383 | 124 | 42 | 250 | NA | NA |
| PCB | g | NA | NA | NA | NA | NA | NA | 0.0058 |

*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 2025/1A Holzfeuerungen) as described in chapter 3.2.1.1.3.

*Fossil fuels for heat production and for power generation with boilers not further defined:*

Emission factors for $NO_x$, CO, NMVOC 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) and Zotter and Nussbaumer (2025). The particulate matter emission factors for natural gas and gas oil from 2020 onwards are also based on Zotter and Nussbaumer (2025).

The emission factors for $SO_x$ are based on the estimated sulphur content for each combustible, see detailed description in chp. 3.2.1.2.

Emission factors for Hg, Pb, Cd, PCDD/PCDF and PAH are taken from the EMEP/EEA guidebook (EMEP/EEA 2019) as follows:

- Gas oil; PAH: chp. 1A4, Tier 1, Table 3.9 liquid fuels
- Gas oil; Pb, Hg, Cd, PCDD/PCDF: chp. 1A4, Table 3.18
- Natural gas; Pb, Hg, Cd, PAH: chp. 1A4, Tier 2, Table 3.13
- Natural gas; PCDD/PCDF: chp. 1A4, Tier 2 Table 3.26

The emission factors of HCB and PCBs are taken from the Danish emission inventory for HCB and PCBs (Nielsen et al. 2013).

*Engines and gas turbines*

The use of fossil and biogenic fuels in engines and gas turbines is described in the specific model description chp. 3.2.1.1.2. For the greenhouse gas inventory under the UNFCCC reporting the fossil carbon fraction in biodiesel is estimated based on the method described in chp. 3.2.1.1.2. For technical reasons in our database, there is a split of the whole biodiesel amount in fossil and biogenic biodiesel and not only for the carbon fraction and $CO_2$. Therefore, there are two lines with biodiesel, one with “biodiesel fossil” and one with “biodiesel biogenic”.

Table 3-34 Implied emission factors for 1A1a Public electricity and heat production of energy industries for fossil fuels, biogenic fuels and wood in 2023.

| 1A1a Public electricity and heat production | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Gas oil | GJ | 38 | 4.3 | 0.84 | 0.40 | 1.8 | 1.8 | 1.8 | 0.13 | 10 |
| Residual fuel oil | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Other bituminous coal | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Natural gas | GJ | 27 | 6.6 | 0.23 | 0.14 | 0.26 | 0.26 | 0.26 | 0.0023 | 14 |
| Biodiesel fossil | GJ | 404 | 50 | 0.30 | 3.5 | 30 | 30 | 30 | 2.3 | 131 |
| Biodiesel biogenic | GJ | 404 | 50 | 0.30 | 3.5 | 30 | 30 | 30 | 2.3 | 131 |
| Biogas | GJ | 54 | 12 | 0.50 | 0.31 | 0.40 | 0.40 | 0.40 | 0.00091 | 23 |
| Wood and wood waste | GJ | 67 | 0.53 | 6.7 | 2.9 | 0.62 | 0.62 | 0.65 | 0.012 | 24 |

| 1A1a Public electricity and heat production | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| Gas oil | GJ | 0.019 | 0.0014 | 0.12 | 1.8 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 216 | 0.11 |
| Residual fuel oil | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Other bituminous coal | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Natural gas | GJ | 0.0036 | 0.00040 | 0.10 | 0.50 | 0.00060 | 0.0013 | 0.00089 | 0.00089 | NA | NA |
| Biodiesel fossil | GJ | 0.15 | 0.0099 | 0.11 | 1.00 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 218 | 0.11 |
| Biodiesel biogenic | GJ | 0.15 | 0.0099 | 0.11 | 1.00 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 218 | 0.11 |
| Biogas | GJ | 0.0060 | 0.00057 | 0.10 | 0.51 | 0.00063 | 0.0018 | 0.00094 | 0.00095 | NA | NA |
| Wood and wood waste | GJ | 38 | 1.3 | 2.0 | 21 | 0.36 | 0.36 | 0.36 | 0.36 | 940 | 10 |

## Activity data (1A1a)

*Municipal solid waste incineration*

Activity data for municipal solid waste and special waste incineration are based on annual waste statistics (FOEN 2024h) and provided in the table below.

Table 3-35 Activity data for 1A1a Other fuels: municipal solid waste and special waste incineration plants (with heat and/or power generation).

| 1A1a Public electricity and heat production | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Waste | kt | 2'470 | 2'270 | 2'801 | 3'297 | 3'717 |
| Hazardous waste | kt | 133 | 163 | 239 | 230 | 252 |
| PCB | t | 60 | 44 | 73 | 49 | 31 |

| 1A1a Public electricity and heat production | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Waste | kt | 3'817 | 3'889 | 4'010 | 4'011 | 4'042 | 4'059 | 4'072 | 4'027 | 3'853 | 3'921 |
| Hazardous waste | kt | 249 | 261 | 254 | 236 | 255 | 262 | 241 | 218 | 261 | 209 |
| PCB | t | 22 | 20 | 18 | 17 | 16 | 14 | 13 | 12 | 11 | 10 |

*Engines and gas turbines*

The use of fossil and biogenic fuels in engines and gas turbines is described in the specific model description chp. 3.2.1.1.2.

*Other public electricity and heat production*

Apart from fossil or biogenic municipal solid waste, hazardous waste, wood waste and wood, fuel consumption (TJ) for Public electricity and heat production (1A1a) as activity data are extracted from the Swiss overall energy statistics (SFOE 2024; Tables 21, 26, and 28).

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 2024b) as described in chapter 3.2.1.1.3 Model for wood energy combustion.

Table 3-36 Fuel consumption of 1A1a Public electricity and heat production.

| 1A1a Public electricity and heat production | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 40'379 | 39'179 | 49'913 | 56'978 | 61'751 |
| Gas oil | TJ | 980 | 554 | 790 | 1'300 | 490 |
| Residual fuel oil | TJ | 3'214 | 1'813 | 340 | 290 | 40 |
| Other bituminous coal | TJ | 530 | 46 | NO | NO | NO |
| Natural gas | TJ | 4'339 | 5'422 | 8'292 | 9'827 | 9'926 |
| Waste fossil | TJ | 13'995 | 13'662 | 17'784 | 20'181 | 21'044 |
| Hazardous waste fossil | TJ | 2'610 | 3'206 | 4'692 | 4'514 | 4'941 |
| Biodiesel fossil | TJ | NO | NO | NO | 0.11 | 0.47 |
| Biodiesel biogenic | TJ | NO | NO | NO | 2.1 | 10 |
| Biogas | TJ | 247 | 614 | 573 | 207 | 49 |
| Waste biogenic | TJ | 14'163 | 13'396 | 16'894 | 19'813 | 22'292 |
| Wood and wood waste | TJ | 301 | 466 | 547 | 844 | 2'958 |

| 1A1a Public electricity and heat production | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 59'325 | 61'386 | 65'017 | 64'752 | 65'311 | 66'482 | 65'552 | 66'108 | 63'324 | 63'158 |
| Gas oil | TJ | 770 | 660 | 430 | 490 | 380 | 450 | 340 | 420 | 420 | 390 |
| Residual fuel oil | 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 |
| Natural gas | TJ | 5'032 | 7'050 | 8'926 | 7'907 | 8'111 | 8'444 | 7'501 | 8'551 | 6'568 | 5'861 |
| Waste fossil | TJ | 21'382 | 22'054 | 23'146 | 23'377 | 23'697 | 23'974 | 24'154 | 23'802 | 22'972 | 23'070 |
| Hazardous waste fossil | TJ | 4'886 | 5'115 | 4'979 | 4'641 | 5'013 | 5'148 | 4'722 | 4'276 | 5'127 | 4'101 |
| Biodiesel fossil | TJ | 0.47 | 0.43 | 0.35 | 0.35 | 0.28 | 0.28 | 0.30 | 0.32 | 0.34 | 0.33 |
| Biodiesel biogenic | TJ | 8.6 | 7.7 | 7.4 | 7.7 | 6.4 | 6.2 | 6.0 | 6.0 | 6.1 | 6.0 |
| Biogas | TJ | 31 | 21 | 13 | 6.5 | 6.0 | 8.4 | 14 | 125 | 138 | 147 |
| Waste biogenic | TJ | 22'893 | 23'379 | 24'296 | 24'298 | 24'387 | 24'430 | 24'372 | 23'781 | 22'725 | 22'823 |
| Wood and wood waste | TJ | 4'321 | 3'098 | 3'218 | 4'024 | 3'710 | 4'022 | 4'443 | 5'147 | 5'366 | 6'759 |

#### *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 (EMEP/EEA 2023), 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. Most of the emission factors were derived from SAEFL (2000) or adopted from EMEP/EEA guidebook 2019.

The fraction of BC from PM 2.5 while burning natural gas in boilers of the refineries was set to 8.6 % according to the EMEP/EEA guidebook (EMEP/EEA 2019, chp. 1.A.1, table 4-6).

Emission factors for gas turbines with SCGT are described in chp. 3.2.1.1.2.

### Activity data (1A1b)

Activity data on fuel combustion for 1A1b Petroleum refining is provided by the Swiss overall energy statistics (SFOE 2024) 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 2024). As one of the refineries ceased operation in 2015, the data are considered confidential since 2014. Data are available to reviewers on request. The use of refinery gas in gas turbines with SCGT is described in chp. 3.2.1.1.2.

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 because 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). Between 2004 and 2015, one of the Swiss refineries is also using petroleum coke as a fuel. Natural gas is used additionally to residual fuel oil and refinery gas since 2017. In 2019, 2020, 2022 and 2023, the application of residual fuel oil was halted.

Net calorific values are provided by the annual monitoring reports of the refining industries for the years 2005-2011 and 2013-2023 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 2024).

Table 3-37 Activity data of 1A1b Petroleum Refining.

| 1A1b Petroleum refining | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 5'629 | 9'836 | 9'636 | 14'548 | 14'176 |
| Petroleum coke | TJ | NO | NO | NO | 1'813 | 2'003 |
| Refinery residual fuel oil | TJ | 1'259 | 1'786 | 1'908 | 902 | 891 |
| Refinery gas | TJ | 4'370 | 8'050 | 7'728 | 11'833 | 11'282 |
| Natural gas | TJ | NO | NO | NO | NO | NO |

| 1A1b Petroleum refining | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 14'173 | 7'232 | 6'355 | 6'298 | 6'627 | 5'911 | 5'987 | 5'160 | 6'575 | 6'198 |
| Petroleum coke | TJ | 1'908 | C | NO | NO | NO | NO | NO | NO | NO | NO |
| Refinery residual fuel oil | TJ | 1'330 | C | C | C | C | NO | NO | C | NO | NO |
| Refinery gas | TJ | 10'935 | C | C | C | C | C | C | C | C | C |
| Natural gas | TJ | NO | NO | NO | C | C | C | C | C | C | C |

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

### Methodology (1A1c)

Based on the decision tree Figure 5.1 in chapter 1A1c Manufacture of solid fuels and other energy industries of the EMEP/EEA guidebook (EMEP/EEA 2023), 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 (IPCC 1996) and for PM10 exhaust and TSP exhaust based on USEPA (1995, Chapter 10.7 Charcoal). PM2.5 exhaust is supposed to be 95 % from PM10 exhaust (EMIS 2025/1A1c). Since there is no information available on BC emissions from source category 1A1c Charcoal production (artisanal) its BC factor (%PM2.5) is set to the default Tier 2 value (48 %) of coke manufacture provided in the EMEP/EEA guidebook (EMEP/EEA 2023, chp. 1A1c Manufacture of solid fuels and other energy industries, Tab. 5-2/5-3). Neither the 1996 IPCC Guidelines nor the EMEP/EEA guidebook provide a $SO_x$ emission factor for charcoal production. The latter one contains data on coke manufacture only which we did not consider as applicable for artisanal charcoal production as the sulphur content of coal is more than one order of magnitude higher than that of wood.

Table 3-38 Emission factors of 1A1c charcoal production in 2023.

| 1A1c Manufacture of solid fuels and other energy industries | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Charcoal | GJ | 10 | 1'700 | NE | NE | 3'700 | 3'900 | 4'800 | 1'776 | 7'000 |

| 1A1c Manufacture of solid fuels and other energy industries | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| Charcoal | GJ | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |

### 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 2025/1A1c).

Table 3-39 Activity data of 1A1c charcoal production.

| 1A1c Manufacture of solid fuels and other energy industries | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Charcoal | TJ | 1.3 | 1.4 | 2.2 | 3.4 | 3.6 |

| 1A1c Manufacture of solid fuels and other energy industries | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Charcoal | TJ | 4.3 | 3.8 | 4.1 | 3.9 | 4.3 | 5.1 | 3.9 | 4.0 | 3.4 | 3.6 |

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

The following recalculations were implemented in submission 2025:

- 1A1, year 2022: Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_2$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated.
- 1A1a: The emission factors of $NO_x$ and CO for natural gas and gas oil boilers were updated for 2022 based on the evaluation of a large number of air pollution control measurements of combustion installations in numerous Swiss cantons. This has resulted in revised emission factors of $NO_x$ and CO for the boilers fuelled with gas oil and natural gas in source categories 1A1a Public electricity and heat production from 2011 onwards. In addition, the values of the $NO_x$ and CO emission factors for the years 1990–2010 and 2001–2010 (gas oil, CO) were also adjusted. The projected emission factor values for all

particulate matter fractions (2035, PM2.5, PM10, TSP and BC) were also updated, resulting in changes to the linearly interpolated emission factors for 2021 and 2022.

- 1A1a: The fossil carbon fraction in biodiesel is now estimated based on the method described in Sebos (2022). The fossil fraction of FAME (Fatty Acid Methyl Ester) is based on the values from HBEFA 4.1 (relevant for the whole EU), while all carbon in HVO (Hydrotreated Vegetable Oil) is considered of biogenic origin. Because biodiesel as reported by Switzerland consists of the sum of FAME and HVO, the fossil fraction of biodiesel varies over time. Overall, around 4.0 to 5.4 % of the total biodiesel are now reported under “fossil liquid fuels” for the years 1996–2022 (no biodiesel in the years before). In consequence, this leads to recalculations in fuel categories including biodiesel as “biomass” or “biofuels” and “liquid fuels” as well.
- 1A1a: Due to new model-runs, there are small recalculations of activity data for all stationary engines and gas turbines 1990-2022.
- 1A1b: The emission factors of $NO_x$ and CO for natural gas and gas oil boilers were updated for 2022 based on the evaluation of a large number of air pollution control measurements of combustion installations in numerous Swiss cantons. This has resulted in revised CO emission factors for the boilers fuelled with refinery liquefied petroleum gas and natural gas in source categories 1A1b Petroleum refining from 2011 onwards. The emission factor values for all particulate matter fractions (2035, PM2.5, PM10, TSP and BC) natural gas boilers were also updated, resulting in changes of the emission factor values in the years 1990–1994, 2001–2004 and 2021–2022.

## 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 derived 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 3-40 Specification of source category 1A2 Stationary combustion in manufacturing industries and construction (stationary without 1A2gvii) in Switzerland.

| 1A2 | Source category | 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 by-products, boilers) |
| 1A2d | Pulp, paper and print | Fuel combustion in pulp, paper and print industry (furnaces of cellulose production (ceased in 2008), boilers and gas turbines) |
| 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, use of fossil fuel and biomass (wood and biogas) in industrial boilers, engines and gas turbines |

Table 3-41 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 1A2 Combustion in manufacturing industries and construction (stationary only).

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 1A2d | Stationary combustion in manufacturing industries and construction: pulp paper and print | SOx | 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 | SOx | L1, L2, T1, T2 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | PM10 | T1 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | NOx | L1, T1, T2 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | SOx | L1, L2 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | PM2.5 | L1, L2 |

### 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 the EMEP/EEA guidebook (EMEP/EEA 2023), the emissions are calculated according to a Tier 2 approach based on country-specific emission factors.

**Overview industry model**

As a sub-model of the Swiss energy model (see chp. 3.1.6.2.2), the industry model disaggregates for each fuel type, the total fuel consumption in the industry sector provided by the Swiss overall energy statistics (SFOE 2024, see also description in chp. 3.1.6.2) into the source categories and processes under 1A2 Manufacturing industries and construction. As visualized in Figure 3-22, the industry model is based on two pillars. First, the energy consumption statistics in the industry and services sectors (SFOE 2024d) provide a comprehensive annual survey of fuel consumptions for all years since 1999 or 2002 (depending on the fuel type, see paragraph “Energy consumption statistics in the industry and services sectors” below). These statistics are consistently extended back to 1990 based on a bottom-up industry model (Prognos 2013, see paragraph “Modelling of industry categories” below). Second, further disaggregation is achieved by using plant-level industry data for specific processes, as far as available (see paragraph “Bottom-up industry data” below).

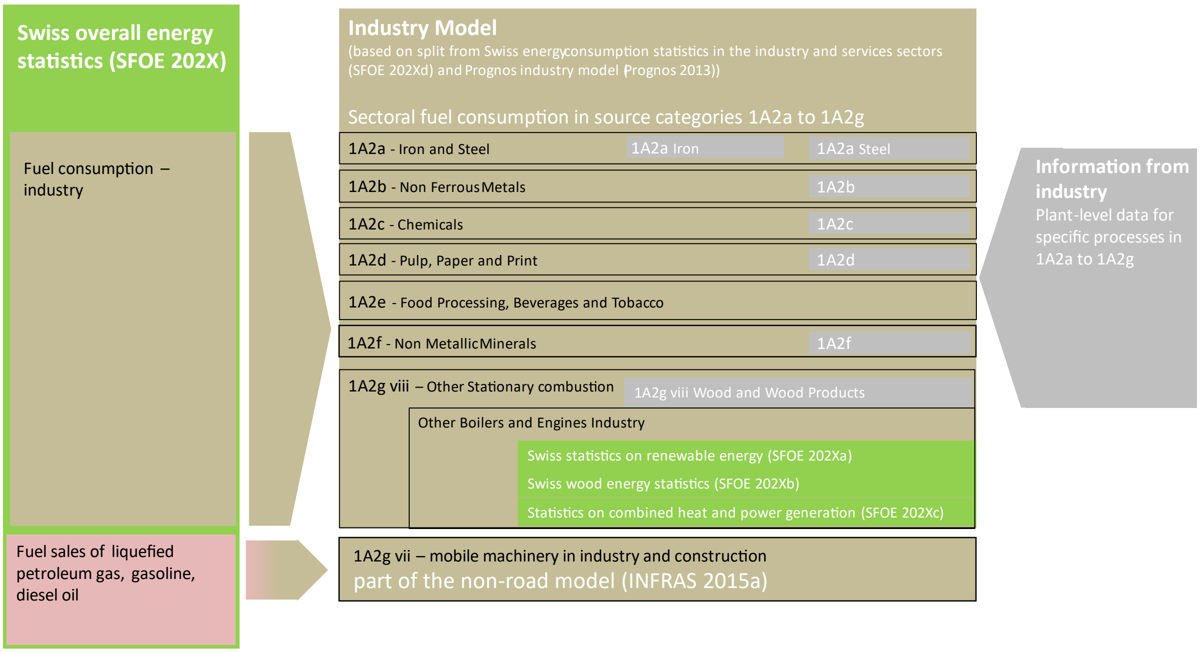



Figure 3-22 Schematic presentation of the data sources used for the industrial sectors 1A2a – 1A2g. The references SFOE 202X, SFOE 202Xa, 202Xb and 202Xc refer to the 2024 edition of the corresponding energy statistics. For each fuel type, the Swiss overall energy statistics provide the total fuel consumption in the industry sector (SFOE 2024). The total fuel consumption is then distributed to the different source categories based on the energy consumption statistics in the industry and services sectors (SFOE 2024d) for all years since 1999 or 2002 (depending on the fuel type), consistently extended back to 1990 based on a bottom-up industry model (Prognos 2013). The grey boxes on the right show the further disaggregation achieved by using plant-level industry data for specific processes.

*Energy consumption statistics in the industry and services sectors*

The energy consumption statistics in the industry and services sectors (SFOE 2024d) refer to representative annual surveys with about 13'000 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 since 1999 for gas oil and natural gas. For all other standard fossil fuels (i.e. residual fuel oil, liquefied petroleum gas, petroleum coke, other bituminous coal and lignite) data are available since 2002.

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 showed 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*

As mentioned above, the energy consumption statistics in the industry and services sectors (SFOE 2024d) are available since 1999 or 2002. In order to get consistent time series starting in 1990, a bottom-up industry model (Prognos 2013) is used. 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 (i.e. surveys and model) 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 2019 Refinement to the 2006 IPCC Guidelines (IPCC 2019, Volume 1, chp. 5.3.3.1, overlap). To illustrate the approach, an example for gas oil attributed to source category 1A2c is provided in Figure 3-23. 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 2025/1A2_Sektorgliederung Industrie).

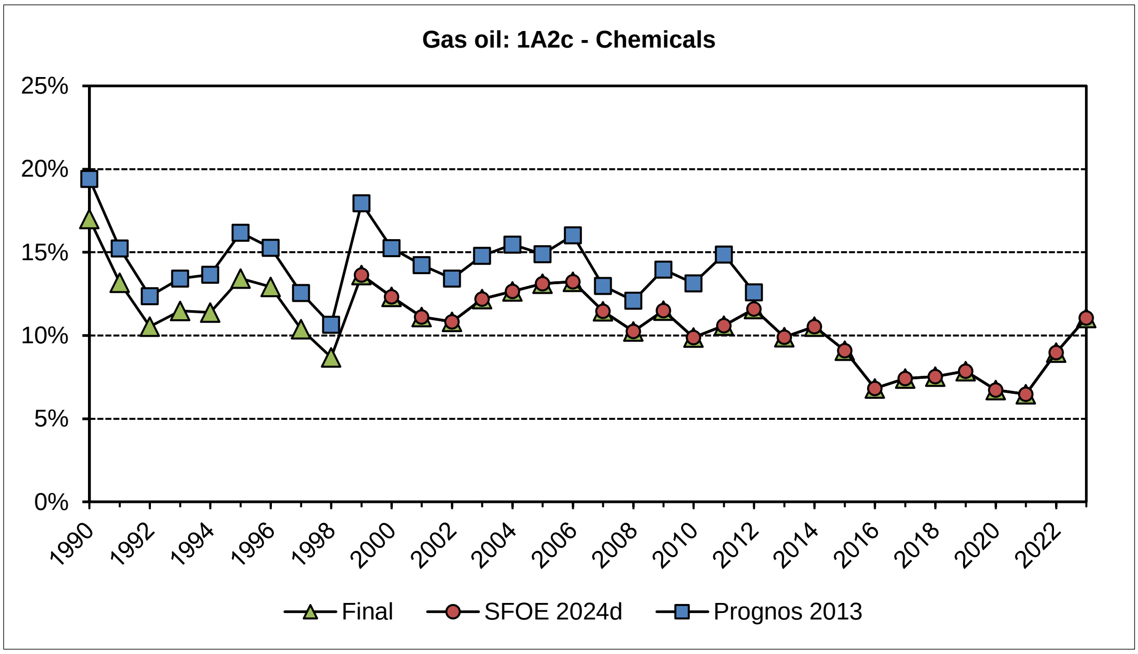



Figure 3-23 Illustrative example for combining time series with consistent overlap according to the 2019 Refinement (IPCC 2019, Volume 1, chp. 5.3.3.1, overlap). The y-axis indicates the share of source category 1A2c in total gas oil consumption in the industry sector. The green triangles correspond to the share finally used to calculate the fuel consumption in 1A2c, based on the combination of the shares from the energy consumption statistics in the industry and services sectors (SFOE 2024d, orange dots, since 1999) and the bottom-up industry model (Prognos 2013, blue squares, from 1990 to 2012). Similar calculations are performed for each source category and fuel type.

*Bottom-up industry data*

Grey colored boxes in Figure 3-22 represent source categories (i.e. 1A2a-d, 1A2f and 1A2gviii) for which bottom-up data from the industry are used in order to further 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 to 3.2.3.2.8.

The bottom-up information provides activity data for specific industrial production processes and forms 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 assigned based on the energy consumption statistics in the industry and services sectors (SFOE 2024d) and the bottom-up industry model (Prognos 2013).

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*

The share of fuel used for co-generation in turbines and engines within 1A2 is derived from a model of stationary engines and gas turbines developed by INFRAS (2022a) as described in chapter 3.2.1.1.2.

Fuel consumption of wood, wood waste and biogas in manufacturing industries is based on the Swiss wood energy statistics (SFOE 2024b) as well as on data from the Swiss renewable energy statistics (SFOE 2024a) and the Statistics on combined heat and power generation in Switzerland (SFOE 2024c), 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. Emission factors for engines and gas turbines are described in chapter 3.2.1.1.2.

For liquefied petroleum gas and petroleum coke, the same emission factors are assumed for all air pollutants as for natural gas and residual fuel oil, respectively, except for $SO_x$ of liquefied petroleum gas (see chp. 3.2.1.2).

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) and 2022 (Zotter and Nussbaumer 2025). 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 and $NH_3$ as well as PM2.5, PM10 and TSP (until 2020) are country-specific and documented in the Handbook on emission factors for stationary sources (SAEFL 2000). The particulate matter emission factors for natural gas and gas oil from 2020 onwards are also based on Zotter and Nussbaumer (2025).

The $SO_x$ emission factors for gas oil, residual fuel oil, liquefied petroleum gas, other bituminous coal, lignite and natural gas are described in chp. 3.2.1.2 and Table 3-30.

Emission factors of BC (% PM2.5), Pb (except natural gas), Cd (except natural gas), Hg, PCDD/PCDF (except natural gas) and PAH (except natural gas) are taken from the EMEP/EEA guidebook (EMEP/EEA 2023). For natural gas, emission factors of Pb, Cd, PCDD/PCDF and PAH are still based on EMEP/EEA (2019). The emission factors of HCB and PCBs are taken from the Danish emission inventory for HCB and PCBs (Nielsen et al. 2013). There is a difficulty with industrial gas oil burners, as there is a lack of data for non-residential medium-sized boiler in the EMEP/EEA guidebook. Therefore, the emission factors available for the different combustion installations burning gas oil were compared and then the most reasonable and most current data were chosen. The emission factors of BC (% PM2.5), Pb, Cd, Hg and PCDD/PCDF are taken from table 3-18 (EMEP/EEA 2023, Tier 2 Residential plants, boilers burning liquid fuels, chp. 1A4). While the emission factors of PAHs are taken from table 3-9 (EMEP/EEA 2023, Tier 1 emission factors for NFR source category 1.A.4.a/c, 1.A.5.a, using liquid fuels) as they represent an average of Tier 2 emission factors for liquid fuel combustion for all technologies.

Table 3-42 Emission factors for fossil fuel boilers of 1A2 Stationary combustion in manufacturing industries and construction in 2023.

| 1A2 Manufacturing industries and construction (Boilers) | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Gas oil | GJ | 28 | 2.0 | 0.84 | 0.0020 | 0.19 | 0.19 | 0.19 | 0.0074 | 3.7 |
| Residual fuel oil | GJ | 125 | 4.0 | 283 | 0.0020 | 20 | 20 | 23 | 2.0 | 10 |
| Liquefied petroleum gas | GJ | 17 | 2.0 | 0.50 | 0.00100 | 0.090 | 0.090 | 0.090 | 0.0049 | 8.1 |
| Petroleum coke | GJ | 125 | 4.0 | 283 | 0.0020 | 20 | 20 | 23 | 2.0 | 10 |
| Other bituminous coal | GJ | 200 | 10 | 500 | 0.0030 | 45 | 45 | 50 | 2.9 | 100 |
| Lignite | GJ | 200 | 10 | 500 | 0.0030 | 45 | 45 | 50 | 2.9 | 100 |
| Natural gas | GJ | 17 | 2.0 | 0.23 | 0.00100 | 0.090 | 0.090 | 0.090 | 0.0049 | 8.1 |

| 1A2 Manufacturing industries and construction (Boilers) | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| Gas oil | GJ | 0.012 | 0.0010 | 0.12 | 1.8 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| Residual fuel oil | GJ | 4.6 | 1.2 | 0.34 | 2.5 | 0.0045 | 0.0045 | 0.0045 | 0.0069 | 220 | 3.2 |
| Liquefied petroleum gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| Petroleum coke | GJ | 4.6 | 1.2 | 0.34 | 2.5 | 0.0045 | 0.0045 | 0.0045 | 0.0069 | 220 | 3.2 |
| Other bituminous coal | GJ | 167 | 1.0 | 16 | 40 | 0.079 | 1.2 | 0.85 | 0.62 | 620 | 53 |
| Lignite | GJ | 167 | 1.0 | 16 | 40 | 0.079 | 1.2 | 0.85 | 0.62 | 620 | 53 |
| Natural gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |

### Activity data (1A2)

Table 3-43 shows the total fuel consumption in 1A2. Table 3-44 to Table 3-49 show 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 fossil fuels occurs mainly in source category 1A2f, where it refers to fossil waste fuels in cement production. But also, the cracker by-products, i.e. gasolio, heating gas and synthesis gas (from 2018 onwards) used for steam production in a chemical plant in source category 1A2c are included. 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 3-43 Total fuel consumption of 1A2 Stationary combustion in manufacturing industries and construction.

| **1A2 Manufacturing industries and constr. (stationary sources)** | **Unit** | **1990** | **1995** | **2000** | **2005** | **2010** |
|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 88'850 | 89'257 | 87'412 | 90'689 | 89'353 |
| Gas oil | TJ | 22'910 | 24'471 | 25'892 | 25'317 | 21'137 |
| Residual fuel oil | TJ | 18'870 | 13'678 | 5'675 | 4'613 | 2'036 |
| Liquefied petroleum gas | TJ | 4'351 | 4'404 | 5'475 | 4'173 | 3'756 |
| Petroleum coke | TJ | 1'400 | 1'260 | 551 | 1'093 | 1'495 |
| Other bituminous coal | TJ | 13'476 | 7'303 | 5'866 | 4'799 | 4'348 |
| Lignite | TJ | 265 | 153 | 124 | 742 | 1'460 |
| Natural gas | TJ | 19'610 | 28'700 | 32'000 | 34'870 | 38'420 |
| Other fossil fuels | TJ | 2'469 | 2'718 | 3'812 | 4'138 | 4'625 |
| Biomass | TJ | 5'500 | 6'570 | 8'018 | 10'944 | 12'077 |

| **1A2 Manufacturing industries and constr. (stationary sources)** | **Unit** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 80'166 | 78'724 | 79'781 | 80'236 | 77'424 | 77'075 | 74'279 | 78'354 | 70'611 | 64'802 |
| Gas oil | TJ | 12'444 | 12'725 | 12'812 | 11'489 | 10'871 | 10'071 | 8'854 | 9'074 | 8'725 | 7'679 |
| Residual fuel oil | TJ | 231 | 196 | 155 | 123 | 34 | 111 | 76 | 55 | NO | 41 |
| Liquefied petroleum gas | TJ | 3'149 | 3'216 | 2'577 | 3'068 | 3'009 | 2'892 | 2'765 | 2'908 | 2'917 | 3'006 |
| Petroleum coke | TJ | 1'240 | 795 | 890 | 763 | 781 | 777 | 700 | 604 | 731 | 763 |
| Other bituminous coal | TJ | 2'403 | 1'946 | 1'517 | 1'634 | 1'665 | 1'481 | 1'186 | 1'184 | 1'364 | 1'070 |
| Lignite | TJ | 3'102 | 3'060 | 3'078 | 2'876 | 2'520 | 2'262 | 2'410 | 2'442 | 2'466 | 1'945 |
| Natural gas | TJ | 40'310 | 39'450 | 39'960 | 41'000 | 39'320 | 39'560 | 38'180 | 39'700 | 33'120 | 29'840 |
| Other fossil fuels | TJ | 4'558 | 4'566 | 5'178 | 5'085 | 5'608 | 5'759 | 5'815 | 5'806 | 5'665 | 5'304 |
| Biomass | TJ | 12'729 | 12'772 | 13'613 | 14'198 | 13'616 | 14'162 | 14'294 | 16'582 | 15'622 | 15'154 |

Table 3-44 Fuel consumption in boilers of 1A2a Stationary combustion in manufacturing industries and construction: Iron and steel.

| 1A2a Iron and steel (Boilers) | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 1'045 | 1'017 | 978 | 1'094 | 1'657 |
| Gas oil | TJ | 480 | 262 | 338 | 401 | 315 |
| Residual fuel oil | TJ | 26 | 131 | 20 | 39 | 51 |
| Liquefied petroleum gas | TJ | 408 | 193 | 286 | 217 | 219 |
| Natural gas | TJ | 131 | 431 | 334 | 437 | 1'072 |

| 1A2a Iron and steel (Boilers) | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 1'513 | 1'920 | 1'892 | 2'159 | 2'292 | 2'143 | 2'141 | 1'935 | 1'823 | 1'725 |
| Gas oil | TJ | 86 | 136 | 134 | 123 | 127 | 97 | 81 | 80 | 57 | 58 |
| Residual fuel oil | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Liquefied petroleum gas | TJ | 388 | 393 | 327 | 368 | 358 | 342 | 327 | 342 | 342 | 352 |
| Natural gas | TJ | 1'039 | 1'391 | 1'431 | 1'669 | 1'808 | 1'704 | 1'732 | 1'513 | 1'424 | 1'315 |

Table 3-45 Fuel consumption in boilers of 1A2b Stationary combustion in manufacturing industries and construction: Non-ferrous metals.

| 1A2b Non-ferrous metals (Boilers) | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 2'256 | 1'969 | 1'555 | 973 | 1'217 |
| Gas oil | TJ | 451 | 336 | 225 | 119 | 108 |
| Residual fuel oil | TJ | NO | NO | NO | NO | 0.024 |
| Liquefied petroleum gas | TJ | 27 | 17 | 15 | 7.1 | 7.7 |
| Natural gas | TJ | 1'779 | 1'616 | 1'315 | 848 | 1'101 |

| 1A2b Non-ferrous metals (Boilers) | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 1'919 | 1'794 | 1'684 | 1'642 | 1'748 | 1'965 | 1'815 | 2'018 | 1'839 | 1'658 |
| Gas oil | TJ | 88 | 77 | 74 | 77 | 53 | 60 | 48 | 64 | 68 | 66 |
| Residual fuel oil | TJ | NO | 44 | NO | 3.7 | NO | NO | NO | NO | NO | NO |
| Liquefied petroleum gas | TJ | 9.8 | 9.9 | 8.3 | 9.3 | 9.0 | 8.6 | 8.3 | 8.6 | 8.6 | 8.9 |
| Natural gas | TJ | 1'821 | 1'664 | 1'602 | 1'552 | 1'686 | 1'897 | 1'758 | 1'945 | 1'762 | 1'583 |

Table 3-46 Fuel consumption in boilers of 1A2c Stationary combustion in manufacturing industries and construction: Chemicals.

| 1A2c Chemicals (Boilers) | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 14'511 | 15'236 | 13'544 | 15'515 | 11'836 |
| Gas oil | TJ | 3'942 | 3'313 | 3'215 | 3'345 | 2'103 |
| Residual fuel oil | TJ | 1'434 | 693 | 252 | 36 | 66 |
| Liquefied petroleum gas | TJ | 15 | 13 | 12 | 10 | 7.5 |
| Natural gas | TJ | 9'119 | 11'217 | 10'065 | 12'124 | 9'660 |

| 1A2c Chemicals (Boilers) | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 12'155 | 12'551 | 14'401 | 13'834 | 13'312 | 11'834 | 10'956 | 10'733 | 9'202 | 8'035 |
| Gas oil | TJ | 1'321 | 1'167 | 881 | 860 | 825 | 799 | 602 | 593 | 790 | 858 |
| Residual fuel oil | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Liquefied petroleum gas | TJ | 8.9 | 9.0 | 7.5 | 8.4 | 8.2 | 7.9 | 7.5 | 7.9 | 7.9 | 8.1 |
| Natural gas | TJ | 10'825 | 11'375 | 13'512 | 12'966 | 12'479 | 11'026 | 10'346 | 10'132 | 8'405 | 7'168 |

Table 3-47 Fuel consumption in boilers of 1A2d Stationary combustion in manufacturing industries and construction: Pulp, paper and print.

| 1A2d Pulp paper and print (Boilers) | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 9'701 | 11'440 | 8'300 | 8'854 | 6'364 | 4'046 | 2'980 | 2'988 | 2'857 | 2'077 | 2'155 | 2'071 | 2'268 | 1'950 | 1'676 |
| Gas oil | TJ | 1'188 | 1'751 | 1'403 | 1'456 | 852 | 297 | 383 | 410 | 288 | 293 | 345 | 284 | 247 | 363 | 260 |
| Residual fuel oil | TJ | 5'250 | 3'061 | 1'417 | 2'092 | 279 | 22 | 19 | 9.0 | 8.8 | NO | NO | NO | NO | NO | NO |
| Liquefied petroleum gas | TJ | 86 | 141 | 148 | 100 | 61 | 60 | 60 | 50 | 57 | 55 | 53 | 50 | 53 | 53 | 54 |
| Natural gas | TJ | 3'177 | 6'486 | 5'333 | 5'206 | 5'172 | 3'667 | 2'518 | 2'518 | 2'504 | 1'729 | 1'757 | 1'737 | 1'968 | 1'534 | 1'362 |

Table 3-48 Fuel consumption in boilers of 1A2e Stationary combustion in manufacturing industries and construction; Food processing, beverages and tobacco.

| 1A2e Food processing beverages and tobacco (Boilers) | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 9'867 | 8'802 | 10'457 | 10'256 | 13'181 | 12'463 | 11'591 | 10'992 | 11'231 | 10'843 | 11'851 | 11'928 | 12'269 | 10'109 | 10'078 |
| Gas oil | TJ | 7'410 | 5'511 | 5'515 | 4'070 | 3'778 | 2'395 | 2'522 | 2'503 | 2'110 | 1'925 | 2'119 | 2'009 | 2'298 | 2'246 | 1'997 |
| Residual fuel oil | TJ | 1'160 | 466 | 137 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Liquefied petroleum gas | TJ | 204 | 308 | 535 | 534 | 659 | 828 | 838 | 699 | 785 | 763 | 731 | 699 | 731 | 731 | 752 |
| Natural gas | TJ | 1'094 | 2'517 | 4'270 | 5'653 | 8'744 | 9'241 | 8'230 | 7'790 | 8'337 | 8'155 | 9'001 | 9'220 | 9'240 | 7'132 | 7'328 |

Table 3-49 Fuel consumption in boilers of 1A2gviii Stationary combustion in manufacturing industries and construction: Other.

| 1A2gviii Stationary combustion Other (Boilers) | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 16'898 | 20'913 | 21'380 | 22'190 | 22'222 | 16'686 | 17'837 | 17'665 | 17'728 | 16'846 | 16'637 | 15'174 | 16'287 | 13'837 | 12'145 |
| Gas oil | TJ | 7'418 | 11'626 | 13'484 | 14'497 | 12'705 | 7'050 | 7'342 | 7'785 | 6'912 | 6'568 | 5'597 | 4'831 | 4'794 | 4'141 | 3'412 |
| Residual fuel oil | TJ | 5'237 | 3'605 | 47 | 4.9 | 9.3 | 0.33 | 2.8 | 7.9 | 4.3 | 2.2 | 2.4 | 3.7 | 2.8 | NO | 41 |
| Liquefied petroleum gas | TJ | 3'087 | 3'233 | 4'011 | 2'979 | 2'697 | 1'810 | 1'852 | 1'441 | 1'798 | 1'772 | 1'705 | 1'634 | 1'725 | 1'712 | 1'683 |
| Petroleum coke | TJ | 765 | 914 | 15 | 383 | 318 | 108 | 104 | 155 | 113 | 168 | 169 | 65 | 21 | 185 | 195 |
| Other bituminous coal | TJ | 205 | 140 | 12 | 88 | 11 | 105 | 134 | 125 | 102 | 91 | 89 | 133 | 47 | 57 | 34 |
| Lignite | TJ | NO | NO | NO | 4.7 | 111 | 189 | 204 | 197 | 182 | 153 | 141 | 144 | 138 | 135 | 122 |
| Natural gas | TJ | 186 | 1'396 | 3'811 | 4'233 | 6'371 | 7'425 | 8'198 | 7'955 | 8'617 | 8'092 | 8'934 | 8'362 | 9'560 | 7'607 | 6'658 |

#### *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 3-42 and Table 3-44, 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 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. The emissions from the electric arc furnaces reported under source category 2C1 Steel production are based on air pollution control measurements at the chimney and thus also include emissions from injection coal, coke and natural gas. Therefore, 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, $SO_x$ 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 factors of BC (% PM2.5) are taken from EMEP/EEA guidebook (EMEP/EEA 2023, chp. 1A4, table Liquid fuels (rounded mean value), Appendix E for residual fuel oil and table 3-26 for natural gas), see EMIS 2025/1A2a Stahl-Produktion Wärmeöfen.

*Cupola furnaces in iron foundries*

Emission factors of $NO_x$, NMVOC, $SO_x$, 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 guidebook (EMEP/EEA 2023, chp.1A4, Table 3-23). Emission factors of PAH are based on data from literature, see USEPA (1998) and EMIS 2025/1A2a Eisengiessereien Kupolöfen). The Hg emission factor is based on the default value for other bituminous coal of Table 3-23 (chp. 1A4) of EMEP/EEA (2023).

Table 3-50 Emission factors of 1A2a Iron and Steel in 2023.

| 1A2a Iron and steel | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Iron foundries, cupola | Iron | t | 67 | 40 | 1'500 | NE | 60 | 110 | 120 | 3.8 | 11'000 |
| Steel plants, reheating furnaces | Steel | t | 75 | 2.8 | 0.71 | NE | 2.1 | 2.1 | 4.1 | 0.11 | 0.50 |

| 1A2a Iron and steel | | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | mg/... | mg/... |
| Iron foundries, cupola | Iron | t | 4'800 | 24 | 80 | 1'300 | 0.13 | 1.4 | 1.2 | 1.6 | NE | NE |
| Steel plants, reheating furnaces | Steel | t | 32 | 3.4 | 0.071 | NE | NE | NE | NE | NE | NA | NA |

## 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 2025/1A2a).

*Reheating furnaces in steel production*

Since 1995, steel production increased continuously until 2004 to reach the same production level as 1990. Up to 2022 the steel production remained about constant. In 2009, the production was significantly lower due to the financial crisis. Due to the economic situation, including the strong rise in electricity prices because of the war in Ukraine, production fell sharply from 2022 to 2023. 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 2024).

Table 3-51 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 | 2010 |
|---|---|---|---|---|---|---|---|
| Iron foundries, cupola | Iron | kt | 90 | 60 | 55 | 32 | 13 |
| Steel plants, reheating furnaces | Steel | kt | 1'108 | 716 | 1'022 | 1'082 | 1'082 |

| 1A2a Iron and steel | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Iron foundries, cupola | Iron | kt | 11 | 9.2 | 8.6 | 8.8 | 8.6 | 6.0 | 5.1 | 5.4 | 5.8 | 5.4 |
| Steel plants, reheating furnaces | Steel | kt | 1'176 | 1'144 | 1'085 | 1'138 | 1'160 | 1'037 | 1'031 | 1'104 | 1'121 | 884 |

### *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 3-42 andTable 3-45, 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 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 2025/1A2b Buntmetallgiessereien übriger Betrieb). The emission factors are based on information of the Swiss foundry association (GVS).

Table 3-52 Emission factors of 1A2b Non-ferrous metals in 2023.

| 1A2b Non-ferrous metals | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Aluminium production remelting plant | Aluminium | t | NO | NO | NO | NO | NO | NO | NO | NO |
| Foundries | Metal | t | 7.0 | 420 | 4.0 | NE | 160 | NA | 170 | NA |

| 1A2b Non-ferrous metals | | Unit | TSP ex | TSP nx | BC ex | CO | Pb | Cd | Hg | PCDD/ PCDF |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | mg/... | mg/... | mg/... | ng I-Teq/... |
| Aluminium production remelting plant | Aluminium | t | NO | NO | NO | NO | NO | NO | NO | NO |
| Foundries | Metal | t | 170 | NA | 6.2 | 2'100 | 510 | 85 | NE | 4'900 |

| 1A2b Non-ferrous metals | | Unit | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | mg/... | mg/... | mg/... |
| Aluminium production remelting plant | Aluminium | t | NO | NO | NO | NO | NO | NO |
| Foundries | Metal | t | NE | NE | NE | NE | NE | NE |

### Activity data (1A2b)

The production data for the non-ferrous metal industry is provided by the largest company (Swissmetal, monitoring reports of the Swiss ETS from 2006 onwards) 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 3-45).

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

Table 3-53 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 | 2010 |
|---|---|---|---|---|---|---|---|
| Aluminium production remelting plant | Aluminium | kt | 34 | NO | NO | NO | NO |
| Foundries | Metal | kt | 60 | 56 | 53 | 33 | 20 |

| 1A2b Non-ferrous metals | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminium production remelting plant | Aluminium | kt | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Foundries | Metal | kt | 9.5 | 8.9 | 9.0 | 8.0 | 6.8 | 6.4 | 5.1 | 7.5 | 7.9 | 5.3 |

## *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 3-42 and Table 3-46, 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. In addition, thermal cracking also produces so-called heating gas and gasolio as by-products. In 2018 the cracking process and the subsequent integrated production chain were modified yielding synthesis gas as additional by-product. 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 2B10a 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 3-42. For synthesis gas (about 23 % vol. CO, 77 % vol. $H_2$) emissions of $NO_x$ and $NH_3$ are assumed only. Thus, for $NO_x$ and $NH_3$, the same emission factors as of boilers, natural gas are applied, see Table 3-42.

### Activity data (1A2c)

Activity data on gasolio, heating gas and synthesis gas (from 2018 onwards) are provided by the industry. Since 2013, they are based on monitoring reports of the Swiss ETS as documented in the EMIS database (EMIS 2025/1A2c 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 3-42 and Table 3-47, 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 $SO_x$ emission factors were derived from air pollution control measurements. The emission factor of BC (% PM2.5) was taken according to the EMEP/EEA guidebook (EMEP/EEA 2023, chp. 1A4, table Liquid fuels (rounded mean value), Appendix E) as documented in the EMIS database (EMIS 2025/1A2d Zellulose-Produktion Feuerung). Emission factors for natural gas used in gas turbines as SCGT or CCGT are described in chapter 3.2.1.1.2.

### Activity data (1A2d)

Activity data on annual cellulose production are provided by the industry as documented in the EMIS database (EMIS 2025/1A2d Zellulose-Produktion Feuerung). The only plant closed in 2008.

In 2023, natural gas is the most important fuel in this category (see Table 3-47). The use of natural gas in gas turbines as SCGT or CCGT is described in chapter 3.2.1.1.2. 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 several 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, a 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 3-42 and Table 3-48, respectively.

In 2023, the fuels used in this category were mainly natural gas as well as gas oil and small amounts of liquefied petroleum gas (Table 3-48). All fuel is consumed in boilers.

### *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 2025/1A2f). 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 2025/1A2f).

Table 3-54 Emission factors for 1A2f Non-metallic minerals in 2023.

| 1A2f Non-metallic minerals | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Brick and tile | Bricks | t | 530 | 140 | 80 | NE | 19 | NA | 29 | NA |
| Cement | Clinker | t | 775 | 67 | 280 | 45 | 3.0 | NA | 4.0 | NA |
| Container glass | Glass | t | C | NA | C | NE | C | NA | C | NA |
| Fine ceramics | Ceramics | t | C | C | C | NE | C | NA | C | NA |
| Glass wool | Glass wool | t | 5’000 | 14 | 3.4 | NE | 342 | NA | 611 | NA |
| Lime | Lime | t | C | C | C | NE | C | NA | C | NA |
| Mixed goods | Mixed goods | t | 10 | 32 | 17 | NE | 1.0 | NA | 2.9 | NA |
| Rock wool | Rock wool | t | C | IE | C | C | C | C | C | C |
| Tableware glass | Glass | t | C | C | C | NE | C | NA | C | NA |

| 1A2f Non-metallic minerals | | Unit | TSP ex | TSP nx | BC ex | CO | Pb | Cd | Hg | PCDD/ PCDF |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | mg/... | mg/... | mg/... | ng I-Teq/... |
| Brick and tile | Bricks | t | 32 | NA | 1.0 | 560 | 45 | 0.70 | 7.0 | 18 |
| Cement | Clinker | t | 5.0 | NA | 0.25 | 2’600 | 20 | 2.0 | 10 | 40 |
| Container glass | Glass | t | C | NA | C | C | C | C | NE | NE |
| Fine ceramics | Ceramics | t | C | NA | C | C | C | C | C | C |
| Glass wool | Glass wool | t | 630 | NA | 18 | 80 | 860 | 90 | 0.34 | NE |
| Lime | Lime | t | C | NA | C | C | C | C | C | C |
| Mixed goods | Mixed goods | t | 3.0 | NA | 0.044 | 85 | 20 | 2.0 | 2.0 | 5.0 |
| Rock wool | Rock wool | t | C | C | C | C | C | C | C | NE |
| Tableware glass | Glass | t | C | NA | C | C | C | C | C | NE |

| 1A2f Non-metallic minerals | | Unit | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | mg/... | mg/... | mg/... |
| Brick and tile | Bricks | t | NE | NE | NE | NE | NE | NE |
| Cement | Clinker | t | 0.060 | 1.0 | 0.040 | 0.30 | 0.0040 | 0.10 |
| Container glass | Glass | t | NE | NE | NE | NE | NA | NA |
| Fine ceramics | Ceramics | t | NE | NE | NE | NE | NA | NA |
| Glass wool | Glass wool | t | NE | NE | NE | NE | NA | NA |
| Lime | Lime | t | NE | NE | NE | NE | NA | NA |
| Mixed goods | Mixed goods | t | 0.040 | 0.060 | 0.040 | 0.040 | NE | NE |
| Rock wool | Rock wool | t | NE | NE | NE | NE | NE | NE |
| Tableware glass | Glass | t | NE | NE | NE | NE | NA | NA |

### Activity data (1A2f)

Table 3-55 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 2025/1A2f).

Table 3-55 Activity data for 1A2f Non-metallic minerals.

| 1A2f Non-metallic minerals | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| Brick and tile | Bricks | kt | 1'271 | 1'115 | 959 | 1'086 | 879 |
| Cement | Clinker | kt | 4'808 | 3'706 | 3'214 | 3'442 | 3'642 |
| Container glass | Glass | kt | C | C | C | C | C |
| Fine ceramics | Ceramics | kt | C | C | C | C | C |
| Glass wool | Glass wool | kt | 24 | 24 | 31 | 37 | 36 |
| Lime | Lime | kt | C | C | C | C | C |
| Mixed goods | Mixed goods | kt | 5'500 | 4'800 | 5'170 | 4'780 | 5'250 |
| Rock wool | Rock wool | kt | C | C | C | C | C |
| Tableware glass | Glass | kt | C | C | C | C | C |

| 1A2f Non-metallic minerals | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brick and tile | Bricks | kt | 765 | 726 | 660 | 622 | 581 | 554 | 531 | 484 | 521 | 449 |
| Cement | Clinker | kt | 3'502 | 3'195 | 3'296 | 3'279 | 3'239 | 3'227 | 3'129 | 3'227 | 3'155 | 2'855 |
| Container glass | Glass | kt | C | C | C | C | C | C | C | C | C | C |
| Fine ceramics | Ceramics | kt | C | C | C | C | C | C | C | C | C | C |
| Glass wool | Glass wool | kt | 32 | 31 | 32 | 36 | 40 | 47 | 40 | 47 | 45 | 37 |
| Lime | Lime | kt | C | C | C | C | C | C | C | C | C | C |
| Mixed goods | Mixed goods | kt | 5'260 | 4'850 | 4'710 | 5'260 | 5'180 | 5'210 | 4'910 | 4'960 | 4'970 | 5'000 |
| Rock wool | Rock wool | kt | C | C | C | C | C | C | C | C | C | C |
| Tableware glass | Glass | kt | C | C | C | C | C | C | C | C | C | C |

### 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 (lignite and other bituminous coal), 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 plastics, waste oil, solvents and residues from distillation or wood waste. The fuels consumed in this category are very diverse and depend on the fuel use within the specific plant (see detailed documentation below).

### Emission factors

Table 3-54 shows product-specific emission factors for cement production (EMIS 2025/1A2f Zementwerke Feuerung). Since 2008, emission factors are based on various air pollution control measurements under the Ordinance on Air Pollution Control (Swiss Confederation 1985). A reassessment of emission measurement reports of the years 2013 and 2018 led to changes in emission factors for the years 2009-2012 and from 2013 onwards. Regarding $NO_x$, industry agreements define an emission reduction path for the years 2016-2021 and 2022-2031, respectively. Emission data for monitoring compliance with the agreement were evaluated and the emission factor for $NO_x$ was computed accordingly. The value for PCB is based on the Tier 2 emission factor in the EMEP/EEA guidebook (EMEP/EEA 2023, chp.1A2, Table 3-25).

### 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 3-55). 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 3-56. The waste derived fuels can be of fossil or biogenic origin and are accordingly differentiated into so-called other fossil fuels and biomass.

The amount of fuels consumed in the Swiss cement production plants is also provided in the annual monitoring reports of the cement production plants as documented in the respective EMIS 2025/1A2f Zementwerke Feuerung.

Table 3-56 Fuel consumption of cement industry (fossil without waste, fossil waste derived, and biomass waste derived).

| 1A2f Non-metallic minerals (Cement industry) | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 17'194 | 12'774 | 11'017 | 11'623 | 12'388 |
| Gas oil | TJ | NO | NO | NO | 72 | 5.4 |
| Residual fuel oil | TJ | 1'907 | 2'825 | 1'530 | 637 | 112 |
| Petroleum coke | TJ | 550 | 300 | 480 | 638 | 1'130 |
| Other bituminous coal | TJ | 12'235 | 6'547 | 5'176 | 4'120 | 3'662 |
| Lignite | TJ | 265 | 153 | 124 | 737 | 1'348 |
| Natural gas | TJ | 362 | 168 | 22 | 3.9 | 21 |
| CSS, fossil | TJ | 5.0 | 29 | 34 | 29 | 26 |
| Mixed industrial waste | TJ | NO | NO | NO | NO | NO |
| Other fossil waste fuels | TJ | NO | NO | NO | NO | 45 |
| Plastics, fossil | TJ | NO | 40 | 413 | 608 | 905 |
| Solvents and residues from distillation, fossil | TJ | 281 | 180 | 422 | 967 | 1'178 |
| Waste coke from coke filters | TJ | 59 | 59 | 59 | 58 | NO |
| Waste oil, fossil | TJ | 1'170 | 1'485 | 1'520 | 1'411 | 1'253 |
| Waste tyres and rubber, fossil | TJ | 241 | 303 | 307 | 471 | 614 |
| Biogas | TJ | NO | NO | NO | NO | NO |
| Wood waste | TJ | NO | 322 | NO | NO | 292 |
| CSS, biogenic | TJ | 18 | 106 | 124 | 105 | 97 |
| Agricultural waste | TJ | NO | NO | NO | NO | 7.3 |
| Animal meal | TJ | NO | NO | 198 | 856 | 624 |
| Dry sewage sludge | TJ | 9.4 | 128 | 333 | 494 | 477 |
| Other biomass | TJ | NO | NO | NO | NO | 5.7 |
| Plastics, biogenic | TJ | NO | 15 | 158 | 233 | 347 |
| Solvents biogenic | TJ | 2.5 | 1.6 | 3.8 | 8.8 | 11 |
| Waste oil, biogenic | TJ | NO | NO | NO | NO | NO |
| Waste tyres and rubber, biogenic | TJ | 89 | 112 | 114 | 174 | 227 |

| 1A2f Non-metallic minerals (Cement industry) | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 12'339 | 11'348 | 11'583 | 11'476 | 11'524 | 11'416 | 11'248 | 11'609 | 11'606 | 10'485 |
| Gas oil | TJ | 75 | 87 | 50 | 56 | 63 | 43 | 54 | 61 | 93 | 81 |
| Residual fuel oil | TJ | 58 | 45 | 90 | 59 | NO | 63 | 35 | 52 | NO | NO |
| Petroleum coke | TJ | 1'052 | 622 | 658 | 574 | 542 | 552 | 591 | 583 | 547 | 568 |
| Other bituminous coal | TJ | 1'713 | 1'267 | 826 | 938 | 987 | 831 | 528 | 587 | 780 | 605 |
| Lignite | TJ | 2'912 | 2'856 | 2'881 | 2'694 | 2'367 | 2'120 | 2'266 | 2'304 | 2'331 | 1'824 |
| Natural gas | TJ | 37 | 41 | 39 | 34 | 56 | 65 | 26 | 28 | 82 | 71 |
| CSS, fossil | TJ | 25 | 20 | 26 | 21 | 20 | 16 | 0.043 | 0.58 | 0.67 | 0.42 |
| Mixed industrial waste | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Other fossil waste fuels | TJ | 19 | 12 | 11 | 5.7 | 5.4 | NO | NO | 13 | NO | NO |
| Plastics, fossil | TJ | 1'016 | 887 | 890 | 1'071 | 1'319 | 1'246 | 1'558 | 1'688 | 1'692 | 1'704 |
| Solvents and residues from distillation, fossil | TJ | 1'193 | 1'194 | 1'397 | 1'254 | 1'238 | 1'456 | 1'155 | 1'107 | 1'265 | 1'121 |
| Waste coke from coke filters | TJ | NO | NO | NO | 66 | 61 | 48 | 52 | 48 | 30 | 24 |
| Waste oil, fossil | TJ | 884 | 1'083 | 1'469 | 1'215 | 1'239 | 1'359 | 1'353 | 1'253 | 1'009 | 973 |
| Waste tyres and rubber, fossil | TJ | 746 | 699 | 694 | 760 | 763 | 760 | 743 | 726 | 730 | 605 |
| Biogas | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Wood waste | TJ | 886 | 896 | 811 | 840 | 840 | 861 | 867 | 973 | 962 | 989 |
| CSS, biogenic | TJ | 78 | 60 | 72 | 57 | 53 | 43 | 0.12 | 1.6 | 1.8 | 1.1 |
| Agricultural waste | TJ | NO | NO | NO | 9.2 | NO | NO | NO | NO | NO | NO |
| Animal meal | TJ | 457 | 412 | 409 | 470 | 522 | 475 | 441 | 454 | 317 | 246 |
| Dry sewage sludge | TJ | 428 | 420 | 479 | 499 | 519 | 512 | 553 | 572 | 578 | 526 |
| Other biomass | TJ | 21 | 42 | 7.9 | 5.6 | 5.4 | 31 | 36 | 147 | 175 | 197 |
| Plastics, biogenic | TJ | 343 | 290 | 281 | 327 | 403 | 381 | 476 | 516 | 517 | 520 |
| Solvents biogenic | TJ | 80 | 98 | 137 | 144 | 142 | 167 | 133 | 127 | 145 | 129 |
| Waste oil, biogenic | TJ | 39 | 60 | 98 | 96 | 98 | 107 | 107 | 99 | 79 | 77 |
| Waste tyres and rubber, biogenic | TJ | 276 | 259 | 257 | 281 | 282 | 281 | 275 | 269 | 270 | 224 |

In 2023, the Swiss cement industry used about two-thirds of waste derived fuels (fossil and biogenic) and one-third of standard fossil fuels. Today, fossil fuels used in cement industry are mainly lignite, plastics, solvents and residues from distillation, waste oil, whereas waste tyres, petroleum coke and other bituminous coal are less important. Biogenic wastes contain mainly wood waste, sewage sludge, (bio)plastics and animal residues (animal meal). The main fossil fuel used in 1990 was other bituminous coal, but residual fuel oil and waste oil were also of importance.

Fuel consumption in cement plants has decreased between 1990 and 2015 and remained rather constant since then. This is partly due to a decrease in production since 1990 and an increase in energy efficiency. In the period 1990-2019, the fuel mix has changed significantly from mainly standard fossil fuels to the above-mentioned mix of fuels.

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 2025/1A2f Hohlglas Produktion) and partly on information from industry. The $SO_x$ emission factor is based on air pollution control measurements from 2011. The emission factor of BC (% PM2.5) are taken from EMEP/EEA guidebook (EMEP/EEA 2023 chp. 1A4, table Liquid fuels (rounded mean value), Appendix E for residual fuel oil and Table 3-26 for natural gas).

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 3-55). 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. Since 2004, the share of natural gas has increased to reach a stable share between 2006 and 2012. In autumn 2013, the plant has switched its glass kiln completely to natural gas.

### 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 $SO_x$, NMVOC, CO are based on information from industry (EMIS 2025/1A2f 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 (liquefied petroleum gas and residual fuel oil until 1995). The emission factors of BC (% PM2.5) are taken from EMEP/EEA guidebook (EMEP/EEA 2023, chp. 1A4, table Liquid fuels (rounded mean value), Appendix E for residual fuel oil and table 3-26 for liquefied petroleum gas).

#### Activity data

For tableware glass production, activity data are provided by monitoring reports of the Swiss ETS (Table 3-55). 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 3-54 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 2025/1A2f Glaswolle Produktion) and partly on information from industry. The emission factor for $SO_x$ 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 guidebook (EMEP/EEA 20123 chp. 1A4, table 3-26).

#### Activity data

Activity data consist of annual production data provided by monitoring reports from the industry (Table 3-55). 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 $NO_x$, $SO_x$, 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. Air pollution control measurements in 2017 led to revised emission factors of these pollutants for the natural gas operation of the kiln from 2014 onwards (EMIS 2025/1A2f). The emission factor of BC (% PM2.5) is taken from EMEP/EEA guidebook (EMEP/EEA 20123 chp. 1A4, table 3-18 for gas oil, table Liquid fuels (rounded mean value), Appendix E for residual fuel oil, table 3-23 for other bituminous coal and table 3-26 for natural gas), see EMIS 2025/1A2f 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; gas oil was only used to start up the kilns. Up to 1995, also other bituminous coal was used and was the most important fuel (up to 1993). However, in 2013, the kiln was switched to natural gas.

## Brick and Tile (1A2f)

### Methodology

In Switzerland there are about 15 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 3-54 shows emission factors for brick and tile production. Emission factors of $NO_x$, NMVOC, $SO_x$, PM2.5/PM10/TSP, CO, Pb, Cd und Hg are derived from air pollution control measurements as described in the EMIS database (EMIS 2025/1A2f Ziegeleien). The emission factors of BC (% PM2.5) are taken from EMEP/EEA guidebook (EMEP/EEA 2023, chp. 1A4, table 3-18 for gas oil, table Liquid fuels (rounded mean value), Appendix E for residual fuel oil, paper pulp and animal fat and table 3-26 for liquefied petroleum gas and natural gas).

### Activity data

Activity data consist of annual production data provided by the industry (Table 3-55). 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 2023 are mainly natural gas as well as small amounts of liquefied petroleum gas and gas oil. 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 fat are used since 2000. But the consumption of wood, paper production residues and animal fat is no longer reported in the monitoring reports since 2013, 2018 and 2021, respectively.

### 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, $SO_x$ 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 $SO_x$ is assumed to be constant. The emission factors of BC (% PM2.5) are taken from EMEP/EEA guidebook (EMEP/EEA 2023 chp. 1A4, table 3-18 for gas oil and table 3-26 for natural gas), see EMIS 2025/1A2f 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. $NO_x$, $NH_3$, $SO_x$) for rock wool production are based on annual flux analysis from industry – except for the emission factors of BC (% PM2.5), which are taken from EMEP/EEA guidebook (EMEP/EEA 2023 chp. 1A4, table 3-18 for gas oil, table 3-23 for other bituminous coal and table 3-26 for liquefied petroleum gas and natural gas), see EMIS 2025/1A2f 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 3-54 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 measurements show no clear trend in the emission factors, a constant country-specific, average emission factor is used from 2001 onwards. Emission factors of $SO_x$, Hg and PCCD/PCDF are based on data from the industry association (Schweizerische Mischgut-Industrie) (EMIS 2025/1A2f Mischgut Produktion).

**Activity data**

Activity data consist of annual production data provided by the industry association (Schweizerische Mischgut-Industrie) (Table 3-55).

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 and biogas 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 was produced in two plants in Switzerland until 2019, where thermal energy is used for heating and drying processes. Since 2020 only one plant is left.

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 industrial source categories 1A2a-f.

**Emission factors (1A2gviii)**

The emission factors for fossil fuel consumption in 1A2gviii in boilers and in fibreboard production are described in chp. 3.2.3.2.1 (see Table 3-42). For animal fat 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 3-24.

The emission factors of the individual wood and wood waste combustion installations are described in chp. 3.2.1.1.3 and listed in Table 3-24. The resulting weighted emission factors of wood and wood waste combustion in manufacturing industries and construction are given in Table 3-57.

Table 3-57 Emission factors (weighted average) for 1A2gviii Wood and wood waste combustion in manufacturing industries and construction in 2023.

| 1A2gviii Stationary combustion Other | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Wood and wood waste | GJ | 108 | 5.9 | 9.2 | 3.2 | 12 | 13 | 14 | 0.74 | 146 |

| 1A2gviii Stationary combustion Other | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| Wood and wood waste | GJ | 46 | 1.4 | 2.0 | 55 | 1.6 | 1.6 | 1.1 | 1.1 | 1'658 | 10 |

Emission factors for stationary engines and gas turbines are based on INFRAS (2022a) as described in chp. 3.2.1.1.2.

#### Activity data (1A2gviii)

Activity data of fossil fuels is derived from the industry model and given in Table 3-44. Fuel consumption of wood and wood waste in in manufacturing industries and construction is based on the Swiss wood energy statistics (SFOE 2024b) (see also chp. 3.2.1.1.3) and is given in Table 3-58. Fuel consumption in stationary engines and gas turbines is as described in chapter 3.2.1.1.2.

Table 3-58 Fuel consumption of 1A2gviii Wood and wood waste combustion in manufacturing industries and construction.

| 1A2gviii Stationary combustion Other (Wood combustion) | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Wood and wood waste | TJ | 3'254 | 4'440 | 5'228 | 6'652 | 9'637 |

| 1A2gviii Stationary combustion Other (Wood combustion) | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wood and wood waste | TJ | 9'838 | 9'974 | 10'789 | 11'207 | 10'550 | 11'100 | 11'210 | 13'213 | 12'335 | 12'031 |

In source category fibreboard production, the fuels currently used are wood waste and natural gas (EMIS 2025/1A2giv). Since 1990, the production of fibreboard and thus the fuel consumption have increased significantly. The fuel mix has strongly shifted between 1990 and 2023 from fossil fuels to biomass (wood waste). Between 2001 and 2013, also animal fat was used

In 2023, fuel consumption of 1A2gviii Other comprises mainly wood/wood waste and natural gas. Overall, there has been a shift in fuel consumption between 1990 and 2023 from liquid and solid fuels to wood/wood waste and natural gas.

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

The following recalculations were implemented in submission 2025:

- 1A2: The emission factors of $NO_x$ and CO for natural gas and gas oil boilers were updated for 2022 based on the evaluation of a large number of air pollution control measurements of combustion installations in numerous Swiss cantons. This has resulted in revised emission factors of $NO_x$ and CO for all boilers fuelled with gas oil, liquefied petroleum gas and natural gas in source category 1A2 Stationary combustion in manufacturing industries and construction as well as 1A2c Cracker by-products, heating gas and 1A2gviii Fibreboard production (gas oil, natural gas) from 2011 onwards. The projected emission factor values for all particulate matter fractions (2035, PM2.5, PM10, TSP and BC) were also updated, resulting in changes to the linearly interpolated emission factors for 2021 and 2022.

- 1A2, activity data: Recalculations in all source categories 1A2a to 1A2g are due to reallocations of all fuel types in these sub-categories of 1A2 Manufacturing industries and construction in the year 2022. The reason is that during the surveys for the energy consumption statistics in the industry and services sectors for the most recent year, the reports from the previous year are reviewed again and, if necessary, adjusted retroactively. Generally, this only affects the disaggregation and not the total amount of fuels used in 1A2 Manufacturing industries and construction for that year. However, additional recalculations were introduced in the overall energy statistics with regard to the total fuel consumption in the industry sector for the following fuel types: Natural gas (2021, 2022), bituminous coal and lignite (2019–2022).
- 1A2, year 2022: Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_2$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated.
- 1A2a: A typing error in the activity data 2022 of source category 1A2a Iron foundries, cupola furnaces was corrected.
- 1A2d: The activity data of 1A2d Gas turbines (years 1992-2015, see Table 3-18) increased by a factor of 2 due to a calculation error. It will be corrected in the next submission.
- 1A2f: For source category 1A2f Cement production, the quantity of waste tyres burned was updated due to a change in the underlying statistics.
- 1A2gviii: The activity data 2022 of 1A2gviii Boiler, other bituminous coal and 1A2gviii Boiler, natural gas were revised due to corrections of a typing error in the activity data (other bituminous coal) of source category 1A2a Iron foundries, cupola furnaces and in the activity data (natural gas) of source category 1A2f Container glass.
- 1A2gviii: The Swiss statistics of energy consumption (SFOE 2024) has recalculated the amount of other bituminous coal used in industry for the years 2019-2022. This leads to recalculation in other industrial boilers of source category 1A2gviii Other.
- 1A2gviii: Activity data of automatic wood combustion installations (≥ 50 kW) in source category 1A2gviii were revised for 2019-2022 due to recalculations in the Swiss wood energy statistics (SFOE 2024b), with the largest changes occurring in 2022. In addition, a typing error in the activity data 2022 of plants for renewable waste from wood products was corrected.
- 1A2gviii: Due to new model-runs, there are small recalculations of activity data for all stationary engines and gas turbines 1990-2022.

## 3.2.4 Source category 1A4 - Stationary combustion in other sectors (commercial, residential, agriculture and forestry)

### 3.2.4.1 Source category description for 1A4 Stationary combustion in other sectors (commercial, residential, agriculture and forestry)

The source category 1A4 Stationary combustion in other sectors comprises all emissions from the combustion of fuels in stationary boilers and cogeneration in facilities within processes in commerce and institutions, households, agriculture and forestry. This includes use of conventional fossil fuels as well as biomass. Within this category, only activities involving fuel combustion are taken into account. Note that information regarding fuel combustion in source category 1A4 Non-road and machinery in other sectors are provided in chapter 3.2.7.

Table 3-59 Specification of source category 1A4 Stationary combustion in other sectors.

| 1A4 | Source category | Specification |
|---|---|---|
| 1A4ai | Commercial/institutional: Stationary | Stationary fuel combustion in commercial and institutional buildings as different wood combustions, boilers and engines with combined heat and power generation unit, engines and gas turbines at biogas and sewage plants, emergency generators |
| 1A4bi | Residential: Stationary | Stationary fuel combustion in households, including different wood combustion installations, boilers and engines |
| 1A4ci | Agriculture/Forestry/Fishing: Stationary | Stationary fuel combustion in agriculture, including different wood combustion installations, engines at biogas plants, emergency generators, heating of greenhouses and grass drying |

Table 3-60 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 1A4 Stationary combustion in other sectors.

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 1A4ai | Commercial/institutional: stationary | NOx | L1, L2, T1, T2 |
| 1A4ai | Commercial/institutional: stationary | SOx | T1, T2 |
| 1A4ai | Commercial/institutional: stationary | PM2.5 | L1, L2, T1 |
| 1A4ai | Commercial/institutional: stationary | PM10 | L1, L2 |
| 1A4bi | Residential: stationary plants | NOx | L1, L2 |
| 1A4bi | Residential: stationary plants | NMVOC | L1, L2 |
| 1A4bi | Residential: stationary plants | SOx | L1, L2, T1, T2 |
| 1A4bi | Residential: stationary plants | PM2.5 | L1, L2, T1, T2 |
| 1A4bi | Residential: stationary plants | PM10 | L1, L2, T1, T2 |
| 1A4ci | Agriculture/forestry/fishing: stationary | SOx | L2 |
| 1A4ci | Agriculture/forestry/fishing: stationary | PM2.5 | L1 |

### 3.2.4.2 Methodological issues for 1A4 Stationary combustion in other sectors (commercial, residential, agriculture and forestry)

#### 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. A considerable part (10-20 %) of the fuel consumption consists of wood and wood wastes. Source category 1A4ai also includes emissions from mobile pellet combustion installations (from 2017 onwards) that are used for temporary applications such as construction drying, events in large marquees or as emergency solutions in the event of heating failures. Beside the main energy sources, also the use of other bituminous coal, charcoal use and bonfires are considered in source category 1A4bi. Emissions from 1A4ci originate from fuel combustion for the heating of greenhouses and grass drying, as well as 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 chapter 1A4 small combustion in the EMEP/EEA guidebook (EMEP/EEA 2023). Emission factors and activity data are specified for different technologies. Direct emission measurements are not available.

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

Table 3-61, Table 3-62 and Table 3-63 present the emission factors applied for source categories 1A4ai, 1A4bi and 1A4ci, respectively. Please note the following additional information:

- For boilers, the emission factors of $NO_x$ and CO for natural gas, biogas and gas oil are based on a study by Leupro (2012) for the years 1990-2010, and Zotter and Nussbaumer (2025) for 2022 (and the projections). Within those studies, measurements from the control of combustion installations in eight and eleven Swiss cantons and the city of Zurich, respectively, were analysed. Emission factors are thus country specific.
- For boilers, the emission factors for PM10, PM2.5 and TSP for natural gas, biogas and gas oil are based on a study by Leupro (2012).
- For boilers, the emission factors for NMVOC are documented in SAEFL (2000).
- For boilers with natural gas or biogas, the emission factors for Pb, Cd, Hg and PAH are taken from the EMEP/EEA guidebook (EMEP/EEA 2019, chp. 1.A.4 Small combustion) as follows. 1A4ai: natural gas/biogas boilers table 3-26, 1A4bi: natural gas boilers table 3-16, 1A4ci: natural gas/biogas boilers table 3-26.
- For boilers with gas oil, the emission factors for Pb, Cd and Hg are taken from table 3-18 in the EMEP/EEA guidebook (EMEP/EEA 2023), PAHs are from table 3-31 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 EMEP/EEA guidebook representing average of Tier 2 emission factors for commercial/institutional liquid fuel combustion for all technologies. These PAH emission factor values have been taken since the proposed values in table 3-18 are based on a relatively old reference from 1995 and are rather high compared to other PAH values within the guidebook.
- For boilers with other bituminous coal in 1A4bi, Hg emission factors stem from table 3-23 in the EMEP/EEA guidebook (EMEP/EEA 2019, chp. 1A4) allocated to non-residential sources (automatic boilers) burning coal fuels and not from table 3-15 in the EMEP/EEA guidebook (EMEP/EEA 2019) allocated to residential boilers burning solid fuels. This choice was made because table 3-15 provides for Hg with 6 g/TJ a lower value than table 3-23 with 16 g/TJ for advanced technology.
- For boilers using gaseous and liquid fuels, the HCB emission factors are based on the approach of the Danish Emission Inventory for hexachlorobenzene and polychlorinated biphenyls (Nielsen et al. 2013).
- For boilers with solid and liquid fossil fuels as well as of wood and wood waste combustion, the emission factors of PCB are taken from the Danish emission inventory for HCB and PCBs (Nielsen et al. 2013).
- Emission factors for $SO_x$ are described in chp. 3.2.1.2.
- Wood combustion in1A4ai/bi/ci: The country-specific emission factor model for wood energy is described in chp. 3.2.1.1.3. For mobile pellet combustion installations in source

category 1A4ai, the same emission factors are assumed as for the installation category (stationary) automatic pellet boilers 50-300 kW.

- Emission factors for combined heat and power generation in turbines and engines are based on INFRAS (2022a) as described in chapter 3.2.1.1.2.
- Bonfires and use of charcoal (within 1A4bi): Emission factors of $NO_x$, NMVOC, $SO_x$, $NH_3$, PM2.5/PM10, TSP, CO, Pb, Cd, Hg, PCDD/PCDF, PAH and HCB are taken from EMEP/EEA guidebook, Tier 2 level of source category open fireplaces burning biomass (EMEP/EEA 2023, chp.1A4, Table 3-39) as shown in Table 3-62. According to the EMEP/EEA guidebook (EMEP/EEA 2023, 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 EMIS 2025/1A4bi Lagerfeuer and EMIS 2025/1A4bi Holzkohle Verbrauch.
- 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).

Table 3-61 Emission factors for 1A4ai for 2023. All fuels not listed are "NO".

| 1A4ai Commercial/Institutional Stationary | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Boilers | Gas oil | GJ | 28 | 6.0 | 0.84 | 0.0010 | 0.19 | 0.19 | 0.19 | 0.0074 | 5.3 |
| Engines | Gas oil | GJ | 819 | 50 | 0.84 | 1.5 | 16 | 16 | 16 | 2.3 | 137 |
| Engines | Liquefied petroleum gas | GJ | 135 | 89 | 0.50 | NA | 2.0 | 2.0 | 2.0 | 0.0050 | 56 |
| Boilers | Natural gas | GJ | 13 | 2.0 | 0.23 | 0.0010 | 0.090 | 0.090 | 0.090 | 0.0049 | 8.7 |
| Engines | Natural gas | GJ | 72 | 89 | 0.23 | 2.5 | 2.0 | 2.0 | 2.0 | 0.0041 | 54 |
| Turbines | Natural gas | GJ | 53 | 1.6 | 0.23 | NA | 0.20 | 0.20 | 0.20 | 0.00050 | 25 |
| Engines | Biodiesel fossil | GJ | 295 | 50 | 0.30 | 5.8 | 30 | 30 | 30 | 2.3 | 134 |
| Engines | Biodiesel biogenic | GJ | 295 | 50 | 0.30 | 5.8 | 30 | 30 | 30 | 2.3 | 134 |
| Engines | Biogas | GJ | 99 | 89 | 0.50 | 3.7 | 2.0 | 2.0 | 2.0 | 0.0039 | 130 |
| Wood combustion | Wood and wood waste | GJ | 109 | 33 | 5.0 | 2.5 | 26 | 28 | 29 | 6.6 | 482 |
| Boilers | Sewage gas | GJ | 13 | 2.0 | 0.50 | 0.0010 | 0.090 | 0.090 | 0.090 | 0.0049 | 8.7 |
| Engines | Sewage gas | GJ | 101 | 89 | 0.50 | 2.0 | 2.0 | 2.0 | 2.0 | 0.0042 | 141 |
| Turbines | Sewage gas | GJ | 48 | 1.6 | 0.50 | NA | 0.23 | 0.23 | 0.23 | 0.00050 | 10.0 |

| 1A4ai Commercial/Institutional Stationary | | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| Boilers | Gas oil | GJ | 0.012 | 0.0010 | 0.12 | 1.8 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| Engines | Gas oil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| Engines | Liquefied petroleum gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0013 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| Boilers | Natural gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| Engines | Natural gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| Turbines | Natural gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| Engines | Biodiesel fossil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| Engines | Biodiesel biogenic | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| Engines | Biogas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| Wood combustion | Wood and wood waste | GJ | 18 | 1.1 | 2.0 | 97 | 7.0 | 7.0 | 4.3 | 4.3 | 2'659 | 15 |
| Boilers | Sewage gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| Engines | Sewage gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| Turbines | Sewage gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |

Table 3-62 Emission factors for 1A4bi (including charcoal and bonfires) for 2023. All fuels not listed are "NO".

| 1A4bi Residential Stationary | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Boilers | Gas oil | GJ | 26 | 6.0 | 0.84 | 0.0010 | 0.19 | 0.19 | 0.19 | 0.0074 | 7.6 |
| Engines | Gas oil | GJ | 137 | 50 | 0.84 | 8.9 | 30 | 30 | 30 | 2.3 | 136 |
| Engines | Liquefied petroleum gas | GJ | 135 | 89 | 0.50 | NA | 2.0 | 2.0 | 2.0 | 0.0050 | 56 |
| Boilers | Other bituminous coal | GJ | 65 | 100 | 350 | 1.6 | 66 | 66 | 96 | 4.2 | 1'000 |
| Boilers | Natural gas | GJ | 11 | 4.0 | 0.23 | 0.0010 | 0.090 | 0.090 | 0.090 | 0.0049 | 10 |
| Engines | Natural gas | GJ | 71 | 89 | 0.23 | 2.5 | 2.0 | 2.0 | 2.0 | 0.0041 | 54 |
| Engines | Biodiesel fossil | GJ | 407 | 50 | 0.30 | 3.5 | 30 | 30 | 30 | 2.3 | 132 |
| Engines | Biodiesel biogenic | GJ | 407 | 50 | 0.30 | 3.5 | 30 | 30 | 30 | 2.3 | 132 |
| Engines | Biogas | GJ | 96 | 89 | 0.50 | 2.5 | 2.0 | 2.0 | 2.0 | 0.0041 | 86 |
| Wood combustion | Wood and wood waste | GJ | 94 | 88 | 7.5 | 2.9 | 47 | 50 | 52 | 22 | 1'183 |
| Use of charcoal | Charcoal | GJ | 50 | 600 | 11 | 8.0 | 820 | 840 | 880 | 57 | 4'000 |
| Bonfires | Wood (bonfires) | GJ | 50 | 600 | 11 | 8.0 | 820 | 840 | 880 | 57 | 4'000 |

| 1A4bi Residential Stationary | | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| Boilers | Gas oil | GJ | 0.012 | 0.0010 | 0.12 | 1.8 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| Engines | Gas oil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| Engines | Liquefied petroleum gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0013 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| Boilers | Other bituminous coal | GJ | 200 | 3.0 | 16 | 500 | 270 | 250 | 100 | 90 | 620 | 66 |
| Boilers | Natural gas | GJ | 0.0015 | 0.00025 | 0.10 | 1.5 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| Engines | Natural gas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| Engines | Biodiesel fossil | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| Engines | Biodiesel biogenic | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| Engines | Biogas | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| Wood combustion | Wood and wood waste | GJ | 18 | 1.0 | 2.0 | 202 | 20 | 20 | 11 | 11 | 3'972 | 26 |
| Use of charcoal | Charcoal | GJ | 27 | 13 | 0.56 | 800 | 121 | 111 | 42 | 71 | 5'000 | 60 |
| Bonfires | Wood (bonfires) | GJ | 27 | 13 | 0.56 | 800 | 121 | 111 | 42 | 71 | 5'733 | 60 |

Table 3-63 Emission factors for 1A4ci for 2023. All fuels not listed are "NO".

| 1A4ci Agriculture/forestry/ fishing | Unit of activity data | $NO_x$ | NMVOC | $SO_x$ | $NH_3$ | PM2.5 | PM10 | TSP | BC | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Drying of grass | GJ | 79 | 107 | 89 | NA | 304 | 304 | 304 | 14 | 609 |
| Heating of greenhouses (weighted average) | GJ | 18 | 2.0 | 0.44 | 0.0013 | 0.12 | 0.12 | 0.12 | 0.0057 | 7.5 |
| Gas oil | GJ | 28 | 2.0 | 0.84 | 0.0020 | 0.19 | 0.19 | 0.19 | 0.0074 | 5.3 |
| Natural gas | GJ | 13 | 2.0 | 0.23 | 0.0010 | 0.090 | 0.090 | 0.090 | 0.0049 | 8.7 |
| Other fossil combustion (weighted average) | GJ | 942 | 50 | 0.84 | 0.10 | 27 | 27 | 27 | 2.3 | 137 |
| Gas oil (engines) | GJ | 942 | 50 | 0.84 | 0.10 | 27 | 27 | 27 | 2.3 | 137 |
| Natural gas (engines) | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Other biomass combustion (weighted average) | GJ | 102 | 67 | 2.1 | 2.9 | 13 | 13 | 14 | 1.6 | 226 |
| Biogas (engines) | GJ | 97 | 89 | 0.50 | 3.2 | 2.0 | 2.0 | 2.0 | 0.0038 | 108 |
| Wood and wood waste (various furnaces) | GJ | 111 | 21 | 5.6 | 2.1 | 35 | 37 | 39 | 4.9 | 476 |

| 1A4ci Agriculture/forestry/ fishing | Unit of activity data | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | ng I-TEQ/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| Drying of grass | GJ | 6.6 | 1.3 | 0.69 | NE | NE | NE | NE | NE | NE | NE |
| Heating of greenhouses (weighted average) | GJ | 0.0051 | 0.00050 | 0.11 | 0.94 | 0.0010 | 0.0056 | 0.0011 | 0.0011 | 75 | 0.037 |
| Gas oil | GJ | 0.012 | 0.0010 | 0.12 | 1.8 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| Natural gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| Other fossil combustion (weighted average) | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| Gas oil (engines) | GJ | 0.15 | 0.010 | 0.11 | 0.99 | 0.0019 | 0.015 | 0.0017 | 0.0015 | 220 | 0.11 |
| Natural gas (engines) | GJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Other biomass combustion (weighted average) | GJ | 5.7 | 0.34 | 0.71 | 25 | 2.2 | 2.2 | 1.1 | 1.1 | 3'335 | 12 |
| Biogas (engines) | GJ | 0.040 | 0.0030 | 0.10 | 0.57 | 0.0012 | 0.0090 | 0.0017 | 0.0018 | NA | NA |
| Wood and wood waste (various furnaces) | GJ | 18 | 1.0 | 2.0 | 77 | 6.7 | 6.7 | 3.4 | 3.4 | 3'335 | 12 |

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

Activity data on consumption of gas oil, residual fuel oil, natural gas and biomass are calculated by the energy model (see chp. 3.1.6.2 for further information) and the Energy model for wood combustion (see chp. 3.2.1.1.3). For other energy sources such as other bituminous coal, activity data are provided directly by the Swiss overall energy statistics (SFOE 2024).

The activity data on fuel consumption in 1A4ai Mobile pellet combustion installations used for temporary applications are based on information from the Swiss wood energy statistics publication (SFOE 2024b, chp. 1.4). However, this is not part of the wood energy statistics model.

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 2024).

As the Swiss wood energy statistics (SFOE 2024b) cover wood used for heating and energy purposes only, no figures are available on wood burnt in source category 1A4bi Bonfires. The activity data of bonfires are thus expert judgements based on a per capita consumption. Two types of bonfires are considered: (public) traditional bonfires such as on national day and (private) bonfires for barbecuing. The number of traditional bonfires has declined, as fewer communities are holding national day bonfires. With the increasing use of gas barbecues, there has also been a decrease in bonfires for barbecuing. Overall, a constant wood consumption was therefore assumed for bonfires due to the declining per capita consumption and increasing population (EMIS 2025/1A4bi Lagerfeuer).

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 3-12 and Figure 3-16.

Since submission 2015, data on fuel consumption for grass drying are available and used for emission calculations (see EMIS 2025/1A4ci Grastrocknung). The use of gas oil and natural gas for grass drying in 1A4ci is subtracted from boilers in 1A4ai.

The fuel consumption for the heating of greenhouses is extrapolated from the information provided by the Energy Agency of the Swiss Private Sector (EnAW) as documented in the EMIS database (EMIS 2025/1A4ci Gewächshäuser).

Table 3-64 Activity data of 1A4ai Commercial/institutional. All fuels not listed are "NO".

| 1A4ai Commercial/Institutional Stationary | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 73'725 | 81'713 | 78'706 | 85'366 | 81'751 |
| Boilers | Gas oil | TJ | 52'548 | 53'823 | 47'804 | 50'261 | 45'940 |
| Engines | Gas oil | TJ | 427 | 554 | 971 | 935 | 583 |
| Engines | Liquefied petroleum gas | TJ | 2.4 | 39 | 108 | 95 | 109 |
| Boilers | Natural gas | TJ | 16'196 | 20'597 | 21'497 | 24'205 | 23'281 |
| Engines | Natural gas | TJ | 355 | 1'408 | 2'170 | 2'597 | 2'090 |
| Turbines | Natural gas | TJ | NO | 0.23 | 0.073 | NO | 0.019 |
| Engines | Biodiesel fossil | TJ | NO | NO | 1.3 | 0.39 | 2.5 |
| Engines | Biodiesel biogenic | TJ | NO | NO | 25 | 7.5 | 54 |
| Engines | Biogas | TJ | NO | 29 | 82 | 143 | 394 |
| Wood combustion | Wood and wood waste | TJ | 2'940 | 3'870 | 4'451 | 5'427 | 7'533 |
| Boilers | Sewage gas | TJ | 468 | 448 | 429 | 410 | 392 |
| Engines | Sewage gas | TJ | 610 | 775 | 1'100 | 1'284 | 1'351 |
| Turbines | Sewage gas | TJ | 179 | 169 | 66 | NO | 18 |

| 1A4ai Commercial/Institutional Stationary | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 63'561 | 69'557 | 72'926 | 70'414 | 63'895 | 64'346 | 61'597 | 70'377 | 57'438 | 56'546 |
| Boilers | Gas oil | TJ | 32'491 | 34'661 | 35'957 | 33'727 | 30'414 | 29'793 | 27'126 | 30'881 | 25'152 | 24'942 |
| Engines | Gas oil | TJ | 499 | 490 | 481 | 493 | 463 | 478 | 468 | 466 | 464 | 459 |
| Engines | Liquefied petroleum gas | TJ | 97 | 87 | 121 | 44 | 29 | 23 | 23 | 23 | 23 | 23 |
| Boilers | Natural gas | TJ | 18'624 | 21'564 | 22'909 | 22'680 | 20'062 | 20'806 | 20'125 | 23'187 | 17'361 | 16'156 |
| Engines | Natural gas | TJ | 1'670 | 1'597 | 1'481 | 1'336 | 1'159 | 999 | 964 | 986 | 1'026 | 1'017 |
| Turbines | Natural gas | TJ | 0.027 | 0.029 | 0.25 | 0.23 | 0.24 | 0.23 | 0.21 | 0.20 | 0.20 | 0.19 |
| Engines | Biodiesel fossil | TJ | 2.7 | 2.6 | 2.2 | 2.0 | 1.9 | 1.6 | 1.7 | 1.8 | 1.9 | 1.9 |
| Engines | Biodiesel biogenic | TJ | 48 | 46 | 47 | 43 | 43 | 35 | 34 | 34 | 34 | 33 |
| Engines | Biogas | TJ | 701 | 738 | 780 | 807 | 818 | 813 | 838 | 821 | 934 | 948 |
| Wood combustion | Wood and wood waste | TJ | 7'720 | 8'702 | 9'516 | 9'642 | 9'258 | 9'763 | 10'367 | 12'320 | 10'833 | 11'365 |
| Boilers | Sewage gas | TJ | 374 | 367 | 360 | 353 | 346 | 338 | 338 | 338 | 338 | 338 |
| Engines | Sewage gas | TJ | 1'306 | 1'274 | 1'241 | 1'257 | 1'264 | 1'259 | 1'276 | 1'282 | 1'235 | 1'227 |
| Turbines | Sewage gas | TJ | 25 | 25 | 26 | 26 | 34 | 33 | 34 | 34 | 33 | 32 |

Table 3-65 Activity data of 1A4bi Residential. All fuels not listed are "NO".

| 1A4bi Residential Stationary | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 185'560 | 189'596 | 170'753 | 186'291 | 182'299 |
| Boilers | Gas oil | TJ | 136'882 | 133'529 | 116'231 | 123'964 | 111'712 |
| Engines | Gas oil | TJ | 4.9 | 19 | 64 | 60 | 20 |
| Engines | Liquefied petroleum gas | TJ | 0.26 | 4.0 | 11 | 11 | 12 |
| Boilers | Other bituminous coal | TJ | 630 | 460 | 130 | 400 | 400 |
| Boilers | Natural gas | TJ | 26'075 | 34'234 | 36'270 | 42'555 | 48'195 |
| Engines | Natural gas | TJ | 39 | 156 | 241 | 288 | 232 |
| Engines | Biodiesel fossil | TJ | NO | NO | NO | 0.035 | 0.15 |
| Engines | Biodiesel biogenic | TJ | NO | NO | NO | 0.69 | 3.3 |
| Engines | Biogas | TJ | NO | NO | NO | NO | NO |
| Wood combustion | Wood and wood waste | TJ | 21'457 | 20'741 | 17'353 | 18'540 | 21'222 |
| Use of charcoal | Charcoal | TJ | 311 | 291 | 292 | 313 | 344 |
| Bonfires | Wood (bonfires) | TJ | 160 | 160 | 160 | 160 | 160 |

| 1A4bi Residential Stationary | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 135'296 | 145'010 | 151'174 | 145'048 | 133'301 | 134'208 | 124'773 | 140'012 | 114'671 | 111'183 |
| Boilers | Gas oil | TJ | 75'126 | 79'398 | 81'332 | 76'104 | 67'896 | 66'635 | 59'369 | 66'042 | 51'241 | 49'794 |
| Engines | Gas oil | TJ | 9.7 | 8.5 | 7.4 | 8.4 | 4.8 | 6.4 | 6.2 | 6.1 | 6.2 | 6.0 |
| Engines | Liquefied petroleum gas | TJ | 11 | 9.6 | 14 | 4.9 | 3.3 | 2.6 | 2.5 | 2.5 | 2.6 | 2.5 |
| Boilers | Other bituminous coal | TJ | 200 | 200 | 200 | 100 | 100 | 100 | 100 | 100 | 50 | 50 |
| Boilers | Natural gas | TJ | 42'369 | 46'118 | 48'862 | 48'380 | 45'992 | 47'671 | 47'308 | 53'185 | 45'411 | 42'992 |
| Engines | Natural gas | TJ | 185 | 177 | 163 | 147 | 128 | 110 | 106 | 109 | 113 | 112 |
| Engines | Biodiesel fossil | TJ | 0.16 | 0.15 | 0.12 | 0.12 | 0.097 | 0.098 | 0.10 | 0.11 | 0.12 | 0.11 |
| Engines | Biodiesel biogenic | TJ | 2.9 | 2.6 | 2.5 | 2.6 | 2.2 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| Engines | Biogas | TJ | NO | NO | NO | NO | NO | NO | 3.5 | 3.7 | 4.1 | 4.4 |
| Wood combustion | Wood and wood waste | TJ | 16'878 | 18'582 | 20'099 | 19'766 | 18'661 | 19'195 | 17'312 | 20'037 | 17'327 | 17'704 |
| Use of charcoal | Charcoal | TJ | 354 | 354 | 334 | 374 | 354 | 325 | 404 | 364 | 353 | 356 |
| Bonfires | Wood (bonfires) | TJ | 160 | 160 | 160 | 160 | 160 | 160 | 160 | 160 | 160 | 160 |

Table 3-66 Activity data of 1A4ci Agriculture / forestry / fishing. All fuels not listed are "NO".

| **1A4ci Other sectors (stationary): Agriculture/forestry/fishing** | **Unit** | **1990** | **1995** | **2000** | **2005** | **2010** |
|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 6'387 | 6'110 | 5'804 | 5'531 | 5'656 |
| Drying of grass | TJ | 1'895 | 1'544 | 1'223 | 994 | 739 |
| Gas oil | TJ | 1'156 | 942 | 746 | 607 | 451 |
| Residual fuel oil | TJ | NO | NO | NO | NO | NO |
| Natural gas | TJ | 739 | 602 | 477 | 388 | 288 |
| Biomass (crop residues, fat, wood) | TJ | NO | NO | NO | NO | NO |
| Heating of greenhouses | TJ | 4'000 | 4'000 | 4'000 | 3'735 | 3'677 |
| Gas oil | TJ | 3'490 | 3'490 | 3'490 | 3'133 | 1'803 |
| Natural gas | TJ | 510 | 510 | 510 | 601 | 1'874 |
| Other fossil combustion | TJ | 4.86 | 3.41 | 4.57 | 4.46 | 2.12 |
| Gas oil (engines) | TJ | 2.1 | 2.12 | 2.12 | 2.12 | 2.12 |
| Natural gas (engines) | TJ | 2.7 | 1.29 | 2.45 | 2.34 | NO |
| Other biomass combustion | TJ | 487 | 563 | 577 | 797 | 1'239 |
| Biogas (engines) | TJ | 59 | 49 | 62 | 128 | 497 |
| Wood and wood waste (various furnaces) | TJ | 428 | 514 | 515 | 669 | 741 |

| **1A4ci Other sectors (stationary): Agriculture/forestry/fishing** | **Unit** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 4'764 | 4'937 | 5'442 | 5'962 | 5'488 | 5'824 | 5'943 | 6'375 | 5'536 | 5'577 |
| Drying of grass | TJ | 524 | 431 | 492 | 610 | 545 | 684 | 721 | 630 | 559 | 495 |
| Gas oil | TJ | 104 | 89 | 86 | 118 | 116 | 124 | 148 | 94 | 99 | 150 |
| Residual fuel oil | TJ | 20 | 22 | 18 | 25 | 13 | NO | NO | NO | NO | NO |
| Natural gas | TJ | 264 | 233 | 279 | 338 | 296 | 427 | 435 | 410 | 347 | 221 |
| Biomass (crop residues, fat, wood) | TJ | 136 | 88 | 109 | 129 | 120 | 132 | 138 | 126 | 113 | 124 |
| Heating of greenhouses | TJ | 2'800 | 2'900 | 2'899 | 3'238 | 2'754 | 2'732 | 2'537 | 2'753 | 2'114 | 2'125 |
| Gas oil | TJ | 1'095 | 1'165 | 1'066 | 1'145 | 930 | 916 | 788 | 861 | 717 | 720 |
| Natural gas | TJ | 1'705 | 1'735 | 1'834 | 2'093 | 1'824 | 1'816 | 1'749 | 1'892 | 1'397 | 1'405 |
| Other fossil combustion | TJ | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| Gas oil (engines) | TJ | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| Natural gas (engines) | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Other biomass combustion | TJ | 1'438 | 1'605 | 2'048 | 2'112 | 2'187 | 2'406 | 2'682 | 2'989 | 2'862 | 2'954 |
| Biogas (engines) | TJ | 928 | 1'041 | 1'192 | 1'272 | 1'403 | 1'612 | 1'762 | 1'909 | 1'946 | 2'003 |
| Wood and wood waste (various furnaces) | TJ | 510 | 564 | 856 | 840 | 784 | 795 | 921 | 1'081 | 916 | 951 |

### 3.2.4.3 Category-specific recalculations for 1A4 Stationary combustion in other sectors (commercial, residential, agriculture and forestry)

The following recalculations were implemented in submission 2025:

- 1A4: Activity data of automatic wood combustion installations (≥ 50 kW) in source categories 1A4ai, 1A4bi and 1A4ci were revised for 2019-2022 due to recalculations in the Swiss wood energy statistics (SFOE 2024b).
- 1A4: The emission factors of $NO_x$ and CO for natural gas and gas oil boilers were updated for 2022 based on the evaluation of a large number of air pollution control measurements of combustion installations in numerous Swiss cantons. This has resulted in revised emission factors of $NO_x$ and CO for all boilers fuelled with gas oil and natural gas in source categories 1A4ai Commercial/Institutional and 1A4bi Residential as well as 1A4ai Boiler, sewage gas, 1A4ai Statistical difference, biogas, and 1A4ci Greenhouses (gas oil, natural gas) from 2011 onwards. In addition, the values of the $NO_x$ and CO emission factors for the years 1990–2010 were also adjusted for 1A4ai Boiler, sewage gas, and 1A4ci Greenhouses (gas oil, natural gas) based on their nominal heat output. The projected emission factor values for all particulate matter fractions (2035, PM2.5, PM10, TSP and BC) were also updated, resulting in changes to the linearly interpolated emission factors for 2021 and 2022.
- 1A4: Due to new model-runs, there are small recalculations of activity data for all stationary engines and gas turbines 1990-2022 in source categories 1A4ai, 1A4bi and 1A4ci.
- 1A4, year 2022: Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_2$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated.
- 1A4ai: Activity data of mobile pellet combustion installations were revised for 2021 and 2022 due to recalculations in the Swiss wood energy statistics publication (SFOE 2024b, chp. 1.3).
- 1A4ai: The Swiss statistic of energy consumption (SFOE 2024) has newly added the amount of Liquefied Natural Gas (LNG) used to the total amount of natural gas used for the years 2020-2022. This leads to small recalculations mainly in source categories 1A3b Road transportation, 1A4ai Commercial/institutional (stationary) and 1B2b Natural gas losses.

## 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 industries and construction

Table 3-67 Specification of source category 1A2 Mobile combustion in manufacturing industries and construction.

| 1A2 | Source category | Specification |
|---|---|---|
| 1A2gvii | Mobile combustion in manufacturing industries and construction | Industry sector: forklifts and snow groomers etc.<br>Construction machines: excavators, loaders, dump trucks, mobile compressors etc. |

Table 3-68 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 1A2 Combustion in manufacturing industries and construction (mobile only).

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 1A2gvii | Mobile combustion in manufacturing industries and construction | NOx | T1 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM2.5 | L1, L2, T1, T2 |
| 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 industries 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 (EMEP/EEA 2023), 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 general sources for the emission factors of the non-road model are described in chp. 3.2.1.1.1. Power class and emission standard-specific emission factors are shown in Table 3-69 to Table 3-72. Implied emission factors for the reporting year are shown in Table 3-73. For the greenhouse gas inventory under UNFCCC the fossil carbon fraction of biodiesel is estimated based on the method described in chapter 3.2.1.1.1. For technical reasons in our database, there is a split of the whole biodiesel amount in fossil and biogenic biodiesel and not only for the carbon fraction and $CO_2$. Therefore, there are two lines with biodiesel, one with "biodiesel fossil" and one with "biodiesel biogenic".

Table 3-69 Emission factors for diesel-powered machinery (1A2gvii) per emission standard.

| 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 3-70 Emission factors for gasoline-powered machinery (4-stroke engines) (1A2gvii) per emission standard. 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 3-71 Emission factors for gasoline-powered machinery (2-stroke engines) (1A2gvii) per emission standard. 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 3-72 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 3-73 Implied emission factors for 1A2gvii in 2023.

| 1A2gvii Mobile combustion in manufacturing industries and construction | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx |
|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Gasoline | GJ | NA | NA | 0.19 | NA | NA | NA | NA | NA |
| Diesel oil | GJ | NA | NA | 0.30 | NA | NA | NA | NA | NA |
| Biodiesel fossil | GJ | 169 | 18 | 0.30 | 0.17 | 3.9 | NA | 3.9 | NA |
| Biodiesel biogenic | GJ | 169 | 18 | 0.30 | 0.17 | 3.9 | NA | 3.9 | NA |
| Bioethanol | GJ | 58 | 305 | 0.19 | 0.091 | 0.29 | NA | 0.29 | NA |
| Working hours gasoline | h | 4.0 | 26 | NA | 0.0040 | 0.058 | NA | 0.058 | NA |
| Working hours diesel oil | h | 48 | 5.0 | NA | 0.048 | 1.1 | NA | 1.1 | NA |
| Working hours LPG | h | 16 | 1.5 | NA | 0.037 | 0.081 | NA | 0.081 | NA |
| Working hours (for non-exhaust only) | h | NA | NA | NA | NA | NA | 2.4 | NA | 16 |

| 1A2gvii Mobile combustion in manufacturing industries and construction | Unit | TSP ex | TSP nx | BC ex | BC nx | CO | Pb | Cd | Hg |
|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | mg/... | mg/... | mg/... |
| Gasoline | GJ | NA | NA | NA | NA | NA | 16 | NA | NA |
| Diesel oil | GJ | NA | NA | NA | NA | NA | NA | NA | NA |
| Biodiesel fossil | GJ | 3.9 | NA | 1.8 | NA | 86 | 0.89 | 2.1 | 0.11 |
| Biodiesel biogenic | GJ | 3.9 | NA | 1.8 | NA | 86 | 0.89 | 2.1 | 0.11 |
| Bioethanol | GJ | 0.29 | NA | 0.014 | NA | 18'557 | 0.59 | 2.3 | 0.20 |
| Working hours gasoline | h | 0.058 | NA | 0.0029 | NA | 889 | 0.027 | 0.10 | 0.0090 |
| Working hours diesel oil | h | 1.1 | NA | 0.52 | NA | 24 | 0.25 | 0.59 | 0.032 |
| Working hours LPG | h | 0.081 | NA | 0.0041 | NA | 4.2 | NA | 0.040 | NA |
| Working hours (for non-exhaust only) | h | NA | 24 | NA | 0.0030 | NA | NA | NA | NA |

| 1A2gvii Mobile combustion in manufacturing industries and construction | Unit | PCDD/ PCDF | BaP | BbF | BkF | IcdP |
|---|---|---|---|---|---|---|
| | | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... |
| Gasoline | GJ | NA | NA | NA | NA | NA |
| Diesel oil | GJ | NA | NA | NA | NA | NA |
| Biodiesel fossil | GJ | 1.5 | 0.64 | 1.1 | 0.79 | 0.18 |
| Biodiesel biogenic | GJ | 1.5 | 0.64 | 1.1 | 0.79 | 0.18 |
| Bioethanol | GJ | 2.7 | 1.0 | 1.0 | 0.099 | 0.30 |
| Working hours gasoline | h | 0.12 | 0.046 | 0.046 | 0.0045 | 0.014 |
| Working hours diesel oil | h | 0.42 | 0.18 | 0.30 | 0.22 | 0.051 |
| Working hours LPG | h | NA | 0.00075 | NA | 0.00075 | 0.00075 |
| Working hours (for non-exhaust only) | h | NA | NA | NA | NA | NA |

## Activity data (1A2gvii)

Table 3-74 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 2024a).

Detailed activity data can be downloaded from the online database INFRAS (2015a).

Table 3-74 Activity data for 1A2gvii.

| 1A2gvii Mobile combustion in manufacturing industries and construction | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 5'721 | 6'852 | 7'636 | 8'169 | 8'779 |
| Gasoline | TJ | 196 | 224 | 227 | 225 | 220 |
| Diesel oil | TJ | 5'359 | 6'380 | 7'108 | 7'630 | 8'259 |
| Liquefied petroleum gas | TJ | 165 | 248 | 294 | 290 | 269 |
| Biodiesel fossil | TJ | NO | NO | 0.41 | 1.2 | 1.4 |
| Biodiesel biogenic | TJ | NO | NO | 7.5 | 23 | 30 |
| Bioethanol | TJ | NO | NO | NO | NO | 0.0029 |

| 1A2gvii Mobile combustion in manufacturing industries and construction | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 8'906 | 8'938 | 8'945 | 8'951 | 8'958 | 8'964 | 8'971 | 8'974 | 8'977 | 8'981 |
| Gasoline | TJ | 191 | 184 | 181 | 179 | 176 | 173 | 171 | 170 | 169 | 169 |
| Diesel oil | TJ | 8'384 | 8'416 | 8'368 | 8'321 | 8'273 | 8'226 | 8'178 | 8'225 | 8'273 | 8'320 |
| Liquefied petroleum gas | TJ | 235 | 226 | 215 | 203 | 192 | 180 | 168 | 142 | 115 | 88 |
| Biodiesel fossil | TJ | 5.0 | 5.9 | 8.9 | 12 | 15 | 18 | 21 | 21 | 20 | 20 |
| Biodiesel biogenic | TJ | 90 | 105 | 170 | 235 | 300 | 365 | 430 | 414 | 397 | 381 |
| Bioethanol | TJ | 0.64 | 0.80 | 1.1 | 1.4 | 1.7 | 1.9 | 2.2 | 2.5 | 2.7 | 2.9 |

#### 3.2.5.3 Category-specific recalculations for 1A2 Mobile combustion in manufacturing industries and construction

The following recalculations were implemented in submission 2025:

- 1A2gvii: The fossil carbon fraction in biodiesel is now estimated based on the method described in Sebos (2022). The fossil fraction of FAME (Fatty Acid Methyl Ester) is based on the values from HBEFA 4.1 (relevant for the whole EU), while all carbon in HVO (Hydrotreated Vegetable Oil) is considered of biogenic origin. Because biodiesel as reported by Switzerland consists of the sum of FAME and HVO, the fossil fraction of biodiesel varies over time. Overall, around 4.0 to 5.4 % of the total biodiesel are now reported under “fossil liquid fuels” for the years 1996–2022 (no biodiesel in the years before). In consequence, this leads to recalculations in fuel categories including biodiesel as “biomass” or “biofuels” and “liquid fuels” as well.
- 1A2gvii: An update of the fuel mix and consumption from non-road machineries leads to small recalculations in all source categories affected by the non-road transportation model and for all years 1990-2022.

## 3.2.6 Source category 1A3 - Transport

### 3.2.6.1 Source category description for 1A3 Transport

The source category 1A3 Transport includes all emissions from fuel combustion in transport processes in the air, on road, on railways, water and pipelines.

Table 3-75 Specification of source category 1A3 Transport.

| 1A3 | Source category | Specification |
|---|---|---|
| 1A3ai(i) | International aviation LTO (civil) | LTO: Landing/Take-off emissons from international flights |
| 1A3ai(ii) | International aviation CR (civil) | CR: Cruise emissions of international flights<br>Memo item – not to be included in national total |
| 1A3aii(i) | Domestic aviation LTO (civil) | LTO: Landing/Take-off emissions from domestic flights<br>Large (jet, turboprop) & small (piston) aircrafts, helicopters |
| 1A3aii(ii) | Domestic aviation CR (civil) | CR: Cruise emissions from domestic flights<br>Large (jet, turboprop) & small (piston) aircrafts, helicopters<br>Memo item – not to be included in national total |
| 1A3bi | Road transportation: Passenger cars | Emissions from passenger cars |
| 1A3bii | Road transportation: Light duty vehicles | Emissions from light duty vehicles |
| 1A3biii | Road transportation:<br>Heavy duty vehicles and buses | Emissions from heavy duty vehicles, coaches and buses |
| 1A3biv | Road transportation: Mopeds & motorcycles | Emissoins from 2-stroke and 4-stroke motorcycles |
| 1A3bv | Road transportation: Gasoline evaporation | NMVOC emissions from gasoline evaporation |
| 1A3bvi | Road transportation:<br>Automobile tyre and brake wear | Non-exhaust emissions from road transportation |
| 1A3bvii | Road transportation:<br>Automobile road abrasion | Not reported separately but included in non-exhaust emissions reported in 1A3bvi |
| 1A3c | Railways | Diesel locomotives, abrasion by merchandise and person traffic |
| 1A3di(ii) | International maritime navigation | Shipping leaving Switzerland on the river Rhine and on Lake Geneva and Lake Constance<br>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 | Gas turbines at the compressor station in Ruswil (canton Lucerne) for the Swiss gas network. |

Note that emissions from cruise in civil aviation (see also Table 3-6; 1A3ai(ii) International aviation CR and 1A3aii(ii) Domestic aviation CR) as well as emissions from international inland waterways are reported under “memo items” and not considered for the national total.

Table 3-76 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 1A3, Transport.

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | NOx | L1, T1, T2 |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | SOx | L1, T1, T2 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NOx | L1, L2, T1, T2 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NMVOC | L1, L2, T1, T2 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | NOx | L1, L2, T1, T2 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | NOx | L1, L2, T1, T2 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | SOx | T1, T2 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | PM2.5 | T1 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | PM10 | T1 |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | NMVOC | L2, T2 |
| 1A3bv(fu) | Road transportation: gasoline evaporation (fuel used) | NMVOC | L1, T1, T2 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM2.5 | L1, L2, T1, T2 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM10 | L1, L2, T1, T2 |
| 1A3c | Railways | PM2.5 | L1, T1, T2 |
| 1A3c | Railways | PM10 | L1, L2, T1, T2 |
| 1A3dii | National navigation (shipping) | 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 the EMEP/EEA guidebook (EMEP/EEA 2023), 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, 2007-2023. The results of the emission modelling have been transmitted from FOCA to FOEN in an aggregated form (FOCA 2006, 2006a, 2007a, 2008-2024). Years in-between are interpolated. Further details of emission modelling are described in Switzerland's National Inventory Document (FOEN 2025).

#### Emission factors (1A3a)

The emission factors used are country-specific or taken from the ICAO engine emissions database from the EMEP/EEA guidebook (EMEP/EEA 2023), 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 emission factors (EF) see Table 3-77.

- $NO_x$, $SO_x$, 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.
- PM10 and PM2.5 have been determined by the Federal Office of Civil Aviation (FOCA 2016b). 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 $EF_{PM2.5\ exhaust} = 2 * EF_{BC}$, see also chapter 1.A.3.a, 1.A.5.b * Aviation of the EMEP/EEA guidebook (EMEP/EEA 2023, notes to table 3.11 on p.28.
- 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.
- The emission of Pb from leaded aviation fuel is assumed to be equal to the maximal allowed content of Pb in the fuel, which is 0.794 g Pb / kg fuel. Emission factors of Pb shown in Table 3-77 are implied emission factors as they are based on the Pb emissions from leaded aviation fuels divided with the sum of leaded aviation fuels and unleaded jet kerosene. The share of leaded aviation fuels in comparison to total kerosene consumption is less than 1%.

*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 3-77 Emission factors for 1A3a Civil aviation, year 2023. (LTO: Landing take-off cycle, CR: cruise.). Sustainable aviation fuels (SAF) are referred to as jet kerosene biogenic.

| 1A3a Aviation | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| 1A3ai(i) International aviation LTO (civil) | Jet kerosene fossil | GJ | 332 | 21 | 23 | NA | 2.4 | 0.0020 | 2.4 | 0.0020 |
| 1A3ai(i) International aviation LTO (civil) | Jet kerosene biogenic | GJ | 349 | 21 | 23 | NA | 2.3 | 0.0021 | 2.3 | 0.0021 |
| 1A3aii(i) Domestic aviation LTO (civil) | Jet kerosene fossil | GJ | 231 | 129 | 20 | NA | 7.1 | 0.0012 | 7.1 | 0.0012 |
| 1A3ai(ii) International aviation cruise (civil) | Jet kerosene fossil | GJ | 426 | 3.7 | 23 | NA | 0.74 | NA | 0.74 | NA |
| 1A3ai(ii) International aviation cruise (civil) | Jet kerosene biogenic | GJ | 447 | 3.6 | 23 | NA | 0.61 | NA | 0.61 | NA |
| 1A3aii(ii) Domestic aviation cruise (civil) | Jet kerosene fossil | GJ | 252 | 82 | 22 | NA | 3.9 | NA | 3.9 | NA |

| 1A3a Aviation | | Unit | TSP ex | TSP nx | BC ex | BC nx | CO | Pb | Cd ex | Cd nx | Hg |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | mg/... | mg/... | mg/... | mg/... |
| 1A3ai(i) International aviation LTO (civil) | Jet kerosene fossil | GJ | 2.4 | 0.0020 | 0.92 | NA | 260 | 5.8 | NA | NA | NA |
| 1A3ai(i) International aviation LTO (civil) | Jet kerosene biogenic | GJ | 2.3 | 0.0021 | 0.81 | NA | 253 | 0.80 | NA | NA | NA |
| 1A3aii(i) Domestic aviation LTO (civil) | Jet kerosene fossil | GJ | 7.1 | 0.0012 | 1.8 | NA | 3'591 | 2'798 | NA | NA | NA |
| 1A3ai(ii) International aviation cruise (civil) | Jet kerosene fossil | GJ | 0.74 | NA | 0.74 | NA | 43 | 4.9 | NA | NA | NA |
| 1A3ai(ii) International aviation cruise (civil) | Jet kerosene biogenic | GJ | 0.61 | NA | 0.61 | NA | 39 | 0.50 | NA | NA | NA |
| 1A3aii(ii) Domestic aviation cruise (civil) | Jet kerosene fossil | GJ | 3.9 | NA | 3.9 | NA | 764 | 1'028 | NA | NA | NA |

| 1A3a Aviation | | Unit | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|
| | | | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| 1A3ai(i) International aviation LTO (civil) | Jet kerosene fossil | GJ | NA | NA | NA | NA | NA | NA | NA |
| 1A3ai(i) International aviation LTO (civil) | Jet kerosene biogenic | GJ | NA | NA | NA | NA | NA | NA | NA |
| 1A3aii(i) Domestic aviation LTO (civil) | Jet kerosene fossil | GJ | NA | NA | NA | NA | NA | NA | NA |
| 1A3ai(ii) International aviation cruise (civil) | Jet kerosene fossil | GJ | NA | NA | NA | NA | NA | NA | NA |
| 1A3ai(ii) International aviation cruise (civil) | Jet kerosene biogenic | GJ | NA | NA | NA | NA | NA | NA | NA |
| 1A3aii(ii) Domestic aviation cruise (civil) | Jet kerosene fossil | GJ | NA | NA | NA | NA | NA | NA | NA |

### 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 3-78 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 from 1990 to 2019 is due to an increasing number of flights. In 2020 and 2021, the COVID-19 pandemic led to a strong reduction of energy consumption compared to 2019 due to significantly reduced number of flights. Since 2022, flight activities and thus the energy consumption increased again. However, the energy consumption remains lower than pre-pandemic level. Since 2021, sustainable aviation fuels (SAF) are reported from Zurich airport and attributed to international flights. The amount is very small compared to the amount of fossil jet fuel.

Table 3-78 Jet 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. Sustainable aviation fuels (SAF) are referred to as jet kerosene biogenic.

| 1A3a Aviation | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 45'334 | 52'993 | 66'267 | 49'477 | 60'028 |
| Total, 1990 = 100 % | | % | 100 | 117 | 146 | 109 | 132 |
| 1A3ai(i) International aviation LTO (civil) | Jet kerosene fossil | TJ | 4'277 | 5'097 | 6'507 | 4'878 | 5'643 |
| 1A3ai(i) International aviation LTO (civil) | Jet kerosene biogenic | TJ | NO | NO | NO | NO | NO |
| 1A3aii(i) Domestic aviation LTO (civil) | Jet kerosene fossil | TJ | 1'050 | 935 | 773 | 518 | 464 |
| 1A3ai(ii) International aviation cruise (civil) | Jet kerosene fossil | TJ | 37'608 | 44'821 | 57'219 | 42'896 | 52'691 |
| 1A3ai(ii) International aviation cruise (civil) | Jet kerosene biogenic | TJ | NO | NO | NO | NO | NO |
| 1A3aii(ii) Domestic aviation cruise (civil) | Jet kerosene fossil | TJ | 2'401 | 2'139 | 1'768 | 1'184 | 1'230 |

| 1A3a Aviation | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 66'927 | 69'220 | 72'534 | 74'465 | 78'793 | 79'767 | 29'250 | 32'683 | 58'443 | 69'786 |
| Total, 1990 = 100 % | | % | 148 | 153 | 160 | 164 | 174 | 176 | 65 | 72 | 129 | 154 |
| 1A3ai(i) International aviation LTO (civil) | Jet kerosene fossil | TJ | 6'142 | 6'459 | 6'529 | 6'728 | 6'953 | 6'963 | 2'395 | 2'718 | 5'129 | 5'915 |
| 1A3ai(i) International aviation LTO (civil) | Jet kerosene biogenic | TJ | NO | NO | NO | NO | NO | NO | NO | 2.0 | 0.029 | 1.4 |
| 1A3aii(i) Domestic aviation LTO (civil) | Jet kerosene fossil | TJ | 525 | 387 | 421 | 384 | 346 | 321 | 170 | 183 | 227 | 236 |
| 1A3ai(ii) International aviation cruise (civil) | Jet kerosene fossil | TJ | 58'864 | 60'874 | 64'073 | 66'096 | 70'261 | 71'233 | 25'799 | 29'129 | 52'369 | 62'966 |
| 1A3ai(ii) International aviation cruise (civil) | Jet kerosene biogenic | TJ | NO | NO | NO | NO | NO | NO | NO | 24 | 0.33 | 17 |
| 1A3aii(ii) Domestic aviation cruise (civil) | Jet kerosene fossil | TJ | 1'396 | 1'500 | 1'511 | 1'257 | 1'234 | 1'250 | 886 | 628 | 717 | 651 |

#### *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 Fig. 3.1 in the chapters 1A3bi-iv Road transport 2024 in the EMEP/EEA guidebook (EMEP/EEA 2023).
- The non-exhaust air pollutant emissions are calculated by a Tier 2 method based on the decision trees Fig. 3.1 in the chapters 1A3bi-iv Road transport 2024 in the EMEP/EEA guidebook (EMEP/EEA 2023).

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 chapter 3.1.6.1 on system boundaries.

The emission computation is based on emission factors and activity data. For general methods see INFRAS (2017c), updated emission factors see INFRAS (2019a), Matzer et al. (2019) and Notter et al. (2022). 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, evaporation running losses), number of starts/stops and vehicle stock (cold start, evaporation soak and diurnal emissions from gasoline passenger cars, light duty vehicles and motorcycles only) or fuel consumption per vehicle category.

For all years up to 2023, statistical data was used for calculating activity data from 1A3b Road transportation (ex-post). Emissions are calculated as follows:

- Hot emissions: $E_{hot} = VKT \cdot EF_{hot}$
- Cold start excess emissions: $E_{start} = N_{start} \cdot EF_{start}$
- Evaporation soak and diurnal NMVOC emissions: $E_{evap,i} = N_{evap,i} \cdot EF_{evap,i}$
- Evaporation running NMVOC losses: $E_{evap-RL} = VKT \cdot EF_{Evap-RL}$

with

- $EF_{hot}$, $EF_{start}$, $EF_{evap}$: Emission factors for ordinary driving conditions (hot engine), cold start and evaporative (VOC) emissions (after stops, running losses, diurnal losses)
- *VKT:* Vehicle km travelled
- $N_{start}$: Number of starts
- $N_{evap,i}$: Number of stops, or number of vehicles and day. *i* runs over two evaporation categories:
  a) evaporation soak emissions, i.e. emissions after stopping when the engine is still hot; and b) evaporation diurnal emissions, i.e. emissions due to daily air temperature differences. For a) the corresponding activity is number of stops, for b) number of vehicles multiplied by the number of days in the reported period (i.e. 365 for annual emissions).
- Emission factors are differentiated by fuel types: Gasoline (4-stroke), gasoline (2-stroke), diesel oil, liquefied petroleum gas, bioethanol, biodiesel, (compressed) natural gas, biogas, and by emission standard (in terms of percentage of vehicles with evaporation control, average tank and canister size, canister purge rates, and percentage of vehicles with mono- vs. multi-layered tanks).

**Emission factors (1A3b)**

Emission factors in 1A3b originate from the following sources:

- Emission factors for exhaust pollutants $NO_x$, NMVOC, $NH_3$, CO, PM2.5, and PM10 are country-specific and have been derived from “emission functions” 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, 2017, 2019 and 2022 (INFRAS 2017c, INFRAS 2019a, Notter et al. 2022). These emission factors are compiled in a database called “Handbook of Emission Factors for Road Transport” (INFRAS 2022). Version 4.2 is presented and documented on the website http://www.hbefa.net/. The resulting emission factors are differentiated by 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, 7 gradient classes (0, +/-2, +/-4, +/-6%), road type, speed limit) and temporal features (levels of service, i.e. traffic density, from free flow to heavy 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. Considering the measuring procedure and the maximum temperature of 52°C, it can be assumed that PM condensables are also included in the measurements. The installed technology also plays a role in this context (petrol engines with/without catalytic converter, diesel engines with/without particulate filter, etc.).

- Emission factors for Pb, Cd exhaust, Zn exhaust, Hg, PCDD/PCDF (except for natural gas engines, see below), PAH and PCB are taken from the EMEP/EEA guidebook (EMEP/EEA 2019, chapter 1.A.3.b.i-iv Road transport 2019).
- $SO_x$ emission factors are based upon the sulphur content of fuels and are country- and fuel-specific (see chp. 3.2.1.2).
- Emission factor for PCDD/PCDF emissions from natural gas engines is taken from Rentz et al. (2008).
- Emission factors for BC and Cd stem from the Handbook of Emission Factors for Road Transport as well as non-exhaust emissions of particulate matter (TSP, PM10, PM2.5), which are based on Düring and Schmidt (2016); their integration into the Handbook of Emission Factors for Road Transport is described in INFRAS (2019a). Details to non-exhaust emission factors can be found in EMIS 2025/1A3b-Strassenverkehr.
- Note that there is still no HCB emission factor available in the EMEP/EEA guidebook (EMEP/EEA 2019). Therefore, these emissions are still NE for the years 1990-2023.

For biofuels, the respective air pollutant emission factors of 1A3b for fossil fuels are used as follows: for biodiesel and vegetable/waste oil the ones from diesel oil, for bioethanol the ones from gasoline and for biogas the ones from (compressed) natural gas use. Table 3-79 shows a selection of implied emission factors (emissions divided by specific fuel consumption per source category) for 2023.

Table 3-79 Implied emission factors for road transportation in 2023 ((fu) means fuel used approach).

| 1A3b(fu) Road Transportation (Gasoline, Bioethanol) | $NO_x$ | NMVOC | $SO_x$ | $NH_3$ | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx | TSP ex | TSP nx | BC ex | BC nx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/TJ | | | | | | | | | | | |
| 1A3bi(fu) Passenger cars | 31 | 43 | 0.19 | 8.8 | 0.60 | NA | 0.60 | NA | 0.60 | NA | 0.093 | NA |
| 1A3bii(fu) Light duty vehicles | 85 | 94 | 0.19 | 10 | 2.6 | NA | 2.6 | NA | 2.6 | NA | 0.44 | NA |
| 1A3biii(fu) Heavy duty vehicles | 784 | 478 | 0.19 | 0.23 | 0.0018 | NA | 0.0018 | NA | 0.0018 | NA | 0.00027 | NA |
| 1A3biv(fu) Motorcycles | 65 | 310 | 0.19 | 1.3 | 21 | NA | 21 | NA | 21 | NA | 4.0 | NA |
| 1A3bv(fu) Gasoline evaporation | NA | 21 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1A3bvi(fu) Automobile tyre and break wear | NA | NA | NA | NA | NA | 5.2 | NA | 14 | NA | 14 | NA | 0.52 |

| 1A3b(fu) Road Transportation (Gasoline, Bioethanol) | CO | Pb | Cd ex | Cd nx | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/TJ | g/TJ | | | | mg I-TEQ/TJ | g/TJ | | | | ng/TJ | |
| 1A3bi(fu) Passenger cars | 539 | 0.59 | 0.0045 | NA | 0.20 | 0.0031 | 0.14 | 0.16 | 0.12 | 0.17 | NE | 619 |
| 1A3bii(fu) Light duty vehicles | 2'465 | 0.59 | 0.0041 | NA | 0.20 | 0.0033 | 0.13 | 0.14 | 0.10 | 0.15 | NE | 657 |
| 1A3biii(fu) Heavy duty vehicles | 602 | 0.59 | 0.0055 | NA | NE | NE | NE | NE | NE | NE | NE | NE |
| 1A3biv(fu) Motorcycles | 1'839 | 0.59 | 0.0042 | NA | 0.19 | 0.0098 | 0.20 | 0.22 | 0.16 | 0.24 | NE | 3'072 |
| 1A3bv(fu) Gasoline evaporation | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1A3bvi(fu) Automobile tyre and break wear | NA | NA | NA | 0.44 | NA | NA | NA | NA | NA | NA | NA | NA |

| 1A3b Road Transportation (Diesel, Biodiesel) | $NO_x$ | NMVOC | $SO_x$ | $NH_3$ | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx | TSP ex | TSP nx | BC ex | BC nx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/TJ | | | | | | | | | | | |
| 1A3bi(fu) Passenger cars | 201 | 3.3 | 0.30 | 2.0 | 0.81 | NA | 0.81 | NA | 0.81 | NA | 0.34 | NA |
| 1A3bii(fu) Light duty vehicles | 224 | 1.6 | 0.30 | 1.5 | 3.0 | NA | 3.0 | NA | 3.0 | NA | 1.5 | NA |
| 1A3biii(fu) Heavy duty vehicles | 105 | 2.6 | 0.30 | 1.2 | 1.3 | NA | 1.3 | NA | 1.3 | NA | 0.46 | NA |
| 1A3biv(fu) Motorcycles | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A3bvi(fu) Automobile tyre and break wear | NA | NA | NA | NA | NA | 4.6 | NA | 13 | NA | 13 | NA | 0.46 |

| 1A3b Road Transportation (Diesel, Biodiesel) | CO | Pb | Cd ex | Cd nx | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/TJ | g/TJ | | | | mg I-TEQ/TJ | g/TJ | | | | ng/TJ | |
| 1A3bi(fu) Passenger cars | 44 | 0.91 | 0.0011 | NA | 0.12 | 0.0018 | 0.66 | 0.74 | 0.58 | 0.62 | NE | 365 |
| 1A3bii(fu) Light duty vehicles | 49 | 0.91 | 0.0011 | NA | 0.12 | 0.0022 | 0.53 | 0.59 | 0.46 | 0.49 | NE | 437 |
| 1A3biii(fu) Heavy duty vehicles | 43 | 0.91 | 0.0010 | NA | 0.21 | 0.00011 | 0.084 | 0.51 | 0.57 | 0.13 | NE | 22 |
| 1A3biv(fu) Motorcycles | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A3bvi(fu) Automobile tyre and break wear | NA | NA | NA | 0.49 | NA | NA | NA | NA | NA | NA | NA | NA |

| 1A3b Road Transportation (Gas, Biogas) | $NO_x$ | NMVOC | $SO_x$ | $NH_3$ | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx | TSP ex | TSP nx | BC ex | BC nx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/TJ | | | | | | | | | | | |
| 1A3bi(fu) Passenger cars | 24 | 1.3 | 0.30 | 9.1 | 1.7 | NA | 1.7 | NA | 1.7 | NA | 0.25 | NA |
| 1A3bii(fu) Light duty vehicles | 14 | 0.57 | 0.30 | 7.7 | 2.4 | NA | 2.4 | NA | 2.4 | NA | 0.35 | NA |
| 1A3biii(fu) Heavy duty vehicles | 92 | 1.5 | 0.30 | NE | 0.42 | NA | 0.42 | NA | 0.42 | NA | 0.064 | NA |
| 1A3biv(fu) Motorcycles | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A3bvi(fu) Automobile tyre and break wear | NA | NA | NA | NA | NA | 4.7 | NA | 15 | NA | 15 | NA | 0.47 |

| 1A3b Road Transportation (Gas, Biogas) | CO | Pb | Cd ex | Cd nx | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/TJ | g/TJ | | | | mg I-TEQ/TJ | g/TJ | | | | ng/TJ | |
| 1A3bi(fu) Passenger cars | 170 | NA | NA | NA | 0.19 | 0.0029 | 0.15 | 0.17 | 0.13 | 0.19 | NE | NA |
| 1A3bii(fu) Light duty vehicles | 1242 | NA | NA | NA | 0.19 | 0.0023 | 0.13 | 0.14 | 0.10 | 0.15 | NE | NA |
| 1A3biii(fu) Heavy duty vehicles | 54 | NA | NA | NA | NE | 0.0013 | 0.0035 | 0.0055 | 0.0028 | 0.0021 | NE | NA |
| 1A3biv(fu) Motorcycles | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A3bvi(fu) Automobile tyre and break wear | NA | NA | NA | 0.51 | NA | NA | NA | NA | NA | NA | NA | NA |

| 1A3b Road Transportation (Liquefied petroleum gas) | $NO_x$ | NMVOC | $SO_x$ | $NH_3$ | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx | TSP ex | TSP nx | BC ex | BC nx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/TJ | | | | | | | | | | | |
| 1A3bi(fu) Passenger cars | 23 | 1.7 | 0.50 | 7.2 | NA | NA | NA | NA | NA | NA | NA | NA |
| 1A3bii(fu) Light duty vehicles | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A3biii(fu) Heavy duty vehicles | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A3biv(fu) Motorcycles | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A3bvi(fu) Automobile tyre and break wear | NA | NA | NA | NA | NA | 4.6 | NA | 12 | NA | 12 | NA | 0.46 |

| 1A3b Road Transportation (Liquefied petroleum gas) | CO | Pb | Cd ex | Cd nx | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/TJ | g/TJ | | | | mg I-TEQ/TJ | g/TJ | | | | ng/TJ | |
| 1A3bi(fu) Passenger cars | 325 | NA | NA | NA | 0.19 | NA | 0.12 | 0.14 | 0.098 | 0.15 | NA | NA |
| 1A3bii(fu) Light duty vehicles | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A3biii(fu) Heavy duty vehicles | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A3biv(fu) Motorcycles | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1A3bvi(fu) Automobile tyre and break wear | NA | NA | NA | 0.38 | NA | NA | NA | NA | NA | NA | NA | NA |

| 1A3b Road Transportation (Electricity, Hydrogen) | $NO_x$ | NMVOC | $SO_x$ | $NH_3$ | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx | TSP ex | TSP nx | BC ex | BC nx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/TJ | | | | | | | | | | | |
| 1A3bi(fu) Passenger cars | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1A3bii(fu) Light duty vehicles | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1A3biii(fu) Heavy duty vehicles | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1A3biv(fu) Motorcycles | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1A3bvi(fu) Automobile tyre and break wear | NA | NA | NA | NA | NA | 14.8 | NA | 39 | NA | 39 | NA | 1.5 |

| 1A3b Road Transportation (Electricity, Hydrogen) | CO | Pb | Cd ex | Cd nx | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/TJ | g/TJ | | | | mg I-TEQ/TJ | g/TJ | | | | ng/TJ | |
| 1A3bi(fu) Passenger cars | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1A3bii(fu) Light duty vehicles | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1A3biii(fu) Heavy duty vehicles | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1A3biv(fu) Motorcycles | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1A3bvi(fu) Automobile tyre and break wear | NA | NA | NA | 1.3 | NA | NA | NA | NA | NA | NA | NA | NA |

### Activity data (1A3b)

The activity data are derived from different data sources:

- Vehicle stock: The federal vehicle registration database IVZ (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 (FSO 2024e). With the help of a fleet turnover model, the vehicle categories are assigned emission standards based on age and thereby 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 specific mileage per vehicle category is an input from Swiss Federal Statistical Office (FSO 2024e, 2024f). It is based on periodical surveys/Mikrozensus (ARE 2002, ARE/SFSO 2005, ARE/SFSO 2012, ARE/SFSO 2017). By means of the vehicle stock data (see paragraph above), the average specific mileage per vehicle category can be derived (SFOE 2024e, INFRAS 2017). The relative differences in specific mileage between vehicles of different technologies and ages within a vehicle category are based on the odometer readings at periodical technical inspections (PTI), which are recorded in the IVZ database (see above).
- Numbers of starts/stops: Derived from vehicles stock and periodical surveys/Mikrozensus (ARE/SFSO 2005, 2012 and 2017).
- 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 2025/1A3bi-viii “Strassenverkehr”), Consumption of biofuels is provided by the statistics of renewable energies (SFOE 2024a).
- For the greenhouse gas inventory under UNFCCC the fossil carbon fraction of biodiesel is estimated based on the method described in Sebos (2022). While all carbon in HVO (Hydrotreated Vegetable Oil) is of biogenic origin, FAME (Fatty Acid Methyl Esters) contains a fossil fraction due to the use of methanol from fossil sources in its production. The shares of FAME and HVO in biodiesel are available from the Swiss overall energy statistics (SFOE 2024). The fossil fraction of FAME depends on the feedstock it is derived from (e.g. rapeseed, soy, palm oil); since the feedstock shares are not captured in the Swiss energy statistics, they are based on European average values from HBEFA 4.1. The resulting overall fossil fraction of biodiesel varies over time – around 4.0 to 5.4 % of total biodiesel are reported under “fossil liquid fuels” as “biodiesel fossil”. For technical reasons in our database, there is a split of the whole biodiesel amount in fossil and biogenic biodiesel and not only for the carbon fraction and $CO_2$.

The total mileage of each vehicle category is differentiated by “traffic situations” (characteristic patterns of driving behaviour) and gradients, which serve as a key to select the appropriate emission factor and which are also available per traffic situation and gradient (see above). The relative shares of the traffic situations and gradients are derived from a national road traffic model (operated by the Federal Office of Spatial Development, see ARE 2022). The traffic model is based on an origin-destination matrix that is assigned to a detailed network of about 600’000 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 and gradients 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 3-80 shows the mileage per vehicle category. Numbers hold for the version “fuel used” and represent the vehicle kilometres driven within the Swiss territory.

Table 3-80 Mileages in millions of vehicle kilometres. PC: passenger cars, LDV: light duty vehicles, HDV: heavy duty vehicles.

| **Veh. category** | **1990** | **1995** | **2000** | **2005** | **2010** |
|---|---|---|---|---|---|
| | million vehicle-km | | | | |
| PC | 47'186 | 44'945 | 50'407 | 51'696 | 56'026 |
| LDV | 2'775 | 2'786 | 2'970 | 3'260 | 3'595 |
| HDV | 1'880 | 1'800 | 1'989 | 2'050 | 2'239 |
| Coaches and urban buses | 266 | 258 | 261 | 323 | 367 |
| 2-Wheelers | 2'260 | 1'724 | 1'910 | 1'957 | 2'039 |
| Sum | 54'366 | 51'512 | 57'537 | 59'287 | 64'266 |
| (1990=100%) | 100% | 95% | 106% | 109% | 118% |

| **Veh. category** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
|---|---|---|---|---|---|---|---|---|---|---|
| | million vehicle-km | | | | | | | | | |
| PC | 59'103 | 57'713 | 58'531 | 60'388 | 61'632 | 62'200 | 55'569 | 57'744 | 59'682 | 61'613 |
| LDV | 4'015 | 3'949 | 4'025 | 4'189 | 4'408 | 4'512 | 4'754 | 4'728 | 4'707 | 4'830 |
| HDV | 2'208 | 2'099 | 2'068 | 2'099 | 2'148 | 2'120 | 2'155 | 2'148 | 2'074 | 2'053 |
| Coaches and urban buses | 394 | 383 | 386 | 394 | 416 | 424 | 418 | 428 | 431 | 454 |
| 2-Wheelers | 2'119 | 2'070 | 2'119 | 2'188 | 2'230 | 2'269 | 2'070 | 2'104 | 2'043 | 2'117 |
| Sum | 67'839 | 66'213 | 67'128 | 69'258 | 70'833 | 71'524 | 64'965 | 67'152 | 68'937 | 71'068 |
| (1990=100%) | 125% | 122% | 123% | 127% | 130% | 132% | 119% | 124% | 127% | 131% |

Since 1990, the total mileage has been increasing by about 1 per cent per year on an average. This trend was halted in 2020 and 2021, as total mileages decreased compared to the years before due to the restrictions related to the COVID-19 pandemic. Since 2022 total mileages have increased again to pre-pandemic levels. 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 3-81 that depicts the specific fuel consumption per vehicle-km. For most vehicle categories, the specific consumption has decreased in the period 1990–2023.

Table 3-81 Specific fuel consumption of road transportation. Data are adopted from the territorial road transportation model. They include excess fuel consumption by cold starts.

| Veh. Category | Fuel | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| | | MJ / veh-km | | | | |
| PC | Gasoline | 3.15 | 3.24 | 3.30 | 3.21 | 3.06 |
| | Diesel oil | 3.36 | 3.18 | 3.07 | 2.79 | 2.81 |
| | Liquefied petroleum gas | NO | NO | NO | NO | NO |
| | CNG | NO | NO | NO | NO | 3.06 |
| LDV | Gasoline | 3.85 | 3.75 | 3.65 | 3.61 | 3.52 |
| | Diesel oil | 4.57 | 4.54 | 4.36 | 4.01 | 3.79 |
| | CNG | NO | NO | NO | NO | 3.68 |
| HDV | Gasoline | 9.06 | 9.07 | 9.07 | 9.11 | 9.15 |
| | Diesel oil | 11.3 | 11.7 | 11.7 | 12.3 | 11.9 |
| | CNG | NO | NO | NO | 25.1 | 19.5 |
| Busses | Gasoline | NO | NO | NO | NO | NO |
| | Diesel oil | 15.0 | 15.2 | 15.4 | 15.4 | 14.7 |
| | CNG | NO | NO | NO | NO | 25.4 |
| 2-Wheeler | Gasoline | 1.49 | 1.66 | 1.48 | 1.59 | 1.51 |
| Average | | 3.54 | 3.67 | 3.69 | 3.56 | 3.39 |
| (1990=100%) | | 100% | 104% | 104% | 101% | 96% |

| Veh. Category | Fuel | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MJ / veh-km | | | | | | | | | |
| PC | Gasoline | 2.80 | 2.73 | 2.67 | 2.53 | 2.48 | 2.44 | 2.41 | 2.36 | 2.29 | 2.26 |
| | Diesel oil | 2.74 | 2.72 | 2.71 | 2.65 | 2.65 | 2.66 | 2.67 | 2.67 | 2.64 | 2.63 |
| | Liquefied petroleum gas | 2.90 | 2.84 | 2.82 | 2.72 | 2.72 | 2.71 | 2.71 | 2.69 | 2.65 | 2.64 |
| | CNG | 3.01 | 3.08 | 2.96 | 2.94 | 2.82 | 2.84 | 2.96 | 2.87 | 2.72 | 2.79 |
| LDV | Gasoline | 3.32 | 3.27 | 3.21 | 3.02 | 2.92 | 2.88 | 2.83 | 2.77 | 2.64 | 2.54 |
| | Diesel oil | 3.72 | 3.71 | 3.70 | 3.55 | 3.50 | 3.46 | 3.41 | 3.37 | 3.33 | 3.30 |
| | CNG | 4.16 | 4.26 | 4.09 | 4.01 | 3.80 | 3.82 | 4.00 | 3.89 | 3.31 | 3.45 |
| HDV | Gasoline | 9.15 | 9.14 | 9.16 | 8.78 | 8.77 | 8.74 | 8.72 | 8.70 | 8.65 | 8.63 |
| | Diesel oil | 11.7 | 11.6 | 11.6 | 11.5 | 11.3 | 11.2 | 11.1 | 10.9 | 10.6 | 10.3 |
| | CNG | 19.9 | 20.5 | 20.1 | 20.6 | 17.1 | 17.2 | 16.6 | 17.2 | 16.4 | 17.1 |
| Busses | Gasoline | NO | NO | NO | NO | 8.91 | 8.88 | 8.86 | 8.83 | NO | 8.81 |
| | Diesel oil | 14.1 | 14.0 | 14.0 | 13.2 | 13.1 | 13.1 | 13.0 | 12.8 | 12.9 | 12.5 |
| | CNG | 25.3 | 26.1 | 25.5 | 24.5 | 24.2 | 24.5 | 25.8 | 25.3 | 24.3 | 26.3 |
| 2-Wheeler | Gasoline | 1.55 | 1.59 | 1.55 | 1.50 | 1.54 | 1.55 | 1.56 | 1.56 | 1.42 | 1.45 |
| Average | | 3.17 | 3.12 | 3.08 | 2.97 | 2.92 | 2.90 | 2.91 | 2.86 | 2.76 | 2.70 |
| (1990=100%) | | 90% | 88% | 87% | 84% | 83% | 82% | 82% | 81% | 78% | 76% |

For modelling evaporative emissions, the stock, mileage, and numbers of stops of gasoline passenger cars and gasoline light duty vehicles are used. For modelling cold start emissions, numbers of starts of passenger cars and light duty vehicles are used as activity data. The corresponding numbers are summarised in Table 3-82. Vehicle stock figures correspond to registration data. The starts per vehicle are based on specific household surveys (ARE/SFSO 2005, 2012, 2017).

Table 3-82 Vehicle stock numbers (gasoline vehicles only – relevant for diurnal evaporation) and average number of starts per vehicle per day (gasoline, diesel oil, and (compressed) natural gas vehicles).

| Veh. Category | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|
| | stock in 1000 veh. (gasoline/bioeth.) | | | | |
| PC | 2822 | 3'033 | 3'282 | 3'247 | 2'931 |
| LDV | 158 | 154 | 136 | 99 | 66 |
| 2-Wheelers | 764 | 688 | 712 | 747 | 778 |
| | starts per veh. per day | | | | |
| PC | 2.9 | 2.7 | 2.9 | 2.5 | 2.6 |
| LDV | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |

| Veh. Category | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| | stock in 1000 veh. (gasoline/bioeth.) | | | | | | | | | |
| PC | 2'719 | 2'667 | 2'625 | 2'621 | 2'626 | 2'623 | 2'705 | 2'736 | 2'686 | 2'732 |
| LDV | 50 | 48 | 46 | 44 | 42 | 41 | 42 | 41 | 39 | 46 |
| 2-Wheelers | 829 | 845 | 862 | 882 | 903 | 915 | 946 | 983 | 967 | 983 |
| | starts per veh. per day | | | | | | | | | |
| PC | 2.5 | 2.5 | 2.6 | 2.6 | 2.6 | 2.6 | 2.3 | 2.4 | 2.6 | 2.6 |
| LDV | 2.0 | 2.0 | 2.0 | 2.0 | 1.9 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |

#### *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 2023), 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 for some short feeder tracks to private companies). Electric locomotives are used in passenger as well as freight railway traffic. Diesel locomotives are used for shunting purposes in marshalling yards and for construction activities only. Their emissions are quantified as exhaust emissions.

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

**Emission factors (1A3c)**

The emission factors are country-specific. The general sources for the emission factors of the non-road model are described in chp. 3.2.1.1.1. Power class and emission standard specific emission factors are shown in Table 3-83.

- Only diesel oil and biodiesel are used as fuels, therefore all emission factors refer to the use of diesel oil and biodiesel for traffic on railways except for non-exhaust emissions.
- Non-exhaust particulate matter emission factors (PM2.5 and PM10) distinguish passenger and freight transport, i.e. they are based on passenger and tonne kilometres. Emission factors are based on a study from the Swiss Federal Railways Company (SBB 2005). Details concerning non-exhaust emission factors can be found in EMIS 2025/1A3c-Schienenverkehr.
- For the greenhouse gas inventory under UNFCCC the fossil carbon fraction of biodiesel is estimated based on the method described in chapter 3.2.1.1.1. For technical reasons in our database, there is a split of the whole biodiesel amount in fossil and biogenic biodiesel and not only for the carbon fraction and $CO_2$. Therefore, there are two lines with biodiesel, one with “biodiesel fossil” and one with “biodiesel biogenic”.

Implied emission factors for the reporting year are shown in Table 3-84.

Table 3-83 Illustration of emission and consumption factors for rail vehicles with diesel engines per emission standard (Pre-EU etc.) and engine power.

| **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 3-84 Implied emission factors in 2023 for 1A3c Railways. Data per TJ refer to exhaust emissions (ex), whereas data per km refer to non-exhaust emissions (nx).

| 1A3c Railways | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx | TSP ex | TSP nx |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Diesel oil | GJ | NA | NA | 0.30 | NA | NA | NA | NA | NA | NA | NA |
| Biodiesel fossil | GJ | 816 | 95 | 0.30 | 0.18 | 5.0 | NA | 5.0 | NA | 5.0 | NA |
| Biodiesel biogenic | GJ | 816 | 95 | 0.30 | 0.18 | 5.0 | NA | 5.0 | NA | 5.0 | NA |
| Working hours diesel oil | h | 718 | 84 | NA | 0.16 | 4.4 | NA | 4.4 | NA | 4.4 | NA |
| Passenger kilometres diesel oil | number | NA | NA | NA | NA | NA | 0.0019 | NA | 0.012 | NA | 0.016 |
| Ton km diesel oil | number | NA | NA | NA | NA | NA | 0.0013 | NA | 0.0088 | NA | 0.012 |

| 1A3c Railways | Unit | BC ex | BC nx | CO | Pb | Cd ex | Cd nx | Hg | PCDD/ PCDF |
|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | mg/... | mg/... | mg/... | mg/... | ng I-Teq/... |
| Diesel oil | GJ | NA | NA | NA | NA | NA | NE | NA | NA |
| Biodiesel fossil | GJ | 1.1 | NA | 480 | 0.89 | 2.2 | NE | 0.12 | 1.5 |
| Biodiesel biogenic | GJ | 1.1 | NA | 480 | 0.89 | 2.2 | NE | 0.12 | 1.5 |
| Working hours diesel oil | h | 0.96 | NA | 423 | 0.78 | 1.9 | NA | 0.10 | 1.4 |
| Passenger kilometres diesel oil | number | NA | NA | NA | NA | NA | NE | NA | NA |
| Ton km diesel oil | number | NA | NA | NA | NA | NA | NE | NA | NA |

| 1A3c Railways | Unit | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| Diesel oil | GJ | NA | NA | NA | NA | NA | NA |
| Biodiesel fossil | GJ | 0.79 | 1.3 | 0.98 | 0.19 | NA | NA |
| Biodiesel biogenic | GJ | 0.79 | 1.3 | 0.98 | 0.19 | NA | NA |
| Working hours diesel oil | h | 0.70 | 1.2 | 0.86 | 0.17 | NA | NA |
| Passenger kilometres diesel oil | number | NA | NA | NA | NA | NA | NA |
| Ton km diesel oil | number | NA | NA | NA | NA | NA | NA |

## Activity data (1A3c)

Table 3-85 shows the activity data of 1A3c taken from FOEN (2015j). Detailed activity data can be downloaded from the online database INFRAS (2015a).

Table 3-85 Activity data for 1A3c Railways is either diesel oil and biodiesel consumption or number of driven km for freight transport as well as number of driven km for passenger transport. Data in TJ refer to exhaust emissions, whereas data in km refer to non-exhaust emissions.

| 1A3c Railways | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Diesel oil | TJ | 390 | 441 | 455 | 472 | 492 |
| Biodiesel fossil | TJ | NO | NO | 0.026 | 0.072 | 0.082 |
| Biodiesel biogenic | TJ | NO | NO | 0.48 | 1.4 | 1.8 |
| Working hours diesel oil | h | 796'752 | 819'585 | 773'446 | 669'195 | 543'637 |
| Passenger kilometres diesel oil | million number | 51'912 | 54'992 | 57'600 | 63'600 | 69'600 |
| Ton km diesel oil | million number | 34'696 | 34'488 | 38'720 | 42'360 | 46'000 |

| 1A3c Railways | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diesel oil | TJ | 411 | 391 | 388 | 385 | 382 | 379 | 376 | 377 | 378 | 379 |
| Biodiesel fossil | TJ | 0.23 | 0.27 | 0.41 | 0.55 | 0.69 | 0.83 | 0.97 | 0.95 | 0.94 | 0.92 |
| Biodiesel biogenic | TJ | 4.3 | 4.9 | 7.9 | 11 | 14 | 17 | 20 | 19 | 18 | 17 |
| Working hours diesel oil | h | 472'246 | 454'398 | 450'869 | 447'340 | 443'810 | 440'281 | 436'752 | 437'681 | 438'610 | 439'539 |
| Passenger kilometres diesel oil | million number | 85'850 | 69'600 | 89'120 | 84'734 | 88'520 | 88'395 | 69'600 | 58'458 | 82'752 | 90'572 |
| Ton km diesel oil | million number | 49'253 | 46'000 | 49'789 | 46'614 | 47'106 | 46'666 | 46'000 | 48'094 | 48'542 | 46'161 |

#### *3.2.6.2.4 Domestic navigation (1A3d)*

**Methodology (1A3d)**

Based on the decision tree Fig. 3.1 in the chapter 1A3d Navigation-shipping in the EMEP/EEA guidebook (EMEP/EEA 2023), 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. The general sources for the emission factors of the non-road model are described in chp. 3.2.1.1.1. Power class and emission standard-specific emission factors are shown in Table 3-86 to Table 3-89 (FOEN 2015j).

For the greenhouse gas inventory under UNFCCC the fossil carbon fraction of biodiesel is estimated based on the method described in chapter 3.2.1.1.1. For technical reasons in our database, there is a split of the whole biodiesel amount in fossil and biogenic biodiesel and not only for the carbon fraction and $CO_2$. Therefore, there are two lines with biodiesel, one with “biodiesel fossil” and one with “biodiesel biogenic”.

Implied emission factors for the reporting year are shown in Table 3-90.

Table 3-86 Emission factors for diesel-powered ships per emission standard.

| 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 3-87 Emission factors for diesel-powered boats per emission standard.

| 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 3-88 Emission factors for gasoline-powered boats per emission standard.

| 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 3-89 Emission factors for steam-powered vessels per emission standard.

| 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 3-90 Implied emission factors in 2023 for 1A3d Navigation.

| 1A3d Navigation | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Gasoline | GJ | NA | NA | 0.19 | NA | NA | NA | NA | NA | NA |
| Diesel oil | GJ | NA | NA | 0.30 | NA | NA | NA | NA | NA | NA |
| Gas oil | GJ | NA | NA | 0.84 | NA | NA | NA | NA | NA | NA |
| Biodiesel fossil | GJ | 680 | 191 | 0.30 | 0.18 | 24 | 24 | 24 | 13 | 472 |
| Biodiesel biogenic | GJ | 680 | 191 | 0.30 | 0.18 | 24 | 24 | 24 | 13 | 472 |
| Bioethanol | GJ | 542 | 400 | 0.19 | 0.086 | NA | NA | NA | NA | 8'648 |
| Working hours gasoline | h | 117 | 90 | NA | 0.018 | 0.033 | 0.033 | 0.033 | 0.0017 | 1'899 |
| Working hours diesel oil | h | 599 | 168 | NA | 0.16 | 21 | 21 | 21 | 11 | 416 |
| Working hours gas oil | h | 386 | 24 | NA | 0.61 | 2.0 | 2.0 | 2.0 | 0.29 | 100 |
| Working hours biodiesel fossil | h | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Working hours biodiesel biogenic | h | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Working hours bioethanol | h | NA | NA | NA | NA | NA | NA | NA | NA | NA |

| 1A3d Navigation | Unit | Pb | Cd ex | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| Gasoline | GJ | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Diesel oil | GJ | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Gas oil | GJ | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Biodiesel fossil | GJ | 0.89 | 2.2 | 0.12 | 1.6 | 0.77 | 1.3 | 0.96 | 0.19 | NA | NA |
| Biodiesel biogenic | GJ | 0.89 | 2.2 | 0.12 | 1.6 | 0.77 | 1.3 | 0.96 | 0.19 | NA | NA |
| Bioethanol | GJ | 0.59 | 2.2 | 0.19 | 2.6 | 1.1 | 1.1 | 0.11 | 0.29 | NA | NA |
| Working hours gasoline | h | 0.13 | 0.46 | 0.040 | 0.56 | 0.23 | 0.23 | 0.023 | 0.062 | NA | NA |
| Working hours diesel oil | h | 0.78 | 2.0 | 0.10 | 1.4 | 0.68 | 1.1 | 0.84 | 0.17 | NA | NA |
| Working hours gas oil | h | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Working hours biodiesel fossil | h | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Working hours biodiesel biogenic | h | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Working hours bioethanol | h | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

### Activity data (1A3d)

Table 3-91 shows the activity data of 1A3di taken from FOEN (2015j). Detailed activity data can be downloaded from the online database INFRAS (2015a).

Table 3-91 Activity Data for domestic navigation.

| 1A3d Navigation | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 1'550 | 1'517 | 1'556 | 1'518 | 1'565 |
| Total, 1990 = 100 % | % | 100 | 98 | 100 | 98 | 101 |
| Gasoline | TJ | 701 | 654 | 616 | 565 | 535 |
| Diesel oil | TJ | 738 | 724 | 792 | 800 | 868 |
| Gas oil | TJ | 110 | 139 | 147 | 150 | 159 |
| Biodiesel fossil | TJ | NO | NO | 0.046 | 0.12 | 0.14 |
| Biodiesel biogenic | TJ | NO | NO | 0.84 | 2.4 | 3.1 |
| Bioethanol | TJ | NO | NO | NO | NO | 0.0079 |

| 1A3d Navigation | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 1'561 | 1'560 | 1'559 | 1'557 | 1'556 | 1'554 | 1'553 | 1'552 | 1'551 | 1'550 |
| Total, 1990 = 100 % | % | 101 | 101 | 101 | 101 | 100 | 100 | 100 | 100 | 100 | 100 |
| Gasoline | TJ | 519 | 515 | 515 | 515 | 515 | 515 | 515 | 515 | 515 | 515 |
| Diesel oil | TJ | 877 | 880 | 871 | 863 | 855 | 847 | 839 | 839 | 840 | 841 |
| Gas oil | TJ | 153 | 151 | 150 | 149 | 148 | 147 | 146 | 145 | 144 | 144 |
| Biodiesel fossil | TJ | 0.52 | 0.62 | 0.93 | 1.2 | 1.5 | 1.9 | 2.2 | 2.1 | 2.1 | 2.0 |
| Biodiesel biogenic | TJ | 9.4 | 11 | 18 | 24 | 31 | 37 | 44 | 42 | 40 | 39 |
| Bioethanol | TJ | 2.0 | 2.5 | 3.4 | 4.4 | 5.4 | 6.4 | 7.4 | 8.1 | 8.9 | 9.7 |

#### *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, PCDD/PCDF and PAH from a compressor station located in Ruswil are considered.

The emissions are calculated with a Tier 2 method (note that the EMEP/EEA guidebook (EMEP/EEA 2023) does not contain a decision tree to determine the Tier level specifically). For the main pollutants, TSP, PM2.5 and PM10, country-specific emission factors were used. For all other pollutants (BC, CO, Hg, PCDD/PCDF and PAH), the emission factors stem from the EMEP/EEA guidebook (EMEP/EEA 2023).

## Emission factors (1A3e)

The same emission factors are used as for gas turbines (see Table 3-61). The emission factors are described in chapter 3.2.1.1.2.

Table 3-92 Emission factors of 1A3e for 2023.

| 1A3e Other transportation | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Natural gas | GJ | 30 | 1.6 | 0.23 | NA | 0.20 | 0.20 | 0.20 | 0.00050 | 11 |
| Biogas | GJ | 48 | 1.6 | 0.50 | NA | 0.20 | 0.20 | 0.20 | 0.00050 | 11 |

| 1A3e Other transportation | Unit | Pb | Cd ex | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| Natural gas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |
| Biogas | GJ | 0.0015 | 0.00025 | 0.10 | 0.50 | 0.00056 | 0.00084 | 0.00084 | 0.00084 | NA | NA |

## 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 2024; Table 17e).

Table 3-93 Activity data of 1A3e.

| 1A3e Other transportation | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 560 | 310 | 340 | 1'070 | 830 |
| Total, 1990 = 100 % | % | 100 | 55 | 61 | 191 | 148 |
| Natural gas | TJ | 560 | 310 | 340 | 1'070 | 830 |
| Biogas | TJ | NO | NO | NO | NO | NO |

| 1A3e Other transportation | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | TJ | 830 | 760 | 340 | 470 | 490 | 600 | 540 | 138 | 420 | 192 |
| Total, 1990 = 100 % | % | 148 | 136 | 61 | 84 | 88 | 107 | 96 | 25 | 75 | 34 |
| Natural gas | TJ | 830 | 760 | 340 | 470 | 490 | 600 | 540 | 120 | 400 | 170 |
| Biogas | TJ | NO | NO | NO | NO | NO | NO | NO | 18 | 20 | 22 |

### 3.2.6.3 Category-specific recalculations for 1A3 Transport

The following recalculations were implemented in submission 2025:

- 1A3, year 2022: Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_2$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated.
- 1A3b: The Swiss statistic of energy consumption (SFOE 2024) has newly added the amount of Liquefied Natural Gas (LNG) used to the total amount of natural gas used for the years 2020-2022. This leads to small recalculations mainly in source categories 1A3b Road transportation, 1A4ai Commercial/institutional (stationary) and 1B2b Natural gas losses.
- 1A3b, 1A3d: The fossil carbon fraction in biodiesel is now estimated based on the method described in Sebos (2022). The fossil fraction of FAME (Fatty Acid Methyl Ester) is based on the values from HBEFA 4.1 (relevant for the whole EU), while all carbon in HVO (Hydrotreated Vegetable Oil) is considered of biogenic origin. Because biodiesel as reported by Switzerland consists of the sum of FAME and HVO, the fossil fraction of biodiesel varies over time. Overall, around 4.0 to 5.4 % of the total biodiesel are now reported under “fossil liquid fuels” for the years 1996–2022 (no biodiesel in the years before). In consequence, this leads to recalculations in fuel categories including biodiesel as “biomass” or “biofuels” and “liquid fuels” as well.
- 1A3b: The difference between the fuel used approach from the road transportation model and the fuel sold information from the energy statistics was previously referred to as "fuel tourism and statistical difference". This was determined using average emission factors for each fuel type to calculate the difference in emissions. The resulting differences in

activity data and emissions were subtracted from the activity data and the previously calculated territorial emissions of each main vehicle category and fuel type in 1A3b Road transportation. Now the relative difference between the territorial fuel consumption modelled by the road transportation model (fuel used) and the fuel sold from the energy statistics is calculated first. The difference in fuel consumption per fuel type is then proportionally allocated to each vehicle category, thus adjusting the activity data to reflect the fuel sold. The emissions per fuel type are then calculated using vehicle category specific emission factors and the adjusted activity data. Therefore, the activity data for 1A3b Road transportation (fuel sold) have been updated for all fuel types and for all years 1990-2022.

- 1A3b: The use of bioethanol has been adopted to the reported amount of bioethanol sold in the Swiss energy statistics. Therefore, missing activity data have been implemented in 1A3b Road Transportation for all processes using bioethanol for the years 2005-2009.
- 1A3b: For the road traffic model in 1A3b Road transportation, adjustments were made to driving performance, mileage and energy consumption and emission factors were adopted to the Handbook for Emission Factors (HBEFA) version 4.2. This leads to recalculations of activity data end emissions for all years 1990-2022.
- 1A3d: An update of the fuel mix and consumption from non-road machineries leads to small recalculations in all source categories affected by the non-road transportation model and for all years 1990-2022.

## 3.2.7 Source category 1A4 – Non-road and machinery in other sectors (commercial, residential, agriculture and forestry)

### 3.2.7.1 Source category description for 1A4 – Non-road and machinery in other sectors (commercial, residential, agriculture and forestry)

The source category 1A4 Non-road and machinery in other sectors comprises all emissions from the combustion of fuels in mobile non-road sources in commerce and institutions, households, agriculture and forestry. This includes use of conventional fossil fuels as well as biofuels. Note that information regarding stationary combustion of source categories 1A4 Stationary combustion in manufacturing industries and construction are provided in chp. 3.2.4.

Table 3-94 Specification of source category 1A4 – Non-road and machinery sources in residential, commercial, agriculture and forestry sectors.

| 1A4 | Source category | Specification |
|---|---|---|
| 1A4aii | Commercial/Institutional: Mobile | Emissions from mobile machinery and motorised equipment used for professional gardening |
| 1A4bii | Residential:<br>Household and gardening (mobile) | Emissions from mobile machinery and motorised equipment used for hobby gardening |
| 1A4cii | Agriculture/Forestry/Fishing:<br>Off-road vehicles and other machinery | Emissions from non-road vehicles and machinery in agriculture and forestry |

Table 3-95 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 1A4 Non-road and machinery in other sectors (mobile).

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | NOx | L1 |

### 3.2.7.2 Methodological issues for 1A4 - Non-road and machinery in other sectors (commercial, residential, agriculture and forestry)

#### Methodology (1A4 - Non-road and machinery in other sectors (commercial, residential, agriculture and forestry))

Based on the decision tree Fig. 3.1 in chapter 1A4 of the EMEP/EEA guidebook (EMEP/EEA 2023), 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 - Non-road and machinery in other sectors (commercial, residential, agriculture and forestry)

The general sources for the emission factors of the non-road model are described in chp. 3.2.1.1.1. Power class and emission standard-specific emission factors are shown in Table 3-69 to Table 3-71 (see chp. 3.2.5.2).

To avoid double counting there are no non-exhaust emissions of PM2.5, PM10 and TSP from resuspension caused by non-road vehicles and machinery in agriculture since they are included in the particle emissions from source categories 3Dc Soils operation of cropland and 3Dc Soils operation of grassland, see chp. 5.3.2.

Implied emission factors for the reporting year for all pollutants are shown in Table 3-96. For the greenhouse gas inventory under UNFCCC the fossil carbon fraction of biodiesel is estimated based on the method described in chapter 3.2.1.1.1. For technical reasons in our database, there is a split of the whole biodiesel amount in fossil and biogenic biodiesel and not only for the carbon fraction and $CO_2$. Therefore, there are two lines with biodiesel, one with “biodiesel fossil” and one with “biodiesel biogenic”.

Table 3-96 Implied emission factors 1A4 - Non-road and machinery in other sectors (commercial, residential, agriculture and forestry) in 2023 based on amount of fuel consumed in GJ.

| 1A4 Other sectors | | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| 1A4aii | Gasoline | GJ | NA | NA | 0.19 | NA | NA | NA | NA | NA | NA |
| 1A4aii | Bioethanol | GJ | 90 | 566 | 0.19 | 0.095 | NA | NA | NA | NA | 24'727 |
| 1A4bii | Gasoline | GJ | NA | NA | 0.19 | NA | NA | NA | NA | NA | NA |
| 1A4bii | Bioethanol | GJ | 108 | 597 | 0.19 | 0.095 | NA | NA | NA | NA | 24'714 |
| 1A4cii | Gasoline | GJ | NA | NA | 0.19 | NA | NA | NA | NA | NA | NA |
| 1A4cii | Diesel oil | GJ | NA | NA | 0.30 | NA | NA | NA | NA | NA | NA |
| 1A4cii | Biodiesel fossil | GJ | 303 | 35 | 0.30 | 0.16 | 23 | 23 | 23 | 15 | 175 |
| 1A4cii | Biodiesel biogenic | GJ | 303 | 35 | 0.30 | 0.16 | 23 | 23 | 23 | 15 | 175 |
| 1A4cii | Bioethanol | GJ | 110 | 753 | 0.19 | 0.087 | NA | NA | NA | NA | 23'554 |

| 1A4 Other sectors | | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| 1A4aii | Gasoline | GJ | NA | NA | NA | NA | NA | NA | NA | NA | NE | NE |
| 1A4aii | Bioethanol | GJ | 0.59 | 2.4 | 0.21 | 2.8 | 0.95 | 0.95 | 0.092 | 0.32 | NE | NE |
| 1A4bii | Gasoline | GJ | NA | NA | NA | NA | NA | NA | NA | NA | NE | NE |
| 1A4bii | Bioethanol | GJ | 0.59 | 2.4 | 0.21 | 2.8 | 0.95 | 0.95 | 0.093 | 0.31 | NE | NE |
| 1A4cii | Gasoline | GJ | NA | NA | NA | NA | NA | NA | NA | NA | NE | NE |
| 1A4cii | Diesel oil | GJ | NA | NA | NA | NA | NA | NA | NA | NA | NE | NE |
| 1A4cii | Biodiesel fossil | GJ | 0.89 | 1.9 | 0.10 | 1.4 | 0.62 | 1.0 | 0.77 | 0.17 | NE | NE |
| 1A4cii | Biodiesel biogenic | GJ | 0.89 | 1.9 | 0.10 | 1.4 | 0.62 | 1.0 | 0.77 | 0.17 | NE | NE |
| 1A4cii | Bioethanol | GJ | 0.59 | 2.2 | 0.19 | 2.6 | 1.1 | 1.1 | 0.10 | 0.29 | NE | NE |

Table 3-97 Implied emission factors 1A4 - Non-road and machinery in other sectors (commercial, residential, agriculture and forestry) in 2023 based on number of working hours per fuel type..

| 1A4 Other sectors | | Unit | NOx | NMVOC | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| 1A4aii | Working hours gasoline | h | 2.8 | 21 | 0.0015 | NA | NA | NA | NA | 451 |
| 1A4bii | Working hours gasoline | h | 2.3 | 14 | 0.0017 | NA | NA | NA | NA | 468 |
| 1A4cii | Working hours gasoline | h | 10 | 81 | 0.0049 | NA | NA | NA | NA | 1'484 |
| 1A4cii | Working hours diesel oil | h | 63 | 7.2 | 0.032 | 4.8 | 4.8 | 4.8 | 3.1 | 36 |

| 1A4 Other sectors | | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | mg/... | mg/... |
| 1A4aii | Working hours gasoline | h | 0.0099 | 0.040 | 0.0035 | 0.048 | 0.016 | 0.016 | 0.0016 | 0.0053 | NE | NE |
| 1A4bii | Working hours gasoline | h | 0.011 | 0.044 | 0.0038 | 0.052 | 0.017 | 0.017 | 0.0017 | 0.0058 | NE | NE |
| 1A4cii | Working hours gasoline | h | 0.035 | 0.13 | 0.012 | 0.16 | 0.061 | 0.061 | 0.0060 | 0.018 | NE | NE |
| 1A4cii | Working hours diesel oil | h | 0.18 | 0.40 | 0.021 | 0.28 | 0.13 | 0.21 | 0.16 | 0.035 | NE | NE |

The Expert Review Team noted during the Stage 3 review in 2016 that the implied emission factors for NMVOC, CO and particulate matter 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 implied emission factor is justified. (The ERT encouraged the Party to include the explanation of this issue in the IIR.)

### Activity data (1A4 - Non-road and machinery in other sectors (commercial, residential, agriculture and forestry)

Table 3-98 shows the activity data of 1A4 – Non-road and machinery in other sectors (commercial, residential, agriculture and forestry) taken from FOEN (2015j). Detailed activity data can be downloaded from the online database INFRAS (2015a). In categories 1A4aii and 1A4bii, only gasoline and bioethanol are used as fuel. In category 1A4cii, mainly diesel oil is consumed and only small amounts of gasoline (e.g. chainsaws) and biodiesel.

Table 3-98 Activity Data for 1A4 - Non-road and machinery in other sectors (commercial, residential, agriculture and forestry).

| 1A4 Other sectors | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 5'761 | 6'073 | 6'349 | 6'103 | 6'042 |
| 1A4aii | Gasoline | TJ | 191 | 245 | 295 | 295 | 287 |
| 1A4aii | Bioethanol | TJ | NO | NO | NO | NO | 0.0024 |
| 1A4bii | Gasoline | TJ | 142 | 155 | 165 | 166 | 163 |
| 1A4bii | Bioethanol | TJ | NO | NO | NO | NO | 0.0021 |
| 1A4cii | Gasoline | TJ | 1'160 | 1'070 | 963 | 824 | 689 |
| 1A4cii | Diesel oil | TJ | 4'269 | 4'604 | 4'921 | 4'804 | 4'884 |
| 1A4cii | Biodiesel fossil | TJ | NO | NO | 0.28 | 0.73 | 0.81 |
| 1A4cii | Biodiesel biogenic | TJ | NO | NO | 5.2 | 14 | 18 |
| 1A4cii | Bioethanol | TJ | NO | NO | NO | NO | 0.0075 |

| 1A4 Other sectors | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total fuel consumption | | TJ | 5'936 | 5'909 | 5'898 | 5'887 | 5'876 | 5'865 | 5'854 | 5'839 | 5'824 | 5'809 |
| 1A4aii | Gasoline | TJ | 260 | 253 | 252 | 251 | 250 | 249 | 248 | 246 | 245 | 243 |
| 1A4aii | Bioethanol | TJ | 0.60 | 0.75 | 1.0 | 1.3 | 1.6 | 1.9 | 2.2 | 2.5 | 2.7 | 2.9 |
| 1A4bii | Gasoline | TJ | 158 | 157 | 156 | 155 | 155 | 154 | 153 | 153 | 152 | 152 |
| 1A4bii | Bioethanol | TJ | 0.53 | 0.67 | 0.93 | 1.2 | 1.4 | 1.7 | 2.0 | 2.2 | 2.4 | 2.6 |
| 1A4cii | Gasoline | TJ | 593 | 569 | 553 | 538 | 523 | 508 | 492 | 480 | 467 | 454 |
| 1A4cii | Diesel oil | TJ | 4'867 | 4'863 | 4'828 | 4'794 | 4'760 | 4'726 | 4'692 | 4'701 | 4'711 | 4'721 |
| 1A4cii | Biodiesel fossil | TJ | 2.9 | 3.4 | 5.1 | 6.9 | 8.6 | 10 | 12 | 12 | 12 | 11 |
| 1A4cii | Biodiesel biogenic | TJ | 52 | 61 | 98 | 135 | 172 | 209 | 247 | 237 | 227 | 216 |
| 1A4cii | Bioethanol | TJ | 1.6 | 2.0 | 2.7 | 3.3 | 4.0 | 4.6 | 5.2 | 5.6 | 5.9 | 6.2 |

### 3.2.7.3 Category-specific recalculations for 1A4 – Non-road and machinery in other sectors (commercial, residential, agriculture and forestry)

The following recalculations were implemented in submission 2025:

- 1A4, year 2022: Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_2$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated.
- 1A4aii, 1A4bii, 1A4cii: The fossil carbon fraction in biodiesel is now estimated based on the method described in Sebos (2022). The fossil fraction of FAME (Fatty Acid Methyl Ester) is based on the values from HBEFA 4.1 (relevant for the whole EU), while all carbon in HVO (Hydrotreated Vegetable Oil) is considered of biogenic origin. Because biodiesel as reported by Switzerland consists of the sum of FAME and HVO, the fossil fraction of biodiesel varies over time. Overall, around 4.0 to 5.4 % of the total biodiesel are now reported under “fossil liquid fuels” for the years 1996–2022 (no biodiesel in the years before). In consequence, this leads to recalculations in fuel categories including biodiesel as “biomass” or “biofuels” and “liquid fuels” as well.
- 1A4aii, 1A4bii, 1A4cii: An update of the fuel mix and consumption from non-road machineries leads to small recalculations in all source categories affected by the non-road transportation model and for all years 1990-2022.

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

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

The source category 1A5b Other includes emissions from fuel combustion in military aircraft and military non-road activities.

Table 3-99 Specification of source category 1A5 Other, mobile (Military)

| 1A5 | Source category | Specification |
|---|---|---|
| 1A5b | Other mobile (including military, land based and recreational boats) | Emissions from military aircrafts and machines like power generators, tanks, bulldozers, boats etc. |

Table 3-100 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 1A5 Other, mobile.

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 1A5b | Other mobile (including military land-based and recreational boats) | PM10 | L1 |

### 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 (EMEP/EEA 2023), 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 information from the Federal Department of Defence, Civil Protection and Sport (DDPS) concerning fuel consumption per aircraft type in the year 2017-2018 (DDPS 2020). These emission factors stay constant for the whole time series from 1990 onwards.
- $SO_x$: the $SO_x$ emission factor is taken from the EMEP/EEA guidebook (EMEP/EEA 2023,chapter 1.A.3.a Aviation 2023, Table 3.11, row “Switzerland/CCD”) and is assumed to be constant over the period 1990–2023. 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 information from DDPS the same way as for $NO_x$, NMVOC, CO (see explanation above).
- TSP, PM10, PM2.5 non-exhaust: emission factors for TSP, PM10, PM2.5 non-exhaust 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 (FOCA 2016b).

- BC exhaust: the BC-factor of 48 % from PM2.5 exhaust is the same as for civil aviation and constant over the period 1990-2023.
- Implied emission factors for the reporting year are shown in Table 3-101.

*Emission factors of military non-road vehicles and machines*

The general sources for the emission factors of the non-road model are described in chp. 3.2.1.1.1. Implied emission factors for the reporting year are shown in Table 3-101. For the greenhouse gas inventory under the UNFCCC the fossil carbon fraction in biodiesel is estimated based on the method described in chapter 3.2.1.1.1. For technical reasons in our database, there is a split of the whole biodiesel amount in fossil and biogenic biodiesel and not only for the carbon fraction and $CO_2$. Therefore, there are two lines with biodiesel, one with “biodiesel fossil” and one with “biodiesel biogenic”.

Table 3-101 Emission factors for 1A5b Other (Military, mobile) in 2023.

| 1A5b Other Mobile | Unit | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx | TSP ex | TSP nx |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Gasoline | GJ | NA | NA | 0.19 | NA | NA | NA | NA | NA | NA | NA |
| Jet kerosene fossil | GJ | 231 | 33 | 23 | NA | 3.4 | 0.0016 | 3.4 | 0.0016 | 3.4 | 0.0016 |
| Diesel oil | GJ | NA | NA | 0.30 | NA | NA | NA | NA | NA | NA | NA |
| Biodiesel fossil | GJ | 247 | 23 | 0.30 | 0.15 | 6.9 | NA | 6.9 | NA | 6.9 | NA |
| Biodiesel biogenic | GJ | 247 | 23 | 0.30 | 0.15 | 6.9 | NA | 6.9 | NA | 6.9 | NA |
| Bioethanol | GJ | 85 | 394 | 0.19 | 0.094 | NA | NA | NA | NA | NA | NA |
| Working hours gasoline | h | 4.3 | 25 | NA | 0.0035 | NA | NA | NA | NA | NA | NA |
| Working hours diesel oil | h | 122 | 12 | NA | 0.074 | 3.4 | NA | 3.4 | NA | 3.4 | NA |
| Working hours (for non-exhaust only) | h | NA | NA | NA | NA | NA | 10 | NA | 67 | NA | 101 |

| 1A5b Other Mobile | Unit | BC ex | BC nx | CO | Pb | Cd | Hg | PCDD/ PCDF |
|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | mg/... | mg/... | mg/... | ng I-Teq/... |
| Gasoline | GJ | NA | NA | NA | NA | NA | NA | NA |
| Jet kerosene fossil | GJ | 1.6 | NA | 235 | NA | NA | NA | NA |
| Diesel oil | GJ | NA | NA | NA | NA | NA | NA | NA |
| Biodiesel fossil | GJ | 3.4 | NA | 117 | 0.89 | 1.9 | 0.10 | 1.3 |
| Biodiesel biogenic | GJ | 3.4 | NA | 117 | 0.89 | 1.9 | 0.10 | 1.3 |
| Bioethanol | GJ | NA | NA | 24'332 | 0.59 | 2.4 | 0.21 | 2.8 |
| Working hours gasoline | h | NA | NA | 941 | 0.022 | 0.090 | 0.0078 | 0.11 |
| Working hours diesel oil | h | 1.7 | NA | 58 | 0.44 | 0.93 | 0.049 | 0.65 |
| Working hours (for non-exhaust only) | h | NA | NA | NA | NA | NA | NA | NA |

| 1A5b Other Mobile | Unit | BaP | BbF | BkF | IcdP | HCB | PCB |
|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | mg/... | ng/... | ng/... |
| Gasoline | GJ | NA | NA | NA | NA | NE | NE |
| Jet kerosene fossil | GJ | NA | NA | NA | NA | NE | NE |
| Diesel oil | GJ | NA | NA | NA | NA | NE | NE |
| Biodiesel fossil | GJ | 0.59 | 0.99 | 0.74 | 0.16 | NE | NE |
| Biodiesel biogenic | GJ | 0.59 | 0.99 | 0.74 | 0.16 | NE | NE |
| Bioethanol | GJ | 0.96 | 0.96 | 0.093 | 0.31 | NE | NE |
| Working hours gasoline | h | 0.036 | 0.036 | 0.0035 | 0.012 | NE | NE |
| Working hours diesel oil | h | 0.29 | 0.49 | 0.36 | 0.080 | NE | NE |
| Working hours (for non-exhaust only) | h | NA | NA | NA | NA | NA | NA |

### Activity data (1A5b)

The fuel consumption of 1A5bi Military aviation is copied from the logbooks of the military aircrafts and summed up yearly by the Swiss Air Force (part of the Swiss Armed Forces, VTG) and provided to FOEN (VTG 2011, VTG 2024).

The fuel consumption of 1A5bii military non-road vehicles and machines is based on activity data provided by DDPS (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 3-102 shows activity data of both categories 1A5bi and 1A5bii.

Table 3-102 Activity data (fuel consumption) for 1A5b Other (Military, mobile).

| 1A5b Other Mobile | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Gasoline | TJ | 16 | 16 | 16 | 16 | 16 |
| Jet kerosene fossil | TJ | 2'733 | 1'955 | 1'794 | 1'624 | 1'592 |
| Diesel oil | TJ | 220 | 228 | 233 | 238 | 256 |
| Biodiesel fossil | TJ | NO | NO | 0.013 | 0.036 | 0.043 |
| Biodiesel biogenic | TJ | NO | NO | 0.25 | 0.71 | 0.92 |
| Bioethanol | TJ | NO | NO | NO | NO | 0.00024 |
| Working hours gasoline | h | 421'417 | 421'542 | 421'667 | 421'417 | 421'161 |
| Working hours diesel oil | h | 431'912 | 448'062 | 483'350 | 486'759 | 526'788 |
| Working hours (for non-exhaust only) | h | 3'413'313 | 3'478'413 | 3'622'184 | 3'638'684 | 3'799'620 |

| 1A5b Other Mobile | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Gasoline | TJ | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 14 | 14 |
| Jet kerosene fossil | TJ | 1'615 | 1'567 | 1'627 | 1'469 | 1'457 | 1'303 | 1'365 | 1'301 | 1'423 | 1'432 |
| Diesel oil | TJ | 255 | 255 | 252 | 249 | 246 | 243 | 240 | 241 | 241 | 241 |
| Biodiesel fossil | TJ | 0.15 | 0.18 | 0.27 | 0.36 | 0.44 | 0.53 | 0.62 | 0.61 | 0.60 | 0.58 |
| Biodiesel biogenic | TJ | 2.7 | 3.2 | 5.1 | 7.0 | 8.8 | 11 | 13 | 12 | 12 | 11 |
| Bioethanol | TJ | 0.058 | 0.072 | 0.100 | 0.13 | 0.16 | 0.18 | 0.21 | 0.23 | 0.25 | 0.27 |
| Working hours gasoline | h | 419'632 | 419'250 | 418'548 | 417'847 | 417'146 | 416'445 | 415'744 | 415'233 | 414'723 | 414'212 |
| Working hours diesel oil | h | 523'569 | 522'764 | 517'850 | 512'936 | 508'022 | 503'108 | 498'194 | 499'216 | 500'237 | 501'258 |
| Working hours (for non-exhaust only) | h | 3'801'430 | 3'801'882 | 3'798'084 | 3'794'285 | 3'790'487 | 3'786'688 | 3'782'890 | 3'782'729 | 3'782'567 | 3'782'406 |

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

The following recalculations were implemented in submission 2025:

- 1A5b, year 2022: Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_2$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated.
- 1A5b: The fossil carbon fraction in biodiesel is now estimated based on the method described in Sebos (2022). The fossil fraction of FAME (Fatty Acid Methyl Ester) is based on the values from HBEFA 4.1 (relevant for the whole EU), while all carbon in HVO (Hydrotreated Vegetable Oil) is considered of biogenic origin. Because biodiesel as reported by Switzerland consists of the sum of FAME and HVO, the fossil fraction of biodiesel varies over time. Overall, around 4.0 to 5.4 % of the total biodiesel are now reported under “fossil liquid fuels” for the years 1996–2022 (no biodiesel in the years before). In consequence, this leads to recalculations in fuel categories including biodiesel as “biomass” or “biofuels” and “liquid fuels” as well.
- 1A5b: An update of the fuel mix and consumption from non-road machineries leads to small recalculations in all source categories affected by the non-road transportation model and for all years 1990-2022.

# 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

The source category 1B1 Fugitive emissions from solid fuels includes non-exhaust emissions from coal handling only. There is no production of solid fuels in Switzerland.

Table 3-103 Specification of source category 1B1a Coal mining and handling.

| 1B1 | Source category | Specification |
|---|---|---|
| 1B1a | Fugitive emission from solid fuels: Coal mining and handling | Only particulate matter emissions from handling of coal |

Table 3-104 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 1B1 Fugitive emissions from solid fuels

| |
|---|
| 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 non-exhaust particulate matter emissions from coal handling occur.

Based on the EMEP/EEA guidebook (EMEP/EEA 2023, 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 the EMEP/EEA guidebook (EMEP/EEA 2023, table 3-7). No BC emission factors are available from literature for coal turnover. It is assumed that coal persists of 60 % of carbon and that the share is equal independent of its size.

Table 3-105 Emission factors in 1B1 Fugitive emissions from solid fuels in 2023.

| 1B1 Solid fuels | | Unit | PM2.5 nx | PM10 nx | TSP nx | BC nx |
|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... |
| 1B1a Coal handling | Other bituminous coal | t | 0.30 | 3.0 | 7.5 | 0.18 |

#### Activity data (1B1)

Activity data are provided by the energy model as described in chapter 3.1.6.2 and are based on the total amount of other bituminous coal imported as published in Swiss overall energy statistics (SFOE 2024).

Table 3-106 Activity data in 1B1 Fugitive emissions from solid fuels.

| 1B1 Solid fuels | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| 1B1a Coal handling | Other bituminous coal | kt | 535 | 286 | 210 | 233 | 248 |

| 1B1 Solid fuels | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1B1a Coal handling | Other bituminous coal | kt | 233 | 214 | 198 | 190 | 176 | 158 | 153 | 154 | 160 | 126 |

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

- 1B1a: The Swiss statistic of energy consumption (SFOE 2024) has recalculated the amount of other bituminous coal used in industry for the years 2019-2022. This leads to recalculation in 1B1a Coal handing in these years, too.

### 3.3.2 Source category 1B2a - Fugitive emissions from oil

#### 3.3.2.1 Source category description for 1B2a

In Switzerland, oil production is not occurring. Fugitive emissions from oil industry in Switzerland result exclusively from the refineries transforming crude oil into liquid fuels and the several gasoline stations and storage tanks for gasoline and jet kerosene. At the beginning of 2015, one of the two refineries ceased operation and there is only one refinery left. Crude oil is imported by underground pipelines only. The extents of the two existing oil pipelines in Switzerland are approximately 40 km and 70 km, respectively.

Table 3-107 Specification of source category 1B2a – Oil.

| 1B2a | Source category | Specification |
|---|---|---|
| 1B2ai | Fugitive emissions oil:<br>Exploration, production, transport | Oil production is not occurring in Switzerland. Emissions only stem from pipeline transport |
| 1B2aiv | Fugitive emissions oil:<br>Refining and storage | SO2 emissions from Claus-units in refineries |
| 1B2av | Distribution of oil products | Fugitive emissions caused by distribution and storage of gasoline and storage of kerosene |

Table 3-108 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 1B2a fugitive emissions from oil.

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 1B2av | Distribution of oil products | NMVOC | L1, T1, T2 |

#### 3.3.2.2 Methodological issues for 1B2a

**Methodology (1B2a)**

1B2ai Exploration, production, transport of oil – pipeline transport: Following the decision tree, Figure 3-1 in the EMEP/EEA guidebook (EMEP/EEA 2023), emissions reported under 1B2ai are estimated using a Tier 3 approach where emission estimates are based on information from experts (Canton of Neuchâtel 2019).

1B2aiv Refining and storage - leakage and emissions from Claus-units in refineries: Following the decision tree, Figure 3-1 in the EMEP/EEA guidebook (EMEP/EEA 2023), NMVOC emissions at refineries due to leakage are estimated using a Tier 2 approach where technology-specific activity data and emission factors are available. This source category also encompasses the $SO_x$ emissions from Claus-units at refineries. An analogous Tier 2 method with country-specific emission factors is used to calculate these emissions.

1B2av Distribution of oil products - emissions from gasoline stations: According to the decision tree in Figure 3-1 in the EMEP/EEA guidebook (EMEP/EEA 2023), the methodology to estimate emissions from gasoline stations follows a Tier 2 approach using technology specific activity data and emission factors. A bottom-up model was developed to estimate and sum up the emissions from each individual source that could cause emissions: (a) gasoline delivery from the main storage tank to the gasoline station, (b) underfloor storage tank filling at the gasoline station, (c) storage in underfloor tank and finally (d) the refuelling process. The model is also based on information from several gasoline station operators, technicians and Swiss cantons. This information entails emission measurements as well as details regarding the number of gasoline stations which are equipped with petrol pumps with vapour recovery systems.

1B2av Distribution of oil products - gasoline and jet kerosene storage tank facilities: According to the decision tree in Figure 3-1 in the EMEP/EEA guidebook (EMEP/EEA 2023), the methodology to estimate emissions from gasoline and jet kerosene storage tanks follows a tier 3 methodology using facility-specific emission estimates available on a yearly basis since 2017. These estimates are used for a model validation. The model extrapolates backwards for previous years using currently available databases on numbers of storage tanks and their respective equipment.

### Emission factors (1B2a)

1B2ai Exploration, production, transport of oil – pipeline transport of crude oil: In Switzerland crude oil is transported by underground pipelines only. According to expert information from oil industry, there are no emissions along the pipelines but only at the pig trap. There is one pig trap per pipeline and one pipeline per refinery. Based on expert estimates, 0.5 $m^3$ air saturated with VOC are emitted per week and pig trap. This leads to negligible NMVOC emissions of 10-20 kg per year.

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 2025/1B2aiv_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 2025/1B2aiv). This emission factor is used for all the years until 1995. For the years 2007-2019 total NMVOC emissions from 1A1b, 1B2aiv and 1B2c correspond to those reported in the Swiss PRTR database (PRTR 2021), including data for the years up to 2019 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, $SO_x$ emission factors from Claus units: For emissions from Claus units, the emission factors per tonne of crude oil are based on values from the project CRISTAL (Raffinerie de Cressier 1992) for the years 1990 and 1995 as well as on estimates from experts from the refinery for the year 2015 (years between 1990-1995 and 1995-2015 are interpolated, from 2015 on the value is kept constant).

1B2av Distribution of oil products - gasoline stations: The emission factors of NMVOC from 1B2av are country-specific and based on a bottom-up model (Luftkollektiv 2023) that sums up the different processes generating fugitive gasoline emissions, i.e. transport to the gasoline station, unloading to the tank at the gasoline station, opening the manhole, pressure equalisation, vapour recovery and finally refuelling of the vehicles. The bottom-up model developed was applied to the state of the years 1990, 2002, 2010, 2020 and 2030 and the respective emission factors were determined. In between, the emission factors are linearly interpolated. The Pb emission factor is based on the lead content of gasoline. Pb emissions only occurred until 1999. Since 2000, only unleaded gasoline is sold.

1B2av Distribution of oil products – gasoline and jet kerosene storage tank facilities: Emission factors for storage tanks are estimated by Carbura based on two studies, one for gasoline storage tanks (Carbura 2022) and one for jet kerosene storage tanks (Carbura 2023). NMVOC emissions for the reporting year were estimated on the basis of information on tank volumes, tank equipment, throughput quantities and maintenance (Carbura 2024). For gasoline storage tanks, detailed information is available for all historical reporting years. For jet kerosene storage tanks, historical data is available since 2000. Due to lack of data for earlier years, the emission factor for 1990 is the same as the one calculated for 2000 and kept constant in between. It should be noted that the storage and handling of jet kerosene causes significantly lower NMVOC emissions than gasoline due to the significantly lower vapour pressure.

Table 3-109 NMVOC and $SO_x$ emission factors in 1B2a – Oil, for 2023. All other emission factors including Pb (where emissions occurred from 1990 to 1999 only) are not applicable for this source category.

| 1B2a Oil | | Unit | NMVOC | SOx | Pb |
|---|---|---|---|---|---|
| | | | g/... | g/... | mg/... |
| 1B2aiii Transport of crude oil by pipelines | Refinery | number | 10'000 | NA | NA |
| 1B2aiv Refinery claus units | Crude oil | t | NA | 5.0 | NA |
| 1B2aiv Refinery leakage | Crude oil | t | 75 | NA | NA |
| 1B2av Gasoline station | Gasoline | GJ | 22 | NA | NA |
| 1B2av Gasoline storage tank | Gasoline | GJ | 1.1 | NA | NA |
| 1B2av Jet kerosene storage tanks | Jet kerosene fossil | GJ | 0.073 | NA | NA |

### Activity data (1B2a)

As crude oil is transported per pipeline to the refineries in Switzerland, activity data for 1B2ai reflect the number of pipelines, which is equal to the number of pipelines and number of pig traps. Activity data for 1B2aiv refining and storage are the amount of crude oil imported. These data are provided by Avenergy Suisse (Avenergy 2024) in their annual statistics and also reported in the Swiss overall energy statistics (SFOE 2024).

The activity data for 1B2av concerning fugitive emissions from gasoline stations and storage tanks is the amount of gasoline sold based on the Swiss overall energy statistics (SFOE 2024), corrected for consumption of Liechtenstein.

The activity data for 1B2av fugitive emissions from jet kerosene storage tanks is the sum of total amount of jet kerosene imported and produced in Swiss refineries. The amount of jet kerosene production in Swiss refineries has decreased steadily since 2005 and is zero since 2021.

Table 3-110 Activity data of 1B2a – Oil.

| 1B2a Oil | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| 1B2aiii Transport of crude oil by pipelines | Refinery | number | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| 1B2aiv Refinery claus units | Crude oil | kt | 3'127 | 4'657 | 4'649 | 4'877 | 4'546 |
| 1B2aiv Refinery leakage | Crude oil | kt | 3'127 | 4'657 | 4'649 | 4'877 | 4'546 |
| 1B2av Gasoline station | Gasoline | TJ | 156'516 | 151'672 | 168'353 | 152'182 | 134'129 |
| 1B2av Gasoline storage tank | Gasoline | TJ | 156'516 | 151'672 | 168'353 | 152'182 | 134'129 |
| 1B2av Jet kerosene storage tanks | Jet kerosene fossil | TJ | 48'160 | 54'739 | 68'310 | 51'004 | 61'815 |

| 1B2a Oil | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1B2aiii Transport of crude oil by pipelines | Refinery | number | 2.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 1B2aiv Refinery claus units | Crude oil | kt | 4'975 | 2'836 | 3'006 | 2'889 | 3'076 | 2'789 | 2'857 | 2'339 | 3'102 | 2'868 |
| 1B2aiv Refinery leakage | Crude oil | kt | 4'975 | 2'836 | 3'006 | 2'889 | 3'076 | 2'789 | 2'857 | 2'339 | 3'102 | 2'868 |
| 1B2av Gasoline station | Gasoline | TJ | 113'956 | 105'664 | 102'367 | 99'223 | 97'654 | 96'850 | 85'769 | 87'628 | 85'110 | 87'891 |
| 1B2av Gasoline storage tank | Gasoline | TJ | 113'956 | 105'664 | 102'367 | 99'223 | 97'654 | 96'850 | 85'769 | 87'628 | 85'110 | 87'891 |
| 1B2av Jet kerosene storage tanks | Jet kerosene fossil | TJ | 68'219 | 70'857 | 73'853 | 75'027 | 80'262 | 83'698 | 34'816 | 31'736 | 54'264 | 72'472 |

#### 3.3.2.3 Category-specific recalculations for 1B2a - Oil

There were no recalculations implemented in submission 2025.

### 3.3.3 Source category 1B2b - Fugitive emissions from natural gas

#### 3.3.3.1 Source category description for 1B2b

Emissions from natural gas production only occurred during the years of operation of the only production plant in Switzerland from 1985 to 1994. The dominating emissions in source category 1B2b stem from natural gas transmission and distribution.

Table 3-111 Specification of source category 1B2b – Natural gas.

| 1B2b | Source category | Specification |
|---|---|---|
| 1B2b | Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other) | Emissions from gas "distribution and transit" network<br>Production of natural gas (only relevant for 1990-1994) |

Table 3-112: Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 1B2b – Natural gas

| |
|---|
| Source category 1B2b – Natural gas is not a key category. |

### 3.3.3.2 Methodological issues for 1B2b

#### Methodology (1B2b)

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 occur in this source category.

According to the decision tree for natural gas systems (IPCC 2006, Volume 2 Energy, chp. 4 Fugitive Emissions, Figure 4.2.1), Switzerland follows a Tier 1 approach for fugitive emissions attributed to production of natural gas and a Tier 2 approach for fugitive emissions attributed to transmission and distribution of natural gas. As source category 1B2b is not a key category and as the contribution from production of natural gas is small, the use of a Tier 1 method for this source category is justified.

An important basis of the methodology to estimate fugitive emissions from natural gas transmission and distribution form the country-specific gas properties which are continuously measured at the various import stations. The Swiss Gas and Water Industry Association (SGWA) reports annually weighted values for densities and net calorific values as well as concentrations of greenhouse gases $CO_2$ and $CH_4$ and the air pollutant NMVOC. The same country-specific properties are used to estimate fugitive emissions from natural gas production as there are no other data available.

Those fugitive emissions from natural gas production are calculated based on annual production data and default emission factors (IPCC Tier 1 approach), taking into account the country-specific gas properties as mentioned above. There has been no natural gas production in Switzerland since 1994, due to the closure of the only production site at that time.

For transmission and distribution, a country-specific methodology – established by Quantis (2014) and fully revised by the Swiss Gas and Water Industry Association (SGWA 2023a) – is applied to derive country-specific losses for each emission source. The methodology assesses losses from transmission and distribution pipelines, including from the transit pipeline and its single compressor station. Calculations of losses from the gas network are based on the length and material of the gas pipelines, distinguishing various pressure levels. Also comprised are leakages from gas devices and network components (e.g. control units and gas meters as well as appliances in households, industry and natural gas fuelling stations), pipeline fittings, small-scale damages and maintenance work. To estimate emissions resulting from the permanent leakiness of the different gas appliances, the number and kind of end users and connected gas appliances are considered. The methodology by SGWA (2023a) provides the amount of gas lost in cubic meters per year which serves – after conversion to energy units (GJ per year) based on the country-specific net calorific values – as the activity data. Finally, emissions of NMVOC are calculated by multiplying the losses (activity data) with the country-specific composition of the gas (emission factor).

## Emission factors (1B2b)

*Production of natural gas*

For natural gas production NMVOC default emission factors are taken from the 2006 IPCC Guidelines (IPCC 2006) as documented in the internal emission database documentation (EMIS 2025/1B2b Gasproduktion). The default emission factors are provided in grams per cubic meter of gas produced and – to match the units of the activity data – are converted to grams per energy unit (GJ) produced based on the country-specific gas properties as mentioned above. As gas production only occurred until 1994, there is no emission factor reported in Table 3-113.

*Transport of natural gas*

For natural gas transmission and distribution, the emission factors represent the composition of the gas lost and are based on the country-specific gas properties as mentioned above.

Table 3-113 Emission factors in 1B2b – Natural gas, for 2023.

| 1B2b Natural gas | | Unit | NMVOC |
|---|---|---|---|
| | | | g/... |
| 1B2bii Natural gas production | Raw gas | GJ | NO |
| 1B2biv Tansmission losses natural gas network | Natural gas | GJ | 2'145 |
| 1B2bv Distribution losses natural gas network | Natural gas | GJ | 2'145 |

## Activity data (1B2b)

*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 2024).

*Transport of natural gas*

For gas transmission and distribution, the activity data represent the amount of natural gas lost from the gas network. All the details are documented in SGWA (2023a) and EMIS 2025/1B2b Diffuse Emissionen.

The key points within transmission are as follows:

- **Compressor Station**: Since 2016 the operator of the transit pipeline provides annual emissions data for specific areas (such as starting gas for turbines, compressor depressurization, control valves, gas meters, etc.). For the years before 2016 and for areas not covered by the operator's data, emission factors from Battelle (1989) are used. The calculations are performed by scaling with the actual compressor power (yearly average).
- **Transit pipeline:** Since 2016, the operator of the transit pipeline provides annual emissions data for losses from operation and maintenance of the transit pipeline. Before 2016, emission factors from Battelle (1989) are used. For pressure reducing and metering stations, emission factors from DVGW (2022) are applied. The calculations are performed by scaling with the pipeline length (gas statistics from SGWA).
- **Components of the transport network (excluding the transit pipeline):** Emission factors from DVGW (2022) for 2020 are converted to the structures of the Swiss gas network. The calculations are performed by scaling with the pipeline length (gas statistics from SGWA).

- **Network Maintenance of the transport network (excluding the transit pipeline):** For 1990, emission factors from Battelle (1989) are used with linear interpolation to the emissions factors for 2020 based on DVGW (2022). The calculations are performed by scaling with the pipeline length (without the share of the transit pipeline; gas statistics from SGWA).

The key points within distribution are as follows:

- **Leakage:** The methodology is based on the actual number of leaks per kilometre for the years since 2017 (gas statistics from SGWA). For 1990, the number of leaks is derived from Battelle (1989). The various materials and pressure levels of the pipelines are distinguished. The losses per leak are based on measurements from DVGW (2022). The calculations are performed by scaling with the pipeline length (gas statistics from SGWA).
- **Damage by external influences (third-party damage):** The methodology is based on actual third-party damage per kilometre since 2017 (gas statistics from SGWA). For 1990, the amount of third-party damage per kilometre is derived from Battelle (1989). The losses per damage are determined based on DVGW (2022). The calculations are performed by scaling with the pipeline length (gas statistics from SGWA).
- **Permeation:** Permeation through polyethylene pipelines is estimated based on DVGW (2022), while permeation is considered to be negligible for other materials. The calculations are performed by scaling with the pipeline length (gas statistics from SGWA).
- **Components:** Emission factors from Battelle (1994) for 1990 and DVGW (2022) for 2020 are considered. The calculations are performed by scaling with the pipeline length (gas statistics from SGWA).
- **Network Maintenanc**e: Emission factors from Battelle (1994) for 1990 and DVGW (2022) for 2020 are considered. The calculations are performed by scaling with the pipeline length (gas statistics from SGWA).
- **Industrial Networks:** Emission factors are formed based on Battelle (1994), referring to the gas quantity used by industrial plants. The calculations are performed by scaling with the gas quantity used by industrial plants (until 2019 based on statistics from the Swiss Gas Industry Association, thereafter, estimated based on the total gas quantity).
- **House Installations:** Emission factors are based on usability tests – for 1990 based on Battelle (1994), for 2020 based on measurement campaigns by the network operators. The calculations are performed by scaling with the number of end users (gas statistics from SGWA).
- **Gas Stoves:** Emission factors according to Battelle (1994) are used. The number of gas stoves is estimated based on the number of end users (as determined by a survey by SGWA).
- **Gas Stations:** Emission factors according to Battelle (1994) are used.
- **Liquefied natural gas:** Calculations are based on the number of transfer operations and the dead volume of the couplings. Additional losses are estimated to amount to one per cent of the total liquefied natural gas quantity used.

Table 3-114 Activity data of 1B2b Fugitive emissions – Natural gas.

| 1B2b Natural gas | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| 1B2bii Natural gas production | Raw gas | TJ | 130 | NO | NO | NO | NO |
| 1B2biv Tansmission losses natural gas network | Natural gas | TJ | 12 | 13 | 14 | 13 | 48 |
| 1B2bv Distribution losses natural gas network | Natural gas | TJ | 162 | 169 | 156 | 139 | 119 |

| 1B2b Natural gas | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1B2bii Natural gas production | Raw gas | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1B2biv Tansmission losses natural gas network | Natural gas | TJ | 12 | 12 | 10 | 18 | 11 | 11 | 14 | 7.8 | 8.9 | 7.2 |
| 1B2bv Distribution losses natural gas network | Natural gas | TJ | 98 | 94 | 91 | 88 | 82 | 79 | 75 | 76 | 74 | 75 |

### 3.3.3.3 Category-specific recalculations for 1B2b

- 1B2b: The Swiss statistic of energy consumption (SFOE 2024) has newly added the amount of Liquefied Natural Gas (LNG) used to the total amount of natural gas used for the years 2020-2022. This leads to small recalculations mainly in source categories 1A3b Road transportation, 1A4ai Commercial/institutional (stationary) and 1B2b Natural gas losses.

## 3.3.4 Source category 1B2c - Fugitive emissions from venting and flaring

### 3.3.4.1 Source category description for 1B2c

This source category contains venting and flaring caused by two types of activities: oil production and refining and gas production. In Switzerland, oil production is not occurring, and only one production site for natural gas production was operational from 1985–1994. Therefore, emissions from flaring result primarily from the gas torches caused by oil refining, which were operational at the two refineries. Since 2015, there is only one refinery in operation. In addition, $CO_2$ emissions from $H_2$ production in one of the two refineries since 2005 are also reported under 1B2c.

Table 3-115 Specification of source category 1B2c – Venting and flaring.

| 1B2c | Source category | Specification |
|---|---|---|
| 1B2c | Venting and flaring (oil, gas, combined oil and gas) | The release/combustion of excess gas at the oil refinery<br>Flaring of gas at gas production facility (only relevant for 1990-1994) |

Table 3-116: Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 1B2c - Fugitive emissions from venting and flaring (oil, gas, combined oil and gas).

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 1B2c | Venting and flaring (oil gas combined oil and gas) | NOx | T2 |

### 3.3.4.2 Methodological issues for 1B2c

#### Methodology (1B2c)

Following the decision tree, Figure 3-1 in the EMEP/EEA guidebook (EMEP/EEA 2023), 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. Between 1990-1994, there was a gas production facility in Switzerland, where gas was flared.

### Emission factors (1B2c)

Emission factors of 1B2c Venting and flaring are based on the following data:

- $NO_x$, NMVOC, $SO_x$ and CO emission factors are provided from the refining industry as documented in the EMIS database (EMIS 2025/1B2c 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, $SO_x$, CO) is assumed to be proportional to the $CO_2$ emission factor. Emission factors for 2023 are considered confidential and are available to reviewers upon request. The NMVOC emissions from flaring in the gas production facility (only occurring from 1990-1994) are calculated based on default emission factors provided in the 2006 IPCC Guidelines.
- PM/TSP exhaust, BC exhaust, heavy metals and PAH emission factors concerning gas venting and flaring for gas production and for oil refining stem from the EMEP/EEA guidebook (EMEP/EEA 2023). For the emission factors applicable at oil refineries, the values from EMEP/EEA (2023), originally in the unit of ton of gas burned, are recalculated per quantity of oil processed for the Swiss inventory. Since the quantity of gas burned per oil processed at refinery is confidential, therefore, the emission factor shown in Table 3-117 is confidential as well.
- The PCDD/PCDF emission factor for venting and flaring at gas production stems from Norway's Informative Inventory Report 2021 (Norwegian Environment Agency 2021). This emission factor is used from 1985 until 1994, when gas production stopped in Switzerland.

Table 3-117 Emission factors in 1B2c – Venting and flaring, for 2023.

| 1B2c Venting and flaring | | Unit | NOx | NMVOC | SOx | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| 1B2cii1 Flaring | Crude oil | t | C | C | C | C | C | C | C | C |
| 1B2cii2 Flaring | Raw gas | GJ | NO | NO | NO | NO | NO | NO | NO | NO |

| 1B2c Venting and flaring | | Unit | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... |
| 1B2cii1 Flaring | Crude oil | t | C | C | C | NA | C | C | C | C |
| 1B2cii2 Flaring | Raw gas | GJ | NO | NO | NO | NO | NO | NO | NO | NO |

### Activity data (1B2c)

*1B2c Fugitive emissions from venting and flaring*

Before 2005, the amount of flared gas in oil refineries (1B2ci) 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 in the refineries. Activity data since 2014 are considered confidential and are available to reviewers on request.

For gas venting and flaring associated with gas production (only occurring from 1990-1994), the amount of gas flared under category 1B2cii is estimated based on the amount of gas produced.

Table 3-118 Activity data of 1B2c – Venting and flaring.

| 1B2c Venting and flaring | | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|---|
| 1B2cii1 Flaring | Crude oil | kt | C | C | C | C | C |
| 1B2cii2 Flaring | Raw gas | TJ | 130 | NO | NO | NO | NO |

| 1B2c Venting and flaring | | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1B2cii1 Flaring | Crude oil | kt | C | C | C | C | C | C | C | C | C | C |
| 1B2cii2 Flaring | Raw gas | TJ | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

### 3.3.4.3 Category-specific recalculations for 1B2c

There were no recalculations implemented in submission 2025.

# 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 2023 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 are the main emission source of NMVOC and contribute to a lesser extent to the emissions of $SO_x$ and particulate matter. Industrial processes and product use are also relevant sources for emissions of priority heavy metals and dominate the PCB 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 industry production
- 2I Wood processing
- 2K Consumption of POPs and heavy metals
- 2L Other production, consumption, storage, transportation or handling of bulk products

### 4.1.1 Overview and trend for NMVOC

According to Figure 4-1 and Table 4-1, total NMVOC emissions from 2 Industrial processes and product use show a considerable decrease between 1990 and 2004 with a weaker decreasing trend until 2016 and rather constant values afterwards. The trend until 2004 is mainly due to reductions in 2D Other solvent and product use and to a lesser extent to reductions in 2G Other 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 to more than half of the NMVOC emissions of source category 2D whereas all the other source categories account for the rest. In 2023, the largest shares in source category 2D come from 2D3d Coating applications and 2D3a Domestic solvent use including fungicides while the shares of 2D3b Road paving with asphalt, 2D3c Asphalt roofing, 2D3e Degreasing, 2D3f Dry cleaning, 2D3g Chemical products, 2D3h Printing and 2D3i Other solvent use account for the rest.

The reduction in 2D3d Coating applications is due to changes in the paint composition, i.e. from solvent-based to water-based paints. Accordingly, emission factors 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 construction (1990–1998) and 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 industrial paint application and paint application in construction whereas in 2023, by emissions from paint application on wood and in construction.

The NMVOC emissions from the most important single source category 2D3a Household cleaning agents, cosmetics and toiletries increase between 1990 and 1996 then they drop until 2000 and since then they show a weaker decline until 2016. From 2017 onwards, the emissions are again increasing. Factors contributing to this trend are changes in the range of product used, product-specific NMVOC contents and population growth.

Within source category 2D, a significant reduction in emissions from 2D3g Chemical products and 2D3h Printing between 1990 and 2023 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), closing down of production, e.g. PVC production in 1996 (2B Chemical industry) and the production decrease in the iron foundries (2C Metal production) contribute to the observed decrease in NMVOC emissions. The NMVOC emissions from 2H Other with main contributions from source category 2H2 Bread production slightly decline as well in the period 1990–2023. In addition, general technological improvements and post-combustion installations contribute to further emission reductions.

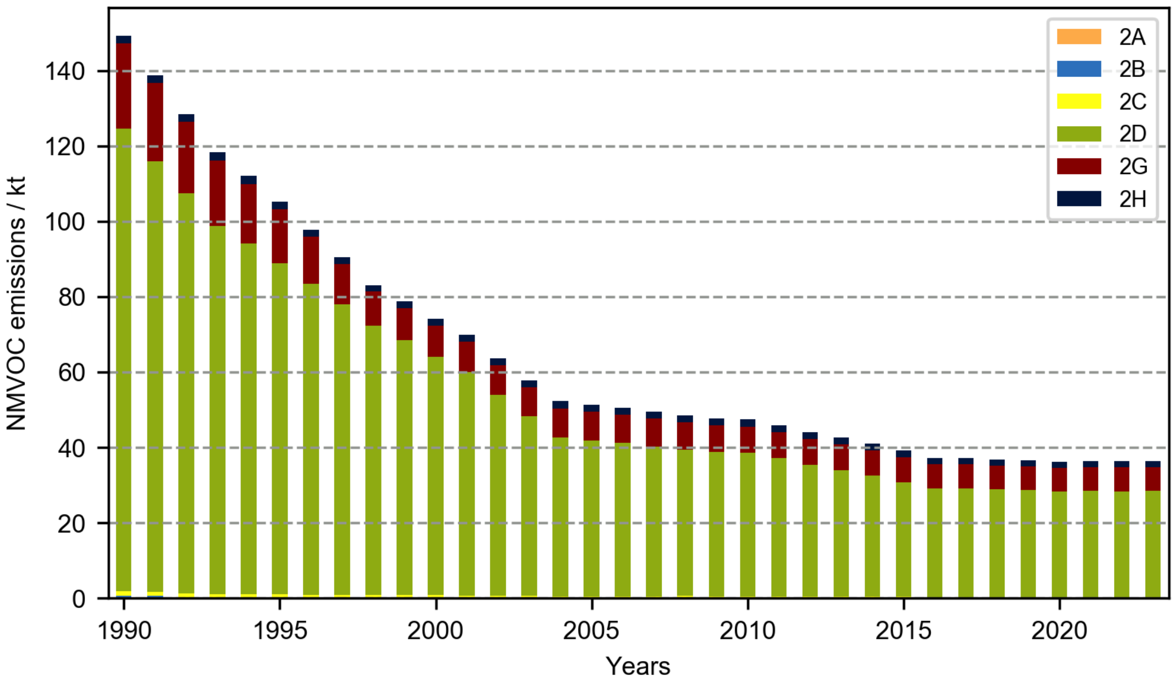



Figure 4-1 Switzerland’s NMVOC emissions from industrial processes and product use by source categories 2A-2D and 2G-2H between 1990 and 2023. The corresponding data can be found in Table 4-1.

Table 4-1 NMVOC emissions from sector 2 Industrial processes and product use by source categories 2A-2D, 2G and 2H. The last column in the third part of the table indicates the relative trend.

| NMVOC | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 2A | kt | 0.047 | 0.037 | 0.032 | 0.035 | 0.037 |
| 2B | kt | 0.61 | 0.18 | 0.025 | 0.028 | 0.037 |
| 2C | kt | 1.1 | 0.76 | 0.71 | 0.45 | 0.35 |
| 2D | kt | 123 | 88 | 63 | 41 | 38 |
| 2G | kt | 22 | 14 | 8.2 | 7.6 | 6.9 |
| 2H | kt | 2.1 | 2.0 | 1.8 | 1.8 | 1.9 |
| 2I | kt | NA | NA | NA | NA | NA |
| 2K | kt | NA | NA | NA | NA | NA |
| 2L | kt | NA | NA | NA | NA | NA |
| Sum | kt | 149 | 105 | 74 | 51 | 47 |

| NMVOC | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 2A | kt | 0.033 | 0.030 | 0.031 | 0.031 | 0.031 |
| 2B | kt | 0.023 | 0.020 | 0.016 | 0.013 | 0.015 |
| 2C | kt | 0.31 | 0.29 | 0.27 | 0.28 | 0.28 |
| 2D | kt | 32 | 30 | 29 | 29 | 28 |
| 2G | kt | 6.7 | 6.6 | 6.5 | 6.4 | 6.3 |
| 2H | kt | 1.8 | 1.8 | 1.7 | 1.7 | 1.7 |
| 2I | kt | NA | NA | NA | NA | NA |
| 2K | kt | NA | NA | NA | NA | NA |
| 2L | kt | NA | NA | NA | NA | NA |
| Sum | kt | 41 | 39 | 37 | 37 | 37 |

| NMVOC | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 2A | kt | 0.030 | 0.029 | 0.030 | 0.029 | 0.026 | -24 |
| 2B | kt | 0.016 | 0.015 | 0.016 | 0.015 | 0.015 | -46 |
| 2C | kt | 0.22 | 0.20 | 0.22 | 0.22 | 0.19 | -58 |
| 2D | kt | 28 | 28 | 28 | 28 | 28 | -32 |
| 2G | kt | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | -17 |
| 2H | kt | 1.7 | 1.6 | 1.7 | 1.7 | 1.6 | -8.1 |
| 2I | kt | NA | NA | NA | NA | NA | - |
| 2K | kt | NA | NA | NA | NA | NA | - |
| 2L | kt | NA | NA | NA | NA | NA | - |
| Sum | kt | 37 | 36 | 36 | 36 | 36 | -29 |

## 4.1.2 Overview and trend for $SO_x$

According to Figure 4-2 and Table 4-2, total $SO_x$ emissions from 2 Industrial processes and product use show an intermittent decrease of almost 70 % in the period 1990-2009. From 2010 to 2018, there is again an increase in $SO_x$ emissions followed by a decrease 2019-2023. In 1990, source categories 2C Metal production and 2B Chemical industry show the largest contributions (around 50 % each) to the total $SO_x$ emissions. In 2023, the emissions are dominated by 2B Chemical industry. The emissions from 2A Mineral products are negligible over the entire time period and there are no emissions from 2D. The highly fluctuating $SO_x$ emissions from 2B Chemical industry stem mainly from the graphite and silicon carbide production, i.e. the raw materials used (petroleum coke and other bituminous coal) and reflect both the production volume and the sulphur content of raw materials between 1990 and 2023. In 2023, it is by far the largest emission source within sector 2. The $SO_x$ 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 $SO_x$ emissions from 2G Other product use stems from the use of fireworks.

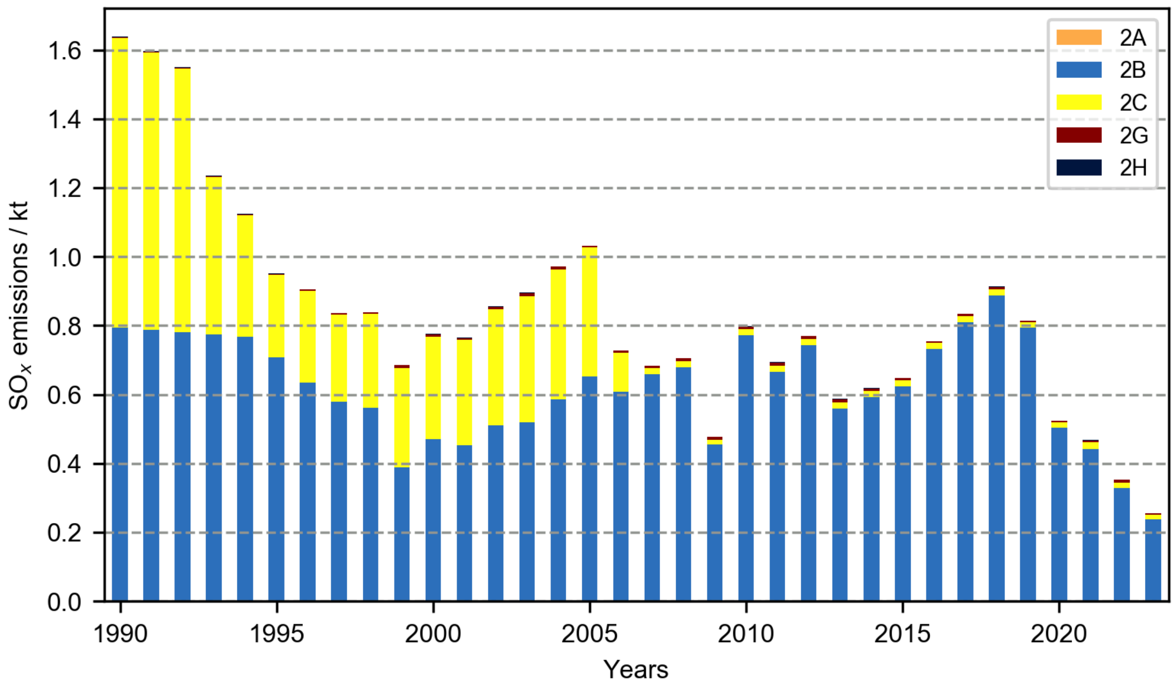



Figure 4-2 Switzerland's $SO_x$ emissions from industrial processes and product use by source categories 2A–2C and 2G-2H between 1990 and 2023. The corresponding data can be found in Table 4-2.

Table 4-2 $SO_x$ emissions from sector 2 Industrial processes and product use by source categories 2A-2C and 2G-2H. The last column in the third part of the table indicates the relative trend.

| SOx | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 2A | kt | 0.00078 | 0.00061 | 0.00054 | 0.00058 | 0.00061 |
| 2B | kt | 0.79 | 0.71 | 0.47 | 0.65 | 0.77 |
| 2C | kt | 0.84 | 0.24 | 0.30 | 0.37 | 0.017 |
| 2D | kt | NA | NA | NA | NA | NA |
| 2G | kt | 0.0034 | 0.0042 | 0.0062 | 0.0056 | 0.0069 |
| 2H | kt | 0.0013 | 0.00066 | 0.00093 | 0.00040 | 0.0012 |
| 2I | kt | NA | NA | NA | NA | NA |
| 2K | kt | NA | NA | NA | NA | NA |
| 2L | kt | NA | NA | NA | NA | NA |
| Sum | kt | 1.6 | 0.95 | 0.78 | 1.0 | 0.80 |

| SOx | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 2A | kt | 0.00055 | 0.00050 | 0.00052 | 0.00051 | 0.00051 |
| 2B | kt | 0.59 | 0.62 | 0.73 | 0.81 | 0.89 |
| 2C | kt | 0.018 | 0.018 | 0.017 | 0.018 | 0.018 |
| 2D | kt | NA | NA | NA | NA | NA |
| 2G | kt | 0.0074 | 0.0066 | 0.0050 | 0.0071 | 0.0075 |
| 2H | kt | 0.0011 | 0.0011 | 0.00033 | 0.00036 | 0.00040 |
| 2I | kt | NA | NA | NA | NA | NA |
| 2K | kt | NA | NA | NA | NA | NA |
| 2L | kt | NA | NA | NA | NA | NA |
| Sum | kt | 0.62 | 0.65 | 0.76 | 0.83 | 0.91 |

| SOx | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 2A | kt | 0.00051 | 0.00049 | 0.00049 | 0.00048 | 0.00044 | -24 |
| 2B | kt | 0.79 | 0.50 | 0.44 | 0.33 | 0.24 | -63 |
| 2C | kt | 0.016 | 0.016 | 0.018 | 0.017 | 0.013 | -96 |
| 2D | kt | NA | NA | NA | NA | NA | - |
| 2G | kt | 0.0041 | 0.0043 | 0.0062 | 0.0077 | 0.0033 | -41 |
| 2H | kt | 0.00034 | 0.00032 | 0.00030 | 0.00033 | 0.00032 | -19 |
| 2I | kt | NA | NA | NA | NA | NA | - |
| 2K | kt | NA | NA | NA | NA | NA | - |
| 2L | kt | NA | NA | NA | NA | NA | - |
| Sum | kt | 0.81 | 0.52 | 0.47 | 0.35 | 0.26 | -75 |

### 4.1.3 Overview and trend for PM2.5

According to Figure 4-3 and Table 4-3, total PM2.5 emissions from sector 2 Industrial processes and product use show a decrease of about 40 % in the period 1990-1999. The emissions are fluctuating with again a decreasing trend since 2008. In 1990, the source categories 2C Metal production, 2G Other product use, 2H Other and 2A Mineral products contribute the most to the total PM2.5 emissions.

In 2023, the highest contribution to the total PM2.5 emissions is due to the source categories 2G, 2H and 2A whereas the other source categories are of minor importance. PM2.5 emissions from 2A Mineral products, with the main contributions from blasting operations in 2A1 Cement production and from 2A5a Quarrying and mining of minerals other than coal, decreased by about a quarter between 1990 and 1999. After a slight increase until 2010, they are decreasing again. On the other hand, PM2.5 emissions from 2C Metal production, which are dominated by the emissions from 2C1 Iron and steel production, show a strong decrease between 1994 and 1999 and are almost exclusively responsible for the total PM2.5 emission reduction in this source category between 1990 and 2023. The reason for the initial emission reduction in 1995 is the closing down of two steel production sites, whereas the drastic emission drop 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 have since decreased by about one third. In 1990, 2G emissions were dominated by tobacco use. The annual fluctuations are due to differences in the consumption of fireworks caused by bans due to dryness on the national holiday. In 2023, tobacco use is still the major emission source but also the use of fireworks contributes considerable amounts. The emissions in 2H Other decreased by about a quarter since 1990. In this source category, the main contributions currently arise from 2H1 Chipboard and fibreboard production and 2H2 Food and beverages industry.

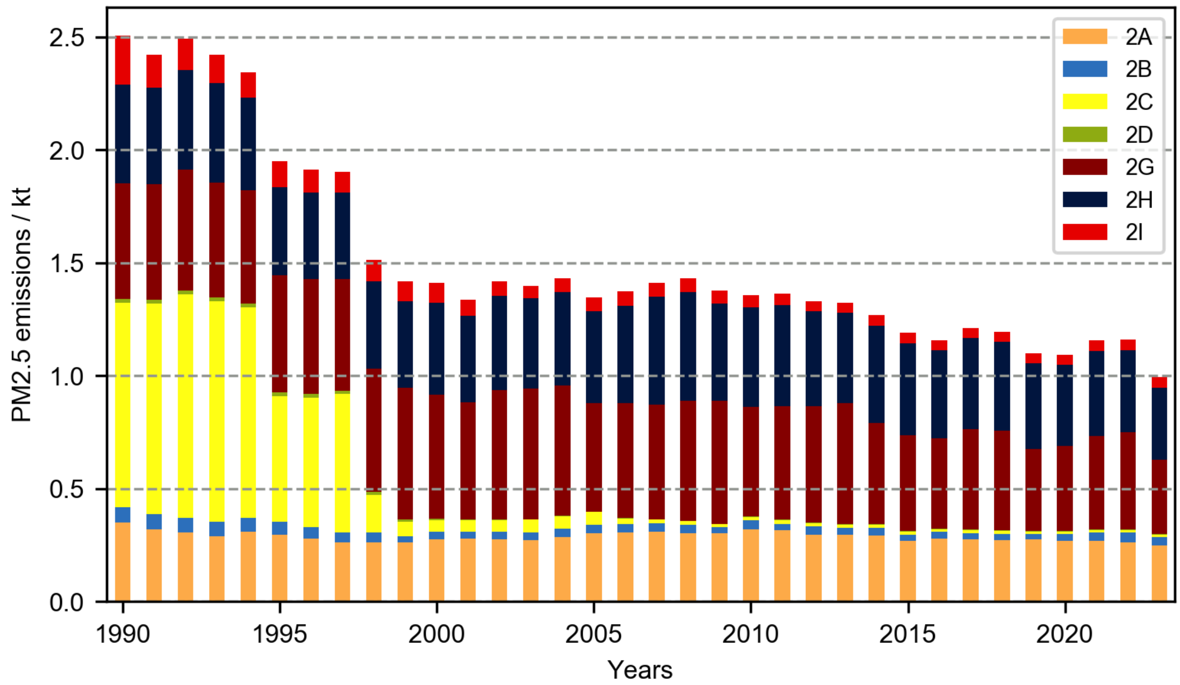



Figure 4-3 Switzerland's PM2.5 emissions from industrial processes and product use by source categories 2A-2D and 2G-2I between 1990 and 2023. The corresponding data can be found in Table 4-3.

Table 4-3 PM2.5 emissions from sector 2 Industrial processes and product use by source categories 2A-2D and 2G-2I. The last column in the third part of the table indicates the relative trend.

| PM2.5 | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 2A | kt | 0.35 | 0.30 | 0.28 | 0.30 | 0.32 |
| 2B | kt | 0.069 | 0.058 | 0.033 | 0.040 | 0.039 |
| 2C | kt | 0.90 | 0.56 | 0.051 | 0.055 | 0.014 |
| 2D | kt | 0.016 | 0.015 | 0.0069 | 0.0024 | 0.0033 |
| 2G | kt | 0.51 | 0.52 | 0.55 | 0.48 | 0.49 |
| 2H | kt | 0.44 | 0.39 | 0.40 | 0.41 | 0.44 |
| 2I | kt | 0.22 | 0.12 | 0.090 | 0.063 | 0.057 |
| 2K | kt | NA | NA | NA | NA | NA |
| 2L | kt | NA | NA | NA | NA | NA |
| Sum | kt | 2.5 | 2.0 | 1.4 | 1.3 | 1.4 |

| PM2.5 | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 2A | kt | 0.29 | 0.27 | 0.28 | 0.27 | 0.27 |
| 2B | kt | 0.033 | 0.029 | 0.031 | 0.029 | 0.029 |
| 2C | kt | 0.013 | 0.012 | 0.012 | 0.012 | 0.012 |
| 2D | kt | 0.0037 | 0.0037 | 0.0037 | 0.0038 | 0.0038 |
| 2G | kt | 0.45 | 0.42 | 0.40 | 0.44 | 0.44 |
| 2H | kt | 0.43 | 0.41 | 0.39 | 0.41 | 0.39 |
| 2I | kt | 0.047 | 0.046 | 0.046 | 0.043 | 0.044 |
| 2K | kt | NA | NA | NA | NA | NA |
| 2L | kt | NA | NA | NA | NA | NA |
| Sum | kt | 1.3 | 1.2 | 1.2 | 1.2 | 1.2 |

| PM2.5 | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 2A | kt | 0.28 | 0.27 | 0.27 | 0.26 | 0.25 | -18 |
| 2B | kt | 0.023 | 0.030 | 0.038 | 0.045 | 0.039 | -0.17 |
| 2C | kt | 0.010 | 0.0098 | 0.011 | 0.011 | 0.0087 | -84 |
| 2D | kt | 0.0038 | 0.0038 | 0.0038 | 0.0038 | 0.0038 | 58 |
| 2G | kt | 0.36 | 0.38 | 0.41 | 0.43 | 0.33 | -32 |
| 2H | kt | 0.38 | 0.36 | 0.38 | 0.36 | 0.32 | -21 |
| 2I | kt | 0.044 | 0.046 | 0.049 | 0.049 | 0.047 | -25 |
| 2K | kt | NA | NA | NA | NA | NA | - |
| 2L | kt | NA | NA | NA | NA | NA | - |
| Sum | kt | 1.1 | 1.1 | 1.2 | 1.2 | 0.99 | -26 |

# 4.2 Source category 2A – Mineral products

## 4.2.1 Source category description of 2A Mineral products

Table 4-4 Specification of source category 2A Mineral products in Switzerland.

| 2A | Source category | Specification |
|---|---|---|
| 2A1 | Cement production | Blasting operations of the cement production,<br>Process emissions from calcination are reported in 1A2f |
| 2A2 | Lime production | Blasting operations of the lime production,<br>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 4-5 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 2A Mineral Products.

| NFR 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 | L2, T2 |
| 2A5a | Quarrying and mining of minerals other than coal | PM10 | L1, L2, 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 the EMEP/EEA guidebook (EMEP/EEA 2023, 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 (2023), 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 2025/2A1. 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 the EMEP/EEA guidebook (EMEP/EEA 2023 chp. 2.A.1, table 3.1).

Table 4-6 Emission factors for blasting operations of 2A1 Cement production in 2023.

| 2A1 Cement production | Unit of activity data | NOx | NMVOC | SOx | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx |
|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Blasting operations | t clinker | 3.3 | 8.6 | 0.14 | 0.51 | 50 | 0.86 | 77 |

| 2A1 Cement production | Unit of activity data | TSP ex | TSP nx | BC ex | CO |
|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... |
| Blasting operations | t clinker | 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 2025/2A1_Zementwerke übriger Betrieb). From 2008 onwards, they are based on plant-specific annual monitoring reports from the Swiss Emissions Trading Scheme (ETS).

Table 4-7 Activity data of 2A1 Cement production.

| 2A1 Cement production | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Blasting operations | kt clinker | 4'808 | 3'706 | 3'214 | 3'442 | 3'642 |

| 2A1 Cement production | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Blasting operations | kt clinker | 3'502 | 3'195 | 3'296 | 3'279 | 3'239 | 3'227 | 3'129 | 3'227 | 3'155 | 2'855 |

## 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 the EMEP/EEA guidebook (EMEP/EEA 2023), emissions from blasting operations in the quarry are determined by a Tier 2 method using country-specific emission factors (EMIS 2025/2A2). 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, $SO_x$, 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 guidebook (EMEP/EEA 2023, chp. 2.A.2, table 3.1).

### 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 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 guidebook (EMEP/EEA 2023), 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. In August 2020, one of the two plaster production plants was closed. The emissions stem mainly from blasting operations and crushing of stones either in plaster production or gravel plants.

Based on the EMEP/EEA guidebook (EMEP/EEA 2023), emissions from blasting operations as well as emissions of particulates from crushing and grinding work are determined by a Tier 2 method using default and country-specific emission factors for gravel plants and plaster production, respectively (EMIS 2025/2A5a). Emissions from storage and handling are also accounted for.

#### Emission factors (2A5a)

The emission factors per tonne of gravel and rocks are based on the calculation model of EMEP/EEA (2023) for small quarries taking into account the process steps material processing, material handling and operation and stockpiles. The process step internal transport was not considered as the emissions of all construction machinery are reported in source category 1A2gvii Mobile combustion (see chp. 3.2.5.2). For plaster production, the emission factors are confidential from 2021 onwards but available to reviewers on request.

Table 4-8 Emission factors of 2A5a Gravel plants and Plaster production in 2023.

| 2A5a Quarrying and mining of minerals | Unit of activity data | NOx | NMVOC | SOx | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx |
|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Gravel plants | t gravel | NA | NA | NA | NA | 1.6 | NA | 6.1 |
| Plaster production | t rocks | C | C | C | C | C | C | C |

| 2A5a Quarrying and mining of minerals | Unit of activity data | TSP ex | TSP nx | BC ex | CO |
|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... |
| Gravel plants | t gravel | NA | 15 | NA | NA |
| Plaster production | t rocks | C | C | NE | C |

#### Activity data (2A5a)

Activity data for 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. From 2021 onwards, activity data are confidential but available to reviewers on request.

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 latest year of the submission.

Table 4-9 Activity data of 2A5a Gravel plants and Plaster production.

| 2A5a Quarrying and mining of minerals | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Gravel plants | kt gravel | 33'798 | 36'791 | 39'785 | 44'960 | 50'540 |
| Plaster production | kt rocks | 319 | 304 | 288 | 327 | 335 |

| 2A5a Quarrying and mining of minerals | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Gravel plants | kt gravel | 53'090 | 50'610 | 52'750 | 51'480 | 49'880 | 54'060 | 54'570 | 53'580 | 52'110 | 52'407 |
| Plaster production | kt rocks | 166 | 140 | 148 | 146 | 152 | 149 | 122 | C | C | C |

#### 4.2.2.5 Construction and demolition (2A5b)

The emissions (from resuspension) of particulate matter (PM2.5, PM10 and TSP) from construction machinery are reported in source category 1A2gvii Mobile combustion in manufacturing industries and construction. Therefore, these emissions are indicated in the reporting tables as "IE".

### 4.2.3 Category-specific recalculations in 2A Mineral products

The following recalculations were implemented in submission 2025:

- 2A5a: The emission factors of PM2.5, PM10, TSP of source category 2A5a Gravel plants were revised based on the 2A5a Quarrying and mining calculation model 2023 (EMEP/EEA 2023) for the entire time series. Also, the last year's extrapolated activity data for 2022 was updated based on the industry association's actual production figure.

# 4.3 Source category 2B – Chemical industry

## 4.3.1 Source category description of 2B Chemical industry

Table 4-10 Specification of source category 2B Chemical industry in Switzerland.

| 2B | Source category | Specification |
|---|---|---|
| 2B1 | Ammonia production | Production of ammonia |
| 2B2 | Nitric acid production | Production of nitric acid (ceased in 2018) |
| 2B5 | Carbide production | Production of silicon carbide and graphite |
| 2B10a | Chemical industry: Other | Production of acetic acid, ammonium nitrate (ceased in 2018), chlorine gas, ethylene, niacin, PVC (ceased in 1996) and sulfuric acid |

Table 4-11 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 2B Chemical Industry.

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 2B5 | Carbide production | SOx | L1, L2, T1, T2 |
| 2B10a | Chemical industry: other | SOx | 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 the EMEP/EEA guidebook (EMEP/EEA 2023), the emissions from 2B1 Ammonia production are calculated by a Tier 2 method using plant-specific emission factors documented in EMIS 2025/2B1.

#### 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 4-12 Emission factor for 2B1 Ammonia production in 2023.

| 2B1 Ammonia production | Unit of activity data | NMVOC | NH3 |
|---|---|---|---|
| | | g/... | g/... |
| Ammonia production | 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 1990-2023. 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 was one single plant producing nitric acid ($HNO_3$) which stopped production in spring 2018. Nitric acid was produced by catalytic oxidation of ammonia ($NH_3$) with air. At temperatures of 800°C nitric monoxide (NO) is formed. During cooling, nitrogen monoxide reacted with excess oxygen to form nitrogen dioxide ($NO_2$). The nitrogen dioxide reacted 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 was installed.

Thus, there resulted also some nitrogen oxide ($NO_x$) as an unintentional by-product. In the Swiss production plant abatement of $NO_x$ was done by selective catalytic reduction (SCR, installed in 1988) which reduced $NO_x$ to $N_2$ and $O_2$ (the SCR in this plant was 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 the EMEP/EEA guidebook (EMEP/EEA 2023), $NH_3$ and $NO_x$ emissions from 2B2 Nitric acid production are calculated by a Tier 2 method using plant-specific emission factors (see EMIS 2025/2B2).

### 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 emission factor 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. From 2013 to 2018, emission factors were based on measurements provided by the plant.

### Activity data (2B2)

Activity data on annual nitric acid (100 %) production was provided for the years 1990 to 2018 by the single production plant in Switzerland and is therefore considered as confidential. However, this information is available to reviewers. From 2013 to 2018, activity data were 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 a single plant. It is produced together with graphite in a coupled process in an electric furnace at temperatures above 2000ºC using the Acheson process. Therefore, emissions include those from the production of both silicon carbide and graphite. Based on the decision tree Fig. 3.1 in chapter 2B Chemical industry in the EMEP/EEA guidebook (EMEP/EEA 2023), the emissions of $SO_{x,}$ particulate matter and CO from 2B5 Silicon carbide production are calculated by a Tier 2 method using plant-specific emission factors (EMIS 2025/2B5).

#### Emission factors (2B5)

The emission factors of $NO_x$, $SO_x$, particulate matter, CO and PAHs are based on data from the production plant. The $SO_x$ emission factor is derived from the sulphur content of the feedstocks, i.e. petroleum coke and anthracite. The CO emission factor is calculated based on the carbon mass balance of the production process and exhaust measurements. The emission factors are expressed in g/t carbide but comprise the (unsplit) emissions from the coupled production process of silicon carbide and graphite. They are confidential but available to reviewers on request.

Table 4-13 Emission factor for 2B5 Carbide production in 2023.

| 2B5 Carbide production | Unit of activity data | NOx | SOx | PM2.5 ex | PM10 ex | TSP ex | BC ex |
|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... |
| Silicon carbid production | t carbide | C | C | C | C | C | NE |

| 2B5 Carbide production | Unit of activity data | CO | BaP | BbF | BkF | IcdP |
|---|---|---|---|---|---|---|
| | | g/... | mg/... | mg/... | mg/... | mg/... |
| Silicon carbid production | t carbide | C | C | C | C | C |

#### Activity data (2B5)

Activity data on annual production of silicon carbide (and graphite) is provided by the production plant from 1995 onwards. For 1990–1994 they are estimates based on industry data. 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 (ceased in 2018), chlorine gas, ethylene, niacin, PVC (ceased in 1996) as well as sulphuric acid. Based on the decision tree Fig. 3.1 in chapter 2B Chemical industry in the EMEP/EEA guidebook (EMEP/EEA 2023), emissions from 2B10a Chemical industry are calculated by a Tier 2 method using plant-specific emission factors (EMIS 2025/2B10a).

## Acetic acid production (2B10a)

In Switzerland there is only one plant producing acetic acid ($CH_3COOH$) remaining 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 2025/2B10 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 4-14 Emission factors of 2B10a Chemical industry: Other in 2023.

| 2B10a Chemical industry Other | Unit of activity data | NOx | NMVOC | SOx | NH3 | PM2.5 nx | PM10 nx | TSP nx | CO | Hg |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | mg/... |
| Acetic acid production | t acid | NA | C | NA | NA | NA | NA | NA | NA | NA |
| Ammonium nitrate production | t ammonium nitrate | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Chlorine gas production | t chlorine | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Ethylene production | t ethylene | NA | C | NA | NA | NA | NA | NA | NA | NA |
| Niacin production | t niacin | C | NA | NA | NA | NA | NA | NA | C | NA |
| PVC production | kg PVC | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Sulfuric acid production | t acid | NA | NA | C | NA | 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 2025/2B10 Essigsäure-Produktion. The data for acetic acid production are confidential since 2013 (only one manufacturer remaining) but available for reviewers on request.

Table 4-15 Activity data of 2B10a Chemical industry: Other.

| 2B10a Chemical industry Other | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Acetic acid production | kt acid | 30 | 27 | 24 | 8.4 | 20 |
| Ammonium nitrate production | kt ammonium nitrate | C | C | C | C | C |
| Chlorine gas production | kt chlorine | C | C | C | C | C |
| Ethylene production | kt ethylene | C | C | C | C | C |
| Niacin production | kt niacin | C | C | C | C | C |
| PVC production | kt PVC | 43 | 43 | NO | NO | NO |
| Sulfuric acid production | kt acid | C | C | C | C | C |

| 2B10a Chemical industry Other | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Acetic acid production | kt acid | C | C | C | C | C | C | C | C | C | C |
| Ammonium nitrate production | kt ammonium nitrate | C | C | C | C | C | NO | NO | NO | NO | NO |
| Chlorine gas production | kt chlorine | C | C | C | C | C | C | C | C | C | C |
| Ethylene production | kt ethylene | C | C | C | C | C | C | C | C | C | C |
| Niacin production | kt niacin | C | C | C | C | C | C | C | C | C | C |
| PVC production | kt PVC | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Sulfuric acid production | kt acid | C | C | C | C | C | C | C | C | C | C |

## Ammonium nitrate production (2B10a)

In Switzerland there was only one plant producing ammonium nitrate; it stopped production in 2018. In the production process emissions of $NH_3$ and particulate matter occurred.

### 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 2025/2B10 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 was based on data from industry for 1990 and from 1997 to 2018 as documented in EMIS 2025/2B10 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 was 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 2025/2B10 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 2025/2B10 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 2025/2B10 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 2025/2B10 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.

### Niacin production (2B10a)

In Switzerland, there is one plant producing niacin that emits $NO_x$ and CO. In the production process of niacin, nitric acid is used as oxidizing agent. Since the nitric acid production plant was closed in spring 2018 the required nitric acid is directly produced within the niacin production plant using a so-called ammonia burner. In autumn 2021, a catalytic converter was installed to treat the non-absorbed gas components of the production plant (incl. ammonia burner). The nitrogen oxides are denitrified with ammonia, and nitrous oxide, hydrocyanic acid and carbon monoxide are decomposed to nitrogen, water and carbon dioxide.

### Emission factors

The emission factors for $NO_x$ and CO from niacin production in Switzerland are plant-specific. They are based on measurement data from industry in 2017, 2018 and 2021 as documented in EMIS 2025/2B10 Niacin Produktion. The emission factors are confidential but available to reviewers on request.

### Activity data

Activity data of annual niacin production were provided by the Swiss production plant for the entire time period as documented in EMIS 2025/2B10 Niacin-Produktion. For the years 2005-2011 and since 2013 they are based on monitoring reports of the Swiss ETS. Activity data are considered 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 $SO_x$ is emitted.

### Emission factors

The emission factor for $SO_x$ 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 2025/2B10 Schwefelsäure-Produktion. Between 1990 and 2008 the mean value is applied. The $SO_x$ 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 2025/2B10 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 2025/2B10 PVC-Produktion).

**Activity data**

The annual amount of PVC produced is based on data from industry and expert estimates documented in EMIS 2025/2B10 PVC-Produktion (see Table 4-15).

### 4.3.3 Category-specific recalculations in 2B Chemical industry

The following recalculations were implemented in submission 2025:

- 2B5: So far not reported $NO_x$ and PAH emissions from source category 2B5 Silicon carbide production are now included in the inventory on the basis of PRTR data (2008-2023).

## 4.4 Source category 2C – Metal production

### 4.4.1 Source category description of 2C Metal production

Table 4-16 Specification of source category 2C Metal production in Switzerland.

| 2C | Source category | 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 4-17 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 2C Metal Production.

| NFR 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. The PCB emissions are modelled within the disposal category of the dynamic mass flow model developed for the usage of PCBs in Switzerland (Glüge et al. 2017), see Annex A2.2. The PCB emission value of the air pollution control measurements in 2014 were included in the model.

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 the EMEP/EEA guidebook (EMEP/EEA 2023), the emissions from 2C1 Iron and steel production are calculated by a Tier 2 method using country-specific emission factors (EMIS 2025/2C1).

**Emission factors (2C1)**

Emission factors for the pollutants emitted from steel production are based on air pollution control measurements of the steel plants. Emission factors of $NO_x$, NMVOC, $SO_x$, 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. The PCB emission factor comes from the dynamic mass flow model for the usage of PCBs in Switzerland, see Annex A2.2. 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 guidebook (EMEP/EEA 2023, chp. 2.C.1, table 3.1).

Table 4-18 Emission factors 2C1 Iron and steel production in 2023.

| 2C1 Iron and steel production | Unit of activity data | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx |
|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Iron production, electric melting furnace | t iron | NA | 33 | NA | NA | 7.0 | NA | 10 | NA |
| Iron production, other processes | t iron | 10 | 4'000 | NA | 70 | NA | 50 | NA | 130 |
| Steel production, electric arc furnace | t steel | 140 | 70 | 14 | NA | 6.0 | NA | 8.0 | NA |
| Steel production, electric arc furnace (PCB) | g PCB | NA | NA | NA | NA | NA | NA | NA | NA |
| Steel production, other processes | t steel | NO | NO | NO | NO | NO | NO | NO | NO |
| Steel production, rolling mill | t steel | NA | 40 | NA | NA | NA | NA | NA | NA |

| 2C1 Iron and steel production | Unit of activity data | TSP ex | TSP nx | BC ex | CO | Pb | Cd | Hg |
|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | mg/... | mg/... | mg/... |
| Iron production, electric melting furnace | t iron | 13 | NA | 0.025 | 93 | 320 | 1.3 | NA |
| Iron production, other processes | t iron | NA | 150 | NA | 4'000 | NA | NA | NA |
| Steel production, electric arc furnace | t steel | 9.0 | NA | 0.022 | 700 | 200 | 4.0 | 40 |
| Steel production, electric arc furnace (PCB) | g PCB | NA | NA | NA | NA | NA | NA | NA |
| Steel production, other processes | t steel | NO | NO | NO | NO | NO | NO | NO |
| Steel production, rolling mill | t steel | NA | NA | NA | NA | NA | NA | NA |

| 2C1 Iron and steel production | Unit of activity data | PCDD/ PCDF | BaP | BbF | BkF | IcdP | PCB |
|---|---|---|---|---|---|---|---|
| | | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | mg/... |
| Iron production, electric melting furnace | t iron | 130 | NA | NA | NA | NA | NA |
| Iron production, other processes | t iron | 1'300 | NA | NA | NA | NA | NA |
| Steel production, electric arc furnace | t steel | 110 | 0.80 | 3.4 | 0.90 | 2.2 | NA |
| Steel production, electric arc furnace (PCB) | g PCB | NA | NA | NA | NA | NA | 11 |
| Steel production, other processes | t steel | NO | NO | NO | NO | NO | NO |
| Steel production, rolling mill | t steel | 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 steel production decreased between 1994 and 1995 significantly due to the closing of two steel production sites in Switzerland. In 2009, there was a remarkable reduction in activity data within the metal industry because of the financial crisis. Due to the economic situation, including the strong rise in electricity prices because of the war in Ukraine, production fell sharply from 2022 to 2023.

Table 4-19 Activity data for 2C1 Iron and steel production.

| 2C1 Iron and steel production | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Iron production, electric melting furnace | kt iron | 80 | 70 | 65 | 35 | 40 |
| Iron production, other processes | kt iron | 170 | 130 | 120 | 67 | 53 |
| Steel production, electric arc furnace | kt steel | 1'108 | 716 | 1'022 | 1'159 | 1'218 |
| Steel production, electric arc furnace (PCB) | t PCB | 0.12 | 0.098 | 0.13 | 0.16 | 0.17 |
| Steel production, other processes | kt steel | 1'108 | 716 | NO | NO | NO |
| Steel production, rolling mill | kt steel | 1'108 | 716 | 1'022 | 1'082 | 1'082 |

| 2C1 Iron and steel production | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Iron production, electric melting furnace | kt iron | 33 | 28 | 26 | 27 | 26 | 18 | 15 | 16 | 17 | 16 |
| Iron production, other processes | kt iron | 43 | 37 | 34 | 35 | 34 | 24 | 20 | 22 | 23 | 22 |
| Steel production, electric arc furnace | kt steel | 1'315 | 1'296 | 1'238 | 1'270 | 1'291 | 1'130 | 1'125 | 1'294 | 1'208 | 936 |
| Steel production, electric arc furnace (PCB) | t PCB | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.16 | 0.16 | 0.16 | 0.15 | 0.15 |
| Steel production, other processes | kt steel | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Steel production, rolling mill | kt steel | 1'176 | 1'144 | 1'085 | 1'138 | 1'160 | 1'037 | 1'031 | 1'104 | 1'121 | 884 |

## 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 in the EMEP/EEA guidebook (EMEP/EEA 2023), emissions from source category 2C3 are calculated by a Tier 2 method using country-specific emission factors (EMIS 2025/2C3).

### 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 2023.

### 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.

Table 4-20 Activity data for the 2C3 Aluminium production.

| 2C3 Aluminium production | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Aluminium production | kt aluminium | 87 | 21 | 36 | 45 | NO |

| 2C3 Aluminium production | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminium production | kt aluminium | 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 primary production of non-ferrous metals occur.

Based on the decision tree Fig. 3.1 in chapter 2C7a in the EMEP/EEA guidebook (EMEP/EEA 2023), emissions from source category 2C7a are calculated by a Tier 2 method (EMIS 2025/2C7a) 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 4-21 Emission factors for 2C7a Foundries of non-ferrous metals in 2023.

| 2C7a Copper production | Unit of activity data | NMVOC | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO | Pb | Cd | PCDD/ PCDF |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | mg/... | mg/... | ng I-Teq/... |
| Foundries of non-ferrous metals | t metal | 50 | 95 | 100 | 100 | 0.095 | 240 | 300 | 50 | 30'000 |

### Activity data (2C7a)

Activity data on annual non-ferrous metal production is based on data from industry (1990 and monitoring reports of the Swiss ETS from 2006 onwards) and the Swiss foundry association (GVS, since 1996) as documented in the EMIS database.

Table 4-22 Activity data for 2C7a Foundries of non-ferrous metals.

| 2C7a Copper production | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Foundries of non-ferrous metals | kt metal | 60 | 56 | 53 | 33 | 20 |

| 2C7a Copper production | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Foundries of non-ferrous metals | kt metal | 9.5 | 8.9 | 9.0 | 8.0 | 6.8 | 6.4 | 5.1 | 7.5 | 7.9 | 5.3 |

### 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 which started operation in 1992 and about a dozen of galvanizing plants. Based on chapter 2C7c in the EMEP/EEA guidebook (EMEP/EEA 2023), emissions from source category 2C7c are calculated by a Tier 2 approach (EMIS 2025/2C7c) using country-specific emission factors.

#### Emission factors (2C7c)

The emission factors for battery recycling between 1992 and 2003 are based on measurements in 2000 (TSP, Hg) and 2003 ($NO_x$, $SO_x$, 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 $NO_x$, $SO_x$, TSP, CO, Pb, Cd, Hg and PCDD/PCDF 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 4-23 Emission factors for 2C7c Other metal production: Battery recycling and Galvanizing in 2023.

| 2C7c Other metal production | Unit of activity data | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx |
|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Battery recycling | t batteries | C | C | C | C | C | NA | C | NA |
| Galvanising plants | t galvanised material | NA | NA | NA | 90 | NA | 15 | NA | 30 |

| 2C7c Other metal production | Unit of activity data | TSP ex | TSP nx | BC ex | CO | Pb | Cd | Hg | PCDD/ PCDF |
|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | mg/... | mg/... | mg/... | ng I-Teq/... |
| Battery recycling | t batteries | C | NA | NE | C | C | C | C | C |
| Galvanising plants | t galvanised material | NA | 37 | NA | NA | NA | 2.5 | NA | 700 |

#### Activity data (2C7c)

Annual activity data on the amount of metal processed is based on data from the only battery recycling site in Switzerland which started operation in 1992 and from the Swiss galvanizing association, as documented in the EMIS database (EMIS 2025/2C7c_Batterie-Recycling, EMIS 2025/2C7c_Verzinkereien).

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

Table 4-24 Activity data for 2C7c Other metal production: Battery recycling and Galvanizing.

| 2C7c Other metal production | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Battery recycling | kt batteries | NO | C | C | C | C |
| Galvanising plants | kt galvanised material | 102 | 84 | 99 | 88 | 93 |

| 2C7c Other metal production | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Battery recycling | kt batteries | C | C | C | C | C | C | C | C | C | C |
| Galvanising plants | kt galvanised material | 92 | 92 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 90 |

## 4.4.3 Category-specific recalculations in 2C Metal production

The following recalculations were implemented in submission 2025:

- 2C1: A typing error in the activity data 2022 of source category 2C1 Iron foundries was corrected.

# 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 4-25 Specification of source category 2D Other solvent use in Switzerland.

| 2D | Source category | Specification |
|---|---|---|
| 2D3a | Domestic solvent use including fungicides | Domestic use of cleaning agents, solvents, cosmetics and 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 car repairing and on wood |
| 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 4-26 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 2D Other Solvent Use.

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 2D3a | Domestic solvent use including fungicides | NMVOC | L1, L2, T1, T2 |
| 2D3b | Road paving with asphalt | NMVOC | L1, L2, T1, T2 |
| 2D3d | Coating applications | NMVOC | L1, L2, T1 |
| 2D3e | Degreasing | NMVOC | L1, T1, T2 |
| 2D3g | Chemical products | NMVOC | L1, L2, T1, T2 |
| 2D3h | Printing | NMVOC | L1, L2, T1 |
| 2D3i | Other solvent use | NMVOC | L1, L2, T2 |

## 4.5.2 Methodological issues of 2D3 Other solvent use

### General comment:

In the past, the data collection of the about 50 processes of solvent and product use (source categories 2D3 and 2G) were carried out for the years1990, 1998 and then at three-years intervals until 2013 for both NMVOC emission factors and activity data. Depending on the available years of the background data (e. g. data from industry associations, employment statistics), these years were preferably used for deriving emission factors and activity data. For activity data based directly on (annual) statistics, all available data is used in the inventory. As a rule of inventory, the values of emission factors and activity data of all years in-between – also between the last survey year and the projected year – are linearly interpolated. In the past, the main data sources for commercial and industrial solvent and product use stem from industry associations. Unfortunately, the availability and quality of the data as well as the technical expertise within the associations have changed over the years. For this reason, the solvent and product use processes have no longer been updated all together since 2016, but as part of a long-term project which started in 2017. This enables a much more thorough and comprehensive, often iterative approach based on different data sets. Thematic priorities are also set, e. g. all paint and coating applications and productions including printing processes (2D3d, 2D3g, 2D3h). On the basis of the thorough new surveys, the values and bases of previous surveys are also evaluated and revised if necessary. If previous values appear implausible or incorrect and cannot be adjusted because data and information are no longer available, they were partially deleted and linearly interpolated over longer periods accordingly.

### 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 pharmaceuticals. These products contain solvents, which evaporate during use or after the application. Up to submission 2022, propellant emissions from the use of spray cans in the household sector were reported as a separate source category. An in-depth discussion with a long-standing expert from the largest contract manufacturer in Switzerland revealed that the aerosol in many spray applications has the function of both propellant and solvent, and a clear distinction is usually not even possible or meaningful. Therefore, the source category 2D3a Domestic use of aerosol cans was removed and its NMVOC emissions were integrated into the respective application sources, also into the two source categories 2D3a Use of cleaning agents and 2D3a Domestic use of pharmaceuticals. Among the numerous NMVOC emission sources, the use of household cleaning agents, cosmetics and toiletries is the largest single source in source category 2D3.

Based on the decision tree Fig. 3.1 in chapter 2D3a in the EMEP/EEA guidebook (EMEP/EEA 2023), the emissions are calculated by a Tier 2 method (EMIS 2025/2D3a) 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 comprises the use of cosmetics, toiletries, cleaning agents and care products including spray cans (aerosol). Its resulting emission factor bases thus on a multitude of products, their consumption figures, NMVOC contents and emission fractions. Currently, about 85 % 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. The most important product classes are hair styling and deodorants with emission shares of about 30 % and just under 20 %, respectively, followed by air refresheners, perfumes and eaux de toilette, nail care and waterproofing sprays with shares between 10 % and 5 %.

Available data sources consist of surveys of the use of household cleaning agents, cosmetics and toiletries in Switzerland (1990) and in Germany (1996 and 2000).

For the current values, a comprehensive study was conducted based on detailed sales figures of the years 2017-2020, NMVOC contents and application-specific emission factors. The sales figures mainly come from a market research institute covering a large part of the

Swiss retail trade, while information on product class-specific NMVOC contents were provided by a large retailer, production companies and a contract manufacturer and are based on the European aerosol statistics as well.

*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 4-27 Emission factors of 2D3a Domestic solvent use including fungicides in 2023.

| 2D3a Domestic solvent use | Unit of activity data | NMVOC |
|---|---|---|
| | | g/... |
| Domestic use of pharmaceutical products | inhabitants | 32 |
| Household cleaning agents | inhabitants | 700 |

### 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 (FSO 2024c).

Table 4-28 Activity data of 2D3a Domestic solvent use including fungicides.

| 2D3a Domestic solvent use | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Domestic use of pharmaceutical products | inhabitants | 6'712'000 | 7'041'000 | 7'184'000 | 7'437'000 | 7'825'000 |
| Household cleaning agents | inhabitants | 6'712'000 | 7'041'000 | 7'184'000 | 7'437'000 | 7'825'000 |

| 2D3a Domestic solvent use | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic use of pharmaceutical products | inhabitants | 8'189'000 | 8'282'000 | 8'373'000 | 8'452'000 | 8'514'000 | 8'575'000 | 8'638'000 | 8'705'000 | 8'739'000 | 8'889'000 |
| Household cleaning agents | inhabitants | 8'189'000 | 8'282'000 | 8'373'000 | 8'452'000 | 8'514'000 | 8'575'000 | 8'638'000 | 8'705'000 | 8'739'000 | 8'889'000 |

## 4.5.2.2 Road paving with asphalt (2D3b)

### Methodology (2D3b)

Based on the decision tree Fig. 3.1 in chapter 2D3b in the EMEP/EEA guidebook (EMEP/EEA 2023), 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 2025/2D3b. 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. Emissions of particulate matter are not estimated so far.

Table 4-29 Emission factors of 2D3b Road paving with asphalt in 2023.

| 2D3b Road paving with asphalt | Unit of activity data | NMVOC | PM2.5 ex | PM10 ex | TSP ex | BC ex |
|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... |
| Asphalt concrete | t mixed goods | 540 | 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 4-30 Activity data of 2D3b Road paving with asphalt.

| 2D3b Road paving with asphalt | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Asphalt concrete | kt mixed goods | 5'500 | 4'800 | 5'170 | 4'780 | 5'250 |

| 2D3b Road paving with asphalt | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Asphalt concrete | kt mixed goods | 5'260 | 4'850 | 4'710 | 5'260 | 5'180 | 5'210 | 4'910 | 4'960 | 4'970 | 5'000 |

## 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 in the EMEP/EEA guidebook (EMEP/EEA 2023), the emissions of NMVOC from Asphalt roofing are determined by a Tier 2 method based on country-specific emission factors as documented in EMIS 2025/2D3c. Emissions of PM2.5, PM10, TSP, BC and CO from the manufacture of asphalt sheeting are determined based on a Tier 1 method using default emission factors (EMEP/EEA 2023). In the past, 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 submission 2018, 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 PM2.5, PM10, TSP, BC (% PM2.5) and CO from the manufacture of asphalt sheeting are taken from the EMEP/EEA guidebook (EMEP/EEA 2023, chp. 2.D.3.c, table 3.1).

Table 4-31 Emission factors of 2D3c Asphalt roofing in 2023.

| 2D3c Asphalt roofing | Unit of activity data | NMVOC | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... |
| Asphalt roofing | t sheeting | 4'700 | 49 | 245 | 980 | 0.0049 | 5.9 |

### Activity data (2D3c)

Activity data is based on data from industry and expert estimates as documented in the EMIS database. From 2012 onwards, they are extrapolated on the basis of the Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020).

Table 4-32 Activity data of 2D3c Asphalt roofing.

| 2D3c Asphalt roofing | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Asphalt roofing | kt sheeting | 54 | 56 | 58 | 51 | 68 |

| 2D3c Asphalt roofing | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Asphalt roofing | kt sheeting | 75 | 75 | 76 | 76 | 76 | 77 | 77 | 77 | 77 | 78 |

### 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. Industrial application also includes commercial applications such as corrosion protection and road marking. A comprehensive assessment of all coating applications and paint production was carried out in 2018-2020. Based on the decision tree Fig. 3.1 in chapter 2D3d in the EMEP/EEA guidebook (EMEP/EEA 2023), for 2D3d Coating applications a bottom-up Tier 2 method based on the consumption of paints, lacquers, glazes, thinners and related materials and their solvent content. Country-specific emission factors are used. In 2023, the most important emission sources are 2D3d Paint application, wood and 2D3d Paint application in construction and to a lesser extent 2D3d 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), the biggest industrial users (incl. surveys of VOC balances), paint producers, and all major Swiss DIY (do it yourself) companies as documented in the EMIS database (EMIS 2025/2D3d). 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). Since 2004, the mean solvent content of paint applied in construction and on wood has remained about constant with some fluctuations whereas a decrease has been observed for paints in industrial applications. For paint application in car repair, even a slight increase in solvent content has been observed in the last few years. Source category 2D3d Paint application, households is based on a comprehensive study including all major Swiss DIY companies and also covers the paint spray aerosols.

Table 4-33 Emission factors of 2D3d Coating applications in 2023.

| 2D3d Coating applications | Unit of activity data | NMVOC |
|---|---|---|
| | | g/... |
| Paint application, car repair | kg paint | 550 |
| Paint application, construction | kg paint | 61 |
| Paint application, households | kg paint | 85 |
| Paint application, industrial | kg paint | 180 |
| Paint application, wood | kg paint | 313 |

#### Activity data (2D3d)

The activity data correspond to the annual consumption of paints which are estimated according to data and information from VSLF, the biggest industrial users (incl. VOC balances), Swiss paint producers, foreign trade statistics and all major Swiss DIY companies for paint applications in households (EMIS 2025/2D3d). 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 2010, the drop thereafter and the slight increase from 2020 onwards can be explained to a certain extent by the development of 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 Between 1990 and 2016, the activity of 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 2007, the activity data show a moderate decrease.

Table 4-34 Activity data of 2D3d Coating application.

| 2D3d Coating applications | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Paint application, car repair | kt paint | 2.7 | 2.2 | 2.0 | 1.9 | 1.7 |
| Paint application, construction | kt paint | 60 | 43 | 33 | 42 | 54 |
| Paint application, households | kt paint | 12 | 13 | 13 | 12 | 11 |
| Paint application, industrial | kt paint | 20 | 21 | 21 | 8.8 | 8.3 |
| Paint application, wood | kt paint | 8.7 | 8.7 | 8.5 | 9.2 | 13 |

| 2D3d Coating applications | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Paint application, car repair | kt paint | 1.1 | 0.97 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| Paint application, construction | kt paint | 49 | 49 | 47 | 46 | 46 | 45 | 45 | 46 | 46 | 46 |
| Paint application, households | kt paint | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Paint application, industrial | kt paint | 7.8 | 7.6 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| Paint application, wood | kt paint | 11 | 10 | 9.5 | 9.3 | 9.2 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |

### 4.5.2.5 Degreasing (2D3e)

#### Methodology (2D3e)

Source category 2D3e comprises emissions from degreasing of electronic components, metal and other industrial cleaning. It covers also the emissions from the use of spray cans in the field of industry, technical products and automotive applications without coating. Based on the decision tree Fig. 3.1 in chapter 2D3e in the EMEP/EEA guidebook (EMEP/EEA 2023), the NMVOC emissions from 2D3e Degreasing are calculated by a Tier 2 method (EMIS 2025/2D3e) 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, 2012 and 2018) and expert estimates as documented in the EMIS database. For the use of spray cans the values are based on an (unpublished) propellant gas statistics, data from the Swiss aerosol association and statistics data of the European aerosol federation (FEA) for the years 1990, 1998 and 2019/2020, respectively.

Table 4-35 Emission factors of 2D3e Degreasing in 2023.

| 2D3e Degreasing | Unit of activity data | NMVOC |
|---|---|---|
| | | g/... |
| Cleaning of electronic components | kg solvent | 478 |
| Degreasing of metal | kg solvent | 541 |
| Other industrial cleaning | kg solvent | 543 |

### Activity data (2D3e)

Activity data correspond to the annual consumption of solvents for degreasing and cleaning. They are based on survey data from the association of Swiss mechanical and electric engineering industries (swissmem) in 2004, 2007, 2012 and 2018, VOC balances of the most important companies, import statistics and expert estimates, documented in the EMIS database (EMIS 2025/2D3e). For the use of spray cans the data are based on an (unpublished) propellant gas statistics, data of the Swiss aerosol association and statistics data of the European aerosol federation (FEA) for the years 1990, 1998 and 2019/2020, respectively.

In 1990 metal degreasing showed by far the highest activity data, i.e. consumption of solvents and NMVOC emissions but with a subsequent sharp decline until around 2004. Since then, other industrial cleaning and metal degreasing are of similar importance.

Table 4-36 Activity data of 2D3e Degreasing (solvent consumption).

| 2D3e Degreasing | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Cleaning of electronic components | kt solvent | 1.7 | 1.5 | 1.3 | 1.1 | 0.84 |
| Degreasing of metal | kt solvent | 13 | 9.1 | 6.2 | 2.7 | 2.3 |
| Other industrial cleaning | kt solvent | 2.9 | 2.5 | 2.0 | 1.8 | 1.4 |

| 2D3e Degreasing | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cleaning of electronic components | kt solvent | 0.59 | 0.49 | 0.38 | 0.28 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| Degreasing of metal | kt solvent | 1.8 | 1.6 | 1.4 | 1.3 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Other industrial cleaning | kt solvent | 1.4 | 1.5 | 1.5 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 |

## 4.5.2.6 Dry cleaning (2D3f)

### Methodology (2D3f)

Based on the decision tree Fig. 3.1 in chapter 2D3f in the EMEP/EEA guidebook (EMEP/EEA 2023), the NMVOC emissions from 2D3f Dry cleaning are calculated by a Tier 2 method (EMIS 2025/2D3f) using country-specific emission factors.

### 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 4-37 Emission factors of 2D3f Dry cleaning in 2023.

| 2D3f Dry cleaning | Unit of activity data | NMVOC |
|---|---|---|
| | | g/... |
| Dry cleaning | kg 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 FSO (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 4-38 Activity data of 2D3f Dry cleaning.

| 2D3f Dry cleaning | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Dry cleaning | kt solvent | 1.3 | 0.77 | 0.23 | 0.097 | 0.081 |

| 2D3f Dry cleaning | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dry cleaning | kt solvent | 0.072 | 0.071 | 0.071 | 0.070 | 0.070 | 0.069 | 0.069 | 0.068 | 0.068 | 0.067 |

#### 4.5.2.7 Chemical products (2D3g)

**Methodology (2D3g)**

Based on the decision tree Fig. 3.1 in chapter 2D3g in the EMEP/EEA guidebook (EMEP/EEA 2023, for source category 2D3g Chemical products a Tier 2 method using country-specific emission factors is used for calculating the NMVOC emissions (EMIS 2025/2D3g).

Although asphalt roofing materials are produced in Switzerland, there is no bitumen blowing. According to information from both manufacturers, all bitumen (including very small amounts of oxidized bitumen) used for the production of polymer-bitumen sealing sheeting is imported. The emissions from the coating machines of the production of polymer-bitumen sheeting and the thinner production are reported in source category 2D3c Asphalt roofing.

Note: The data for the chemical industry and plastics processing are currently being updated.

**Emission factors (2D3g)**

Emission factors for NMVOC in the period 1990 to approximately 2010 were 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 period from around 2010 and the other processes in source category 2D3g, data are based on information from individual industrial companies (e.g. ink and paint production), surveys of VOC balances (e.g. ink production), emission control authorities (e.g. polystyrene processing) and expert estimates as documented in the EMIS database.

Table 4-39 Emission factors of 2D3g Chemical products in 2023.

| 2D3g Chemical products | Unit of activity data | NMVOC |
|---|---|---|
| | | g/... |
| Fine chemicals production | production index | 3'340'000 |
| Glue production | kg glue | 0.51 |
| Handling and storing of solvents | production index | 1'500'000 |
| Ink production | kg ink | 5.0 |
| PVC processing | kg PVC | 4.0 |
| Paint production | kg paint | 3.0 |
| Pharmaceutical production | kg pharmaceuticals | 7.0 |
| Polyester processing | kg polyester | 70 |
| Polystyrene processing | kg polystyrene | 31 |
| Polyurethane processing | kg polyurethane | 3.0 |
| Production of adhesive tape | kg adhesive tape | NO |
| Rubber processing | tyres | 140 |
| Tanning of leather materials | employees | NO |

**Activity data (2D3g)**

The activity data are mainly production or consumption data provided by the Swiss Federal Office of Statistics, Swiss foreign trade statistics and industry associations, 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
- polystyrene processing: Swiss foreign trade statistics (annual net import figures)
- tanning of leather: Swiss leather tanning association.

In addition, and for the other processes in source category 2D3g, data are based on information from individual industrial companies and expert estimates as documented in the EMIS database. Activity data on handling and storage of solvents, production of fine chemicals and pharmaceuticals as well as production of inks, are extrapolated on the basis of the Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020) from 2012 and 2017, respectively, onwards. Since 1994 no production of adhesive tape is occurring in Switzerland anymore. The last Swiss tannery ceased production in 2015.

Table 4-40 Activity data of 2D3g Chemical products.

| 2D3g Chemical products | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Fine chemicals production | production index | 70 | 100 | 163 | 224 | 314 |
| Glue production | kt glue | 19 | 39 | 58 | 72 | 82 |
| Handling and storing of solvents | production index | 70 | 100 | 163 | 224 | 314 |
| Ink production | kt ink | 20 | 29 | 36 | 55 | 65 |
| PVC processing | kt PVC | 94 | 94 | 78 | 64 | 52 |
| Paint production | kt paint | 88 | 78 | 72 | 77 | 78 |
| Pharmaceutical production | kt pharmaceuticals | 16 | 21 | 20 | 28 | 30 |
| Polyester processing | kt polyester | 11 | 7.0 | 6.5 | 6.9 | 3.4 |
| Polystyrene processing | kt polystyrene | 20 | 19 | 19 | 24 | 35 |
| Polyurethane processing | kt polyurethane | 17 | 35 | 45 | 54 | 54 |
| Production of adhesive tape | kt adhesive tape | 1.5 | NO | NO | NO | NO |
| Rubber processing | tyres | 120'000 | 119'375 | 103'667 | 67'000 | 77'500 |
| Tanning of leather materials | employees | 110 | 108 | 102 | 88 | 65 |

| 2D3g Chemical products | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fine chemicals production | production index | 293 | 291 | 289 | 286 | 284 | 282 | 280 | 278 | 276 | 274 |
| Glue production | kt glue | 94 | 97 | 99 | 102 | 105 | 106 | 107 | 108 | 109 | 109 |
| Handling and storing of solvents | production index | 293 | 291 | 289 | 286 | 284 | 282 | 280 | 278 | 276 | 274 |
| Ink production | kt ink | 52 | 43 | 35 | 36 | 36 | 37 | 37 | 38 | 39 | 39 |
| PVC processing | kt PVC | 37 | 36 | 35 | 34 | 32 | 31 | 30 | 30 | 30 | 30 |
| Paint production | kt paint | 66 | 63 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| Pharmaceutical production | kt pharmaceuticals | 29 | 29 | 29 | 29 | 29 | 28 | 28 | 28 | 28 | 27 |
| Polyester processing | kt polyester | 3.6 | 3.5 | 3.5 | 3.4 | 3.4 | 3.3 | 3.3 | 3.3 | 3.4 | 3.4 |
| Polystyrene processing | kt polystyrene | 29 | 27 | 23 | 24 | 22 | 23 | 23 | 24 | 24 | 25 |
| Polyurethane processing | kt polyurethane | 38 | 37 | 37 | 36 | 36 | 35 | 35 | 35 | 35 | 35 |
| Production of adhesive tape | kt adhesive tape | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Rubber processing | tyres | 82'000 | 83'000 | 84'000 | 85'000 | 86'000 | 87'000 | 88'000 | 88'533 | 89'067 | 89'600 |
| Tanning of leather materials | employees | 22 | 11 | NO | NO | NO | NO | NO | NO | 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 the EMEP/EEA guidebook (EMEP/EEA 2023), a Tier 2 method using country-specific emission factors is used for calculating the NMVOC emissions from the ink applications (EMIS 2025/2D3h).

#### 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), Swiss organisation for the print and media industry (viscom)), surveys on the VOC balances, emission control authorities, German studies on NMVOC emissions from solvent use (Theloke 2005) and expert estimates, as documented in the EMIS database. For packaging printing, emission factors are derived for the years 1990, 1998, 2001, 2004, 2007, 2010, 2013 and 2016 whereas for the other printing processes for 1990, 1998, 2001, 2013 and 2016.

Table 4-41 Emission factors of 2D3h Printing in 2023.

| 2D3h Printing | Unit of activity data | NMVOC |
|---|---|---|
| | | g/... |
| Other printing | kg ink | 280 |
| Package printing | kg ink | 130 |

#### Activity data (2D3h)

The activity data correspond to the consumption of printing ink. These data stem from industry associations (SOLV, viscom), surveys on the VOC balances, Swiss Federal Office of Statistics, emission control authorities and expert estimates, documented in the EMIS database. For packaging printing, activity data are available for the years 1990, 1998, 2001, 2004, 2007, 2010, 2013 and 2016 whereas for the other printing processes for 1990, 1998, 2001, 2005, 2008, 2013 and 2016. From 2017 onwards, they are extrapolated on the basis of the Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020).

Table 4-42 Activity data of 2D3h Printing (ink consumption).

| 2D3h Printing | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Other printing | kt ink | 13 | 13 | 14 | 12 | 8.3 |
| Package printing | kt ink | 5.9 | 5.9 | 5.5 | 9.1 | 13 |

| 2D3h Printing | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Other printing | kt ink | 7.8 | 7.7 | 7.5 | 7.5 | 7.4 | 7.4 | 7.3 | 7.3 | 7.3 | 7.2 |
| Package printing | kt ink | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 12 | 12 | 12 |

### 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 the EMEP/EEA guidebook (EMEP/EEA 2023), 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 2025/2D3i). 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, retail trade, German studies on NMVOC emissions from solvent use (Theloke et al. 2000 and Theloke 2005), VOC balances and expert estimates, as documented in the EMIS database.

Table 4-43 Emission factors of 2D3i Other solvent use in 2023.

| 2D3i Other solvent use | Unit of activity data | NMVOC |
|---|---|---|
| | | g/... |
| Fat, edible and non-edible oil extraction | kg oil and grease | NO |
| Production of cosmetics | employees | 62'182 |
| Production of flavours and fragarances | employees | 30'000 |
| Production of paper and paperboard | kg paper | 0.013 |
| Production of textiles | kg solvent | 180 |
| Production of tobacco | employees | 12'000 |
| Removal of paint and lacquer | kg removal agent | 350 |
| Scientific laboratories | employees | 15'000 |
| Vehicle dewaxing | vehicles | NO |

#### Activity data (2D3i)

For some production processes and services – such as production of perfume and flavour and scientific laboratories – the activity data correspond to the number of employees in the respective industrial sectors (FSO 2024d). 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) and the Swiss association of paper, cardboard and foil manufacturers (SPKF) for the years 1997 – 2011 and from 2016 onwards, respectively. For the production of textiles, the activity data is the solvent consumption based on VOC balances and industry data. 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 4-44 Activity data of 2D3i Other solvent use.

| 2D3i Other solvent use | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Fat, edible and non-edible oil extraction | kt oil and grease | 40 | 38 | 12 | NO | NO |
| Production of cosmetics | employees | 2'200 | 2'200 | 2'267 | 2'100 | 2'100 |
| Production of flavours and fragarances | employees | 2'200 | 2'325 | 2'567 | 3'200 | 3'475 |
| Production of paper and paperboard | kt paper | 1'510 | 1'560 | 1'780 | 1'750 | 1'540 |
| Production of textiles | kt solvent | 0.60 | 0.50 | 0.40 | 0.29 | 0.19 |
| Production of tobacco | employees | 3'300 | 2'988 | 2'733 | 2'700 | 3'200 |
| Removal of paint and lacquer | kt removal agent | 0.70 | 0.60 | 0.50 | 0.40 | 0.31 |
| Scientific laboratories | employees | 10'194 | 18'604 | 23'217 | 23'000 | 23'000 |
| Vehicle dewaxing | vehicles | 200'000 | 166'250 | 72'667 | NO | NO |

| 2D3i Other solvent use | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fat, edible and non-edible oil extraction | kt oil and grease | 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 flavours and fragarances | employees | 3'290 | 3'220 | 3'150 | 3'080 | 3'010 | 2'940 | 2'870 | 2'800 | 2'800 | 2'800 |
| Production of paper and paperboard | kt paper | 1'390 | 1'393 | 1'396 | 1'362 | 1'056 | 1'034 | 967 | 1'024 | 1'061 | 1'099 |
| Production of textiles | kt solvent | 0.21 | 0.21 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 |
| Production of tobacco | 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 | kt removal agent | 0.23 | 0.21 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 |
| Scientific laboratories | employees | 23'250 | 23'333 | 23'417 | 23'500 | 23'583 | 23'667 | 23'750 | 23'833 | 23'917 | 24'000 |
| Vehicle dewaxing | vehicles | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

### 4.5.3 Category-specific recalculations in 2D3 Other solvent use

There were no recalculations implemented in submission 2025.

# 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 4-45 Specification of source category 2G Other product use in Switzerland.

| 2G | Source category | Specification |
|---|---|---|
| 2G | Other product use | Use of spray cans in industry (commercial insecticide application only), 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 4-46 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 2G Other product use.

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 2G | Other product use | NMVOC | L1, L2, T2 |
| 2G | Other product use | PM2.5 | L1, L2, T1, T2 |
| 2G | Other product use | PM10 | L1, L2 |

## 4.6.2 Methodological issues of 2G Other product use

### 4.6.2.1 Other product use (2G)

**General comment:**

In the past, the data collection of the about 50 processes of solvent and product use (source categories 2D3 and 2G) were carried out for the years 1990, 1998 and then at three-years intervals until 2013 for both NMVOC emission factors and activity data. Depending on the available years of the background data (e. g. data from industry associations, employment statistics), these years were preferably used for deriving emission factors and activity data. For activity data based directly on (annual) statistics, all available data is used in the inventory. As a rule of inventory, the values of emission factors and activity data of all years in-between – also between the last survey year and the projected year – are linearly interpolated. In the past, the main data sources for commercial and industrial solvent and product use stem from industry associations. Unfortunately, the availability and quality of the data as well as the technical expertise within the associations have changed over the years. For this reason, the solvent and product use processes have no longer been updated all together since 2016, but as part of a long-term project which started in 2017. This enables a much more thorough and comprehensive, often iterative approach based on different data sets. Thematic priorities are also set, e. g. all paint and coating applications and productions including printing processes (2D3d, 2D3g, 2D3h). On the basis of the thorough new surveys, the values and bases of previous surveys are also evaluated and revised if necessary. If previous values appear implausible or incorrect and cannot be adjusted because data and information are no longer available, they were partially deleted and linearly interpolated over longer periods accordingly.

### Methodology (2G)

Within source category 2G Other product use, the major NMVOC emission sources in 2023 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 the EMEP/EEA guidebook (EMEP/EEA 2023), 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 2025/2G).

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. An in-depth discussion with a long-standing expert from the largest contract manufacturer in Switzerland revealed that the aerosol in many spray applications has the function of both propellant and solvent, and a clear distinction is usually not even possible or meaningful. Therefore, the aerosol emissions from the use of spray cans, except for a residual batch of commercial insecticide application, were integrated into the respective application sources, e.g. the use of spray cans in the field of industry and technical products and automotive without paints into 2D3e Degreasing and the disinfectant sprays in 2G Health care other and 2G Medical practices.

### Emission factors (2G)

Emission factors for NMVOC are based on data from individual industrial companies, services and Swiss airports, industry associations, survey on co-formulants in pesticides, German studies on NMVOC emissions from solvent use (Theloke et al. 2000 and Theloke 2005), VOC balances, post-combustion plants, statistics (aerosol) and expert estimates, as documented in the EMIS database.

Table 4-47 Emission factors of 2G Other product use in 2023.

| 2G Other product use | Unit of activity data | NMVOC |
|---|---|---|
| | | g/... |
| Application of glues and adhesives | kg solvent | 386 |
| Commercial and industrial use of cleaning agents | employees | 400 |
| Cosmetic institutions | employees | 27'500 |
| De-icing of airplanes | kg de-icing agent | 54 |
| De-icing of airport surfaces | kg de-icing agent | NO |
| Glass wool enduction | t glass wool | 131 |
| Hairdressers | employees | 2'100 |
| Health care other | employees | 9'100 |
| Medical practices | employees | 8'200 |
| Preservation of wood | kg paint | 30 |
| Rock wool enduction | t rock wool | C |
| Underseal treatment and conservation of vehicles | kg underseal agent | 450 |
| Use of antifreeze agents in vehicles | Mio veh. km | 8'000 |
| Use of concrete additives | kg additive | 0.74 |
| Use of cooling lubricants | kg cooling lubricant | 6.0 |
| Use of lubricants | kg lubricant | 120 |
| Use of pesticides | kg pesticides | 116 |
| Use of tobacco | Mio cigarette eq. | 4'840 |

Emission factors for pollutants other than NMVOC from 2G Use of fireworks and tobacco and 2G Glass wool enduction (EMIS 2025/2G) are displayed in Table 4-48. Emission factors of fireworks are documented in FOEN (2014p). Emission factors for use of tobacco are according to the EMEP/EEA guidebook (EMEP/EEA 2023, chp. 2.D.3.i, 2.G, table 3-15) with the following exceptions: The emission factor for PCDD/PCDF is according to the UK National Atmospheric Emissions Inventory (UK NAEI 2019). The emission factors for Cd and Pb are country-specific estimates based on an averaged measured Pb and Cd content in cigarettes representative for Europe (Watanabe 1987, Caruso 2013, Piadé 2014, Armendariz 2015). They are assumed to remain constant over time due to globally sourced and therefore chemically homogenous tobacco leaves. shows product-specific emission factors for glass wool production. For glass wool enduction, the $NH_3$ emission factor is based on various air pollution control measurements under the Ordinance on Air Pollution Control and partly on information from industry.

Table 4-48 Emission factors of all pollutants other than NMVOC from 2G Other product use in 2023.

| 2G Other product use | Unit of activity data | NOx | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Fireworks | kg fireworks | 0.26 | 4.1 | NA | 90 | 180 | 180 | NE | 7.4 |
| Glass wool enduction | t glass wool | NA | NA | 778 | NA | NA | NA | NA | NA |
| Use of tobacco | Mio cigarette eq. | 1'800 | NE | 4'150 | 27'000 | 27'000 | 27'000 | 122 | 55'100 |

| 2G Other product use | Unit of activity data | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP |
|---|---|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... |
| Fireworks | kg fireworks | 130 | 3.0 | 0.10 | NE | NE | NE | NE | NE |
| Glass wool enduction | t glass wool | NA | NA | NA | NA | NA | NA | NA | NA |
| Use of tobacco | Mio cigarette eq. | 800 | 970 | NE | 100 | 111 | 45 | 45 | 45 |

### Activity data (2G)

For the production processes, such as enduction of glass and rock wool and part of the applications in services or agriculture, such as preservation of wood, pesticides 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 referenced to the number of employees in order to calculate the Swiss total.

The activity data stem from individual industrial companies, services, Swiss airports (since 2011 no VOC-containing agents are used for de-icing of airport surfaces anymore), industry associations, Swiss Federal Statistical Office, Swiss Federal Office for Agriculture (sales statistics of pesticides), VOC balances, foreign trade statistics and expert estimates. They 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 2024), respectively. Activity data for concrete additives are extrapolated from 2017 onwards, based on the Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020).

Table 4-49 Activity data of 2G Other product use.

| 2G Other product use | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Application of glues and adhesives | kt solvent | 4.8 | 4.0 | 3.2 | 2.7 | 2.5 |
| Commercial and industrial use of cleaning agents | employees | 3'950'000 | 3'867'500 | 3'954'667 | 4'133'667 | 4'404'000 |
| Cosmetic institutions | employees | 2'600 | 3'100 | 3'533 | 3'800 | 4'800 |
| De-icing of airplanes | kt de-icing agent | 1.2 | 2.4 | 1.8 | 2.5 | 3.3 |
| De-icing of airport surfaces | kt de-icing agent | 0.34 | 0.39 | 0.32 | 0.41 | 0.018 |
| Fireworks | kt fireworks | 0.84 | 1.0 | 1.5 | 1.4 | 1.7 |
| Glass wool enduction | kt glass wool | 24 | 24 | 31 | 37 | 36 |
| Hairdressers | employees | 20'553 | 22'826 | 23'530 | 22'200 | 26'761 |
| Health care other | employees | 113'000 | 129'250 | 145'667 | 161'667 | 163'000 |
| Medical practices | employees | 27'625 | 42'047 | 50'833 | 55'357 | 58'700 |
| Preservation of wood | kt paint | 4.8 | 6.5 | 7.8 | 6.6 | 0.97 |
| Rock wool enduction | kt rock wool | C | C | C | C | C |
| Underseal treatment and conservation of vehicles | kt underseal agent | 0.060 | 0.060 | 0.076 | 0.12 | 0.16 |
| Use of antifreeze agents in vehicles | Mio veh. km | 47'523 | 46'479 | 51'142 | 53'723 | 57'039 |
| Use of concrete additives | kt additive | 24 | 25 | 29 | 36 | 41 |
| Use of cooling lubricants | kt cooling lubricant | 5.0 | 5.2 | 5.8 | 7.8 | 7.0 |
| Use of lubricants | kt lubricant | 1.3 | 1.3 | 1.3 | 4.4 | 2.4 |
| Use of pesticides | kt pesticides | 2.4 | 2.4 | 2.3 | 2.3 | 2.1 |
| Use of tobacco | Mio cigarette eq. | 16'192 | 15'774 | 15'328 | 13'256 | 12'360 |

| 2G Other product use | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Application of glues and adhesives | kt solvent | 2.4 | 2.4 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 |
| Commercial and industrial use of cleaning agents | employees | 4'236'000 | 4'280'000 | 4'324'000 | 4'368'000 | 4'412'000 | 4'456'000 | 4'500'000 | 4'500'000 | 4'500'000 | 4'500'000 |
| Cosmetic institutions | employees | 5'333 | 5'444 | 5'556 | 5'667 | 5'778 | 5'889 | 6'000 | 6'100 | 6'200 | 6'300 |
| De-icing of airplanes | kt de-icing agent | 2.3 | 2.3 | 2.3 | 2.3 | 2.4 | 2.4 | 2.4 | 2.5 | 2.5 | 2.5 |
| De-icing of airport surfaces | kt de-icing agent | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Fireworks | kt fireworks | 1.8 | 1.6 | 1.2 | 1.7 | 1.8 | 1.0 | 1.0 | 1.5 | 1.9 | 0.80 |
| Glass wool enduction | kt glass wool | 32 | 31 | 32 | 36 | 40 | 47 | 40 | 47 | 45 | 37 |
| Hairdressers | employees | 29'499 | 29'854 | 30'109 | 30'075 | 30'170 | 30'610 | 30'270 | 30'519 | 30'767 | 31'016 |
| 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 paint | 0.57 | 0.62 | 0.68 | 0.70 | 0.49 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 |
| Rock wool enduction | kt rock wool | C | C | C | C | C | C | C | C | C | C |
| Underseal treatment and conservation of vehicles | kt underseal agent | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Use of antifreeze agents in vehicles | Mio veh. km | 60'913 | 61'881 | 62'260 | 62'638 | 63'017 | 63'395 | 63'774 | 64'259 | 64'744 | 65'229 |
| Use of concrete additives | kt additive | 39 | 39 | 39 | 39 | 40 | 40 | 40 | 40 | 40 | 40 |
| Use of cooling lubricants | kt cooling lubricant | 7.4 | 7.5 | 7.7 | 7.8 | 8.0 | 8.1 | 8.1 | 8.2 | 8.2 | 8.2 |
| Use of lubricants | kt lubricant | 1.6 | 1.6 | 1.7 | 1.7 | 1.7 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| Use of pesticides | kt pesticides | 2.2 | 2.2 | 2.2 | 2.0 | 2.1 | 2.1 | 2.2 | 2.2 | 2.2 | 2.2 |
| Use of tobacco | Mio cigarette eq. | 10'628 | 10'284 | 10'702 | 10'702 | 10'318 | 10'030 | 10'510 | 10'222 | 9'742 | 9'455 |

### 4.6.3 Category-specific recalculations in 2G Other product use

The following recalculations were implemented in submission 2025:

- 2G: For source category 2G Hairdressers, the activity data for the years 2012–2020 were supplemented and the emission factor for 2004 was adjusted, resulting in changed linear interpolated values for the years 2021 and 2022 as well as 1991–2003 and 2005–2010.
- 2G: For source category 2G Consumption of tobacco products, the emission factor for Cd was updated, using a country-specific estimation, for the years 1990-2022, causing a decrease by 82 %. A new emission factor for Pb was introduced for the years 1990-2022, using a country-specific estimation.
- 2G Consumption of tobacco products: The activity data value for the year 2020 was updated due to a typing mistake.

## 4.7 Source categories 2H – Other industry production

### 4.7.1 Source category description of 2H Other industry production

Table 4-50 Specification of source category 2H Other industry production in Switzerland.

| 2H | Source category | 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 |

Table 4-51 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 2H Other industry production.

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 2H1 | Pulp and paper industry | PM2.5 | L1, L2, T2 |
| 2H2 | Food and beverages industry | NMVOC | L2, T1, T2 |
| 2H2 | Food and beverages industry | PM2.5 | L1, L2, T1, T2 |
| 2H2 | Food and beverages industry | PM10 | L1, L2, T2 |

## 4.7.2 Methodological issues of 2H Other industry production

### 4.7.2.1 Pulp and paper industry (2H1)

#### Methodology (2H1)

Today, 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 were produced in one and two plants, respectively, until 2019. Since 2020 only one plant is left. The cellulose production was closed in 2008 and is not occurring anymore in Switzerland.

Based on the decision tree Fig. 3.1 in chapter 2H1 in the EMEP/EEA guidebook (EMEP/EEA 2023), the emissions are calculated by a Tier 2 method using country-specific emission factors (EMIS 2025/2H1).

#### 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. They are confidential but available to reviewers on request.

Table 4-52 Emission factors for 2H1 Pulp and paper industry in 2023.

| 2H1 Pulp and paper industry | Unit of activity data | NOx | NMVOC | SOx | PM2.5 nx | PM10 nx | TSP nx | BC nx | CO | PCDD/ PCDF |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | ng I-Teq/... |
| Cellulose production | t cellulose | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Chipboard production | t chipboard | NE | C | NE | C | C | C | NE | NE | C |
| Fibreboard production | t fibreboard | NE | C | NE | C | C | C | NE | NE | NA |

#### 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.

Due to the production structure in Switzerland, i.e. one production site for cellulose (ceased in 2008), one for chipboard and two for fibreboard (one ceased in 2019), activity data have been confidential since 2020. Detailed data can be accessed by reviewers on request.

Table 4-53 Activity data of 2H1 Pulp and paper industry.

| 2H1 Pulp and paper industry | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Cellulose production | kt cellulose | 121 | 134 | 133 | 118 | NO |
| Chipboard production | kt chipboard | C | C | C | C | C |
| Fibreboard production | kt fibreboard | 51 | 121 | 192 | 263 | 297 |

| 2H1 Pulp and paper industry | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cellulose production | kt cellulose | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Chipboard production | kt chipboard | C | C | C | C | C | C | C | C | C | C |
| Fibreboard production | kt fibreboard | 241 | 243 | 243 | 231 | 240 | 182 | C | C | C | C |

### 4.7.2.2 Food and beverages industry (2H2)

#### Methodology (2H2)

Based on the decision tree Fig. 3.1 in chapter 2H2 in the EMEP/EEA guidebook (EMEP/EEA 2023), the emissions from the source category 2H2 Food and beverages industry, are calculated by a Tier 2 method using country-specific emission factors (EMIS 2025/2H2).

#### 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 measurement campaigns conducted at some of the major Swiss bread producers as documented in the EMIS database (EMIS 2025/2H2 Brot Produktion).

Table 4-54 Emission factors for 2H2 Food and beverages industry in 2023.

| 2H2 Food and beverages industry | Unit of activity data | NMVOC | NH3 | PM2.5 ex | PM2.5 nx | PM10 ex | PM10 nx |
|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... |
| Bread production | t bread | 2'900 | NA | NA | NA | NA | NA |
| Breweries | m3 beer | 250 | NA | NA | NA | NA | NA |
| Meat smokehouses | t meat | 1'300 | NA | 350 | NA | 350 | NA |
| Milling companies | t flour | NA | NA | NA | 50 | NA | 100 |
| Roasting facilities | t coffee | 30 | NA | NA | 30 | NA | 60 |
| Spirits production | m3 alcohol | 10'000 | NA | NA | NA | NA | NA |
| Sugar production | t sugar | 195 | 239 | NA | 260 | NA | 520 |
| Wine production | m3 wine | 580 | NA | NA | NA | NA | NA |

| 2H2 Food and beverages industry | Unit of activity data | TSP ex | TSP nx | BC ex | CO | PCDD/ PCDF |
|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | ng I-Teq/... |
| Bread production | t bread | NA | NA | NA | NA | NA |
| Breweries | m3 beer | NA | NA | NA | NA | NA |
| Meat smokehouses | t meat | 350 | NA | NA | 250 | 3'000 |
| Milling companies | t flour | NA | 160 | NA | NA | NA |
| Roasting facilities | t coffee | NA | 60 | NA | NA | NA |
| Spirits production | m3 alcohol | NA | NA | NA | NA | NA |
| Sugar production | t sugar | NA | 600 | NA | NA | NA |
| Wine production | m3 wine | NA | NA | NA | NA | NA |

#### Activity data (2H2)

Activity data on annual production have been provided by industry, by the Federal Office for Customs and Border Security (FOCBS), the Swiss farmers' union (SBV), the Swiss Fatstock and Meat Suppliers Cooperative (Schweizerische 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 (FSO 2024c) and the annual bread consumption per inhabitant provided by the Swiss bread statistics (Schweizerische Brotinformation, SBI) for the time period between 1990 and 2010. A value for 2017 per capita bread consumption has been provided by the Swiss Bread Association as documented in the EMIS database (EMIS 2025/2H2 Brot Produktion).

Table 4-55 Activity data of 2H2 Food and beverages industry.

| 2H2 Food and beverages industry | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bread production | kt bread | 336 | 352 | 359 | 372 | 386 | 378 | 376 | 373 | 370 | 373 | 376 | 378 | 381 | 383 | 389 |
| Breweries | m3 beer | 414'300 | 367'100 | 354'100 | 341'600 | 353'800 | 343'100 | 342'700 | 341'900 | 346'300 | 365'900 | 367'500 | 340'400 | 338'200 | 368'600 | 359'600 |
| Meat smokehouses | kt meat | 66 | 64 | 60 | 61 | 66 | 67 | 67 | 67 | 67 | 67 | 66 | 67 | 68 | 67 | 68 |
| Milling companies | kt flour | 1'644 | 1'519 | 1'603 | 1'425 | 1'602 | 1'625 | 1'645 | 1'663 | 1'626 | 1'665 | 1'685 | 1'650 | 1'705 | 1'791 | 1'675 |
| Roasting facilities | kt coffee | 56 | 50 | 58 | 78 | 102 | 119 | 125 | 127 | 131 | 141 | 148 | 161 | 172 | 177 | 161 |
| Spirits production | m3 alcohol | 4'158 | 3'271 | 2'179 | 2'266 | 1'945 | 1'150 | 1'636 | 1'211 | 1'010 | 961 | 1'624 | 1'224 | 1'233 | 744 | 1'067 |
| Sugar production | kt sugar | 147 | 129 | 219 | 197 | 241 | 344 | 261 | 240 | 299 | 246 | 273 | 226 | 199 | 223 | 206 |
| Wine production | m3 wine | 120'000 | 111'693 | 123'073 | 108'526 | 108'319 | 99'556 | 99'859 | 90'174 | 88'116 | 90'404 | 95'742 | 96'107 | 91'458 | 88'813 | 92'013 |

### 4.7.2.3 Other industrial processes (2H3)

#### Methodology (2H3)

Source category 2H3 Other industrial processes encompasses the emissions from blasting and shooting only. 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 4-56 Emission factors for 2H3 Other industrial processes in 2023.

| 2H3 Other industrial processes | Unit of activity data | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | mg/... |
| Blasting and shooting | kg explosive | 35 | 60 | 0.50 | 0.40 | 6.0 | 6.0 | 6.0 | NE | 310 | 0.010 |

#### Activity data (2H3)

Activity data for blasting and shooting is taken from federal statistics on explosives (FEDPOL 2024).

Table 4-57 Activity data of 2H3 Other industrial processes.

| 2H3 Other industrial processes | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Blasting and shooting | kt explosive | 2.6 | 1.3 | 1.9 | 0.79 | 2.4 | 2.1 | 2.1 | 0.67 | 0.73 | 0.81 | 0.67 | 0.63 | 0.61 | 0.65 | 0.65 |

## 4.7.3 Category-specific recalculations in 2H Other

The following recalculations were implemented in submission 2025:

- 2H2: For source category 2H2 Bread production, the emission factor for NMVOCs was updated using a country-specific estimation, for the years 1990-2022, causing a decrease by 36 %.
- 2H2: For source category 2H2 Meat smokehouses, the activity data was modified for the years 1999-2022 due to an update in the underlying statistics.
- 2H2: For source category 2H2 Flour production, the activity data was modified for the years 2012 and 2018-2022 due to an update in the underlying statistics.

# 4.8 Source categories 2I – Wood processing, 2K – Consumption of POPs and heavy metals and 2L – Other production, consumption, storage, transportation or handling of bulk products

## 4.8.1 Source category description of 2I Wood processing, 2K Consumption of POPs and heavy metals and 2L Other production, consumption, storage, transportation or handling of bulk products

Table 4-58 Specification of source category 2I Wood processing, 2K Consumption of POPs and heavy metals and 2L Other production, consumption, storage, transportation or handling of bulk products in Switzerland.

| 2I, 2K, 2L | Source category | Specification |
|---|---|---|
| 2I | Wood processing | Wood processing |
| 2K | Consumption of POPs and heavy metals | Emissions of PCBs from usage of PCBs in transformers, large and small capacitors, anti-corrosive paints and joint sealants as well as from demolition/renovation of PCB containing anti-corrosive paints and joint-sealants |
| 2L | Other production, consumption, storage, transportation or handling of bulk products | Ammonia emissions from freezers (filling and storage) |

Table 4-59 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 2I Wood processing, 2K Consumption of POPs and heavy metals and 2L Other production, consumption, storage, transportation or handling of bulk products.

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 2I | Wood processing | PM2.5 | L2 |
| 2I | Wood processing | PM10 | L2, T2 |

## 4.8.2 Methodological issues of 2I Wood processing, 2K Consumption of POPs and heavy metals and 2L Other production, consumption, storage, transportation or handling of bulk products

### 4.8.2.1 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 the EMEP/EEA guidebook (EMEP/EEA 2023), the calculation of emissions is based on a Tier 1 method based on country-specific emission factors (EMIS 2025/2I Holzbearbeitung).

#### Emission factors (2I)

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

Table 4-60 Emission factors for 2I Wood processing in 2023.

| 2I Wood processing | Unit of activity data | PM2.5 nx | PM10 nx | TSP nx |
|---|---|---|---|---|
| | | g/... | g/... | g/... |
| Wood processing | t sawnwood | 74 | 294 | 735 |

### Activity data (2I)

Activity data of wood processing are the annual amount of sawnwood based on the yearbook forest and wood (FOEN 2024f).

Table 4-61 Activity data of 2I Wood processing.

| 2I Wood processing | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Wood processing | kt sawnwood | 1'168 | 827 | 901 | 853 | 774 |

| 2I Wood processing | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wood processing | kt sawnwood | 634 | 626 | 622 | 578 | 597 | 598 | 623 | 664 | 666 | 638 |

## 4.8.2.2 Usage of PCBs (2K)

### Methodology (2K)

Source category 2K includes PCB emissions from use of polychlorinated biphenyls (PCBs) in transformers, small and large capacitors, anti-corrosive paints and joint sealants in Switzerland between 1946 and 1986. In 1986, a total ban was placed on any form of PCB use. The use in so-called open systems, i.e. anti-corrosive paints and joint sealants, was allowed until 1972 only. For the time being, anti-corrosive paints and joint sealants are the predominant PCB emission sources. Emissions from demolition/renovation of steel constructions and buildings containing PCBs in anti-corrosive paints and joint sealants, respectively, are also reported in source category 2K.

A dynamic mass flow model was developed for the usage of PCBs in Switzerland for the time period 1930 to 2100 (Glüge et al. 2017). The model takes into account the entire life cycle, i.e. import, usage, export, treatment, disposal and accidental release of PCBs. A description of the model is given in Annex A2.2.

The emissions are calculated by multiplying the annual mass of PCBs involved in a source (e.g. tonnes of PCBs in use in joint sealants) with a source-specific emission factor (e.g. tonnes of PCBs emitted/tonnes of PCBs in use). This country-specific approach corresponds to a Tier 2 method according to the EMEP/EEA guidebook (EMEP/EEA 2023).

### Emission factors (2K)

The PCB emission factors from the use of PCBs in transformers, small and large capacitors, anti-corrosive paints and joint sealants are expressed in units per tonnes of PCBs available in the respective application, see Table 4-62. The PCB emission factors for demolition/renovation of steel constructions and buildings containing PCBs in anti-corrosive paints and joint sealants are expressed in units per tonnes of PCBs demolished or renovated.

Table 4-62 Emission factors for 2K Usage of PCBs in 2023.

| 2K Consumption of POPs and heavy metals | Unit of activity data | PCB |
|---|---|---|
| | | mg/... |
| Anti-corrosive paints | g PCB | 2.5 |
| Demolition and renovation | g PCB | 2.5 |
| Joint sealants | g PCB | 2.5 |
| Large capacitors | g PCB | 0.47 |
| Small capacitors | g PCB | 0.47 |
| Transformers | g PCB | 0.0022 |

### Activity data (2K)

The five usage categories are PCB stocks, which means that PCBs are stored in these applications and passed on through the system with a temporal delay (lifetime). In these cases, the activity data are the amounts of PCBs stored in the stock. The treatment category demolition and renovation is an instantaneous category. In this case, the activity data corresponds to the amount of PCBs treated in the respective year.

Table 4-63 Activity data for 2K Usage of PCBs.

| 2K Consumption of POPs and heavy metals | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Anti-corrosive paints | t PCB | 209 | 196 | 178 | 156 | 128 |
| Demolition and renovation | t PCB | 2.4 | 4.0 | 6.2 | 8.5 | 10 |
| Joint sealants | t PCB | 209 | 196 | 178 | 156 | 129 |
| Large capacitors | t PCB | 356 | 235 | 139 | 73 | 33 |
| Small capacitors | t PCB | 361 | 213 | 108 | 47 | 17 |
| Transformers | t PCB | 1'257 | 840 | 501 | 265 | 123 |

| 2K Consumption of POPs and heavy metals | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Anti-corrosive paints | t PCB | 104 | 98 | 92 | 86 | 80 | 73 | 68 | 62 | 56 | 51 |
| Demolition and renovation | t PCB | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 10 | 10 | 9.7 |
| Joint sealants | t PCB | 104 | 98 | 92 | 86 | 80 | 73 | 68 | 62 | 56 | 51 |
| Large capacitors | t PCB | 16 | 13 | 11 | 9.0 | 7.3 | 5.8 | 4.7 | 3.7 | 2.9 | 2.3 |
| Small capacitors | t PCB | 6.7 | 5.2 | 4.0 | 3.1 | 2.4 | 1.8 | 1.3 | 1.0 | 0.75 | 0.56 |
| Transformers | t PCB | 60 | 50 | 41 | 33 | 27 | 22 | 18 | 14 | 11 | 8.7 |

## 4.8.2.3 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, 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 database (EMIS 2025/2 F_2 L_NH3 aus Kühlanlagen). Emission factors are assumed constant over the entire time period (see Table 4-64).

Table 4-64 Emission factors for 2L Ammonia in freezers in 2023.

| 2L Other | Unit of activity data | NH3 |
|---|---|---|
| | | g/... |
| Freezers filling | t ammonia | 1'000 |
| Freezers storage | t ammonia | 2'000 |

### 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, 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 2025/2 F_2 L_NH3 aus Kühlanlagen) (see Table 4-65).

Table 4-65 Activity data of 2L Ammonia in freezers.

| 2L Other | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Freezers filling | kt ammonia | 0.18 | 0.20 | 0.22 | 0.24 | 0.27 |
| Freezers storage | kt ammonia | 1.1 | 1.1 | 1.2 | 1.2 | 1.2 |

| 2L Other | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Freezers filling | kt ammonia | 0.28 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.30 | 0.30 | 0.30 | 0.30 |
| Freezers storage | kt ammonia | 1.5 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.7 | 1.7 | 1.7 | 1.7 |

## 4.8.3 Category-specific recalculations in 2I Wood processing, 2K Consumption of POPs and heavy metals and 2L Other production, consumption, storage, transportation or handling of bulk products

The following recalculations were implemented in submission 2025:

- 2I: The 2022 activity data of source category 2I Wood processing was updated based on the revised annual amount of sawnwood reported in the yearbook forest and wood.
- 2L: There were small corrections of the amount of $NH_3$ used in cooling systems. Therefore, the emissions of $NH_3$ from cooling systems have changed a little (less than 1t/a $NH_3$) for the years 1991-2022.

# 5 Agriculture

## 5.1 Overview of emissions

This introductory chapter contains an overview of emissions from sector 3 Agriculture. $NO_x$, NMVOC, $NH_3$, PM2.5, PM10 and TSP are the reported 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 field burning of crop residues, as this is prohibited in Switzerland. 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 2-8). They show a decreasing trend over the whole period 1990-2023 (see Figure 5-1 and Table 5-1). The trend was more pronounced between 1990 and 2004, and since then continues on a lower level with some fluctuations. Main source is category 3D Crop production and agricultural soils, where 3Da2a Animal manure applied to soils is the most relevant emission source. Accordingly, the development of $NO_x$ emissions in category 3D depends on the development of livestock numbers and thus N excretions, which decreased by 17 % between 1990 and 2020 (Kupper et al. 2022) with a similar pattern as overall $NO_x$ emissions from the agriculture sector. The decrease in inorganic N-fertiliser use (3Da1) additionally contributed to the reduction of $NO_x$ emissions (N applied between 1990 and 2020 was reduced by 38 %; Kupper et al. 2022).

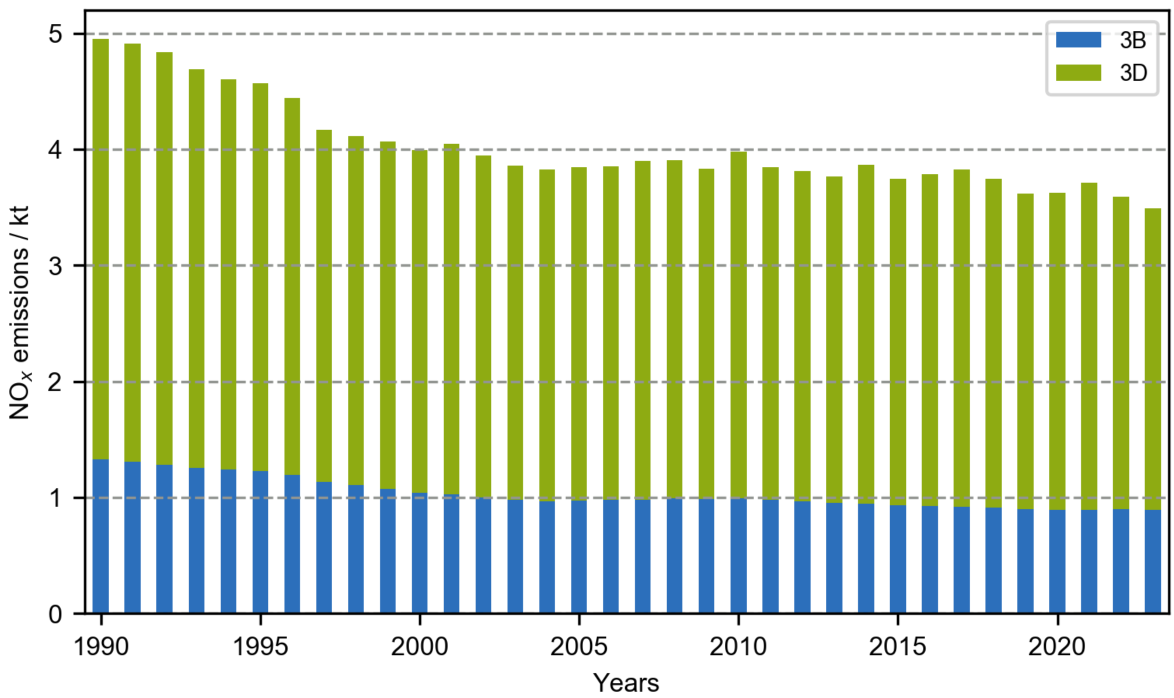



Figure 5-1 Switzerland's $NO_x$ emissions from agriculture by source categories 3B and 3D. The corresponding data can be found in Table 5-1.

Table 5-1 $NO_x$ emissions from Sector 3 Agriculture by source categories 3B and 3D. The last column in the third part of the table indicates the relative trend.

| NOx | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3B | kt | 1.3 | 1.2 | 1.0 | 0.97 | 0.99 |
| 3D | kt | 3.6 | 3.3 | 3.0 | 2.9 | 3.0 |
| Sum | kt | 5.0 | 4.6 | 4.0 | 3.8 | 4.0 |

| NOx | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 3B | kt | 0.95 | 0.93 | 0.93 | 0.92 | 0.91 |
| 3D | kt | 2.9 | 2.8 | 2.9 | 2.9 | 2.8 |
| Sum | kt | 3.9 | 3.7 | 3.8 | 3.8 | 3.7 |

| NOx | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 3B | kt | 0.90 | 0.89 | 0.89 | 0.90 | 0.89 | -8.6 |
| 3D | kt | 2.7 | 2.7 | 2.8 | 2.7 | 2.6 | -9.4 |
| Sum | kt | 3.6 | 3.6 | 3.7 | 3.6 | 3.5 | -9.2 |

### 5.1.2 Overview and trend for NMVOC

NMVOC emissions from animal husbandry are the main reason why the emissions from sector agriculture provide a significant contribution to the national total of NMVOC emissions (see Table 2-9). The trend of NMVOC emissions within agriculture is depicted in Figure 5-2 and Table 5-2. The emissions are dominated by source category 3B Manure management, where emissions stem from cattle husbandry fed by silage, as dominant emission source. Emissions were stable between 1990 and 2000, before an increasing trend started between 2000 and 2008 due to a significant increase in the number of non-dairy cattle which predominately are fed by silage. Since 2014, the emissions have remained at about constant level.

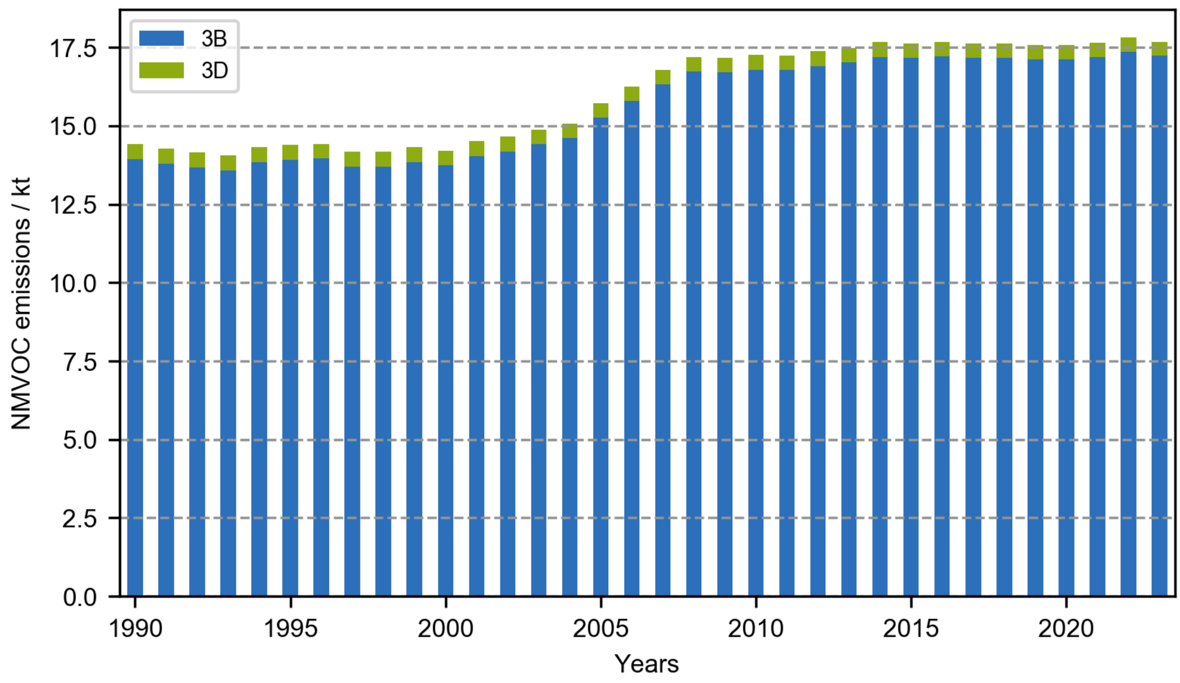



Figure 5-2 Switzerland's NMVOC emissions from agriculture by source categories 3B and 3D. The corresponding data can be found in Table 5-2.

Table 5-2 NMVOC emissions from Sector 3 Agriculture by source category 3B and 3D. The last column in the third part of the table indicates the relative trend.

| NMVOC | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3B | kt | 14 | 14 | 14 | 15 | 17 |
| 3D | kt | 0.48 | 0.48 | 0.47 | 0.47 | 0.46 |
| Sum | kt | 14 | 14 | 14 | 16 | 17 |

| NMVOC | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 3B | kt | 17 | 17 | 17 | 17 | 17 |
| 3D | kt | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 |
| Sum | kt | 18 | 18 | 18 | 18 | 18 |

| NMVOC | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 3B | kt | 17 | 17 | 17 | 17 | 17 | 13 |
| 3D | kt | 0.46 | 0.46 | 0.46 | 0.45 | 0.45 | -3.6 |
| Sum | kt | 18 | 18 | 18 | 18 | 18 | 12 |

### 5.1.3 Overview and trend for $NH_3$

Agriculture is by far the most important source of $NH_3$ emissions in Switzerland (see Table 2-11). The trend of $NH_3$ emissions within agriculture is depicted in Figure 5-3 and Table 5-3. While source category 3B Manure management slightly increased in the period 1990-2023, category 3D Crop production and agricultural soils shows a fluctuating and decreasing trend. Both categories are about equally important in the year 2023. Agricultural ammonia emissions decreased between 1990 and 2004, followed by a slight increase until 2007 and another decrease since then. This non-monotonic trend results from a combination of changes in animal numbers, introduction of nutrient balance regulations for nitrogen, introduction of new housing systems and more grazing due to developments in animal welfare regulations, increase of animal productivity, changes in production techniques and a considerable decrease of N fertiliser use due to nutrient balance restrictions (Kupper et al. 2015, Kupper et al. 2018, Kupper et al. 2022). Between 1990 and 2020, N excretions from livestock decreased by 17 % and N excretions of livestock going into the manure stream even by 27 % (Kupper et al. 2022). A further reason for the downward trend of agricultural $NH_3$ emissions is the growing importance of grazing due to animal welfare incentives. The share of soluble N (TAN) of excretions of livestock going to grazing increased from 8 % in 1990 to 17 % in 2020 (Kupper et al. 2022).

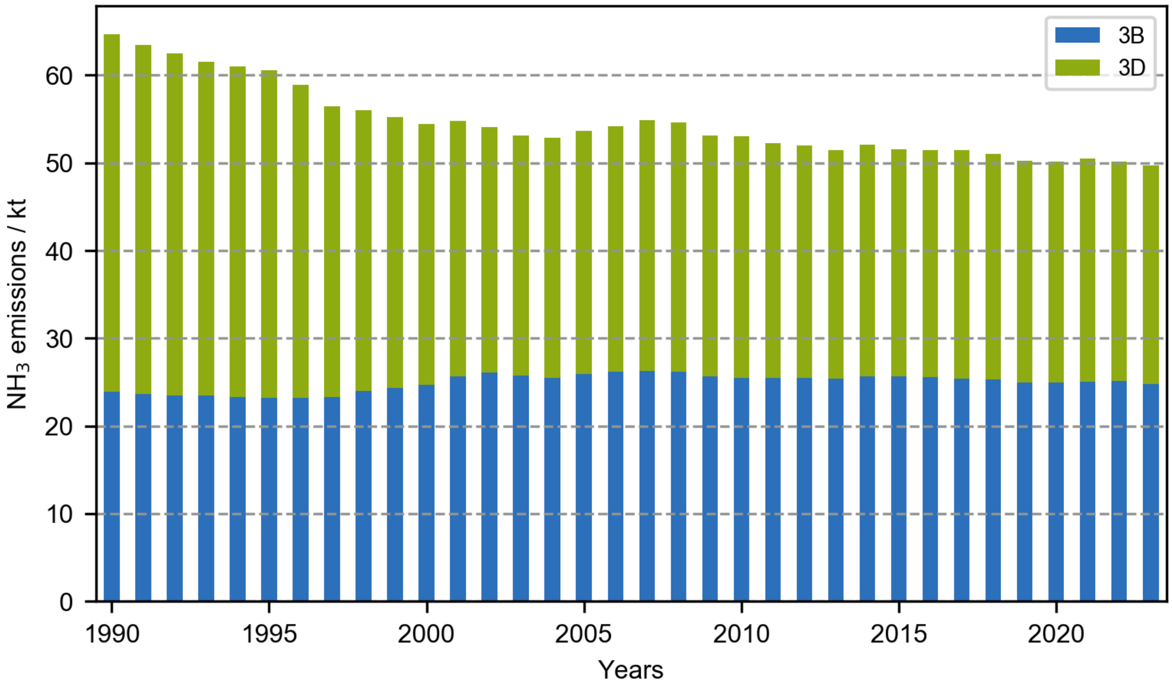



Figure 5-3 Switzerland's $NH_3$ emissions from agriculture by source categories 3B and 3D. The corresponding data can be found in Table 5-3.

Table 5-3 $NH_3$ emissions from Sector 3 Agriculture by source categories 3B and 3D. The last column in the third part of the table indicates the relative trend.

| NH3 | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3B | kt | 24 | 23 | 25 | 26 | 26 |
| 3D | kt | 41 | 37 | 30 | 28 | 27 |
| Sum | kt | 65 | 61 | 54 | 54 | 53 |

| NH3 | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 3B | kt | 26 | 26 | 26 | 25 | 25 |
| 3D | kt | 26 | 26 | 26 | 26 | 26 |
| Sum | kt | 52 | 52 | 51 | 51 | 51 |

| NH3 | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 3B | kt | 25 | 25 | 25 | 25 | 25 | -4.5 |
| 3D | kt | 25 | 25 | 25 | 25 | 25 | -10 |
| Sum | kt | 50 | 50 | 50 | 50 | 50 | -7.5 |

## 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. It includes emissions of $NO_x$ and $NH_3$ from animal manure (except categories 3Da2a Animal manure applied to soils and 3Da3 Urine and dung deposited by grazing animals). Also, 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 as well.

Table 5-4 Specification of source category 3B Manure Management.

| 3B | Source category | Specification |
|---|---|---|
| 3B1a | Manure management - Dairy cattle | Mature dairy cattle, water 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 management - Laying hens | |
| 3B4gii | Manure management - Broilers | |
| 3B4giii | Manure management - 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 (3B4hi), bisons (3B4hii) |

Table 5-5 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 3B, Manure Management.

| NFR 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 | NH3 | L1, L2, T2 |
| 3B4gi | Manure management - Laying hens | NMVOC | T2 |
| 3B4gi | Manure management - Laying hens | PM10 | L2 |
| 3B4gii | Manure management - Broilers | NMVOC | L2, T2 |
| 3B4gii | Manure management - Broilers | NH3 | L2, 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 (EMEP/EEA 2023).

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 2018 revision of the model (Kupper et al. 2018) it was extended to cover not only $NH_3$ emissions but all nitrogen 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 farm management. 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, 2015 and 2019. Each survey consisted of a representative stratified random sample covering approximately 2000 to 3000 farms (in total, in 2020 there were about 49'000 farms in Switzerland). The strata cover five different farm types, three regions of Switzerland and three altitude classes (valley zone, hill zone, mountain zone). The questionnaire contained detailed questions on livestock housing, feeding and grazing for different livestock categories, as well as manure storage and spreading, and use of mineral fertiliser. 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 emission factors for each strata group and the five respective survey years. For the national extrapolation of the emission data, the weighted average (according to share of the total livestock population of the respective livestock categories) input data on production of the different strata group was used. The emission time series from 2002 to 2019 was established with the calculated emission factors (2002, 2007, 2010, 2015, 2019), with interpolated emission factors for the years 2003-2006, 2008-2009, 2011-2014 and 2016-2018, and the known development of the number of animals in different livestock categories (activity data). Emission factors beyond 2019 are kept constant until new survey results are available (expected in 2025). The experience gained from the detailed surveys between 2002 and 2019 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 Kupper et al. (2022).

A comparison of the country-specifically calculated Tier 3 results (using the AGRAMMON version 2018) for N flows and $NH_3$ emissions from animal husbandry (3B Manure management, 3Da2a Animal manure applied to soils and 3Da3 Urine and dung deposited by grazing animals) with the results of the Tier 2 calculations based on the TFEIP N flow tool was performed for 2015 (at the time the last year with a representative survey on farm management). The comparison and discussion of the results are given in Annex A2.3. In the framework of the Stage 3 in-depth review of emission inventories in summer 2020, Switzerland provided detailed information on the development of the nitrogen (N) flow distribution to liquid and solid manure depending on management technique modelled within AGRAMMON.

For nitrogen flux calculations, AGRAMMON uses nitrogen excretions of different livestock categories according to the values valid in the respective reference years of the "Principles of Agricultural Crop Fertilisation in Switzerland" (Richner and Sinaj 2017). The values have partly changed over time depending on the development of production technology (especially breeding, feeding) and have been adjusted accordingly (Kupper et al. 2018, Kupper et al. 2022). To take into account the varying milk yield level of dairy cattle, a linear correction factor given in Richner and Sinaj (2017) was applied. The TAN proportions in the excreta of the animal categories which are used in AGRAMMON are as follows: Dairy cattle and other cattle categories: 55 %; swine: 70 %; poultry: 60 %; horses and other equids as well as sheeps, goats and all other animals are assumed to have 40 % TAN (Kupper et al. 2018, Kupper et al. 2022). N-excretion values and the proportion of TAN therein is based on models which employed experimental data obtained from dairy cattle and fattening swines. The proportion of TAN has been extrapolated from the values to the other cattle and swine categories. For poultry, horses and other equids, sheeps, goats and other animals it is based on expert judgments. The proportion of TAN is equated with urine N, 'Documentation on the Technical Parameters' in AGRAMMON 2018 describes how the values were derived.

Table 5-6 shows that the share of the total N excretions from all agricultural livestock that went into the slurry flow decreased from 64 % to 56 % from 1990 to 2019. Table 5-7 shows that this was not the case for the N excretions of cattle (all categories together) that remained almost constant around 60 %. This probably was because an increase in grazing – which reduced the share of N collected in the housing area – compensated the increase of the share of N going to slurry in the housing area. The share of total N excretions of all livestock going to pasture, range and paddock (Table 5-6) roughly doubled because of animal welfare incentives and the considerable decrease of pig production. The share going to digesters increased from 0.6 % to 6.9 % and the share going to deep litter and poultry manure rose from 5.4 % to 8.5 % due to a strong growth of poultry production. The share going to solid manure decreased by nearly halve, mainly because of the shift from tied to loose housing systems for cattle. Table 5-8 shows the share of N excretions going to the liquid manure flow (including digesters) for the different livestock categories. The shares strongly increase for the cattle categories. For swine, which produce only liquid manure and for equids (horse, mules and asses), sheep, goats and poultry which produce only solid manure the values logically remained constant.

Table 5-6 Development of the share of the total N excretions from livestock (incl. cattle) going to the paths liquid slurry / solid manure / other (deep litter / poultry manure) / digesters / pasture, range and paddock in Switzerland from 1990 to 2019 (in % of total N excretions). Data based on representative surveys on farm management technique in 2002, 2007, 2010, 2015 and 2019; for 1990 and 1995 based on expert assumptions (Kupper et al. 2022).

| **Distribution of N excretion [%]** | **1990** | **1995** | **2002** | **2007** | **2010** | **2015** | **2019** |
|---|---|---|---|---|---|---|---|
| Liquid / Slurry | 63.8% | 64.0% | 58.7% | 59.4% | 58.7% | 58.7% | 55.6% |
| Solid manure | 21.3% | 20.3% | 16.5% | 13.9% | 13.3% | 11.6% | 10.8% |
| Other (deep litter, poultry manure) | 5.4% | 5.3% | 5.8% | 6.8% | 7.7% | 7.5% | 8.5% |
| Digesters | 0.6% | 0.5% | 0.6% | 1.6% | 2.3% | 4.4% | 6.9% |
| Pasture, range and paddock | 8.9% | 9.9% | 18.5% | 18.2% | 18.0% | 17.9% | 18.3% |

Table 5-7 Development of the share of the N excretions from cattle (sum of all three categories) going to the paths liquid slurry / solid manure / other (deep litter) / digesters / pasture, range and paddock in Switzerland from 1990 to 2019 (in % of total N excretions). Data based on representative surveys on farm management technique in 2002, 2007, 2010, 2015 and 2019; for 1990 and 1995 based on expert assumptions (Kupper et al. 2022).

| **Distribution of N excretion [%]** | **1990** | **1995** | **2002** | **2007** | **2010** | **2015** | **2019** |
|---|---|---|---|---|---|---|---|
| Liquid / Slurry | 60.5% | 61.7% | 58.7% | 61.6% | 61.6% | 62.9% | 60.8% |
| Solid manure | 26.9% | 24.7% | 18.7% | 15.4% | 14.4% | 12.0% | 11.2% |
| Other (deep litter) | 1.3% | 1.3% | 1.3% | 1.2% | 1.4% | 1.2% | 1.2% |
| Digesters | 0.5% | 0.5% | 0.6% | 1.5% | 2.2% | 4.1% | 6.4% |
| Pasture, range and paddock | 10.7% | 11.8% | 20.7% | 20.3% | 20.4% | 19.8% | 20.4% |

Table 5-8 Development of the share of N excretions going to the liquid phase of manure (including digestate) for the different livestock categories in Switzerland from 1990 to 2019 (in % of total N excretions of the respective category). Data based on representative surveys on farm management technique in 2002, 2007, 2010, 2015 and 2019; for 1990 and 1995 based on expert assumptions (Kupper et al. 2022).

| **% N excretion going to liquid phase** | **1990** | **1995** | **2002** | **2007** | **2010** | **2015** | **2019** |
|---|---|---|---|---|---|---|---|
| Dairy cattle | 66.2% | 67.9% | 66.0% | 69.6% | 70.8% | 73.6% | 74.4% |
| Other mature cattle | 41.6% | 39.0% | 43.8% | 55.2% | 55.9% | 58.5% | 55.9% |
| Growing cattle | 50.0% | 50.5% | 45.8% | 50.1% | 50.7% | 54.8% | 55.7% |
| Sheep | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Swine | 100% | 100% | 98.7% | 99.0% | 99.5% | 99.8% | 99.9% |
| Goats | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Horses | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Mules and asses | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Poultry (layers, broilers, turkey, growers) | 0% | 0% | 0% | 0% | 0% | 0% | 0% |

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 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 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 from the EMEP/EEA guidebook (EMEP/EEA 2023). 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 cited in the EMEP/EEA guidebook at that time (EMEP/EEA 2016, unchanged in EMEP/EEA 2023) showed several inconsistencies that could affect significantly the emission factors. It also remains 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 conducted between 2018 and 2021 in order to measure NMVOC emissions from dairy cattle with and without silage feeding in an experimental dairy housing during summer, winter and transitional season and to derive emission factors that are representative for cattle husbandry in Switzerland (Schrade et al. 2025). However, it should be noted that the time the animals spend on pasture is not taken into account in this study and NMVOC emissions are thus probably rather overestimated.

Please note that we are aware that Tier 2 methodologies are in principle required for emission calculations of key categories. But due to lack of data, this was not possible to implement for all categories (e.g. NMVOC (3B) and PM (3B4gii)).

### Emission factors (3B)

The consideration of structural and management parameters based on representative stratified surveys on farm management practice 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 (Kupper et al. 2015, Kupper et al. 2018, Kupper et al. 2022). National standard N excretion rates are used (Richner and Sinaj 2017), considering animal category specific correction factors as also described under methodology.

For the volatilisation of $NO_x$, which is 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 in the form of $NO_x$. These values are considerably higher than the ones based on the EMEP/EEA guidebook (Table 3.10 and A1.8; EMEP/EEA 2023), especially for liquid/slurry systems which in 2020 account for about 70 % of the total N flow through manure storage (Kupper et al. 2022). 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 5-9 and Table 5-10. 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 5-9 and Table 5-10, but are given in the tables of chp. 5.3.2.

Table 5-9 Time series of $NH_3$ emission factors for livestock categories (3B4a Buffalos: IE (3B1a)). Note that the emissions from grazing and for the application of manure are not included in these emission factors (see chp. 5.3.2).

| NH3 emission factors | unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3B1a Dairy cattle | kg/animal | 11.9 | 12.6 | 15.9 | 17.5 | 17.5 |
| 3B1b Other mature cattle | kg/animal | 11.8 | 12.9 | 14.4 | 16.2 | 16.1 |
| 3B1b Growing cattle | kg/animal | 4.76 | 5.03 | 5.33 | 5.61 | 5.66 |
| 3B2 Sheep | kg/animal | 1.29 | 1.31 | 1.12 | 1.04 | 1.24 |
| 3B3 Swine | kg/animal | 3.54 | 3.71 | 3.93 | 3.84 | 3.37 |
| 3B4d Goats | kg/animal | 2.32 | 2.30 | 2.12 | 1.87 | 1.92 |
| 3B4e Horses | kg/animal | 9.10 | 9.08 | 8.31 | 7.97 | 8.09 |
| 3B4f Mules and asses | kg/animal | 3.34 | 3.34 | 3.20 | 2.99 | 2.90 |
| 3B4gi Laying hens | kg/animal | 0.317 | 0.308 | 0.269 | 0.256 | 0.218 |
| 3B4gii Broilers | kg/animal | 0.0899 | 0.0855 | 0.0842 | 0.0880 | 0.0796 |
| 3B4giii Turkeys | kg/animal | 0.315 | 0.314 | 0.294 | 0.304 | 0.281 |
| 3B4giv Other poultry: Growers | kg/animal | 0.168 | 0.155 | 0.129 | 0.112 | 0.0834 |
| 3B4giv Other poultry: Other | kg/animal | 0.168 | 0.168 | 0.169 | 0.172 | 0.172 |
| 3B4h Rabbits | kg/animal | 0.230 | 0.230 | 0.230 | 0.230 | 0.230 |
| 3B4h Bisons | kg/animal | NO | 6.76 | 6.99 | 6.39 | 6.26 |
| 3B4h Camels and llamas | kg/animal | NO | NO | 2.08 | 1.83 | 2.02 |
| 3B4h Deer | kg/animal | 3.40 | 3.72 | 3.29 | 3.12 | 3.60 |

| NH3 emission factors | unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3B1a Dairy cattle | kg/animal | 18.3 | 18.5 | 18.6 | 18.8 | 18.9 | 19.1 | 19.1 | 19.1 | 19.1 | 19.1 |
| 3B1b Other mature cattle | kg/animal | 16.4 | 16.5 | 16.3 | 16.1 | 15.9 | 15.7 | 15.7 | 15.7 | 15.7 | 15.7 |
| 3B1b Growing cattle | kg/animal | 5.96 | 6.02 | 5.99 | 5.98 | 5.96 | 5.95 | 5.93 | 5.91 | 5.90 | 5.88 |
| 3B2 Sheep | kg/animal | 1.16 | 1.13 | 1.14 | 1.16 | 1.17 | 1.19 | 1.18 | 1.18 | 1.19 | 1.18 |
| 3B3 Swine | kg/animal | 3.35 | 3.38 | 3.39 | 3.38 | 3.37 | 3.37 | 3.37 | 3.37 | 3.37 | 3.36 |
| 3B4d Goats | kg/animal | 1.95 | 1.91 | 1.87 | 1.83 | 1.79 | 1.75 | 1.75 | 1.75 | 1.75 | 1.75 |
| 3B4e Horses | kg/animal | 8.25 | 8.31 | 8.28 | 8.25 | 8.22 | 8.19 | 8.20 | 8.20 | 8.20 | 8.19 |
| 3B4f Mules and asses | kg/animal | 2.98 | 3.00 | 3.01 | 3.02 | 3.02 | 3.03 | 3.03 | 3.03 | 3.03 | 3.03 |
| 3B4gi Laying hens | kg/animal | 0.198 | 0.193 | 0.189 | 0.184 | 0.180 | 0.175 | 0.175 | 0.175 | 0.175 | 0.175 |
| 3B4gii Broilers | kg/animal | 0.0665 | 0.0632 | 0.0635 | 0.0637 | 0.0640 | 0.0642 | 0.0642 | 0.0642 | 0.0642 | 0.0642 |
| 3B4giii Turkeys | kg/animal | 0.312 | 0.319 | 0.305 | 0.291 | 0.277 | 0.262 | 0.262 | 0.262 | 0.262 | 0.262 |
| 3B4giv Other poultry: Growers | kg/animal | 0.0773 | 0.0757 | 0.0743 | 0.0729 | 0.0715 | 0.0701 | 0.0701 | 0.0701 | 0.0701 | 0.0701 |
| 3B4giv Other poultry: Other | kg/animal | 0.171 | 0.171 | 0.169 | 0.166 | 0.164 | 0.161 | 0.161 | 0.161 | 0.161 | 0.161 |
| 3B4h Rabbits | kg/animal | 0.230 | 0.230 | 0.230 | 0.230 | 0.230 | 0.230 | 0.230 | 0.230 | 0.230 | 0.230 |
| 3B4h Bisons | kg/animal | 6.08 | 6.07 | 6.09 | 6.03 | 7.95 | 7.79 | 7.74 | 7.70 | 7.70 | 7.68 |
| 3B4h Camels and llamas | kg/animal | 1.88 | 1.82 | 1.83 | 1.84 | 1.85 | 1.88 | 1.89 | 1.89 | 1.88 | 1.88 |
| 3B4h Deer | kg/animal | 3.37 | 3.29 | 3.35 | 3.41 | 3.47 | 3.53 | 3.53 | 3.54 | 3.57 | 3.58 |

Table 5-10 Time series of $NO_x$ emission factors for livestock categories (3B4a Buffalos: IE (3B1a)).

| NOx emission factors | unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3B1a Dairy cattle | g/animal | 858 | 829 | 773 | 742 | 730 |
| 3B1b Other mature cattle | g/animal | 635 | 657 | 558 | 535 | 518 |
| 3B1b Growing cattle | g/animal | 318 | 317 | 282 | 267 | 268 |
| 3B2 Sheep | g/animal | 171 | 174 | 150 | 142 | 170 |
| 3B3 Swine | g/animal | 94.3 | 92.1 | 73.0 | 62.9 | 60.8 |
| 3B4d Goats | g/animal | 317 | 314 | 280 | 264 | 265 |
| 3B4e Horses | g/animal | 624 | 623 | 569 | 547 | 546 |
| 3B4f Mules and asses | g/animal | 229 | 229 | 223 | 209 | 202 |
| 3B4gi Laying hens | g/animal | 2.33 | 2.32 | 2.24 | 2.35 | 2.45 |
| 3B4gii Broilers | g/animal | 1.31 | 1.31 | 1.31 | 1.40 | 1.47 |
| 3B4giii Turkeys | g/animal | 4.60 | 4.58 | 4.50 | 4.49 | 4.51 |
| 3B4giv Other poultry: Growers | g/animal | 1.12 | 1.11 | 1.11 | 1.05 | 1.000 |
| 3B4giv Other poultry: Other | g/animal | 1.84 | 1.84 | 1.80 | 1.81 | 1.80 |
| 3B4h Rabbits | g/animal | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| 3B4h Bisons | g/animal | NO | 908 | 892 | 813 | 799 |
| 3B4h Camels and llamas | g/animal | NO | NO | 262 | 224 | 252 |
| 3B4h Deer | g/animal | 459 | 502 | 415 | 383 | 450 |

| NOx emission factors | unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3B1a Dairy cattle | g/animal | 720 | 717 | 715 | 713 | 711 | 707 | 705 | 704 | 703 | 702 |
| 3B1b Other mature cattle | g/animal | 502 | 498 | 498 | 497 | 497 | 496 | 494 | 493 | 492 | 492 |
| 3B1b Growing cattle | g/animal | 260 | 259 | 257 | 255 | 253 | 251 | 250 | 248 | 248 | 249 |
| 3B2 Sheep | g/animal | 156 | 152 | 153 | 156 | 157 | 159 | 159 | 159 | 159 | 159 |
| 3B3 Swine | g/animal | 59.6 | 59.7 | 60.1 | 59.9 | 59.8 | 59.9 | 59.8 | 60.0 | 59.9 | 59.7 |
| 3B4d Goats | g/animal | 274 | 269 | 263 | 258 | 253 | 248 | 248 | 248 | 248 | 248 |
| 3B4e Horses | g/animal | 560 | 565 | 562 | 558 | 555 | 552 | 552 | 553 | 552 | 552 |
| 3B4f Mules and asses | g/animal | 204 | 205 | 206 | 208 | 210 | 211 | 211 | 211 | 211 | 211 |
| 3B4gi Laying hens | g/animal | 2.44 | 2.44 | 2.44 | 2.44 | 2.44 | 2.44 | 2.44 | 2.44 | 2.44 | 2.44 |
| 3B4gii Broilers | g/animal | 1.24 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 | 1.18 |
| 3B4giii Turkeys | g/animal | 4.47 | 4.46 | 4.46 | 4.46 | 4.46 | 4.46 | 4.46 | 4.46 | 4.46 | 4.46 |
| 3B4giv Other poultry: Growers | g/animal | 0.977 | 0.972 | 0.969 | 0.966 | 0.964 | 0.961 | 0.961 | 0.961 | 0.961 | 0.961 |
| 3B4giv Other poultry: Other | g/animal | 1.79 | 1.79 | 1.79 | 1.79 | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 |
| 3B4h Rabbits | g/animal | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 | 31.5 |
| 3B4h Bisons | g/animal | 778 | 777 | 780 | 773 | 1'019 | 999 | 993 | 987 | 987 | 985 |
| 3B4h Camels and llamas | g/animal | 236 | 229 | 229 | 231 | 233 | 236 | 237 | 237 | 236 | 236 |
| 3B4h Deer | g/animal | 423 | 413 | 420 | 428 | 435 | 443 | 442 | 443 | 447 | 449 |

For all cattle categories country specific NMVOC emission factors are used based on a comprehensive study in which emission measurements were carried out in an experimental dairy housing (Schrade et al. 2025). NMVOC emissions from dairy cattle with and without silage feeding were measured during summer, winter and transitional season. For a representative determination of emissions from silage, measurements were carried out with three different silage rations. Based on these measurements, NMVOC emission factors were derived for dairy cattle with and without silage for the lowlands and mountain area, respectively, see Table 5-11. A distinction was also made between the summer and winter feeding period, as there are clear differences between the proportions of dairy cows with and without silage feeding in the two feeding periods. For silage feeding, emission factors (weighted for feeding periods) of 24.0 kg/animal and 21.9 kg/animal resulted for dairy cattle in the lowlands and the mountain area, respectively. The values are higher than the default Tier 1 emission factor of 17.937 provided in the EMEP/EEA guidebook (EMEP/EEA 2023, chp. 3B Manure management, Table 3.4). It should be noted that the weight of Swiss dairy cattle (660 kg, Richner and Sinaj 2017) is higher than the one of dairy cattle in EMEP/EEA (2023) (600 kg, chp. 3B, Table A1.7). On the other hand, the emission factors without silage feeding (weighted for feeding periods) of 1.1 kg/animal and 0.9 kg/animal for the lowlands and the mountain area, respectively, are considerably lower than the one given in EMEP/EEA (2023) (8.047 kg/animal). For non-dairy cattle the same emission factors are assumed whereas for young cattle categories, the emission factors were scaled with the ratio of the gross energy intake of the respective categories related to the one of dairy cattle. For the calculation of NMVOC emissions, the proportion of animals kept in the lowlands and mountain area as well as their proportion with and without silage feeding were taken into account, see Table 5-12. The proportions are derived from the on-farm surveys on farm and manure management conducted by HAFL (2002, 2007, 2010, 2015 and 2019) in connection with the AGRAMMON model (Kupper and Häni 2022). The relatively high proportion of dairy cattle that is fed without silage in Switzerland is due to the fact that unpasteurised milk is used for hard cheese production and that farms producing milk for hard cheese production are not allowed to produce and use silage for all cattle. Between 1990 and 2019, the share of dairy cattle receiving silage increased almost continuously, e.g. in the lowlands from 37 % to 61 %. For all livestock categories other than cattle, the NMVOC emission factors are based on default Tier 1 emission factors (EMEP/EEA 2023, chp. 3B Manure management, Table 3.4). As the livestock category swine comprises of five categories, namely boars, dry sows, nursing sows (including suckling piglets), fattening pigs and weaned piglets, the NMVOC emission factor is an implied factor based on the default Tier 1 emission factors for swine (sows) and swine (finishing pigs) and also takes into account the empty periods for fattening pigs. The resulting NMVOC emission factors for cattle categories and swine as well as the default emission factors for all other animal categories are given in Table 5-13.

Table 5-11 NMVOC emission factors of dairy cattle with and without silage feeding derived by Schrade et al. 2025 for the Swiss lowlands and mountain area.

| **3B1 Dairy cattle** | **Silage** | **w/o Silage** |
|---|---|---|
| **NMVOC emission factors** | kg/animal | kg/animal |
| Lowlands, summer feeding | 26.5 | 1.3 |
| Lowlands, winter feeding | 20.6 | 0.8 |
| Lowlands, weighted for feeding periods | 24.0 | 1.1 |
| Mountain area, summer feeding | 24.5 | 1.1 |
| Mountain area, winter feeding | 19.3 | 0.7 |
| Mountain area, weighted for feeding | 21.9 | 0.9 |

Table 5-12 Time series of the share of cattle categories kept in the lowlands as well as of animals receiving silage feeding in the lowlands and mountain area, respectively.

| | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|
| **3B1a Dairy cattle** | | | | | |
| Lowlands | 62% | 61% | 60% | 60% | 60% |
| Silage feeding, lowlands | 37% | 41% | 45% | 53% | 56% |
| Silage feeding, mountain area | 30% | 31% | 33% | 38% | 39% |
| **3B1b Other mature cattle** | | | | | |
| Lowlands | 62% | 61% | 58% | 58% | 58% |
| Silage feeding, lowlands | 95% | 95% | 95% | 95% | 95% |
| Silage feeding, mountain area | 95% | 95% | 95% | 95% | 95% |
| **3B1c Growing cattle** | | | | | |
| Lowlands | 51% | 51% | 55% | 56% | 56% |
| Silage feeding, lowlands | 48% | 52% | 56% | 64% | 70% |
| Silage feeding, mountain area | 43% | 46% | 43% | 47% | 58% |

| | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| **3B1a Dairy cattle** | | | | | | | | | | |
| Lowlands | 60% | 60% | 60% | 60% | 60% | 59% | 59% | 59% | 59% | 59% |
| Silage feeding, lowlands | 56% | 56% | 57% | 59% | 60% | 61% | 61% | 61% | 61% | 61% |
| Silage feeding, mountain area | 42% | 43% | 42% | 41% | 41% | 40% | 40% | 40% | 40% | 40% |
| **3B1b Other mature cattle** | | | | | | | | | | |
| Lowlands | 57% | 57% | 56% | 56% | 56% | 56% | 56% | 56% | 56% | 56% |
| Silage feeding, lowlands | 95% | 95% | 95% | 95% | 95% | 95% | 95% | 95% | 95% | 95% |
| Silage feeding, mountain area | 95% | 95% | 95% | 95% | 95% | 95% | 95% | 95% | 95% | 95% |
| **3B1c Growing cattle** | | | | | | | | | | |
| Lowlands | 57% | 57% | 57% | 57% | 57% | 57% | 57% | 57% | 57% | 57% |
| Silage feeding, lowlands | 73% | 73% | 73% | 73% | 73% | 73% | 73% | 73% | 73% | 73% |
| Silage feeding, mountain area | 60% | 60% | 59% | 59% | 59% | 59% | 59% | 59% | 59% | 59% |

Table 5-13 Time series of NMVOC emission factors for livestock categories (3B4a Buffalos: IE (3B1a)).

| NMVOC emission factors | unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3B1a Dairy cattle | kg/animal | 8.19 | 8.84 | 9.63 | 11.1 | 11.7 |
| 3B1b Other mature cattle | kg/animal | 22.1 | 22.0 | 22.0 | 22.0 | 22.0 |
| 3B1b Growing cattle | kg/animal | 4.58 | 4.72 | 4.60 | 4.78 | 5.24 |
| 3B2 Sheep | kg/animal | 0.169 | 0.169 | 0.169 | 0.169 | 0.169 |
| 3B3 Swine | kg/animal | 0.573 | 0.569 | 0.553 | 0.551 | 0.549 |
| 3B4d Goats | kg/animal | 0.542 | 0.542 | 0.542 | 0.542 | 0.542 |
| 3B4e Horses | kg/animal | 4.28 | 4.28 | 4.28 | 4.28 | 4.28 |
| 3B4f Mules and asses | kg/animal | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 |
| 3B4gi Laying hens | kg/animal | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 |
| 3B4gii Broilers | kg/animal | 0.108 | 0.108 | 0.108 | 0.108 | 0.108 |
| 3B4giii Turkeys | kg/animal | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 |
| 3B4giv Other poultry: Growers | kg/animal | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 |
| 3B4giv Other poultry: Other | kg/animal | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 |
| 3B4h Rabbits | kg/animal | 0.0590 | 0.0590 | 0.0590 | 0.0590 | 0.0590 |
| 3B4h Bisons | kg/animal | NO | 3.60 | 3.60 | 3.60 | 3.60 |
| 3B4h Camels and llamas | kg/animal | NO | NO | 0.271 | 0.271 | 0.271 |
| 3B4h Deer | kg/animal | 0.0450 | 0.0450 | 0.0450 | 0.0450 | 0.0450 |

| NMVOC emission factors | unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3B1a Dairy cattle | kg/animal | 12.1 | 12.2 | 12.2 | 12.3 | 12.3 | 12.4 | 12.4 | 12.4 | 12.4 | 12.4 |
| 3B1b Other mature cattle | kg/animal | 22.0 | 22.0 | 22.0 | 22.0 | 22.0 | 22.0 | 22.0 | 22.0 | 22.0 | 22.0 |
| 3B1b Growing cattle | kg/animal | 5.40 | 5.39 | 5.33 | 5.31 | 5.23 | 5.23 | 5.20 | 5.15 | 5.18 | 5.09 |
| 3B2 Sheep | kg/animal | 0.169 | 0.169 | 0.169 | 0.169 | 0.169 | 0.169 | 0.169 | 0.169 | 0.169 | 0.169 |
| 3B3 Swine | kg/animal | 0.548 | 0.551 | 0.551 | 0.550 | 0.548 | 0.548 | 0.545 | 0.546 | 0.547 | 0.547 |
| 3B4d Goats | kg/animal | 0.542 | 0.542 | 0.542 | 0.542 | 0.542 | 0.542 | 0.542 | 0.542 | 0.542 | 0.542 |
| 3B4e Horses | kg/animal | 4.28 | 4.28 | 4.28 | 4.28 | 4.28 | 4.28 | 4.28 | 4.28 | 4.28 | 4.28 |
| 3B4f Mules and asses | kg/animal | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 | 1.47 |
| 3B4gi Laying hens | kg/animal | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 |
| 3B4gii Broilers | kg/animal | 0.108 | 0.108 | 0.108 | 0.108 | 0.108 | 0.108 | 0.108 | 0.108 | 0.108 | 0.108 |
| 3B4giii Turkeys | kg/animal | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 |
| 3B4giv Other poultry: Growers | kg/animal | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 | 0.165 |
| 3B4giv Other poultry: Other | kg/animal | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 | 0.489 |
| 3B4h Rabbits | kg/animal | 0.0590 | 0.0590 | 0.0590 | 0.0590 | 0.0590 | 0.0590 | 0.0590 | 0.0590 | 0.0590 | 0.0590 |
| 3B4h Bisons | kg/animal | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 |
| 3B4h Camels and llamas | kg/animal | 0.271 | 0.271 | 0.271 | 0.271 | 0.271 | 0.271 | 0.271 | 0.271 | 0.271 | 0.271 |
| 3B4h Deer | kg/animal | 0.0450 | 0.0450 | 0.0450 | 0.0450 | 0.0450 | 0.0450 | 0.0450 | 0.0450 | 0.0450 | 0.0450 |

The particulate matter emission factors (PM2.5, PM10, and TSP) are listed in Table 5-14. They are 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 from the EMEP/EEA guidebook (EMEP/EEA 2023, 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 emission factors as for the corresponding agricultural animals are applied (see chp. 7.2.2).

Table 5-14 Emission factors of PM2.5, PM10 and TSP for livestock categories (3B4a Buffalos: IE (3B1a)) for the years 1990-2023 (based on measurements in Switzerland, literature data and EMEP/EEA 2023.

| 3B Manure management | Unit of activity data | PM2.5 nx | PM10 nx | TSP nx |
|---|---|---|---|---|
| | | g/... | g/... | g/... |
| 3B1a Dairy cattle | animal | 43 | 177 | 609 |
| 3B1b Other mature cattle | animal | 22 | 92 | 314 |
| 3B1b Growing cattle | animal | 22 | 91 | 313 |
| 3B2 Sheep | animal | 2.0 | 50 | 140 |
| 3B3 Swine | animal | 4.5 | 101 | 439 |
| 3B4d Goats | animal | 2.0 | 50 | 140 |
| 3B4e Horses | animal | 140 | 220 | 480 |
| 3B4f Mules and asses | animal | 100 | 160 | 340 |
| 3B4gi Laying hens | animal | 3.0 | 40 | 190 |
| 3B4gii Broilers | animal | 2.0 | 20 | 40 |
| 3B4giii Turkeys | animal | 20 | 110 | 110 |
| 3B4giv Other poultry: Growers | animal | 2.0 | 20 | 40 |
| 3B4giv Other poultry: Other | animal | 25 | 190 | 190 |
| 3B4h Rabbits | animal | 4.0 | 8.0 | 18 |
| 3B4h Bisons | animal | 2.0 | 50 | 140 |
| 3B4h Camels and llamas | animal | 2.0 | 50 | 140 |
| 3B4h Deer | animal | 2.0 | 50 | 140 |

**Activity data (3B)**

The number of animals in the different livestock categories (SBV 2024, FSO 2024a) for the time period 1990 to 2023 is shown in Table 5-15. The figures represent harmonised livestock numbers coming from various sources since 1990. The methodology of the harmonisation, which was a joint effort of the Agroscope Reckenholz Tänikon Research Station (ART) and the Swiss College of Agriculture (SHL) in 2011 for the 1990-2010 time series, is documented in ART/SHL (2012). The livestock category swine comprises the five categories boars, dry sows, nursing sows (including suckling piglets), fattening pigs (> 25 kg) and weaned piglets (up to 25 kg). Because the official livestock census statistics are based on a key date (1st May until 2014, 1st January since 2015), the Federal Office of Statistics provided a dataset with average livestock numbers over the whole year, as suggested by the EMEP/EEA guidebook (EMEP/EEA 2023). Thus, for fattening pigs over 25 kg and broilers also empty periods were taken into account. Data for horses, mules and asses were derived from background data of the gross nutrient balance of the Swiss Federal Statistical Office (FSO 2024b).

Table 5-15 Time series of animal numbers for livestock categories (in thousand animals, 3B4a Buffalos: IE (3B1a)).

| 3B Manure management (number of animals) | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3B1a Dairy cattle | 1000 animals | 783 | 740 | 669 | 621 | 589 |
| 3B1b Other mature cattle | 1000 animals | 12 | 23 | 45 | 78 | 111 |
| 3B1b Growing cattle | 1000 animals | 1'060 | 986 | 874 | 856 | 891 |
| 3B2 Sheep | 1000 animals | 395 | 387 | 421 | 446 | 434 |
| 3B3 Swine | 1000 animals | 1'965 | 1'739 | 1'670 | 1'744 | 1'750 |
| 3B4d Goats | 1000 animals | 68 | 53 | 62 | 74 | 83 |
| 3B4e Horses | 1000 animals | 28 | 41 | 50 | 55 | 62 |
| 3B4f Mules and asses | 1000 animals | 5.9 | 7.6 | 12 | 16 | 20 |
| 3B4gi Laying hens | 1000 animals | 3'083 | 2'118 | 2'150 | 2'189 | 2'438 |
| 3B4gii Broilers | 1000 animals | 3'392 | 3'637 | 3'985 | 5'711 | 7'184 |
| 3B4giii Turkeys | 1000 animals | 95 | 170 | 173 | 132 | 58 |
| 3B4giv Other poultry: Growers | 1000 animals | 719 | 714 | 832 | 868 | 926 |
| 3B4giv Other poultry: Other | 1000 animals | 22 | 17 | 21 | 11 | 23 |
| 3B4h Rabbits | 1000 animals | 61 | 41 | 28 | 25 | 35 |
| 3B4h Bisons | 1000 animals | NO | 0.10 | 0.26 | 0.37 | 0.51 |
| 3B4h Camels and llamas | 1000 animals | NO | NO | 1.0 | 3.1 | 6.1 |
| 3B4h Deer | 1000 animals | 0.17 | 1.4 | 2.8 | 3.8 | 5.5 |

| 3B Manure management (number of animals) | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3B1a Dairy cattle | 1000 animals | 587 | 583 | 576 | 569 | 564 | 555 | 546 | 546 | 543 | 532 |
| 3B1b Other mature cattle | 1000 animals | 118 | 118 | 121 | 123 | 125 | 128 | 131 | 135 | 138 | 140 |
| 3B1b Growing cattle | 1000 animals | 857 | 853 | 859 | 852 | 854 | 842 | 837 | 833 | 845 | 856 |
| 3B2 Sheep | 1000 animals | 403 | 395 | 397 | 398 | 403 | 400 | 398 | 398 | 403 | 409 |
| 3B3 Swine | 1000 animals | 1'631 | 1'605 | 1'553 | 1'546 | 1'501 | 1'447 | 1'449 | 1'470 | 1'475 | 1'409 |
| 3B4d Goats | 1000 animals | 85 | 84 | 85 | 88 | 91 | 92 | 90 | 91 | 92 | 92 |
| 3B4e Horses | 1000 animals | 57 | 55 | 56 | 56 | 46 | 47 | 47 | 47 | 48 | 48 |
| 3B4f Mules and asses | 1000 animals | 20 | 20 | 20 | 21 | 34 | 34 | 33 | 33 | 33 | 33 |
| 3B4gi Laying hens | 1000 animals | 2'665 | 2'822 | 3'056 | 3'174 | 3'371 | 3'486 | 3'854 | 3'867 | 3'893 | 3'841 |
| 3B4gii Broilers | 1000 animals | 8'506 | 8'614 | 9'064 | 8'857 | 9'430 | 9'593 | 10'097 | 10'522 | 10'702 | 10'596 |
| 3B4giii Turkeys | 1000 animals | 57 | 49 | 71 | 77 | 84 | 75 | 88 | 83 | 82 | 121 |
| 3B4giv Other poultry: Growers | 1000 animals | 1'196 | 1'033 | 959 | 1'084 | 1'078 | 1'242 | 1'150 | 1'177 | 1'300 | 1'231 |
| 3B4giv Other poultry: Other | 1000 animals | 22 | 23 | 30 | 16 | 20 | 21 | 24 | 25 | 28 | 26 |
| 3B4h Rabbits | 1000 animals | 27 | 25 | 25 | 22 | 22 | 21 | 19 | 17 | 16 | 14 |
| 3B4h Bisons | 1000 animals | 0.53 | 0.56 | 0.56 | 0.57 | 0.54 | 0.46 | 0.46 | 0.43 | 0.40 | 0.38 |
| 3B4h Camels and llamas | 1000 animals | 6.1 | 6.4 | 6.5 | 6.6 | 6.7 | 6.6 | 6.5 | 6.5 | 6.7 | 6.8 |
| 3B4h Deer | 1000 animals | 5.7 | 6.0 | 6.0 | 6.0 | 6.4 | 6.6 | 6.6 | 6.6 | 6.7 | 6.6 |

### 5.2.3 Category-specific recalculations 3B Manure management

The following recalculations were implemented in submission 2025.

- 3B1: Updated data on the amount of manure digested anaerobically (SFOE 2024b, particularly in the years 1990-1999) led to minimal changes in the $NO_x$ emission factors for manure management and application for all cattle categories (3B1, 3Da2a1, 3Da31).
- 3B3: The activity data and emission factors ($NO_x$, NMVOC, $NH_3$, PM2.5, PM10 and TSP) of 3B3 Manure management - Swine were recalculated for the years 2021 and 2022 due to updated data for fattening pigs >25 kg from FSO 2024b.
- 3B4gii: The activity data of 3B4gii Manure management - Broilers was recalculated for the years 2021 and 2022 due to updated data from FSO 2024b.
- 3B4h: Allocation of manure to the different management systems (MS) was revised for "other roughage eaters" (Bisons, Camelids, Deer, Rabbits) based on Kupper et al. 2022 yielding changes in the $NO_x$ emission factors of source categories 3B4h Manure management - Other animals for the entire time series (1990-2022).

## 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 fertilisers (mineral (inorganic N-) fertiliser, sewage sludge, compost and other residue fertilisers) and animal manure applied on these soils as well as excretions 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). Emissions due to potential HCB impurities or by-products in certain pesticides (3Df) are not estimated.

Table 5-16 Specification of source category 3D Agricultural Soils.

| 3D | Source category | Specification |
|---|---|---|
| 3Da1 | Inorganic N-fertilisers | Application of urea-containing fertilisers and other inorganic fertilisers |
| 3Da2a | Livestock manure applied to soils | Application of livestock manure (incl. digestate from agricultural biogas plants) to soils (dairy cattle, non-dairy cattle, sheep, swine, buffalos, goats, horses, mules/asses, laying hens, broilers, turkeys, growers, 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 from non-agricultural biogas plants) |
| 3Da3 | Urine and dung deposited by grazing livestock | Deposition of urine and dung by grazing livestock |
| 3De | Cultivated crops | For particulate matter emissions: Soil cultivation and crop harvesting (operation of tractors and machinery).<br>For NMVOC emissions: Crop production, differentiated for cropland, grassland and summering pastures |

Table 5-17 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 3D Agricultural Soils.

| NFR 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, T1, 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 (including compost) | NOx | T2 |
| 3Da2c | Other organic fertilisers applied to soils (including compost) | NH3 | T1, T2 |
| 3Da3 | Urine and dung deposited by grazing animals | NOx | L2, T2 |
| 3Da3 | Urine and dung deposited by grazing animals | NH3 | L2, T1, T2 |
| 3De | Cultivated crops | 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, 3Da3 ($NH_3$)), Tier 2 (3Da1, 3De) and Tier 1 (3Da2b, 3Da2c, 3Da3 ($NO_x$)) methods based on the decision tree in Fig. 3.1 in chapter 3D Crop production and agricultural soils of the EMEP/EEA guidebook (EMEP/EEA 2023).

- 3Da1: For the application of nitrogen containing inorganic fertilisers the Tier 2 method and $NH_3$ emission factors according to the EMEP/EEA guidebook (EMEP/EEA 2019) were used. In 3Da1 only the agricultural use of inorganic fertilisers is reported, while private use is reported under 6A3.
- 3Da2a: As described in chapter 5.2.2, emissions from livestock manure management are calculated with livestock specific emission factors multiplied by the number of livestock. Both the emission factors for 3B and 3D are generated from stratified samples considering different farm types, regions, height above sea level and application

techniques (Tier 3). This category also includes emissions from digestate originating from agricultural biogas plants (at least 80 % of the substrate is livestock manure).

- 3Da2b/3Da2c: $NH_3$ and $NO_x$ emissions from field application of sewage sludge and compost (including solid and liquid digestate from non-agricultural sources) derived from organic residues are included in this category (Tier 1 except for $NH_3$ from 3Da2c). For $NH_3$ emissions from 3Da2c, a Tier 2 method based on Kupper et al. (2022) is used. In Switzerland, the application of sewage sludge as fertiliser is prohibited since 2006 (with some exceptions, it was applied in certain cantons until the end of 2008).
- 3Da3: $NH_3$ emission from urine and dung deposited by grazing livestock are determined by multiplying animal specific emission factors (see chapter 5.2.2) with the number of animals. For $NO_x$ emissions, the Tier 1 method and emission factors described in the EMEP/EEA guidebook (EMEP/EEA 2023) were used.
- 3De: 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 are estimated with a Tier 2 approach according to the EMEP/EEA guidebook (EMEP/EEA 2016, unchanged in EMEP/EEA 2023) 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.
- Since the publication of the EMEP/EEA guidebook version 2023, (EMEP/EEA 2023), it is recommended to report the activity “Sewage sludge spreading” within 3D instead of 5E. Sewage sludge spreading as a sludge drying process is not occurring in Switzerland, mostly due to restrictions in available space. In Swiss wastewater treatment plants, sewage sludge, after anaerobic digestion and generation of biogas, is stored in sludge tanks and in a first step, chemical and mechanical means are applied to dehydrate the sludge. Of the dehydrated sewage sludge, 70 – 80 % is incinerated in municipal solid waste incineration plants or in dedicated sewage sludge incineration plants. The remaining 20 – 30 % is used as alternative fuel in the cement industry (1A2f). For this purpose, the water content of the sludge has to be reduced to 10 %, which requires thermal drying processes. The thermal drying predominantly occurs in large thermal drying plants equipped with flue gas treatment systems.

**Emission factors (3Da)**

For fertiliser, default Tier 2 $NH_3$ emission factors from the EMEP/EEA guidebook (EMEP/EEA 2019, 3D Crop production and agricultural soils, Table 3.2) were used for the whole time series. The climate zone for Switzerland is "cool". Based on official fertiliser trade statistics (Agricura 2023) and an assessment of soil pH based on the Swiss agricultural soil use capability map (Frei et al. 1980), 54 % of fertilisers are used on soils with pH > 7.0 and 46 % on soils with pH > 7.0.

$NH_3$-emission factors for 3Da2c are based on Kupper et al. (2022; chp. 7.4.2). The emission factors used were 60 % of TAN for liquid residues and 80 % of TAN for solid residues.

Table 5-18 shows $NH_3$ and $NO_x$ emission factors for nitrogen containing fertiliser, sewage sludge and compost applied to soils. For other synthetic N fertilisers, they are weighted mean factors. 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 5-18 $NH_3$ and $NO_x$ emission factors 2023 for nitrogen containing fertiliser.

| 3Da Direct emissions from managed soils | Unit of activity data | NOx | NH3 |
|---|---|---|---|
| | | g/... | g/... |
| 3Da1 Urea containing fertiliser | kg N | 18 | 159 |
| 3Da1 Other synthetic N-fertiliser | kg N | 18 | 37 |
| 3Da2b Sewage sludge applied to soils | kg N | NO | NO |
| 3Da2c Other organic fertilisers applied to soils | kg N | 18 | 154 |

Emission factors for the application of animal manure are displayed in Table 5-19 and Table 5-20. They are based on the livestock category specific N flow calculations with AGRAMMON (see chapter 5.2.2).

Table 5-19 Time series of $NH_3$ emission factors for the application of animal manure to soils (3Da2a, Buffalos: IE (Dairy cattle)).

| NH3 emission factors | unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3Da2a Dairy cattle | kg/animal | 26.0 | 25.7 | 23.1 | 23.0 | 22.6 |
| 3Da2a Other mature cattle | kg/animal | 13.4 | 12.7 | 11.4 | 12.0 | 12.3 |
| 3Da2a Growing cattle | kg/animal | 6.61 | 6.54 | 5.60 | 5.37 | 5.29 |
| 3Da2a Sheep | kg/animal | 0.225 | 0.228 | 0.191 | 0.204 | 0.250 |
| 3Da2a Swine | kg/animal | 3.26 | 3.09 | 2.00 | 1.58 | 1.44 |
| 3Da2a Goats | kg/animal | 0.444 | 0.440 | 0.334 | 0.497 | 0.408 |
| 3Da2a Horses | kg/animal | 1.76 | 1.76 | 1.57 | 1.52 | 1.47 |
| 3Da2a Mules and asses | kg/animal | 0.648 | 0.648 | 0.621 | 0.611 | 0.651 |
| 3Da2a Laying hens | kg/animal | 0.0594 | 0.0615 | 0.0671 | 0.0746 | 0.0874 |
| 3Da2a Broilers | kg/animal | 0.0634 | 0.0645 | 0.0526 | 0.0544 | 0.0627 |
| 3Da2a Turkey | kg/animal | 0.222 | 0.221 | 0.206 | 0.180 | 0.170 |
| 3Da2a Other poultry: Growers | kg/animal | 0.0230 | 0.0268 | 0.0321 | 0.0322 | 0.0351 |
| 3Da2a Other poultry: Other | kg/animal | 0.0746 | 0.0746 | 0.0700 | 0.0537 | 0.0769 |
| 3Da2a Rabbits | kg/animal | 0.0368 | 0.0368 | 0.0357 | 0.0354 | 0.0353 |
| 3Da2a Bisons | kg/animal | NO | 0.841 | 0.834 | 0.747 | 0.731 |
| 3Da2a Camels and llamas | kg/animal | NO | NO | 0.227 | 0.195 | 0.225 |
| 3Da2a Deer | kg/animal | 0.376 | 0.411 | 0.359 | 0.332 | 0.401 |

| NH3 emission factors | unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3Da2a Dairy cattle | kg/animal | 21.5 | 21.3 | 21.3 | 21.2 | 21.2 | 21.2 | 21.2 | 21.2 | 21.2 | 21.2 |
| 3Da2a Other mature cattle | kg/animal | 11.9 | 11.8 | 11.7 | 11.6 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 |
| 3Da2a Growing cattle | kg/animal | 5.08 | 5.02 | 5.00 | 5.00 | 4.99 | 5.00 | 4.97 | 4.96 | 4.95 | 4.92 |
| 3Da2a Sheep | kg/animal | 0.212 | 0.201 | 0.205 | 0.211 | 0.215 | 0.219 | 0.219 | 0.218 | 0.219 | 0.219 |
| 3Da2a Swine | kg/animal | 1.36 | 1.35 | 1.36 | 1.36 | 1.36 | 1.36 | 1.36 | 1.36 | 1.36 | 1.36 |
| 3Da2a Goats | kg/animal | 0.433 | 0.428 | 0.431 | 0.434 | 0.437 | 0.440 | 0.440 | 0.440 | 0.440 | 0.440 |
| 3Da2a Horses | kg/animal | 1.56 | 1.60 | 1.58 | 1.56 | 1.53 | 1.51 | 1.51 | 1.51 | 1.51 | 1.51 |
| 3Da2a Mules and asses | kg/animal | 0.613 | 0.604 | 0.620 | 0.637 | 0.653 | 0.670 | 0.670 | 0.670 | 0.670 | 0.670 |
| 3Da2a Laying hens | kg/animal | 0.0946 | 0.0964 | 0.0957 | 0.0950 | 0.0943 | 0.0936 | 0.0936 | 0.0936 | 0.0936 | 0.0936 |
| 3Da2a Broilers | kg/animal | 0.0511 | 0.0482 | 0.0485 | 0.0489 | 0.0493 | 0.0496 | 0.0496 | 0.0496 | 0.0496 | 0.0496 |
| 3Da2a Turkey | kg/animal | 0.161 | 0.159 | 0.158 | 0.156 | 0.154 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 |
| 3Da2a Other poultry: Growers | kg/animal | 0.0387 | 0.0396 | 0.0365 | 0.0334 | 0.0303 | 0.0272 | 0.0272 | 0.0272 | 0.0272 | 0.0272 |
| 3Da2a Other poultry: Other | kg/animal | 0.0665 | 0.0639 | 0.0641 | 0.0643 | 0.0644 | 0.0646 | 0.0646 | 0.0646 | 0.0646 | 0.0646 |
| 3Da2a Rabbits | kg/animal | 0.0353 | 0.0353 | 0.0353 | 0.0353 | 0.0352 | 0.0352 | 0.0352 | 0.0352 | 0.0352 | 0.0352 |
| 3Da2a Bisons | kg/animal | 0.707 | 0.704 | 0.707 | 0.700 | 0.922 | 0.904 | 0.899 | 0.894 | 0.894 | 0.892 |
| 3Da2a Camels and llamas | kg/animal | 0.207 | 0.200 | 0.197 | 0.196 | 0.194 | 0.194 | 0.195 | 0.195 | 0.194 | 0.194 |
| 3Da2a Deer | kg/animal | 0.371 | 0.360 | 0.361 | 0.362 | 0.363 | 0.364 | 0.364 | 0.365 | 0.368 | 0.369 |

Table 5-20 Time series of $NO_x$ emission factors for the application of animal manure to soils (3Da2a, Buffalos: IE (Dairy cattle)).

| NOx emission factors | unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3Da2a Dairy cattle | g/animal | 1'443 | 1'427 | 1'322 | 1'305 | 1'347 |
| 3Da2a Other mature cattle | g/animal | 875 | 859 | 761 | 785 | 818 |
| 3Da2a Growing cattle | g/animal | 416 | 414 | 360 | 341 | 347 |
| 3Da2a Sheep | g/animal | 68.3 | 69.3 | 59.9 | 57.0 | 68.4 |
| 3Da2a Swine | g/animal | 200 | 192 | 136 | 110 | 112 |
| 3Da2a Goats | g/animal | 127 | 126 | 112 | 107 | 107 |
| 3Da2a Horses | g/animal | 527 | 526 | 481 | 462 | 460 |
| 3Da2a Mules and asses | g/animal | 194 | 194 | 189 | 178 | 171 |
| 3Da2a Laying hens | g/animal | 7.76 | 7.82 | 7.99 | 8.79 | 9.85 |
| 3Da2a Broilers | g/animal | 5.70 | 5.73 | 5.74 | 6.18 | 6.69 |
| 3Da2a Turkey | g/animal | 19.9 | 19.8 | 19.7 | 19.5 | 20.0 |
| 3Da2a Other poultry: Growers | g/animal | 3.48 | 3.63 | 4.03 | 3.95 | 4.11 |
| 3Da2a Other poultry: Other | g/animal | 7.35 | 7.35 | 7.12 | 7.13 | 7.09 |
| 3Da2a Rabbits | g/animal | 12.7 | 12.7 | 12.7 | 12.7 | 12.7 |
| 3Da2a Bisons | g/animal | NO | 364 | 352 | 321 | 315 |
| 3Da2a Camels and llamas | g/animal | NO | NO | 103 | 87.6 | 99.0 |
| 3Da2a Deer | g/animal | 184 | 201 | 163 | 149 | 176 |

| NOx emission factors | unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3Da2a Dairy cattle | g/animal | 1'356 | 1'359 | 1'357 | 1'355 | 1'353 | 1'351 | 1'351 | 1'351 | 1'351 | 1'351 |
| 3Da2a Other mature cattle | g/animal | 814 | 813 | 810 | 806 | 803 | 799 | 799 | 799 | 799 | 799 |
| 3Da2a Growing cattle | g/animal | 352 | 352 | 350 | 348 | 347 | 346 | 345 | 344 | 343 | 342 |
| 3Da2a Sheep | g/animal | 62.6 | 60.7 | 61.1 | 62.4 | 63.0 | 63.8 | 63.5 | 63.6 | 63.8 | 63.6 |
| 3Da2a Swine | g/animal | 110 | 110 | 111 | 110 | 110 | 111 | 111 | 111 | 111 | 110 |
| 3Da2a Goats | g/animal | 111 | 109 | 107 | 105 | 103 | 101 | 101 | 101 | 101 | 101 |
| 3Da2a Horses | g/animal | 471 | 476 | 473 | 470 | 467 | 464 | 464 | 465 | 464 | 464 |
| 3Da2a Mules and asses | g/animal | 172 | 173 | 174 | 176 | 178 | 179 | 179 | 179 | 179 | 179 |
| 3Da2a Laying hens | g/animal | 10.1 | 10.2 | 10.3 | 10.3 | 10.4 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 |
| 3Da2a Broilers | g/animal | 5.63 | 5.37 | 5.36 | 5.36 | 5.35 | 5.34 | 5.34 | 5.34 | 5.34 | 5.34 |
| 3Da2a Turkey | g/animal | 19.3 | 19.1 | 19.3 | 19.5 | 19.7 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| 3Da2a Other poultry: Growers | g/animal | 4.08 | 4.07 | 4.08 | 4.09 | 4.09 | 4.10 | 4.10 | 4.10 | 4.10 | 4.10 |
| 3Da2a Other poultry: Other | g/animal | 7.03 | 7.01 | 7.05 | 7.08 | 7.11 | 7.14 | 7.14 | 7.14 | 7.14 | 7.14 |
| 3Da2a Rabbits | g/animal | 12.7 | 12.7 | 12.7 | 12.7 | 12.7 | 12.7 | 12.7 | 12.7 | 12.7 | 12.7 |
| 3Da2a Bisons | g/animal | 308 | 307 | 308 | 306 | 403 | 395 | 393 | 390 | 390 | 390 |
| 3Da2a Camels and llamas | g/animal | 92.7 | 89.9 | 89.8 | 90.8 | 91.4 | 92.7 | 93.1 | 92.9 | 92.8 | 92.6 |
| 3Da2a Deer | g/animal | 166 | 162 | 165 | 168 | 171 | 174 | 174 | 174 | 176 | 176 |

In the following, Table 5-21 and Table 5-22 list the emission factors for $NH_3$ and $NO_x$ for N excretion on pasture and paddock during grazing. They are based on the livestock category specific N flow calculations with AGRAMMON (see chapter 5.2.2). The considerable increase between 1990 and 2010 (e.g. dairy cattle, young cattle (calves), sheep, goats, horses) was a consequence of a strong increase of grazing linked to animal welfare incentives.

Table 5-21 Time series of $NH_3$ emission factors for N excretion during grazing (3Da3) for different livestock categories (Buffalos: IE: (Dairy cattle)).

| NH3 emission factors | unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3Da3 Dairy cattle | kg/animal | 0.470 | 0.550 | 0.871 | 1.03 | 1.06 |
| 3Da3 Other mature cattle | kg/animal | 1.39 | 1.39 | 1.63 | 1.48 | 1.38 |
| 3Da3 Growing cattle | kg/animal | 0.288 | 0.292 | 0.442 | 0.466 | 0.449 |
| 3Da3 Sheep | kg/animal | 0.136 | 0.139 | 0.212 | 0.230 | 0.199 |
| 3Da3 Swine | kg/animal | NO | NO | 0.00356 | 0.0100 | 0.00457 |
| 3Da3 Goats | kg/animal | 0.0921 | 0.0914 | 0.166 | 0.188 | 0.192 |
| 3Da3 Horses | kg/animal | 0.338 | 0.337 | 0.543 | 0.630 | 0.635 |
| 3Da3 Mules and asses | kg/animal | 0.124 | 0.124 | 0.146 | 0.198 | 0.224 |
| 3Da3 Laying hens | kg/animal | NO | 0.00213 | 0.0144 | 0.0243 | 0.0281 |
| 3Da3 Broilers | kg/animal | NO | 0.000801 | 0.00121 | 0.00213 | 0.000974 |
| 3Da3 Turkey | kg/animal | NO | 0.00280 | 0.0158 | 0.0171 | 0.0135 |
| 3Da3 Other poultry: Growers | kg/animal | NO | 0.00102 | 0.000952 | 0.00149 | 0.00294 |
| 3Da3 Other poultry: Other | kg/animal | NO | NO | 0.00626 | 0.00462 | 0.00573 |
| 3Da3 Rabbits | kg/animal | NO | NO | NO | NO | NO |
| 3Da3 Bisons | kg/animal | NO | 0.660 | 0.845 | 0.846 | 0.792 |
| 3Da3 Camels and llamas | kg/animal | NO | NO | 0.376 | 0.359 | 0.293 |
| 3Da3 Deer | kg/animal | 0.433 | 0.474 | 0.594 | 0.613 | 0.521 |

| NH3 emission factors | unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3Da3 Dairy cattle | kg/animal | 1.03 | 1.02 | 1.03 | 1.03 | 1.03 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 |
| 3Da3 Other mature cattle | kg/animal | 1.38 | 1.38 | 1.40 | 1.42 | 1.44 | 1.46 | 1.46 | 1.46 | 1.46 | 1.46 |
| 3Da3 Growing cattle | kg/animal | 0.445 | 0.442 | 0.441 | 0.444 | 0.441 | 0.441 | 0.438 | 0.440 | 0.439 | 0.433 |
| 3Da3 Sheep | kg/animal | 0.226 | 0.232 | 0.228 | 0.227 | 0.224 | 0.221 | 0.221 | 0.220 | 0.221 | 0.220 |
| 3Da3 Swine | kg/animal | 0.00207 | 0.00146 | 0.00132 | 0.00117 | 0.00102 | 0.000872 | 0.000870 | 0.000869 | 0.000866 | 0.000860 |
| 3Da3 Goats | kg/animal | 0.199 | 0.196 | 0.205 | 0.215 | 0.224 | 0.233 | 0.233 | 0.233 | 0.233 | 0.233 |
| 3Da3 Horses | kg/animal | 0.590 | 0.575 | 0.587 | 0.599 | 0.610 | 0.624 | 0.623 | 0.622 | 0.623 | 0.624 |
| 3Da3 Mules and asses | kg/animal | 0.217 | 0.215 | 0.209 | 0.203 | 0.196 | 0.190 | 0.190 | 0.190 | 0.190 | 0.190 |
| 3Da3 Laying hens | kg/animal | 0.0286 | 0.0287 | 0.0288 | 0.0288 | 0.0289 | 0.0290 | 0.0290 | 0.0290 | 0.0290 | 0.0290 |
| 3Da3 Broilers | kg/animal | 0.000638 | 0.000554 | 0.000650 | 0.000746 | 0.000843 | 0.000939 | 0.000939 | 0.000939 | 0.000939 | 0.000939 |
| 3Da3 Turkey | kg/animal | 0.0202 | 0.0219 | 0.0219 | 0.0219 | 0.0219 | 0.0219 | 0.0219 | 0.0219 | 0.0219 | 0.0219 |
| 3Da3 Other poultry: Growers | kg/animal | 0.00234 | 0.00220 | 0.00260 | 0.00301 | 0.00341 | 0.00382 | 0.00382 | 0.00382 | 0.00382 | 0.00382 |
| 3Da3 Other poultry: Other | kg/animal | 0.00772 | 0.00821 | 0.00835 | 0.00849 | 0.00863 | 0.00876 | 0.00876 | 0.00876 | 0.00876 | 0.00876 |
| 3Da3 Rabbits | kg/animal | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 3Da3 Bisons | kg/animal | 0.784 | 0.786 | 0.779 | 0.761 | 0.990 | 0.958 | 0.953 | 0.947 | 0.947 | 0.945 |
| 3Da3 Camels and llamas | kg/animal | 0.342 | 0.350 | 0.344 | 0.340 | 0.335 | 0.334 | 0.336 | 0.334 | 0.334 | 0.333 |
| 3Da3 Deer | kg/animal | 0.613 | 0.632 | 0.631 | 0.629 | 0.628 | 0.626 | 0.626 | 0.627 | 0.632 | 0.634 |

Table 5-22 Time series of $NO_x$ emission factors for N excretion during grazing (3Da3) for different livestock categories (Buffalos: IE (Dairy cattle)).

| NOx emission factors | unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3Da3 Dairy cattle | g/animal | 150 | 176 | 280 | 333 | 342 |
| 3Da3 Other mature cattle | g/animal | 455 | 455 | 532 | 482 | 451 |
| 3Da3 Growing cattle | g/animal | 93.9 | 95.1 | 144 | 152 | 146 |
| 3Da3 Sheep | g/animal | 40.6 | 41.5 | 63.0 | 68.6 | 59.3 |
| 3Da3 Swine | g/animal | NO | NO | 0.379 | 1.07 | 0.486 |
| 3Da3 Goats | g/animal | 27.4 | 27.2 | 49.4 | 56.0 | 57.0 |
| 3Da3 Horses | g/animal | 101 | 100 | 162 | 187 | 189 |
| 3Da3 Mules and asses | g/animal | 37.0 | 37.0 | 43.5 | 58.9 | 66.8 |
| 3Da3 Laying hens | g/animal | NO | 0.0756 | 0.509 | 0.862 | 0.997 |
| 3Da3 Broilers | g/animal | NO | 0.0284 | 0.0429 | 0.0756 | 0.0345 |
| 3Da3 Turkey | g/animal | NO | 0.0994 | 0.562 | 0.607 | 0.479 |
| 3Da3 Other poultry: Growers | g/animal | NO | 0.0362 | 0.0337 | 0.0529 | 0.104 |
| 3Da3 Other poultry: Other | g/animal | NO | NO | 0.222 | 0.164 | 0.203 |
| 3Da3 Rabbits | g/animal | NO | NO | NO | NO | NO |
| 3Da3 Bisons | g/animal | NO | 173 | 251 | 252 | 235 |
| 3Da3 Camels and llamas | g/animal | NO | NO | 110 | 109 | 88.1 |
| 3Da3 Deer | g/animal | 109 | 120 | 175 | 185 | 157 |

| NOx emission factors | unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3Da3 Dairy cattle | g/animal | 333 | 331 | 333 | 334 | 335 | 337 | 337 | 337 | 337 | 337 |
| 3Da3 Other mature cattle | g/animal | 449 | 449 | 456 | 462 | 469 | 476 | 476 | 476 | 476 | 476 |
| 3Da3 Growing cattle | g/animal | 145 | 144 | 144 | 145 | 144 | 144 | 143 | 144 | 143 | 141 |
| 3Da3 Sheep | g/animal | 67.4 | 68.9 | 67.9 | 67.6 | 66.5 | 65.7 | 65.7 | 65.6 | 65.7 | 65.6 |
| 3Da3 Swine | g/animal | 0.220 | 0.155 | 0.141 | 0.125 | 0.108 | 0.0927 | 0.0924 | 0.0924 | 0.0920 | 0.0914 |
| 3Da3 Goats | g/animal | 59.3 | 58.3 | 61.1 | 63.9 | 66.6 | 69.4 | 69.4 | 69.5 | 69.4 | 69.4 |
| 3Da3 Horses | g/animal | 176 | 171 | 175 | 178 | 182 | 186 | 185 | 185 | 185 | 186 |
| 3Da3 Mules and asses | g/animal | 64.5 | 63.9 | 62.1 | 60.3 | 58.5 | 56.7 | 56.7 | 56.7 | 56.7 | 56.7 |
| 3Da3 Laying hens | g/animal | 1.01 | 1.02 | 1.02 | 1.02 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 |
| 3Da3 Broilers | g/animal | 0.0226 | 0.0196 | 0.0230 | 0.0264 | 0.0299 | 0.0333 | 0.0333 | 0.0333 | 0.0333 | 0.0333 |
| 3Da3 Turkey | g/animal | 0.717 | 0.776 | 0.776 | 0.776 | 0.776 | 0.776 | 0.776 | 0.776 | 0.776 | 0.776 |
| 3Da3 Other poultry: Growers | g/animal | 0.0831 | 0.0778 | 0.0922 | 0.106 | 0.121 | 0.135 | 0.135 | 0.135 | 0.135 | 0.135 |
| 3Da3 Other poultry: Other | g/animal | 0.273 | 0.291 | 0.296 | 0.301 | 0.306 | 0.311 | 0.311 | 0.311 | 0.311 | 0.311 |
| 3Da3 Rabbits | g/animal | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 3Da3 Bisons | g/animal | 230 | 230 | 228 | 223 | 290 | 281 | 279 | 277 | 278 | 277 |
| 3Da3 Camels and llamas | g/animal | 102 | 104 | 102 | 100 | 98.4 | 97.4 | 98.2 | 97.8 | 97.5 | 97.3 |
| 3Da3 Deer | g/animal | 182 | 188 | 187 | 186 | 184 | 183 | 183 | 183 | 185 | 185 |

### Emission factors (3De)

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 3-4 of the EMEP/EEA guidebook (EMEP/EEA 2023) taking into account country-specific values for the mean dry matter yield (Richner and Sinaj 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 (Richner and Sinaj 2017). The resulting NMVOC emission factors are constant for the entire time series and are given in Table 5-23.

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 (EMEP/EEA 2023, chp. 3D, Tables 3-6 and 3-8). 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 literature values are available (Richner and Sinaj 2017) for five different altitude classes. 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 (aggregated) emission factors result for grassland.

Unfortunately, the guidebook provides emission factors for PM10 and PM2.5 only. A couple of European countries assume for TSP the same values as of PM10. 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 estimated 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 5-23.

Table 5-23 NMVOC and PM2.5 emission factors of 2023 for 3De Crop production and agricultural soils.

| 3De Cultivated crops | Unit of activity data | NMVOC | PM2.5 nx | PM10 nx | TSP nx |
|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... |
| 3De Cropland | ha cropland | 376 | 40 | 752 | 7'520 |
| 3De Grassland | ha grassland | 397 | 47 | 1'100 | 11'000 |
| 3De Summering pastures | ha summering pastures | 141 | NA | NA | NA |

### Activity data (3Da)

The nitrogen amount applied with urea-containing and other synthetic fertilisers (SBV 2024, Agricura 2023, 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 5-24.

Activity data for emissions from N excretion resulting from the application of animal manure to soils (3Da2a) and from grazing (3Da3) are the livestock numbers for source category 3B. Manure management which are given in Table 5-15. 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 non agricultural biogas plants are based on a study from the year 2017 (Schleiss 2017, covering the period from

1990 to 2015 and subsequent annual update) and on data from the statistics of renewable energies (SFOE 2024a), 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 5-24 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).

| 3Da Direct emissions from managed soils | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3Da1 Urea containing fertiliser | t N | 16'286 | 10'708 | 7'632 | 6'606 | 7'102 |
| 3Da1 Other synthetic N-fertiliser | t N | 50'398 | 47'659 | 43'048 | 43'485 | 45'991 |
| 3Da2b Sewage sludge applied to soils | t N | 4'815 | 4'942 | 3'356 | 1'054 | NO |
| 3Da2c Other organic fertilisers applied to soils | t N | 817 | 1'286 | 1'829 | 2'169 | 3'281 |

| 3Da Direct emissions from managed soils | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3Da1 Urea containing fertiliser | t N | 7'943 | 7'224 | 8'873 | 9'251 | 8'325 | 7'754 | 7'398 | 8'101 | 6'913 | 8'180 |
| 3Da1 Other synthetic N-fertiliser | t N | 41'399 | 36'527 | 37'537 | 40'119 | 37'439 | 32'406 | 33'700 | 37'270 | 31'523 | 25'526 |
| 3Da2b Sewage sludge applied to soils | t N | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 3Da2c Other organic fertilisers applied to soils | t N | 4'709 | 4'908 | 5'435 | 5'542 | 5'669 | 6'211 | 6'357 | 6'548 | 6'394 | 6'766 |

Table 5-25 Time series of agricultural areas (in ha; cropland, grassland, summering pastures).

| 3De Cultivated crops | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 3De Cropland | ha cropland | 312'398 | 307'754 | 289'939 | 283'003 | 269'390 |
| 3De Grassland | ha grassland | 724'556 | 735'408 | 743'756 | 742'379 | 741'775 |
| 3De Summering pastures | ha summering pastures | 538'683 | 499'781 | 497'322 | 489'245 | 486'988 |

| 3De Cultivated crops | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3De Cropland | ha cropland | 267'809 | 268'449 | 267'702 | 268'563 | 269'701 | 265'917 | 267'854 | 270'043 | 269'671 | 267'971 |
| 3De Grassland | ha grassland | 740'002 | 737'403 | 736'429 | 732'101 | 729'044 | 731'265 | 728'787 | 729'460 | 724'886 | 725'443 |
| 3De Summering pastures | ha summering pastures | 475'069 | 473'650 | 471'239 | 471'252 | 469'334 | 467'640 | 464'386 | 463'443 | 460'545 | 457'574 |

**Activity data (3De)**

As activity data of source category 3De 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 (FSO 2024i). In addition, for NMVOC emissions also the emissions from summering pastures (FSO 2024b) are included where no agricultural crop operations take place. The activity data of these agricultural areas are also given in Table 5-25. While cropland and grassland are part of the agricultural farms (farmland), summering pastures are alpine land (usually at an altitude of more than 1000-2500 m) which is grazed for around 100 days per year by dairy cows (for mountain cheese production), heifers, sheep and goats.

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

The following recalculations were implemented in submission 2025.

- 3Da: Allocation of manure to the different management systems (MS) was revised for "other roughage eaters" (Bisons, Camelids, Deer, Rabbits) based on Kupper et al. 2022 yielding changes in the $NO_x$ emission factors of source categories 3Da2a4h Animal manure applied to soils - Other animals and 3Da34h Urine and dung deposited by grazing animals - Other animals for the entire time series (1990-2022).
- 3Da: The activity data and emission factors ($NO_x$ and $NH_3$) of 3Da2a3 Animal manure applied to soils - Swine and 3Da33 Urine and dung deposited by grazing animals - Swine were recalculated for the years 2021 and 2022 due to updated data for fattening pigs >25 kg from FSO 2024b.
- 3Da: The activity data of 3Da2a4 Animal manure applied to soils - Broilers and 3Da34 Urine and dung deposited by grazing animals - Broilers were recalculated for the years 2021 and 2022 due to updated data from FSO 2024b.

- 3Da1: The amount of synthetic fertilisers applied in Liechtenstein was updated for the years 1990-2022 yielding revised activity data of source categories 3Da1 Inorganic N-fertilisers (including urea) for the entire time series.
- 3Da2a1: Updated data on the amount of manure digested anaerobically (SFOE 2024b, particularly in the years 1990-1999) led to minimal changes in the $NO_x$ emission factors for manure management and application for all cattle categories (3B1, 3Da2a1, 3Da31).
- 3Da2c: The amount of nitrogen inputs from compost and digestates was updated for the years 1996-2022 due to new activity data from SFOE 2024a. This resulted in revised activity data and $NH_3$ emission factors of source category 3Da2c Other organic fertilisers applied to soils.
- 3Da31: Updated data on the amount of manure digested anaerobically (SFOE 2024b, particularly in the years 1990-1999) led to minimal changes in the $NO_x$ emission factors for manure management and application for all cattle categories (3B1, 3Da2a1, 3Da31).
- 3De: The activity data of source category 3De Summering pastures were updated based on revised data from FSO 2024b for the entire time series.

## 5.4 Source category 3F – Field burning of agricultural residuals

Burning of crop residues in fields is prohibited in Switzerland. Only the burning of branches and twigs is allowed under certain conditions. These emissions are reported in source category 5C2 Open burning of agricultural waste.

# 6 Waste

## 6.1 Overview of emissions

In this introductory chapter, an overview of emissions, separated according to the most relevant pollutants, is presented. Trends and changes for individual source categories in the period between 1990 and 2023 are analysed and discussed. In absolute figures, processes in sector 5 Waste emit mainly NMVOC and $NH_3$. The contributions of PM2.5, heavy metals (Pb and Hg) and PCDD/F are smaller in absolute terms, but larger relative to total national emissions.

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 EMEP/EEA guidebook (EMEP/EEA 2023) **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 increasing trend of total NMVOC emissions from 2006 to 2021 can be observed. This is mainly explained by the continuous positive trend for category 5B Biological treatment of waste - Composting and anaerobic digestion, which is a key category according to the trend assessment. The contribution of the waste sector still remains small in comparison to the national total. Therefore, there are no source categories from the waste sector that are key categories for NMVOC according to the level assessment.

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 originate from 5B Biological treatment of solid waste. The reason for this development is the increase in industrial and commercial composting activities, particularly the digestion of organic waste. The latter has become economically more beneficial due to cost covering feed-in tariffs for electricity and due to additional revenues as $CO_2$ compensation projects. The increase in digested quantities is also linked to population growth. 5A Solid waste disposal shows a decreasing trend.

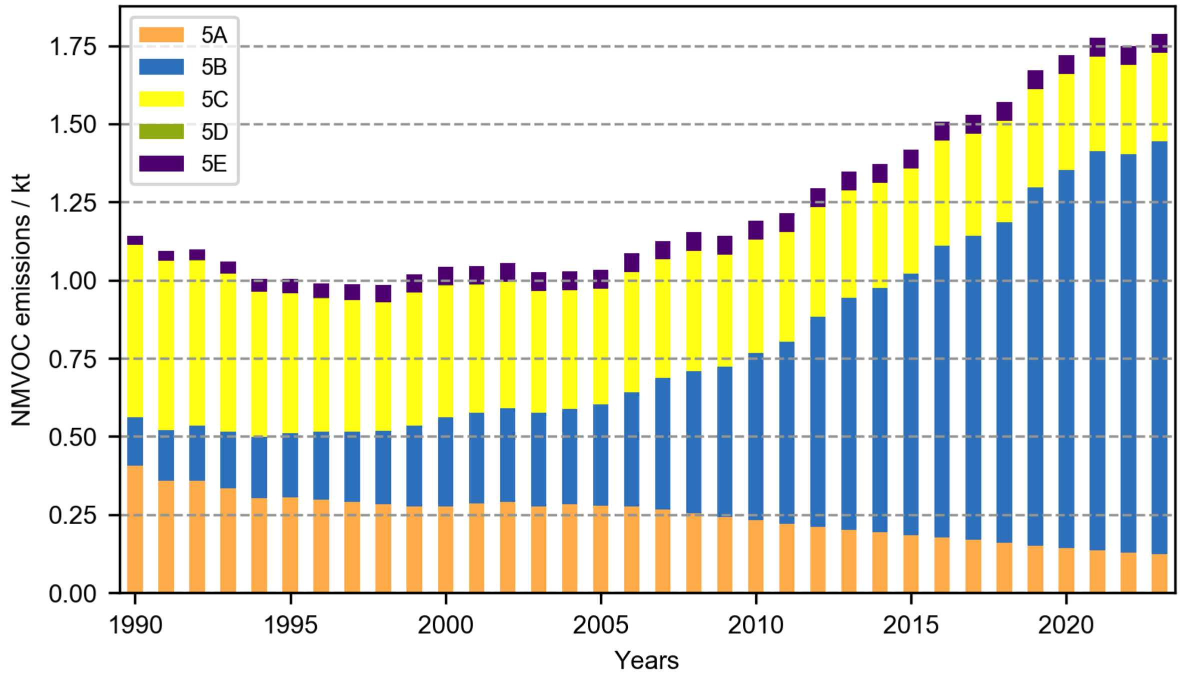



Figure 6-1 Switzerland's NMVOC emissions from the waste sector by source categories 5A-5E. The corresponding data can be found in Table 6-1.

Table 6-1 NMVOC emissions from sector 5 Waste by source categories 5A-5E. The last column in the third part of the table indicates the relative trend.

| NMVOC | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 5A | kt | 0.41 | 0.30 | 0.28 | 0.28 | 0.23 |
| 5B | kt | 0.15 | 0.21 | 0.28 | 0.32 | 0.54 |
| 5C | kt | 0.55 | 0.45 | 0.42 | 0.37 | 0.36 |
| 5D | kt | 0.00052 | 0.00041 | 0.00026 | 0.00011 | 0.000100 |
| 5E | kt | 0.028 | 0.045 | 0.060 | 0.060 | 0.060 |
| Sum | kt | 1.1 | 1.0 | 1.0 | 1.0 | 1.2 |

| NMVOC | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 5A | kt | 0.19 | 0.19 | 0.18 | 0.17 | 0.16 |
| 5B | kt | 0.78 | 0.83 | 0.93 | 0.97 | 1.0 |
| 5C | kt | 0.34 | 0.34 | 0.34 | 0.33 | 0.32 |
| 5D | kt | 0.00012 | 0.00011 | 0.00012 | 0.00012 | 0.00012 |
| 5E | kt | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 |
| Sum | kt | 1.4 | 1.4 | 1.5 | 1.5 | 1.6 |

| NMVOC | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 5A | kt | 0.15 | 0.14 | 0.14 | 0.13 | 0.12 | -56 |
| 5B | kt | 1.1 | 1.2 | 1.3 | 1.3 | 1.3 | 309 |
| 5C | kt | 0.31 | 0.31 | 0.30 | 0.29 | 0.28 | -24 |
| 5D | kt | 0.00012 | 0.00012 | 0.00012 | 0.00013 | 0.00012 | 16 |
| 5E | kt | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 | 0.000000 |
| Sum | kt | 1.7 | 1.7 | 1.8 | 1.7 | 1.8 | 73 |

### 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 is significantly contributing to total PM2.5 emissions from the waste sector over the entire reporting period and thus is key category.

Between 1990 and 2023 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 due to emission reductions from sewage sludge incineration, refurbishment of crematoriums, the cessation of burning cable insulation in 1995 as well as clinical waste incineration in 2002 as well as due to an overall decreasing trend in the open burning of natural residues in agriculture and households.

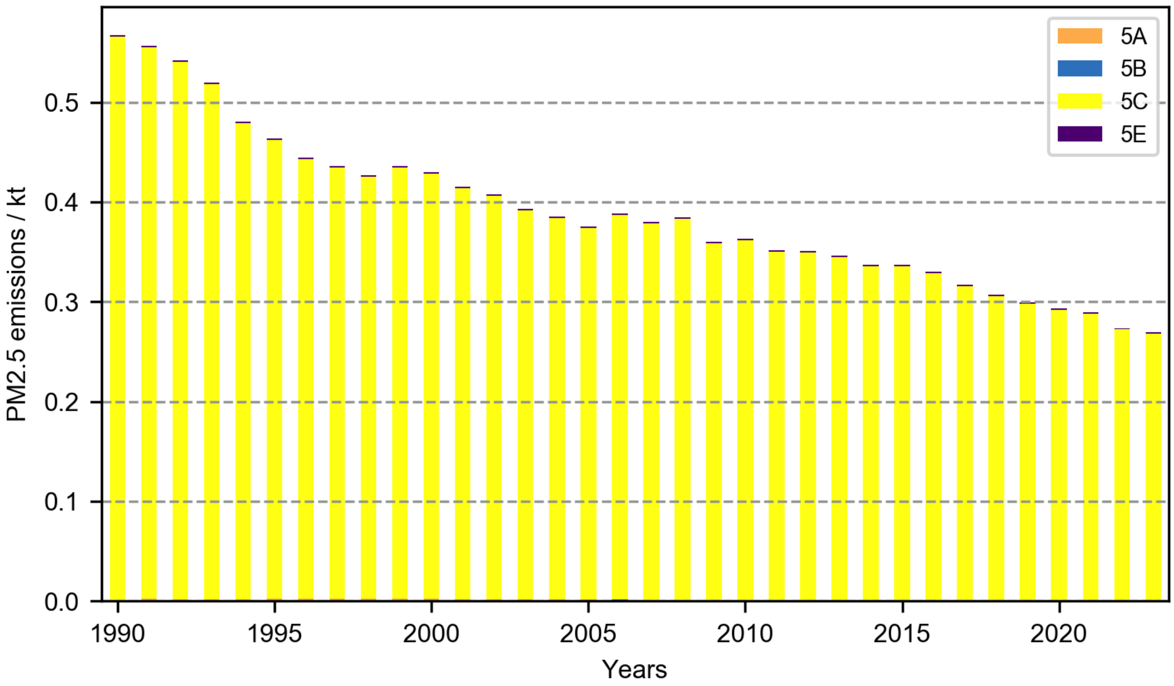



Figure 6-2 Switzerland's PM2.5 emissions from the waste sector by source categories 5 A-5C and 5E. Note that PM2.5 emissions from 5D are not occurring. The corresponding data can be found in Table 6-2.

Table 6-2 PM2.5 emissions from sector 5 Waste by source categories 5A-5C and 5E. The last column in the third part of the table indicates the relative trend.

| PM2.5 | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 5A | kt | 0.00073 | 0.0021 | 0.0022 | 0.0014 | 0.00097 |
| 5B | kt | NA | 0.000001 | 0.000004 | 0.000007 | 0.000023 |
| 5C | kt | 0.57 | 0.46 | 0.43 | 0.37 | 0.36 |
| 5D | kt | NA | NA | NA | NA | NA |
| 5E | kt | 0.0014 | 0.0015 | 0.0015 | 0.0015 | 0.0015 |
| Sum | kt | 0.57 | 0.46 | 0.43 | 0.38 | 0.36 |

| PM2.5 | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 5A | kt | 0.00054 | 0.00055 | 0.00055 | 0.00055 | 0.00055 |
| 5B | kt | 0.000041 | 0.000044 | 0.000047 | 0.000049 | 0.000051 |
| 5C | kt | 0.33 | 0.33 | 0.33 | 0.31 | 0.31 |
| 5D | kt | NA | NA | NA | NA | NA |
| 5E | kt | 0.0015 | 0.0015 | 0.0015 | 0.0015 | 0.0015 |
| Sum | kt | 0.34 | 0.34 | 0.33 | 0.32 | 0.31 |

| PM2.5 | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 5A | kt | 0.00054 | 0.00054 | 0.00053 | 0.00051 | 0.00050 | -63 |
| 5B | kt | 0.000053 | 0.000054 | 0.000054 | 0.000054 | 0.000065 | 872 |
| 5C | kt | 0.30 | 0.29 | 0.29 | 0.27 | 0.27 | -28 |
| 5D | kt | NA | NA | NA | NA | NA | - |
| 5E | kt | 0.0015 | 0.0015 | 0.0015 | 0.0015 | 0.0015 | 0.000000 |
| Sum | kt | 0.30 | 0.29 | 0.29 | 0.27 | 0.27 | -28 |

## 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 includes all emissions from solid waste handling 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 2024a). The landfill gas is generally used in combined heat and power plants for the production of electricity and heat (reported under 1A Fuel combustion). A fraction of landfill gas is used to generate heat only. A very small fraction of the landfill gas is flared (reported under 5A).

Methane emissions are estimated by using a First Order Decay (FOD) model compliant with the 2006 IPCC Guidelines (IPCC 2006; see below). Following legal requirements and regulations it is assumed that open burning ceased after 1990 (Consaba 2016).

Table 6-3 Specification of source category 5A Biological treatment of waste - Solid waste disposal on land.

| 5A | Source category | Specification |
|---|---|---|
| 5A | Solid waste disposal on land | Emissions from handling of solid waste on landfill sites |

Table 6-4 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 5A Biological treatment of waste - Solid waste disposal on land.

| |
|---|
| 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. See decision tree in chapter 5A Biological treatment of waste – Solid waste disposal on land of the EMEP/EEA guidebook (EMEP/EEA 2023).

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 2024):

1. $CH_4$ emissions are modelled with the FOD model according to the 2006 IPCC Guidelines (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.

The PCB emissions from landfills are modelled within the disposal category of the dynamic mass flow model developed for the usage of PCBs in Switzerland (Glüge et al. 2017), see Annex A2.2.

### Emission factors (5A)

Emission factors are country-specific based on measurements and expert estimates, documented in EMIS (EMIS 2025/1A1a & 5A), see Table 6-5. The PCB emission factor expressed in units per tonnes of PCBs stored in landfills is based on the dynamic mass flow model for the usage of PCBs in Switzerland, see Annex A2.2. 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 6-5 Emission factors 2023 for 5A Biological treatment of waste - Solid waste disposal on land.

| 5A Solid waste disposal on land | Unit of activity data | NOx | NMVOC | NH3 | PM2.5 ex | PM10 ex | TSP ex | CO | PCB |
|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | mg/... |
| Landfill: flaring | t CH4 | 1’000 | 82 | NA | 400 | 400 | 400 | 17’000 | NA |
| Landfill: direct emissions | t CH4 | NA | 13’171 | 20’000 | NA | NA | NA | NA | NA |
| Landfill: PCB quantity available in waste | g PCB | NA | NA | NA | NA | NA | NA | NA | 0.010 |

### **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 2025/1A1a & 5A. Table 6-6 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.

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 6-6). The quantity of $CH_4$ flared on Swiss landfill sites was assessed in 2015 and is documented in a separate report (Consaba 2016). For PCB emissions, the activity data is the amount of PCBs stored in landfills based on the dynamic mass flow model for the usage of PCBs in Switzerland, see Annex A2.2.

Table 6-6 Activity data of 5A Biological treatment of waste - Solid waste disposal on land.

| 5A Solid waste disposal on land | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Waste quantity: total | kt waste | 860 | 628 | 350 | 16 | NO |
| Waste quantity: from municipal solid waste | kt waste | 650 | 540 | 292 | 14 | NO |
| Waste quantity: from construction | kt waste | 150 | 60 | 54 | 1.4 | NO |
| Waste quantity: from sewage sludge (dry) | kt waste | 60 | 28 | 4.2 | 0.98 | NO |
| Landfill: flaring | kt CH4 | 1.8 | 5.3 | 5.6 | 3.4 | 2.4 |
| Landfill: direct emissions | kt CH4 | 31 | 23 | 21 | 21 | 18 |
| Landfill: PCB quantity available in waste | t PCB | 395 | 374 | 353 | 333 | 319 |
| Landfill memo item: CH4 recovery | kt CH4 | -4.9 | -12 | -11 | -4.1 | -0.97 |

| 5A Solid waste disposal on land | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Waste quantity: total | kt waste | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Waste quantity: from municipal solid waste | kt waste | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Waste quantity: from construction | kt waste | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Waste quantity: from sewage sludge (dry) | kt waste | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Landfill: flaring | kt CH4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.3 | 1.3 | 1.2 |
| Landfill: direct emissions | kt CH4 | 15 | 14 | 13 | 13 | 12 | 11 | 11 | 10 | 9.8 | 9.3 |
| Landfill: PCB quantity available in waste | t PCB | 311 | 309 | 307 | 305 | 304 | 302 | 300 | 299 | 297 | 295 |
| Landfill memo item: CH4 recovery | kt CH4 | -0.62 | -0.42 | -0.25 | -0.13 | -0.12 | -0.17 | -0.078 | -0.078 | -0.100 | -0.087 |

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 implemented in submission 2025.

## 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 using biogas from digestion are reported under 1A2gviii Other and 1A4a Commercial/Institutional.

5B1 Composting distinguishes between industrial composting and backyard composting. Industrial composting covers 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 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 2025/5B1 Kompostierung has been revised accordingly.

Within 5B2 Anaerobic digestion at biogas facilities two plant types are distinguished: (1) industrial biogas plants and (2) 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 or upgraded and used as fuel for cars or fed into the natural gas grid.

Table 6-7 Specification of source category 5B Biological treatment of waste - Composting and anaerobic digestion at biogas facilities.

| 5B | Source category | Specification |
|---|---|---|
| 5B1 | Composting | Emissions from composting activities |
| 5B2 | Anaerobic digestion at biogas facilities | Emissions from digesting of organic waste at biogas facilities |

Table 6-8 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 5B Biological treatment of waste – Composting and anaerobic digestion at biogas facilities

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 5B2 | Biological treatment of waste - Anaerobic digestion at biogas facilities | NMVOC | T1 |

## 6.3.2 Methodological issues of 5B Biological treatment of waste - Composting and anaerobic digestion at biogas facilities

### Methodology (5B)

A Tier 2 method is applied to estimate emissions from 5B1 Composting (see decision tree in chapter 5B1 Biological treatment of waste – Composting of the EMEP/EEA guidebook (EMEP/EEA 2023).

Emissions from 5B2 Anaerobic digestion are estimated by applying a Tier 2 method (see decision tree in chapter 5B2 Biological treatment of waste – Anaerobic digestion at biogas facilities of the EMEP/EEA guidebook (EMEP/EEA 2023).

Figure 6-3 depicts a schematic design of an industrial biogas plant. Six emission-relevant process steps are taken into account. 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 combined heat and power generation units
- P6: Emissions from flaring of biogas

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

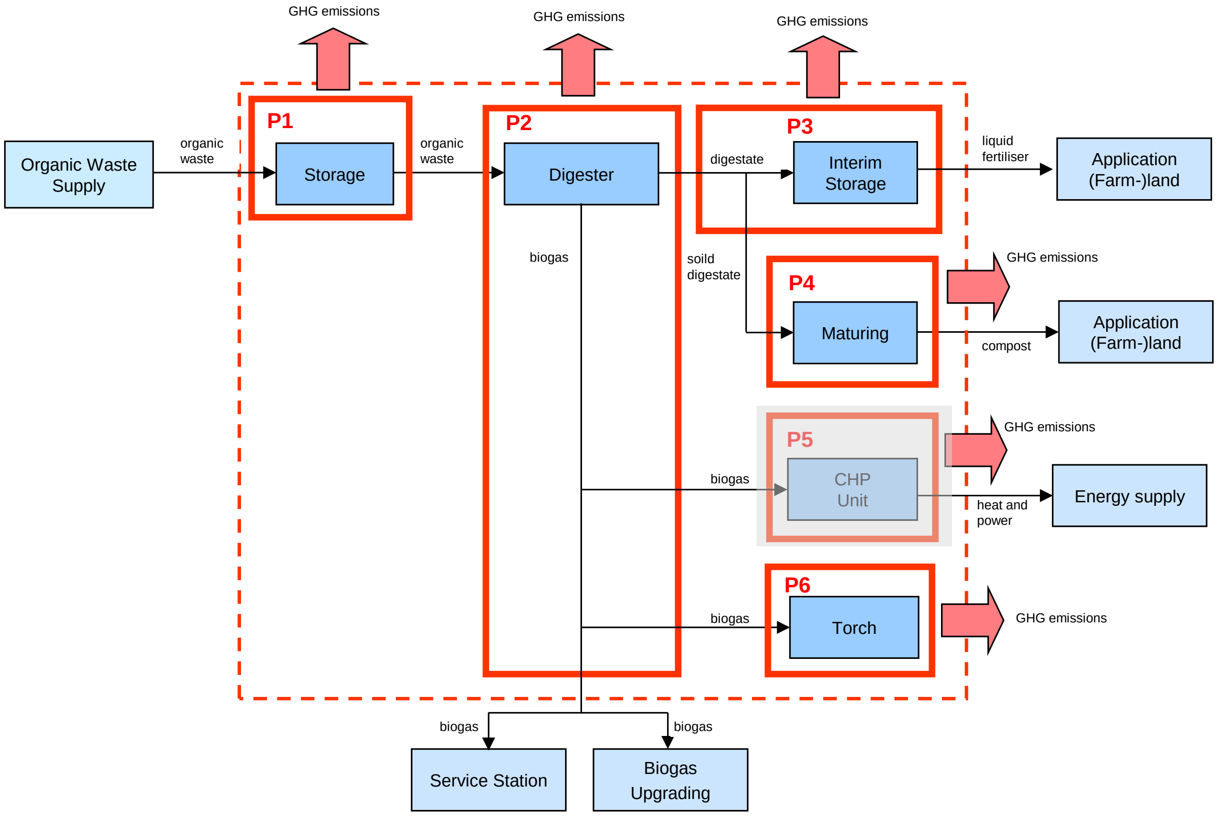



Figure 6-3 Schematic design of an industrial biogas plant.

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 combined heat and power generation 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.

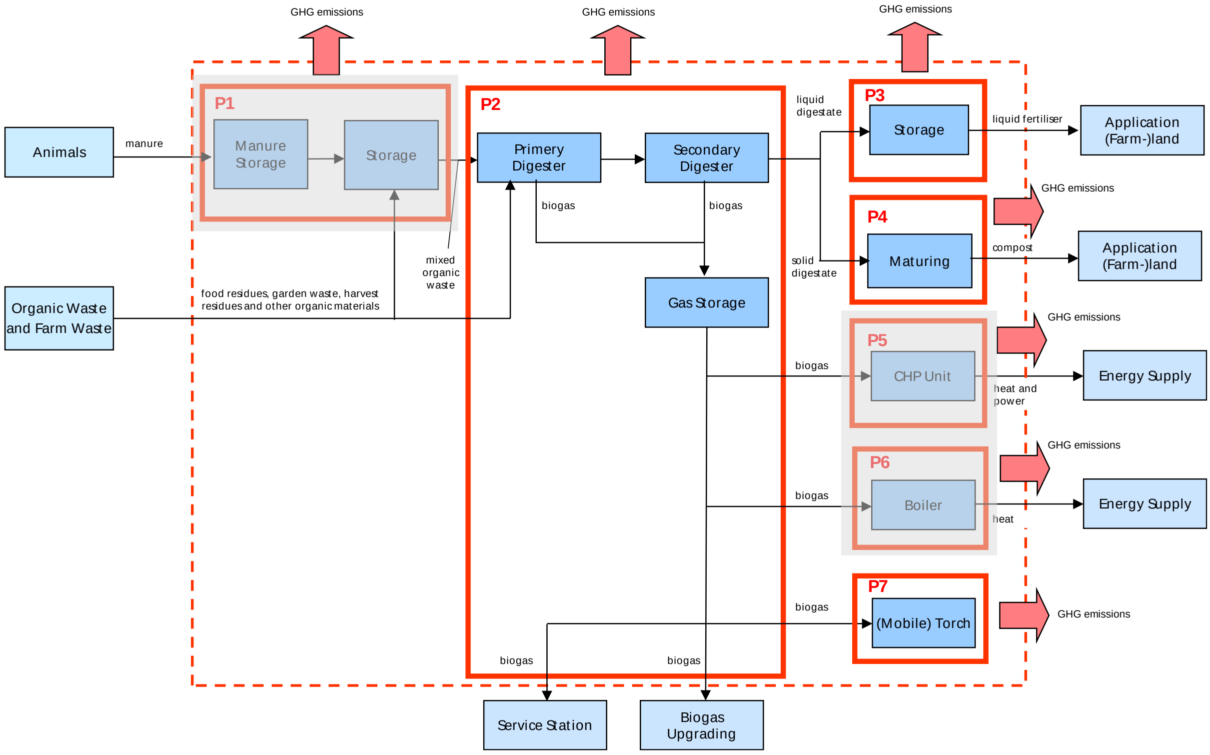



Figure 6-4 Schematic design of an agricultural biogas plant.

## Emission factors (5B)

Emission factors for 5B1 Composting are country-specific based on measurements and expert estimates (EMIS 2025/5B1 Kompostierung). Emission factors are assumed to remain constant over the reporting period.

Emission factors for 5B2 Anaerobic digestion are country-specific based on measurements according to Edelmann and Schleiss (1999), Butz (2003) and Cuhls et al. (2010) as documented in comments to the database (EMIS 2025/1A2g and 5B2 Vergärung IG and EMIS 2025/1A4a and 5B2 Vergärung LW). Table 6-9 presents the emission factors used in 5B.

Table 6-9 Emission factors of 5B Biological treatment of waste - Composting and anaerobic digestion at biogas facilities in 2023.

| 5B Biological treatment of solid waste | Unit of activity data | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Composting: industrial | t composted waste (dry) | NA | 750 | NA | 1'250 | NA | NA | NA | NA | NA |
| Composting: backyard | t composted waste (dry) | NA | 750 | NA | 1'250 | NA | NA | NA | NA | NA |
| Digestion ind.: digestable waste / storage | t digestable waste (wet) | NA | 70 | NA | 5.6 | NA | NA | NA | NA | NA |
| Digestion ind.: digested waste liquid / storage | t digested waste liquid (wet) | NA | 400 | NA | 80 | NA | NA | NA | NA | NA |
| Digestion ind.: digested waste solid / rotting | t digested waste solid (wet) | NA | 230 | NA | 104 | NA | NA | NA | NA | NA |
| Digestion ind.: CH4 flaring | t CH4 | 4'066 | 82 | 616 | NA | 37 | 37 | 37 | 0.91 | 2'054 |
| Digestion agri.: digested waste liquid / process water | t digested waste liquid (wet) | NA | 400 | NA | 80 | NA | NA | NA | NA | NA |
| Digestion agri.: digested waste solid / rotting | t digested waste solid (wet) | NA | 230 | NA | 104 | NA | NA | NA | NA | NA |
| Digestion agri.: CH4 flaring | t CH4 | 4'066 | 82 | 616 | NA | 37 | 37 | 37 | 0.91 | 2'054 |

### Activity data (5B)

Activity data for 5B Biological treatment of waste are extracted from EMIS 2025/5B1 Kompostierung, EMIS 2025/1A1a and 5B2 Vergärung IG and EMIS 2025/1A1a and 5B2 Vergärung LW. Activity data for digestion are based on reliable statistical data from the statistics of renewable energies (SFOE 2024a). Activity data for industrial and backyard composting are based on a study by Schleiss (2017) using data of the years 1989, 1993, 2000 and 2013, supplied by plant operators. From 2014 onwards, activity data for industrial composting are adopted from the annual statistical reports by the inspectorate system for the Composting and Fermentation Industry in Switzerland CVIS as recommended by Schleiss (2017). As of 2012, activity data for backyard composting are assumed to be constant as recommended by Schleiss (2017). Data on the amount of waste is provided in tonnes of wet matter. In order to comply with UNFCCC reporting guidelines, a factor 0.40 (Baier 2023) is applied for the conversion of wet substance to dry substance.

There is a continuous increase of organic material composted until the year 2000 and afterwards a strong increase of organic material digested.

Table 6-10 Activity data of 5B Biological treatment of waste.

| 5B Biological treatment of solid waste | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Composting: industrial | kt composted waste (dry) | 96 | 144 | 208 | 210 | 212 |
| Composting: backyard | kt composted waste (dry) | 44 | 62 | 72 | 68 | 48 |
| Digestion ind.: digestable waste / storage | kt digestable waste (wet) | NO | 27 | 60 | 108 | 289 |
| Digestion ind.: digested waste liquid / storage | kt digested waste liquid (wet) | NO | 15 | 33 | 60 | 161 |
| Digestion ind.: digested waste solid / rotting | kt digested waste solid (wet) | NO | 9.4 | 20 | 37 | 99 |
| Digestion ind.: CH4 flaring | kt CH4 | NO | 0.037 | 0.10 | 0.18 | 0.51 |
| Digestion agri.: digested waste liquid / process water | kt digested waste liquid (wet) | 120 | 100 | 125 | 181 | 569 |
| Digestion agri.: digested waste solid / rotting | kt digested waste solid (wet) | 6.3 | 5.2 | 6.5 | 9.5 | 30 |
| Digestion agri.: CH4 flaring | kt CH4 | NO | NO | NO | NO | 0.12 |

| 5B Biological treatment of solid waste | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Composting: industrial | kt composted waste (dry) | 191 | 172 | 201 | 196 | 190 | 218 | 209 | 219 | 194 | 194 |
| Composting: backyard | kt composted waste (dry) | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Digestion ind.: digestable waste / storage | kt digestable waste (wet) | 590 | 650 | 695 | 712 | 729 | 770 | 792 | 792 | 794 | 866 |
| Digestion ind.: digested waste liquid / storage | kt digested waste liquid (wet) | 329 | 362 | 387 | 397 | 406 | 429 | 441 | 441 | 442 | 482 |
| Digestion ind.: digested waste solid / rotting | kt digested waste solid (wet) | 201 | 222 | 237 | 243 | 249 | 263 | 270 | 270 | 271 | 296 |
| Digestion ind.: CH4 flaring | kt CH4 | 0.90 | 0.95 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.3 |
| Digestion agri.: digested waste liquid / process water | kt digested waste liquid (wet) | 940 | 1'053 | 1'201 | 1'290 | 1'416 | 1'619 | 1'767 | 1'914 | 1'949 | 2'002 |
| Digestion agri.: digested waste solid / rotting | kt digested waste solid (wet) | 50 | 55 | 63 | 68 | 75 | 85 | 93 | 101 | 103 | 105 |
| Digestion agri.: CH4 flaring | kt CH4 | 0.23 | 0.26 | 0.29 | 0.31 | 0.34 | 0.40 | 0.43 | 0.47 | 0.48 | 0.49 |

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

The following recalculations were implemented in submission 2025.

- 5B2: The activity data for 5B2 Anaerobic digestion at biogas facilities have been updated due to an update in the underlying statistics (Swiss statistics of renewable energies). This affects all years from 1994 until 2022.

# 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. Since 1991, the incineration of waste has only been legally permitted in appropriate plants with a rated thermal input of at least 350 kW (Ordinance on Air Pollution Control (Swiss Confederation 1985)). Consequently, the open burning of waste has been prohibited. 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 2006 IPCC Guidelines 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 6-11.

Table 6-11 Specification of source category 5C Waste incineration and open burning of waste, and indication of source categories where other waste incineration activities are reported in the national inventory.

| 5C | Source category | Specification |
|---|---|---|
| 5C1a | Municipal waste incineration | Emissions from illegal incineration of municipal solid wastes at home; emissions from waste incineration at construction sites (open burning)<br>Reported under 1A1a Public electricity and heat production: Emissions from waste incineration in municipal solid waste incineration plants; emissions from incinerating industrial and hazardous wastes<br>Reported under 1A2f Non-metallic minerals: Emissions from waste incineration as alternative fuels in cement kilns |
| 5C1bi | Industrial waste incineration | Emissions from incinerating cable insulation materials |
| 5C1bii | Hazardous waste incineration | PCB emissions from combustion of PCB contaminated waste oil (transformers and large capacitors, ceased in 1999)<br>Reported under 1A1a Public electricity and heat production: Emissions from incinerating industrial and hazardous wastes |
| 5C1biii | Clinical waste incineration | Emissions from incinerating hospital waste in hospital incinerators (ceased in 2002) |
| 5C1biv | Sewage sludge incineration | Emissions from sewage sludge incineration plants<br>Reported under 1A2d Pulp paper and print: Emissions from incineration of residues and sludge from industrial waste water treatment plants as fuel for paper/pulp production |
| 5C1bv | 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 6-12 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 5C Waste incineration and open burning of waste.

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 5C1a | Municipal waste incineration | PM2.5 | L1, L2 |
| 5C1a | Municipal waste incineration | PM10 | L1 |

## 6.4.2 Methodological issues of 5C Waste incineration and open burning of waste

### Methodology (5C)

For the calculation of the emissions from municipal waste incineration (illegal burning of municipal waste) a Tier 2 method is used (see decision tree in chapter 5C1a Municipal waste incineration, EMEP/EEA 2023).

For the calculation of the emissions from the incineration of insulation materials from cables a Tier 2 method is used (see decision tree in chapter 5C1b Industrial waste incineration including special waste and sewage sludge, EMEP/EEA 2023).

Until 1999, also PCB emissions from so-called open burning of PCB contaminated waste oil in outdoor fires (i.e. outside of a container) occurred in Switzerland. They are modelled within the disposal category of the dynamic mass flow model developed for the usage of PCBs in Switzerland (Glüge et al. 2017), see Annex A2.2.

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 2023).

For the calculation of the emissions from sewage sludge incineration plants a Tier 2 method is used (see decision tree in chapter 5C1b Industrial waste incineration including special waste and sewage sludge, EMEP/EEA 2023).

For the calculation of the emissions from cremation a Tier 2 method is used (see decision tree in chapter 5C1bv Cremation, EMEP/EEA 2023).

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 2023).

### Emission factors (5C)

Emission factors are country-specific based on measurements and expert estimates as documented in the EMIS database (EMIS 2025/5C1 Abfallverbrennung illegal, EMIS 2025/5C1 Kabelbrand, EMIS 2025/5C1 Spitalabfallverbrennung, EMIS 2025/5C1 Krematorien, EMIS 2025/5C1 Klärschlammverbrennung, EMIS 2025/5C2 Abfallverbrennung Land- und Forstwirtschaft).

The emission factor of dioxine for 5C1 Illegal waste incineration in particular is defined based on Wevers et al. (2004) and Lemieux et al. (2003). Emission factors for the other pollutants of 5C1 Illegal waste incineration are based on SAEFL (2000) and USEPA (1995, Chapter 2.5 Open Burning).

Emission factors for 5C2 Open burning of agricultural and private gardening waste were, upon recommendation by INFRAS (2014) taken from the EMEP/EEA guidebook (EMEP/EEA 2023, chp. 5.C.2, table 3-2). INFRAS (2014) concluded, that Tier 2 default emission factor for incineration of natural residues in forestry would best account for emission factors for incineration of natural residues in agriculture and private gardens as well, except for $NH_3$ (EMEP/EEA 2002), Hg (Sigler et al. 2003) and IcdP (USEPA 1998, Table 4.10.5-1 Open burning of Municipal Refuse).

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 of plants in the region of Basel (accounting for about 1/3 of the national total quantities). Emission factors for 2015 have been re-investigated based on emission declarations of the same plants in the region of Basel. Based on 27 air pollution control measurement reports under the Ordinance on Air Pollution Control of 11 different sewage sludge incineration plants, emission factors have again been estimated for 2018 (TBF 2021). For documentation see EMIS 2025/5C1 (5C1biv UNECE) Klärschlammverbrennung. From 1990 to 2002 from

2002 to 2015 and from 2015 to 2018 emission factors are interpolated linearly. From 2018 onwards the emission factors are assumed to be constant.

The following Table 6-13 depicts the emission factors used in 5C.

Table 6-13 Emission factors for 5C Waste incineration and open burning of waste in 2023.

| 5C Incineration and open burning of waste | Unit of activity data | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Illegal incineration of biogenic waste | t waste biogenic | 2'500 | 16'000 | 750 | NA | 14'400 | 16'000 | 20'000 | 1'008 | 50'000 |
| Illegal incineration of fossil waste | t waste fossil | 2'500 | 16'000 | 750 | NA | 14'400 | 16'000 | 20'000 | 1'008 | 50'000 |
| Insulation material from cables | t cables | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Hazardous waste incineration of PCB | g PCB | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Clinical waste incineration | t waste fossil | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Sewage sludge incineration | t sewage sludge | 400 | 189 | 162 | 19 | 28 | 40 | 40 | 0.25 | 97 |
| Cremation | cremations | 210 | 5.8 | NA | NA | 13 | 13 | 15 | 0.12 | 37 |
| Open burning of natural residues in agriculture | t gardening waste | 1'380 | 1'470 | 30 | 800 | 3'760 | 4'130 | 4'310 | 348 | 48'790 |
| Open burning of natural residues in private households | t gardening waste | 1'380 | 1'470 | 30 | 800 | 3'760 | 4'130 | 4'310 | 348 | 48'790 |

| 5C Incineration and open burning of waste | Unit of activity data | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | PCB |
|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | mg/... |
| Illegal incineration of biogenic waste | t waste biogenic | 100'000 | 200 | 100 | 160'000 | 0.34 | 0.20 | 0.27 | 0.100 | NA |
| Illegal incineration of fossil waste | t waste fossil | 100'000 | 200 | 100 | 160'000 | 0.34 | 0.20 | 0.27 | 0.100 | NA |
| Insulation material from cables | t cables | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Hazardous waste incineration of PCB | g PCB | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Clinical waste incineration | t waste fossil | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Sewage sludge incineration | t sewage sludge | 280 | 33 | 200 | 140 | NA | NA | NA | NA | NA |
| Cremation | cremations | 46 | NA | 86 | 500 | NA | NA | NA | NA | NA |
| Open burning of natural residues in agriculture | t gardening waste | 320 | 130 | 60 | 10'000 | 3'150 | 6'450 | 5'150 | 1'700 | NA |
| Open burning of natural residues in private households | t gardening waste | 320 | 130 | 60 | 10'000 | 3'150 | 6'450 | 5'150 | 1'700 | NA |

### Activity data (5C)

The clinical waste incineration quantities are based on rough expert estimates (EMIS 2025/5C1 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 illegal nature of the process, there is a lack of reliable data. Thus, 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 estimate the quantity of illegal waste, the percentage quotation is multiplied by the total amount of municipal solid waste and waste from construction work (EMIS 2025/5C1 Abfallverbrennung illegal).

The sewage sludge quantity for 1990, 1994 and 1999 are taken from Külling and Stadelmann (2002). The total amount of sewage sludge produced in Switzerland as of 2000 is calculated by multiplying the per capita sludge production per person and year as reported by VBSA (2017) with the total population (FSO 2024c). The per capita sewage sludge production for 2000, 2004, 2008, 2012, 2016 and 2017 as reported in VBSA 2017 have been derived by compiling the respective amounts of sewage sludge incinerated in municipal solid waste incineration plant, sewage sludge incineration plants and used as alternative fuel in the cement industry and dividing it by the total population count (VBSA 2017). Per capita sludge productions for the intervening years were interpolated linearly. 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 residues (see Table 6-14) is estimated based on a study conducted by INFRAS (2014). The burnt quantity is decreasing because 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 2024/5C2 Abfallverbrennung Land- und Forstwirtschaft). Since the greenhouse gas inventory UNFCC in-country review 2016, greenhouse gas emissions from open burning of natural residues in forestry (5C2ii) are reported under source category 4(IV)A1 in the greenhouse gas inventory. The corresponding air pollutant emissions are reported under 11B Forest fires within the informative inventory report (chp. 7.3).

Table 6-14 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 | 2010 |
|---|---|---|---|---|---|---|
| Illegal incineration of biogenic waste | kt waste biogenic | 16 | 13 | 12 | 11 | 11 |
| Illegal incineration of fossil waste | kt waste fossil | 16 | 13 | 13 | 11 | 10 |
| Insulation material from cables | kt cables | 7.5 | NO | NO | NO | NO |
| Hazardous waste incineration of PCB | t PCB | 1.1 | 0.20 | NO | NO | NO |
| Clinical waste incineration | kt waste fossil | 15 | 8.8 | 2.5 | NO | NO |
| Sewage sludge incineration | kt sewage sludge | 57 | 50 | 64 | 95 | 90 |
| Cremation | cremations | 37'513 | 40'968 | 44'821 | 48'169 | 52'813 |
| Open burning of natural residues in agriculture | kt gardening waste | 13 | 12 | 12 | 12 | 11 |
| Open burning of natural residues in private households | kt gardening waste | 4.4 | 3.6 | 2.8 | 2.0 | 1.2 |

| 5C Incineration and open burning of waste | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Illegal incineration of biogenic waste | kt waste biogenic | 10.0 | 9.9 | 9.8 | 9.3 | 9.1 | 8.8 | 8.5 | 8.3 | 7.8 | 7.6 |
| Illegal incineration of fossil waste | kt waste fossil | 9.3 | 9.4 | 9.3 | 9.0 | 8.8 | 8.6 | 8.4 | 8.3 | 7.8 | 7.7 |
| Insulation material from cables | kt cables | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Hazardous waste incineration of PCB | t PCB | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Clinical waste incineration | kt waste fossil | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Sewage sludge incineration | kt sewage sludge | 93 | 97 | 99 | 102 | 98 | 100 | 97 | 96 | 97 | 106 |
| Cremation | cremations | 55'616 | 59'664 | 54'634 | 57'694 | 54'842 | 57'746 | 68'148 | 64'106 | 65'688 | 63'546 |
| Open burning of natural residues in agriculture | kt gardening waste | 11 | 11 | 11 | 11 | 11 | 11 | 10 | 10 | 10 | 10 |
| Open burning of natural residues in private households | kt gardening waste | 1.2 | 1.2 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |

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

The following recalculations were implemented in submission 2025.

- 5C2: The activity data for 5C2 Open burning of waste was updated based on a newly used study (see method description). This leads to recalculations in the years 1990-2022.

## 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 treat wastewater from either individual cities or several cities and/or municipalities together. Wastewater in general is treated in three consecutive steps: 1. mechanical treatment, 2. biological treatment, and 3. chemical treatment. The treated wastewater flows into a receiving system (lake, river or stream). The wastewater treatment infrastructure in Switzerland is now virtually complete (FOEN 2017l). The vast majority of wastewater treatment plants apply 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 includes 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 wastewater treatment plants) 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 wastewater treatment plants.

Table 6-15 Specification of source category 5D Wastewater handling.

| 5D | Source category | 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 |

Table 6-16 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 5D Wastewater handling

| |
|---|
| 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. 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 municipal solid waste 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.

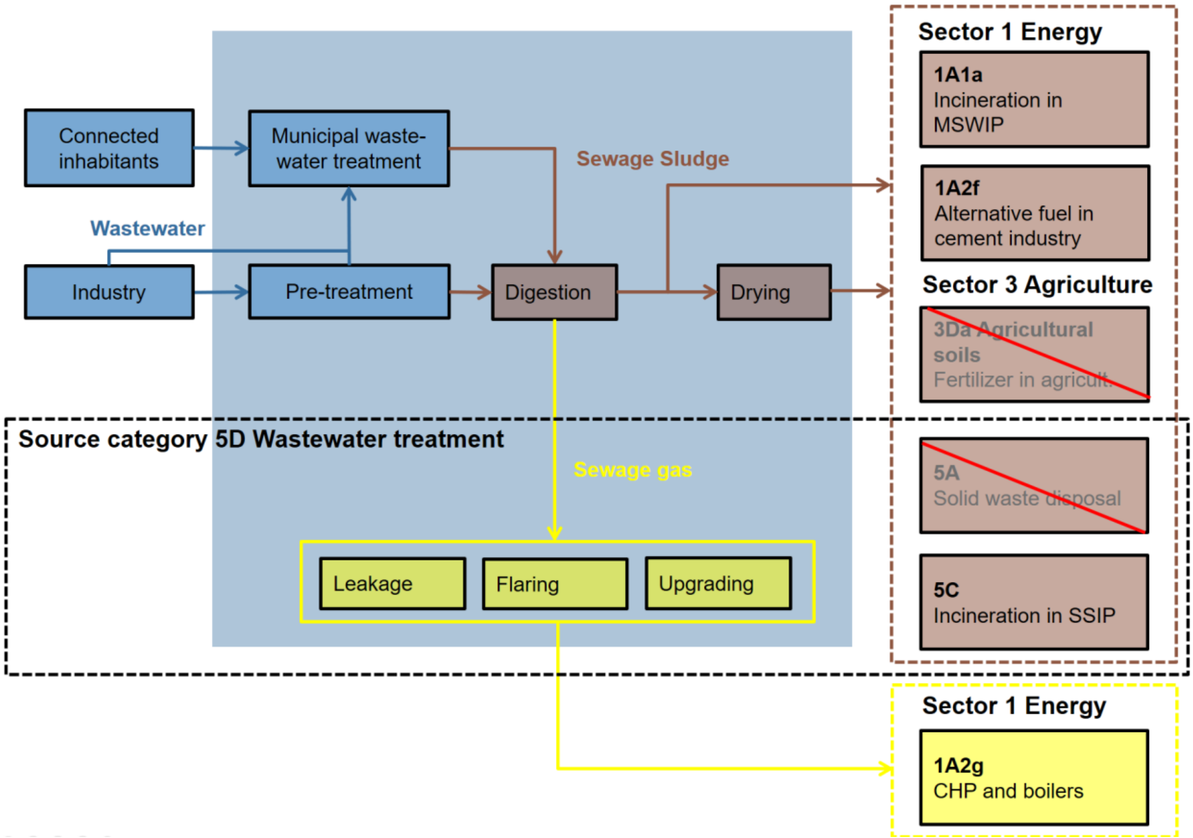



Figure 6-5 System boundaries of emissions related to wastewater handling. Abbreviations: CHP Combined Heat and Power Generation, MSWIP municipal solid waste incineration plant, SSIP sewage sludge incineration plant.

## 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 2023).

For 5D1 Domestic wastewater handling emission factors are calculated on the basis of the total emissions divided by the number of inhabitants (Swiss population, FSO 2024c). 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 2025/5D1, EMIS 2025/5D2), see Table 6-17.

Table 6-17 Emission factors for 5D Wastewater handling in 2023.

| 5D Wastewaster handling | Unit of activity data | NOx | NMVOC | SOx | NH3 | CO |
|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... |
| Domestic wastewater handling | inhabitants | 0.57 | 0.011 | 0.0029 | 14 | 0.28 |
| Industrial wastewater handling | inhabitants | 0.13 | 0.0026 | 0.00064 | NA | 0.063 |

## Activity data (5D)

Activity data for 5D1 Domestic wastewater handling and 5D2 Industrial wastewater handling are the total number of inhabitants extracted from FSO (2024c). The number of inhabitants connected to the system is the product of the number of inhabitants and the service level. The fraction and number of persons connected to wastewater systems are indicated for informational reason in Table 6-18.

Table 6-18: Activity data in 5D Wastewater handling: Population and fraction connected to wastewater treatment plants. Emissions resulting from CH4 recovery are reported in Sector 1 in source category 1A2gviii Other.

| 5D Wastewaster handling | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Domestic wastewater handling | inhabitants | 6'712'000 | 7'041'000 | 7'184'000 | 7'437'000 | 7'825'000 |
| Fraction connected to wastewater treatment plants | % sewage sludge | 90.0 | 93.7 | 95.4 | 96.8 | 97.2 |
| Inhabitants connected | inhabitants | 5'998'514 | 6'551'235 | 6'805'561 | 7'148'623 | 7'552'659 |
| Domestic wastewater handling memo item: CH4 recovery | kt CH4 | -26 | -30 | -34 | -37 | -41 |
| Industrial wastewater handling | inhabitants | 6'712'000 | 7'041'000 | 7'184'000 | 7'437'000 | 7'825'000 |

| 5D Wastewaster handling | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic wastewater handling | inhabitants | 8'189'000 | 8'282'000 | 8'373'000 | 8'452'000 | 8'514'000 | 8'575'000 | 8'638'000 | 8'705'000 | 8'739'000 | 8'889'000 |
| Fraction connected to wastewater treatment plants | % sewage sludge | 97.3 | 97.3 | 97.3 | 97.3 | 97.3 | 97.3 | 97.3 | 97.3 | 97.3 | 97.3 |
| Inhabitants connected | inhabitants | 7'912'122 | 8'001'977 | 8'089'900 | 8'166'229 | 8'226'133 | 8'285'071 | 8'345'941 | 8'410'675 | 8'443'526 | 8'588'454 |
| Domestic wastewater handling memo item: CH4 recovery | kt CH4 | -46 | -47 | -49 | -50 | -51 | -52 | -51 | -51 | -55 | -54 |
| Industrial wastewater handling | inhabitants | 8'189'000 | 8'282'000 | 8'373'000 | 8'452'000 | 8'514'000 | 8'575'000 | 8'638'000 | 8'705'000 | 8'739'000 | 8'889'000 |

## 6.5.3 Category-specific recalculations in 5D Wastewater handling

There were no recalculations implemented in submission 2025.

# 6.6 Source category 5E – Other waste, shredding

## 6.6.1 Source category description of 5E Other waste, shredding

In source category 5E only shredding of cars and electronic waste containing PCBs in small capacitors is considered.

Table 6-19 Specification of source category 5E Other waste, shredding

| 5E | Source category | Specification |
|---|---|---|
| 5E | Other waste | Emissions from car shredding plants;<br>PCB emissions from shredding of electronic waste containing small capacitors |

Table 6-20 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 5E Other waste, shredding

| |
|---|
| Source category 5E Other waste, shredding is not a key category. |

## 6.6.2 Methodological issues of 5E Other waste, shredding

### Methodology (5E)

For the emissions from car shredding a Tier 2 method is used (see decision tree in chapter 5E Other, EMEP/EEA 2023). Emissions are calculated by multiplying the quantity of scrap by respective emission factors. The PCB emissions from shredding of electronic waste containing PCBs in small capacitors are modelled within the treatment category of the dynamic mass flow model developed for the usage of PCBs in Switzerland (Glüge et al. 2017), see Annex A2.2.

### Emission factors (5E)

For the emissions from car shredding country-specific emission factors are used (SAEFL 2000 and EMIS 2025/5E Shredder Anlagen). For all years, emission factors are considered to remain constant. The PCB emission factor expressed in units per tonnes of PCBs shredded is based on the dynamic mass flow model for the usage of PCBs in Switzerland, see Annex A2.2.

Table 6-21 Emission factors for 5E Other waste, car shredding and shredder in 2022.

| 5E Other waste | Unit of activity data | NMVOC | PM2.5 nx | PM10 nx | TSP nx | CO | Pb | Cd | PCDD/ PCDF | PCB |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | mg/... | mg/... | ng I-Teq/... | mg/... |
| Car shredding | t scrap | 200 | 5.0 | 10 | 12 | 5.0 | 22 | 2.5 | 400 | NA |
| Shredder | g PCB | NA | NA | NA | NA | NA | NA | NA | NA | 71 |

### Activity data (5E)

The quantities of shredded cars from 1990 are data provided by the Swiss shredder association. The data from 2003 and 2007 are taken from Swiss waste statistics. Data for the years in between is interpolated. From 2007 onwards the quantities are assumed to remain constant due to the lack of data (EMIS 2025/5E Shredder Anlagen). For PCB emissions, the activity data is the amount of PCBs shredded based on the dynamic mass flow model for the usage of PCBs in Switzerland, see Annex A2.2. As a consequence of the legal ban of disposal of combustible waste in landfills, a sharp increase in shredding of small capacitors occurred in 1999 although they should have been treated as special waste from 1998 onwards.

Table 6-22 Activity data for car shredding (source EMIS 2025/5E Shredder Anlagen)

| 5E Other waste | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Car shredding | kt scrap | 280 | 300 | 300 | 300 | 300 |
| Shredder | t PCB | 3.0 | 3.3 | 10 | 3.5 | 0.71 |

| 5E Other waste | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Car shredding | kt scrap | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| Shredder | t PCB | 0.31 | 0.25 | 0.20 | 0.15 | 0.12 | 0.092 | 0.070 | 0.053 | 0.040 | 0.030 |

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

There were no recalculations implemented in submission 2025.

# 7 Other and natural emissions

## 7.1 Overview of emissions

In this introductory chapter, an overview of emissions separated according to the most relevant pollutants is presented. Trends and changes for individual source categories in the period between 1990 and 2023 are analysed and discussed. In sectors 6 Other and 11 Natural emissions $NH_3$, $NO_x$, PM2.5 and NMVOC are the most relevant pollutants.

The following source categories are reported:

- 6A1 Humans
- 6A2 Pets
- 6A3 Fertilisers (private use)
- 6A4 Fire damages buildings and motor vehicles
- 6A5 Accidental PCB release (by fire and to soil)
- 11B Forest fires and open burning of residues in forestry
- 11C Other natural emissions (NMVOC from forest stands)

There are no emissions reported under memo item 6B Other.

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

### 7.1.1 Overview and trend for $NH_3$

Figure 7-1 shows the trend of $NH_3$ emissions in sector 6 Other since 1990. The source category 6A Other sources is a key category for $NH_3$. Total emissions fluctuate and have continuously slightly increased within the reporting period. Emissions from source category 6A2 Pets, which includes cats, dogs and livestock outside agriculture (i.e. asses, goats, horses and sheep) as well as zoo animals, contributes the largest share to total emissions. The emissions fluctuate due to the variability in the animal numbers. The emissions from 6A1 Humans show an increasing trend in line with the population growth, while the ones of 6A3 Fertilisers almost halved between 1990 and 1999 and have remained roughly constant since then. There is no ammonia emission from categories 6A4 Fire damages and 6A5 Accidental PCB release.

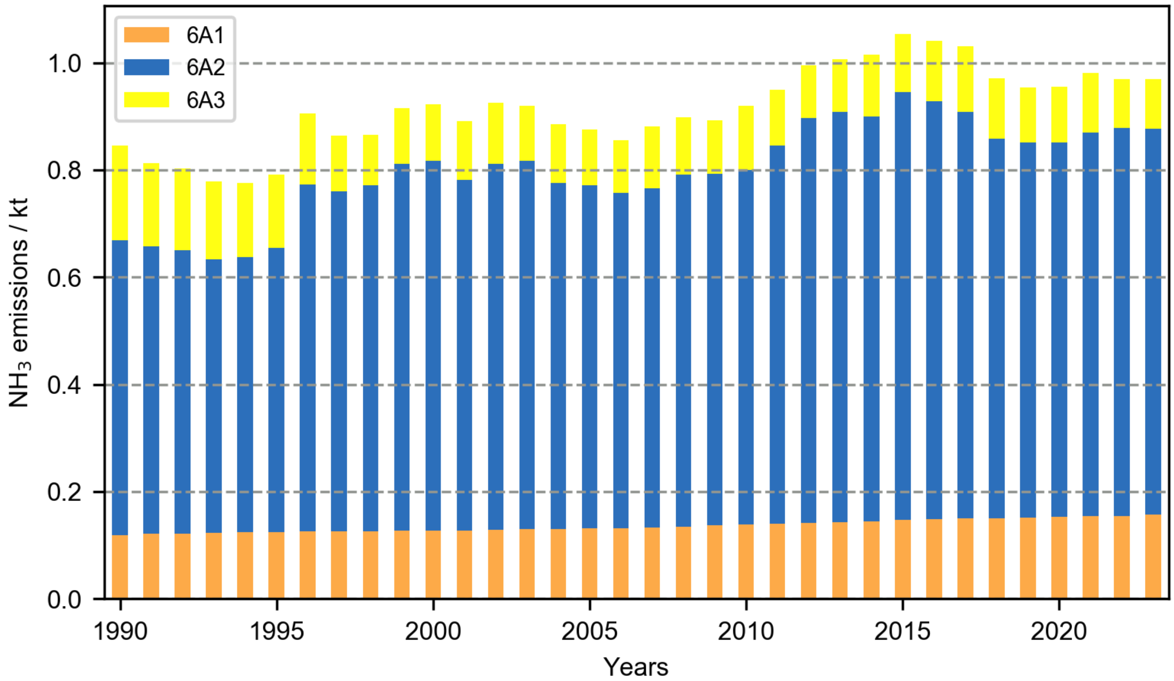



Figure 7-1 Switzerland's $NH_3$ emissions from sector 6 Other and natural emissions by source categories 6A1, 6A2 and 6A3. The corresponding data can be found in Table 7-1.

Table 7-1 $NH_3$ emissions from sector 6 Other by source categories 6A1, 6A2 and 6A3. The last column in the third part of the table indicates the relative trend.

| NH3 | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 6A1 | kt | 0.12 | 0.12 | 0.13 | 0.13 | 0.14 |
| 6A2 | kt | 0.55 | 0.53 | 0.69 | 0.64 | 0.66 |
| 6A3 | kt | 0.18 | 0.14 | 0.11 | 0.10 | 0.12 |
| 6A4 | kt | NA | NA | NA | NA | NA |
| Sum | kt | 0.85 | 0.79 | 0.92 | 0.88 | 0.92 |

| NH3 | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 6A1 | kt | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 |
| 6A2 | kt | 0.75 | 0.80 | 0.78 | 0.76 | 0.71 |
| 6A3 | kt | 0.12 | 0.11 | 0.11 | 0.12 | 0.11 |
| 6A4 | kt | NA | NA | NA | NA | NA |
| Sum | kt | 1.0 | 1.1 | 1.0 | 1.0 | 0.97 |

| NH3 | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 6A1 | kt | 0.15 | 0.15 | 0.15 | 0.15 | 0.16 | 20 |
| 6A2 | kt | 0.70 | 0.70 | 0.72 | 0.72 | 0.72 | 12 |
| 6A3 | kt | 0.10 | 0.10 | 0.11 | 0.091 | 0.094 | -10 |
| 6A4 | kt | NA | NA | NA | NA | NA | - |
| Sum | kt | 0.95 | 0.96 | 0.98 | 0.97 | 0.97 | 11 |

### 7.1.2 Overview and trend for $NO_x$

$NO_x$ emissions from the source categories 6A2 Pets, 6A3 Fertilisers and 6A4 Fire damages buildings and motor vehicles between 1990 and 2023 are summarised in Figure 7-2. The contribution of sector 6A is very small in comparison to the national total and is not a key category for $NO_x$. The overall emissions fluctuate due to changes in the number of livestock outside agriculture (6A2) but remain at about the same (low) level within the reporting period.

For all years, 6A2 Pets and 6A3 Fertilisers contribute the most to total emissions. Emissions from 6A3 Fertilisers and 6A4 Fire damages buildings and motor vehicles show a slight decrease during the reporting period.

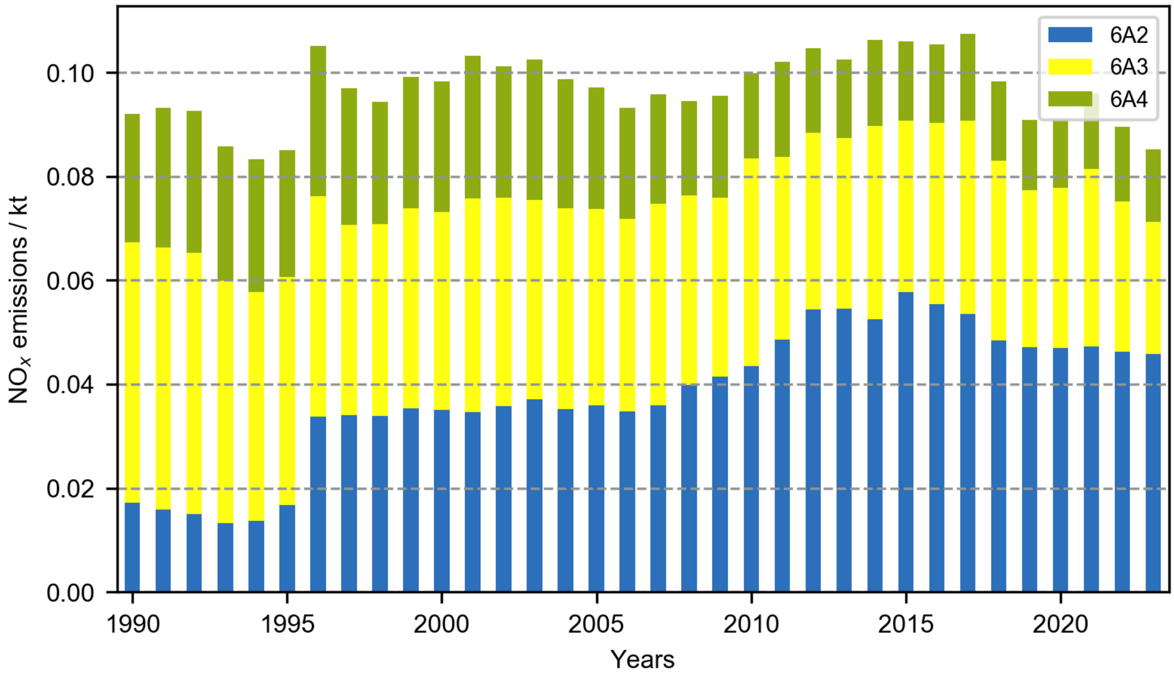



Figure 7-2 Switzerland's $NO_x$ emissions from the sector 6 Other and natural emissions by source categories 6A2, 6A3 and 6A4. The corresponding data can be found in Table 7-2.

Table 7-2 $NO_x$ emissions from sector 6 Other by source categories 6A2, 6A3 and 6A4. The last column in the third part of the table indicates the relative trend.

| NOx | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 6A1 | kt | NA | NA | NA | NA | NA |
| 6A2 | kt | 0.017 | 0.017 | 0.035 | 0.036 | 0.043 |
| 6A3 | kt | 0.050 | 0.044 | 0.038 | 0.038 | 0.040 |
| 6A4 | kt | 0.025 | 0.024 | 0.025 | 0.023 | 0.016 |
| Sum | kt | 0.092 | 0.085 | 0.098 | 0.097 | 0.100 |

| NOx | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 6A1 | kt | NA | NA | NA | NA | NA |
| 6A2 | kt | 0.053 | 0.058 | 0.055 | 0.054 | 0.048 |
| 6A3 | kt | 0.037 | 0.033 | 0.035 | 0.037 | 0.034 |
| 6A4 | kt | 0.017 | 0.015 | 0.015 | 0.017 | 0.015 |
| Sum | kt | 0.11 | 0.11 | 0.11 | 0.11 | 0.098 |

| NOx | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 6A1 | kt | NA | NA | NA | NA | NA | - |
| 6A2 | kt | 0.047 | 0.047 | 0.047 | 0.046 | 0.046 | 27 |
| 6A3 | kt | 0.030 | 0.031 | 0.034 | 0.029 | 0.025 | -33 |
| 6A4 | kt | 0.013 | 0.013 | 0.014 | 0.014 | 0.014 | -40 |
| Sum | kt | 0.091 | 0.091 | 0.096 | 0.090 | 0.085 | -12 |

### 7.1.3 Overview and trend for PM2.5

Figure 7-3 depicts the trend of PM2.5 emissions in sector 6 Other since 1990. The contribution of sector 6A is very small in comparison to the national total and is not a key category for PM2.5. Emissions from source category 6A2 Pets originate from livestock outside agriculture. They fluctuate due to changes in animal numbers and show an increasing trend from 2008 to 2015. Emissions from 6A4 Fire damages buildings and motor vehicles have a decreasing trend over the entire time period because the number of building fires is decreasing.

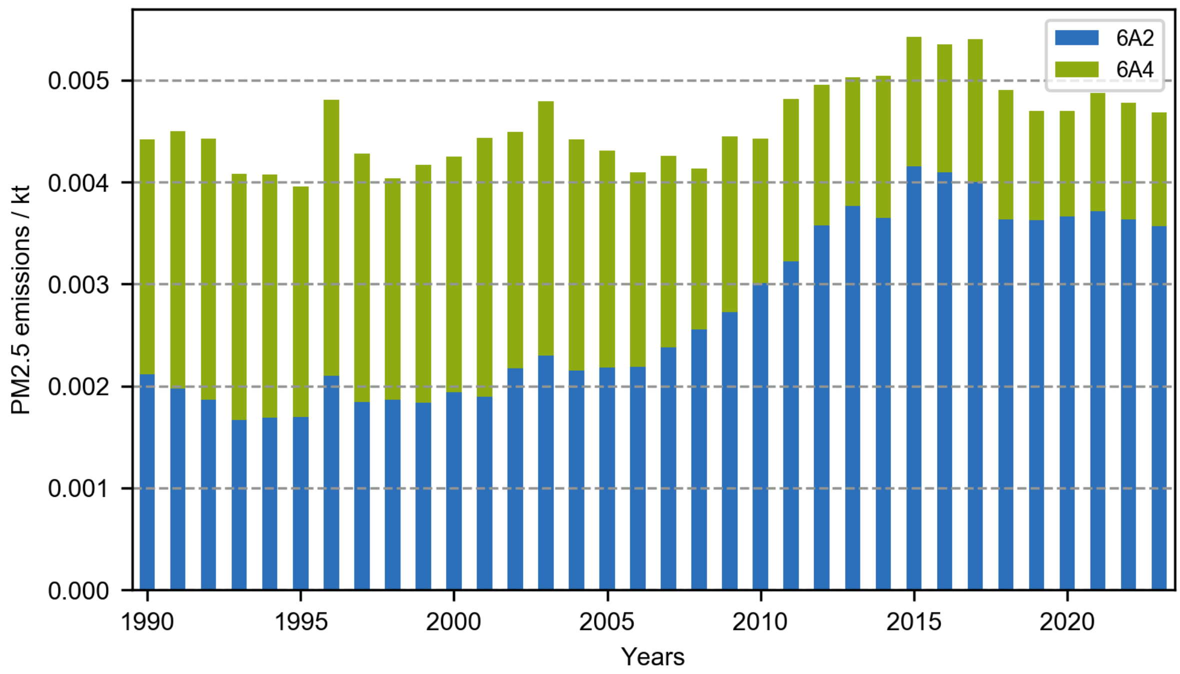



Figure 7-3 Switzerland's PM2.5 emissions from the sector 6 Other emissions. The corresponding data can be found in Table 7-3.

Table 7-3 PM2.5 emissions from sector 6 Other by source categories 6A2 and 6A4. The last column in the third part of the table indicates the relative trend.

| PM2.5 | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 6A1 | kt | NA | NA | NA | NA | NA |
| 6A2 | kt | 0.0021 | 0.0017 | 0.0019 | 0.0022 | 0.0030 |
| 6A3 | kt | NA | NA | NA | NA | NA |
| 6A4 | kt | 0.0023 | 0.0023 | 0.0023 | 0.0021 | 0.0014 |
| Sum | kt | 0.0044 | 0.0040 | 0.0042 | 0.0043 | 0.0044 |

| PM2.5 | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 6A1 | kt | NA | NA | NA | NA | NA |
| 6A2 | kt | 0.0036 | 0.0042 | 0.0041 | 0.0040 | 0.0036 |
| 6A3 | kt | NA | NA | NA | NA | NA |
| 6A4 | kt | 0.0014 | 0.0013 | 0.0013 | 0.0014 | 0.0013 |
| Sum | kt | 0.0050 | 0.0054 | 0.0053 | 0.0054 | 0.0049 |

| PM2.5 | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 6A1 | kt | NA | NA | NA | NA | NA | - |
| 6A2 | kt | 0.0036 | 0.0037 | 0.0037 | 0.0036 | 0.0036 | 64 |
| 6A3 | kt | NA | NA | NA | NA | NA | - |
| 6A4 | kt | 0.0011 | 0.0010 | 0.0012 | 0.0011 | 0.0011 | -47 |
| Sum | kt | 0.0047 | 0.0047 | 0.0049 | 0.0048 | 0.0047 | 8.8 |

### 7.1.4 Overview and trend for NMVOC from Forests

Figure 7-4 depicts the trend of NMVOC emissions in the sector 11C Other natural emissions since 1990 for various tree species. The emissions stem predominantly from Norway spruce, fir and oak stands. They are considerably high in comparison to the national total of NMVOC emissions. However, sector 11C is reported as a memo item only and is therefore not a key category for NMVOC. Total emissions in 1990 were 60.8 kt; they are increasing on average by 0.34 % per year. The annual fluctuations are due to the meteorological conditions, which influence the emission rates of the trees. The year 2023 was interpolated between 2022 and 2050.

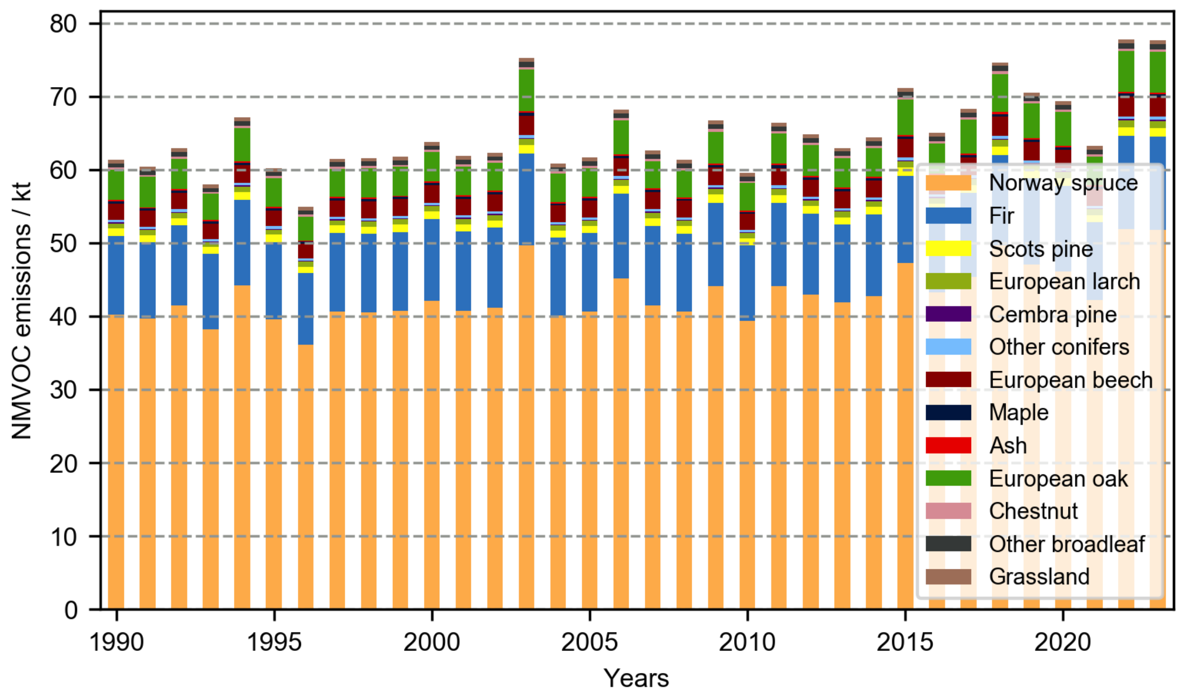



Figure 7-4 Switzerland's NMVOC emissions from the sector 11C Other natural emissions (forest stands).

## 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 7-4 are considered.

Table 7-4 Specification of sector 6 Other emissions.

| 6A | Source category | Specification |
|---|---|---|
| 6A1 | Human emissions | NH3 emissions from respiration and transpiration and diapers |
| 6A2 | Pets and livestock outside agriculture | NOx, NMVOC, NH3, PM2.5, PM10 and TSP emissions of domestic and zoo animals and of livestock not included in sector 3 Agriculture |
| 6A3 | Private application of synthetic fertilizer and urea | NOx and NH3 emissions |
| 6A4 | Fire damages | Emissions from building fires and motor vehicle fires |
| 6A5 | Accidental PCB release | Emissions from accidental PCB releases by fire and to soil |

Table 7-5 Key categories, approaches 1 and 2, level assessment 2023 (L1, L2) and trend assessment 1990-2023 (T1, T2) for source category 6A Other emissions.

| NFR code | Source category | Pollutant | Identification criteria |
|---|---|---|---|
| 6A | Other sources | NH3 | L2, T2 |

### 7.2.2 Methodological issues of 6 Other emissions

**Methodology (6A)**

*Human emissions (6A1)*

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

*Emissions from pets and livestock outside agriculture (6A2)*

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 (6A3)*

The methodology for calculating emissions of $NO_x$ and $NH_3$ from private use of inorganic N-fertiliser is the same as for fertilisers used 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 the EMEP/EEA guidebook (EMEP/EEA 2019) taking into account the specified list of fertilisers, climate zone and pH. Emission factors and activity data are given in Table 7-6 and Table 7-13, respectively.

*Emissions from fire damage buildings and motor vehicles (6A4)*

Activity data for 6A4 Fire damage buildings are estimated yearly based on the number of building fires reported to insurance companies for the given year. This information is annually published by the fire insurance association of the cantons (Vereinigung kantonaler Feuerversicherungen, VKF).

VKF publishes the number of fire incidents in buildings each year and the total sum of monetary damage. Using the data from 1992 to 2001, the average damage sum per fire incident in buildings amounts to approximately CHF 16’000. This corresponds – based on the assumption of typical damage costs of CHF 20’000 per 1’000 kg of burnt material – to 800 kg of flammable material per case. It is further assumed that on average 50 % of the flammable material gets destroyed during an incident because of the intervention of the fire brigade, yet without actually being set on fire. Thus, an average amount of 400 kg of burnt material per fire case is estimated and held constant throughout the time series. This is the same order of magnitude as the range of 272–417 kg of burnt material estimated based on a test fire as published in FM Global (2010). With these assumptions, the amount of burnt material for each year can be estimated using the total number of building fires published by VKF (EMIS 2025/6A), multiplied by the burnt material (400 kg) per fire incident. The resulting value of 9 kt burnt goods is used for the year 1990.

Activity data for 6A4 Fire damage motor vehicles are estimated yearly based on the vehicle number published annually by the Federal Statistical Office FSO (EMIS 2025/6A). Based on data from a Swiss insurance company with 25 % market share in 2002, the number of reported cases of fire damage to vehicles was extrapolated to the total vehicle number in

Switzerland. This results in one fire case per 790 vehicles for the year 2002. It is assumed that this ratio has remained constant during the reporting period. By applying this ratio to the actual vehicle number published annually by the FSO, the total number of vehicles with fire damages in Switzerland can be calculated for each year. During a car fire incident, a car burns down only partially. It is assumed that approximately 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.

*Emissions from accidental release of PCBs by fire and to soil (6A5)*

From all PCB usage in transformers, large and small capacitors, anti-corrosive paints and joint-sealants, PCBs can be accidentally released by fire or spilling to soil. These PCB emissions are modelled within the accidental release category of the dynamic mass flow model developed for the usage of PCBs in Switzerland (Glüge et al. 2017), see Annex A2.2.

**Emission factors (6A)**

The emission factors for the source categories 6A1 to 6A3 are depicted in Table 7-6 to Table 7-8. Emission factors for fertiliser see also Table 5-18.

*Ammonia emissions (6A1-6A3)*

Emission factors for human ammonia emissions are extracted from Sutton et al. (2000). Emission factors for pet (cats, dogs and zoo animals) ammonia emissions are retrieved from Reidy and Menzi (2005). The ammonia emission factors for livestock outside agriculture are derived from source category 3B – Manure management (see chp. 5.2.2).

*NOx, NMVOC, PM2.5, PM10 and TSP non-exhaust (6A2)*

The emission factors for NOx, NMVOC, PM2.5, PM10 and TSP from livestock outside agriculture are implied values based on emission factors of the respective animal categories (asses, goats, horses and sheep) in source categories 3B Manure management and 3D Crop production and agricultural soils (see chp. 5.2.2 and chp. 5.3.2).

Table 7-6 Emission factors for the year 2023 in sector 6A1 Other emissions, Humans (source EMIS 2025/6A).

| 6A1 Humans | Unit of activity data | NH3 |
|---|---|---|
| | | g/... |
| Aged inhabitants | persons | 42 |
| Children 1-3 years | children | 15 |
| Children <1 year | children | 12 |
| Human respiration | inhabitants | 3.0 |
| Human transpiration | inhabitants | 14 |

Table 7-7 Emission factors for the year 2023 in sector 6A2 Other emissions, Pets (source EMIS 2025/6A).

| 6A2 Pets and livestock outside agriculture | Unit | NOx | NMVOC | NH3 | PM2.5 nx | PM10 nx | TSP nx |
|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... |
| Livestock outside agriculture | number | 457 | 980 | 3'281 | 36 | 90 | 217 |
| Cats | number | NA | NA | 90 | NA | NA | NA |
| Dogs | number | NA | NA | 400 | NA | NA | NA |
| Weight of zoo and circus animals | t | NA | NA | 41'400 | NA | NA | NA |

Table 7-8 Emission factors for the year 2023 in sector 6A3 Other emissions, Fertilisers (source EMIS 2025/6A).

| 6A3 Fertilisers | Unit of activity data | NOx | NH3 |
|---|---|---|---|
| | | g/... | g/... |
| Fertiliser outside agriculture | kg N | 18 | 67 |

*Fire damages (6A4)*

Fire damages buildings (EMIS 2025/6A Immobilienbraende): Emission factors for CO, $NO_x$ and $SO_x$ 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 buildings. The emission factors for Cd and Hg are country-specific and based on measurements from a study about a cable recycling company in Switzerland (Graf 1990). For Pb, the emission factor is updated yearly and derived from a bottom-up estimation based on estimation of the fraction of new or renovated buildings (therefore without lead-containing paint) and a rough inventory of lead-containing items within a building. For Pb, the emission factor decreases gradually from 1990 until the reporting year, due to the progressive ban of lead in construction items and consumption goods, as enforced by the Chemical Risk Reduction Ordinance ORRChem. It is assumed that the PCDD/PCDF emission factor is the same as for illegal waste incineration. The emission factor for B(a)P is taken from USEPA 1998 (Table 4.10.5-1 Open burning of municipal refuse).

Fire damage motor vehicles (EMIS 2025/6A Fahrzeugbraende): The following emission factors are constant over the reporting period and derived from three scientific publications reporting estimations based on real car fire experiments:

- CO and $NO_x$ (ADEME 2013, INERIS 2019)
- Heavy metals As, Cd, Cr, Cu, Hg, Ni, Se, Zn (Lönnermark and Blomqvist 2006 and ADEME 2013)
- PCB and PCDD/PCDF (INERIS 2019)

For Pb, the emission factor reported by Lönnermark and Blomqvist 2006 (820 g/t, car model from 1998) is significantly higher than the one reported in ADEME 2013 (31 g/t, car model between 2008 and 2013). This reported discrepancy may be explained by additional legal measures to decrease lead content in cars over the years. One such measure in Switzerland is the ban of lead as weel weight that entered into force in 2005. We therefore use for Pb an emission factor that is yearly updated and computed as an average of the two published values, weighted by the fraction of cars in service since 2005.

The emission factor for NMVOC, PM10, PM2.5 and $SO_x$ are country-specific and based on measurements and expert estimates originally derived for wire burn off. The emission factors for PAH are determined by USEPA 1998 (chp. 4.10.2 Open burning of scrap tires). It is assumed that the emission factor for B(a)P is slightly higher than the study-based emission factor for B(a)P of car scrap due to higher B(a)P emission factor values of car tires.

Table 7-9 presents the emission factors used for the reporting year.

Table 7-9 Emission factors for fires reported under 6A4 Fire damages buildings and motor vehicles in 2023 as kg/t burned good and g/t burned good, respectively.

| 6A4 Fire damages | Unit of activity data | NOx | NMVOC | SOx | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Building fire | t burnt material biogenic | 2'500 | 16'000 | 750 | 250 | 25'000 | 30'000 | 18 | 100'000 |
| Building fire | t burnt material fossil | 2'500 | 16'000 | 750 | 250 | 25'000 | 30'000 | 18 | 100'000 |
| Fire damage motor vehicles combustion | t burnt material fossil | 4'500 | 2'000 | 5'000 | 100 | 1'000 | 70'050 | 7.0 | 51'750 |

| 6A4 Fire damages | Unit of activity data | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP | PCB |
|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... | mg/... |
| Building fire | t burnt material biogenic | 391'000 | 200 | 100 | 160'000 | 0.34 | 0.20 | 0.27 | 0.100 | NA |
| Building fire | t burnt material fossil | 391'000 | 200 | 100 | 160'000 | 0.34 | 0.20 | 0.27 | 0.100 | NA |
| Fire damage motor vehicles combustion | t burnt material fossil | 100'719 | 955 | 383 | 395'000 | 50'000 | 30'000 | 40'000 | 15'000 | 0.027 |

### *Emissions from accidental release of PCBs (6A5)*

The PCB emission factors from accidental release of PCBs by fire and to soil are expressed in units per tonnes of PCBs incinerated and stored in soil, respectively, see Table 7-10. They are based on the dynamic mass flow model for the usage of PCBs in Switzerland, see Annex A2.2.

Table 7-10 PCB emission factors for accidental release of PCB by fire and to soil, respectively, reported under 6A5 Other emissions in 2023 as kg/t released PCB.

| 6A5 Accidental release of PCB | Unit of activity data | PCB |
|---|---|---|
| | | mg/... |
| Accidental release of PCB by fire | g PCB | 100 |
| Accidental release of PCB to soil | g PCB | 0.36 |

## Activity data (6A)

### *Human emissions (6A1)*

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.

Table 7-11 Activity data causing N emissions in sector 6A1 Other emissions, Humans.

| 6A1 Humans | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Aged inhabitants | persons | 9'000 | 9'752 | 10'504 | 11'029 | 17'357 |
| Children 1-3 years | children | 238'030 | 253'652 | 237'941 | 217'302 | 229'471 |
| Children <1 year | children | 83'939 | 82'203 | 78'458 | 72'903 | 80'290 |
| Human respiration | inhabitants | 6'712'000 | 7'041'000 | 7'184'000 | 7'437'000 | 7'825'000 |
| Human transpiration | inhabitants | 6'712'000 | 7'041'000 | 7'184'000 | 7'437'000 | 7'825'000 |

| 6A1 Humans | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aged inhabitants | persons | 18'679 | 19'278 | 19'244 | 19'793 | 20'337 | 20'661 | 19'827 | 19'946 | 20'957 | 20'957 |
| Children 1-3 years | children | 245'703 | 250'182 | 254'577 | 259'729 | 261'823 | 263'115 | 261'404 | 259'937 | 261'730 | 257'929 |
| Children <1 year | children | 85'287 | 86'559 | 87'883 | 87'381 | 87'851 | 86'172 | 85'914 | 89'644 | 82'371 | 80'024 |
| Human respiration | inhabitants | 8'189'000 | 8'282'000 | 8'373'000 | 8'452'000 | 8'514'000 | 8'575'000 | 8'638'000 | 8'705'000 | 8'739'000 | 8'889'000 |
| Human transpiration | inhabitants | 8'189'000 | 8'282'000 | 8'373'000 | 8'452'000 | 8'514'000 | 8'575'000 | 8'638'000 | 8'705'000 | 8'739'000 | 8'889'000 |

### *Pets and livestock outside agriculture (6A2)*

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[5].

Table 7-12 Activity data in sector 6A2 Other emissions, Pets.

| 6A2 Pets and livestock outside agriculture | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Livestock outside agriculture | number | 16'326 | 18'649 | 88'285 | 89'276 | 95'332 | 108'866 | 120'094 | 113'379 | 109'783 | 107'715 | 103'135 | 102'173 | 102'912 | 100'749 | 100'222 |
| Cats | number | 1'164'786 | 1'205'000 | 1'379'000 | 1'417'000 | 1'507'000 | 1'599'634 | 1'655'951 | 1'655'951 | 1'645'096 | 1'634'240 | 1'678'277 | 1'722'313 | 1'788'036 | 1'853'759 | 1'853'759 |
| Dogs | number | 456'015 | 438'000 | 513'000 | 487'000 | 445'000 | 516'594 | 521'891 | 521'891 | 513'816 | 505'740 | 504'375 | 503'009 | 523'734 | 544'459 | 544'459 |
| Weight of zoo and circus animals | t | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 |

## *Emissions from private fertiliser use (6A3)*

For 6A3 only mineral fertilisers (no urea-based fertilisers) are used for private applications outside agriculture.

Table 7-13 Activity data causing N emissions in sector 6 Other emissions.

| 6A3 Fertilisers | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fertiliser outside agriculture | t N | 2'779 | 2'432 | 2'112 | 2'087 | 2'212 | 2'056 | 1'823 | 1'934 | 2'057 | 1'907 | 1'673 | 1'712 | 1'890 | 1'602 | 1'404 |

## *Fire damages (6A4)*

Activity data for source category 6A4 Fire damages are given in Table 7-14.

Table 7-14 Activity data in source category 6A4 Fire damages: Burnt goods (source EMIS 2025/6A).

| 6A4 Fire damages | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building fire | kt burnt material biogenic | 2.9 | 2.3 | 1.8 | 1.6 | 1.1 | 1.1 | 0.95 | 0.94 | 1.1 | 0.95 | 0.79 | 0.76 | 0.87 | 0.85 | 0.83 |
| Building fire | kt burnt material fossil | 6.1 | 6.5 | 7.2 | 6.6 | 4.3 | 4.2 | 3.8 | 3.8 | 4.2 | 3.8 | 3.2 | 3.0 | 3.5 | 3.4 | 3.3 |
| Fire damage motor vehicles combustion | kt burnt material fossil | 0.48 | 0.52 | 0.58 | 0.64 | 0.68 | 0.73 | 0.75 | 0.76 | 0.77 | 0.77 | 0.78 | 0.79 | 0.80 | 0.81 | 0.82 |

## *Accidental release of PCBs (6A5)*

Activity data for source category 6A5 Accidental release of PCBs by fire and to soil are given in Table 7-15. The activity data are the amounts of PCBs incinerated and stored in soil, respectively, based on the dynamic mass flow model for the usage of PCBs in Switzerland, see Annex A2.2.

Table 7-15 Activity data in source category 6A5 Accidental release of PCB (source EMIS 2025/6A).

| 6A5 Accidental release of PCB | Unit | 1990 | 1995 | 2000 | 2005 | 2010 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Accidental release of PCB by fire | t PCB | 2.4 | 1.7 | 1.1 | 0.70 | 0.43 | 0.29 | 0.26 | 0.24 | 0.22 | 0.20 | 0.18 | 0.16 | 0.14 | 0.13 | 0.11 |
| Accidental release of PCB to soil | t PCB | 39 | 41 | 41 | 41 | 41 | 41 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 39 | 39 |

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

### 7.2.3 Recalculations in 6 Other emissions

The following recalculations were implemented in submission 2025:

- 6A3: The amount of synthetic fertilisers applied in Liechtenstein was updated for the years 1990-2022 yielding revised activity data and emission factors ($NO_x$, $NH_3$) of source category 6A3 Private application of inorganic N-fertilisers (including urea) for the entire time series.
- Remark to 6A: The former source categories 6Aa–d were renamed to 6A1–4, and accidental PCB emissions are now reported under 6A5.

## 7.3 Source category 11B - Forest fires

### 7.3.1 Source category description of 11B Forest fires

Within 11B Forest fires, emissions of $NO_x$, NMVOC, $SO_x$, $NH_3$, particulate matter, CO, Pb, Cd, Hg, PCDD/PCDF and PAH are reported.

Table 7-16 Specification of source category 11B Forest fires in Switzerland.

| 11B | Source category | Specification |
|---|---|---|
| 11B | Forest fires | Emissions from natural wildfires on forest land and grassland;<br>Emissions from open burning of natural residues in forestry |

Note that emissions are reported under 11B Natural emissions but are not accounted for in the national totals and are reported as memo item only. In the greenhouse gas inventory, wildfires are reported in sector 4(IV).

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) was moved from sector 5C to sector 4(IV)A1. 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 the EMEP/EEA guidebook (EMEP/EEA 2023). Emissions of wildfires are calculated by multiplying the annual area of forest and grassland burnt by the appropriate emission factors.

For the calculation of the emissions from burning of silvicultural residues a country-specific Tier 2 method is used (see decision tree in chapter 5C2 Open burning of waste, EMEP/EEA 2023).

**Emission factors (11B)**

Emission factors for forest and grassland fires are specified in the EMIS database (EMIS 2025/4VA1-11B-NFR_Waldbrände). Between 1900 and 1990, the available fuel on forest land, i.e. the mean biomass stocks, increased by a factor of 2.3 (Kurz et al. 1998). This information was used to calculate time series of the emission factors for most pollutants. For burnt grassland, the emission factors remain constant.

Emission factors for open burning of natural residues in forestry are taken from EMEP guidebook (EMEP/EEA 2023, chp. 5.C.2, table 3-2) and USEPA as documented in EMIS 2025/5C2 Abfallverbrennung Land- und Forstwirtschaft.

Table 7-17 Emission factors 2023 of 11B Forest fires, grassland fires and open burning of natural residues in forestry.

| 11B Forest fires | Unit of activity data | NOx | NMVOC | SOx | NH3 | PM2.5 ex | PM10 ex | TSP ex | BC ex | CO |
|---|---|---|---|---|---|---|---|---|---|---|
| | | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... | g/... |
| Forest wildfires | ha area burned | 87'000 | 500'000 | 43'000 | 43'000 | 1'000'000 | 1'200'000 | 1'800'000 | 90'000 | 2'280'000 |
| Grassland wildfires | ha area burned | 13'000 | 34'000 | 3'000 | 3'000 | 110'000 | 140'000 | 210'000 | 9'900 | 373'000 |
| Open burning of natural residues in forestry | t burned wood | 1'380 | 1'470 | 30 | 800 | 3'760 | 4'130 | 4'310 | 348 | 48'790 |

| 11B Forest fires | Unit of activity data | Pb | Cd | Hg | PCDD/ PCDF | BaP | BbF | BkF | IcdP |
|---|---|---|---|---|---|---|---|---|---|
| | | mg/... | mg/... | mg/... | ng I-Teq/... | mg/... | mg/... | mg/... | mg/... |
| Forest wildfires | ha area burned | NE | NE | 1'400 | 400'000 | 80'000 | 140'000 | 140'000 | 180'000 |
| Grassland wildfires | ha area burned | NE | NE | 1'400 | 400'000 | 80'000 | 140'000 | 140'000 | 180'000 |
| Open burning of natural residues in forestry | t burned wood | 320 | 130 | 60 | 10'000 | 3'150 | 6'450 | 5'150 | 1'700 |

### Activity data (11B)

The area of forest land and grassland burnt is provided by swissfire, a database of wildfires managed by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) as documented in the EMIS database (EMIS 2025/4VA1-11B-NFR_Waldbrände). For the years since 1990, the swissfire database is also used in the GHGI (FOEN 2025). Burned grassland areas also include woody grassland.

The activity data for burning of silvicultural residues is estimated based on a study conducted by INFRAS (2014). The burned quantity of silvicultural residues 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 of 1 January 2009). Activity data are documented in EMIS 2025/5C2 Abfallverbrennung Land- und Forstwirtschaft.

Table 7-18 Activity data of 11B Forest fires, grassland fires and open burning of natural residues in forestry.

| 11B Forest fires | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Forest wildfires | ha area burned | 1'067 | 363 | 58 | 41 | 42 |
| Grassland wildfires | ha area burned | 637 | 82 | 22 | 20 | 1.3 |
| Open burning of natural residues in forestry | kt burned wood | 34 | 28 | 23 | 17 | 11 |

| 11B Forest fires | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Forest wildfires | ha area burned | 43 | 45 | 256 | 110 | 58 | 17 | 15 | 27 | 274 | 197 |
| Grassland wildfires | ha area burned | 2.6 | 14 | 213 | 38 | 32 | 16 | 31 | 9.9 | 63 | 9.1 |
| Open burning of natural residues in forestry | kt burned wood | 11 | 11 | 11 | 11 | 11 | 11 | 10 | 10 | 10 | 10 |

## 7.3.3 Recalculations in 11B Forest fires

The following recalculations were implemented in submission 2025:

- 11B: The activity data for source category 11B Open burning of natural residues from forestry was updated based on a newly used study (see method description). This leads to a recalculation the years 1990-2022.

# 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. 11C also includes NMVOC emissions from natural grassland.

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.

Table 7-19 Specification of source category 11C Other natural emissions in Switzerland.

| **11C** | **Source category** | **Specification** |
|---|---|---|
| 11C | Other natural emissions | Natural NMVOC emissions from forest trees;<br>NMVOC emissions from natural grassland |

## 7.4.2 Methodology of 11C Other natural emissions

The biogenic NMVOC emissions from forests were calculated for the years 1900-2022 and 2050 on the basis of monthly maps for the parameters temperature, vegetation period and for 12 different tree species (Meteotest 2019a, EMIS 2025/11C Wald). This corresponds to the simplified method according to chapter 11C (B1101 Non-managed & managed forests) in the EMEP/EEA guidebook (EMEP/EEA 2023) 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.

The NMVOC emission of natural grassland is 0.51 kt $yr^{-1}$ for all years according to SAEFL (1996a).

### Emission factors (11C)

Emission factors for NMVOC emissions of different tree species are specified in the EMIS database (Table 7-20). They represent annual implied emission factors derived from the monthly emission maps. The values after 2022 are interpolated between the modelled years 2020 and 2050.

Table 7-20 Implied emission factors 2023 of 11C NMVOC for different tree species.

| 11C Other natural emissions | Unit of activity data | NMVOC |
|---|---|---|
| | | g/... |
| Natural emissions from forest | ha Norway spruce | 88’427 |
| Natural emissions from forest | ha fir | 91’005 |
| Natural emissions from forest | ha Scots pine | 23’061 |
| Natural emissions from forest | ha European larch | 11’207 |
| Natural emissions from forest | ha Cembra pine | 15’156 |
| Natural emissions from forest | ha Other conifers | 123’074 |
| Natural emissions from forest | ha European beech | 11’594 |
| Natural emissions from forest | ha maple | 22’849 |
| Natural emissions from forest | ha ash | 8’437 |
| Natural emissions from forest | ha European oak | 221’081 |
| Natural emissions from forest | ha chestnut | 13’166 |
| Natural emissions from forest | ha other broadleaf | 11’487 |

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, EMIS 2025/11C Wald).

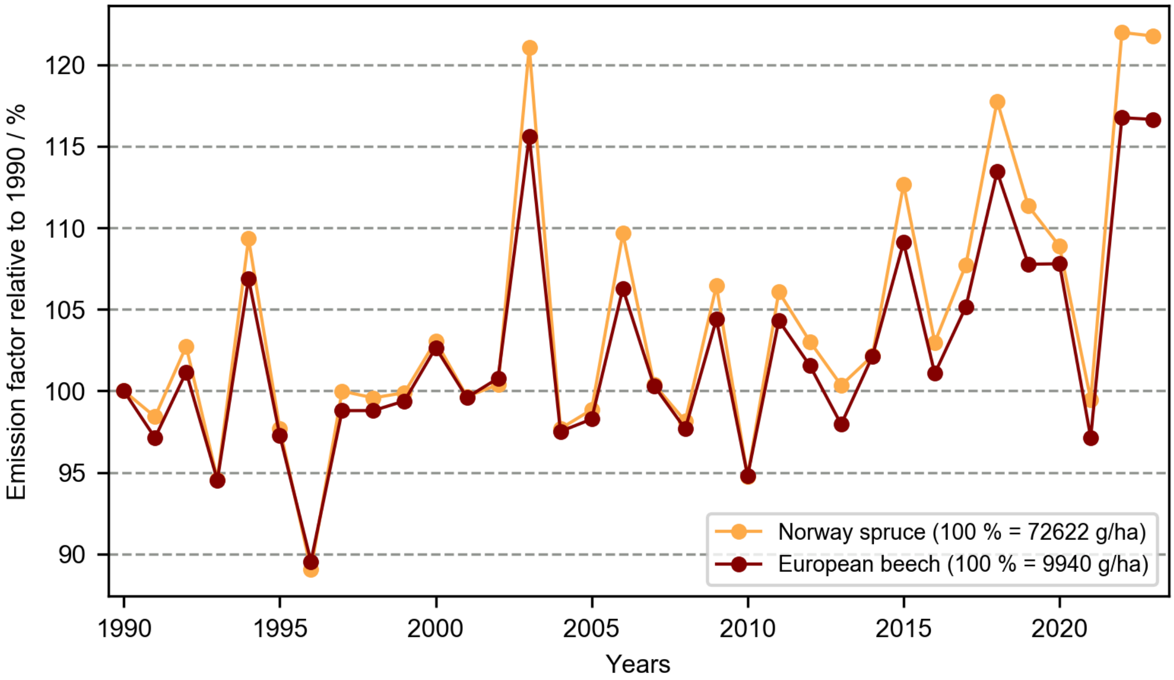



Figure 7-5 Relative trends of the (implied) NMVOC emission factors for two selected tree species 1990-2023.

## 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 7-21.

Table 7-21 Activity data of 11C; forest areas covered by the twelve main tree species.

| 11C Other natural emissions | Unit | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| Total | | 1'211'651 | 1'220'183 | 1'229'051 | 1'237'835 | 1'247'057 |
| Natural emissions from forest | ha Norway spruce | 554'168 | 558'151 | 562'292 | 566'457 | 571'778 |
| Natural emissions from forest | ha fir | 138'196 | 138'374 | 138'497 | 138'634 | 138'930 |
| Natural emissions from forest | ha Scots pine | 49'503 | 49'823 | 50'136 | 50'400 | 50'688 |
| Natural emissions from forest | ha European larch | 73'421 | 74'919 | 76'432 | 77'933 | 79'282 |
| Natural emissions from forest | ha Cembra pine | 11'025 | 11'261 | 11'502 | 11'745 | 11'964 |
| Natural emissions from forest | ha Other conifers | 3'257 | 3'261 | 3'268 | 3'269 | 3'278 |
| Natural emissions from forest | ha European beech | 226'751 | 227'722 | 228'738 | 229'799 | 230'716 |
| Natural emissions from forest | ha maple | 15'325 | 15'461 | 15'614 | 15'729 | 15'857 |
| Natural emissions from forest | ha ash | 28'555 | 28'655 | 28'782 | 28'911 | 28'991 |
| Natural emissions from forest | ha European oak | 24'911 | 24'919 | 24'978 | 25'023 | 25'027 |
| Natural emissions from forest | ha chestnut | 26'877 | 27'097 | 27'353 | 27'578 | 27'674 |
| Natural emissions from forest | ha other broadleaf | 59'662 | 60'540 | 61'459 | 62'357 | 62'872 |

| 11C Other natural emissions | Unit | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | 1'254'489 | 1'256'307 | 1'258'136 | 1'260'026 | 1'261'840 | 1'263'687 | 1'265'518 | 1'267'457 | 1'269'355 | 1'270'076 |
| Natural emissions from forest | ha Norway spruce | 576'243 | 577'328 | 578'465 | 579'544 | 580'618 | 581'777 | 582'896 | 584'087 | 585'229 | 585'664 |
| Natural emissions from forest | ha fir | 139'220 | 139'295 | 139'380 | 139'463 | 139'535 | 139'606 | 139'670 | 139'725 | 139'793 | 139'821 |
| Natural emissions from forest | ha Scots pine | 50'939 | 51'002 | 51'056 | 51'119 | 51'163 | 51'219 | 51'269 | 51'343 | 51'418 | 51'440 |
| Natural emissions from forest | ha European larch | 80'282 | 80'532 | 80'733 | 81'007 | 81'244 | 81'478 | 81'748 | 82'013 | 82'274 | 82'370 |
| Natural emissions from forest | ha Cembra pine | 12'161 | 12'196 | 12'241 | 12'296 | 12'353 | 12'395 | 12'442 | 12'505 | 12'552 | 12'571 |
| Natural emissions from forest | ha Other conifers | 3'286 | 3'288 | 3'292 | 3'295 | 3'299 | 3'303 | 3'306 | 3'316 | 3'318 | 3'319 |
| Natural emissions from forest | ha European beech | 231'422 | 231'609 | 231'780 | 231'974 | 232'161 | 232'314 | 232'462 | 232'615 | 232'790 | 232'861 |
| Natural emissions from forest | ha maple | 15'982 | 16'007 | 16'039 | 16'067 | 16'095 | 16'125 | 16'158 | 16'180 | 16'210 | 16'221 |
| Natural emissions from forest | ha ash | 29'037 | 29'047 | 29'062 | 29'082 | 29'095 | 29'109 | 29'128 | 29'154 | 29'167 | 29'172 |
| Natural emissions from forest | ha European oak | 25'039 | 25'040 | 25'041 | 25'043 | 25'047 | 25'051 | 25'052 | 25'055 | 25'058 | 25'059 |
| Natural emissions from forest | ha chestnut | 27'693 | 27'700 | 27'706 | 27'715 | 27'724 | 27'731 | 27'739 | 27'741 | 27'750 | 27'753 |
| Natural emissions from forest | ha other broadleaf | 63'185 | 63'263 | 63'341 | 63'421 | 63'506 | 63'579 | 63'648 | 63'723 | 63'796 | 63'825 |

### 7.4.3 Recalculations in 11C Other natural emissions

There were no recalculations implemented in submission 2025.

# 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. Improvements realised for this submission and leading to recalculations are described in chp. 1.4.1.

### 8.1.1 1 Energy

#### 8.1.1.1 Category specific recalculations for 1A1 Energy industries (stationary)

- 1A1, year 2022: Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_2$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated.
- 1A1a: The emission factors of $NO_x$ and CO for natural gas and gas oil boilers were updated for 2022 based on the evaluation of a large number of air pollution control measurements of combustion installations in numerous Swiss cantons. This has resulted in revised emission factors of $NO_x$ and CO for the boilers fuelled with gas oil and natural gas in source categories 1A1a Public electricity and heat production from 2011 onwards. In addition, the values of the $NO_x$ and CO emission factors for the years 1990–2010 and 2001–2010 (gas oil, CO) were also adjusted. The projected emission factor values for all particulate matter fractions (2035, PM2.5, PM10, TSP and BC) were also updated, resulting in changes to the linearly interpolated emission factors for 2021 and 2022.
- 1A1a: The fossil carbon fraction in biodiesel is now estimated based on the method described in Sebos (2022). The fossil fraction of FAME (Fatty Acid Methyl Ester) is based on the values from HBEFA 4.1 (relevant for the whole EU), while all carbon in HVO (Hydrotreated Vegetable Oil) is considered of biogenic origin. Because biodiesel as reported by Switzerland consists of the sum of FAME and HVO, the fossil fraction of biodiesel varies over time. Overall, around 4.0 to 5.4 % of the total biodiesel are now reported under “fossil liquid fuels” for the years 1996–2022 (no biodiesel in the years before). In consequence, this leads to recalculations in fuel categories including biodiesel as “biomass” or “biofuels” and “liquid fuels” as well.
- 1A1a: Due to new model-runs, there are small recalculations of activity data for all stationary engines and gas turbines 1990-2022.
- 1A1b: The emission factors of $NO_x$ and CO for natural gas and gas oil boilers were updated for 2022 based on the evaluation of a large number of air pollution control measurements of combustion installations in numerous Swiss cantons. This has resulted in revised CO emission factors for the boilers fuelled with refinery liquefied petroleum gas and natural gas in source categories 1A1b Petroleum refining from 2011 onwards. The emission factor values for all particulate matter fractions (2035, PM2.5, PM10, TSP and BC) natural gas boilers were also updated, resulting in changes of the emission factor values in the years 1990–1994, 2001–2004 and 2021–2022.

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

- 1A2: The emission factors of $NO_x$ and CO for natural gas and gas oil boilers were updated for 2022 based on the evaluation of a large number of air pollution control measurements of combustion installations in numerous Swiss cantons. This has resulted in revised emission factors of $NO_x$ and CO for all boilers fuelled with gas oil, liquefied petroleum gas and natural gas in source category 1A2 Stationary combustion in manufacturing industries and construction as well as 1A2c Cracker by-products, heating gas and 1A2gviii Fibreboard production (gas oil, natural gas) from 2011 onwards. The projected emission factor values for all particulate matter fractions (2035, PM2.5, PM10, TSP and BC) were also updated, resulting in changes to the linearly interpolated emission factors for 2021 and 2022.

- 1A2, activity data: Recalculations in all source categories 1A2a to 1A2g are due to reallocations of all fuel types in these sub-categories of 1A2 Manufacturing industries and construction in the year 2022. The reason is that during the surveys for the energy consumption statistics in the industry and services sectors for the most recent year, the reports from the previous year are reviewed again and, if necessary, adjusted retroactively. Generally, this only affects the disaggregation and not the total amount of fuels used in 1A2 Manufacturing industries and construction for that year. However, additional recalculations were introduced in the overall energy statistics with regard to the total fuel consumption in the industry sector for the following fuel types: Natural gas (2021, 2022), bituminous coal and lignite (2019–2022).
- 1A2, year 2022: Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_2$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated.
- 1A2a: A typing error in the activity data 2022 of source category 1A2a Iron foundries, cupola furnaces was corrected.
- 1A2d: The activity data of 1A2d Gas turbines (years 1992-2015, see Table 3-18) increased by a factor of 2 due to a calculation error. It will be corrected in the next submission.
- 1A2f: For source category 1A2f Cement production, the quantity of waste tyres burned was updated due to a change in the underlying statistics.
- 1A2gviii: The activity data 2022 of 1A2gviii Boiler, other bituminous coal and 1A2gviii Boiler, natural gas were revised due to corrections of a typing error in the activity data (other bituminous coal) of source category 1A2a Iron foundries, cupola furnaces and in the activity data (natural gas) of source category 1A2f Container glass.
- 1A2gviii: The Swiss statistics of energy consumption (SFOE 2024) has recalculated the amount of other bituminous coal used in industry for the years 2019-2022. This leads to recalculation in other industrial boilers of source category 1A2gviii Other.
- 1A2gviii: Activity data of automatic wood combustion installations (≥ 50 kW) in source category 1A2gviii were revised for 2019-2022 due to recalculations in the Swiss wood energy statistics (SFOE 2024b), with the largest changes occurring in 2022. In addition, a typing error in the activity data 2022 of plants for renewable waste from wood products was corrected.
- 1A2gviii: Due to new model-runs, there are small recalculations of activity data for all stationary engines and gas turbines 1990-2022.

#### 8.1.1.3 Category-specific recalculations for 1A4 Stationary combustion in other sectors (commercial, residential, agriculture and forestry)

- 1A4: Activity data of automatic wood combustion installations (≥ 50 kW) in source categories 1A4ai, 1A4bi and 1A4ci were revised for 2019-2022 due to recalculations in the Swiss wood energy statistics (SFOE 2024b).
- 1A4: The emission factors of $NO_x$ and CO for natural gas and gas oil boilers were updated for 2022 based on the evaluation of a large number of air pollution control measurements of combustion installations in numerous Swiss cantons. This has resulted in revised emission factors of $NO_x$ and CO for all boilers fuelled with gas oil and natural

gas in source categories 1A4ai Commercial/Institutional and 1A4bi Residential as well as 1A4ai Boiler, sewage gas, 1A4ai Statistical difference, biogas, and 1A4ci Greenhouses (gas oil, natural gas) from 2011 onwards. In addition, the values of the $NO_x$ and CO emission factors for the years 1990–2010 were also adjusted for 1A4ai Boiler, sewage gas, and 1A4ci Greenhouses (gas oil, natural gas) based on their nominal heat output. The projected emission factor values for all particulate matter fractions (2035, PM2.5, PM10, TSP and BC) were also updated, resulting in changes to the linearly interpolated emission factors for 2021 and 2022.

- 1A4: Due to new model-runs, there are small recalculations of activity data for all stationary engines and gas turbines 1990-2022 in source categories 1A4ai, 1A4bi and 1A4ci.
- 1A4, year 2022: Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_2$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated.
- 1A4ai: Activity data of mobile pellet combustion installations were revised for 2021 and 2022 due to recalculations in the Swiss wood energy statistics publication (SFOE 2024b, chp. 1.3).
- 1A4ai: The Swiss statistic of energy consumption (SFOE 2024) has newly added the amount of Liquefied Natural Gas (LNG) used to the total amount of natural gas used for the years 2020-2022. This leads to small recalculations mainly in source categories 1A3b Road transportation, 1A4ai Commercial/institutional (stationary) and 1B2b Natural gas losses.

#### 8.1.1.4 Category-specific recalculations for 1A2 Mobile combustion in manufacturing industry and construction (1A2gvii)

- 1A2gvii: The fossil carbon fraction in biodiesel is now estimated based on the method described in Sebos (2022). The fossil fraction of FAME (Fatty Acid Methyl Ester) is based on the values from HBEFA 4.1 (relevant for the whole EU), while all carbon in HVO (Hydrotreated Vegetable Oil) is considered of biogenic origin. Because biodiesel as reported by Switzerland consists of the sum of FAME and HVO, the fossil fraction of biodiesel varies over time. Overall, around 4.0 to 5.4 % of the total biodiesel are now reported under “fossil liquid fuels” for the years 1996–2022 (no biodiesel in the years before). In consequence, this leads to recalculations in fuel categories including biodiesel as “biomass” or “biofuels” and “liquid fuels” as well.
- 1A2gvii: An update of the fuel mix and consumption from non-road machineries leads to small recalculations in all source categories affected by the non-road transportation model and for all years 1990-2022.

#### 8.1.1.5 Category-specific recalculations for 1A3 Transport

- 1A3, year 2022: Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_2$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated.
- 1A3b: The Swiss statistic of energy consumption (SFOE 2024) has newly added the amount of Liquefied Natural Gas (LNG) used to the total amount of natural gas used for the years 2020-2022. This leads to small recalculations mainly in source categories 1A3b Road transportation, 1A4ai Commercial/institutional (stationary) and 1B2b Natural gas losses.

- 1A3b, 1A3d: The fossil carbon fraction in biodiesel is now estimated based on the method described in Sebos (2022). The fossil fraction of FAME (Fatty Acid Methyl Ester) is based on the values from HBEFA 4.1 (relevant for the whole EU), while all carbon in HVO (Hydrotreated Vegetable Oil) is considered of biogenic origin. Because biodiesel as reported by Switzerland consists of the sum of FAME and HVO, the fossil fraction of biodiesel varies over time. Overall, around 4.0 to 5.4 % of the total biodiesel are now reported under “fossil liquid fuels” for the years 1996–2022 (no biodiesel in the years before). In consequence, this leads to recalculations in fuel categories including biodiesel as “biomass” or “biofuels” and “liquid fuels” as well.
- 1A3b: The difference between the fuel used approach from the road transportation model and the fuel sold information from the energy statistics was previously referred to as "fuel tourism and statistical difference". This was determined using average emission factors for each fuel type to calculate the difference in emissions. The resulting differences in activity data and emissions were subtracted from the activity data and the previously calculated territorial emissions of each main vehicle category and fuel type in 1A3b Road transportation. Now the relative difference between the territorial fuel consumption modelled by the road transportation model (fuel used) and the fuel sold from the energy statistics is calculated first. The difference in fuel consumption per fuel type is then proportionally allocated to each vehicle category, thus adjusting the activity data to reflect the fuel sold. The emissions per fuel type are then calculated using vehicle category specific emission factors and the adjusted activity data. Therefore, the activity data for 1A3b Road transportation (fuel sold) have been updated for all fuel types and for all years 1990-2022.
- 1A3b: The use of bioethanol has been adopted to the reported amount of bioethanol sold in the Swiss energy statistics. Therefore, missing activity data have been implemented in 1A3b Road Transportation for all processes using bioethanol for the years 2005-2009.
- 1A3b: For the road traffic model in 1A3b Road transportation, adjustments were made to driving performance, mileage and energy consumption and emission factors were adopted to the Handbook for Emission Factors (HBEFA) version 4.2. This leads to recalculations of activity data end emissions for all years 1990-2022.
- 1A3d: An update of the fuel mix and consumption from non-road machineries leads to small recalculations in all source categories affected by the non-road transportation model and for all years 1990-2022.

#### 8.1.1.6 Category-specific recalculations for 1A4 Non-road and machinery in other sectors (commercial, residential, agriculture and forestry)

- 1A4, year 2022: Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_2$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated.
- 1A4aii, 1A4bii, 1A4cii: The fossil carbon fraction in biodiesel is now estimated based on the method described in Sebos (2022). The fossil fraction of FAME (Fatty Acid Methyl Ester) is based on the values from HBEFA 4.1 (relevant for the whole EU), while all carbon in HVO (Hydrotreated Vegetable Oil) is considered of biogenic origin. Because biodiesel as reported by Switzerland consists of the sum of FAME and HVO, the fossil fraction of biodiesel varies over time. Overall, around 4.0 to 5.4 % of the total biodiesel are now reported under “fossil liquid fuels” for the years 1996–2022 (no biodiesel in the years before). In consequence, this leads to recalculations in fuel categories including biodiesel as “biomass” or “biofuels” and “liquid fuels” as well.
- 1A4aii, 1A4bii, 1A4cii: An update of the fuel mix and consumption from non-road machineries leads to small recalculations in all source categories affected by the non-road transportation model and for all years 1990-2022.

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

- 1A5b, year 2022: Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_2$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated.
- 1A5b: The fossil carbon fraction in biodiesel is now estimated based on the method described in Sebos (2022). The fossil fraction of FAME (Fatty Acid Methyl Ester) is based on the values from HBEFA 4.1 (relevant for the whole EU), while all carbon in HVO (Hydrotreated Vegetable Oil) is considered of biogenic origin. Because biodiesel as reported by Switzerland consists of the sum of FAME and HVO, the fossil fraction of biodiesel varies over time. Overall, around 4.0 to 5.4 % of the total biodiesel are now reported under “fossil liquid fuels” for the years 1996–2022 (no biodiesel in the years before). In consequence, this leads to recalculations in fuel categories including biodiesel as “biomass” or “biofuels” and “liquid fuels” as well.
- 1A5b: An update of the fuel mix and consumption from non-road machineries leads to small recalculations in all source categories affected by the non-road transportation model and for all years 1990-2022.

#### 8.1.1.8 Category-specific recalculations for 1B Fugitive emissions from fuels

- 1B1a: The Swiss statistic of energy consumption (SFOE 2024) has recalculated the amount of other bituminous coal used in industry for the years 2019-2022. This leads to recalculation in 1B1a Coal handing in these years, too.
- 1B2b: The Swiss statistic of energy consumption (SFOE 2024) has newly added the amount of Liquefied Natural Gas (LNG) used to the total amount of natural gas used for the years 2020-2022. This leads to small recalculations mainly in source categories 1A3b Road transportation, 1A4ai Commercial/institutional (stationary) and 1B2b Natural gas losses.

### 8.1.2 2 Industrial processes and product use

#### 8.1.2.1 Category-specific recalculations in 2A Mineral products

- 2A5a: The emission factors of PM2.5, PM10, TSP of source category 2A5a Gravel plants were revised based on the 2A5a Quarrying and mining calculation model 2023 (EMEP/EEA 2023) for the entire time series. Also, the last year's extrapolated activity data for 2022 was updated based on the industry association's actual production figure.

#### 8.1.2.2 Category-specific recalculations in 2B Chemical industry

- 2B5: So far not reported $NO_x$ and PAH emissions from source category 2B5 Silicon carbide production are now included in the inventory on the basis of PRTR data (2008-2023).

#### 8.1.2.3 Category-specific recalculations in 2C Metal production

- 2C1: A typing error in the activity data 2022 of source category 2C1 Iron foundries was corrected.

#### 8.1.2.4 Category-specific recalculations in 2D Other solvent use

There were no recalculations implemented in submission 2025.

#### 8.1.2.5 Category-specific recalculations in 2G Other product use

- 2G: For source category 2G Hairdressers, the activity data for the years 2012–2020 were supplemented and the emission factor for 2004 was adjusted, resulting in changed linear interpolated values for the years 2021 and 2022 as well as 1991–2003 and 2005–2010.
- 2G: For source category 2G Consumption of tobacco products, the emission factor for Cd was updated, using a country-specific estimation, for the years 1990-2022, causing a decrease by 82 %. A new emission factor for Pb was introduced for the years 1990-2022, using a country-specific estimation.
- 2G Consumption of tobacco products: The activity data value for the year 2020 was updated due to a typing mistake.

#### 8.1.2.6 Category-specific recalculations in 2H Other industry production

- 2H2: For source category 2H2 Bread production, the emission factor for NMVOCs was updated using a country-specific estimation, for the years 1990-2022, causing a decrease by 36 %.
- 2H2: For source category 2H2 Meat smokehouses, the activity data was modified for the years 1999-2022 due to an update in the underlying statistics.
- 2H2: For source category 2H2 Flour production, the activity data was modified for the years 2012 and 2018-2022 due to an update in the underlying statistics.

#### 8.1.2.7 Category-specific recalculations in 2I Wood processing, 2K Consumption of POPs and heavy metals and 2L Other production, consumption, storage, transportation or handling of bulk products

- 2I: The 2022 activity data of source category 2I Wood processing was updated based on the revised annual amount of sawnwood reported in the yearbook forest and wood.
- 2L: There were small corrections of the amount of $NH_3$ used in cooling systems. Therefore, the emissions of $NH_3$ from cooling systems have changed a little (less than 1t/a $NH_3$) for the years 1991-2022.

### 8.1.3 3 Agriculture

#### 8.1.3.1 Category-specific recalculations in 3B Manure management

- 3B1: Updated data on the amount of manure digested anaerobically (SFOE 2024b, particularly in the years 1990-1999) led to minimal changes in the $NO_x$ emission factors for manure management and application for all cattle categories (3B1, 3Da2a1, 3Da31).
- 3B3: The activity data and emission factors ($NO_x$, NMVOC, $NH_3$, PM2.5, PM10 and TSP) of 3B3 Manure management - Swine were recalculated for the years 2021 and 2022 due to updated data for fattening pigs >25 kg from FSO 2024b.

- 3B4gii: The activity data of 3B4gii Manure management - Broilers was recalculated for the years 2021 and 2022 due to updated data from FSO 2024b.
- 3B4h: Allocation of manure to the different management systems (MS) was revised for "other roughage eaters" (Bisons, Camelids, Deer, Rabbits) based on Kupper et al. 2022 yielding changes in the $NO_x$ emission factors of source categories 3B4h Manure management - Other animals for the entire time series (1990-2022).

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

- 3Da: Allocation of manure to the different management systems (MS) was revised for "other roughage eaters" (Bisons, Camelids, Deer, Rabbits) based on Kupper et al. 2022 yielding changes in the $NO_x$ emission factors of source categories 3Da2a4h Animal manure applied to soils - Other animals and 3Da34h Urine and dung deposited by grazing animals - Other animals for the entire time series (1990-2022).
- 3Da: The activity data and emission factors ($NO_x$ and $NH_3$) of 3Da2a3 Animal manure applied to soils - Swine and 3Da33 Urine and dung deposited by grazing animals - Swine were recalculated for the years 2021 and 2022 due to updated data for fattening pigs >25 kg from FSO 2024b.
- 3Da: The activity data of 3Da2a4 Animal manure applied to soils - Broilers and 3Da34 Urine and dung deposited by grazing animals - Broilers were recalculated for the years 2021 and 2022 due to updated data from FSO 2024b.
- 3Da1: The amount of synthetic fertilisers applied in Liechtenstein was updated for the years 1990-2022 yielding revised activity data of source categories 3Da1 Inorganic N-fertilisers (including urea) for the entire time series.
- 3Da2a1: Updated data on the amount of manure digested anaerobically (SFOE 2024b, particularly in the years 1990-1999) led to minimal changes in the $NO_x$ emission factors for manure management and application for all cattle categories (3B1, 3Da2a1, 3Da31).
- 3Da2c: The amount of nitrogen inputs from compost and digestates was updated for the years 1996-2022 due to new activity data from SFOE 2024a. This resulted in revised activity data and $NH_3$ emission factors of source category 3Da2c Other organic fertilisers applied to soils.
- 3Da31: Updated data on the amount of manure digested anaerobically (SFOE 2024b, particularly in the years 1990-1999) led to minimal changes in the $NO_x$ emission factors for manure management and application for all cattle categories (3B1, 3Da2a1, 3Da31).
- 3De: The activity data of source category 3De Summering pastures were updated based on revised data from FSO 2024b for the entire time 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 implemented in submission 2025.

#### 8.1.4.2 Category-specific recalculations in 5B Biological treatment of waste – Composting and anaerobic digestion at biogas facilities

- 5B2: The activity data for 5B2 Anaerobic digestion at biogas facilities have been updated due to an update in the underlying statistics (Swiss statistics of renewable energies). This affects all years from 1994 until 2022.

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

- 5C2: The activity data for 5C2 Open burning of waste was updated based on a newly used study (see method description). This leads to recalculations in the years 1990-2022.

#### 8.1.4.4 Category-specific recalculations in 5D Wastewater handling

There were no recalculations implemented in submission 2025.

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

There were no recalculations implemented in submission 2025.

### 8.1.5 6 Other

#### 8.1.5.1 Recalculations in 6 Other emissions

- 6A3: The amount of synthetic fertilisers applied in Liechtenstein was updated for the years 1990-2022 yielding revised activity data and emission factors ($NO_x$, $NH_3$) of source category 6A3 Private application of inorganic N-fertilisers (including urea) for the entire time series.
- Remark to 6A: The former source categories 6Aa–d were renamed to 6A1–4, and accidental PCB emissions are now reported under 6A5.

#### 8.1.5.2 Recalculations in 11B Forest fires

- 11B: The activity data for source category 11B Open burning of natural residues from forestry was updated based on a newly used study (see method description). This leads to a recalculation the years 1990-2022.

#### 8.1.5.3 Recalculations in 11C Other natural emissions

There were no recalculations implemented in submission 2025.

### 8.1.6 Implications of recalculation for emission levels

Table 8-1 shows the effect of recalculations on the emission levels 2022 and 1990, based on the previous (2024) and latest (2025) submission.

In 2022, the recalculations cause a lower emission level by 10.4 % for Cd. For $NO_x$, NMVOC, $SO_x$, PM2.5, CO and Pb, recalculations lead to a decrease of emissions in 2022 between 1 % and 3 %. For all other pollutants, the difference does not exceed 1 %.

In 1990, the recalculations cause a lower emission level by 2.2 % for Cd. For all other pollutants, the difference in emissions due to recalculations for 1990 does not exceed 1 %.

Table 8-1 Recalculations: Implications for the emission levels 2022 and 1990. The values refer to the NFR submission 2024 (previous) and 2025 (latest). Differences are given in absolute and relative numbers for all pollutants.

| Pollutant | Units | 2022 | | | |
|---|---|---|---|---|---|
| | | previous subm. 2024 | latest subm. 2025 | difference (abs.) | difference (rel.) previous = 100% |
| $NO_x$ | kt | 50 | 49 | -0.61 | -1.2% |
| NMVOC | kt | 73 | 71 | -1.1 | -1.6% |
| $SO_x$ | kt | 3.2 | 3.2 | -0.043 | -1.3% |
| $NH_3$ | kt | 53 | 53 | -0.023 | 0.0% |
| PM2.5 | kt | 6.6 | 6.5 | -0.11 | -1.6% |
| PM10 | kt | 14 | 14 | 0.026 | 0.2% |
| TSP | kt | 28 | 28 | 0.11 | 0.4% |
| BC | kt | 0.88 | 0.88 | -0.00089 | -0.1% |
| CO | kt | 143 | 141 | -2.3 | -1.6% |
| Pb | t | 8.4 | 8.2 | -0.24 | -2.9% |
| Cd | t | 0.46 | 0.42 | -0.048 | -10.4% |
| Hg | t | 0.58 | 0.57 | -0.0043 | -0.8% |
| PCDD/PCDF | g I-TEQ | 13 | 12 | -0.11 | -0.9% |
| PAH (total) | t | 2.4 | 2.4 | 0.015 | 0.6% |
| HCB | kg | 0.34 | 0.34 | -0.0017 | -0.5% |
| PCB | kg | 341 | 341 | -0.000022 | 0.0% |

| Pollutant | Units | 1990 | | | |
|---|---|---|---|---|---|
| | | previous subm. 2024 | latest subm. 2025 | difference (abs.) | difference (rel.) previous = 100% |
| $NO_x$ | kt | 141 | 141 | -0.09 | -0.1% |
| NMVOC | kt | 296 | 295 | -0.74 | -0.3% |
| $SO_x$ | kt | 39 | 39 | 0.01315 | 0.0% |
| $NH_3$ | kt | 68 | 68 | -0.0038 | 0.0% |
| PM2.5 | kt | 27 | 27 | -0.10 | -0.4% |
| PM10 | kt | 37 | 36 | -0.10 | -0.3% |
| TSP | kt | 56 | 56 | -0.079 | -0.1% |
| BC | kt | 5.7 | 5.7 | -0.0017 | 0.0% |
| CO | kt | 756 | 752 | -4.6 | -0.6% |
| Pb | t | 354 | 355 | 0.528 | 0.1% |
| Cd | t | 3.3 | 3.2 | -0.072 | -2.2% |
| Hg | t | 6.3 | 6.3 | -0.00029 | 0.0% |
| PCDD/PCDF | g I-TEQ | 192 | 192 | -0.054 | 0.0% |
| PAH (total) | t | 8.1 | 8.0 | -0.077 | -1.0% |
| HCB | kg | 173 | 173 | – | – |
| PCB | kg | 2'332 | 2'332 | -0.0000001 | 0.0% |

The source categories with the most important recalculations implemented for main pollutants and PM2.5 in submission 2025 in terms of absolute emissions are listed in Table 8-2 and Table 8-3 for the years 2022 and 1990, respectively. The most important recalculations for 1990 and the last year reported in both submissions and each main pollutant are the following:

$NO_x$

The most important recalculations of $NO_x$ emissions were made in sector 1A Fuel combustion. The main changes concern the road transportation model, emission factors of natural gas and gas oil boilers as well as activity data of wood waste. These and further recalculations are documented in Table 8-2 and Table 8-3 and described as follows:

- In the Handbook of Emission Factors for Road Transport (HBEFA, version 4.2), adjustments were made to driving performance, mileage and energy consumption. Additionally, new emission factors were adopted to the handbook. This leads to changes in activity data and emission factors in source category 1A3b Road transportation for all vehicle categories and all years.
- $NO_x$ emission factors for natural gas and gas oil boilers were updated for 2022 based on an evaluation of a large number of air pollution control measurements of combustion installations in numerous Swiss cantons. This leads to changes in all source categories within stationary combustion. The largest changes in 2022 are visible in source category 1A4 Stationary combustion in other sectors (especially 1A4bi Residential and 1A4ai Commercial/institutional). As a consequence, the $NO_x$ emission factors from previous years (1990-2010) were also reviewed and adjusted for some source categories. The largest change in the year 1990 resulted for source category 1A1a Public electricity and heat production.
- The activity data (wood waste) of source category 1A2gviii Plants for renewable waste from wood products was corrected for the year 2022.

NMVOC

The most important recalculation regarding NMVOC emissions occurred in source category 2H2 Food and beverages industry. In addition, the changes in the road transportation model led to recalculations of NMVOC emissions in sector 1A3b Road transportation. These and further recalculations are documented in Table 8-2 and Table 8-3 and described as follows:

- In source category 2H2 Food and beverages industry, the NMVOC emission factor for bread production was updated for the whole time series based on new measurements in two of the largest industrial bakeries.
- In the Handbook of Emission Factors for Road Transport (HBEFA, version 4.2), adjustments were made to driving performance, mileage and energy consumption. Additionally, new emission factors were adopted to the handbook. This leads to changes in activity data and emission factors in source category 1A3b Road transportation for all vehicle categories and all years.

$SO_x$

The most important recalculation regarding $SO_x$ emissions occurred in source category 1A2gviii Other due to a correction of activity data for wood waste. Apart from that, small changes to the sulphur content of several fuels were made because they are based on a 3-years running mean and change with newly available data. The corresponding main recalculations are described as follows:

- The activity data (wood waste) of source category 1A2gviii Plants for renewable waste from wood products was corrected for the year 2022., which is especially visible in source category 1A2gviii Other.
- Due to new data for the year 2023, the 3-years running mean for the sulphur content and therefore the $SO_x$ emission factor for residual fuel oil, gas oil, diesel oil, biodiesel, gasoline and bioethanol has been updated. This change leads to minor changes within different stationary and mobile source categories in sector 1A Fuel combustion in the

year 2022 (especially visible in source category 1A4bi Residential and 1A3b Road transportation.

- Also for $SO_x$, the adjustments to driving performance, mileage and energy consumption and the new emission factors in the Handbook of Emission Factors for Road Transport (HBEFA, version 4.2) have implications for emission levels. These implications are minor for the whole time series, however still visible in the year 1990 for source category 1A3b Road transportation due to the lack of other relevant recalculations.

$NH_3$

The most important recalculation regarding $NH_3$ emissions occurred in source category 1A2gviii Other due to a correction of activity data for wood waste. In addition, small changes were made in sector 3 Agriculture regarding nitrogen inputs from compost and digestates as well as for manure management of broilers. These and further recalculations are documented in Table 8-2 and Table 8-3 and described as follows:

- The activity data (wood waste) of source category 1A2gviii Plants for renewable waste from wood products was corrected for the year 2022.
- The amount of nitrogen inputs from compost and digestates was updated due to new activity data. This leads to revised $NH_3$ emission factors for source category 3Da2c Other organic fertilisers applied to soils for the years 1996-2022.
- The activity data of 3B4gii Manure management – Broilers was recalculated due to updated statistical data. This leads to revised $NH_3$ emissions for the years 2021 and 2022.
- Also for $NH_3$, but with a comparably lower effect, the adjustments to driving performance, mileage and energy consumption and the new emission factors in the Handbook of Emission Factors for Road Transport (HBEFA, version 4.2) have implications for emission levels.
- For the whole time series, but especially visible in the year 1990, a recalculation of $NH_3$ emissions occurred due to changed activity data for source category 5C2 Open burning of waste based on newly used study.

PM2.5

The most important recalculation regarding PM2.5 occurred in source category 2A5a Quarrying and mining of minerals other than coal, where the EMEP/EEA (2023) calculation model for quarrying and mining was applied. In addition, fuel mix and consumption for nonroad machineries and activity data for flour production were modified. These and further recalculations are documented in Table 8-2 and Table 8-3 and described as follows:

- The emission factors of PM2.5 of source category 2A5a Gravel plants were revised based on the 2A5a Quarrying and mining calculation model 2023 (EMEP/EEA 2023) for the entire time series. Also, last year's extrapolated activity data for 2022 was updated based on the industry association's actual production figure. Overall, this leads to the most relevant PM2.5 recalculation in the year 2022 and in the base year 1990.
- For nonroad machineries, fuel mix and consumption data were updated for the whole time series. This is especially visible for source category 1A3c Railways in the year 2022.
- In source category 2H2 Food and beverages industry, the activity data for flour production was modified, which is especially visible for the year 2022.
- For the whole time series, but especially visible in the year 1990, a recalculation of PM2.5 emissions occurred due to changed activity data for source category 5C2 Open burning of waste based on newly used study.

- Also for PM2.5, the adjustments to driving performance, mileage and energy consumption and the new emission factors in the Handbook of Emission Factors for Road Transport (HBEFA, version 4.2) have implications for emission levels.

Table 8-2 NFR categories with most important implications of recalculations on emission levels in 2022 in terms of absolute differences for the main pollutants and PM2.5. The values refer to the NFR submission 2024 and 2025. The list is ranked for each pollutant in terms of the absolute difference in emission levels due to recalculations ((fu) means fuel used approach).

| $NO_x$ (as $NO_2$) | kt | NMVOC | kt | $SO_x$ (as $SO_2$) | kt | $NH_3$ | kt | $PM_{2.5}$ | kt |
|---|---|---|---|---|---|---|---|---|---|
| 1 A 3 b i (fu)_Road transport: Passenger cars (fuel used) | 0.52 | 2 H 2_Food and beverages industry | -0.61 | 1 A 2 g viii_Stationary combustion in manufacturing industries and construction: Other | -0.035 | 1 A 2 g viii_Stationary combustion in manufacturing industries and construction: Other | -0.013 | 2 A 5 a NFR_Quarrying and mining of minerals other than coal | -0.13 |
| 1 A 4 b i_Residential: Stationary | -0.49 | 1 A 3 b i (fu)_Road transport: Passenger cars (fuel used) | -0.19 | 1 A 4 b i_Residential: Stationary | -0.0022 | 3 D a 2 c_Other organic fertilisers applied to soils (including compost) | -0.0075 | 1 A 3 c_Railways | 0.019 |
| 1 A 2 g viii_Stationary combustion in manufacturing industries and construction: Other | -0.35 | 1 A 3 b v (fu)_Road transport: Gasoline evaporation (fuel used) | -0.18 | 1 A 3 b i (fu)_Road transport: Passenger cars (fuel used) | -0.0022 | 1 A 3 b i (fu)_Road transport: Passenger cars (fuel used) | -0.0027 | 2 H 2_Food and beverages industry | 0.0085 |
| 1 A 4 a i_Commercial/Institutional: Stationary | -0.13 | 1 A 3 b iv (fu)_Road transport: Mopeds & motorcycles (fuel used) | -0.12 | 1 A 2 c_Stationary combustion in manufacturing industries and construction: Chemicals | -0.0015 | 3 B 4 g ii_Manure management - Broilers | 0.0019 | 1 A 3 b iv (fu)_Road transport: Mopeds & motorcycles (fuel used) | -0.0073 |
| 1 A 3 b ii (fu)_Road transport: Light duty vehicles (fuel used) | -0.11 | 1 A 3 b ii (fu)_Road transport: Light duty vehicles (fuel used) | -0.031 | 1 A 4 a i_Commercial/Institutional: Stationary | -0.00089 | 1 A 3 b ii (fu)_Road transport: Light duty vehicles (fuel used) | -0.0014 | 1 A 2 g viii_Stationary combustion in manufacturing industries and construction: Other | -0.0031 |

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 2024 and 2025. The list is ranked for each pollutant in terms of the absolute difference in emission levels due to recalculations ((fu) means fuel used approach).

| $NO_x$ (as $NO_2$) | kt | NMVOC | kt | $SO_x$ (as $SO_2$) | kt | $NH_3$ | kt | $PM_{2.5}$ | kt |
|---|---|---|---|---|---|---|---|---|---|
| 1 A 1 a_Public electricity and heat production | -0.058 | 2 H 2_Food and beverages industry | -0.54 | 1 A 3 b i (fu)_Road transport: Passenger cars (fuel used) | 0.0065 | 5 C 2_Open burning of waste | -0.0043 | 2 A 5 a NFR_Quarrying and mining of minerals other than coal | -0.081 |
| 1 A 3 b iii (fu)_Road transport: Heavy duty vehicles and buses (fuel used) | -0.027 | 1 A 3 b i (fu)_Road transport: Passenger cars (fuel used) | -0.36 | 1 A 3 b iii (fu)_Road transport: Heavy duty vehicles and buses (fuel used) | 0.0050 | 3 D a 1_Inorganic N-fertilizers (includes also urea application) | 0.00049 | 5 C 2_Open burning of waste | -0.020 |
| 1 A 3 b i (fu)_Road transport: Passenger cars (fuel used) | -0.023 | 1 A 3 b v (fu)_Road transport: Gasoline evaporation (fuel used) | 0.19 | 1 A 3 b ii (fu)_Road transport: Light duty vehicles (fuel used) | 0.0018 | 6 A_Other (included in national total for entire territory) | 0.000021 | 1 A 3 b iii (fu)_Road transport: Heavy duty vehicles and buses (fuel used) | -0.0036 |
| 1 A 4 c i_Agriculture/Forestry/Fishing: Stationary | -0.0098 | 1 A 3 b ii (fu)_Road transport: Light duty vehicles (fuel used) | -0.051 | 5 C 2_Open burning of waste | -0.00016 | 1 A 3 b iv (fu)_Road transport: Mopeds & motorcycles (fuel used) | -0.0000011 | 1 A 3 b ii (fu)_Road transport: Light duty vehicles (fuel used) | 0.0019 |
| 5 C 2_Open burning of waste | -0.0075 | 1 A 3 b iii (fu)_Road transport: Heavy duty vehicles and buses (fuel used) | 0.019 | 1 A 3 b iv (fu)_Road transport: Mopeds & motorcycles (fuel used) | -0.0000027 | 1 A 3 b i (fu)_Road transport: Passenger cars (fuel used) | 0.00000015 | 1 A 3 c_Railways | -0.0016 |

### 8.1.7 Implications of recalculation for emission trends of main pollutants and PM2.5

The emission trends 1990–2022 of the main pollutants and PM2.5 are only slightly affected through the recalculations in the latest submission (difference of less than 0.5 percentage point).

Table 8-4 Recalculations: Implications for the emission trends between 1990 and 2022 for the main pollutants. The values refer to the previous submission 2024 and latest submission 2025.

| **Pollutant** | **Trend 1990-2022 (1990 = 100%)** | |
|---|---|---|
| | **previous subm. 2024** | **latest subm. 2025** |
| | % | % |
| $NO_x$ | 35 | 35 |
| NMVOC | 25 | 24 |
| $SO_x$ | 8 | 8 |
| $NH_3$ | 78 | 78 |
| PM2.5 | 24 | 24 |

## 8.2 Planned improvements

The following improvements are planned for the submission 2026. Improvements for source categories which are key categories are, as much as possible, given priority.

### General (not sector specific)

As the new EMEP Guidebook (EMEP/EEA 2023) is available since the end of 2023, all emission factors used from EMEP/EEA 2019 have been verified with the corresponding ones in the newest Guidebook (EMEP/EEA 2023). If equal, the reference has been changed to EMEP/EEA 2023. If not equal a change of emission factors in the database according to EMEP/EEA 2023 has to be verified and adapted, if necessary, in future submissions. This process is on-going.

It is planned to analyse the recommendations from the upcoming review of the forecasts and to implement them in future submissions.

**Energy (stationary)** no planned improvements

### Energy (mobile)

- 1A3bvi-vii: With reference to the recommendation in paragraph 88 of the last report from the stage 3 in-depth review of Switzerland's emission inventory in 2020, it is planned to report the non-exhaust emissions from automobile road abrasion separately in source category 1A3bvII instead to include them in 1A3bvi automobile tyre and brake wear in a later submission. Modelling work for the determination of traffic situation-dependent emission factors for brake and tyre abrasion is in progress and could subsequently be integrated into the HBEFA database and thus also into the Swiss road traffic model. Source category 1A3bvi is a key category for PM2.5 and PM10.

**Energy (fugitive emissions)** no planned improvements

### IPPU

- 2D3 and 2G: A comprehensive update of all NMVOC emissions from solvent and product use is on-going. These two source categories are both key categories for NMVOC.

### Agriculture

- 3B1: Since cattle also spend a part of their time on pasture and this has not yet been taken into account in the calculation of NMVOC emissions, emission measurements in the experimental dairy housing during grazing are being planned (later than submission 2025). Source categories 3B1a and 3B1b are both key categories for NMVOC.
- 3B and 3D: Several adjustments are being developed and integrated in the AGRAMMON model 2025, which will have an impact on the overall emission values of $NH_3$ and $NO_x$. It is planned to report these values in 2026 submission. 3B and 3D are key categories for $NH_3$.
- 3Da1: Emission factors for inorganic N fertilisers are planned to be adjusted in accordance with the EMEP/EEA 2023 Guidebook for 2026 submission.
- 3Da4: Crop residues applied to soils according to Guidebook (EMEP/EEA 2023) are planned to be reported in 2026 submission.

**Waste** no planned improvements

**Other and Natural** no planned improvements

# 9 Emission projections 2025–2035

## 9.1 Comments on projections

The activity data for the sectors energy, IPPU and waste are in accordance with the base scenario of the Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020). The base scenario called in German "Weiter wie bisher" (WWB), which means as much as to continue with the existing policy measure at that time, bases on the reference year 2017 and is reported as "With Measures" (WM) scenario in the reporting tables of the latest submission. Other scenarios elaborated in the Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020) have the focus on how to get to net zero greenhouse gas emissions in the year 2050 and beyond, which future developments in the emission sources will contribute and which further measures are necessary to achieve this goal. As these net zero greenhouse gas emissions scenarios do not include any "additional (technological and legal) measures" aimed at reducing air pollution, none of these scenarios were implemented in the database of air pollutant emissions so far. Therefore, the air pollutant emissions in chps. 9.3 to 9.6 are shown for the "With Measures" (WM) scenario only.

Note further that:

- due to lack of detailed data for all sectors with non-road vehicles and machineries (mobile sources under 1A2gvii, 1A3c/d, 1A4aii/bii/cii), the projections for these source categories are based on the previous energy scenarios (Prognos 2012a) instead of the new Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020). However, total fuel consumption corresponds to the new Swiss Energy Perspectives 2050+.
- for activity data based on population size the latest perspectives for Switzerland's inhabitants are used (SFSO 2020p).
- for the agricultural sector, independent scenarios were developed according to the agricultural policy 2018-2021 (Swiss Confederation 2017) and an adopted parliamentary initiative (Mack and Möhring 2021).

Note also that emission data published in the submission table for the projections ("Annex IV WM") refer to the "national total" assessment based on the fuel sold principle for road transportation. All tables and figures in this chapter refer to the "national total for compliance" assessment based on fuel used principle (for details see chapter 1.4.2 and 3.1.6.1).

## 9.2 Assumptions for projections for the WM scenario

### 9.2.1 Emission factors

Emission factors for the sector 1 Energy are mainly based on available emission measurements, models, EMEP/EEA guidebook (EMEP/EEA 2019 and EMEP/EEA 2023) and expert estimates as described in chapter 3 and assumptions about their future development. Where no such assumptions can be made, the emission factors are kept constant.

Table 9-1 Overview of sources and references for emission factors in the WM scenario.

| Sector | Sources and references for emission factors |
|---|---|
| 1 Energy | In general, the emission factors used in fuel combustion and heating systems are described in Chapter 3 and have been kept constant for the future. The emission factors for specific models are described with the models and the references are as follows:<br><br>- Wood energy combustion: Zotter and Nussbaumer (2022)<br>- Road transportation: EMEP/EEA guidebook (EMEP/EEA 2019), INFRAS (2022)<br>- Domestic aviation: EMEP/EEA guidebook (EMEP/EEA 2023), FOCA (2006, 2006a, 2007a, 2008-2024)<br>- Stationary engines and gas turbines: INFRAS (2022a), EMEP/EEA guidebook (EMEP/EEA 2019, EMEP/EEA 2023)<br>- Non-road vehicles: EMEP/EEA guidebook (EMEP/EEA 2023), FOEN (2015j), INFRAS (2015a) |
| 2 IPPU | Emission measurements, industry data and factors from the EMEP/EEA guidebook (EMEP/EEA 2023) as described in chapter 4 and assumptions about their future development. Where no assumption can be made, emission factors are kept constant. |
| 3 Agriculture | AGRAMMON model (Kupper et al. 2022), EMEP/EEA guidebook (EMEP/EEA 2019 and EMEP/EEA 2023) and country-specific studies (Bühler and Kupper 2018, Schrade et al. 2025). The underlying emission factors are kept constant as in 2019 due to uncertain assumptions about the evolution of production parameters (according to Kupper et al. 2022). See chapter 5 for further information. |
| 5 Waste | Various literature sources and EMEP/EEA guidebook 2023 (EMEP/EEA 2023), see chapter 6. |
| 6 Other | Various literature sources and EMEP/EEA guidebook (EMEP/EEA 2019 and EMEP/EEA 2023), see chapter 7. |

### 9.2.2 Activity data

As described in chapter 9.1 and Table 9-2, activity data base mainly on the Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020) and the agricultural policy 2018-2021 (Swiss Confederation 2017). Due to the lack of detailed, disaggregated data elaborated in the Swiss Energy Perspectives 2050+ for the non-road model, projected developments from earlier projections (Prognos 2012a) are used. The total amount of fuel used in non-road sectors is then subtracted from the projected overall fuel consumption in the Swiss Energy Perspectives 2050+, which has some influence on the allocation of fuel consumption to the different source categories, whereas the overall fuel consumption remains the same as projected in the Swiss Energy Perspectives 2050+.

The Swiss Energy Perspectives 2050+ base on the reference year 2017 for the energy consumption in the different source categories and other statistics. Energy consumption data from the year 2017 was used to develop the future scenarios. The base scenario is the scenario “WWB” called in German “Weiter wie bisher”, which means as much as a continuation with the so far implemented energy and climate policy measures. To avoid unplausible leaps from the latest submission year to the first projected year, projections of the Swiss Energy Perspectives 2050+ are used for the years 2025 and later and data in between are linearly interpolated. Except for 1A3b Road transportation, model data was already calculated for the Swiss Energy Perspectives 2050+ with an annual resolution and for the detailed activity data.

Table 9-2 provides an overview of the respective sectoral references. A detailed description of the WM scenario can be found in Switzerland’s First Biennial Transparency Report under the Paris Agreement– therein named as “With Existing Measures (WEM)” (FOEN 2024d).

Table 9-2 Overview of sectoral underlying detailed scenarios in the WM scenario of the latest submission.

| Sector | Scenario | Sectoral scenario | Reference |
|---|---|---|---|
| 1 Energy | WM | Swiss Energy Perspectives 2050+ scenario "WWB" (continutation with measures implemented up to base year 2017) updated with new national reference scenario for popoulation ("A-00-2020"). Activity data for road transportation and stationary engines and gas turbines are modelled based on assumptions in the Swiss energy perspectives 2050+.<br>Activity data in the nonroad sectors still base on assumptions of Prognos (2012a). | Prognos/INFRAS/TEP/Ecoplan 2020<br>INFRAS 2022 and 2022a<br>SFSO 2020p<br>Prognos 2012a |
| 2 IPPU | WM | Scenario based on key parameters of the Swiss Energy Perspectives 2050+ but updated with new national reference scenario for popoulation ("A-00-2020") | Prognos/INFRAS/TEP/Ecoplan 2020<br>SFSO 2020p |
| 3 Agriculture | WM | Continuation of Agricultural policy 2018-2021 | Swiss Confederation 2017<br>Mack and Möhring 2021 |
| 5 Waste | WM | Scenario based on key parameters of the Swiss Energy Perspectives 2050+ but updated with new national reference scenario for popoulation ("A-00-2020") | Prognos/INFRAS/TEP/Ecoplan 2020<br>SFSO 2020p |

Table 9-3 lists the key factors underlying the WM scenario of the latest submission and their assumed development until 2035.

Table 9-3 Trend of underlying key factors of the WM scenario between 2010 and 2035 (FSO 2022c and SFSO 2020p for population, INFRAS 2017 for vehicle km, and Prognos/INFRAS/TEP/Ecoplan 2020 for the rest).

| Indicator | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2010-2035 |
|---|---|---|---|---|---|---|---|
| Population (million) | 7.83 | 8.28 | 8.64 | 9.02 | 9.39 | 9.73 | 24% |
| GDP (prices 2017, billion CHF) | 603 | 648 | 713 | 760 | 805 | 851 | 41% |
| Oil price (prices 2017, USD/barrel) | 88 | - | 75 | 88 | 96 | 105 | 19% |
| Gas price (prices 2017, CHF/MWh) | 28 | - | 24 | 27 | 28 | 29 | 4% |
| Heating degree days | 3'586 | 3'075 | 3'182 | 3'135 | 3'089 | 3'042 | -15% |
| Cooling degree days | 153 | 263 | 177 | 188 | 199 | 213 | 39% |
| Energy reference area (million $m^2$) | 706 | 744 | 782 | 816 | 847 | 874 | 24% |
| Passenger cars (million vehicle km) | 56'026 | 57'713 | 55'569 | 61'749 | 63'691 | 65'335 | 17% |

Please note that the population data in the Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020) do not match the official statistics used within the air pollutant (and greenhouse gas) inventory (SFSO 2020p).

For each sector, further specific methods and respective assumptions apply that are described below in more detail:

### Sector 1 Energy

As mentioned above, energy consumption is based on the scenario “WWB” of the Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020). Main measures and underlying assumptions in the energy scenario “WWB” and the different source categories are described in detail in Prognos/INFRAS/TEP/Ecoplan (2020). The projections 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. The energy model used for the emission projections is shown in Figure 9-1.

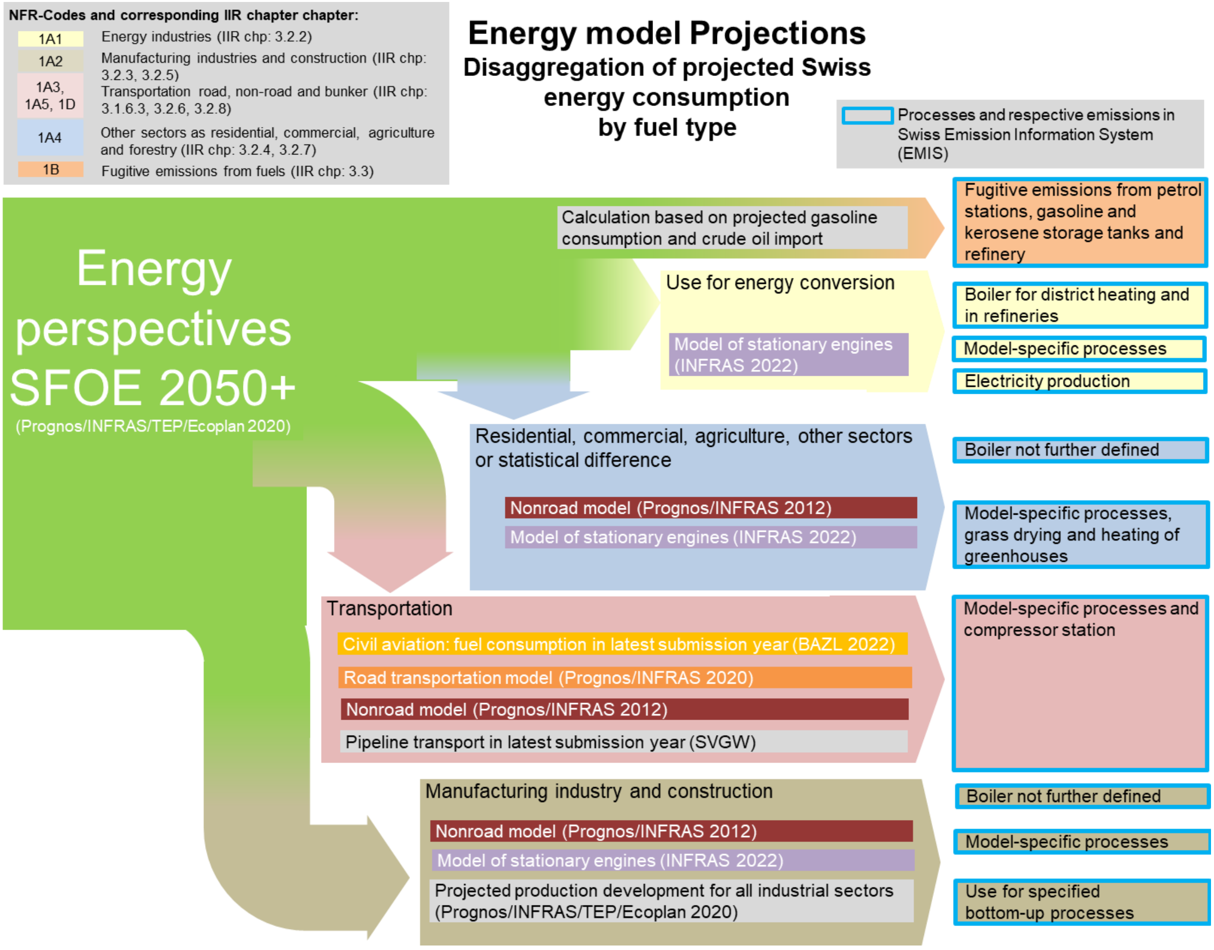



Figure 9-1 Overview of Switzerland's energy model as used for the emission projections.

Figure 9-2 depicts the total fuel consumption in recent years and as projected up to 2035 for each source category in the energy sector. Figure 9-3 shows the fuel consumption of source category 1A Fuel combustion same information broken down by fuel types.

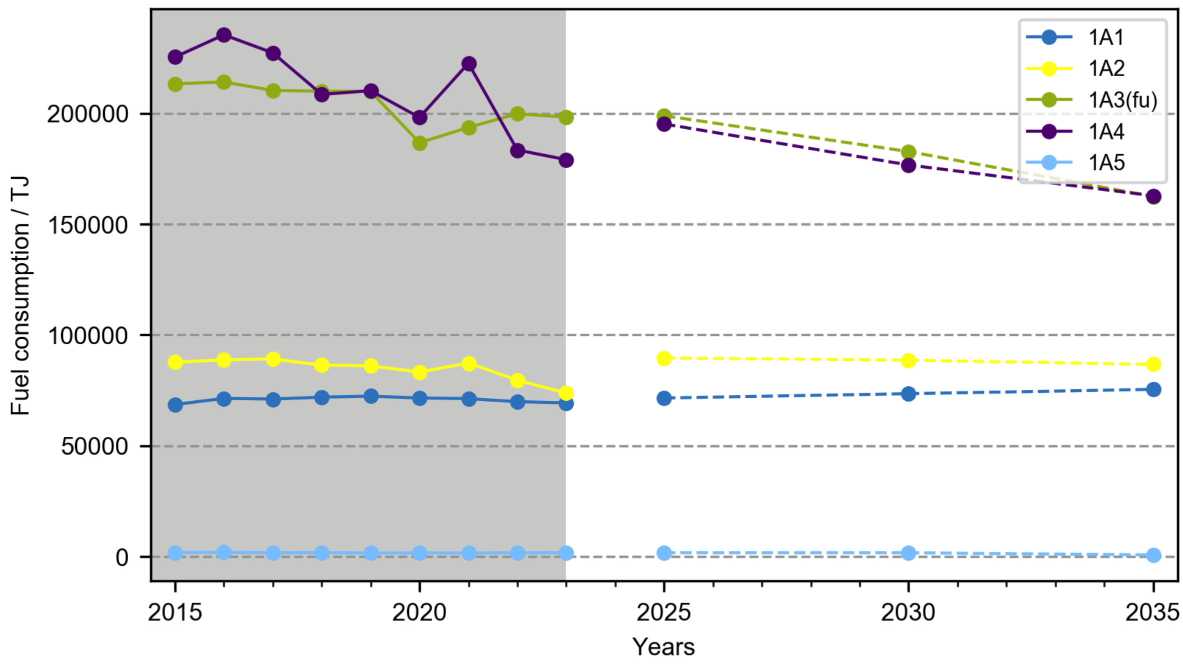



Figure 9-2 Fuel consumption in Switzerland as projected in the WM scenario in source categories 1A1 – 1A5 of the source category 1A Fuel combustion ((fu) means fuel used approach).

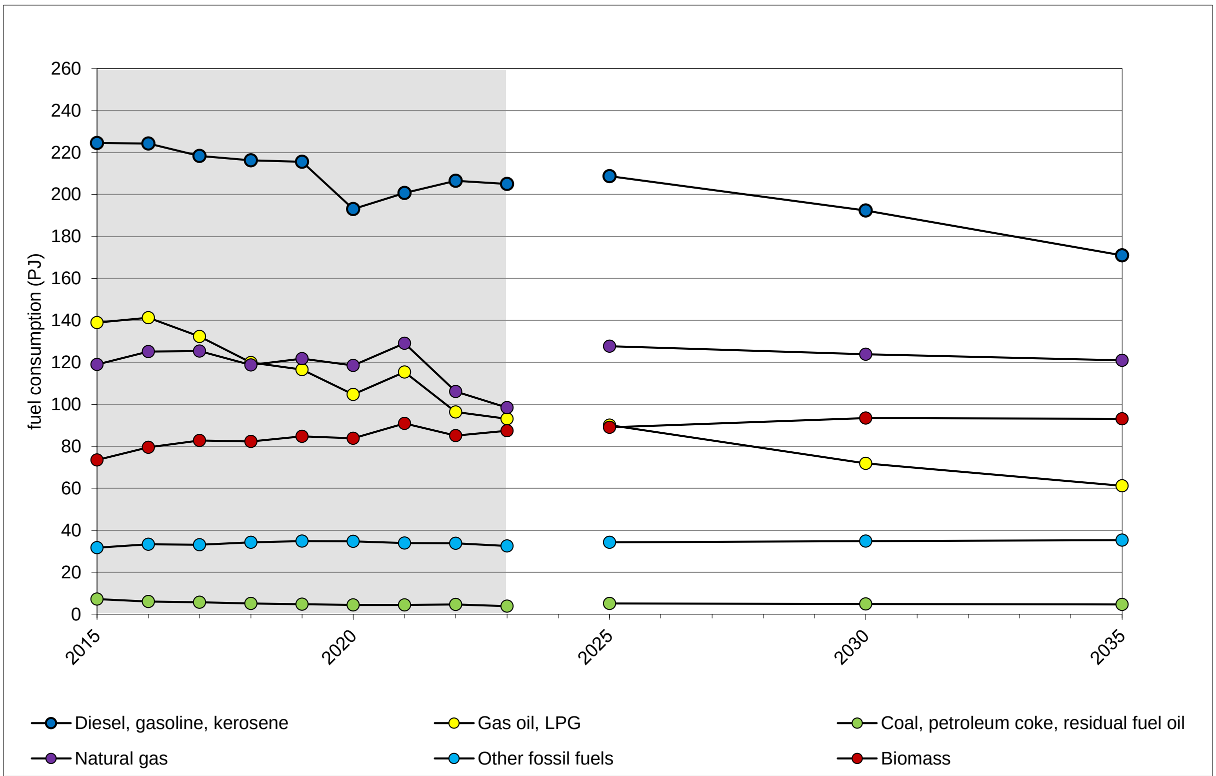



Figure 9-3 Fuel consumption in Switzerland as projected in the WM scenario for the source category 1A Fuel combustion ((fu) means fuel used approach).

It turns out that current fuel consumption in 1A4 Other sectors and 1A2 Combustion in manufacturing industry and construction has fallen much more than was probably assumed when the Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020) were elaborated. If we look at the development at the fuel level, this decline is mainly due to the large drop in natural gas consumption caused by the war in Ukraine. It is unclear how large the recovery in natural gas will be in the future. However, it can be assumed that the perspectives overestimate gas consumption, since heat demand in 1A4 was not completely saved, but probably mostly replaced by heat pumps, electricity, biomass, and local and district heating. In industry, there have also been closures of production plants, not all of which will likely be restarted in the future when natural gas prices are lower. Current consumption of heavy fossil fuels (coal, residual fuel oil, petroleum coke), which are still used primarily in fuel-intensive production processes, is also considerably below the projected values. It is unlikely that the use of heavy fossil fuels will increase again either, but rather that their replacement or the closure of production plants has been accelerated in recent years, also due to the requirements of the emissions trading scheme. Accordingly, the consumption figures for the last container glass production (natural gas), which was closed in the summer of 2024, and for the cupola furnace in rock wool production, which was replaced by an electric furnace at the beginning of 2024, were subtracted from the respective projected fuel consumption.

The growing fuel consumption in 1A1 Energy industries is mainly driven by source category 1A1a Public electricity and heat production that includes waste incineration depending on the population growth. The electricity production of the existing Swiss power plant park is projected with a bottom-up approach, taking into account the lifetime of the power plants. While the amount of waste per capita is assumed to remain at the current level, the amount of waste is increasing due to population growth and therefore leading to growing fuel consumption. An increasing use of biogas in gas turbines as SCGT or CCGT and of natural gas in boilers for district heating is considered, too. The amount of wood consumption is considered to increase only slightly compared to natural gas, biogas and waste in this source category. The amounts of fuels used in 1A1b Petroleum refining is hold constant for projected years based on the amount reported in the latest submission year, assuming that the only refinery in Switzerland will maintain operations in the future at the same level as they do today. Source category 1A1c Manufacture of Solid Fuel and Other only contains a little amount of charcoal production which is considered to stay constant at the level of the latest submission year.

Fuel consumption in 1A2 Manufacturing industries and construction is modelled for the main fuel types based on a large number of industrial production processes, taking into account their production development, broken down by the most important industrial sectors, including a residual sector for all other industrial sectors. Fuel consumption is then projected based on activity data for the sectors and specific energy use per process – including the assumption of a 5% improvement in the energy efficiency of the furnaces between the current level and 2050.

For the source category 1A3 Transport, parameters such as tonne-kilometres, passenger-kilometres, vehicle-kilometres, specific energy use and substitution effects were determined on the basis of model estimations. For more detailed information see section below.

In source category 1A4ai Commercial/Institutional: Stationary, the energy demand from commercial and institutional buildings is based on energy use for heating, hot water, air conditioning, lighting, office appliances, engines and other uses, split for different energy sources, trades and services. Projections are then driven by gross value-creating activity, number of employees, energy reference area and technical standards. Also considered are the use of biogas and sewage gas in boilers, engines and gas turbines.

In source category 1A4bi Residential: Stationary, the 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. Also considered is the use of biogas in engines.

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.

*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 duty vehicles, energy efficiency labelling, as well as economic incentives for low-emission vehicles.
- Road transportation: Projections of the mileage by vehicle categories and of fuel consumption factors are given by the Swiss Federal Office of Statistics and are represented in Prognos/INFRAS/TEP/Ecoplan (2020) and Swiss Confederation (2021).
- Non-road source categories: 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, Prognos 2012a). In addition, (compressed) natural gas in non-road has been replaced with liquefied petroleum gas, 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 Swiss Energy Perspectives 2050+ (Prognos/INFRAS/TEP/Ecoplan 2020). In particular, sectoral indices of production volumes for clinker, cement, iron and steel, non-iron metals, glass, food, construction, and so-called other industry have been used. For other processes, such as production of basic chemicals of source category 2B Chemical industry, the provided 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 (SFSO 2020p). However, the Energy Perspectives 2050+ provide no appropriate key parameters or measures for several source categories mainly within solvent and product use. For these source categories, projections are thus estimates based on information from industry, industry associations or expert judgement.

**Sector 3 Agriculture**

The basis of the WM scenario is the continuation of the agricultural policy 2018–2021 (Swiss Confederation 2017). The planned new agricultural policy (AP22+) should have become effective in 2022, but it was rejected by the parliament. Thus, central elements of the policy will be implemented through a parliamentary initiative (19.475, Swiss Confederation 2019), which was adopted in 2021. Their effects were modelled by Mack and Möhring (2021) and they elaborated respective projections of animal populations, milk yields, cropping areas and fertiliser use based on the explanatory report (FOAG 2021). Thus, the so-called parliamentary initiative scenario of Mack and Möhring (2021) was used as basis for the calculations of the WM scenario. Projections are thus based on data and information available by 2021 on (i) the development of the macro-economic variables (gross domestic product, population, crop yields), (ii) the expected development of the domestic producer prices and (iii) the actual agricultural policy with the respective subsidy system. 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. The cattle population is projected to decline slightly, whereas the number of swine and poultry remains more or less constant. Dairy cows are projected to exhibit a further increase in milk yield. Beyond 2027, 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 since 2019 together with all other parameters affecting manure management.
- 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). In general, arable crop production is projected to slightly decline whereas feed production from grasslands will remain more or less constant. Beyond 2027, constant yields and areas were assumed due to the lack of further projections.
- Fertilisers and fertiliser management: Use of commercial fertilisers is projected to decrease slightly until 2027 (Mack and Möhring 2021). Beyond 2027, 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 2018 in the projections up to 2035. 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.

## 9.3 Main pollutants and CO for the WM scenario

According to the projections, total $NO_x$ and CO emissions will continue to decrease significantly between 2025 and 2035, while total emissions of NMVOC, $SO_x$ and $NH_3$ will remain at more or less constant levels. The gaps in Figure 9-4 between the latest reporting year and 2025 symbolises the fact that most of the scenarios used to calculate emissions projections for the individual sectors and source categories cover the period from 2025 onwards. Accordingly, the emissions in between are interpolated linearly.

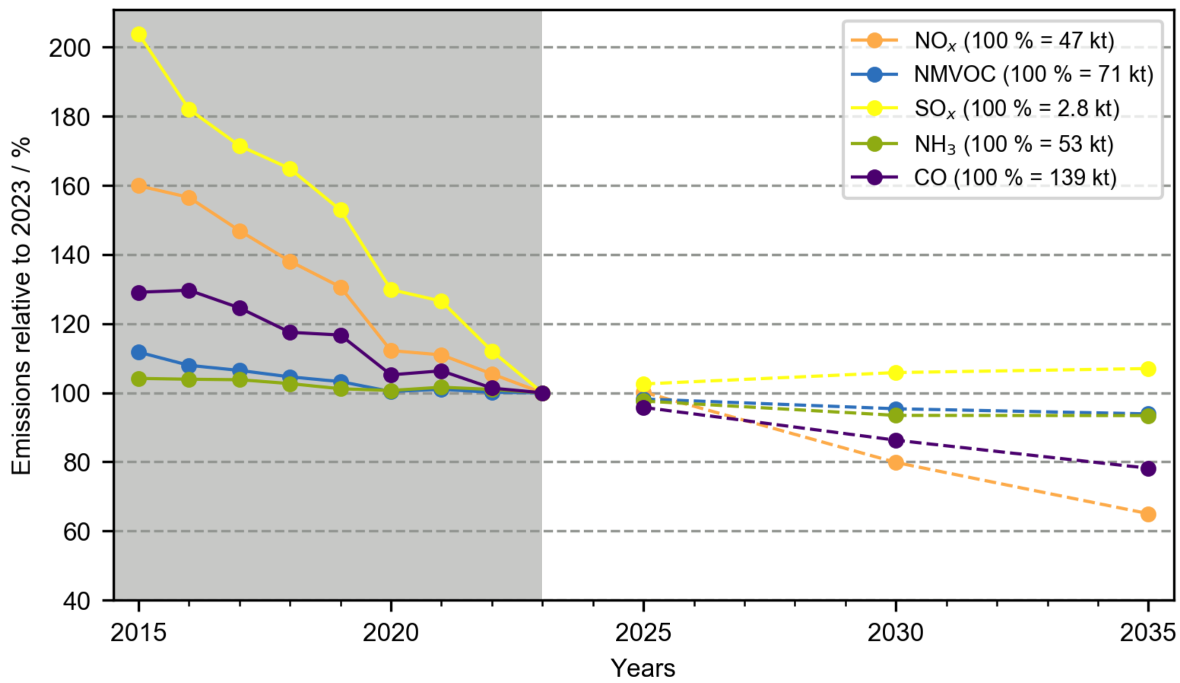



Figure 9-4 Relative trends for the total emissions of main air pollutants and CO in Switzerland as projected in the WM scenario. 100 % corresponds to levels of the latest reporting year.

Table 9-4 Main air pollutants and CO: Total emissions of the WM projections until 2035 in kt.

| Year | $NO_x$ | NMVOC | $SO_x$ | $NH_3$ | CO |
|---|---|---|---|---|---|
| | kt | kt | kt | kt | kt |
| 2005 | 94 | 112 | 14 | 60 | 305 |
| 2010 | 83 | 97 | 10 | 58 | 241 |
| 2015 | 75 | 80 | 5.8 | 55 | 179 |
| 2020 | 52 | 72 | 3.7 | 53 | 146 |
| 2023 | 47 | 71 | 2.8 | 53 | 139 |
| 2025 | 47 | 70 | 2.9 | 52 | 133 |
| 2030 | 37 | 68 | 3.0 | 49 | 120 |
| 2035 | 30 | 67 | 3.0 | 49 | 108 |
| 2035 vs. 2023 (%) | -35% | -6% | 7% | -7% | -22% |
| 2035 vs. 2005 (%) | -68% | -40% | -79% | -17% | -64% |
| Gothenburg protocol, emission reduction (2020 vs 2005) | | | | | |
| | -41% | -30% | -21% | -8% | – |

## 9.3.1 Projections for $NO_x$

$NO_x$ emissions are projected to continue to decrease until 2035 (see Figure 9-4 and Table 9-5). The most significant reductions are projected for source category 1A3 Transport, which will also remain the main source of $NO_x$ emissions in 2035, as in the latest reporting year. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 1A3 Transport: Emissions are projected to be reduced especially in 1A3b Road Transportation due to improvements in emission abatement technology, improved in-use compliance under real driving conditions for road vehicles (triggered by the Euro 6/VI standards) and a reduction of fuel consumption due to the increase of electromobility (see Figure 9-2).

- 1A4 Other sectors: A reduction of emissions is projected due to measures related to domestic and commercial heating such as better insulation of buildings and increasing use of heat pumps.
- 1A2 Manufacturing industry and construction: Emission reductions are expected due to the so-called $NO_x$ industry agreement with the cement industry (1A2f), which includes a reduction path for the $NO_x$ emission limit value by 2032.
- 3 Agriculture: $NO_x$ emissions from agriculture are projected to remain about constant between 2025-2035. Similar as in the latest reporting year, source category 3D Agricultural soils (in particular 3Da2 Use of organic nitrogen fertilisers) is expected to contribute the largest share of $NO_x$ emissions in 2035.

Table 9-5 WM projections: Trends of $NO_x$ emissions per sector.

| **$NO_x$ emissions** | **2023** | **2025** | **2030** | **2035** | **share in 2023** | **share in 2035** | **2023-2035** |
|---|---|---|---|---|---|---|---|
| | **kt** | **kt** | **kt** | **kt** | | | **kt** |
| 1 Energy | 43 | 43 | 34 | 27 | 92% | 88% | -16 |
| 1A Fuel combustion | 43 | 43 | 34 | 27 | 92% | 88% | -16 |
| *1A1 Energy industries* | 2.6 | 2.7 | 2.7 | 2.8 | 5.6% | 9.1% | 0.17 |
| *1A2 Manufacturing industries and constr.* | 6.5 | 6.9 | 6.1 | 5.6 | 14% | 18% | -1.0 |
| *1A3 Transport* | 25 | 25 | 17 | 12 | 53% | 39% | -13 |
| *1A4 Other sectors* | 8.3 | 8.1 | 7.2 | 6.4 | 18% | 21% | -2.0 |
| *1A5 Other (Military)* | 0.40 | 0.39 | 0.38 | 0.15 | 0.85% | 0.5% | -0.25 |
| 1B Fugitive emissions from fuels | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.001% | 0.002% | 0.00002 |
| 2 IPPU | 0.20 | 0.22 | 0.22 | 0.22 | 0.43% | 0.72% | 0.021 |
| 3 Agriculture | 3.5 | 3.4 | 3.4 | 3.4 | 7.5% | 11% | -0.13 |
| 5 Waste | 0.12 | 0.12 | 0.12 | 0.11 | 0.27% | 0.38% | -0.011 |
| 6 Other | 0.085 | 0.084 | 0.081 | 0.081 | 0.18% | 0.27% | -0.0044 |
| National total | 47 | 47 | 37 | 30 | 100% | 100% | -16 |

## 9.3.2 Projections for NMVOC

NMVOC emissions are projected to remain almost constant between 2025 and 2035 (see Figure 9-4 and Table 9-6). On the one hand, a decrease of NMVOC emissions is expected in source categories 1A3 Transport and 1A4 Other sectors. On the other hand, an increase in the sector 2 IPPU is projected. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 2 IPPU: Population growth and, to some extent, the stagnation of the effects of the VOC incentive tax (Swiss Confederation 1997) are projected to lead to a slight increase of NMVOC emissions.
- 3 Agriculture: Slight reductions of emissions are projected due to the expected development of cattle population.
- 1A3 Transport: Emissions are projected to be reduced especially in 1A3b Road Transportation due to improvements in emission abatement technology, improved in-use compliance under real driving conditions for road vehicles (triggered by the Euro 6/VI standards) and a reduction of fuel consumption due to the increase of electromobility (see Figure 9-2).
- 1A4 Other sectors: A decline of overall fuel consumption, but in particular of log wood in manually operated furnaces, is expected to lead to a reduction of NMVOC emissions (see Figure 9-2).

Table 9-6 WM projections: Trends of NMVOC emissions per sector.

| NMVOC emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | | | kt |
| 1 Energy | 15 | 14 | 12 | 11 | 21% | 16% | -4.6 |
| 1A Fuel combustion | 13 | 12 | 10 | 9.1 | 18% | 14% | -3.8 |
| *1A1 Energy industries* | 0.20 | 0.20 | 0.20 | 0.21 | 0.28% | 0.31% | 0.014 |
| *1A2 Manufacturing industries and constr.* | 0.85 | 0.89 | 0.86 | 0.84 | 1.2% | 1.3% | -0.011 |
| *1A3 Transport* | 7.0 | 6.2 | 5.1 | 4.6 | 9.9% | 6.8% | -2.5 |
| *1A4 Other sectors* | 4.7 | 4.5 | 3.9 | 3.4 | 6.6% | 5.1% | -1.3 |
| *1A5 Other (Military)* | 0.064 | 0.063 | 0.062 | 0.030 | 0.09% | 0.04% | -0.034 |
| 1B Fugitive emissions from fuels | 2.4 | 2.2 | 1.8 | 1.6 | 3.4% | 2.4% | -0.84 |
| 2 IPPU | 36 | 37 | 37 | 37 | 51% | 55% | 0.7 |
| 3 Agriculture | 18 | 17 | 17 | 17 | 25% | 26% | -0.39 |
| 5 Waste | 1.8 | 1.6 | 1.7 | 1.7 | 2.5% | 2.6% | -0.067 |
| 6 Other | 0.17 | 0.17 | 0.16 | 0.16 | 0.23% | 0.24% | -0.006 |
| National total | 71 | 70 | 68 | 67 | 100% | 100% | -4.4 |

### 9.3.3 Projections for $SO_x$

$SO_x$ emissions are projected to remain almost constant between 2025 and 2035 (see Figure 9-4 and Table 9-7). In Figure 9-4 (relative trends), a slight increase of $SO_x$ emissions is visible – however, this increase is very small in absolute numbers. On the one hand, an increase is expected in sector 2 IPPU and source category 1A1 Energy industries. An emission reduction is mainly expected in source categories 1A2 Manufacturing industries and construction and 1A4 Other sectors. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 1A2 Manufacturing industries and construction: A reduction of emissions between 2025 and 2035 is mainly expected due to a projected decline in production volumes and an improve of energy efficiencies in the non-metallic minerals processing industry (rock wool, cement, brick and tile 1A2f).
- 2 IPPU: An increase of the production volume of silicon carbide and graphite (2B5) and thus of the use of sulphur-containing feedstocks is expected.
- 1A1 Energy industries: A slight increase of emissions is expected due to an increase in the use of residual fuel oil in 1A1b Petroleum refining.
- 1A4 Other sectors: The projected decrease is mainly due to an expected reduced use of gas oil because of better insulation of buildings, a higher share of heat pumps as well as a fuel switch to natural gas (revised $CO_2$ law, Swiss Confederation 2011).
- 1A3 Transport: The slight increase of $SO_x$ emissions between 2025 and 2035 is mainly due to an expected increase of international flights up to 2030 (i.e. landing and take-off cycles). In contrast, $SO_x$ emissions from source category 1A3b Road transportation are expected to slightly decrease between 2025 and 2035 as fuel consumption (especially diesel oil) decreases due to the increase of electromobility.

Table 9-7 WM projections: Trends of $SO_x$ emissions per sector.

| $SO_x$ emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | | | kt |
| 1 Energy | 2.5 | 2.5 | 2.5 | 2.4 | 90% | 80% | -0.121 |
| 1A Fuel combustion | 2.5 | 2.5 | 2.5 | 2.4 | 89% | 79% | -0.12 |
| *1A1 Energy industries* | 0.31 | 0.43 | 0.43 | 0.44 | 11% | 14% | 0.12 |
| *1A2 Manufacturing industries and constr.* | 1.6 | 1.5 | 1.5 | 1.4 | 58% | 47% | -0.21 |
| *1A3 Transport* | 0.19 | 0.24 | 0.25 | 0.26 | 6.8% | 8.5% | 0.066 |
| *1A4 Other sectors* | 0.34 | 0.33 | 0.30 | 0.27 | 12% | 8.9% | -0.07 |
| *1A5 Other (Military)* | 0.033 | 0.033 | 0.033 | 0.011 | 1.2% | 0.37% | -0.022 |
| 1B Fugitive emissions from fuels | 0.015 | 0.016 | 0.016 | 0.016 | 0.54% | 0.52% | 0.0006 |
| 2 IPPU | 0.26 | 0.34 | 0.46 | 0.58 | 9% | 19% | 0.32 |
| 3 Agriculture | NA | NA | NA | NA | – | – | – |
| 5 Waste | 0.030 | 0.029 | 0.028 | 0.027 | 1.1% | 0.88% | -0.0035 |
| 6 Other | 0.0072 | 0.0072 | 0.0072 | 0.0072 | 0.25% | 0.24% | 0.00003 |
| National total | 2.8 | 2.9 | 3.0 | 3.0 | 100% | 100% | 0.20 |

### 9.3.4 Projections for $NH_3$

$NH_3$ emissions are projected to remain almost constant between 2025 and 2035 (see Figure 9-4 and Table 9-4). Emission projections for $NH_3$ are highly dependent on sector 3 Agriculture. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 3 Agriculture: Emissions are highly dependent on livestock numbers, particularly cattle. A slight reduction of livestock numbers for cattle until 2027 is expected. Furthermore, the application of existing programs with incentives to introduce low-emission techniques or animal welfare programs is expected to reduce $NH_3$ emissions.
  Note: The emission projections for the sector 3 Agriculture up to 2035 are based on Swiss modelling studies covering the expected development of livestock numbers under specified economic and regulatory conditions (Mack and Möhring 2021). Projections are calculated with unchanged emission factors (except for dairy cattle, see chapter 9.2), which resulted for different livestock categories on the basis of the detailed farm survey carried out in 2019 (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 and boars with constant emission factors for each.
- 6 Other: A slight increase in source category 6A1 Human emissions is expected due to population growth.
- 5 Waste: An increase of the use of biogas is expected, which leads to an increase of $NH_3$ emissions of 5B2 Anaerobic digestion at biogas facilities.

Table 9-8 WM projections: Trends of $NH_3$ emissions per sector.

| $NH_3$ emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | | | kt |
| 1 Energy | 1.3 | 1.2 | 1.2 | 1.2 | 2.4% | 2.3% | -0.10 |
| 1A Fuel combustion | 1.3 | 1.2 | 1.2 | 1.2 | 2.4% | 2.3% | -0.10 |
| *1A1 Energy industries* | 0.042 | 0.044 | 0.048 | 0.049 | 0.08% | 0.10% | 0.007 |
| *1A2 Manufacturing industries and constr.* | 0.21 | 0.23 | 0.23 | 0.22 | 0.40% | 0.45% | 0.014 |
| *1A3 Transport* | 0.90 | 0.85 | 0.82 | 0.78 | 1.7% | 1.6% | -0.12 |
| *1A4 Other sectors* | 0.10 | 0.10 | 0.10 | 0.096 | 0.19% | 0.20% | -0.0066 |
| *1A5 Other (Military)* | 0.00004 | 0.00004 | 0.00004 | 0.00004 | 0.00008% | 0.00008% | -0.0000006 |
| 1B Fugitive emissions from fuels | NA | NA | NA | NA | – | – | – |
| 2 IPPU | 0.13 | 0.14 | 0.12 | 0.11 | 0.25% | 0.22% | -0.022 |
| 3 Agriculture | 50 | 48 | 46 | 46 | 94% | 94% | -3.3 |
| 5 Waste | 0.86 | 0.82 | 0.84 | 0.86 | 1.6% | 1.7% | -0.0065 |
| 6 Other | 0.97 | 0.96 | 0.95 | 0.95 | 1.8% | 1.9% | -0.017 |
| National total | 53 | 52 | 49 | 49 | 100% | 100% | -3.5 |

## 9.3.5 Projections for CO

CO emissions are projected to continue to decrease until 2035 (see Figure 9-4 and Table 9-9). Similar to $NO_x$, the most significant reductions are expected to happen in source category 1A3 Transport and 1A4 Other sectors, which will also remain the main sources of CO emissions in 2035. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 1A4 Other sectors: Emission reductions are expected due to measures related to domestic heating such as better insulation of buildings, higher share of heat pumps, both continuous technological improvements of wood combustion installations and decrease in wood energy consumption in manually operated furnaces as well as further reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves).
- 1A3 Transport: Further improvements in emission abatement technology (triggered by the Euro 6/VI standards) and a reduction of fuel consumption due to the increase of electromobility (see Figure 9-2) are expected to lead to emission reductions.
- 1A2 Manufacturing industries and construction: A minor reduction between 2025 and 2035 is expected due to an expected higher proportion of modern wood combustion plants with lower proportions of non-optimal operating phases and a projected decline of the production volumes and improve of energy efficiencies in the non-metallic minerals processing industry (1A2f).
- 2 IPPU: Emissions are projected to slightly increase between 2025 and 2035, especially due to an expected increase of the production volume of silicon carbide and graphite (2B5).

Table 9-9 WM projections: Trends of CO emissions per sector.

| CO emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | | | kt |
| 1 Energy | 133 | 126 | 112 | 101 | 96% | 93% | -32 |
| 1A Fuel combustion | 133 | 126 | 112 | 101 | 96% | 93% | -32 |
| *1A1 Energy industries* | 0.66 | 0.68 | 0.70 | 0.68 | 0.47% | 0.63% | 0.026 |
| *1A2 Manufacturing industries and constr.* | 14 | 15 | 15 | 15 | 10% | 14% | 0.46 |
| *1A3 Transport* | 63 | 57 | 48 | 42 | 45% | 39% | -21 |
| *1A4 Other sectors* | 54 | 52 | 48 | 43 | 39% | 39% | -11 |
| *1A5 Other (Military)* | 0.76 | 0.76 | 0.76 | 0.53 | 0.55% | 0.49% | -0.24 |
| 1B Fugitive emissions from fuels | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001% | 0.0001% | 0.000005 |
| 2 IPPU | 4.4 | 5.2 | 5.7 | 6.2 | 3.2% | 5.7% | 1.8 |
| 3 Agriculture | NA | NA | NA | NA | – | – | – |
| 5 Waste | 1.4 | 1.3 | 1.2 | 1.1 | 0.99% | 0.99% | -0.29 |
| 6 Other | 0.46 | 0.45 | 0.42 | 0.41 | 0.33% | 0.38% | -0.045 |
| National total | 139 | 133 | 120 | 108 | 100% | 100% | -30 |

## 9.4 Suspended particulate matter

According to the projections, exhaust and non-exhaust suspended particulate matter emissions are expected to develop differently between 2025 and 2035. While non-exhaust emissions of all fractions increase, exhaust emissions decrease (see Figure 9-5, Table 9-10 and Table 9-11). Overall, this leads to a decrease of the smaller fractions of suspended particulate matter (PM2.5) and BC between 2025 and 2035 (see Figure 9-6 and Table 9-12). In contrast, the larger PM fractions (PM10, TSP) are expected to remain at more or less constant levels. The gaps in Figure 9-5 and Figure 9-6 between the latest reporting year and 2025 symbolise the fact that most of the scenarios used to calculate emissions projections for the individual sectors and source categories cover the period from 2025 onwards. Accordingly, the emissions in between are interpolated linearly.

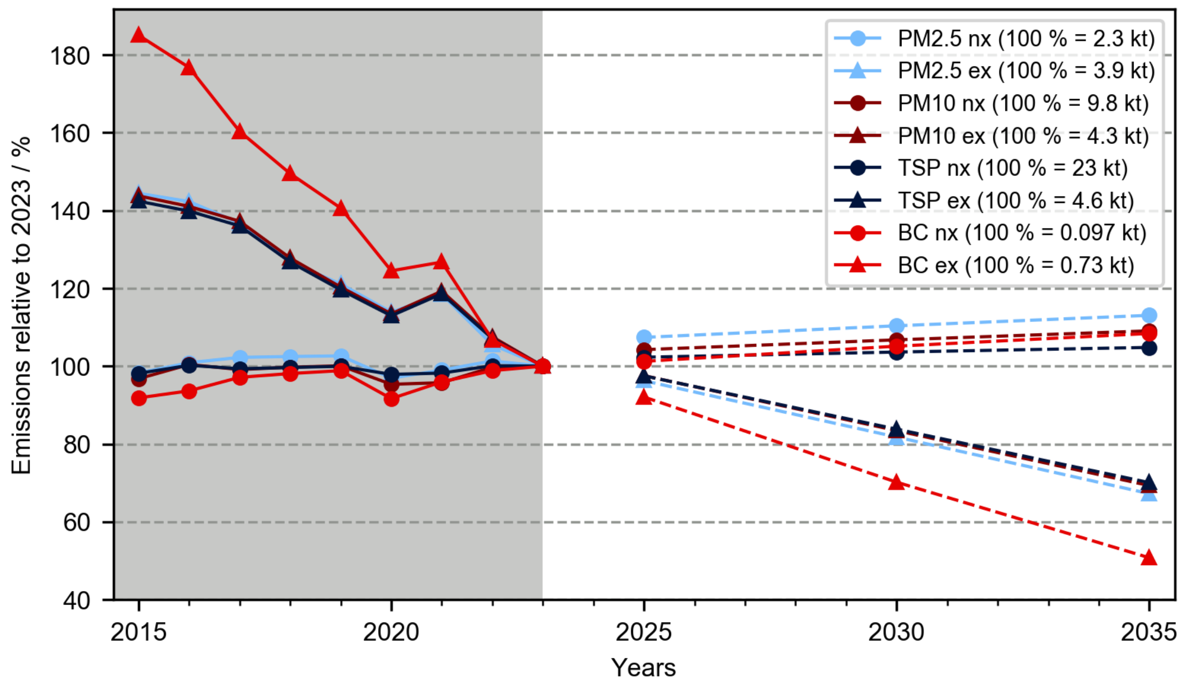



Figure 9-5 Projection of exhaust and non-exhaust emissions of suspended particulate matter PM2.5, PM10, TSP and BC in Switzerland of the WM scenario. 100 % corresponds to levels of the latest reporting year.

Table 9-10 Suspended particulate matter: Total exhaust emissions of the WM projections until 2035 in kt.

| Year | PM2.5 ex | PM10 ex | TSP ex | BC ex |
|---|---|---|---|---|
| | kt | kt | kt | kt |
| 2005 | 12 | 13 | 13 | 3.4 |
| 2010 | 8.9 | 9.7 | 10 | 2.5 |
| 2015 | 5.6 | 6.2 | 6.6 | 1.3 |
| 2020 | 4.4 | 4.9 | 5.2 | 0.91 |
| 2023 | 3.9 | 4.3 | 4.6 | 0.73 |
| 2025 | 3.8 | 4.2 | 4.5 | 0.68 |
| 2030 | 3.3 | 3.7 | 4.0 | 0.52 |
| 2035 | 2.6 | 3.0 | 3.2 | 0.37 |
| 2035 vs. 2023 (%) | -33% | -31% | -30% | -49% |

Table 9-11 Suspended particulate matter: Total non-exhaust emissions of the WM projections until 2035 in kt.

| Year | PM2.5 nx | PM10 nx | TSP nx | BC nx |
|---|---|---|---|---|
| | kt | kt | kt | kt |
| 2005 | 2.2 | 9.0 | 22 | 0.082 |
| 2010 | 2.3 | 9.5 | 23 | 0.088 |
| 2015 | 2.3 | 9.5 | 23 | 0.090 |
| 2020 | 2.3 | 9.4 | 23 | 0.092 |
| 2023 | 2.3 | 9.7 | 23 | 0.096 |
| 2025 | 2.4 | 10 | 23 | 0.098 |
| 2030 | 2.5 | 10 | 24 | 0.10 |
| 2035 | 2.5 | 10 | 24 | 0.11 |
| 2035 vs. 2023 (%) | 10% | 3% | 1% | 10% |

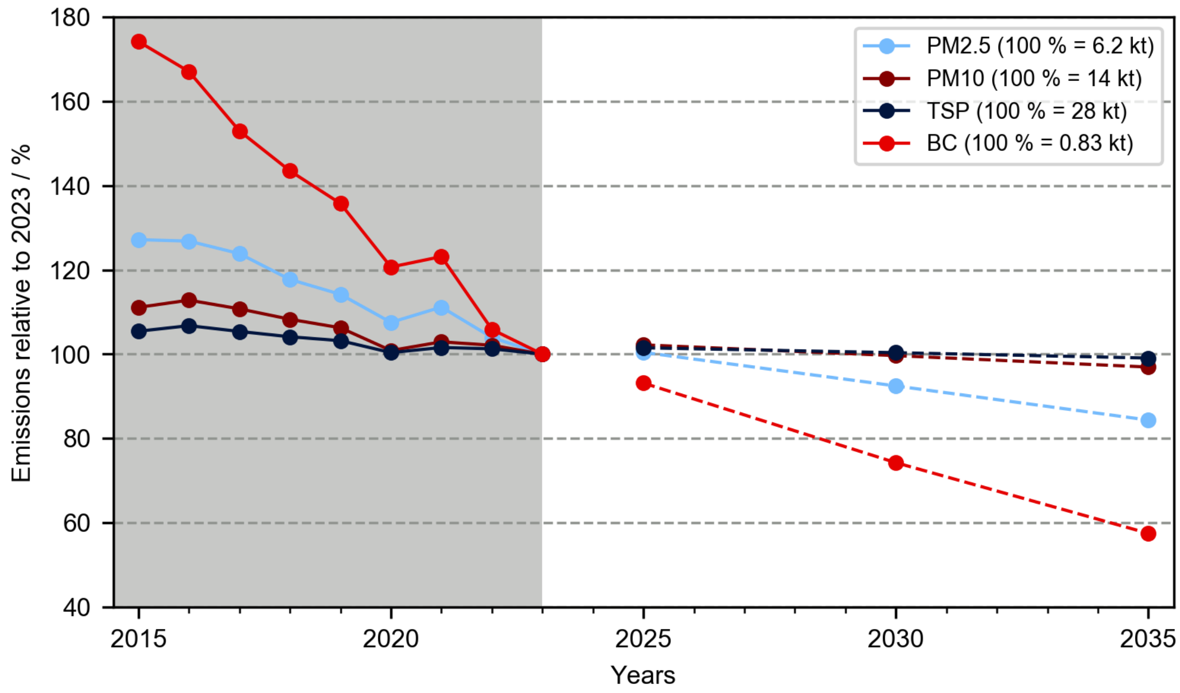



Figure 9-6 Projection of total emissions of suspended particulate matter PM2.5, PM10, TSP and BC in Switzerland of the WM (WEM) scenario. 100 % corresponds to levels of the latest reporting year. The figure shows the sum of exhaust and non-exhaust particles.

Table 9-12 Suspended particulate matter: Total emissions of the WM projections until 2035 in kt.

| Year | PM2.5 | PM10 | TSP | BC |
|---|---|---|---|---|
| | kt | kt | kt | kt |
| 2005 | 14 | 21 | 36 | 3.5 |
| 2010 | 11 | 19 | 33 | 2.6 |
| 2015 | 7.9 | 16 | 30 | 1.4 |
| 2020 | 6.7 | 14 | 28 | 1.0 |
| 2023 | 6.2 | 14 | 28 | 0.83 |
| 2025 | 6.3 | 14 | 28 | 0.77 |
| 2030 | 5.8 | 14 | 28 | 0.62 |
| 2035 | 5.3 | 14 | 28 | 0.48 |
| 2035 vs. 2023 (%) | -16% | -3% | -1% | -42% |
| 2035 vs. 2005 (%) | -62% | -36% | -22% | -87% |
| Gothenburg protocol, emission reduction (2020 vs 2005) | | | | |
| | -26% | – | – | – |

## 9.4.1 Projections for PM2.5

PM2.5 emissions are projected to continue to decrease until 2035 (see Figure 9-6 and Table 9-13). The most significant reductions are expected in source category 1A4 Other sectors. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 1A4 Other sectors: Continuous technological improvements of small wood combustion installations (due to compliance with stricter air pollution control requirements from 2007 onwards) and a further reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves) lead to projected emission reductions. Furthermore, a decrease in wood energy consumption in manually operated furnaces is expected.
- 1A3 Transport: Emissions are expected to remain about constant between 2025 and 2035. In source category 1A3b Road transportation, the ongoing replacement of older vehicles with vehicles with stricter emission standards or with electric engines will lead to reduced PM2.5 exhaust emissions. However, at the same time non-exhaust emissions are expected to increase with increasing activity (vehicle kilometres), which partially compensates the decrease of exhaust emissions. This effect is more relevant for the larger particles (TSP, PM10) and less for smaller fractions.
- 2 IPPU: The main contributors to PM2.5 emissions are source categories 2A Mineral industry (especially 2A1 Cement production), 2G Other product manufacture and use and 2H Other (especially 2H1 Pulp and paper and 2H2 Food and beverages industry). The emissions of all these source categories are expected to remain about constant between 2025 and 2035.
- 1A2 Manufacturing industries and construction: An emission reduction is projected due to the expected higher proportion of modern wood combustion plants with lower proportions of non-optimal operating phases (1A2gviii Other boilers and engines industry).

Table 9-13 WM projections: Trends of PM2.5 emissions per sector.

| PM2.5 emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | | | kt |
| 1 Energy | 4.8 | 4.7 | 4.2 | 3.7 | 77% | 71% | -1.1 |
| 1A Fuel combustion | 4.8 | 4.7 | 4.2 | 3.7 | 77% | 71% | -1.1 |
| *1A1 Energy industries* | 0.061 | 0.071 | 0.073 | 0.074 | 0.98% | 1.4% | 0.013 |
| *1A2 Manufacturing industries and constr.* | 0.62 | 0.60 | 0.57 | 0.53 | 10% | 10% | -0.086 |
| *1A3 Transport* | 1.5 | 1.5 | 1.5 | 1.5 | 24% | 29% | 0.045 |
| *1A4 Other sectors* | 2.6 | 2.4 | 2.0 | 1.5 | 42% | 29% | -1.1 |
| *1A5 Other (Military)* | 0.045 | 0.045 | 0.045 | 0.041 | 0.72% | 0.78% | -0.0039 |
| 1B Fugitive emissions from fuels | 0.00004 | 0.00004 | 0.00004 | 0.00004 | 0.0006% | 0.0007% | -0.000001 |
| 2 IPPU | 0.99 | 1.2 | 1.2 | 1.2 | 16% | 23% | 0.22 |
| 3 Agriculture | 0.15 | 0.15 | 0.14 | 0.14 | 2.3% | 2.8% | -0.0009 |
| 5 Waste | 0.27 | 0.26 | 0.22 | 0.19 | 4.3% | 3.6% | -0.082 |
| 6 Other | 0.0047 | 0.0047 | 0.0047 | 0.0046 | 0.08% | 0.09% | -0.00004 |
| National total | 6.2 | 6.3 | 5.8 | 5.3 | 100% | 100% | -0.97 |

### 9.4.2 Projections for PM10

PM10 emissions are projected to remain about constant between 2025-2035 (see Figure 9-6 and Table 9-14). A decrease is expected in source category 1A4 Other sectors. On the opposite, an increase is expected in source category 1A3 Transport. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 1A3 Transport: Despite of a reduction of exhaust emissions due to the ongoing replacement of older vehicles with vehicles with tightened emission standards or with electric engines, the projected increase of vehicle kilometres and thereby increase of non-exhaust emissions leads to an overall increase in PM10 emissions.
- 1A2 Manufacturing industries and construction: As for PM2.5, there is an emission reduction projected for wood energy combustion (higher proportion of modern combustion plants with lower proportions of non-optimal operating phases, 1A2gviii). However, this will be offset by an increase in non-exhaust PM10 emissions from the re-suspension of construction machinery (1A2gvii), the dominant PM emission source within 1A2, due to a predicted increase in activity.
- 2 IPPU: Similar to PM2.5, the main contributors to PM10 emissions are source categories 2A Mineral industry (especially 2A1 Cement production and 2A5a Quarrying and mining of minerals other than coal), 2G Other product manufacture and use and 2H Other (especially 2H1 Pulp and paper and 2H2 Food and beverages industry). In addition, also source category 2I Wood processing is relevant for PM10 emissions. The emissions of all these source categories are expected to remain about constant between 2025 and 2035.
- 3 Agriculture: PM10 emissions originate from source categories 3De Cultivated crops and 3B Manure management (especially 3B4g Poultry, due to high livestock numbers) and are assumed to remain about constant until 2035.
- 1A4 Other sectors: As for PM2.5, continuous technological improvements of small wood combustion installations (due to compliance with stricter air pollution control requirements from 2007 onwards) and a further reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves) lead to the projected emission reductions. Furthermore, a decrease in wood energy consumption in manually operated furnaces is expected.

Table 9-14 WM projections: Trends of PM10 emissions per sector.

| PM10 emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | | | kt |
| 1 Energy | 10 | 10 | 9.9 | 9.5 | 72% | 70% | -0.6 |
| 1A Fuel combustion | 10 | 10 | 9.9 | 9.5 | 72% | 70% | -0.6 |
| *1A1 Energy industries* | 0.062 | 0.072 | 0.074 | 0.075 | 0.44% | 0.55% | 0.013 |
| *1A2 Manufacturing industries and constr.* | 2.6 | 2.6 | 2.7 | 2.7 | 19% | 19% | 0.010 |
| *1A3 Transport* | 4.4 | 4.6 | 4.8 | 4.9 | 31% | 36% | 0.49 |
| *1A4 Other sectors* | 2.8 | 2.6 | 2.1 | 1.7 | 20% | 12% | -1.1 |
| *1A5 Other (Military)* | 0.26 | 0.26 | 0.26 | 0.26 | 1.9% | 1.9% | -0.0049 |
| 1B Fugitive emissions from fuels | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.003% | 0.003% | 0.00 |
| 2 IPPU | 1.7 | 2.0 | 2.0 | 2.0 | 12% | 15% | 0.31 |
| 3 Agriculture | 1.8 | 1.8 | 1.8 | 1.8 | 13% | 13% | -0.002 |
| 5 Waste | 0.30 | 0.29 | 0.25 | 0.21 | 2.1% | 1.5% | -0.09 |
| 6 Other | 0.11 | 0.11 | 0.10 | 0.10 | 0.8% | 0.7% | -0.012 |
| National total | 14 | 14 | 14 | 14 | 100% | 100% | -0.43 |

### 9.4.3 Projections for TSP

The opposing trend of exhaust and non-exhaust emissions is best visible for the largest fractions of particulate matter: exhaust emissions are expected to decrease, whereas non-exhaust emissions increase. Overall, TSP emissions are projected to remain about constant between 2025-2035 (see Figure 9-6 and Table 9-15, Table 9-16, Table 9-17). An important source of TSP, where emissions are expected to remain constant, is sector 5 Agriculture. An increase of TSP emissions is expected in source category 1A3 Transport and a decrease in source category 1A4 Other sectors and sector 5 Waste. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 3 Agriculture: The sector contributes considerably to total TSP emissions. They are dominated by non-exhaust TSP emissions from source category 3De Cultivated crops (field and arable tillage) that are assumed to remain about constant until 2035. Thus, the relative share of agriculture sector on total TSP emissions is increasing over time (since exhaust TSP emissions from the energy sector are generally decreasing). Considering both non-exhaust and total TSP emissions, agriculture even is and remains the predominating emission source.
  It should be noted that these emissions (3De) have a very high degree of uncertainty, since the EMEP/EEA guidebook (EMEP/EEA 2023) provides emission factors for PM10 and PM2.5 only. A couple of European countries assume for TSP the same values as for PM10. But this assumption does not seem appropriate, 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 estimated according to the Danish emission inventory (Danish Informative Inventory Report 2018) with a fraction of PM10/TSP of 10 %.
- 1A3 Transport: Despite a reduction of exhaust emissions due to the ongoing replacement of older vehicles with vehicles with tightened emission standards or with electric engines, the projected increase of vehicle kilometres and thereby increase of non-exhaust emissions leads to an overall increase in TSP emissions.
- 1A2 Manufacturing industries and construction: As for PM10, an emission reduction is projected for wood energy combustion (higher proportion of modern combustion plants with lower proportions of non-optimal operating phases, 1A2gviii), which will be offset by an increase in non-exhaust PM emissions from the re-suspension of construction machinery (1A2gvii), the dominant PM emission source within 1A2, due to a predicted increase in activity.

- 2 IPPU: Similar to PM10, the main contributors to TSP emissions are source categories 2A Mineral industry (especially 2A1 Cement production and 2A5 Quarrying and mining of minerals other than coal), 2G Other product manufacture and use, 2H Other (especially 2H1 Pulp and paper and 2H2 Food and beverages industry).and 2I Wood processing. The emissions of all these source categories are expected to remain about constant between 2025 and 2035.
- 1A4 Other sectors: Continuous technological improvements of small wood combustion installations (due to compliance with stricter air pollution control requirements from 2007 onwards) and a further reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves) lead to projected emission reductions. Furthermore, a decrease in wood energy consumption in manually operated furnaces is expected.
- 5 Waste: The projected reduction of TSP emissions is mainly due to an assumed reduction of illegal waste incineration (in source category 5C1a).

Table 9-15 WM projections: Trends of total TSP emissions per sector.

| **TSP emissions** | **2023** | **2025** | **2030** | **2035** | **share in 2023** | **share in 2035** | **2023-2035** |
|---|---|---|---|---|---|---|---|
| | **kt** | **kt** | **kt** | **kt** | | | **kt** |
| 1 Energy | 12 | 12 | 12 | 12 | 43% | 42% | -0.50 |
| 1A Fuel combustion | 12 | 12 | 12 | 12 | 43% | 42% | -0.50 |
| *1A1 Energy industries* | 0.065 | 0.077 | 0.079 | 0.080 | 0.23% | 0.29% | 0.014 |
| *1A2 Manufacturing industries and constr.* | 3.8 | 3.8 | 3.9 | 3.9 | 14% | 14% | 0.064 |
| *1A3 Transport* | 4.9 | 5.2 | 5.4 | 5.5 | 17% | 20% | 0.62 |
| *1A4 Other sectors* | 2.9 | 2.7 | 2.3 | 1.8 | 10% | 6.3% | -1.2 |
| *1A5 Other (Military)* | 0.39 | 0.39 | 0.39 | 0.38 | 1.4% | 1.4% | -0.0055 |
| 1B Fugitive emissions from fuels | 0.0009 | 0.0010 | 0.0010 | 0.0009 | 0.0034% | 0.0033% | -0.00002 |
| 2 IPPU | 2.8 | 3.1 | 3.1 | 3.1 | 10% | 11% | 0.35 |
| 3 Agriculture | 13 | 13 | 13 | 13 | 45% | 45% | 0.018 |
| 5 Waste | 0.37 | 0.35 | 0.30 | 0.25 | 1.3% | 0.91% | -0.11 |
| 6 Other | 0.20 | 0.20 | 0.20 | 0.19 | 0.72% | 0.70% | -0.009 |
| National total | 28 | 28 | 28 | 28 | 100% | 100% | -0.26 |

Table 9-16 WM projections: Trends of TSP exhaust emissions per sector.

| **TSP exhaust emissions** | **2023** | **2025** | **2030** | **2035** | **share in 2023** | **share in 2035** | **2023-2035** |
|---|---|---|---|---|---|---|---|
| | **kt** | **kt** | **kt** | **kt** | | | **kt** |
| 1 Energy | 3.5 | 3.3 | 2.7 | 2.1 | 76% | 66% | -1.4 |
| 1A Fuel combustion | 3.5 | 3.3 | 2.7 | 2.1 | 76% | 66% | -1.4 |
| *1A1 Energy industries* | 0.065 | 0.077 | 0.079 | 0.080 | 1.4% | 2.5% | 0.014 |
| *1A2 Manufacturing industries and constr.* | 0.33 | 0.30 | 0.26 | 0.21 | 7.0% | 6.5% | -0.12 |
| *1A3 Transport* | 0.28 | 0.29 | 0.22 | 0.19 | 6.0% | 5.8% | -0.09 |
| *1A4 Other sectors* | 2.8 | 2.6 | 2.2 | 1.7 | 61% | 51% | -1.19 |
| *1A5 Other (Military)* | 0.0066 | 0.0065 | 0.0064 | 0.0029 | 0.14% | 0.09% | -0.0038 |
| 1B Fugitive emissions from fuels | 0.000001 | 0.000001 | 0.000001 | 0.000001 | 0.00003% | 0.00004% | 0.00000004 |
| 2 IPPU | 0.57 | 0.69 | 0.69 | 0.69 | 12% | 21% | 0.122 |
| 3 Agriculture | NA | NA | NA | NA | – | – | – |
| 5 Waste | 0.36 | 0.34 | 0.30 | 0.25 | 7.8% | 7.6% | -0.11 |
| 6 Other | 0.18 | 0.18 | 0.17 | 0.17 | 3.9% | 5.3% | -0.009 |
| National total | 4.6 | 4.5 | 3.9 | 3.2 | 100% | 100% | -1.4 |

Table 9-17 WM projections: Trends of TSP non-exhaust emissions per sector.

| TSP non-exhaust emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | | | kt |
| 1 Energy | 8.6 | 8.9 | 9.2 | 9.5 | 37% | 39% | 0.88 |
| 1A Fuel combustion | 8.6 | 8.9 | 9.2 | 9.5 | 37% | 39% | 0.88 |
| *1A1 Energy industries* | NA | NA | NA | NA | – | – | – |
| *1A2 Manufacturing industries and constr.* | 3.5 | 3.5 | 3.6 | 3.7 | 15% | 15% | 0.18 |
| *1A3 Transport* | 4.6 | 4.9 | 5.1 | 5.3 | 20% | 22% | 0.71 |
| *1A4 Other sectors* | 0.10 | 0.10 | 0.098 | 0.096 | 0.44% | 0.39% | -0.0061 |
| *1A5 Other (Military)* | 0.38 | 0.38 | 0.38 | 0.38 | 1.6% | 1.5% | -0.0017 |
| 1B Fugitive emissions from fuels | 0.0009 | 0.0010 | 0.0010 | 0.0009 | 0.004% | 0.004% | -0.00002 |
| 2 IPPU | 2.2 | 2.4 | 2.4 | 2.4 | 9.5% | 10% | 0.23 |
| 3 Agriculture | 13 | 13 | 13 | 13 | 54% | 51% | 0.018 |
| 5 Waste | 0.0036 | 0.0036 | 0.0036 | 0.0036 | 0.02% | 0.01% | – |
| 6 Other | 0.022 | 0.022 | 0.022 | 0.022 | 0.09% | 0.09% | -0.0001 |
| National total | 23 | 24 | 24 | 25 | 100% | 100% | 1.1 |

### 9.4.4 Projections for BC

The decreasing trend of emissions from PM2.5 is also reflected in the trends of BC emissions and is even more pronounced since the reduction measures mainly focus on combustion particles which largely consists of BC (see Figure 9-6 and Table 9-18). The decrease is mainly expected in source categories 1A4 Other sectors and 1A3 Transport. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 1A4 Other sectors: Continuous technological improvements of small wood combustion installations (due to compliance with stricter air pollution control requirements from 2007 onwards) and a further reduction in the number of emission intensive types of wood furnaces (e.g. cooking stoves) lead to projected emission reductions. Furthermore, a decrease in wood energy consumption in manually operated furnaces is expected.
- 1A3 Transport: Emissions are expected slightly decline between 2025 and 2035. In source category 1A3b Road transport, the ongoing replacement of older vehicles with vehicles with tightened emission standards or with electric engines will lead to reduced BC emissions.

Table 9-18 WM projections: Trends of BC emissions per sector.

| BC emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | kt | kt | kt | kt | | | kt |
| 1 Energy | 0.81 | 0.76 | 0.60 | 0.46 | 98% | 97% | -0.35 |
| 1A Fuel combustion | 0.81 | 0.76 | 0.60 | 0.46 | 97% | 97% | -0.35 |
| *1A1 Energy industries* | 0.0072 | 0.0083 | 0.0084 | 0.0084 | 0.87% | 1.7% | 0.0011 |
| *1A2 Manufacturing industries and constr.* | 0.030 | 0.022 | 0.013 | 0.010 | 3.6% | 2.1% | -0.020 |
| *1A3 Transport* | 0.19 | 0.19 | 0.16 | 0.15 | 23% | 31% | -0.041 |
| *1A4 Other sectors* | 0.58 | 0.53 | 0.41 | 0.29 | 70% | 62% | -0.29 |
| *1A5 Other (Military)* | 0.0032 | 0.0032 | 0.0030 | 0.0014 | 0.39% | 0.28% | -0.0019 |
| 1B Fugitive emissions from fuels | 0.00002 | 0.00003 | 0.00002 | 0.00002 | 0.003% | 0.005% | -0.0000004 |
| 2 IPPU | 0.0012 | 0.0012 | 0.0013 | 0.0013 | 0.15% | 0.27% | 0.00007 |
| 3 Agriculture | NA | NA | NA | NA | – | – | – |
| 5 Waste | 0.019 | 0.019 | 0.016 | 0.014 | 2.3% | 2.9% | -0.0057 |
| 6 Other | 0.00008 | 0.00008 | 0.00007 | 0.00007 | 0.009% | 0.01% | -0.00001 |
| National total | 0.83 | 0.77 | 0.62 | 0.48 | 100% | 100% | -0.35 |

## 9.5 Priority heavy metals

According to the projections, total Pb emissions will decrease between 2025 and 2035 whereas total Cd and Hg emissions are remaining about constant. The gaps in Figure 9-7 between the latest reporting year and 2025 symbolises the fact that most of the scenarios used to calculate emissions projections for the individual sectors and source categories cover the period from 2025 onwards. Accordingly, the emissions in between are interpolated linearly.

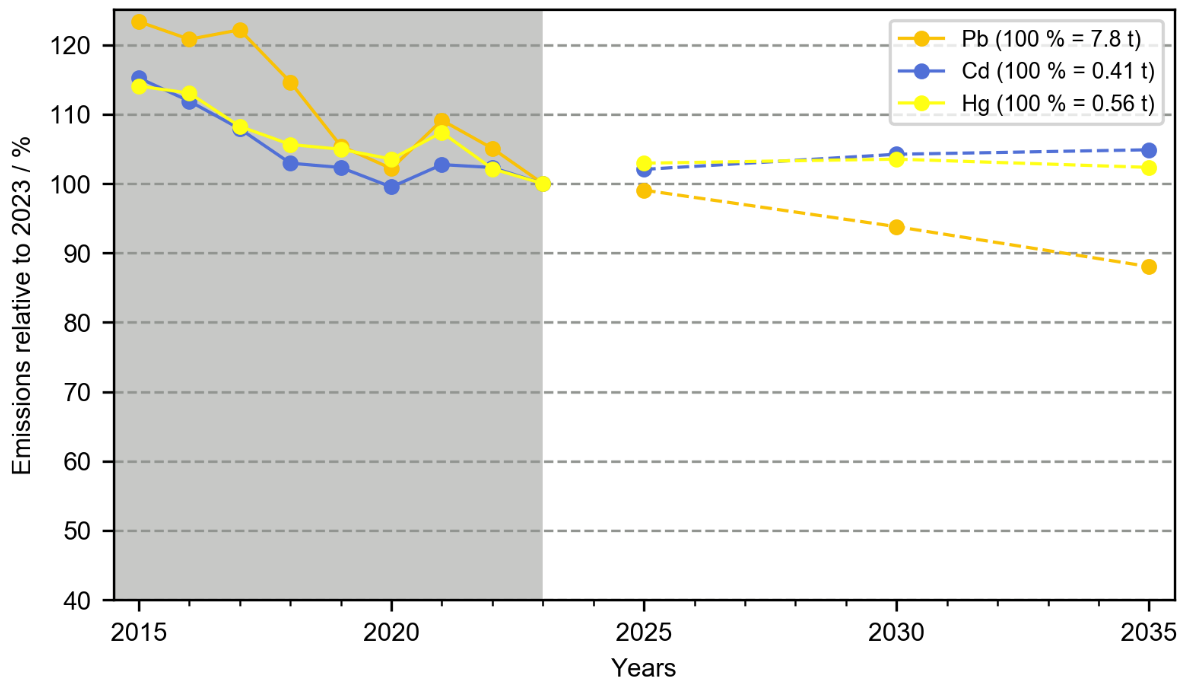



Figure 9-7 Relative trends for the total emissions of priority heavy metals in Switzerland as projected in the WM scenario. 100 % corresponds to levels of the latest reporting year.

Table 9-19 Priority heavy metals: Total emissions of the WM projections until 2035 in t.

| **Year** | **Pb** | **Cd** | **Hg** |
|---|---|---|---|
| | t | t | t |
| 2005 | 18 | 0.48 | 0.73 |
| 2010 | 12 | 0.50 | 0.74 |
| 2015 | 9.6 | 0.47 | 0.64 |
| 2020 | 8.0 | 0.41 | 0.58 |
| 2023 | 7.8 | 0.41 | 0.56 |
| 2025 | 7.7 | 0.42 | 0.58 |
| 2030 | 7.3 | 0.42 | 0.58 |
| 2035 | 6.9 | 0.43 | 0.58 |
| 2035 vs. 2023 (%) | -12% | 5% | 2% |

### 9.5.1 Projections for lead (Pb)

Pb emissions are projected to continue to decrease until 2035 (see Table 9-20 and Figure 9-7). The most significant reductions are expected in sectors 5 Waste, 6 Other and 1A4

Other sectors. In return, an increase is projected in source category 1A1 Energy industries. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 1A1 Energy industries: Pb emissions are expected to increase due to growing amounts of waste and wood waste incinerated.
- 6 Other: It is assumed that the number of buildings fires (under the source category 6A4 Fire damage buildings and motor vehicles) will continue to decrease between 2025 and 2035 due to improvement in safety. In parallel, we expect newly constructed and renovated buildings to contain much less lead due to a continuous increase in the ban of lead in many products, as enforced by the Chemical Risk Reduction Ordinance ORRChem (Swiss Confederation 2005).
- 5 Waste: The projected reduction of Pb emissions is mainly due to an assumed reduction of illegal waste incineration (in source category 5C1a).
- 1A2 Manufacturing industries and construction: The main contributors to Pb emissions are source categories 1A2gviii Other (especially wood waste and wood) and 1A2f Non-metallic minerals. Emissions from these source categories are projected to remain about constant between 2025 and 2035.
- 1A3 Transport: Emissions are dominated by source category 1A3a Civil aviation and are projected to slightly decrease.
- 2 IPPU: The main contributors to Pb emissions are source categories 2C1 Iron and steel production and 2G Other product use. The emissions from these source categories are projected to remain about constant between 2025 and 2035.
- 1A4 Other sectors: A reduction of emissions is expected through continuous technological improvements in small wood combustion installations, a further reduction in the number of emission intensive types of wood furnaces and in the combustion of wood in manually operated furnaces and wood waste in commercial installations (source category 1A4ai).

Table 9-20 WM projections: Trends of Pb emissions per sector.

| **Pb emissions** | **2023** | **2025** | **2030** | **2035** | **share in 2023** | **share in 2035** | **2023-2035** |
|---|---|---|---|---|---|---|---|
| | t | t | t | t | | | t |
| 1 Energy | 4.0 | 4.0 | 4.1 | 4.0 | 52% | 58% | -0.06 |
| 1A Fuel combustion | 4.0 | 4.0 | 4.1 | 4.0 | 52% | 58% | -0.06 |
| *1A1 Energy industries* | 1.7 | 1.7 | 1.8 | 1.8 | 22% | 27% | 0.12 |
| *1A2 Manufacturing industries and constr.* | 0.89 | 0.90 | 0.96 | 0.93 | 11% | 14% | 0.04 |
| *1A3 Transport* | 0.84 | 0.85 | 0.83 | 0.82 | 11% | 12% | -0.024 |
| *1A4 Other sectors* | 0.57 | 0.53 | 0.45 | 0.37 | 7.3% | 5.3% | -0.20 |
| *1A5 Other (Military)* | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.003% | 0.003% | -0.000004 |
| 1B Fugitive emissions from fuels | 0.000002 | 0.000002 | 0.000002 | 0.000002 | 0.00003% | 0.00003% | 0.0000001 |
| 2 IPPU | 0.51 | 0.59 | 0.59 | 0.59 | 6.5% | 8.6% | 0.080 |
| 3 Agriculture | NA | NA | NA | NA | – | – | – |
| 5 Waste | 1.6 | 1.5 | 1.2 | 1.0 | 20% | 15% | -0.57 |
| 6 Other | 1.7 | 1.6 | 1.4 | 1.3 | 22% | 19% | -0.38 |
| National total | 7.8 | 7.7 | 7.3 | 6.9 | 100% | 100% | -0.93 |

### 9.5.2 Projections for cadmium (Cd)

Cadmium emissions are expected to remain about constant until 2035 (see Table 9-21 and Figure 9-7). Only marginal changes of cadmium emission levels are projected for any sector. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 1A1 Energy industries: A slight increase is projected due to population growth and thereby increased amount of waste incinerated as well as an increase in consumption of wood and wood waste.
- 1A3 Transport: An increase of traffic volumes is projected to also lead to a slight increase of Cd emissions from tyre abrasion.
- 1A2 Manufacturing industries and construction: Emissions are expected to remain about constant. Minor changes are expected due to changes in activity, especially increased activity in source category 1A2gvii Mobile combustion in manufacturing industries and construction (non-road vehicles and machinery) or reduced production volumes in source category 1A2f Non-metallic minerals.
- 1A4 Other sectors: Emissions are expected to remain about constant. Minor changes are expected through continuous technological improvements in small wood combustion installations and a reduction in the number of emission intensive types of wood furnaces and in the combustion of wood in manually operated.
- 2 IPPU: The main contributor to Cd emissions is source category 2G Other product use (tobacco consumption and fireworks use), where emissions are projected to remain about constant.

Table 9-21 WM projections: Trends of Cd emissions per sector.

| **Cd emissions** | **2023** | **2025** | **2030** | **2035** | **share in 2023** | **share in 2035** | **2023-2035** |
|---|---|---|---|---|---|---|---|
| | **t** | **t** | **t** | **t** | | | **t** |
| 1 Energy | 0.37 | 0.37 | 0.38 | 0.38 | 90% | 90% | 0.019 |
| 1A Fuel combustion | 0.37 | 0.37 | 0.38 | 0.38 | 90% | 90% | 0.019 |
| *1A1 Energy industries* | 0.15 | 0.15 | 0.16 | 0.16 | 37% | 38% | 0.011 |
| *1A2 Manufacturing industries and constr.* | 0.066 | 0.070 | 0.071 | 0.070 | 16% | 16% | 0.0045 |
| *1A3 Transport* | 0.096 | 0.097 | 0.10 | 0.10 | 24% | 24% | 0.0072 |
| *1A4 Other sectors* | 0.051 | 0.050 | 0.049 | 0.047 | 12% | 11% | -0.0038 |
| *1A5 Other (Military)* | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.13% | 0.12% | -0.000008 |
| 1B Fugitive emissions from fuels | 0.000003 | 0.000003 | 0.000003 | 0.000003 | 0.0007% | 0.0007% | 0.0000001 |
| 2 IPPU | 0.031 | 0.033 | 0.033 | 0.033 | 7.6% | 7.8% | 0.0024 |
| 3 Agriculture | NA | NA | NA | NA | – | – | – |
| 5 Waste | 0.0088 | 0.0086 | 0.0082 | 0.0078 | 2.2% | 1.8% | -0.0010 |
| 6 Other | 0.0016 | 0.0016 | 0.0016 | 0.0016 | 0.40% | 0.37% | -0.00002 |
| National total | 0.41 | 0.42 | 0.42 | 0.43 | 100% | 100% | 0.020 |

### 9.5.3 Projections for mercury (Hg)

Mercury emissions are expected to remain about constant until 2035 (see Table 9-22 and Figure 9-7). Only marginal changes of mercury emission levels are projected for any sector. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 1A1 Energy industries: An increase is projected as a result of an increase in the amounts of waste, wood and wood waste incinerated.
- 1A2 Manufacturing industries and construction: Emissions are expected to remain about constant. Minor changes are expected due to changes in activity data such as reduced production volumes in source category 1A2f Non-metallic minerals.
- 1A4 Other sectors: A reduction of emissions is expected in stationary combustion. This reduction is due to the projected general decrease in the combustion of wood, gas oil and wood waste.
- 2 IPPU: The main contributor to Hg emissions is source category 2C1 Iron and steel production, where emissions are expected to remain about constant due to projected roughly constant production volumes in secondary steel production.

Table 9-22 WM projections: Trends of Hg emissions per sector.

| Hg emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | t | t | t | t | | | t |
| 1 Energy | 0.49 | 0.51 | 0.51 | 0.51 | 88% | 88% | 0.016 |
| 1A Fuel combustion | 0.49 | 0.51 | 0.51 | 0.51 | 88% | 88% | 0.016 |
| *1A1 Energy industries* | 0.29 | 0.30 | 0.31 | 0.32 | 52% | 55% | 0.022 |
| *1A2 Manufacturing industries and constr.* | 0.088 | 0.10 | 0.10 | 0.097 | 16% | 17% | 0.0085 |
| *1A3 Transport* | 0.032 | 0.032 | 0.029 | 0.025 | 5.7% | 4.4% | -0.0068 |
| *1A4 Other sectors* | 0.078 | 0.079 | 0.076 | 0.069 | 14% | 12% | -0.0084 |
| *1A5 Other (Military)* | 0.00003 | 0.00003 | 0.00003 | 0.00003 | 0.005% | 0.005% | -0.0000004 |
| 1B Fugitive emissions from fuels | 0.0000005 | 0.0000005 | 0.0000005 | 0.0000005 | 0.00009% | 0.00009% | 0.00000002 |
| 2 IPPU | 0.040 | 0.040 | 0.040 | 0.040 | 7.1% | 7.0% | 0.0005 |
| 3 Agriculture | NA | NA | NA | NA | – | – | – |
| 5 Waste | 0.029 | 0.028 | 0.027 | 0.026 | 5.2% | 4.5% | -0.0029 |
| 6 Other | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.13% | 0.12% | -0.00002 |
| National total | 0.56 | 0.58 | 0.58 | 0.58 | 100% | 100% | 0.013 |

## 9.6 Persistent organic pollutants (POPs)

According to the projections, total emissions of all persistent organic pollutants (POPs) will decrease between 2025 and 2035. The decrease is most significant for PCB and less for the other POPs (PCDD/PCDF, PAH, HCB). The gaps in Figure 9-8 between the latest reporting year and 2025 symbolises the fact that most of the scenarios used to calculate emissions projections for the individual sectors and source categories cover the period from 2025 onwards. Accordingly, the emissions in between are interpolated linearly.

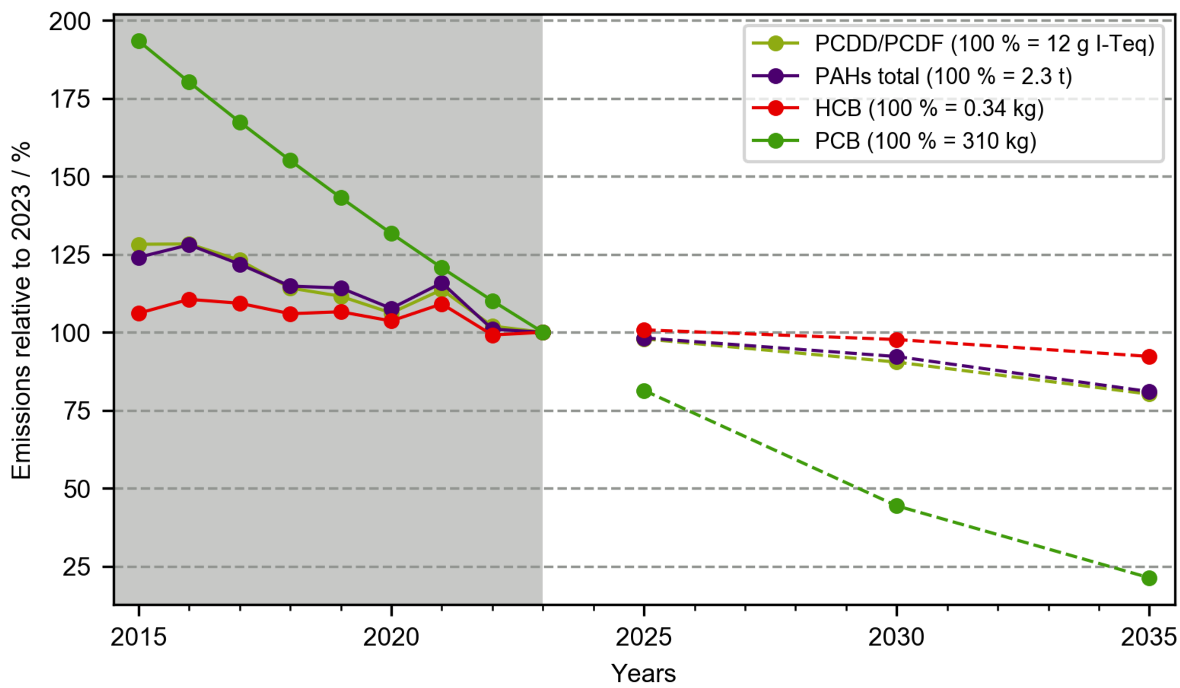



Figure 9-8 Relative trends for the total emissions of POPs: PCDD/PCDF, PAH (as the sum of benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene), and HCB in Switzerland in the WM scenario. 100 % corresponds to levels of the latest reporting year.

Table 9-23 Persistent organic pollutants (POPs): Total emissions of the WM projections until 2035 (please take note of the different units).

| Year | PCDD/ PCDF | BaP | BbF | BkF | IcdP | PAH tot | HCB | PCB |
|---|---|---|---|---|---|---|---|---|
| | g I-Teq | t | t | t | t | t | kg | kg |
| 2005 | 31 | 1.4 | 1.6 | 1.0 | 0.82 | 4.9 | 0.44 | 1'270 |
| 2010 | 25 | 1.3 | 1.3 | 0.77 | 0.71 | 4.0 | 0.45 | 827 |
| 2015 | 16 | 0.89 | 0.94 | 0.57 | 0.51 | 2.9 | 0.36 | 600 |
| 2020 | 13 | 0.76 | 0.81 | 0.51 | 0.45 | 2.5 | 0.35 | 408 |
| 2023 | 12 | 0.70 | 0.75 | 0.47 | 0.42 | 2.3 | 0.34 | 310 |
| 2025 | 12 | 0.69 | 0.74 | 0.47 | 0.41 | 2.3 | 0.34 | 252 |
| 2030 | 11 | 0.65 | 0.70 | 0.44 | 0.38 | 2.2 | 0.33 | 138 |
| 2035 | 9.7 | 0.57 | 0.62 | 0.39 | 0.33 | 1.9 | 0.31 | 66 |
| 2035 vs. 2023 (%) | -20% | -19% | -18% | -19% | -22% | -19% | -8% | -79% |

### 9.6.1 Projections for PCDD/PCDF

PCDD/PCDF emissions are projected to continue to decrease until 2035 (see Table 9-24 and Figure 9-8). The most significant (approximately equal) reductions are expected in source category 1A4 Other sectors, which is also the main source of PCDD/PCDF emissions in 2035, and in sector 5 Waste. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 1A4 Other sectors: The emission reduction is projected to result from a continuous improvement in wood combustion installations, a continued decrease in wood energy consumption in manually operated furnaces as well as further reductions in the number of emission intensive types of wood furnaces (e.g. cooking stoves).
- 5 Waste: Emission reductions are projected due to a reduction of illegally incinerated waste under source category 5C1a.
- 1A1 Energy industries: Emissions are expected to increase due to the projected increase in volumes in waste incineration plants.
- 6 Other: It is assumed that the number of building fires (under source category 6A4d Fire damage buildings and motor vehicles) will continue to decrease between 2025 and 2035 due to improvement in safety.
- 1A2 Manufacturing industries and construction: A reduction is mainly due to an expected higher proportion of modern wood combustion plants with lower proportions of non-optimal operating phases (1A2gviii Other boilers and engines industry) and a projected decline of the production volumes and improve of energy efficiencies in the non-metallic minerals processing industry (1A2f).
- 2 IPPU: The main contributors to PCDD/PCDF emissions are source categories 2C Metal industry (especially 2C1 Secondary steel production and 2C7a Non-ferrous metal foundries) and 2H Other (2H1 chipboard production and 2H2 Meat smokehouses). The emissions of all these source categories are expected to remain about constant between 2025 and 2035 due to projected roughly constant production volumes.

Table 9-24 WM projections: Trends of PCDD/PCDF emissions per sector.

| PCDD/PCDF emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | g I-Teq | g I-Teq | g I-Teq | g I-Teq | | | g I-Teq |
| 1 Energy | 7.7 | 7.6 | 7.1 | 6.3 | 64% | 64% | -1.5 |
| 1A Fuel combustion | 7.7 | 7.6 | 7.1 | 6.3 | 64% | 64% | -1.5 |
| *1A1 Energy industries* | 0.99 | 1.0 | 1.0 | 1.0 | 8.1% | 11% | 0.047 |
| *1A2 Manufacturing industries and constr.* | 0.90 | 0.94 | 0.94 | 0.85 | 7.4% | 8.8% | -0.04 |
| *1A3 Transport* | 0.43 | 0.40 | 0.30 | 0.26 | 3.6% | 2.7% | -0.17 |
| *1A4 Other sectors* | 5.4 | 5.3 | 4.8 | 4.1 | 45% | 42% | -1.3 |
| *1A5 Other (Military)* | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.003% | 0.004% | -0.000006 |
| 1B Fugitive emissions from fuels | NA | NA | NA | NA | – | – | – |
| 2 IPPU | 0.69 | 0.72 | 0.73 | 0.74 | 5.7% | 7.6% | 0.047 |
| 3 Agriculture | NA | NA | NA | NA | – | – | – |
| 5 Waste | 2.7 | 2.6 | 2.2 | 1.8 | 22% | 18% | -0.93 |
| 6 Other | 0.99 | 0.98 | 0.94 | 0.94 | 8.1% | 9.6% | -0.047 |
| National total | 12 | 12 | 11 | 9.7 | 100% | 100% | -2.4 |

### 9.6.2 Projections for polycyclic aromatic hydrocarbons (PAH)

PAH emissions are projected to continue to decrease until 2035 (see Table 9-25 and Figure 9-8). The most significant reduction is expected in source category 1A4 Other sectors, which is also the main source of PAH emissions in 2035. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 1A4 Other sectors: The emission reduction is projected to result from a continuous improvement in wood combustion installations, a continued decrease in wood energy consumption in manually operated furnaces as well as further reductions in the number of emission intensive types of wood furnaces (e.g. cooking stoves).
- 1A3 Transport: Emissions from 1A3 Transport are expected to remain about constant between 2025-2035. The main contributor to PAH emissions is diesel consumption from passenger cars (1A3bi). The mileage of passenger cars fuelled with diesel is expected to remain about constant between 2025 and 2035. As the PAH emission factors from the EMEP/EEA Guidebook (EMEP/EEA 2019) are used (constant over time, in g/km). Accordingly, the emission projection is correlated with mileage of diesel vehicles and is also expected to remain about constant.
- 5 Waste: PAH emissions are dominated by field burning of agricultural waste (5C2 Open burning of waste), which is expected to remain about constant.
- 6 Other: PAH emissions are dominated by vehicles fires and are expected to slightly increase between 2025 and 2035 due to an increase in the number of fires (source category 6A4b).
- 1A2 Manufacturing industries and construction: PAH emissions are expected to decrease between 2025 and 2035 mainly due to an expected higher proportion of modern wood combustion plants with lower proportions of non-optimal operating phases.

Table 9-25 WM projections: Trends of PAHs emissions per sector.

| PAHs emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | t | t | t | t | | | t |
| 1 Energy | 2.0 | 2.0 | 1.8 | 1.6 | 86% | 82% | -0.46 |
| 1A Fuel combustion | 2.0 | 2.0 | 1.8 | 1.6 | 86% | 82% | -0.46 |
| *1A1 Energy industries* | 0.0098 | 0.010 | 0.010 | 0.0088 | 0.42% | 0.47% | -0.0010 |
| *1A2 Manufacturing industries and constr.* | 0.095 | 0.094 | 0.089 | 0.080 | 4.1% | 4.2% | -0.015 |
| *1A3 Transport* | 0.29 | 0.31 | 0.31 | 0.30 | 12% | 16% | 0.011 |
| *1A4 Other sectors* | 1.6 | 1.6 | 1.4 | 1.2 | 70% | 62% | -0.45 |
| *1A5 Other (Military)* | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.03% | 0.03% | -0.00002 |
| 1B Fugitive emissions from fuels | NA | NA | NA | NA | – | – | – |
| 2 IPPU | 0.019 | 0.021 | 0.021 | 0.022 | 0.80% | 1.1% | 0.0027 |
| 3 Agriculture | NA | NA | NA | NA | – | – | – |
| 5 Waste | 0.19 | 0.19 | 0.19 | 0.19 | 8.1% | 10% | 0.0008 |
| 6 Other | 0.11 | 0.11 | 0.12 | 0.12 | 4.7% | 6.4% | 0.011 |
| National total | 2.3 | 2.3 | 2.2 | 1.9 | 100% | 100% | -0.45 |

### 9.6.3 Projections for hexachlorobenzene (HCB)

HCB emissions are projected to continue to decrease until 2035 (see Table 9-26 and Figure 9-8). The most significant reductions are expected in source category 1A4 Other sectors. On the opposite, an increase is projected for source category 1A1 Energy industries, which is the main source of HCB emissions in 2035. It should be noted that emissions from mobile sources (1A3, 1A2gvii, and 1A4aii/bii/cii) are not estimated in the inventory. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 1A1 Energy industries: Emissions are expected to increase due to the projected increase in volumes in waste incineration plants.
- 1A4 Other sectors: The emission reduction is projected to result from a continuous improvement in wood combustion installations a continued decrease in wood energy consumption in manually operated furnaces as well as further reductions in the number of emission intensive types of wood furnaces (e.g. cooking stoves).
- 1A2 Manufacturing and constructing industries: The emission reduction is mainly due to an expected higher proportion of modern wood combustion plants with lower proportions of non-optimal operating phases in source category 1A2gviii Stationary combustion in manufacturing industries and construction: Other but also partly due to a projected improve of energy efficiency in cement production (1A2f).

Table 9-26 WM projections: Trends of HCB emissions per sector.

| HCB emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | kg | kg | kg | kg | | | kg |
| 1 Energy | 0.34 | 0.34 | 0.33 | 0.31 | 100% | 100% | -0.026 |
| 1A Fuel combustion | 0.34 | 0.34 | 0.33 | 0.31 | 100% | 100% | -0.026 |
| *1A1 Energy industries* | 0.18 | 0.19 | 0.19 | 0.20 | 54% | 62% | 0.012 |
| *1A2 Manufacturing industries and constr.* | 0.033 | 0.039 | 0.038 | 0.034 | 9.8% | 11% | 0.0007 |
| *1A3 Transport* | NE | NE | NE | NE | – | – | – |
| *1A4 Other sectors* | 0.12 | 0.12 | 0.10 | 0.084 | 36% | 27% | -0.039 |
| *1A5 Other (Military)* | NE | NE | NE | NE | – | – | – |
| 1B Fugitive emissions from fuels | NA | NA | NA | NA | – | – | – |
| 2 IPPU | NA | NA | NA | NA | – | – | – |
| 3 Agriculture | NA | NA | NA | NA | – | – | – |
| 5 Waste | NA | NA | NA | NA | – | – | – |
| 6 Other | NA | NA | NA | NA | – | – | – |
| National total | 0.34 | 0.34 | 0.33 | 0.31 | 100% | 100% | -0.026 |

## 9.6.4 Projections for polychlorinated biphenyl (PCBs)

PCB emissions are projected to decrease considerably until 2035 (see Table 9-27 and Figure 9-8). The main reduction is expected in sector 2 IPPU, which remains the main emission source in 2035. The most important source categories in the future and the reasons for their emission trends are briefly described below, in order of the emissions shares in 2035:

- 2 IPPU: Also in future, the main relevant PCB emission sources remain anti-corrosive paints and joint sealants (2K) which were applied on steel and in window frames, respectively, prior to the ban of PCBs in so-called open application in 1972.
- 6 Other: To a lesser extent than the emissions of 2K, also accidental releases of PCB by fire and from soil due to former PCB spillages (6A5) contribute to future PCB emissions. These are also expected to decline between 2025 and 2035.

Table 9-27 WM projections: Trends of PCB emissions per sector.

| PCB emissions | 2023 | 2025 | 2030 | 2035 | share in 2023 | share in 2035 | 2023-2035 |
|---|---|---|---|---|---|---|---|
| | kg | kg | kg | kg | | | kg |
| 1 Energy | 0.36 | 0.39 | 0.37 | 0.35 | 0.11% | 0.53% | -0.006 |
| 1A Fuel combustion | 0.36 | 0.39 | 0.37 | 0.35 | 0.11% | 0.53% | -0.006 |
| *1A1 Energy industries* | 0.061 | 0.053 | 0.033 | 0.017 | 0.02% | 0.03% | -0.043 |
| *1A2 Manufacturing industries and constr.* | 0.29 | 0.34 | 0.33 | 0.33 | 0.09% | 0.50% | 0.038 |
| *1A3 Transport* | 0.00009 | 0.00008 | 0.00006 | 0.00005 | 0.00003% | 0.00008% | -0.00004 |
| *1A4 Other sectors* | 0.0007 | 0.0007 | 0.0006 | 0.0005 | 0.0002% | 0.0008% | -0.0001 |
| *1A5 Other (Military)* | NE | NE | NE | NE | – | – | – |
| 1B Fugitive emissions from fuels | NA | NA | NA | NA | – | – | – |
| 2 IPPU | 279 | 225 | 118 | 51 | 90% | 77% | -228 |
| 3 Agriculture | NA | NA | NA | NA | – | – | – |
| 5 Waste | 5.1 | 3.8 | 2.2 | 1.5 | 1.6% | 2.3% | -3.6 |
| 6 Other | 25 | 23 | 17 | 13 | 8.2% | 20% | -12 |
| National total | 310 | 252 | 138 | 66 | 100% | 100% | -244 |

# 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 2023). 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 to deal with tasks related to climate change and its effect on air pollution.
- Pollution levels can be assessed at a finer spatial resolution to provide more detailed information on pollution levels within territories of parties of the convention.

Figure 10-1 shows the EMEP grid domain.

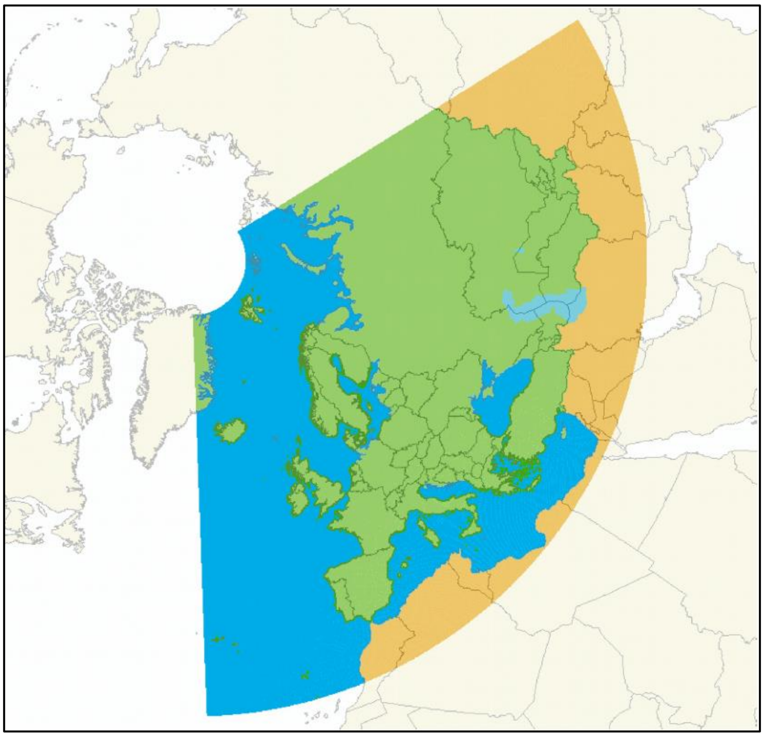


Figure 10-1 EMEP domain in the latitude-longitude projection (30°N-82°N, 30°W-90°E) (EMEP 2012a, https://www.emep.int/grid/lonlatgrid.pdf).

### 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.

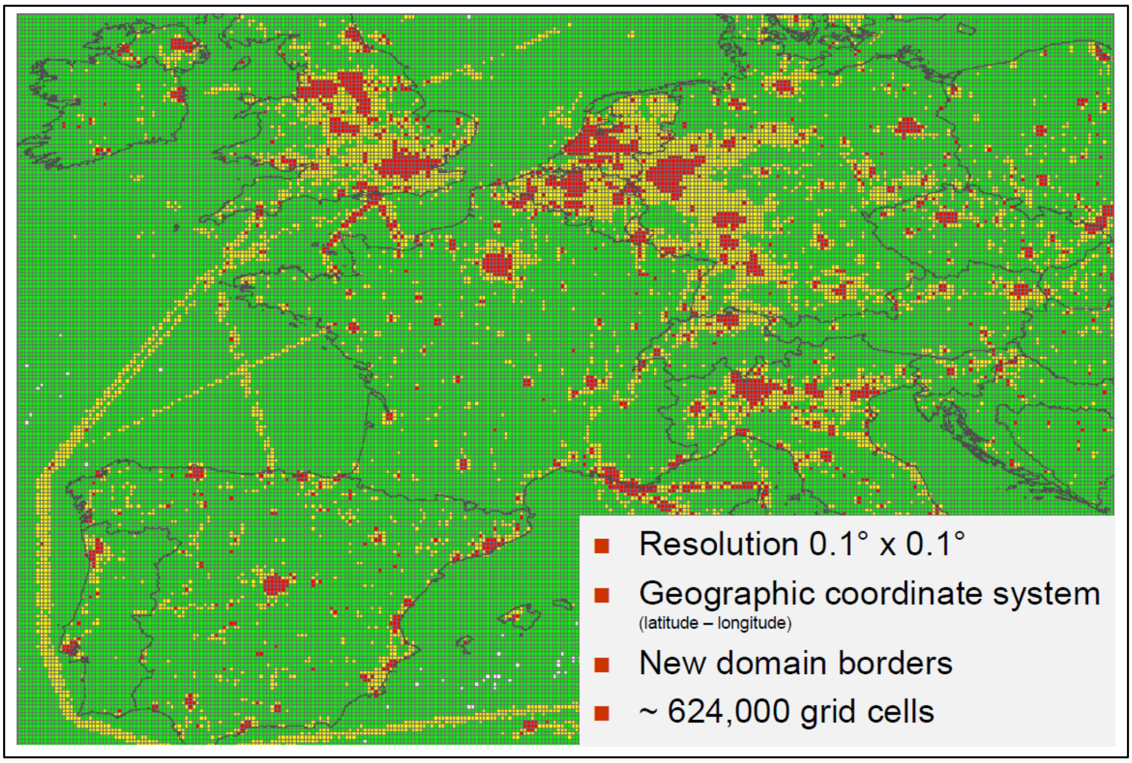



Figure 10-2 Resolution of the EMEP grid for Europe (EMEP 2012b).

In Switzerland's air pollution inventory of the latest submission 2025, the EMEP grid on local scale (0.1° x 0.1°) is applied (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 and 2021a).

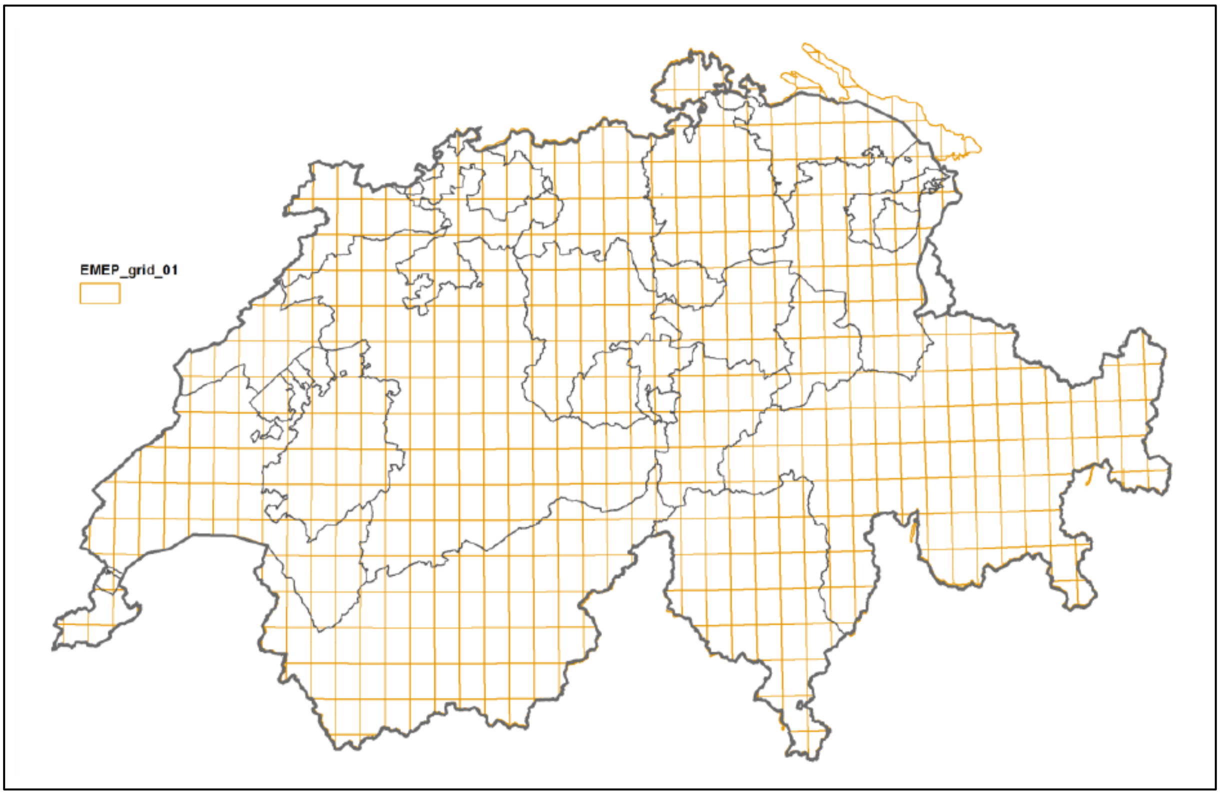



Figure 10-3 EMEP grid in Switzerland with 0.1° x 0.1° spatial resolution (from Meteotest 2013, downloaded from EMEP).

## 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 2023a). Table 10-1 shows the relative shares of the GNFR categories of Switzerland’s total emissions (national total) in 2023 for all main air pollutants including PM2.5 and CO.

Table 10-1 GNFR categories and their part (%) of total emissions in 2023 (national total) for the main air pollutants, PM2.5 and CO.

| GNFR aggregated sectors | $NO_x$ | NMVOC | $SO_x$ | $NH_3$ | PM2.5 | CO |
|---|---|---|---|---|---|---|
| A_PublicPower | 5.0% | 0.26% | 9.1% | 0.080% | 0.74% | 0.41% |
| B_Industry | 12% | 7.7% | 69% | 0.51% | 15% | 10% |
| C_OtherStatComb | 15% | 4.9% | 12% | 0.19% | 40% | 22% |
| D_Fugitive | 0.0013% | 3.4% | 0.54% | NA | 0.00063% | 0.00010% |
| E_Solvents | 0.038% | 44% | 0.12% | 0.13% | 5.3% | 0.37% |
| F_RoadTransport | 45% | 9.5% | 1.7% | 1.7% | 19% | 41% |
| G_Shipping | 2.0% | 0.54% | 0.017% | 0.00040% | 0.35% | 3.5% |
| H_Aviation | 4.4% | 0.22% | 5.0% | NA | 0.25% | 1.7% |
| I_Offroad | 8.7% | 2.2% | 1.3% | 0.0048% | 13% | 20% |
| J_Waste | 0.27% | 2.5% | 1.1% | 1.6% | 4.3% | 0.97% |
| K_AgriLivestock | 2.0% | 24% | NA | 47% | 1.6% | NA |
| L_AgriOther | 5.7% | 0.63% | NA | 47% | 0.72% | NA |
| M_Other | 0.19% | 0.23% | 0.25% | 1.8% | 0.075% | 0.32% |
| **Total** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

### 10.2.2 Data availability for emission allocation

To allocate the emissions of each GNFR category, an adequate allocation key has to be determined. Numerous GNFR categories overlap with various source categories thus it 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. Details of this work can be found in Meteotest 2013 and 2021a.

For the latest submission 2025, Switzerland calculated gridded emissions for the entire time series 1980-2023. For the allocation process of the emissions various data sources were applied for the time intervals 1980-1989, 1990-1999, 2000-2009, 2010-2015, 2016-2019 and >2020. 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, 2000-2009, 2010-2015, 2016-2019 and >2020 (Meteotest 2013 and 2021a).

| Data source | Distribution pattern | Applied data source for gridded emission time series | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1980-89** | **1990-99** | **2000-09** | **2010-15** | **2016-19** | **> 2020** |
| Population data | 1990, 2000, annually from 2010 | 1990 | 1990 | 2000 | 2013 | 2017 | 2020 |
| Census of enterprises sector 1 | 1996, 2000, 2005, 2008, annually from 2011 | 1996 | 1996 | 2005 | 2013 | 2017 | 2018 |
| Census of enterprises sector 2+3 | 1995, 2000, 2001, 2005, 2008, annually from 2011 | 1995 | 1995 | 2005 | 2013 | 2017 | 2018 |
| Land use statistics | 1979/85, 1992/97, 2004/09, 2013/18 | 1979/85 | 1992/97 | 2004/09 | 2013/18 | 2013/18 | 2013/18 |
| $NO_X$ emission maps | 1990, 2000, 2005, 2010, 2015 | 2005 | 2005 | 2005 | 2015 | 2015 | 2015 |
| PM10 emission maps | 2005, 2010, 2015 | 2005 | 2005 | 2005 | 2015 | 2015 | 2015 |
| $NH_3$ emission maps | 1990, 2000, 2007, 2010 (manure management) | 1990 | 2000 | 2007 | 2010 | 2010 | 2010 |
| Aviation | annual passenger numbers | 1985 | 1995 | 2005 | 2013 | 2017 | 2019 |
| Refineries | number of refineries | 2 | 2 | 2 | 2 | 1 | 1 |
| Cement production | number of cement plants (1990, 1998, 2006, 2013) | 1990 | 1998 | 2006 | 2013 | 2013 | 2013 |

## 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 (see Figure 10-4).

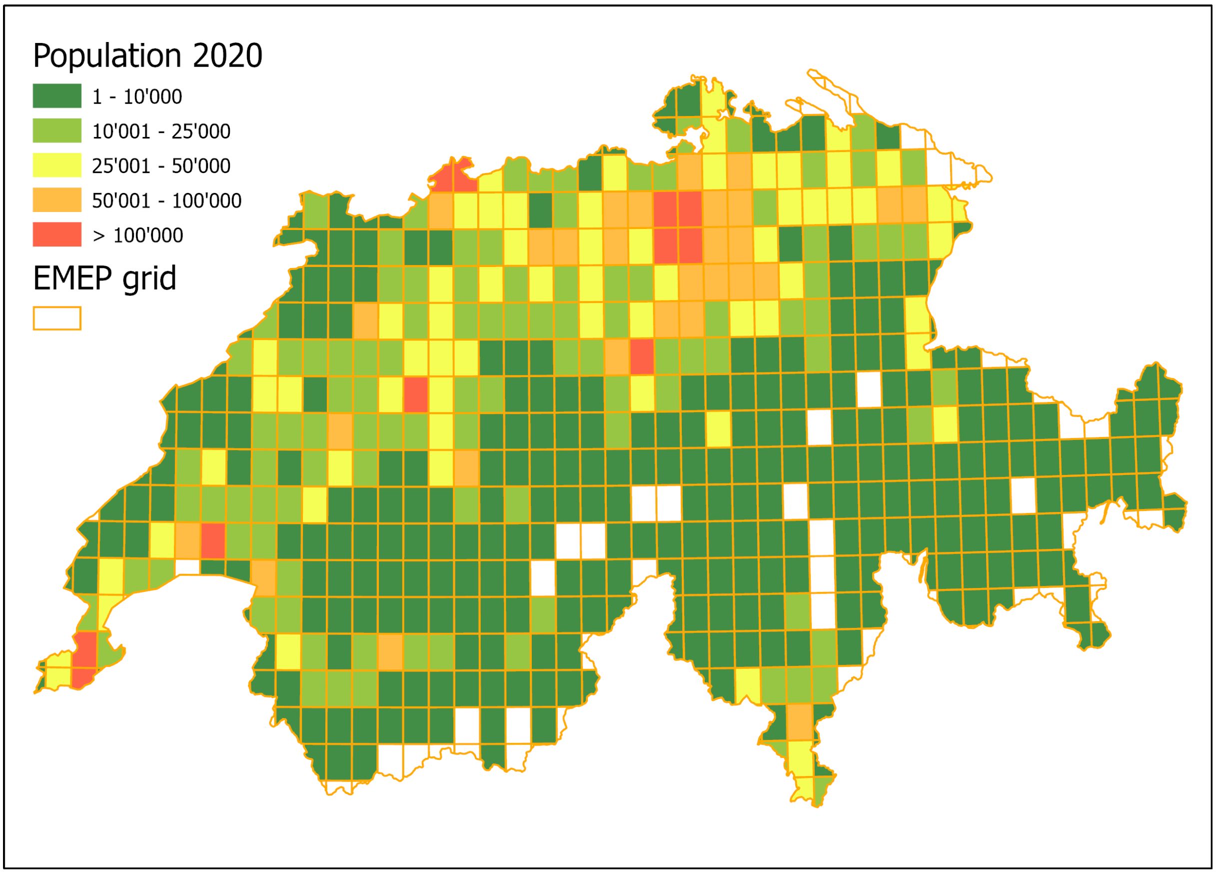



Figure 10-4 Population number per EMEP grid cell in Switzerland in 2020.

## Census of enterprises/number of employees 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 annually by the Federal Statistical Office. For several GNFR categories covering industrial production, the number of employees 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 by the Federal Statistical Office 74 categories are available. They are aggregated to 9 main land use categories to apply them to the EMEP grid (Meteotest 2013). 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
- Wastewater treatment plants

**Air pollution modelling data**

The results of specific emissions models are used as additional data for allocation purposes. These specific emission models are described in detail in the associated documentations (FOEN 2011b, FOEN 2013a, Meteotest 2020a and Meteotest 2019b) 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 2011b, Meteotest 2020a)
- $NO_x$: Emissions of navigation (FOEN 2011b, Meteotest 2020a)
- $NO_x$: Emissions of construction machinery (FOEN 2011b, Meteotest 2020a)
- $NO_x$: Emissions of industrial vehicles (FOEN 2011b, Meteotest 2020a)
- PM10: Emissions of rail traffic (FOEN 2013a, Meteotest 2020a)
- $NH_3$: Emissions of manure management - farming of animals without pasture (Meteotest 2019b)

### 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 2021a).

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 2023 are described under chp. 10.4 and illustrated in Figure 10-11.

### 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 (2021a).

Table 10-3 GNFR categories and their allocation indicators.

| GNFR category | Source category | Distribution according to |
|---|---|---|
| A_PublicPower | 1A1ai - 1A1aiii | Population density |
| | 1A1aiv | Point sources |
| B_Industry | 2A - 2I | Employees in the industry sector (sector 2) |
| | 1A1b - 1A1c | Point sources |
| | 1A2a - 1A2g | Employees in the industry sector (sector 2) |
| | 1A2f | Point sources |
| C_OtherStatComb | 1A4ai | Employees in the service sector (sector 3) |
| | 1A4bi | Population density |
| | 1A4ci | Employees in the agricultural sector (sector 1) |
| D_Fugitive | 1B1a, 1B2aiii, 1B2av, 1B2b | Inhabited area |
| | 1B2aiv, 1B2c | Employees in the industry sector (sector 2) |
| E_Solvents | 2D3aCRT, 2D3b, 2D3h | Employees in the industry sector (sector 2) |
| | 2D3aNFR | Population density |
| | 2D3i, 2G3, 2G4 | Inhabited area |
| F_RoadTransport | 1A3bi - 1A3bvii | Air pollution modelling data of $NO_X$ emissions from road transport (fuel sold) |
| G_Shipping | 1A3d | Air pollution modelling data of $NO_X$ Emissions from navigation |
| H_Aviation | 1A3ai(i), 1A3aii(i) | Statistics of flight passengers of the six largest airports in Switzerland (excluding Basel since it lies on French territory) |
| I_Offroad | 1A2gvii | Air pollution modelling data of NOx-Emissions of construction machinery and industrial vehicles |
| | 1A4aii, 1A4bii | Private gardening |
| | 1A4cii | Agricultural area |
| | 1A5bi, 1A5bii | Area of Switzerland below 1'500m a.s.l. |
| | 1A3c | Air pollution modelling data of PM10-Emissions from rail transport |
| | 1Ae | Employees in the industry sector (sector 2) |
| J_Waste | 5A1, 5B1, 5B2, 5E | Inhabited area |
| | 5D2 | Employees in the industry sector (sector 2) |
| | 5D1 | Wastewater treatment plants |
| | 5C1, 5C2 | Population density |
| K_AgriLivestock | 3B1 - 3B4 | Air pollution modelling data of NH3-Emissions of manure management - farming of animals without pasture |
| L_AgriOther | 3Da - 3Db | Agricultural area |
| M_Other | 3A4h, 3B4, 6Aa - 6Ad | Population density |

### Emissions not included in national total emissions

The following GNFR categories are not part of the national total emissions for the EMEP grid domain. These emissions are, therefore, not allocated to the EMEP grid cells.

Table 10-4 GNFR categories not included in the EMEP grid domain (according to Meteotest 2013).

| 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 2023

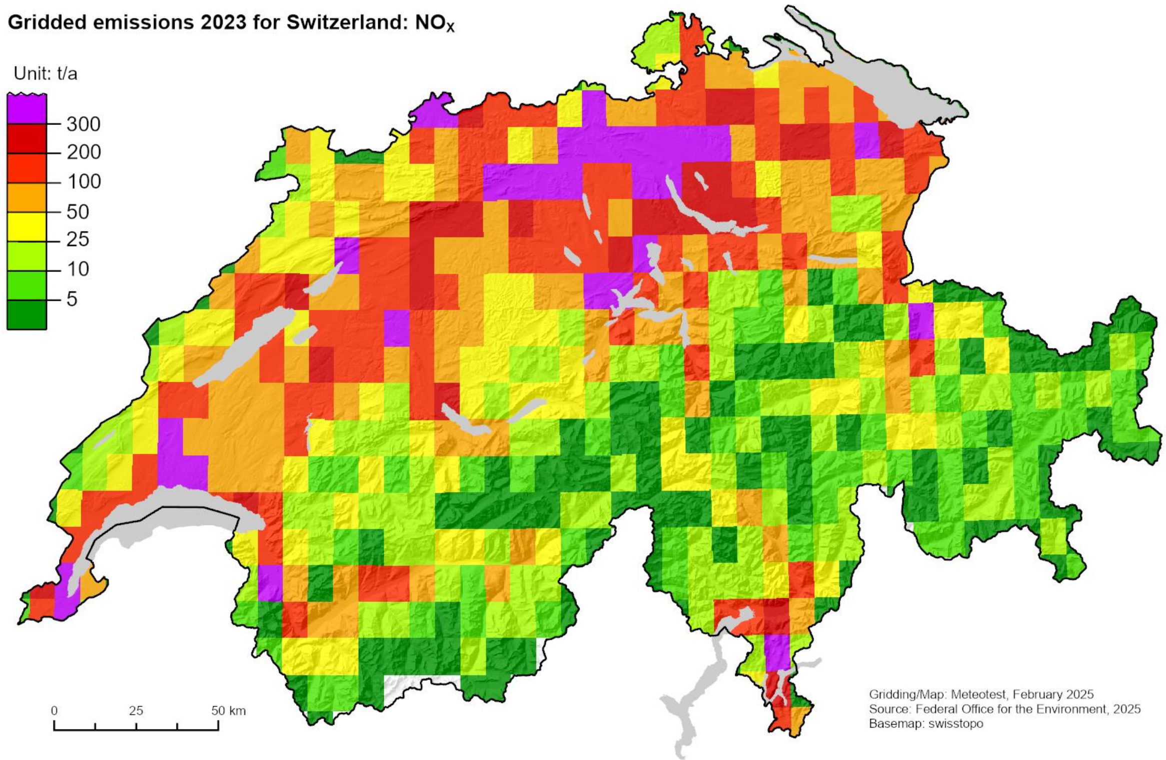



Figure 10-5 Spatial distribution of the $NO_x$ emissions in Switzerland.

### 10.3.2 Spatial distribution of Switzerland's NMVOC emissions 2023

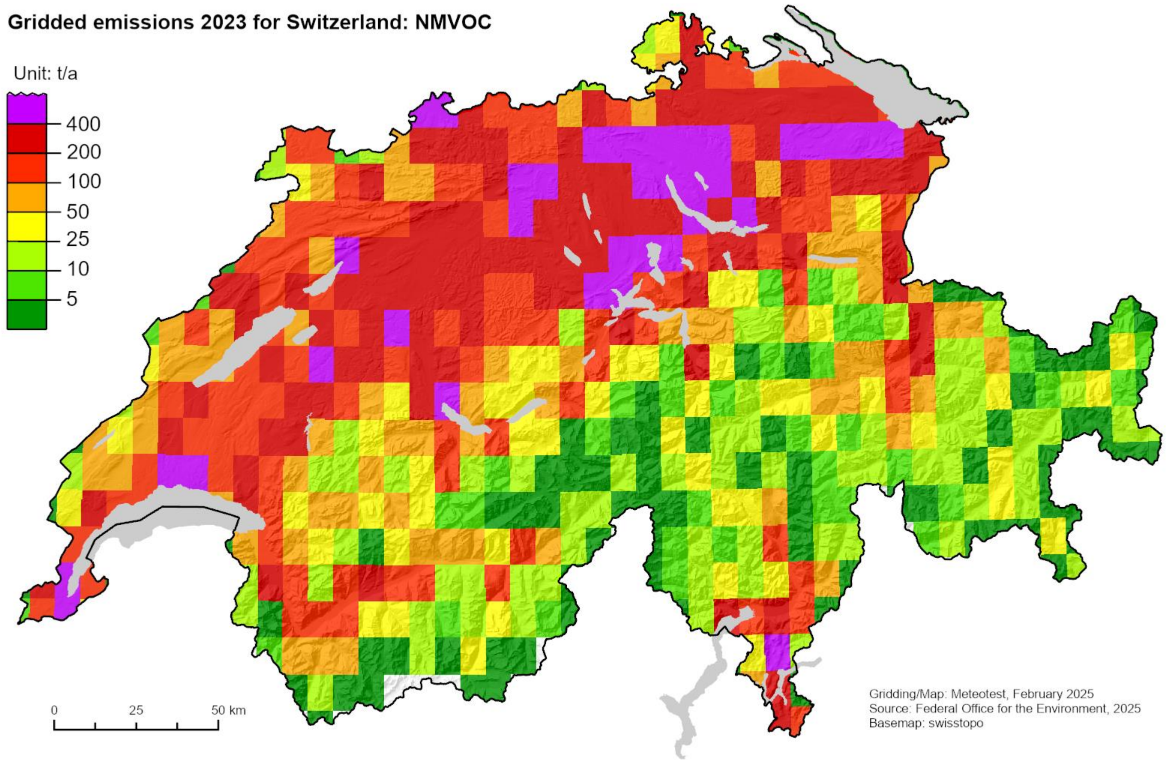



Figure 10-6 Spatial distribution of the NMVOC emissions in Switzerland.

### 10.3.3 Spatial distribution of Switzerland's $SO_x$ emissions 2023

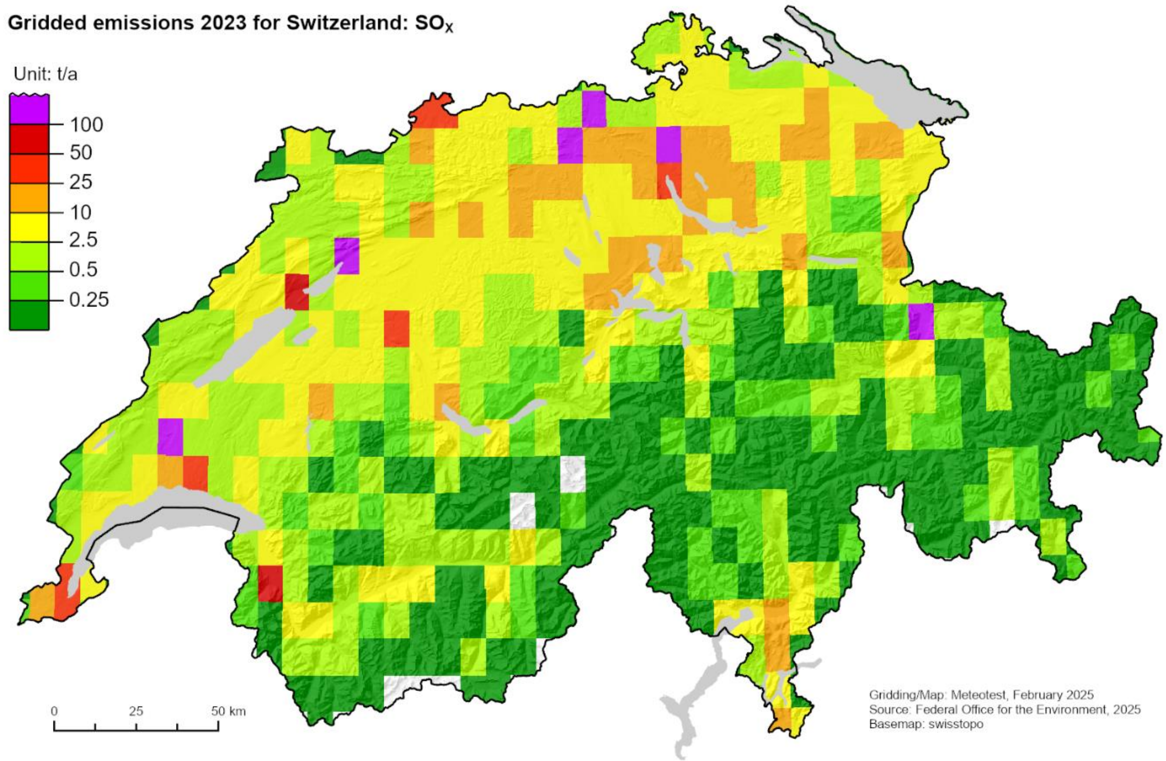



Figure 10-7 Spatial distribution of the $SO_x$ emissions in Switzerland.

### 10.3.4 Spatial distribution of Switzerland's $NH_3$ emissions 2023

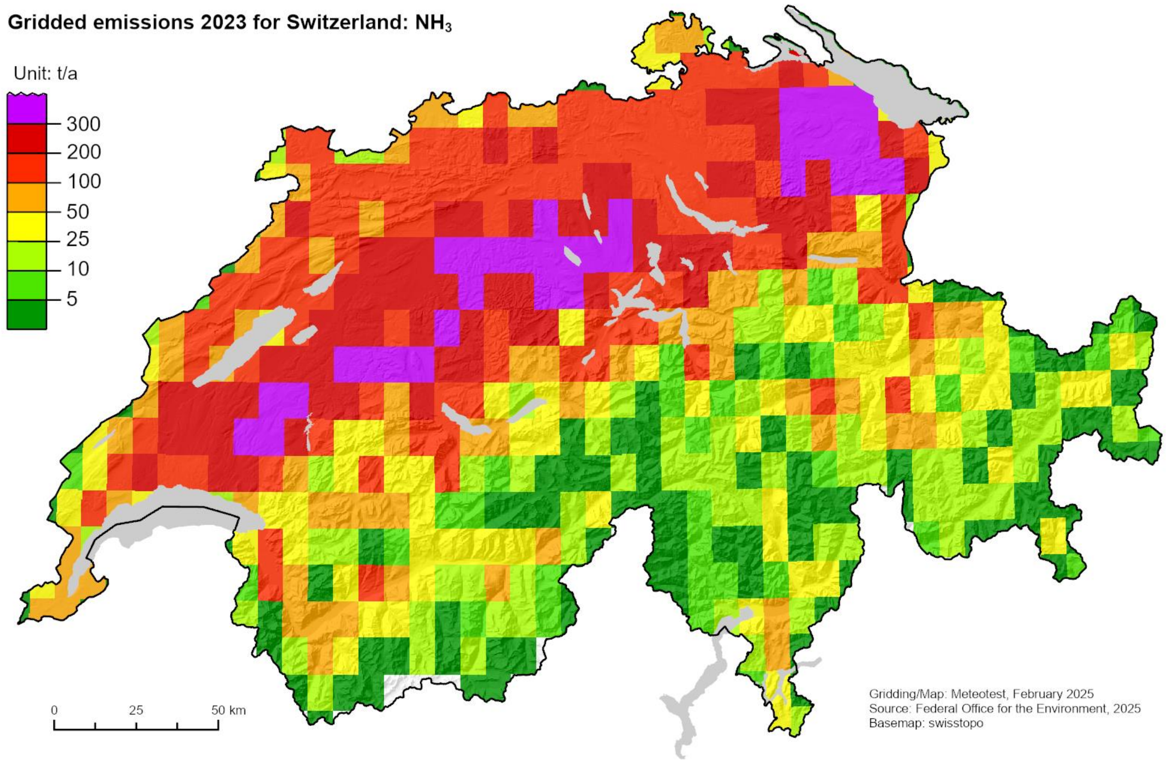



Figure 10-8 Spatial distribution of the $NH_3$ emissions in Switzerland.

### 10.3.5 Spatial distribution of Switzerland's PM2.5 emissions 2023

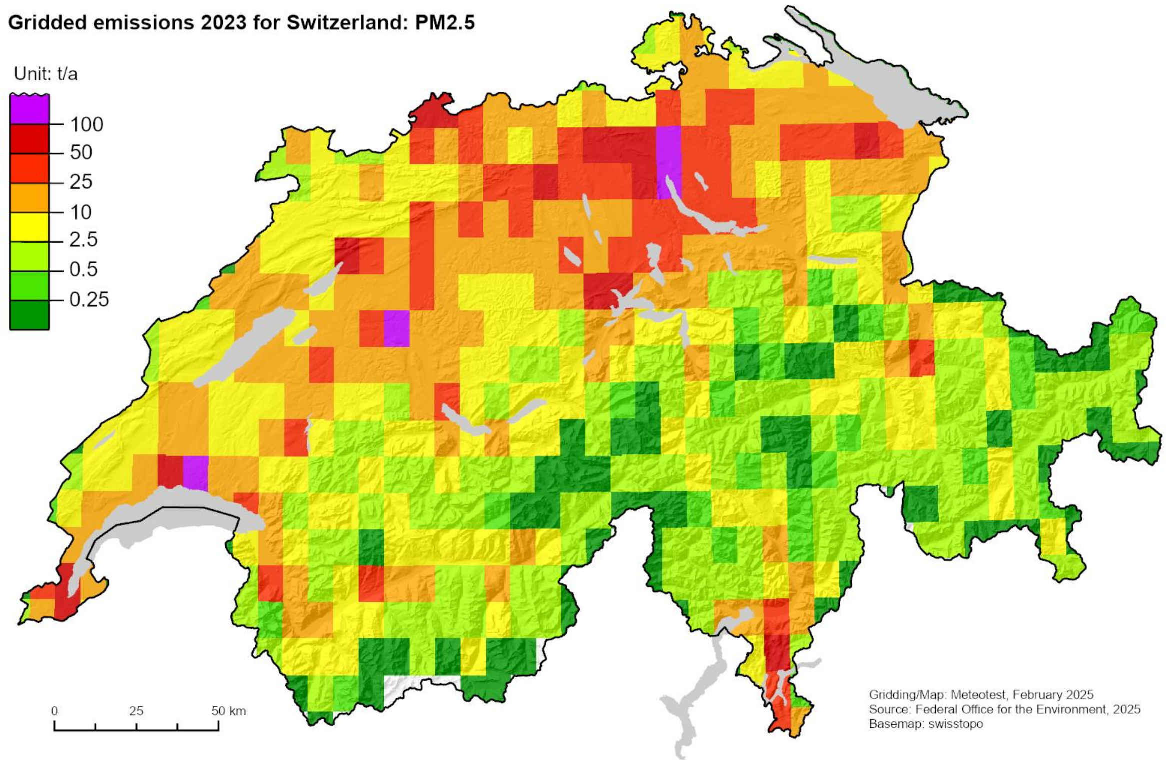



Figure 10-9 Spatial distribution of the PM2.5 emissions in Switzerland.

## 10.3.6 Spatial distribution of Switzerland's CO emissions 2023

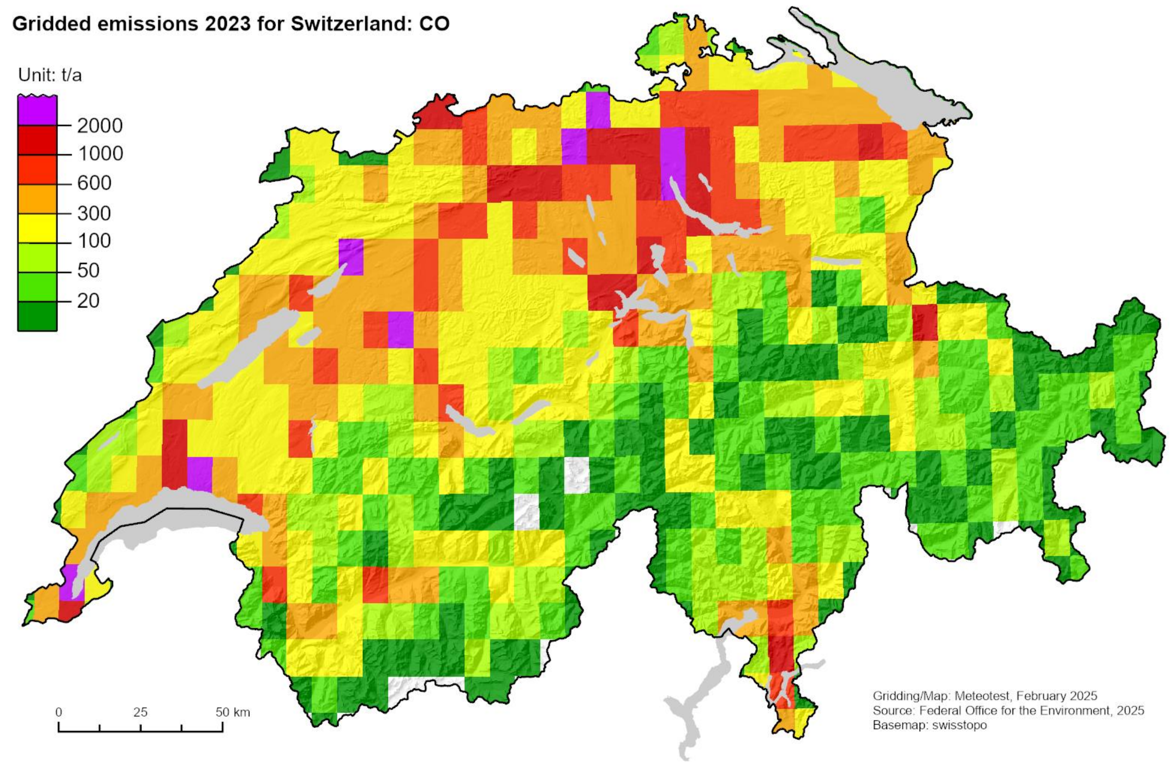



Figure 10-10 Spatial distribution of the CO emissions in Switzerland.

## 10.4 Large point sources (LPS)

Large Point Sources (LPS) are reported according to the definitions of the ECE Guidelines (ECE 2023). 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 2023).

Facility designations, locations and emissions of Switzerland's LPS of the years 2007-2023 are reported based on the most recent data of the Swiss Pollution Release and Transfer Register (PRTR 2025). 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 2023, the list of Switzerland's LPS includes 32 facilities, in particular of the industrial and waste sectors. As in previous years, most significant LPS are cement production plants and municipal solid waste incineration plants, followed by different facilities of the manufacturing industry such as steel production and chemicals (see Figure 10-11).

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.

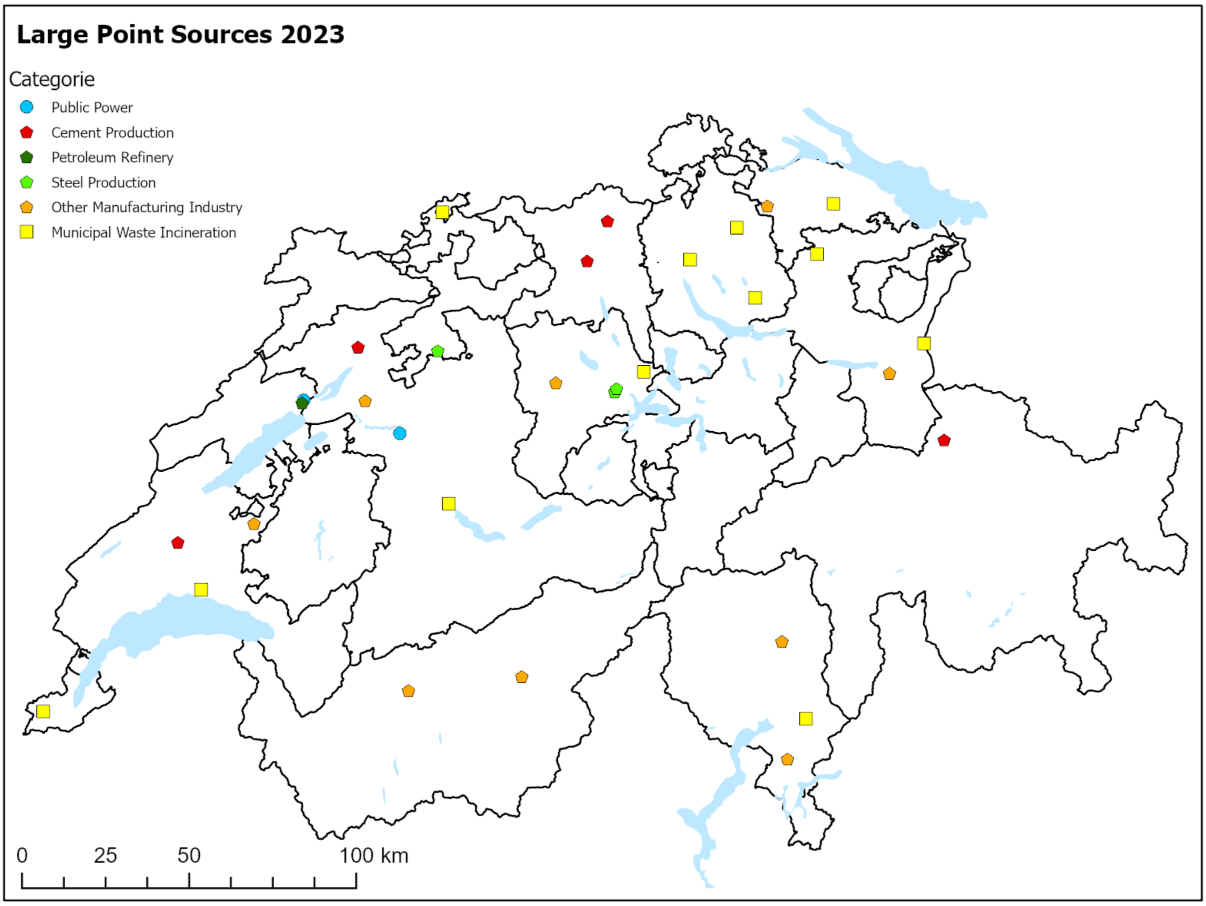



Figure 10-11 Spatial distribution of Switzerland's LPS in 2023. Note, that this figure only shows the LPS that exceed the limit values of emissions as defined in ECE (2023) and not all existing plants in Switzerland of the categories listed.

# 11 Adjustments

There are no adjustments in Switzerland’s air pollutant emission inventory.

# 12 References and assignments to EMIS categories

## 12.1 References


**ADEME 2013:** Improvement of the knowledge of the atmospheric emission from vehicles fires – Contribution of this source to the national emission inventory. Final Report in French, 07.05.2013, decision 11-81C0087, technical coordination: Emmanuel Fiani. Programme EMBRUVE, Agence de l'Environnement et de la Maîtrise de l'Energie ADEME (FR). https://librairie.ademe.fr/air-et-bruit/2748-embruve-improving-knowledge-of-atmospheric-emissions-from-burning-vehicles.html [15.01.2024]

**AGRAMMON 2018:** The Swiss agricultural ammonia emission calculation model, developed by the Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences in cooperation with Bonjour Engineering GmbH and Oetiker + Partner AG on behalf of the Federal Office for the Environment FOEN. Internet version 5.0 in German, French and English: https://agrammon.ch/de/downloads/ [05.02.2025]; Technical description for download (updated periodically): https://agrammon.ch/en/dokumentation-zum-modell/ [05.02.2024]

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# 12.2 Assignment of EMIS categories to NFR code

Table 12-1 Assignments of NFR Code to titles of EMIS database comments. In case the code corresponding to the CLRTAP nomenclature is different compared to the code given by the UNFCCC nomenclature, or in case the code is only applicable for the CLRTAP, the code for the CLRTAP is given in square brackets.

| "NFR code" for reporting to the UNFCCC and CLRTAP, if different, code for CLRTAP in brackets [] | Title in EMIS | "NFR code" for reporting to the UNFCCC and CLRTAP, if different, code for CLRTAP in brackets [] | Title in EMIS |
|---|---|---|---|
| 1 A | Energiemodell*** | 2 D 3 a [2 D 3 g] | Feinchemikalien-Produktion** |
| 1 A | Holzfeuerungen | 2 D 3 a [2 D 3 g] | Gummi-Verarbeitung** |
| 1 A | Non-Road | 2 D 3 a [2 D 3 g] | Klebband-Produktion |
| 1 A | Stationary engines and gas turbines | 2 D 3 a [2 D 3 g] | Klebstoff-Produktion** |
| 1 A 2 | Sektorgliederung Industrie | 2 D 3 a [2 D 3 g] | Lösungsmittel-Umschlag und -Lager |
| 1 A 1 a | Kehrichtverbrennungsanlagen | 2 D 3 a [2 D 3 g] | Pharmazeutische Produktion** |
| 1 A 1 a | Sondermüllverbrennungsanlagen | 2 D 3 a [2 D 3 g] | Polyester-Verarbeitung** |
| 1 A 1 a & 5 A | Kehrichtdeponien | 2 D 3 a [2 D 3 g] | Polystyrol-Verarbeitung** |
| 1 A 1 b | Heizkessel Raffinerien* (ab 2015) | 2 D 3 a [2 D 3 g] | Polyurethan-Verarbeitung |
| 1 A 1 c | Holzkohle Produktion | 2 D 3 a [2 D 3 g] | PVC-Verarbeitung |
| 1 A 2 a & 2 C 1 | Eisengiessereien Kupolöfen | 2 D 3 a [2 D 3 g] | Gerben von Ledermaterialien |
| 1 A 2 a | Stahl-Produktion Wärmeöfen** | 2 D 3 b | Strassenbelagsarbeiten** |
| 1 A 2 b | Buntmetallgiessereien übriger Betrieb** | 2 D 3 c | Dachpappe** |
| 1 A 2 b & 2 C 3 | Aluminium Produktion | 2 D 3 d | Urea (AdBlue) Einsatz Strassenverkehr |
| 1 A 2 c & 2 B 8 b [2 B 10 a] | Ethen-Produktion* | 2 G 3 a | Lachgasanwendung Spitäler** |
| 1 A 2 d & 2 A 4 d | Zellulose-Produktion Feuerung* | 2 G 3 b | Lachgasanwendung Haushalt** |
| 1 A 2 f | Kalkproduktion, Feuerung* | 2 G 4 [2 D 3 a ] | Pharma-Produkte im Haushalt |
| 1 A 2 f | Mischgut Produktion | 2 G 4 [2 D 3 a ] | Reinigungs- und Lösemittel; Haushalte |
| 1 A 2 f | Zementwerke Feuerung | 2 G 4 [2 D 3 h ] | Verpackungsdruckereien** |
| 1 A 2 f & 2 A 3 | Glas übrige Produktion* | 2 G 4 [2 D 3 h ] | Druckereien uebrige** |
| 1 A 2 f & 2 A 3 | Glaswolle Produktion Rohprodukt** | 2 G 4 [2 D 3 i ] | Entfernung von Farben und Lacken** |
| 1 A 2 f & 2 A 3 | Hohlglas Produktion* | 2 G 4 [2 D 3 i ] | Entwachsung von Fahrzeugen |
| 1 A 2 f & 2 A 4 a | Feinkeramik Produktion* | 2 G 4 [2 D 3 i ] | Kosmetika-Produktion** |
| 1 A 2 f & 2 A 4 a | Ziegeleien** | 2 G 4 [2 D 3 i ] | Lösungsmittel-Emissionen IG nicht zugeordnet |
| 1 A 2 f & 2 A 4 d | Steinwolle Produktion* | 2 G 4 [2 D 3 i ] | Öl- und Fettgewinnung |
| 1 A 2 g iv [1 A 2 g viii] | Faserplatten Produktion* (ab 2020) | 2 G 4 [2 D 3 i ] | Papier- und Karton-Produktion** |
| 1 A 2 g viii & 5 B 2 | Vergärung IG (industriell-gewerblich) | 2 G 4 [2 D 3 i ] | Parfum- und Aromen-Produktion** |
| 1 A 3 a & 1 A 5 | Flugverkehr | 2 G 4 [2 D 3 i ] | Tabakwaren Produktion** |
| 1 A 3 b i-v [1 A 3 b i-vi] | Strassenverkehr | 2 G 4 [2 D 3 i ] | Textilien-Produktion** |
| 1 A 3 c | Schienenverkehr | 2 G 4 [2 D 3 i ] | Wissenschaftliche Laboratorien |
| 1 A 3 e | Gastransport Kompressorstation | 2 G 4 [2 G] | Korrosionsschutz im Freien |
| 1 A 4 b i | Holzkohle-Verbrauch | 2 G 4 [2 G] | Betonzusatzmittel-Anwendung |
| 1 A 4 b i | Lagerfeuer | 2 G 4 [2 G] | Coiffeursalons |
| 1 A 4 c i | Gewächshäuser** | 2 G 4 [2 G] | Fahrzeug-Unterbodenschutz** |
| 1 A 4 c i | Grastrocknung** | 2 G 4 [2 G] | Feuerwerke |
| 1 A 4 c i & 5 B 2 | Vergärung LW (landwirtschaftlich) | 2 G 4 [2 G] | Flaechenenteisung Flughaefen |
| 1 B 2 a iii | Raffinerie, Pipelinetransport | 2 G 4 [2 G] | Flugzeug-Enteisung |
| 1 B 2 a iv | Raffinerie, Leckverluste* | 2 G 4 [2 G] | Frostschutzmittel Automobil |
| 1 B 2 a iv | H2-Produktion* | 2 G 4 [2 G] | Gas-Anwendung |
| 1 B 2 a iv | Raffinerie, Clausanlage* | 2 G 4 [2 G] | Gesundheitswesen, übrige** |
| 1 B 2 a v | Benzinumschlag Tanklager | 2 G 4 [2 G] | Glaswolle Imprägnierung** |
| 1 B 2 a v | Benzinumschlag Tankstellen | 2 G 4 [2 G] | Holzschutzmittel-Anwendung |
| 1 B 2 b ii & 1 B 2 c ii 2 | Gasproduktion & Gasproduktion, Flaring | 2 G 4 [2 G] | Klebstoff-Anwendung** |
| 1 B 2 b iv-vi | Netzverluste Erdgas | 2 G 4 [2 G] | Kosmetik-Institute |
| 1 B 2 c ii 1 | Raffinerie, Abfackelung | 2 G 4 [2 G] | Kühlschmiermittel-Verwendung |
| 2 A 1 | Zementwerke Rohmaterial | 2 G 4 [2 G] | Medizinische Praxen** |
| 2 A 4 d [2 A 1] | Zementwerke übriger Betrieb | 2 G 4 [2 G] | Pflanzenschutzmittel-Verwendung |
| 2 A 2 | Kalkproduktion, Rohmaterial* | 2 G 4 [2 G] | Reinigung Gebäude IGD** |
| 2 A 4 d [2 A 2] | Kalkproduktion, übriger Betrieb* | 2 G 4 [2 G] | Schmierstoff-Verwendung |
| 2 A 4 d | Kehrichtverbrennungsanlagen Karbonat** | 2 G 4 [2 G] | Spraydosen IndustrieGewerbe |
| 2 A 4 d | Karbonatanwendung weitere | 2 G 4 [2 G] | Tabakwaren Konsum |
| 2 A 4 d [2 A 5 a] | Gips-Produktion übriger Betrieb* (ab 2021) | 2 G 4 [2 G] | Steinwolle-Imprägnierung* |
| 2 A 5 a | Kieswerke | 2 H 1 | Faserplatten Produktion* (ab 2020) |
| 2 B 1 | Ammoniak-Produktion* | 2 H 1 | Zellulose Produktion übriger Betrieb* |
| 2 B 10 b [2 B 10 a] | Ammoniumnitrat-Produktion* | 2 H 1 | Spanplatten Produktion* |
| 2 B 10 b [2 B 10 a] | Chlorgas-Produktion* | 2 H 2 | Bierbrauereien |
| 2 B 10 b [2 B 10 a] | Essigsäure-Produktion* (ab 2013) | 2 H 2 | Branntwein Produktion |
| *2 B 10 b [2 B 10 a]* | *Formaldehyd-Produktion* | 2 H 2 | Brot Produktion |
| 2 B 10 b [2 B 10 a] | PVC-Produktion | 2 H 2 | Fleischräuchereien |
| *2 B 10 b [2 B 10 a]* | *Salzsäure-Produktion** | 2 H 2 | Kaffeeröstereien |
| 2 B 10 b [2 B 10 a] | Schwefelsäure-Produktion* | 2 H 2 | Müllereien |
| 2 B 10 b | Kalksteingrube* | 2 H 2 | Wein Produktion |
| 2 B 10 b [2 B 10 a] | Niacin-Produktion* | 2 H 2 | Zucker Produktion |
| 2 B 2 | Salpetersäure Produktion* | 2 H 3 | Sprengen und Schiessen |
| 2 B 5 | Graphit und Siliziumkarbid Produktion* | [2 I] | Holzbearbeitung |
| 2 C - 2 G | Synthetische Gase | [2K, 1A1a, 2C1, 5A, 5C1, 5E & 6A5] | Emissions due to former PCB usage |
| 2 C 1 | Eisengiessereien Elektroschmelzöfen | 2 H 3 [2 L] | NH3 aus Kühlanlagen |
| 2 C 1 | Eisengiessereien übriger Betrieb | 3 | Landwirtschaft |
| 2 C 1 & 1 A 2 a | Stahl-Produktion Elektroschmelzöfen** | 3 B | Tierhaltung |
| 2 C 1 | Stahl-Produktion übriger Betrieb** | 3 C | Reisanbau |
| 2 C 1 | Stahl-Produktion Walzwerke** | [3 D e] | Landwirtschaftsflächen |
| 2 C 7 a | Buntmetallgiessereien Elektroöfen** | 4(IV) A 1 [11 B] | Waldbrände |
| 2 C 7 c | Verzinkereien | 5 B 1 | Kompostierung |
| 2 C 7 c | Batterie-Recycling* | 5 B 2 | Biogasaufbereitung (Methanverlust) |
| 2 D 1 | Schmiermittel-Anwendung | 5 C 1 a i & 5 C 1 b i [5 C 1 a] | Abfallverbrennung illegal |
| 2 D 1 | Schmiermittel-Verbrauch B2T | 5 C 1 b ii 1 [5 C 1 b i] | Kabelabbrand |
| 2 D 2 | Paraffinwachs-Anwendung | 5 C 1 b ii 3 [5 C 1 b iii] | Spitalabfallverbrennung |
| 2 D 3 a [2 D 3 d] | Farben-Anwendung Bau | 5 C 1 a ii 4 [5 C 1 b iv] | Klärschlammverbrennung |
| 2 D 3 a [2 D 3 d] | Farben-Anwendung andere | 5 C 1 [5 C 1 b v] | Krematorien |
| 2 D 3 a [2 D 3 d] | Farben-Anwendung Haushalte** | 5 C 2 & 4(IV) A 1 (Forstwirtschaft) | Abfallverbrennung Land- und Forstwirtschaft und Private |
| 2 D 3 a [2 D 3 d] | Farben-Anwendung Holz | 5 D 1 | Kläranlagen kommunal (Luftschadstoffe) |
| 2 D 3 a [2 D 3 d] | Farben-Anwendung Autoreparatur** | 5 D 2 | Kläranlagen industriell (Luftschadstoffe) |
| 2 D 3 a [2 D 3 e] | Elektronik-Reinigung** | 5 D 1 & 5 D 2 | Abwasserbehandlung GHG |
| 2 D 3 a [2 D 3 e] | Metallreinigung** | 5 E | Shredder Anlagen |
| 2 D 3 a [2 D 3 e] | Reinigung Industrie übrige** | 6 A 1 [6 A 4] | Brand- und Feuerschäden Immobilien |
| 2 D 3 a [2 D 3 f] | Chemische Reinigung** | 6 A 1 [6 A 4] | Brand- und Feuerschäden Motorfahrzeuge |
| 2 D 3 a [2 D 3 g] | Druckfarben Produktion** | [11 C] | NMVOC Emissionen Wald |
| 2 D 3 a [2 D 3 g] | Farben-Produktion** | 1, 2, 5, 6 - indirect | Indirekte Emissionen |

* confidential process
** confidential EMIS comment
*** work in progress
*Italic: process not relevant for the years after 1990.*
New model / comment for the current submission.

# Annexes

# Annex 1 Key category analysis (KCA)

## A1.1 Overview

The following table provides an overview over the level (1990 and 2023) and trend (1990-2023) assessments based on approach 1 and approach 2 of the key category analysis. Note that the key category analysis is performed based on the approach “fuels used” (in contrast to “fuels sold”; for differentiation of the two approaches see chapter 3.1.6.1). Columns A to D in the following two tables are labelled according to Table 2-6 from the EMEP/EEA guidebook (EMEP/EEA 2023, part A, chp. 2, “Methodological choice and Key category analysis”.

Table A - 1 Summary of Switzerland's key category analysis, for the main pollutants, PM2.5 and PM10. L: level assessment (2023); T: trend assessment (1990-2023); 1: KCA approach 1; 2: KCA approach 2. Note that categories which are key for the level assessment for the base year only are not reported in this table.

| SUMMARIES TO IDENTIFY KEY CATEGORIES | | | | | | | |
|---|---|---|---|---|---|---|---|
| A | B | C & D | | | | | |
| NFR Code | Source category | NOx | NMVOC | SOx | NH3 | PM2.5 | PM10 |
| 1A1a | Public electricity and heat production | L1, L2 | | L1, L2 | | T1, T2 | T1, T2 |
| 1A2d | Stationary combustion in manufacturing industries and construction: pulp paper and print | | | T1, T2 | | | |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | L1, L2, T1, T2 | | L1, L2, T1, T2 | | | T1 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | T1 | | | | L1, L2, T1, T2 | L1, L2, T1, T2 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | L1, T1, T2 | | L1, L2 | | L1, L2 | |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | L1, T1, T2 | | L1, T1, T2 | | | |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | L1, L2, T1, T2 | L1, L2, T1, T2 | | | | |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | L1, L2, T1, T2 | | | | | |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | L1, L2, T1, T2 | | T1, T2 | | T1 | T1 |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | | L2, T2 | | | | |
| 1A3bv(fu) | Road transportation: gasoline evaporation (fuel used) | | L1, T1, T2 | | | | |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | | | | | L1, L2, T1, T2 | L1, L2, T1, T2 |
| 1A3c | Railways | | | | | L1, T1, T2 | L1, L2, T1, T2 |
| 1A3dii | National navigation (shipping) | T1 | | | | | |
| 1A4ai | Commercial/institutional: stationary | L1, L2, T1, T2 | | T1, T2 | | L1, L2, T1 | L1, L2 |
| 1A4bi | Residential: stationary plants | L1, L2 | L1, L2 | L1, L2, T1, T2 | | L1, L2, T1, T2 | L1, L2, T1, T2 |
| 1A4ci | Agriculture/forestry/fishing: stationary | | | L2 | | L1 | |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | L1 | | | | | |
| 1A5b | Other mobile (including military land-based and recreational boats) | | | | | | L1 |
| 1B2av | Distribution of oil products | | L1, T1, T2 | | | | |
| 1B2c | Venting and flaring (oil gas combined oil and gas) | T2 | | | | | |
| 2A1 | Cement production | | | | | L2, T2 | L2 |
| 2A5a | Quarrying and mining of minerals other than coal | | | | | L2, T2 | L1, L2, T2 |
| 2B5 | Carbide production | | | L1, L2, T1, T2 | | | |
| 2B10a | Chemical industry: other | | | L2, T2 | | | |
| 2C1 | Iron and steel production | | | | | T1, T2 | T1, T2 |
| 2D3a | Domestic solvent use including fungicides | | L1, L2, T1, T2 | | | | |
| 2D3b | Road paving with asphalt | | L1, L2, T1, T2 | | | | |
| 2D3d | Coating applications | | L1, L2, T1 | | | | |
| 2D3e | Degreasing | | L1, T1, T2 | | | | |
| 2D3g | Chemical products | | L1, L2, T1, T2 | | | | |
| 2D3h | Printing | | L1, L2, T1 | | | | |
| 2D3i | Other solvent use | | L1, L2, T2 | | | | |
| 2G | Other product use | | L1, L2, T2 | | | L1, L2, T1, T2 | L1, L2 |
| 2H1 | Pulp and paper industry | | | | | L1, L2, T2 | |
| 2H2 | Food and beverages industry | | L2, T1, T2 | | | L1, L2, T1, T2 | L1, L2, T2 |
| 2I | Wood processing | | | | | L2 | 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 | | | | L1, L2, T2 | | |
| 3B4gi | Manure management - Laying hens | | T2 | | | | L2 |
| 3B4gii | Manure management - Broilers | | L2, T2 | | L2, T2 | | L2, T2 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | L2, T2 | | | L1, L2, T1, 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 (including compost) | T2 | | | T1, T2 | | |
| 3Da3 | Urine and dung deposited by grazing animals | L2, T2 | | | L2, T1, T2 | | |
| 3De | Cultivated crops | | | | | | L1, L2, T1, T2 |
| 5B2 | Biological treatment of waste - Anaerobic digestion at biogas facilities | | T1 | | | | |
| 5C1a | Municipal waste incineration | | | | | L1, L2 | L1 |
| 6A | Other sources | | | | L2, T2 | | |

Table A - 2 Summary of Switzerland's key category analysis, for TSP, BC, CO, priority heavy metals, PCDD/PCDF, PAHs total, HCB and PCBs. L: level assessment (2023); T: trend assessment (1990-2023); 1: KCA approach 1. No approach 2 analysis was conducted. Note that categories which are key for the level assessment for the base year only are not reported in this table.

| NFR Code | Source category | TSP | BC | CO | Pb | Cd | Hg | PCDD/PCDF | PAHs total | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A1a | Public electricity and heat production | | | | L1, T1 | L1, T1 | L1, T1 | L1, T1 | | L1, T1 | T1 |
| 1A2b | Stationary combustion in manufacturing industries and construction: non-ferrous metals | | | | | | | | | T1 | |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | T1 | | L1, T1 | | L1, T1 | L1, T1 | | | | |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | L1, T1 | T1 | | | L1, T1 | | | | | |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | | | | L1 | | L1, T1 | | | | |
| 1A3aii(i) | Civil aviation (domestic cruise) | | | | L1, T1 | | | | | | |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | | | L1, T1 | T1 | | | | L1, T1 | | |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | | | T1 | | | | | | | |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | T1 | T1 | | | | | | | | |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | | | L1 | | | | | | | |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | L1, T1 | L1, T1 | | | L1, T1 | | | | | |
| 1A3c | Railways | L1, T1 | | | | | | | | | |
| 1A3dii | National navigation (shipping) | | | L1 | | | | | | | |
| 1A4ai | Commercial/institutional: stationary | L1 | L1, T1 | L1, T1 | | | T1 | L1, T1 | L1, T1 | L1 | |
| 1A4aii | Commercial/institutional: mobile | | | L1, T1 | | | | | | | |
| 1A4bi | Residential: stationary plants | L1, T1 | L1, T1 | L1, T1 | L1 | L1 | L1, T1 | L1, T1 | L1, T1 | L1, T1 | |
| 1A4bii | Residential: household and gardening (mobile) | | | T1 | | | | | | | |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | | L1, T1 | L1, T1 | | | | | | | |
| 2A5a | Quarrying and mining of minerals other than coal | L1 | | | | | | | | | |
| 2B10a | Chemical industry: other | | | | | | T1 | | | | |
| 2C1 | Iron and steel production | T1 | | | T1 | T1 | L1, T1 | | | | |
| 2C3 | Aluminium production | | | | | | | | T1 | | |
| 2G | Other product use | | | | | L1, T1 | | | | | |
| 2I | Wood processing | T1 | | | | | | | | | |
| 2K | Consumption of POPs and heavy metals (e.g. electrical and scientific equipment) | | | | | | | | | | L1, T1 |
| 3B3 | Manure management - Swine | L1 | | | | | | | | | |
| 3B4gi | Manure management - Laying hens | L1 | | | | | | | | | |
| 3De | Cultivated crops | L1, T1 | | | | | | | | | |
| 5C1a | Municipal waste incineration | | | | L1, T1 | | | L1, T1 | | | |
| 5C2 | Open burning of waste | | | | | | | | L1, T1 | | |
| 5E | Other waste | | | | | | | | | | T1 |
| 6A | Other sources | | | | L1, T1 | | | L1, T1 | | | |

## A1.2 Detailed results of approach 1 assessment

The following tables report the detailed results for the key category analysis, approach 1, level and trend assessments, for the reporting year 2023 and the base year 1990. Columns labelled A to F for the level assessments correspond exactly to columns A to F from Table 3-1 from the EMEP/EEA guidebook (EMEP/EEA 2023, part A, chp. 2, “Key category analysis and methodological choice 2019”. For the table reporting the trend assessment, columns labelled A to H correspond exactly to columns A to H from Table 3-2 from the same guidelines. Equations referenced hereafter are also from the same guidelines.

Explanations of headers for tables in this Annex are:

- $E_{x,t}$: emission estimate for the reporting year.
- $E_{x,0}$: emission estimate for the base year.
- $L_{x,t}$: level assessment for the reporting year (EMEP/EAA guidebook part A, chp. 2, equ. 1 for approach 1).
- $L_{x,0}$: level assessment for the base year (EMEP/EAA guidebook part A, chp. 2, equ. 1 for approach 1).
- Trend assessment: computed according to EMEP/EAA guidebook part A, chp. 2, equ. 2 for approach 1.

Table A - 3 Switzerland's key categories according to approach 1 level assessment for the year 2023, sorted by decreasing contribution, for the main pollutants, PM2.5 and PM10. Categories in grey are not key and are given for information only.

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| NFR code | Source category | Pollutant | Ex, t (t) | Lx, t (%) | Cumu-lative Total (%) |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NOx | 15'010 | 32.1 | 32.1 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | NOx | 3'494 | 7.5 | 39.6 |
| 1A4bi | Residential: stationary plants | NOx | 3'464 | 7.4 | 47.0 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | NOx | 3'029 | 6.5 | 53.5 |
| 1A4ai | Commercial/institutional: stationary | NOx | 2'832 | 6.1 | 59.5 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | NOx | 2'825 | 6.0 | 65.6 |
| 1A1a | Public electricity and heat production | NOx | 2'267 | 4.8 | 70.4 |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | NOx | 1'966 | 4.2 | 74.6 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | NOx | 1'638 | 3.5 | 78.1 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | NOx | 1'608 | 3.4 | 81.6 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | NOx | 1'537 | 3.3 | 84.9 |
| 3Da2a | Animal manure applied to soils | NOx | 1'449 | 3.1 | 88.0 |
| 2D3d | Coating applications | NMVOC | 8'286 | 11.6 | 11.6 |
| 3B1b | Manure management - Non-dairy cattle | NMVOC | 7'441 | 10.4 | 22.1 |
| 3B1a | Manure management - Dairy cattle | NMVOC | 6'585 | 9.2 | 31.3 |
| 2D3a | Domestic solvent use including fungicides | NMVOC | 6'507 | 9.1 | 40.4 |
| 2G | Other product use | NMVOC | 6'316 | 8.9 | 49.3 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NMVOC | 3'635 | 5.1 | 54.4 |
| 2D3h | Printing | NMVOC | 3'617 | 5.1 | 59.5 |
| 2D3g | Chemical products | NMVOC | 3'185 | 4.5 | 63.9 |
| 2D3b | Road paving with asphalt | NMVOC | 2'700 | 3.8 | 67.7 |
| 1A4bi | Residential: stationary plants | NMVOC | 2'347 | 3.3 | 71.0 |
| 1B2av | Distribution of oil products | NMVOC | 2'021 | 2.8 | 73.8 |
| 2D3i | Other solvent use | NMVOC | 1'933 | 2.7 | 76.5 |
| 1A3bv(fu) | Road transportation: gasoline evaporation (fuel used) | NMVOC | 1'773 | 2.5 | 79.0 |
| 2D3e | Degreasing | NMVOC | 1'566 | 2.2 | 81.2 |
| 2H2 | Food and beverages industry | NMVOC | 1'417 | 2.0 | 83.2 |
| 5B2 | Biological treatment of waste - Anaerobic digestion at biogas facilities | NMVOC | 1'147 | 1.6 | 84.8 |
| 3B4gii | Manure management - Broilers | NMVOC | 1'144 | 1.6 | 86.4 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | SOx | 1'300 | 45.9 | 45.9 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | SOx | 260 | 9.2 | 55.1 |
| 1A1a | Public electricity and heat production | SOx | 256 | 9.0 | 64.2 |
| 1A4bi | Residential: stationary plants | SOx | 207 | 7.3 | 71.5 |
| 2B5 | Carbide production | SOx | 198 | 7.0 | 78.5 |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | SOx | 137 | 4.9 | 83.3 |
| 1A4ai | Commercial/institutional: stationary | SOx | 83 | 2.9 | 86.3 |
| 3Da2a | Animal manure applied to soils | NH3 | 20'191 | 38.2 | 38.2 |
| 3B1a | Manure management - Dairy cattle | NH3 | 10'144 | 19.2 | 57.4 |
| 3B1b | Manure management - Non-dairy cattle | NH3 | 7'241 | 13.7 | 71.0 |
| 3B3 | Manure management - Swine | NH3 | 4'736 | 9.0 | 80.0 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | NH3 | 2'251 | 4.3 | 84.2 |
| 3Da3 | Urine and dung deposited by grazing animals | NH3 | 1'413 | 2.7 | 86.9 |
| 1A4bi | Residential: stationary plants | PM2.5 | 1'852 | 29.8 | 29.8 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM2.5 | 958 | 15.4 | 45.1 |
| 1A4ai | Commercial/institutional: stationary | PM2.5 | 430 | 6.9 | 52.1 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM2.5 | 384 | 6.2 | 58.2 |
| 2G | Other product use | PM2.5 | 327 | 5.3 | 63.5 |
| 1A3c | Railways | PM2.5 | 233 | 3.7 | 67.2 |
| 5C1a | Municipal waste incineration | PM2.5 | 221 | 3.5 | 70.8 |
| 1A4ci | Agriculture/forestry/fishing: stationary | PM2.5 | 205 | 3.3 | 74.1 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | PM2.5 | 186 | 3.0 | 77.1 |
| 2H2 | Food and beverages industry | PM2.5 | 166 | 2.7 | 79.7 |
| 2H1 | Pulp and paper industry | PM2.5 | 151 | 2.4 | 82.1 |
| 2A1 | Cement production | PM2.5 | 143 | 2.3 | 84.4 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | PM2.5 | 128 | 2.1 | 86.5 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM10 | 2'610 | 18.5 | 18.5 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM10 | 2'366 | 16.8 | 35.3 |
| 1A4bi | Residential: stationary plants | PM10 | 1'948 | 13.8 | 49.2 |
| 1A3c | Railways | PM10 | 1'517 | 10.8 | 60.0 |
| 3De | Cultivated crops | PM10 | 1'000 | 7.1 | 67.1 |
| 1A4ai | Commercial/institutional: stationary | PM10 | 457 | 3.2 | 70.3 |
| 2G | Other product use | PM10 | 399 | 2.8 | 73.1 |
| 2A5a | Quarrying and mining of minerals other than coal | PM10 | 348 | 2.5 | 75.6 |
| 2H2 | Food and beverages industry | PM10 | 308 | 2.2 | 77.8 |
| 1A5b | Other mobile (including military land-based and recreational boats) | PM10 | 261 | 1.9 | 79.7 |
| 5C1a | Municipal waste incineration | PM10 | 245 | 1.7 | 81.4 |
| 2A1 | Cement production | PM10 | 222 | 1.6 | 83.0 |
| 3B4gii | Manure management - Broilers | PM10 | 212 | 1.5 | 84.5 |
| 1A4ci | Agriculture/forestry/fishing: stationary | PM10 | 208 | 1.5 | 86.0 |

Table A - 4 Switzerland's key categories according to approach 1 level assessment for the year 1990, sorted by decreasing contribution, for the main pollutants, PM2.5 and PM10. Categories in grey are not key and are given for information only.

| KCA APPROACH 1 LEVEL ASSESSMENT FOR 1990 | | | | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| NFR code | Source category | Pollutant | Ex, 0 (t) | Lx, 0 (%) | Cumu-lative Total (%) |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NOx | 43'748 | 31.1 | 31.1 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | NOx | 29'631 | 21.1 | 52.1 |
| 1A4bi | Residential: stationary plants | NOx | 11'636 | 8.3 | 60.4 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | NOx | 10'535 | 7.5 | 67.9 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | NOx | 6'334 | 4.5 | 72.4 |
| 1A1a | Public electricity and heat production | NOx | 6'279 | 4.5 | 76.9 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | NOx | 6'199 | 4.4 | 81.3 |
| 1A4ai | Commercial/institutional: stationary | NOx | 5'139 | 3.7 | 84.9 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | NOx | 4'358 | 3.1 | 88.0 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NMVOC | 55'582 | 18.8 | 18.8 |
| 2D3d | Coating applications | NMVOC | 40'731 | 13.8 | 32.7 |
| 2D3g | Chemical products | NMVOC | 27'504 | 9.3 | 42.0 |
| 2G | Other product use | NMVOC | 22'432 | 7.6 | 49.6 |
| 2D3h | Printing | NMVOC | 20'354 | 6.9 | 56.5 |
| 1B2av | Distribution of oil products | NMVOC | 19'127 | 6.5 | 63.0 |
| 1A3bv(fu) | Road transportation: gasoline evaporation (fuel used) | NMVOC | 17'166 | 5.8 | 68.8 |
| 2D3e | Degreasing | NMVOC | 11'731 | 4.0 | 72.8 |
| 1A4bi | Residential: stationary plants | NMVOC | 10'056 | 3.4 | 76.2 |
| 2D3a | Domestic solvent use including fungicides | NMVOC | 8'867 | 3.0 | 79.2 |
| 3B1a | Manure management - Dairy cattle | NMVOC | 6'413 | 2.2 | 81.4 |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | NMVOC | 5'737 | 1.9 | 83.3 |
| 2D3i | Other solvent use | NMVOC | 5'470 | 1.9 | 85.2 |
| 1A4bi | Residential: stationary plants | SOx | 10'355 | 26.4 | 26.4 |
| 1A4ai | Commercial/institutional: stationary | SOx | 3'870 | 9.9 | 36.3 |
| 1A1a | Public electricity and heat production | SOx | 3'679 | 9.4 | 45.7 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | SOx | 3'534 | 9.0 | 54.7 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | SOx | 3'530 | 9.0 | 63.7 |
| 1A2d | Stationary combustion in manufacturing industries and construction: pulp paper and print | SOx | 3'238 | 8.3 | 72.0 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | SOx | 1'843 | 4.7 | 76.7 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | SOx | 1'619 | 4.1 | 80.8 |
| 1A2c | Stationary combustion in manufacturing industries and construction: chemicals | SOx | 1'187 | 3.0 | 83.9 |
| 1A2e | Stationary combustion in manufacturing industries and construction: food processing beverages and tobacco | SOx | 1'078 | 2.8 | 86.6 |
| 3Da2a | Animal manure applied to soils | NH3 | 34'567 | 50.5 | 50.5 |
| 3B1a | Manure management - Dairy cattle | NH3 | 9'337 | 13.6 | 64.1 |
| 3B3 | Manure management - Swine | NH3 | 6'965 | 10.2 | 74.3 |
| 3B1b | Manure management - Non-dairy cattle | NH3 | 5'191 | 7.6 | 81.8 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | NH3 | 4'259 | 6.2 | 88.1 |
| 1A4bi | Residential: stationary plants | PM2.5 | 14'536 | 53.5 | 53.5 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | PM2.5 | 1'584 | 5.8 | 59.3 |
| 1A4ai | Commercial/institutional: stationary | PM2.5 | 1'354 | 5.0 | 64.3 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | PM2.5 | 873 | 3.2 | 67.5 |
| 2C1 | Iron and steel production | PM2.5 | 818 | 3.0 | 70.5 |
| 1A1a | Public electricity and heat production | PM2.5 | 782 | 2.9 | 73.4 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM2.5 | 729 | 2.7 | 76.1 |
| 1A4ci | Agriculture/forestry/fishing: stationary | PM2.5 | 697 | 2.6 | 78.7 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM2.5 | 690 | 2.5 | 81.2 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | PM2.5 | 579 | 2.1 | 83.3 |
| 2G | Other product use | PM2.5 | 513 | 1.9 | 85.2 |
| 1A4bi | Residential: stationary plants | PM10 | 15'326 | 42.0 | 42.0 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM10 | 2'173 | 6.0 | 48.0 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM10 | 2'046 | 5.6 | 53.6 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | PM10 | 1'584 | 4.3 | 57.9 |
| 2C1 | Iron and steel production | PM10 | 1'485 | 4.1 | 62.0 |
| 1A4ai | Commercial/institutional: stationary | PM10 | 1'428 | 3.9 | 65.9 |
| 3De | Cultivated crops | PM10 | 1'054 | 2.9 | 68.8 |
| 1A1a | Public electricity and heat production | PM10 | 1'045 | 2.9 | 71.7 |
| 1A3c | Railways | PM10 | 970 | 2.7 | 74.3 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | PM10 | 913 | 2.5 | 76.8 |
| 2I | Wood processing | PM10 | 864 | 2.4 | 79.2 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | PM10 | 833 | 2.3 | 81.5 |
| 1A4ci | Agriculture/forestry/fishing: stationary | PM10 | 710 | 1.9 | 83.4 |
| 2G | Other product use | PM10 | 588 | 1.6 | 85.0 |

Table A - 5 Switzerland's key categories according to approach 1 trend assessment for 1990-2023, sorted by decreasing contribution, for the main pollutants, PM2.5 and PM10. Categories in orange have increased emissions in 2023 compared to 1990. Categories in grey are not key and are given for information only.

| KCA APPROACH 1 TREND ASSESSMENT 1990 - 2023 | | | | | | | |
|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H |
| NFR code | Source category | Pollutant | Ex, 0 (t) | Ex, t (t) | Trend Assess-ment | Contri-bution to trend assess. (%) | Cumu-lative Total (%) |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | NOx | 29'631 | 3'029 | 0.048 | 36.9 | 36.9 |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | NOx | 1'214 | 1'966 | 0.011 | 8.5 | 45.4 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | NOx | 6'199 | 3'494 | 0.010 | 7.8 | 53.2 |
| 1A4ai | Commercial/institutional: stationary | NOx | 5'139 | 2'832 | 0.008 | 6.1 | 59.3 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | NOx | 2'182 | 1'638 | 0.006 | 4.9 | 64.2 |
| 3Da2a | Animal manure applied to soils | NOx | 2'075 | 1'449 | 0.005 | 4.1 | 68.3 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | NOx | 10'535 | 2'825 | 0.005 | 3.7 | 72.0 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | NOx | 6'334 | 1'537 | 0.004 | 3.1 | 75.1 |
| 1A3dii | National navigation (shipping) | NOx | 1'055 | 898 | 0.004 | 3.0 | 78.0 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NOx | 43'748 | 15'010 | 0.003 | 2.6 | 80.6 |
| 1A4bi | Residential: stationary plants | NOx | 11'636 | 3'464 | 0.003 | 2.2 | 82.8 |
| 1A2d | Stationary combustion in manufacturing industries and construction: pulp paper and print | NOx | 1'262 | 31 | 0.003 | 2.1 | 84.9 |
| 3Da3 | Urine and dung deposited by grazing animals | NOx | 243 | 417 | 0.002 | 1.8 | 86.7 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NMVOC | 55'582 | 3'635 | 0.033 | 18.9 | 18.9 |
| 3B1b | Manure management - Non-dairy cattle | NMVOC | 5'122 | 7'441 | 0.021 | 12.0 | 30.9 |
| 3B1a | Manure management - Dairy cattle | NMVOC | 6'413 | 6'585 | 0.017 | 9.7 | 40.7 |
| 2D3a | Domestic solvent use including fungicides | NMVOC | 8'867 | 6'507 | 0.015 | 8.4 | 49.1 |
| 2D3g | Chemical products | NMVOC | 27'504 | 3'185 | 0.012 | 6.7 | 55.8 |
| 1B2av | Distribution of oil products | NMVOC | 19'127 | 2'021 | 0.009 | 5.0 | 60.8 |
| 1A3bv(fu) | Road transportation: gasoline evaporation (fuel used) | NMVOC | 17'166 | 1'773 | 0.008 | 4.6 | 65.4 |
| 2D3d | Coating applications | NMVOC | 40'731 | 8'286 | 0.005 | 3.0 | 68.5 |
| 2D3b | Road paving with asphalt | NMVOC | 4'895 | 2'700 | 0.005 | 2.9 | 71.4 |
| 2D3h | Printing | NMVOC | 20'354 | 3'617 | 0.004 | 2.5 | 73.9 |
| 2D3e | Degreasing | NMVOC | 11'731 | 1'566 | 0.004 | 2.5 | 76.4 |
| 5B2 | Biological treatment of waste - Anaerobic digestion at biogas facilities | NMVOC | 50 | 1'147 | 0.004 | 2.2 | 78.5 |
| 2H2 | Food and beverages industry | NMVOC | 1'413 | 1'417 | 0.004 | 2.1 | 80.6 |
| 3B4gii | Manure management - Broilers | NMVOC | 366 | 1'144 | 0.004 | 2.0 | 82.7 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | NMVOC | 4'869 | 132 | 0.004 | 2.0 | 84.7 |
| 2G | Other product use | NMVOC | 22'432 | 6'316 | 0.003 | 1.7 | 86.4 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | SOx | 3'530 | 1'300 | 0.027 | 35.7 | 35.7 |
| 1A4bi | Residential: stationary plants | SOx | 10'355 | 207 | 0.014 | 18.5 | 54.1 |
| 1A2d | Stationary combustion in manufacturing industries and construction: pulp paper and print | SOx | 3'238 | 1 | 0.006 | 8.0 | 62.1 |
| 1A4ai | Commercial/institutional: stationary | SOx | 3'870 | 83 | 0.005 | 6.7 | 68.8 |
| 2B5 | Carbide production | SOx | 625 | 198 | 0.004 | 5.2 | 74.0 |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | SOx | 100 | 137 | 0.003 | 4.4 | 78.4 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | SOx | 1'843 | 9 | 0.003 | 4.2 | 82.7 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | SOx | 1'619 | 35 | 0.002 | 2.8 | 85.5 |
| 3Da2a | Animal manure applied to soils | NH3 | 34'567 | 20'191 | 0.095 | 32.9 | 32.9 |
| 3B1b | Manure management - Non-dairy cattle | NH3 | 5'191 | 7'241 | 0.047 | 16.4 | 49.2 |
| 3B1a | Manure management - Dairy cattle | NH3 | 9'337 | 10'144 | 0.043 | 14.8 | 64.1 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | NH3 | 4'259 | 2'251 | 0.015 | 5.3 | 69.3 |
| 3Da2c | Other organic fertilisers applied to soils (including compost) | NH3 | 34 | 1'042 | 0.015 | 5.1 | 74.5 |
| 3Da2b | Sewage sludge applied to soils | NH3 | 1'169 | 0 | 0.013 | 4.6 | 79.0 |
| 3Da3 | Urine and dung deposited by grazing animals | NH3 | 761 | 1'413 | 0.012 | 4.2 | 83.2 |
| 3B3 | Manure management - Swine | NH3 | 6'965 | 4'736 | 0.009 | 3.3 | 86.5 |
| 1A4bi | Residential: stationary plants | PM2.5 | 14'536 | 1'852 | 0.054 | 31.4 | 31.4 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM2.5 | 690 | 958 | 0.029 | 17.0 | 48.5 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | PM2.5 | 1'584 | 36 | 0.012 | 6.9 | 55.4 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM2.5 | 729 | 384 | 0.008 | 4.6 | 60.0 |
| 2G | Other product use | PM2.5 | 513 | 327 | 0.008 | 4.5 | 64.5 |
| 1A3c | Railways | PM2.5 | 173 | 233 | 0.007 | 4.1 | 68.6 |
| 2C1 | Iron and steel production | PM2.5 | 818 | 7 | 0.007 | 3.8 | 72.4 |
| 1A1a | Public electricity and heat production | PM2.5 | 782 | 46 | 0.005 | 2.8 | 75.3 |
| 2H2 | Food and beverages industry | PM2.5 | 188 | 166 | 0.005 | 2.6 | 77.9 |
| 1A4ai | Commercial/institutional: stationary | PM2.5 | 1'354 | 430 | 0.004 | 2.5 | 80.4 |
| 5C1a | Municipal waste incineration | PM2.5 | 465 | 221 | 0.004 | 2.4 | 82.8 |
| 2H1 | Pulp and paper industry | PM2.5 | 236 | 151 | 0.004 | 2.1 | 84.9 |
| 2A1 | Cement production | PM2.5 | 240 | 143 | 0.003 | 1.9 | 86.8 |
| 1A4bi | Residential: stationary plants | PM10 | 15'326 | 1'948 | 0.109 | 29.8 | 29.8 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM10 | 2'046 | 2'610 | 0.050 | 13.7 | 43.5 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM10 | 2'173 | 2'366 | 0.042 | 11.5 | 55.0 |
| 1A3c | Railways | PM10 | 970 | 1'517 | 0.031 | 8.6 | 63.6 |
| 3De | Cultivated crops | PM10 | 1'054 | 1'000 | 0.016 | 4.5 | 68.1 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | PM10 | 1'584 | 36 | 0.016 | 4.3 | 72.4 |
| 2C1 | Iron and steel production | PM10 | 1'485 | 10 | 0.015 | 4.2 | 76.6 |
| 1A1a | Public electricity and heat production | PM10 | 1'045 | 46 | 0.010 | 2.7 | 79.3 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | PM10 | 833 | 68 | 0.007 | 1.9 | 81.2 |
| 2A5a | Quarrying and mining of minerals other than coal | PM10 | 302 | 348 | 0.006 | 1.7 | 83.0 |
| 2H2 | Food and beverages industry | PM10 | 310 | 308 | 0.005 | 1.4 | 84.4 |
| 3B4gii | Manure management - Broilers | PM10 | 68 | 212 | 0.005 | 1.4 | 85.8 |

Table A - 6 Switzerland's key categories according to approach 1 level assessment for the year 2023, sorted by decreasing contribution, for TSP, BC, CO, priority heavy metals, PCDD/PCDF, PAHs total, HCB and PCBs. Categories in grey are not key and are given for information only.

| KCA APPROACH 1 LEVEL ASSESSMENT FOR 2023 | | | | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| NFR code | Source category | Pollutant (unit) | Ex, t | Lx, t (%) | Cumu-lative Total (%) |
| 3De | Cultivated crops | TSP (t) | 9'995 | 35.6 | 35.6 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | TSP (t) | 3'532 | 12.6 | 48.2 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | TSP (t) | 2'610 | 9.3 | 57.5 |
| 1A4bi | Residential: stationary plants | TSP (t) | 2'040 | 7.3 | 64.8 |
| 1A3c | Railways | TSP (t) | 2'014 | 7.2 | 72.0 |
| 2A5a | Quarrying and mining of minerals other than coal | TSP (t) | 828 | 3.0 | 74.9 |
| 3B4gi | Manure management - Laying hens | TSP (t) | 730 | 2.6 | 77.5 |
| 3B3 | Manure management - Swine | TSP (t) | 618 | 2.2 | 79.7 |
| 1A4ai | Commercial/institutional: stationary | TSP (t) | 475 | 1.7 | 81.4 |
| 2I | Wood processing | TSP (t) | 469 | 1.7 | 83.1 |
| 2H2 | Food and beverages industry | TSP (t) | 425 | 1.5 | 84.6 |
| 3B4gii | Manure management - Broilers | TSP (t) | 424 | 1.5 | 86.1 |
| 1A4bi | Residential: stationary plants | BC (t) | 416 | 50.0 | 50.0 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | BC (t) | 96 | 11.5 | 61.6 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | BC (t) | 78 | 9.3 | 70.9 |
| 1A4ai | Commercial/institutional: stationary | BC (t) | 76 | 9.1 | 80.0 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | BC (t) | 29 | 3.5 | 83.5 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | BC (t) | 23 | 2.7 | 86.3 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | CO (t) | 45'779 | 33.0 | 33.0 |
| 1A4bi | Residential: stationary plants | CO (t) | 23'878 | 17.2 | 50.2 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | CO (t) | 12'216 | 8.8 | 59.0 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | CO (t) | 8'146 | 5.9 | 64.9 |
| 1A4aii | Commercial/institutional: mobile | CO (t) | 6'484 | 4.7 | 69.6 |
| 1A4ai | Commercial/institutional: stationary | CO (t) | 6'179 | 4.5 | 74.0 |
| 1A3dii | National navigation (shipping) | CO (t) | 4'996 | 3.6 | 77.6 |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | CO (t) | 4'911 | 3.5 | 81.1 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | CO (t) | 4'087 | 2.9 | 84.1 |
| 1A4bii | Residential: household and gardening (mobile) | CO (t) | 3'886 | 2.8 | 86.9 |
| 1A1a | Public electricity and heat production | Pb (kg) | 1'721 | 22.0 | 22.0 |
| 6A | Other sources | Pb (kg) | 1'701 | 21.8 | 43.8 |
| 5C1a | Municipal waste incineration | Pb (kg) | 1'532 | 19.6 | 63.5 |
| 1A3aii(i) | Civil aviation (domestic cruise) | Pb (kg) | 661 | 8.5 | 71.9 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | Pb (kg) | 584 | 7.5 | 79.4 |
| 1A4bi | Residential: stationary plants | Pb (kg) | 341 | 4.4 | 83.8 |
| 2G | Other product use | Pb (kg) | 311 | 4.0 | 87.8 |
| 1A1a | Public electricity and heat production | Cd (kg) | 152 | 37.5 | 37.5 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | Cd (kg) | 92 | 22.5 | 60.0 |
| 2G | Other product use | Cd (kg) | 27 | 6.5 | 66.5 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | Cd (kg) | 25 | 6.2 | 72.7 |
| 1A4bi | Residential: stationary plants | Cd (kg) | 25 | 6.2 | 78.9 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | Cd (kg) | 19 | 4.7 | 83.6 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | Cd (kg) | 17 | 4.3 | 87.8 |
| 1A1a | Public electricity and heat production | Hg (kg) | 293 | 52.2 | 52.2 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | Hg (kg) | 56 | 10.0 | 62.3 |
| 1A4bi | Residential: stationary plants | Hg (kg) | 47 | 8.3 | 70.6 |
| 2C1 | Iron and steel production | Hg (kg) | 37 | 6.7 | 77.2 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | Hg (kg) | 28 | 5.0 | 82.2 |
| 1A4ai | Commercial/institutional: stationary | Hg (kg) | 28 | 4.9 | 87.1 |
| 1A4bi | Residential: stationary plants | PCDD/PCDF (mg I-TEQ) | 4'176 | 34.4 | 34.4 |
| 5C1a | Municipal waste incineration | PCDD/PCDF (mg I-TEQ) | 2'451 | 20.2 | 54.5 |
| 1A4ai | Commercial/institutional: stationary | PCDD/PCDF (mg I-TEQ) | 1'157 | 9.5 | 64.1 |
| 6A | Other sources | PCDD/PCDF (mg I-TEQ) | 986 | 8.1 | 72.2 |
| 1A1a | Public electricity and heat production | PCDD/PCDF (mg I-TEQ) | 985 | 8.1 | 80.3 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | PCDD/PCDF (mg I-TEQ) | 680 | 5.6 | 85.9 |
| 1A4bi | Residential: stationary plants | PAHs total (kg) | 1'342 | 57.3 | 57.3 |
| 1A4ai | Commercial/institutional: stationary | PAHs total (kg) | 257 | 11.0 | 68.2 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | PAHs total (kg) | 209 | 8.9 | 77.2 |
| 5C2 | Open burning of waste | PAHs total (kg) | 189 | 8.1 | 85.2 |
| 1A1a | Public electricity and heat production | HCB (g) | 184 | 54.0 | 54.0 |
| 1A4bi | Residential: stationary plants | HCB (g) | 84 | 24.7 | 78.7 |
| 1A4ai | Commercial/institutional: stationary | HCB (g) | 36 | 10.5 | 89.3 |
| 2K | Consumption of POPs and heavy metals (e.g. electrical and scientific equipment) | PCB (g) | 277'566 | 89.5 | 89.5 |

Table A - 7 Switzerland's key categories according to approach 1 level assessment for the year 1990, sorted by decreasing contribution, for TSP, BC, CO, priority heavy metals, PCDD/PCDF, PAHs total, HCB and PCBs. Categories in grey are not key and are given for information only.

| KCA APPROACH 1 LEVEL ASSESSMENT FOR 1990 | | | | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| NFR code | Source category | Pollutant (unit) | Ex, 0 | Lx, 0 (%) | Cumu-lative Total (%) |
| 1A4bi | Residential: stationary plants | TSP (t) | 16'162 | 28.8 | 28.8 |
| 3De | Cultivated crops | TSP (t) | 10'536 | 18.8 | 47.6 |
| 2I | Wood processing | TSP (t) | 4'322 | 7.7 | 55.3 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | TSP (t) | 3'023 | 5.4 | 60.7 |
| 2C1 | Iron and steel production | TSP (t) | 2'686 | 4.8 | 65.5 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | TSP (t) | 2'046 | 3.6 | 69.1 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | TSP (t) | 1'584 | 2.8 | 71.9 |
| 1A4ai | Commercial/institutional: stationary | TSP (t) | 1'501 | 2.7 | 74.6 |
| 1A3c | Railways | TSP (t) | 1'280 | 2.3 | 76.9 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | TSP (t) | 1'227 | 2.2 | 79.1 |
| 1A1a | Public electricity and heat production | TSP (t) | 1'059 | 1.9 | 81.0 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | TSP (t) | 972 | 1.7 | 82.7 |
| 3B3 | Manure management - Swine | TSP (t) | 915 | 1.6 | 84.3 |
| 1A4ci | Agriculture/forestry/fishing: stationary | TSP (t) | 724 | 1.3 | 85.6 |
| 1A4bi | Residential: stationary plants | BC (t) | 3'220 | 56.2 | 56.2 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | BC (t) | 792 | 13.8 | 70.0 |
| 1A4ai | Commercial/institutional: stationary | BC (t) | 301 | 5.2 | 75.3 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | BC (t) | 256 | 4.5 | 79.7 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | BC (t) | 242 | 4.2 | 84.0 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | BC (t) | 232 | 4.1 | 88.0 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | CO (t) | 421'663 | 56.1 | 56.1 |
| 1A4bi | Residential: stationary plants | CO (t) | 111'881 | 14.9 | 71.0 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | CO (t) | 71'839 | 9.6 | 80.5 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | CO (t) | 28'368 | 3.8 | 84.3 |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | CO (t) | 24'679 | 3.3 | 87.6 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | Pb (kg) | 211'660 | 59.7 | 59.7 |
| 2C1 | Iron and steel production | Pb (kg) | 59'858 | 16.9 | 76.6 |
| 1A1a | Public electricity and heat production | Pb (kg) | 29'818 | 8.4 | 85.0 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | Pb (kg) | 11'971 | 3.4 | 88.4 |
| 1A1a | Public electricity and heat production | Cd (kg) | 1'754 | 55.1 | 55.1 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | Cd (kg) | 665 | 20.9 | 76.0 |
| 2C1 | Iron and steel production | Cd (kg) | 443 | 13.9 | 90.0 |
| 1A1a | Public electricity and heat production | Hg (kg) | 3'915 | 62.1 | 62.1 |
| 2C1 | Iron and steel production | Hg (kg) | 1'108 | 17.6 | 79.7 |
| 2B10a | Chemical industry: other | Hg (kg) | 384 | 6.1 | 85.7 |
| 1A1a | Public electricity and heat production | PCDD/PCDF (mg I-TEQ) | 130'484 | 67.8 | 67.8 |
| 1A4bi | Residential: stationary plants | PCDD/PCDF (mg I-TEQ) | 17'674 | 9.2 | 77.0 |
| 2C1 | Iron and steel production | PCDD/PCDF (mg I-TEQ) | 12'419 | 6.5 | 83.5 |
| 5C1biii | Clinical waste incineration | PCDD/PCDF (mg I-TEQ) | 6'900 | 3.6 | 87.0 |
| 1A4bi | Residential: stationary plants | PAHs total (kg) | 5'698 | 70.9 | 70.9 |
| 2C3 | Aluminium production | PAHs total (kg) | 940 | 11.7 | 82.5 |
| 1A4ai | Commercial/institutional: stationary | PAHs total (kg) | 516 | 6.4 | 89.0 |
| 1A2b | Stationary combustion in manufacturing industries and construction: non-ferrous metals | HCB (g) | 172'000 | 99.7 | 99.7 |
| 2K | Consumption of POPs and heavy metals (e.g. electrical and scientific equipment) | PCB (g) | 1'525'788 | 65.4 | 65.4 |
| 6A | Other sources | PCB (g) | 281'955 | 12.1 | 77.5 |
| 5E | Other waste | PCB (g) | 215'511 | 9.2 | 86.8 |

Table A - 8 Switzerland's key categories according to approach 1 trend assessment for 1990-2023, sorted by decreasing contribution, for TSP, BC, CO, priority heavy metals, PCDD/PCDF, PAHs total, HCB and PCBs. Categories in orange have increased emissions in 2023 compared to 1990. Categories in grey are not key and are given for information only.

| KCA APPROACH 1 TREND ASSESSMENT 1990 - 2023 | | | | | | | |
|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H |
| NFR code | Source category | Pollutant (unit) | Ex, 0 | Ex, t | Trend Assess-ment | Contri-bution to trend assess. (%) | Cumu-lative Total (%) |
| 1A4bi | Residential: stationary plants | TSP (t) | 16'162 | 2'040 | 0.108 | 24.4 | 24.4 |
| 3De | Cultivated crops | TSP (t) | 10'536 | 9'995 | 0.084 | 19.1 | 43.5 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | TSP (t) | 3'023 | 3'532 | 0.036 | 8.2 | 51.7 |
| 2I | Wood processing | TSP (t) | 4'322 | 469 | 0.030 | 6.8 | 58.5 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | TSP (t) | 2'046 | 2'610 | 0.028 | 6.4 | 65.0 |
| 1A3c | Railways | TSP (t) | 1'280 | 2'014 | 0.024 | 5.6 | 70.5 |
| 2C1 | Iron and steel production | TSP (t) | 2'686 | 12 | 0.024 | 5.4 | 75.9 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | TSP (t) | 1'584 | 36 | 0.013 | 3.1 | 78.9 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | TSP (t) | 1'227 | 78 | 0.010 | 2.2 | 81.1 |
| 2A5a | Quarrying and mining of minerals other than coal | TSP (t) | 651 | 828 | 0.009 | 2.0 | 83.1 |
| 1A1a | Public electricity and heat production | TSP (t) | 1'059 | 46 | 0.009 | 2.0 | 85.1 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | BC (t) | 792 | 13 | 0.018 | 25.4 | 25.4 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | BC (t) | 69 | 96 | 0.015 | 21.4 | 46.8 |
| 1A4bi | Residential: stationary plants | BC (t) | 3'220 | 416 | 0.009 | 12.8 | 59.6 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | BC (t) | 232 | 78 | 0.008 | 10.9 | 70.5 |
| 1A4ai | Commercial/institutional: stationary | BC (t) | 301 | 76 | 0.006 | 8.1 | 78.6 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | BC (t) | 256 | 17 | 0.004 | 5.1 | 83.6 |
| 5C1a | Municipal waste incineration | BC (t) | 33 | 15 | 0.002 | 2.7 | 86.3 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | CO (t) | 421'663 | 45'779 | 0.043 | 37.2 | 37.2 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | CO (t) | 71'839 | 3'592 | 0.013 | 11.2 | 48.5 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | CO (t) | 28'368 | 12'216 | 0.009 | 8.1 | 56.6 |
| 1A4aii | Commercial/institutional: mobile | CO (t) | 4'117 | 6'484 | 0.008 | 6.6 | 63.2 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | CO (t) | 13'126 | 8'146 | 0.008 | 6.6 | 69.9 |
| 1A4ai | Commercial/institutional: stationary | CO (t) | 11'356 | 6'179 | 0.005 | 4.7 | 74.6 |
| 1A4bii | Residential: household and gardening (mobile) | CO (t) | 3'271 | 3'886 | 0.004 | 3.8 | 78.4 |
| 1A4bi | Residential: stationary plants | CO (t) | 111'881 | 23'878 | 0.004 | 3.7 | 82.2 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | CO (t) | 7'253 | 4'087 | 0.004 | 3.2 | 85.4 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | Pb (kg) | 211'660 | 104 | 0.013 | 36.7 | 36.7 |
| 6A | Other sources | Pb (kg) | 7'612 | 1'701 | 0.004 | 12.3 | 49.0 |
| 5C1a | Municipal waste incineration | Pb (kg) | 3'230 | 1'532 | 0.004 | 11.7 | 60.7 |
| 2C1 | Iron and steel production | Pb (kg) | 59'858 | 192 | 0.003 | 9.1 | 69.8 |
| 1A1a | Public electricity and heat production | Pb (kg) | 29'818 | 1'721 | 0.003 | 8.6 | 78.4 |
| 1A3aii(i) | Civil aviation (domestic cruise) | Pb (kg) | 2'027 | 661 | 0.002 | 5.0 | 83.3 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | Pb (kg) | 975 | 584 | 0.002 | 4.5 | 87.8 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | Cd (kg) | 65 | 92 | 0.026 | 21.8 | 21.8 |
| 1A1a | Public electricity and heat production | Cd (kg) | 1'754 | 152 | 0.023 | 18.8 | 40.6 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | Cd (kg) | 665 | 25 | 0.019 | 15.6 | 56.2 |
| 2C1 | Iron and steel production | Cd (kg) | 443 | 4 | 0.017 | 13.8 | 70.0 |
| 2G | Other product use | Cd (kg) | 30 | 27 | 0.007 | 5.9 | 75.9 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | Cd (kg) | 12 | 19 | 0.006 | 4.6 | 80.6 |
| 1A4bi | Residential: stationary plants | Cd (kg) | 62 | 25 | 0.005 | 4.5 | 85.0 |
| 2C1 | Iron and steel production | Hg (kg) | 1'108 | 37 | 0.010 | 17.7 | 17.7 |
| 1A1a | Public electricity and heat production | Hg (kg) | 3'915 | 293 | 0.009 | 16.0 | 33.8 |
| 1A4bi | Residential: stationary plants | Hg (kg) | 72 | 47 | 0.006 | 11.7 | 45.5 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | Hg (kg) | 226 | 56 | 0.006 | 10.5 | 56.0 |
| 2B10a | Chemical industry: other | Hg (kg) | 384 | 0 | 0.005 | 9.9 | 65.9 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | Hg (kg) | 13 | 28 | 0.004 | 7.7 | 73.6 |
| 1A4ai | Commercial/institutional: stationary | Hg (kg) | 14 | 28 | 0.004 | 7.7 | 81.3 |
| 5C1biii | Clinical waste incineration | Hg (kg) | 240 | 0 | 0.003 | 6.2 | 87.5 |
| 1A1a | Public electricity and heat production | PCDD/PCDF (mg I-TEQ) | 130'484 | 985 | 0.038 | 41.2 | 41.2 |
| 1A4bi | Residential: stationary plants | PCDD/PCDF (mg I-TEQ) | 17'674 | 4'176 | 0.016 | 17.4 | 58.5 |
| 5C1a | Municipal waste incineration | PCDD/PCDF (mg I-TEQ) | 5'168 | 2'451 | 0.011 | 12.1 | 70.6 |
| 1A4ai | Commercial/institutional: stationary | PCDD/PCDF (mg I-TEQ) | 2'112 | 1'157 | 0.005 | 5.8 | 76.4 |
| 6A | Other sources | PCDD/PCDF (mg I-TEQ) | 1'633 | 986 | 0.005 | 5.0 | 81.4 |
| 2C1 | Iron and steel production | PCDD/PCDF (mg I-TEQ) | 12'419 | 133 | 0.003 | 3.7 | 85.1 |
| 1A4bi | Residential: stationary plants | PAHs total (kg) | 5'698 | 1'342 | 0.040 | 26.4 | 26.4 |
| 2C3 | Aluminium production | PAHs total (kg) | 940 | 0 | 0.034 | 22.7 | 49.0 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | PAHs total (kg) | 103 | 209 | 0.022 | 14.8 | 63.8 |
| 5C2 | Open burning of waste | PAHs total (kg) | 282 | 189 | 0.013 | 8.8 | 72.7 |
| 1A4ai | Commercial/institutional: stationary | PAHs total (kg) | 516 | 257 | 0.013 | 8.8 | 81.5 |
| 6A | Other sources | PAHs total (kg) | 65 | 111 | 0.011 | 7.6 | 89.1 |
| 1A2b | Stationary combustion in manufacturing industries and construction: non-ferrous metals | HCB (g) | 172'000 | 0 | 0.002 | 50.0 | 50.0 |
| 1A1a | Public electricity and heat production | HCB (g) | 114 | 184 | 0.001 | 27.1 | 77.1 |
| 1A4bi | Residential: stationary plants | HCB (g) | 322 | 84 | 0.000 | 12.3 | 89.4 |
| 2K | Consumption of POPs and heavy metals (e.g. electrical and scientific equipment) | PCB (g) | 1'525'788 | 277'566 | 0.032 | 49.6 | 49.6 |
| 5E | Other waste | PCB (g) | 215'511 | 2'128 | 0.011 | 17.6 | 67.3 |
| 1A1a | Public electricity and heat production | PCB (g) | 164'493 | 61 | 0.009 | 14.5 | 81.8 |
| 5C1bii | Hazardous waste incineration | PCB (g) | 111'813 | 0 | 0.006 | 9.9 | 91.7 |

## A1.3 Detailed results of approach 2 assessment

The following tables report the detailed results for the key category analysis, approach 2, level and trend assessments, for the reporting year 2023 and the base year 1990. Columns labelled A to F for the level assessments correspond exactly to columns A to F from Table 3-1 from the EMEP/EEA guidebook (EMEP/EEA 2023, part A, chp. 2, “Methodological choice and Key category analysis”. For the table reporting the trend assessment, columns labelled A to H correspond exactly to columns A to H from Table 3-2 from the same guidelines. Equations referenced hereafter are also from the same guidelines.

Explanations of headers for tables in this Annex are:

- $E_{x,t}$: emission estimate for the reporting year.
- $E_{x,0}$: emission estimate for the base year.
- $L_{x,t}$: level assessment for the reporting year (EMEP/EAA guidebook part A, chp. 2, equ. 3 for approach 2).
- $L_{x,0}$: level assessment for the base year (EMEP/EAA guidebook part A, chp. 2, equ. 3 for approach 2).
- Trend assessment: computed according to the EMEP/EAA guidebook part A, chp. 2, equ. 4 for approach 2.

Table A - 9 Switzerland's key categories according to approach 2 level assessment for the year 2023, sorted by decreasing contribution, for the main pollutants, PM2.5 and PM10. Categories in grey are not key and are given for information only.

| KCA APPROACH 2, UNCERTAINTY APPROACH 2, LEVEL ASSESSMENT FOR 2023 | | | | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| NFR code | Source category | Pollutant | Ex, t (t) | Lx, t (%) | Cumu-lative Total (%) |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NOx | 15'010 | 42.3 | 42.3 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | NOx | 3'494 | 8.3 | 50.6 |
| 3Da2a | Animal manure applied to soils | NOx | 1'449 | 5.4 | 56.0 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | NOx | 609 | 4.5 | 60.5 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | NOx | 3'029 | 4.0 | 64.5 |
| 1A1a | Public electricity and heat production | NOx | 2'267 | 3.6 | 68.1 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | NOx | 2'825 | 3.6 | 71.6 |
| 1A4bi | Residential: stationary plants | NOx | 3'464 | 3.4 | 75.1 |
| 1A4ai | Commercial/institutional: stationary | NOx | 2'832 | 3.3 | 78.4 |
| 3Da3 | Urine and dung deposited by grazing animals | NOx | 417 | 3.1 | 81.5 |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | NOx | 1'966 | 2.9 | 84.4 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | NOx | 1'638 | 2.1 | 86.5 |
| 2G | Other product use | NMVOC | 6'316 | 17.6 | 17.6 |
| 3B1b | Manure management - Non-dairy cattle | NMVOC | 7'441 | 9.5 | 27.1 |
| 3B1a | Manure management - Dairy cattle | NMVOC | 6'585 | 7.2 | 34.3 |
| 2D3d | Coating applications | NMVOC | 8'286 | 6.7 | 41.1 |
| 2D3a | Domestic solvent use including fungicides | NMVOC | 6'507 | 5.9 | 47.0 |
| 2D3g | Chemical products | NMVOC | 3'185 | 5.5 | 52.5 |
| 2D3i | Other solvent use | NMVOC | 1'933 | 5.0 | 57.6 |
| 2D3b | Road paving with asphalt | NMVOC | 2'700 | 4.5 | 62.1 |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | NMVOC | 827 | 3.7 | 65.7 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NMVOC | 3'635 | 3.4 | 69.2 |
| 3B4gii | Manure management - Broilers | NMVOC | 1'144 | 3.2 | 72.4 |
| 2D3h | Printing | NMVOC | 3'617 | 2.9 | 75.3 |
| 1A4bi | Residential: stationary plants | NMVOC | 2'347 | 2.9 | 78.2 |
| 2H2 | Food and beverages industry | NMVOC | 1'417 | 2.4 | 80.6 |
| 3B3 | Manure management - Swine | NMVOC | 770 | 2.1 | 82.7 |
| 2D3e | Degreasing | NMVOC | 1'566 | 1.8 | 84.5 |
| 3B4gi | Manure management - Laying hens | NMVOC | 634 | 1.8 | 86.3 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | SOx | 1'300 | 45.3 | 45.3 |
| 1A1a | Public electricity and heat production | SOx | 256 | 11.3 | 56.6 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | SOx | 260 | 9.1 | 65.6 |
| 2B5 | Carbide production | SOx | 198 | 7.3 | 72.9 |
| 1A4bi | Residential: stationary plants | SOx | 207 | 4.0 | 76.9 |
| 2B10a | Chemical industry: other | SOx | 40 | 2.9 | 79.9 |
| 1A4ci | Agriculture/forestry/fishing: stationary | SOx | 51 | 2.6 | 82.5 |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | SOx | 137 | 2.5 | 85.0 |
| 2C1 | Iron and steel production | SOx | 13 | 2.2 | 87.2 |
| 3Da2a | Animal manure applied to soils | NH3 | 20'191 | 24.1 | 24.1 |
| 3B1a | Manure management - Dairy cattle | NH3 | 10'144 | 16.4 | 40.5 |
| 3B1b | Manure management - Non-dairy cattle | NH3 | 7'241 | 10.9 | 51.4 |
| 3B3 | Manure management - Swine | NH3 | 4'736 | 10.4 | 61.9 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | NH3 | 2'251 | 6.1 | 68.0 |
| 6A | Other sources | NH3 | 970 | 5.6 | 73.6 |
| 3Da3 | Urine and dung deposited by grazing animals | NH3 | 1'413 | 4.8 | 78.4 |
| 3B4gii | Manure management - Broilers | NH3 | 680 | 3.2 | 81.6 |
| 3Da2c | Other organic fertilisers applied to soils (including compost) | NH3 | 1'042 | 3.1 | 84.6 |
| 3B4gi | Manure management - Laying hens | NH3 | 674 | 3.0 | 87.6 |
| 1A4bi | Residential: stationary plants | PM2.5 | 1'852 | 27.0 | 27.0 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM2.5 | 958 | 9.2 | 36.2 |
| 2H2 | Food and beverages industry | PM2.5 | 166 | 8.7 | 44.9 |
| 1A4ai | Commercial/institutional: stationary | PM2.5 | 430 | 6.4 | 51.3 |
| 2G | Other product use | PM2.5 | 327 | 5.9 | 57.2 |
| 2A5a | Quarrying and mining of minerals other than coal | PM2.5 | 98 | 5.1 | 62.3 |
| 2H1 | Pulp and paper industry | PM2.5 | 151 | 4.4 | 66.8 |
| 2A1 | Cement production | PM2.5 | 143 | 4.2 | 70.9 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM2.5 | 384 | 3.7 | 74.6 |
| 2I | Wood processing | PM2.5 | 47 | 2.5 | 77.1 |
| 5C1a | Municipal waste incineration | PM2.5 | 221 | 2.5 | 79.6 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | PM2.5 | 186 | 2.3 | 81.9 |
| 1A3c | Railways | PM2.5 | 233 | 2.2 | 84.1 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | PM2.5 | 128 | 2.0 | 86.1 |
| 3De | Cultivated crops | PM10 | 1'000 | 12.1 | 12.1 |
| 1A4bi | Residential: stationary plants | PM10 | 1'948 | 11.8 | 23.8 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM10 | 2'610 | 10.4 | 34.2 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM10 | 2'366 | 9.4 | 43.6 |
| 2A5a | Quarrying and mining of minerals other than coal | PM10 | 348 | 7.5 | 51.1 |
| 2H2 | Food and beverages industry | PM10 | 308 | 6.7 | 57.8 |
| 1A3c | Railways | PM10 | 1'517 | 6.0 | 63.8 |
| 2I | Wood processing | PM10 | 188 | 4.1 | 67.9 |
| 3B4gii | Manure management - Broilers | PM10 | 212 | 3.4 | 71.3 |
| 2G | Other product use | PM10 | 399 | 3.0 | 74.3 |
| 1A4ai | Commercial/institutional: stationary | PM10 | 457 | 2.8 | 77.2 |
| 2A1 | Cement production | PM10 | 222 | 2.7 | 79.8 |
| 3B4gi | Manure management - Laying hens | PM10 | 154 | 2.5 | 82.3 |
| 3B3 | Manure management - Swine | PM10 | 143 | 2.3 | 84.6 |
| 2H1 | Pulp and paper industry | PM10 | 156 | 1.9 | 86.5 |

Table A - 10 Switzerland's key categories according to approach 2 level assessment for the year 1990, sorted by decreasing contribution, for the main pollutants, PM2.5 and PM10. Categories in grey are not key and are given for information only.

| KCA APPROACH 2, UNCERTAINTY APPROACH 2, LEVEL ASSESSMENT FOR 1990 | | | | | |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| NFR code | Source category | Pollutant | Ex, 0 (t) | Lx, 0 (%) | Cumu-lative Total (%) |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NOx | 43'748 | 45.3 | 45.3 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | NOx | 29'631 | 14.5 | 59.8 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | NOx | 6'199 | 5.4 | 65.2 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | NOx | 10'535 | 4.9 | 70.0 |
| 1A4bi | Residential: stationary plants | NOx | 11'636 | 4.2 | 74.3 |
| 1A1a | Public electricity and heat production | NOx | 6'279 | 3.7 | 77.9 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | NOx | 1'205 | 3.3 | 81.2 |
| 3Da2a | Animal manure applied to soils | NOx | 2'075 | 2.8 | 84.0 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | NOx | 6'334 | 2.2 | 86.3 |
| 2G | Other product use | NMVOC | 22'432 | 16.6 | 16.6 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NMVOC | 55'582 | 14.0 | 30.7 |
| 2D3g | Chemical products | NMVOC | 27'504 | 12.7 | 43.4 |
| 2D3d | Coating applications | NMVOC | 40'731 | 8.8 | 52.2 |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | NMVOC | 5'737 | 6.8 | 59.0 |
| 2D3h | Printing | NMVOC | 20'354 | 4.4 | 63.4 |
| 2D3i | Other solvent use | NMVOC | 5'470 | 3.8 | 67.2 |
| 1B2av | Distribution of oil products | NMVOC | 19'127 | 3.7 | 70.9 |
| 2D3e | Degreasing | NMVOC | 11'731 | 3.6 | 74.5 |
| 1A3bv(fu) | Road transportation: gasoline evaporation (fuel used) | NMVOC | 17'166 | 3.3 | 77.8 |
| 1A4bi | Residential: stationary plants | NMVOC | 10'056 | 3.3 | 81.1 |
| 2D3b | Road paving with asphalt | NMVOC | 4'895 | 2.2 | 83.3 |
| 2D3a | Domestic solvent use including fungicides | NMVOC | 8'867 | 2.1 | 85.4 |
| 1A4bi | Residential: stationary plants | SOx | 10'355 | 15.7 | 15.7 |
| 2C3 | Aluminium production | SOx | 696 | 15.1 | 30.8 |
| 1A1a | Public electricity and heat production | SOx | 3'679 | 12.6 | 43.4 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | SOx | 3'534 | 9.6 | 53.0 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | SOx | 3'530 | 9.6 | 62.6 |
| 1A2d | Stationary combustion in manufacturing industries and construction: pulp paper and print | SOx | 3'238 | 6.5 | 69.1 |
| 1A4ai | Commercial/institutional: stationary | SOx | 3'870 | 5.6 | 74.7 |
| 1B2aiv | Fugitive emissions oil: refining / storage | SOx | 419 | 3.3 | 78.0 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | SOx | 1'843 | 2.6 | 80.6 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | SOx | 1'619 | 2.3 | 82.9 |
| 1A2c | Stationary combustion in manufacturing industries and construction: chemicals | SOx | 1'187 | 1.9 | 84.8 |
| 2C1 | Iron and steel production | SOx | 144 | 1.9 | 86.7 |
| 3Da2a | Animal manure applied to soils | NH3 | 34'567 | 33.9 | 33.9 |
| 3B3 | Manure management - Swine | NH3 | 6'965 | 12.6 | 46.5 |
| 3B1a | Manure management - Dairy cattle | NH3 | 9'337 | 12.4 | 58.8 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | NH3 | 4'259 | 9.5 | 68.4 |
| 3B1b | Manure management - Non-dairy cattle | NH3 | 5'191 | 6.4 | 74.8 |
| 6A | Other sources | NH3 | 846 | 4.0 | 78.8 |
| 3B4gi | Manure management - Laying hens | NH3 | 979 | 3.6 | 82.4 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NH3 | 1'325 | 3.0 | 85.3 |
| 1A4bi | Residential: stationary plants | PM2.5 | 14'536 | 53.8 | 53.8 |
| 1A4ai | Commercial/institutional: stationary | PM2.5 | 1'354 | 5.1 | 58.9 |
| 2C1 | Iron and steel production | PM2.5 | 818 | 4.4 | 63.3 |
| 2I | Wood processing | PM2.5 | 216 | 2.9 | 66.1 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | PM2.5 | 873 | 2.8 | 68.9 |
| 1A1a | Public electricity and heat production | PM2.5 | 782 | 2.7 | 71.6 |
| 2H2 | Food and beverages industry | PM2.5 | 188 | 2.5 | 74.1 |
| 2G | Other product use | PM2.5 | 513 | 2.4 | 76.5 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | PM2.5 | 1'584 | 2.1 | 78.6 |
| 2A1 | Cement production | PM2.5 | 240 | 1.8 | 80.4 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM2.5 | 729 | 1.8 | 82.1 |
| 2H1 | Pulp and paper industry | PM2.5 | 236 | 1.8 | 83.9 |
| 1A4cii | Agriculture/forestry/fishing: off-road vehicles and other machinery | PM2.5 | 435 | 1.7 | 85.6 |
| 1A4bi | Residential: stationary plants | PM10 | 15'326 | 38.4 | 38.4 |
| 2I | Wood processing | PM10 | 864 | 7.8 | 46.2 |
| 2C1 | Iron and steel production | PM10 | 1'485 | 5.4 | 51.5 |
| 3De | Cultivated crops | PM10 | 1'054 | 5.3 | 56.8 |
| 1A4ai | Commercial/institutional: stationary | PM10 | 1'428 | 3.7 | 60.5 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM10 | 2'173 | 3.6 | 64.1 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM10 | 2'046 | 3.4 | 67.4 |
| 2H2 | Food and beverages industry | PM10 | 310 | 2.8 | 70.2 |
| 2A5a | Quarrying and mining of minerals other than coal | PM10 | 302 | 2.7 | 72.9 |
| 1A1a | Public electricity and heat production | PM10 | 1'045 | 2.5 | 75.4 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | PM10 | 913 | 2.0 | 77.4 |
| 2A1 | Cement production | PM10 | 374 | 1.9 | 79.2 |
| 2G | Other product use | PM10 | 588 | 1.8 | 81.1 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | PM10 | 833 | 1.8 | 82.9 |
| 1A3c | Railways | PM10 | 970 | 1.6 | 84.5 |
| 3B3 | Manure management - Swine | PM10 | 213 | 1.4 | 85.9 |

Table A - 11 Switzerland's key categories according to approach 2 trend assessment for 1990-2023, sorted by decreasing contribution, for the main pollutants, PM2.5 and PM10. Categories in orange have increased emissions in 2023 compared to 1990. Categories in grey are not key and are given for information only.

| KCA APPROACH 2, UNCERTAINTY APPROACH 2, TREND ASSESSMENT 1990 - 2023 | | | | | | | |
|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | G | H |
| NFR code | Source category | Pollutant | Ex, 0 (t) | Ex, t (t) | Trend Assess-ment | Contri-bution to trend assess. (%) | Cumu-lative Total (%) |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | NOx | 29'631 | 3'029 | 6.666 | 26.4 | 26.4 |
| 1A3bii(fu) | Road transportation: light duty vehicles (fuel used) | NOx | 6'199 | 3'494 | 2.506 | 9.9 | 36.3 |
| 3Da2a | Animal manure applied to soils | NOx | 2'075 | 1'449 | 2.077 | 8.2 | 44.5 |
| 3Da3 | Urine and dung deposited by grazing animals | NOx | 243 | 417 | 1.828 | 7.2 | 51.8 |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | NOx | 1'214 | 1'966 | 1.696 | 6.7 | 58.5 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | NOx | 1'205 | 609 | 1.132 | 4.5 | 63.0 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NOx | 43'748 | 15'010 | 0.989 | 3.9 | 66.9 |
| 1A4ai | Commercial/institutional: stationary | NOx | 5'139 | 2'832 | 0.978 | 3.9 | 70.8 |
| 1A2gviii | Stationary combustion in manufacturing industries and construction: other | NOx | 2'182 | 1'638 | 0.848 | 3.4 | 74.1 |
| 3Da2c | Other organic fertilisers applied to soils (including compost) | NOx | 15 | 122 | 0.654 | 2.6 | 76.7 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | NOx | 10'535 | 2'825 | 0.625 | 2.5 | 79.2 |
| 1B2c | Venting and flaring (oil gas combined oil and gas) | NOx | 211 | 1 | 0.576 | 2.3 | 81.5 |
| 1A4ci | Agriculture/forestry/fishing: stationary | NOx | 389 | 379 | 0.497 | 2.0 | 83.4 |
| 3B1b | Manure management - Non-dairy cattle | NOx | 344 | 282 | 0.458 | 1.8 | 85.2 |
| 1A3bi(fu) | Road transportation: passenger cars (fuel used) | NMVOC | 55'582 | 3'635 | 9.881 | 14.4 | 14.4 |
| 3B1b | Manure management - Non-dairy cattle | NMVOC | 5'122 | 7'441 | 8.436 | 12.3 | 26.6 |
| 2D3g | Chemical products | NMVOC | 27'504 | 3'185 | 6.402 | 9.3 | 35.9 |
| 3B1a | Manure management - Dairy cattle | NMVOC | 6'413 | 6'585 | 5.873 | 8.5 | 44.5 |
| 2D3a | Domestic solvent use including fungicides | NMVOC | 8'867 | 6'507 | 4.217 | 6.1 | 50.6 |
| 3B4gii | Manure management - Broilers | NMVOC | 366 | 1'144 | 3.102 | 4.5 | 55.1 |
| 2D3b | Road paving with asphalt | NMVOC | 4'895 | 2'700 | 2.696 | 3.9 | 59.0 |
| 1A3biv(fu) | Road transportation: mopeds and motorcycles (fuel used) | NMVOC | 5'737 | 827 | 2.650 | 3.9 | 62.9 |
| 2G | Other product use | NMVOC | 22'432 | 6'316 | 2.648 | 3.9 | 66.7 |
| 1B2av | Distribution of oil products | NMVOC | 19'127 | 2'021 | 1.984 | 2.9 | 69.6 |
| 2H2 | Food and beverages industry | NMVOC | 1'413 | 1'417 | 1.924 | 2.8 | 72.4 |
| 1A3bv(fu) | Road transportation: gasoline evaporation (fuel used) | NMVOC | 17'166 | 1'773 | 1.833 | 2.7 | 75.1 |
| 2D3i | Other solvent use | NMVOC | 5'470 | 1'933 | 1.693 | 2.5 | 77.6 |
| 2D3e | Degreasing | NMVOC | 11'731 | 1'566 | 1.560 | 2.3 | 79.8 |
| 3B4gi | Manure management - Laying hens | NMVOC | 509 | 634 | 1.506 | 2.2 | 82.0 |
| 3B3 | Manure management - Swine | NMVOC | 1'126 | 770 | 1.461 | 2.1 | 84.1 |
| 2D3d | Coating applications | NMVOC | 40'731 | 8'286 | 1.349 | 2.0 | 86.1 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | SOx | 3'530 | 1'300 | 6.811 | 43.2 | 43.2 |
| 1A4bi | Residential: stationary plants | SOx | 10'355 | 207 | 1.969 | 12.5 | 55.6 |
| 1A2d | Stationary combustion in manufacturing industries and construction: pulp paper and print | SOx | 3'238 | 1 | 1.128 | 7.1 | 62.8 |
| 2B5 | Carbide production | SOx | 625 | 198 | 1.048 | 6.6 | 69.4 |
| 1A4ai | Commercial/institutional: stationary | SOx | 3'870 | 83 | 0.677 | 4.3 | 73.7 |
| 1A3ai(i) | Civil aviation (domestic landing/take-off (LTO)) | SOx | 100 | 137 | 0.447 | 2.8 | 76.5 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | SOx | 1'843 | 9 | 0.428 | 2.7 | 79.3 |
| 2B10a | Chemical industry: other | SOx | 168 | 40 | 0.381 | 2.4 | 81.7 |
| 1A2e | Stationary combustion in manufacturing industries and construction: food processing beverages and tobacco | SOx | 1'078 | 4 | 0.307 | 1.9 | 83.6 |
| 1B2aiv | Fugitive emissions oil: refining / storage | SOx | 419 | 14 | 0.303 | 1.9 | 85.5 |
| 3Da2a | Animal manure applied to soils | NH3 | 34'567 | 20'191 | 7.225 | 20.4 | 20.4 |
| 3B1b | Manure management - Non-dairy cattle | NH3 | 5'191 | 7'241 | 4.546 | 12.8 | 33.2 |
| 3B1a | Manure management - Dairy cattle | NH3 | 9'337 | 10'144 | 4.405 | 12.4 | 45.6 |
| 3Da2c | Other organic fertilisers applied to soils (including compost) | NH3 | 34 | 1'042 | 2.775 | 7.8 | 53.5 |
| 3Da1 | Inorganic N-fertilizers (includes also urea application) | NH3 | 4'259 | 2'251 | 2.638 | 7.4 | 60.9 |
| 3Da3 | Urine and dung deposited by grazing animals | NH3 | 761 | 1'413 | 2.606 | 7.4 | 68.3 |
| 3B4gii | Manure management - Broilers | NH3 | 305 | 680 | 1.939 | 5.5 | 73.7 |
| 6A | Other sources | NH3 | 846 | 970 | 1.693 | 4.8 | 78.5 |
| 3B3 | Manure management - Swine | NH3 | 6'965 | 4'736 | 1.320 | 3.7 | 82.2 |
| 5B2 | Biological treatment of waste - Anaerobic digestion at biogas facilities | NH3 | 10 | 245 | 0.938 | 2.6 | 84.9 |
| 5B1 | Biological treatment of waste - Composting | NH3 | 175 | 292 | 0.812 | 2.3 | 87.2 |
| 1A4bi | Residential: stationary plants | PM2.5 | 14'536 | 1'852 | 23.900 | 29.8 | 29.8 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM2.5 | 690 | 958 | 8.525 | 10.6 | 40.4 |
| 2H2 | Food and beverages industry | PM2.5 | 188 | 166 | 7.139 | 8.9 | 49.3 |
| 2A5a | Quarrying and mining of minerals other than coal | PM2.5 | 102 | 98 | 4.336 | 5.4 | 54.7 |
| 2C1 | Iron and steel production | PM2.5 | 818 | 7 | 4.209 | 5.2 | 60.0 |
| 2G | Other product use | PM2.5 | 513 | 327 | 4.205 | 5.2 | 65.2 |
| 2H1 | Pulp and paper industry | PM2.5 | 236 | 151 | 3.167 | 3.9 | 69.2 |
| 2A1 | Cement production | PM2.5 | 240 | 143 | 2.833 | 3.5 | 72.7 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM2.5 | 729 | 384 | 2.305 | 2.9 | 75.6 |
| 1A3c | Railways | PM2.5 | 173 | 233 | 2.055 | 2.6 | 78.1 |
| 1A1a | Public electricity and heat production | PM2.5 | 782 | 46 | 2.033 | 2.5 | 80.7 |
| 1A4ai | Commercial/institutional: stationary | PM2.5 | 1'354 | 430 | 1.988 | 2.5 | 83.1 |
| 1A3biii(fu) | Road transportation: heavy duty vehicles and buses (fuel used) | PM2.5 | 1'584 | 36 | 1.879 | 2.3 | 85.5 |
| 1A4bi | Residential: stationary plants | PM10 | 15'326 | 1'948 | 22.676 | 27.5 | 27.5 |
| 1A3bvi(fu) | Road transportation: automobile tyre and brake wear (fuel used) | PM10 | 2'046 | 2'610 | 6.845 | 8.3 | 35.8 |
| 3De | Cultivated crops | PM10 | 1'054 | 1'000 | 6.785 | 8.2 | 44.0 |
| 1A2gvii | Mobile combustion in manufacturing industries and construction | PM10 | 2'173 | 2'366 | 5.733 | 7.0 | 51.0 |
| 2A5a | Quarrying and mining of minerals other than coal | PM10 | 302 | 348 | 4.741 | 5.7 | 56.7 |
| 2C1 | Iron and steel production | PM10 | 1'485 | 10 | 4.649 | 5.6 | 62.4 |
| 1A3c | Railways | PM10 | 970 | 1'517 | 4.303 | 5.2 | 67.6 |
| 2H2 | Food and beverages industry | PM10 | 310 | 308 | 3.880 | 4.7 | 72.3 |
| 2I | Wood processing | PM10 | 864 | 188 | 3.001 | 3.6 | 75.9 |
| 3B4gii | Manure management - Broilers | PM10 | 68 | 212 | 2.845 | 3.5 | 79.4 |
| 1A1a | Public electricity and heat production | PM10 | 1'045 | 46 | 1.924 | 2.3 | 81.7 |
| 3B4gi | Manure management - Laying hens | PM10 | 123 | 154 | 1.619 | 2.0 | 83.7 |
| 1A2f | Stationary combustion in manufacturing industries and construction: non-metallic minerals | PM10 | 833 | 68 | 1.237 | 1.5 | 85.2 |

# 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[6]), which is the data pool of FOEN (2015j). They can be queried by year, non-road family (see categories in Table A - 13), machine type, engine type (diesel, gasoline/2-/4-stroke, liquefied petroleum gas, 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 - 12 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 |

[6] https://www.bafu.admin.ch/bafu/en/home/topics/air/state/non-road-datenbank.html [06.02.2025]

### 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 - 13 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 |
| **Total** | **1'701'994** | **2'098'151** | **2'528'136** | **2'889'193** | **3'026'135** | **3'060'441** |

| **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 |
| Military machinery | 64 | 64 | 63 | 73 | 74 | 74 |

| **Category** | **1980** | **1990** | **2000** | **2010** | **2020** | **2030** |
|---|---|---|---|---|---|---|
| | million operating hours per year | | | | | |
| Construction machinery | 16 | 19 | 21 | 24 | 26 | 27 |
| Industrial machinery | 18 | 29 | 48 | 48 | 47 | 47 |
| Agricultural machinery | 40 | 39 | 38 | 33 | 31 | 29 |
| Forestry machinery | 2.4 | 2.8 | 2.6 | 2.3 | 2.0 | 1.9 |
| Garden-care / hobby appliances | 15 | 26 | 39 | 150 | 191 | 201 |
| Navigation machinery | 3.7 | 3.9 | 3.5 | 3.4 | 3.4 | 3.4 |
| Railway machinery | 0.50 | 0.80 | 0.80 | 0.50 | 0.50 | 0.50 |
| Military machinery | 0.80 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| **Total** | **95** | **121** | **155** | **261** | **301** | **311** |

# A2.2 Emissions due to former usage (2K) and subsequent disposal of polychlorinated biphenyls (1A1a, 2C1, 5A, 5C1, 5E, 6A)

## A2.2.1 Mass flow and emission model of former use and disposal of PCBs

Polychlorinated biphenyls (PCBs) were used in Switzerland between 1946 and 1986. In 1986, a total ban was placed on any form of PCB use. The use in so-called 'open applications' was allowed until 1972. Open applications include joint (elastic) sealants, anti-corrosion coatings, paints and varnishes. All other uses were allowed until 1986.

An emission inventory based on a dynamic mass flow model was developed for PCBs for Switzerland for the time period 1930 to 2100. The model takes into account the import, usage, export, treatment, disposal and accidental release of PCBs, see Figure A - 1. PCB emissions to the environment occur from all stages of their lifecycle. A detailed documentation of the emission inventory is available in Glüge et al. 2017. Additionally, the underlying model is available in Microsoft Excel/VBA and can be downloaded.

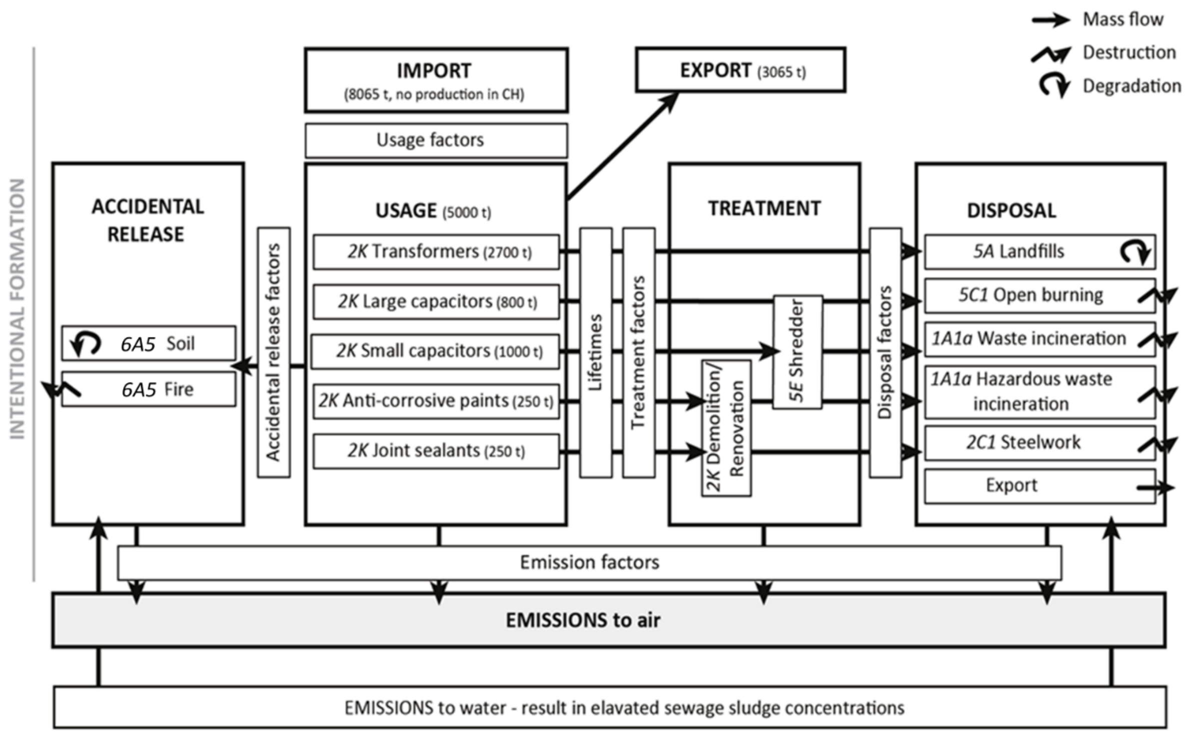


Figure A - 1 Model setup for the dynamic mass flow and emissions of PCBs taking into account the import, usage, export, treatment, disposal and accidental release. Emissions to air occur from usage, treatment, disposal, and accidental release. (Waste and hazardous waste incineration correspond to municipal solid waste and special waste incineration, respectively.)

Besides this intentional usage of PCBs, PCBs can also be emitted by unintentional formation, e.g. in combustion processes. Emissions from unintentional formation are not part of this mass flow model but are included in the air pollutant emission inventory for stationary combustion of solid and liquid fossil fuels as well as of wood and wood waste, see chapters 3.2.2 – 3.2.4.

### Import and usage

PCBs have not been produced in Switzerland. Therefore, the chemicals enter the system solely through import (Figure A - 1, top part). The imported amounts are then distributed to the usage categories according to usage factors (Figure A - 1, middle part). The imported amounts, as well as the usage factors, vary over time. In this study, five usage categories that were identified to be important for Switzerland are included: transformers, large capacitors (> 1 kg), small capacitors (< 1 kg), anti-corrosive paints on steel and joint sealants. Other uses, such as PCBs in hydraulic oils (used in mining), plastics, or insecticides are considered as being of minor importance in Switzerland and are thus, not included in the model. For the time being, anti-corrosive paints and joint sealants are the predominant PCB emission sources (see Figure A - 2). The emissions from the five usage categories are reported in source category 2K Consumption of POPs and heavy metals.

### Export

The exported amounts to other countries could have been estimated only roughly. PCBs were mainly exported in disposed PCB-containing transformers and capacitors and electronic waste, but also in old installations, such as for example hydraulic turbines with PCB-containing paints.

### Disposal

When a PCB-containing product reaches its end of life it is disposed of. In the model, six disposal categories that have been relevant in Switzerland are included: landfills (5A), open burning (5C1), municipal waste incineration (1A1a), special waste incineration (1A1a), steelworks (2C1), and export (Figure A - 1, right part). For all usage categories, specific disposal factors, which vary over time, are applied to the six disposal categories and export. Here, open burning refers to combustion of PCB contaminated waste oil in outdoor fires (i.e. outside of a container). Open burning was ceased in 1999. Steelworks represent scrap metal that is melted in electric arc furnaces of secondary steel production plants. Thereby PCB-containing paint residues are combusted at temperatures of around 1600°C. Landfills are disposal sites where the waste is dumped. Since 2000, the incineration of combustible waste is mandatory in Switzerland, therefore, disposing of to landfills stopped. In landfills, PCBs are partly stored and partly degraded. When waste is exported, its emissions abroad are not included in the Swiss emission inventory. When combusted, PCBs are partly destroyed by high temperatures and partly emitted to the environment.

### Treatment

Before disposal, some usage categories undergo specific treatment processes (Figure A - 1, right part). Two treatment categories are included in the model: Demolition/renovation of steel constructions and buildings containing PCBs in anti-corrosive paints and joint sealants, respectively (2K), as well as Shredding of electronic waste containing PCBs in small capacitors (5E).

Demolition/renovation can induce elevated emissions to the environment, as has been observed for buildings. Shredding of electronic waste occurs at fast rotation velocity that leads to increased temperature and dust production. As a consequence of the legal ban of disposal of combustible waste in landfills, a sharp increase in shredding of small capacitors occurred in 1999 although they should have been treated as special waste from 1998 onwards (see Figure A - 2). Shearing of steel constructions (heavy scrap), otherwise, is supposed to produce little dust and yield no evaporation of the substances in the coating. Therefore, no emissions to air from the shearing of steel constructions were assumed.

### Accidental release

From each usage category, PCBs can be accidentally released (Figure A - 1, left part). The model includes two release categories: soil and fire (6A5). When released to soil, PCBs are partly stored and partly degraded. In the case of fire, PCBs are partly destroyed by high temperatures and partly emitted to the environment.

### Release to water

The release of PCBs to water bodies is only partly included in this model. Release to water bodies is important for anti-corrosive paints and to a smaller degree also for leachate from landfills. The measured PCB concentrations in sewage sludge and the total amount of produced sewage sludge per year was used to determine the mass of PCBs released to water. This approach overlooks emissions to natural water bodies, but it captures emissions to wastewater.

## A2.2.2 Emission methodology

Emissions to air occur from the entire system: usage, treatment, disposal and accidental release. The emissions are calculated by multiplying the annual mass of PCBs involved in a source category (e.g. tonnes of PCBs in use in joint sealants) with a source-specific emission factor (e.g. tonnes of PCBs emitted/tonnes of PCBs in use). This country-specific approach corresponds to a Tier 2 method according to EMEP/EEA (2023).

The five usage categories as well as landfills and soils are PCB stocks, which means that PCBs are stored in these categories and passed on through the system with a temporal delay according to their lifetime or residence time. In these cases, the activity data are the amounts of PCBs stored in the stock. The treatment categories of renovation and shredder and all incineration categories (including fire) are instantaneous categories, where PCBs are not stored. In these cases, the activity data correspond to the amount of PCBs treated or incinerated in the respective year.

PCB emissions are sometimes reported as sum of the so-called indicator PCBs (iPCBs, i.e. PCB congeners 28, 52, 101, 138, 153, and 180), sometimes as sum of the dioxin-like PCBs (dl-PCBs, i.e. PCB congeners 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189) and sometimes as sum of all 209 congeners. The emission model is run for all congeners, so emission numbers are available for all three sums. Where data such as typically emission factors are not available for all congeners, estimates are derived from the iPCBs using the chlorination degrees of the congeners. Please note that the PCB emissions reported in Switzerland's air pollutant emission inventory comprise the sum of all 209 congeners.

Figure A - 2 shows the resulting PCB emissions from all stages of the life cycle of PCB applications, i.e. usage, treatment, disposal and accidental release. Anti-corrosive paints and joint sealants are the predominant PCB emission sources for most of the time. Between 1975 and 1985 and around 2000, open burning and the above-mentioned shredding of small capacitors, respectively, were the dominant PCB sources. Only after 2040, emissions from soil due to former accidental releases to soil become the most important emission source. Mainly in the seventies and eighties, accidental release by fire, small and large capacitors and waste incineration were important emission sources as well.

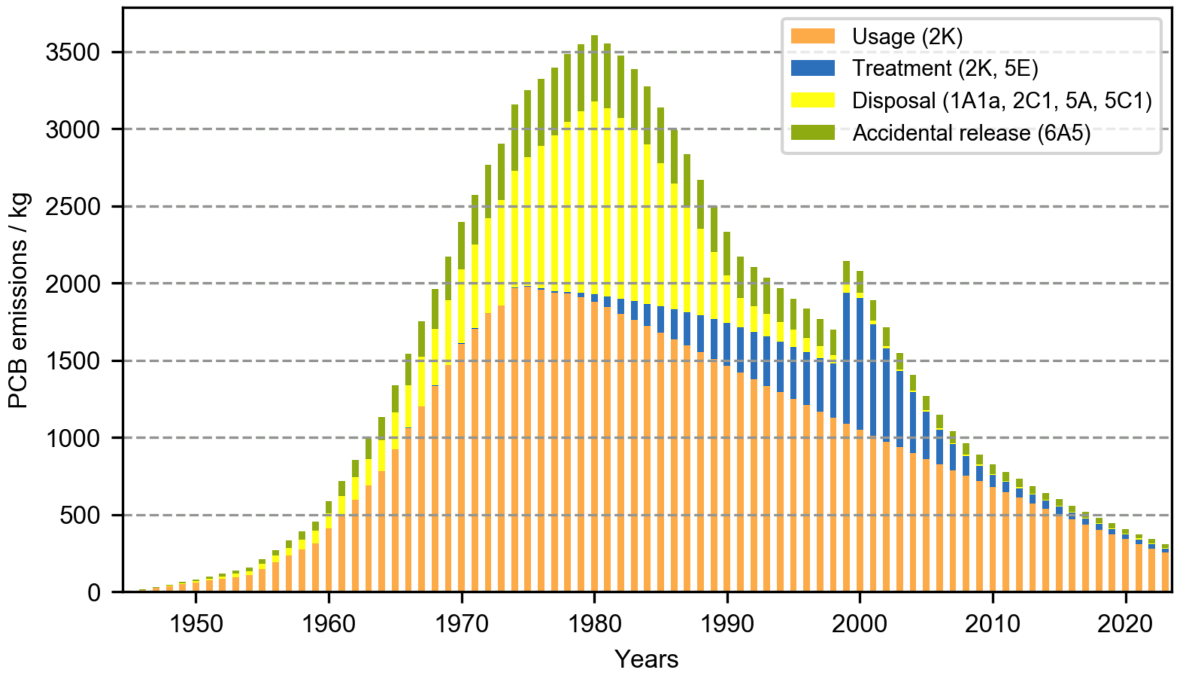


Figure A - 2 PCB emissions from usage (2K Transformers, large and small condensators, anti-corrosive paints and joint sealants), treatment (2K Demolition and renovation, 5E Shredder), disposal (1A1a Municipal solid waste and special waste incineration, 2C1 Secondary steel production, 5A Landfills, 5C1 Open burning (until 1999)) and accidental release (6A5 Accidental release by fire and to soil).

## A2.3 Comparison of the country-specifically calculated Tier 3 results for N flows and $NH_3$ emissions from animal husbandry with the results of the Tier 2 calculations using the TFEIP N-flow tool (3B, 3Da2a, 3Da3)

In the report of the Stage 3 in-depth review in summer 2020 it was recommended "To present more details regarding the country-specific emission factors as well as a comparison of the national emission factors and the Guidebook emission factors with a rationale of the discrepancies." Because it is not only the emission factors that have a strong influence on the emission inventory calculations but also other assumptions like N excretions, length of housed period or percentage of TAN in the manure, it was decided to not only compare the emission factors but rather the total N flows and $NH_3$ emissions resulting from the calculations with the model AGRAMMON (see chp. 5.2.2) and the TFEIP N flow tool (downloaded from https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/4-agriculture/manure-management-n-flow-tool/view, version Jan 2021). The comparison was made for the year 2015, which at the time was the last year with data from a representative survey on farm and manure management, using the previous version of the AGRAMMON model (Kupper et al. 2018). The procedure and the results are summarised in an internal memo (Menzi 2022). An overview of the results is shown in Tables A-14 to A-16. The main results can be summarised as follows:

N excretions

- Total N excretions from livestock production shown for the livestock categories used in the N flow tool were 4 % lower in the N flow tool than according to the Swiss AGRAMMON tool (Swiss reporting). The lower total N excretion was mainly due to cattle and swine which contributed over 75 % and over 10 %, respectively, of the N excretions from agricultural livestock.
- For dairy cows the value used in the N flow tool is 6 % lower than in the Swiss reporting. This can be explained by the average weight assumed. In the N flow tool, it is 600 kg while it is 660 kg in Switzerland (according to Swiss Fertiliser Guidelines). With a correction to 660 kg N the N flow tool shows excretions of 113.9 kg N per dairy cow place and year, which is 1.8 % more than the Swiss value.
- For all main livestock categories except small ruminants and equids the difference of N excretion between the two approaches was less than 10 %.

$NH_3$ emissions livestock

- Total $NH_3$ emissions from livestock and manure management differ less than 10 % between the two approaches, the N flow tool being a bit lower than the Swiss reporting. This holds for both 3B (housing and manure storage) and 3D (manure application and grazing) emission categories and is also true for cattle, which contribute about three fourths of the $NH_3$ emissions from livestock and manure management. For the cattle categories the relative difference is in the same proportion as the difference for N excretion. Total emissions from pig production were well comparable between the two approaches (N flow tool 4 % lower than Swiss reporting). Pig production in 2015 was responsible for around 15 % of the emissions from livestock and manure management. According to the N flow tool the values for the category 3B were nearly 20 % lower than according to the Swiss reporting and those for the category 3D about 25 % higher. This can mainly be explained by the high importance of animal friendly housing system in Switzerland, which cannot be considered in the N flow tool.

<u>Distribution of $NH_3$ emissions to the stages of the manure management chain</u>

- The distribution of $NH_3$ emissions to housing, storage, application and grazing the N-flow tool has a lower share for housing and a higher share for grazing as compared to the Swiss reporting. Housing emissions (including yards) were 22 % lower in the N flow tool compared to the Swiss reporting because of the assumptions on grazing and housing and the high importance of special animal friendly housing systems which cannot be considered in the N flow tool.
- In spite of the lower N flow through the manure cascade (because of assumption about grazing) emissions from manure storage were 21 % higher in the N flow tool than in the Swiss reporting (slurry +37 %, solid manure -12 %), probably mainly because of the high share of covered slurry stores (89 %; not considered in the N flow tool) and the importance of liquid and solid manure (Switzerland 2015 share N flow going to storage: 74 % slurry, 26 % solid manure).
- Emissions from manure application were 19 % lower in the N flow tool than in the Swiss reporting, probably mainly because of the lower N flow through the manure cascade and the importance of low emission spreading technique in Switzerland (2015 38 % of the slurry) which cannot be considered in the N flow tool.
- Emissions from grazing were nearly fourfold as high in the N low tool as compared to the Swiss reporting because of the assumptions about housing and grazing.
- The distribution of emissions from livestock and manure management to the Guidebook categories 3B (housing, manure storage) and 3D (Manure application, grazing) agreed well between the two approaches (share 3B: N flow tool 54 %, Swiss reporting 55 %). However, within the category 3B the distribution to housing and manure storage differed quite a bit (N flow tool 58 %/42 %, Swiss reporting 68 %/32 %). For the category 3D the distribution to manure application and grazing was 77 %/23 % for the N flow tool and 94 %/6 % for the Swiss reporting. Looking at the distribution of total emissions to housing/manure storage/manure application/grazing the distribution was 31 %/23 %/36 %/10 % for the N flow tool and 37 %/17 %/43 %/3 % for the Swiss reporting.

A direct comparison of N flows or emission factors is impeded in various places by the differences between the models in the allocation of N flows. Important examples are:

a) The N-flow tool differentiates between emission factors for liquid and solid manure in the housing area while AGRAMMON has only one emission factor for housing because a clear allocation of excreta and soiled surfaces to liquid and solid manure is not possible.

b) For slurry storage, the emission factors are in percent of TAN in the N flow model and in g per $m^2$ slurry surface and day in AGRAMMON.

c) AGRAMMON takes into account a different allocation of TAN excretions to liquid and solid manure. As urine (containing soluble N, which is potentially emitted) is primarily collected in the liquid manure, the emissions are higher than for a comparable N flow in the form of faeces, which primarily contain organic N and mostly go into solid manure.

d) AGRAMMON takes into account the immobilisation of TAN and the release of TAN from the degradation of organic N in housing and during manure storage, which is not considered in the N flow tool.

The comparison of the two approaches shows that the Tier 2 approach can hardly cope with farm management conditions that differ strongly from the assumption in the N-flow tool and can only be transferred to the input variables with difficulty. If such detailed farm management data is available, it is more reliable and maybe even easier to use a country-specific Tier 3 approach.

Table A - 14 N excretions of livestock in Switzerland according to the Swiss reporting (AGRAMMON model, Tier 3 methodology) and the N flow tool (Tier 2 methodology) for the year 2015.

| **Swiss reporting (Tier 3)** AGRAMMON Model | | **dairy cows** | **non-d. cattle** | **calves** | **catttle exc DC** | **cattle total** | **finishing pigs** | **sows** | **pigs total** | **sheep** | **goats** | **small ruminants** | **horses** | **mules+asses** | **equids** | **laying hens** | **broilers** | **turkeys** | **poultry total** | **total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N excretion housing & yard | kt N | 54.74 | 25.63 | 3.18 | 28.80 | 83.55 | 11.43 | 3.59 | 15.02 | 2.10 | 0.84 | 2.94 | 1.91 | 0.24 | 2.16 | 2.41 | 3.09 | 0.07 | 5.57 | 109.24 |
| N excretion grazing | kt N | 10.38 | 8.81 | 0.67 | 9.49 | 19.86 | 0.002 | 0.002 | 0.003 | 1.23 | 0.11 | 1.34 | 0.52 | 0.07 | 0.59 | 0.16 | 0.01 | 0.002 | 0.17 | 21.96 |
| N excretion total | kt N | 65.12 | 34.44 | 3.85 | 38.29 | 103.41 | 11.44 | 3.59 | 15.02 | 3.33 | 0.95 | 4.29 | 2.43 | 0.31 | 2.75 | 2.57 | 3.10 | 0.07 | 5.74 | 131.21 |
| % category of total | | 49.6% | 26.2% | 2.9% | 29.2% | 78.8% | 8.7% | 2.7% | 11.5% | 2.5% | 0.7% | 3.3% | 1.9% | 0.2% | 2.1% | 2.0% | 2.4% | 0.1% | 4.4% | 100% |
| % during grazing | | 16% | 26% | 17% | 25% | 19% | 0.02% | 0.05% | 0.02% | 37% | 12% | 31% | 21% | 22% | 21% | 6% | 0.2% | 3% | 9% | 17% |

| **N flow tool (Tier 2)** | | **dairy cows** | **non-d. cattle** | **calves** | **cattle exc DC** | **cattle total** | **finishing pigs** | **sows** | **pigs total** | **sheep** | **goats** | **small ruminants** | **horses** | **mules+asses** | **equids** | **laying hens** | **broilers** | **turkeys** | **poultry total** | **total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N excretion housing & yard | kt N | 38.01 | 17.31 | 1.90 | 19.22 | 57.22 | 9.44 | 4.23 | 13.67 | 0.54 | 0.14 | 0.68 | 1.30 | 0.32 | 1.62 | 2.97 | 2.77 | 0.09 | 5.83 | 79.02 |
| N excretion grazing | kt N | 23.31 | 14.52 | 1.60 | 16.12 | 39.43 | - | - | - | 4.84 | 1.53 | 6.37 | 1.33 | 0.33 | 1.67 | - | - | - | - | 47.46 |
| N excretion total | kt N | 61.31 | 31.83 | 3.50 | 35.33 | 96.65 | 9.44 | 4.23 | 13.67 | 5.38 | 1.66 | 7.05 | 2.63 | 0.65 | 3.29 | 2.97 | 2.77 | 0.09 | 5.83 | 126.48 |
| % category of total | | 48.5% | 25.2% | 2.8% | 27.9% | 76.4% | 7.5% | 3.3% | 10.8% | 4.3% | 1.3% | 5.6% | 2.1% | 0.5% | 2.6% | 2.3% | 2.2% | 0.1% | 4.6% | 100.0% |
| % during grazing | | 38% | 46% | 46% | 46% | 41% | - | - | - | 90% | 92% | 90% | 51% | 51% | 51% | - | - | - | - | 38% |

Table A - 15 $NH_3$ emissions from livestock and manure management in Switzerland according to the Swiss reporting (AGRAMMON model) for the different livestock categories and steps of the manure cascade for the year 2015.

| Swiss reporting (Tier 3) AGRAMMON Model | | dairy cows | non-d. cattle | calves | catttle exc DC | cattle total | finishing pigs | sows | pigs total | sheep | goats | small ruminants | horses | mules+ asses | equids | laying hens | broilers | turkeys | poultry total | total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N excretion housing & yard | kt N | 54.74 | 25.63 | 3.18 | 28.80 | 83.55 | 11.43 | 3.59 | 15.02 | 2.10 | 0.84 | 2.94 | 1.91 | 0.24 | 2.16 | 2.41 | 3.09 | 0.07 | 5.57 | 109.24 |
| N excretion grazing | kt N | 10.38 | 8.81 | 0.67 | 9.49 | 19.86 | 0.00 | 0.00 | 0.00 | 1.23 | 0.11 | 1.34 | 0.52 | 0.07 | 0.59 | 0.16 | 0.01 | 0.00 | 0.17 | 21.96 |
| N excretion total | kt N | 65.12 | 34.44 | 3.85 | 38.29 | 103.41 | 11.44 | 3.59 | 15.02 | 3.33 | 0.95 | 4.29 | 2.43 | 0.31 | 2.75 | 2.57 | 3.10 | 0.07 | 5.74 | 131.21 |
| % category of total | | 49.6% | 26.2% | 2.9% | 29.2% | 78.8% | 8.7% | 2.7% | 11.5% | 2.5% | 0.7% | 3.3% | 1.9% | 0.2% | 2.1% | 2.0% | 2.4% | 0.1% | 4.4% | 100% |
| % during grazing | | 16% | 26% | 17% | 25% | 19% | 0.02% | 0.05% | 0.02% | 37% | 12% | 31% | 21% | 22% | 21% | 6% | 0% | 3% | 9% | 17% |
| emissions housing | kt N | 4.34 | 2.14 | 0.31 | 2.45 | 6.79 | 2.78 | 0.93 | 3.72 | 0.25 | 0.10 | 0.35 | 0.14 | 0.01 | 0.15 | 0.37 | 0.38 | 0.01 | 0.76 | 11.77 |
| emissions yard | kt N | 1.55 | 1.33 | 0.10 | 1.43 | 2.98 | - | - | - | - | - | - | 0.11 | 0.02 | 0.13 | - | - | - | - | 3.11 |
| emissions housing & yard | kt N | 5.89 | 3.47 | 0.41 | 3.88 | 9.77 | 2.78 | 0.93 | 3.72 | 0.25 | 0.10 | 0.35 | 0.25 | 0.03 | 0.28 | 0.37 | 0.38 | 0.01 | 0.76 | 14.88 |
| emissions storage liq. | kt N | 2.72 | 1.19 | 0.08 | 1.28 | 4.00 | 0.47 | 0.16 | 0.63 | - | - | - | - | - | - | - | - | - | - | 4.63 |
| storage solid | kt N | 0.80 | 0.70 | 0.19 | 0.89 | 1.69 | - | - | - | 0.17 | 0.06 | 0.22 | 0.14 | 0.02 | 0.16 | 0.12 | 0.065 | 0.00 | 0.19 | 2.27 |
| storage total | kt N | 3.53 | 1.89 | 0.27 | 2.16 | 5.69 | 0.47 | 0.16 | 0.63 | 0.17 | 0.06 | 0.22 | 0.14 | 0.02 | 0.16 | 0.12 | 0.06 | 0.00 | 0.19 | 6.89 |
| application liquid | kt N | 8.58 | 3.14 | 0.23 | 3.36 | 11.95 | 1.44 | 0.42 | 1.86 | - | - | - | - | - | - | - | - | - | - | 13.80 |
| application solid | kt N | 1.16 | 1.02 | 0.25 | 1.27 | 2.44 | - | - | - | 0.07 | 0.04 | 0.11 | 0.08 | 0.01 | 0.08 | 0.26 | 0.34 | 0.01 | 0.61 | 3.24 |
| application total | kt N | 9.75 | 4.16 | 0.48 | 4.64 | 14.38 | 1.44 | 0.42 | 1.86 | 0.07 | 0.04 | 0.11 | 0.08 | 0.01 | 0.08 | 0.26 | 0.34 | 0.01 | 0.61 | 17.05 |
| emissions grazing | kt N | 0.48 | 0.40 | 0.03 | 0.43 | 0.91 | 0.0002 | 0.0002 | 0.001 | 0.06 | 0.01 | 0.07 | 0.03 | 0.00 | 0.03 | 0.07 | 0.003 | 0.001 | 0.07 | 1.08 |
| % of grazing emissions | | 44.2% | 37.4% | 2.9% | 40.3% | 84.5% | 0.02% | 0.02% | 0.05% | 5.7% | 0.5% | 6.2% | 2.4% | 0.3% | 2.7% | 6.1% | 0.3% | 0.1% | 6.5% | 100% |
| % of total emissions | | 1.2% | 1.0% | 0.1% | 1.1% | 2.3% | 0.001% | 0.001% | 0.001% | 0.2% | 0.0% | 0.2% | 0.06% | 0.01% | 0.1% | 0.2% | 0.01% | 0.002% | 0.2% | 2.7% |
| 3B total | kt N | 9.41 | 5.37 | 0.68 | 6.05 | 15.46 | 3.25 | 1.09 | 4.34 | 0.42 | 0.16 | 0.58 | 0.39 | 0.05 | 0.44 | 0.49 | 0.45 | 0.01 | 0.95 | 21.77 |
| % category of total | | 43.2% | 24.6% | 3.1% | 27.8% | 71.0% | 14.9% | 5.0% | 20.0% | 1.9% | 0.7% | 2.7% | 1.8% | 0.2% | 2.0% | 2.3% | 2.0% | 0.1% | 4.4% | 100% |
| 3D total (manure) | kt N | 10.22 | 4.56 | 0.51 | 5.07 | 15.29 | 1.44 | 0.42 | 1.86 | 0.14 | 0.04 | 0.18 | 0.10 | 0.01 | 0.11 | 0.33 | 0.35 | 0.01 | 0.68 | 18.12 |
| % category of total | | 56.4% | 25.2% | 2.8% | 28.0% | 84.4% | 7.9% | 2.3% | 10.3% | 0.7% | 0.2% | 1.0% | 0.6% | 0.1% | 0.6% | 1.8% | 1.9% | 0.0% | 3.8% | 100% |
| Emissions manure tot. | kt N | 19.64 | 9.93 | 1.19 | 11.11 | 30.75 | 4.69 | 1.51 | 6.20 | 0.55 | 0.20 | 0.75 | 0.49 | 0.06 | 0.56 | 0.82 | 0.79 | 0.02 | 1.63 | 39.90 |
| % category of total | | 49.2% | 24.9% | 3.0% | 27.9% | 77.1% | 11.8% | 3.8% | 15.5% | 1.4% | 0.5% | 1.9% | 1.2% | 0.2% | 1.4% | 2.0% | 2.0% | 0.1% | 4.1% | 100% |
| % of N excretion | | 30.2% | 28.8% | 30.8% | 29.0% | 29.7% | 41.0% | 42.1% | 41.3% | 16.6% | 21.0% | 17.6% | 20.3% | 20.1% | 20.2% | 31.8% | 25.6% | 29.5% | 28.4% | 30.4% |

Table A - 16 $NH_3$ emissions from livestock and manure management in Switzerland according to the N flow tool for the different livestock categories and steps of the manure cascade for the year 2015.

| N flow tool (Tier 2) | | dairy cows | non-d cattle | calves | catttle exc DC | cattle total | finishing pigs | sows | pigs total | sheep | goats | small ruminants | horses | mules+ asses | equids | laying hens | broilers | turkeys | poultry total | total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N excretion housing & yard | kt N | 38.01 | 17.31 | 1.90 | 19.22 | 57.22 | 9.44 | 4.23 | 13.67 | 0.54 | 0.14 | 0.68 | 1.30 | 0.32 | 1.62 | 2.97 | 2.77 | 0.09 | 5.83 | 79.02 |
| N excretion grazing | kt N | 23.31 | 14.52 | 1.60 | 16.12 | 39.43 | - | - | - | 4.84 | 1.53 | 6.37 | 1.33 | 0.33 | 1.67 | - | - | - | - | 47.46 |
| N excretion total | kt N | 61.31 | 31.83 | 3.50 | 35.33 | 96.65 | 9.44 | 4.23 | 13.67 | 5.38 | 1.66 | 7.05 | 2.63 | 0.65 | 3.29 | 2.97 | 2.77 | 0.09 | 5.83 | 126.48 |
| % category of total | | 48.5% | 25.2% | 2.8% | 27.9% | 76.4% | 7.5% | 3.3% | 10.8% | 4.3% | 1.3% | 5.6% | 2.1% | 0.5% | 2.6% | 2.3% | 2.2% | 0.1% | 4.6% | 100% |
| % during grazing | | 38% | 46% | 46% | 46% | 41% | 0% | 0% | 0% | 90% | 92% | 90% | 51% | 51% | 51% | 0% | 0% | 0% | 0% | 38% |
| emissions housing | kt N | 2.08 | 1.49 | 0.14 | 1.63 | 3.71 | 1.78 | 1.04 | 2.82 | 0.05 | 0.02 | 0.06 | 0.17 | 0.04 | 0.21 | 0.42 | 0.41 | 0.02 | 0.85 | 7.65 |
| emissions yards | kt N | 2.76 | 1.01 | 0.11 | 1.12 | 3.88 | - | - | - | 0.04 | - | | - | - | - | - | - | - | - | 3.92 |
| emissions housing & yard | kt N | 4.84 | 2.50 | 0.25 | 2.75 | 7.59 | 1.78 | 1.04 | 2.82 | 0.09 | 0.02 | 0.10 | 0.17 | 0.04 | 0.21 | 0.42 | 0.41 | 0.02 | 0.85 | 11.57 |
| storage liquid | kt N | 4.14 | 1.30 | 0.11 | 1.41 | 5.55 | 0.56 | 0.23 | 0.79 | - | - | - | - | - | - | - | - | - | - | 6.34 |
| storage solid | kt N | 0.46 | 0.67 | 0.04 | 0.71 | 1.17 | - | - | - | 0.04 | 0.01 | 0.05 | 0.15 | 0.03 | 0.18 | 0.13 | 0.46 | 0.01 | 0.60 | 2.00 |
| storage total | kt N | 4.60 | 1.97 | 0.15 | 2.12 | 6.72 | 0.56 | 0.23 | 0.79 | 0.04 | 0.01 | 0.05 | 0.15 | 0.03 | 0.18 | 0.13 | 0.46 | 0.01 | 0.60 | 8.34 |
| application liquid | kt N | 6.73 | 2.11 | 0.18 | 2.29 | 9.03 | 1.81 | 0.53 | 2.34 | - | - | - | - | - | - | - | - | - | - | 11.37 |
| application solid | kt N | 0.34 | 0.50 | 0.03 | 0.53 | 0.87 | - | - | - | 0.04 | 0.02 | 0.05 | 0.12 | 0.02 | 0.15 | 0.46 | 0.23 | 0.01 | 0.69 | 1.76 |
| application total | kt N | 7.08 | 2.61 | 0.21 | 2.82 | 9.90 | 1.81 | 0.53 | 2.34 | 0.04 | 0.02 | 0.05 | 0.12 | 0.02 | 0.15 | 0.46 | 0.23 | 0.01 | 0.69 | 13.13 |
| grazing | kt N | 1.96 | 1.22 | 0.13 | 1.35 | 3.31 | - | - | - | 0.22 | 0.07 | 0.29 | 0.28 | 0.07 | 0.35 | - | - | - | - | 3.95 |
| % of grazing emissions | | 49.6% | 30.9% | 3.4% | 34.3% | 83.9% | - | - | - | 5.5% | 1.7% | 7.3% | 7.1% | 1.8% | 8.9% | - | - | - | - | 100% |
| % of total emissions | | 5.3% | 3.3% | 0.4% | 3.7% | 9.0% | - | - | - | 0.6% | 0.2% | 0.8% | 0.8% | 0.2% | 0.9% | - | - | - | - | 10.7% |
| 3B total | kt N | 9.44 | 4.47 | 0.40 | 4.87 | 14.32 | 2.35 | 1.26 | 3.61 | 0.13 | 0.03 | 0.15 | 0.32 | 0.07 | 0.39 | 0.55 | 0.87 | 0.03 | 1.45 | 19.92 |
| % category of total | | 47.4% | 22.4% | 2.0% | 24.5% | 71.9% | 11.8% | 6.3% | 18.1% | 0.6% | 0.1% | 0.8% | 1.6% | 0.4% | 2.0% | 2.8% | 4.4% | 0.2% | 7.3% | 100% |
| 3D total (manure) | kt N | 9.03 | 3.83 | 0.35 | 4.18 | 13.21 | 1.81 | 0.53 | 2.34 | 0.26 | 0.08 | 0.34 | 0.40 | 0.09 | 0.50 | 0.46 | 0.23 | 0.01 | 0.69 | 17.08 |
| % category of total | | 52.9% | 22.4% | 2.0% | 24.5% | 77.4% | 10.6% | 3.1% | 13.7% | 1.5% | 0.5% | 2.0% | 2.4% | 0.6% | 2.9% | 2.7% | 1.3% | 0.1% | 4.0% | 100% |
| Emissions manure tot. | kt N | 18.48 | 8.30 | 0.75 | 9.05 | 27.53 | 4.16 | 1.79 | 5.95 | 0.38 | 0.11 | 0.50 | 0.72 | 0.17 | 0.89 | 1.00 | 1.09 | 0.04 | 2.14 | 36.99 |
| % category of total | | 49.9% | 22.4% | 2.0% | 24.5% | 74.4% | 11.2% | 4.8% | 16.1% | 1.0% | 0.3% | 1.3% | 1.9% | 0.4% | 2.4% | 2.7% | 3.0% | 0.1% | 5.8% | 100% |
| % of N excretion | | 30.1% | 26.1% | 21.4% | 25.6% | 28.5% | 44.0% | 42.3% | 43.5% | 7.1% | 6.7% | 7.0% | 27.4% | 25.4% | 27.0% | 33.8% | 39.4% | 46.4% | 36.7% | 29.2% |

# Annex 3 Additional information and explanations concerning the NFR tables

Table A - 17 Explanation of the NE notation key in the NFR tables from the latest submission.

| NFR code | Substance(s) | Reason for notation key NE |
|---|---|---|
| all | As, Cr, Cu, Ni, Se, Zn | Lack of data |
| 1A (Nonroad) | HCB, PCBs | Lack of data |
| 1A (mobile) | HCB, PCBs | Lack of data (for the years 1980-1989) |
| 1A1c | $SO_x$, $NH_3$, Pb, Cd, Hg, POPs | Lack of data |
| 1A3b | HCB | no EF available |
| 1A3di(i) | TSP, $PM_{10}$, $PM_{2.5}$, BC, Pb, Cd, Hg, PCDD/PCDF, PAHs, PCBs | no EF available |
| 1A3dii | PCBs | no EF available |
| 2A5a | BC | no EF available |
| 2B5 | BC | no EF available |
| 2C3 | Pb, Hg, PCDD/PCDF, HCB, PCBs | no EF available (production only from 1980 to 2006) |
| 2C7c | BC | no EF available |
| 2D3b | $PM_{2.5}$, $PM_{10}$, TSP, BC | Lack of data |
| 2H1 | $NO_x$, $SO_x$, BC, CO | no EF available |
| 2H2 | BC | no EF available |
| 2H3 | BC | no EF available |
| 3Df | HCB | Lack of data |
| 11B | BC, PCBs | no EF available |

Table A - 18 Explanation of the IE Notation key in the NFR tables from the latest submission.

| NFR code | Substance(s) | Included in NFR code |
|---|---|---|
| 1A1b | Activity Data "Gaseous Fuels" | 1A1b - Activity Data "Liquid Fuels" (for the years 2017 onwards) |
| 1A3bvii | TSP, $PM_{10}$, $PM_{2.5}$, BC, Cd, Activity Data "Other activity" | 1A3bvi |
| 1A4ciii | $NO_x$, NMVOC, $SO_x$, $NH_3$, $PM_{2.5}$, $PM_{10}$, TSP, BC, CO, Pb, Cd, Hg, PCDD/PCDF, PAHs, Activity Data "Liquid Fuels", "Biomass", "Other activity" | 1A3dii |
| 2A3 | $NO_x$, $SO_x$, $PM_{2.5}$, $PM_{10}$, TSP, BC, CO, Pb, Cd, Hg | 1A2f |
| 2A5b | $PM_{2.5}$, $PM_{10}$, TSP | 1A2gvii |
| 2B1 | NMVOC | 2B10a |
| 2D3c | NMVOC | 2D3i (for the years 1980-1989) |
| 2D3e | NMVOC | 2D3i (for the years 1980-1989) |
| 2D3f | NMVOC | 2D3i (for the years 1980-1989) |
| 2D3g | NMVOC | 2D3i (for the years 1980-1989) |
| 2D3h | NMVOC | 2D3i (for the years 1980-1989) |
| 3B4a | $NO_x$, NMVOC, $NH_3$, $PM_{2.5}$, $PM_{10}$, TSP, Activity Data "Other activity" | 3B1a |
| 5D2 | $NO_x$, NMVOC, $SO_x$, $NH_3$, CO, Activity Data "Other activity" | 5D1 (for the years 1980-1989) |

Table A - 19 List of sub-sources accounted for in reporting codes "other" in the NFR tables from the latest submission.

| NFR code | Substance(s) reported | Sub-source description |
|---|---|---|
| 1A2gviii | $NO_x$, NMVOC, $SO_x$, $NH_3$, $PM_{2.5}$, $PM_{10}$, TSP, BC, CO, Pb, Cd, Hg, PCDD/PCDF, PAHs, HCB, PCB | Industrial combustion of wood and wood waste, other boilers and engines in industry, fibreboard production |
| 1A3eii | - | NO |
| 1A5a | - | NO |
| 1A5b | $NO_x$, NMVOC, $SO_x$, $NH_3$, $PM_{2.5}$, $PM_{10}$, TSP, BC, CO, Pb, Cd, Hg, PCDD/PCDF, PAHs | Military mobile only (aviation and nonroad) |
| 1B1c | - | NO |
| 1B2d | - | NO |
| 2A6 | - | NO |
| 2B10a | $NO_x$, NMVOC, $SO_x$, CO, Hg (until 2016) | Acetic acid, ammonium nitrate (until 2018), chlorine gas, ehtylene, formaldehyde (until 1989), PVC (until 1996), niacin and sulphuric acid |
| 2C7c | $NO_x$, NMVOC, $SO_x$, $NH_3$, $PM_{2.5}$, $PM_{10}$, TSP, CO, Pb, Cd, Hg, PCDD/PCDF | Battery recycling, galvanizing plants, silicium production (until 1988) |
| 2D3i | NMVOC | Removal of paint and lacquer, vehicles dewaxing (until 2001), production of perfume/arome, cosmetics, paper/paper board, tobacco products and textiles, extraction of oil and fat (until 2000) and scientific laboratories, unspecified commercial and industrial solvent emissions |
| 2G | $NO_x$, NMVOC, $SO_x$, $NH_3$, $PM_{2.5}$, $PM_{10}$, 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 and air-port surfaces (until 2011), glass wool enduction, hairdressers, health care other, medical practices, preservation of wood, renovation of anti-corrosive coatings, rock wool enduction, underseal treatment and conservation of vehicles and use of concrete additives, cooling lubricants, fireworks, lubricants and pesticides |
| 2H3 | NO, NMVOC, $SO_x$, $NH_3$, $PM_{2.5}$, $PM_{10}$, TSP, CO, Pb | Blasting and shooting |
| 2L | $NH_3$ | Use of $NH_3$ as refrigerant |
| 3B4h | $NO_x$, NMVOC, $NH_3$, $PM_{2.5}$, $PM_{10}$, TSP | Bisons, camels and llamas, deer, rabbits |
| 3I | - | NO |
| 5C1bvi | - | NO |
| 5D3 | - | NO |
| 5E | NMVOC, $PM_{2.5}$, $PM_{10}$, TSP, CO, Pb, Cd, PCDD/F, PCBs | Car shredding |
| 6A | $NO_x$, NMVOC, $SO_x$, NH3, $PM_{2.5}$, $PM_{10}$, TSP, BC, CO, Pb, Cd, Hg, PCDD/PCDF, PAHs, PCB | Human ammonia emissions (breath, transpiration, nappies), pet ammonia emissions, pet PM emissions (keeping of horses, sheep, goats and donkeys outside agriculture), domestic use of fertilisers, fire damages estates and motor vehicles, accidental release of PCB |
| 6B | - | NO |
| 11C | NMVOC | Natural NMVOC emissions from forest and grassland. |

Table A - 20 Basis for estimating emissions from mobile sources in the NFR tables from the latest 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, Cruise) | X | | |
| 1A3b | Road transport | (X) | X | "NATIONAL TOTAL" reported as "fuel sold", "COMPLIANCE TOTAL (CLRTAP)" as "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 | Included in 1A3dii |
| 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 2023 and 1990 in TJ as published by the Swiss Federal Office of Energy (SFOE 2024, SFOE 1991) in German and French.

**Fig. 5 Detailliertes Energieflussdiagramm der Schweiz 2023 (in TJ)**
**Flux énergétique détaillé de la Suisse en 2023 (en TJ)**

*BFE, Schweizerische Gesamtenergiestatistik 2023 (Fig. 5)*
*OFEN, Statistique globale suisse de l'énergie 2023 (fig. 5)*

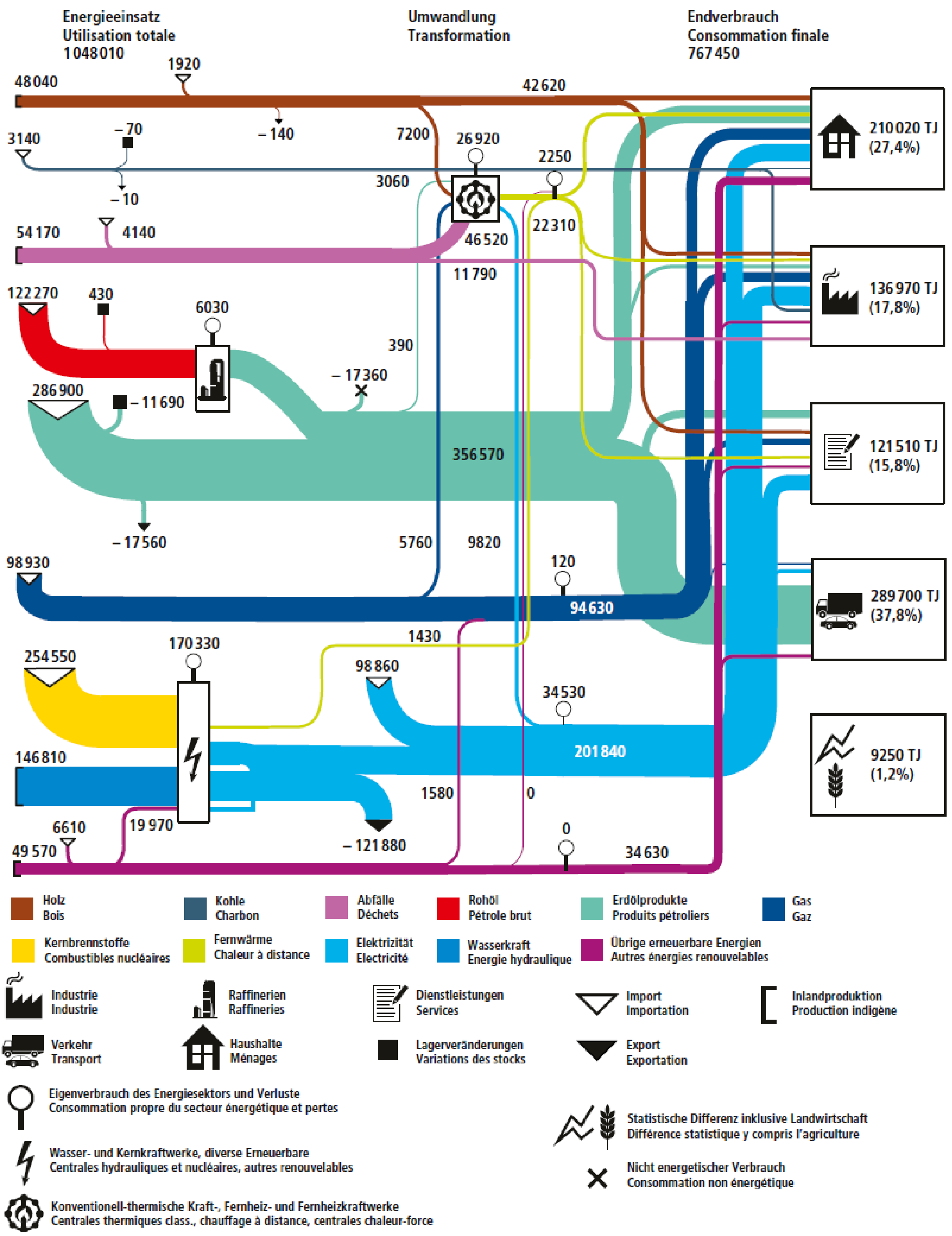


Figure A - 3 Energy flow in Switzerland 2023 (SFOE 2024, figure 5). Depicted values are in TJ.

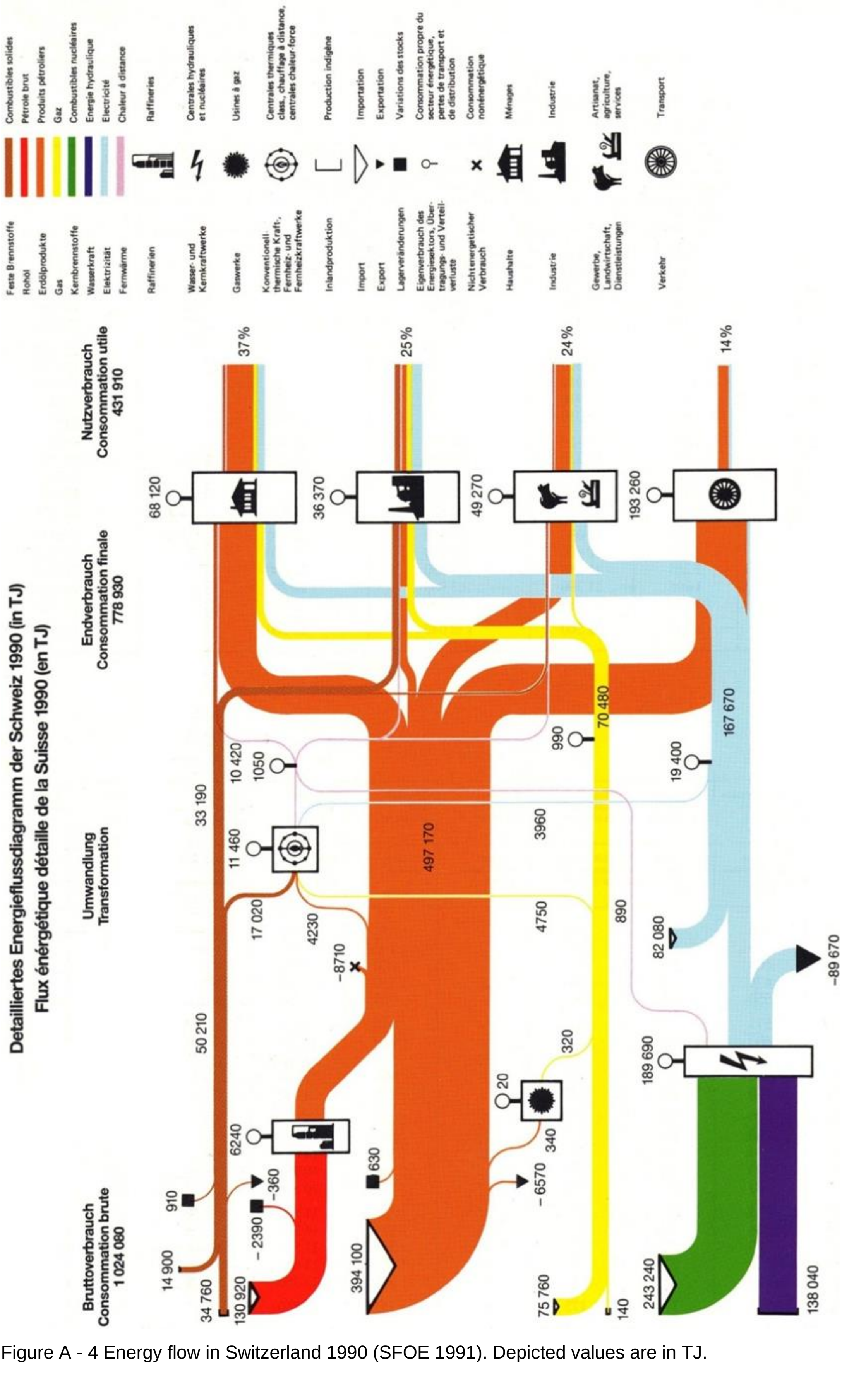


Figure A - 4 Energy flow in Switzerland 1990 (SFOE 1991). Depicted values are in TJ.

Table A - 21 Energy balance for Switzerland 2023 (table 4, Swiss overall energy statistics, SFOE 2024) in TJ.[7].

**Tab. 4 Energiebilanz der Schweiz für das Jahr 2022 (in TJ)**
**Bilan énergétique de la Suisse pour 2022 (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) | 45 430 | – | 58 540 | 0 | – | – | 120600 | – | 44 650 | – | – | 269 220 | Production indigène |
| + Import | (b) | 2 390 | 3 870 | – | 133 310 | 246 440 | 106720 | – | 252140 | 6 270 | 119 220 | – | 870 360 | + Importation |
| + Export | (c) | –110 | – | – | 0 | –25 170 | – | – | – | – | –107 040 | – | –132 320 | + Exportation |
| + Lagerveränderung[1] | (d) | – | –20 | – | –600 | 18 740 | – | – | – | – | – | – | 18 120 | + Variation de stock[1] |
| = Bruttoverbrauch | (e) | 47 710 | 3 850 | 58 540 | 132 710 | 240 010 | 106720 | 120600 | 252140 | 50 920 | 12 180 | – | 1 025 380 | = Consommation brute |
| + Energieumwandlung: | | | | | | | | | | | | | | + Transformation d'énergie: |
| - Wasserkraftwerke | (f) | – | – | – | – | – | – | –120600 | – | – | 120 600 | – | 0 | - Centrales hydrauliques |
| - Kernkraftwerke | (g) | – | – | – | – | – | – | – | –252140 | – | 83 210 | 1 390 | –167 540 | - Centrales nucléaires |
| - konventionell-thermische Kraft-, Fernheiz- und Fernheizkraft-werke | (h) | –3 720 | 0 | –46 260 | – | –420 | –6460 | – | – | – | 7 060 | 22 320 | –27 480 | - Centrales thermiques class., chauffage à distance, centrales chaleur-force |
| - Gaswerke | (i) | – | – | – | – | – | 0 | – | – | – | – | – | 0 | - Usines à gaz |
| - Raffinerien | (j) | – | – | – | –132 710 | 132 710 | – | – | – | – | – | – | 0 | - Raffineries |
| - Diverse Erneuerbare | (k) | –2 720 | – | – | – | – | 1520 | – | – | –18 660 | 17 740 | – | –2 120 | - Renouvelables div. |
| + Eigenverbrauch des Energie-sektors, Netzverluste, Verbrauch der Speicherungen | (l) | – | – | – | – | –6 320 | –130 | – | – | – | –35 480 | –2 350 | –44 280 | + Consommation propre du secteur énergétique, pertes de réseau, pompage d'accumulation |
| + Nichtenergetischer Verbrauch | (m) | – | – | – | – | –18 890 | – | – | – | – | – | – | –18 890 | + Consommation non énergétique |
| = Endverbrauch | (n) | 41 270 | 3 850 | 12 280 | – | 347 090 | 101650 | – | – | 32 260 | 205 310 | 21 360 | 765 070 | = Consommation finale |
| Haushalte | (o) | 17 140 | 50 | – | – | 51 320 | 45550 | – | – | 19 050 | 69 680 | 8 520 | 211 310 | Ménages |
| Industrie | (p) | 12 920 | 3 800 | 12 010 | – | 11 610 | 33100 | – | – | 2 030 | 62 310 | 7 770 | 145 550 | Industrie |
| Dienstleistungen | (q) | 10 230 | 0 | 270 | – | 25 730 | 20250 | – | – | 3 920 | 57 040 | 5 070 | 122 510 | Services |
| Verkehr | (r) | – | – | – | – | 256 310 | 920 | – | – | 6 730 | 12 850 | – | 276 810 | Transport |
| Statistische Differenz inkl. Landwirtschaft | (s) | 980 | 0 | 0 | – | 2 120 | 1830 | – | – | 530 | 3 430 | 0 | 8 890 | Différence statistique, y compris l'agriculture |

[1] + Lagerabnahme
– Lagerzunahme

[1] + diminution de stock
– augmentation de stock

BFE, Schweizerische Gesamtenergiestatistik 2022 (Tab. 4)
OFEN, Statistique globale suisse de l'énergie 2022 (tabl. 4)

[7] Note that Liechtenstein's consumption of liquid fuels is included in these numbers (see chp. 3.1.6.2).

# Annex 5 Additional information concerning uncertainties

The tables in the following chapters provide information about the level and trend uncertainty analysis of all relevant air pollutant emissions in 1990 and 2023. Input data used for the uncertainty estimation are the same for approach 1 (uncertainty propagation) and approach 2 (Monte Carlo simulations) and listed in Annex A5.1. Uncertainty estimates obtained by approach 1 are given in the tables in Annex A5.2 and uncertainty estimates obtained by approach 2 are given in the tables in Annex A5.3.

Categories for which no emission is quantified for neither the base year nor the reporting year are not listed in the tables.

For tables reporting input uncertainties in Annex A5.1 and results from approach 1 in Annex A5.2, columns labelled A to M correspond exactly to columns A to M from Table 5-1 from the EMEP/EEA guidebook (EMEP/EEA 2023, part A, chp. 5, “Uncertainties”, or Table 3.2, chp. 3, from the 2006 IPCC Guidelines (IPCC 2006).

For tables reporting uncertainty results from approach 2, columns labelled A to J correspond exactly to columns A to J from Table 3.3, chp. 3, from the 2006 IPCC Guidelines (IPCC 2006).

## A5.1 Uncertainty estimations: input data

**Bibliographic references for tables of Annex A5.1:**

EMEP/EEA 2019: Default values of EMEP/EEA 2019 and associated uncertainty ranges (activity data and emission factors).

EMIS: Uncertainties that are implemented in the EMIS database (activity data and emission factors).

GHGI: Uncertainty analysis of Switzerland’s greenhouse gas inventory (FOEN 2025); mainly activity data.

France/Sweden: Uncertainties from France’s or Sweden’s Informative Inventory Reports (Citepa 2012, SEPA 2010); mainly emission factors.

UBA: Uncertainties for mobile sources from IFEU/INFRAS (2010), in which uncertainties are evaluated for road and non-road vehicles via Monte Carlo simulations (for emission factors).

UBA/INFRAS: PM10 emission factor uncertainties derived from raw data of IFEU/INFRAS (2010).

Kupper 2012: see References (chp. 12.1).

INFRAS 2017b: see References (chp. 12.1).

INFRAS 2021: see References (chp. 12.1).

Schleiss 2017: see References (chp. 12.1).

Schrade et al. 2025: see References (chp. 12.1).

Table A - 22 Input uncertainties for $NO_x$ for the year 2023, assigned to activity data (col. E) and emissions factors (col. F). For normal and gamma distributions, the given uncertainty is the standard deviation with a coverage factor of 2, expressed in percentage of the mean ((fu) means fuel used approach).

| A | B | E | | | | F | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year 2023 | | | | | | | | | |
| NFR code | Pollutant | Activity data uncertainty for a 95 % confidence | | | | Emission factor uncertainty for a 95 % | | | |
| | | Distribu-tion type | std. dev. % | Corr. | Ref. | Distribu-tion type | std. dev. % | Corr. | Ref. |
| 1A1a | NOx (as NO2) | normal | 10 | no | GHGI | normal | 19 | yes | EMIS |
| 1A1b | NOx (as NO2) | normal | 1 | no | GHGI | normal | 20 | yes | EMIS |
| 1A1c | NOx (as NO2) | normal | 5 | no | EMIS | normal | 20 | yes | EMEP/EEA 2019 |
| 1A2a | NOx (as NO2) | normal | 2 | no | GHGI | normal | 27 | yes | EMIS |
| 1A2b | NOx (as NO2) | normal | 2 | no | GHGI | normal | 20 | yes | EMIS |
| 1A2c | NOx (as NO2) | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2d | NOx (as NO2) | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2e | NOx (as NO2) | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2f | NOx (as NO2) | normal | 2 | no | GHGI | normal | 17 | yes | EMIS |
| 1A2gvii | NOx (as NO2) | normal | 1 | no | GHGI | normal | 13 | yes | UBA |
| 1A2gviii | NOx (as NO2) | normal | 2 | no | GHGI | normal | 17 | yes | EMIS |
| 1A3ai(i) | NOx (as NO2) | normal | 1 | no | GHGI | normal | 20 | yes | EMEP/EEA 2019 |
| 1A3aii(i) | NOx (as NO2) | normal | 1 | no | GHGI | normal | 20 | yes | EMEP/EEA 2019 |
| 1A3bi(fu) | NOx (as NO2) | normal | 1 | no | GHGI | normal | 38 | yes | UBA |
| 1A3bii(fu) | NOx (as NO2) | normal | 1 | no | GHGI | normal | 32 | yes | UBA |
| 1A3biii(fu) | NOx (as NO2) | normal | 1 | no | GHGI | normal | 18 | yes | UBA |
| 1A3biv(fu) | NOx (as NO2) | normal | 1 | no | GHGI | normal | 36 | yes | UBA |
| 1A3c | NOx (as NO2) | normal | 1 | no | GHGI | normal | 13 | yes | UBA |
| 1A3dii | NOx (as NO2) | normal | 1 | no | GHGI | normal | 13 | yes | UBA |
| 1A3ei | NOx (as NO2) | normal | 2 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 1A4ai | NOx (as NO2) | normal | 2 | no | GHGI | normal | 16 | yes | EMIS |
| 1A4aii | NOx (as NO2) | normal | 1 | no | GHGI | normal | 13 | yes | UBA |
| 1A4bi | NOx (as NO2) | normal | 4 | no | GHGI | normal | 13 | yes | EMIS |
| 1A4bii | NOx (as NO2) | normal | 1 | no | GHGI | normal | 30 | yes | EMIS |
| 1A4ci | NOx (as NO2) | normal | 21 | no | GHGI | normal | 30 | yes | EMIS |
| 1A4cii | NOx (as NO2) | normal | 1 | no | GHGI | normal | 13 | yes | UBA |
| 1A5b | NOx (as NO2) | normal | 1 | no | GHGI | normal | 13 | yes | UBA |
| 1B2c | NOx (as NO2) | normal | 22 | no | EMIS | gamma | 200 | yes | EMIS |
| 2A1 | NOx (as NO2) | normal | 2 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 2A2 | NOx (as NO2) | normal | 2 | no | GHGI | gamma | 500 | yes | EMEP/EEA 2019 |
| 2A5a | NOx (as NO2) | normal | 5 | no | EMIS | gamma | 500 | yes | EMEP/EEA 2019 |
| 2B2 | NOx (as NO2) | normal | 2 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 2B5 | NOx (as NO2) | normal | 2 | no | GHGI | normal | 40 | yes | EMEP/EEA 2019 |
| 2B10a | NOx (as NO2) | normal | 2 | no | GHGI | normal | 60 | yes | EMEP/EEA 2019 |
| 2C1 | NOx (as NO2) | normal | 2 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 2C3 | NOx (as NO2) | normal | 5 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 2C7c | NOx (as NO2) | normal | 5 | no | EMIS | gamma | 100 | yes | EMEP/EEA 2019 |
| 2G | NOx (as NO2) | normal | 25 | no | EMIS | gamma | 100 | yes | EMEP/EEA 2019 |
| 2H3 | NOx (as NO2) | normal | 3 | no | EMIS | gamma | 200 | yes | EMEP/EEA 2019 |
| 3B1a | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3B1b | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3B2 | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3B3 | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3B4d | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3B4e | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3B4f | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3B4gi | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3B4gii | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3B4giii | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3B4giv | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3B4h | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3Da1 | NOx (as NO2) | normal | 5 | no | GHGI | normal | 100 | yes | EMEP/EEA 2019 |
| 3Da2a | NOx (as NO2) | normal | 6 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 3Da2b | NOx (as NO2) | normal | 6 | no | GHGI | normal | 100 | yes | EMEP/EEA 2019 |
| 3Da2c | NOx (as NO2) | normal | 20 | no | Schleiss 2017 | normal | 100 | yes | EMEP/EEA 2019 |
| 3Da3 | NOx (as NO2) | normal | 6 | no | GHGI | normal | 100 | yes | EMEP/EEA 2019 |
| 5A | NOx (as NO2) | normal | 10 | no | GHGI | normal | 50 | yes | EMIS |
| 5B2 | NOx (as NO2) | normal | 20 | no | EMIS | normal | 100 | yes | EMEP/EEA 2019 |
| 5C1a | NOx (as NO2) | normal | 50 | no | EMIS | normal | 40 | yes | EMIS |
| 5C1bi | NOx (as NO2) | normal | 30 | no | EMIS | normal | 30 | yes | EMIS |
| 5C1biii | NOx (as NO2) | normal | 30 | no | EMIS | normal | 30 | yes | EMIS |
| 5C1biv | NOx (as NO2) | normal | 20 | no | EMIS | normal | 50 | yes | EMIS |
| 5C1bv | NOx (as NO2) | normal | 5 | no | EMIS | normal | 30 | yes | EMIS |
| 5C2 | NOx (as NO2) | normal | 48 | no | EMIS | gamma | 156 | yes | EMIS |
| 5D1 | NOx (as NO2) | normal | 1 | no | EMIS | normal | 10 | yes | EMIS |
| 5D2 | NOx (as NO2) | normal | 10 | no | EMIS | normal | 10 | yes | EMIS |
| 6A | NOx (as NO2) | normal | 30 | no | EMIS | normal | 50 | yes | EMIS |

Table A - 23 Input uncertainties for NMVOC for the year 2023, assigned to activity data (col. E) and emissions factors (col. F). For normal and gamma distributions, the given uncertainty is the standard deviation with a coverage factor of 2, expressed in percentage of the mean ((fu) means fuel used approach).

| A | B | E | | | | F | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year 2023 | | | | | | | | | |
| NFR code | Pollutant | Activity data uncertainty for a 95 % confidence | | | | Emission factor uncertainty for a 95 % | | | |
| | | Distribu-tion type | std. dev. % | Corr. | Ref. | Distribu-tion type | std. dev. % | Corr. | Ref. |
| 1A1a | NMVOC | normal | 10 | no | GHGI | normal | 32 | yes | EMIS |
| 1A1b | NMVOC | normal | 1 | no | GHGI | normal | 20 | yes | EMIS |
| 1A1c | NMVOC | normal | 5 | no | EMIS | normal | 20 | yes | EMEP/EEA 2019 |
| 1A2a | NMVOC | normal | 2 | no | GHGI | normal | 18 | yes | EMIS |
| 1A2b | NMVOC | normal | 2 | no | GHGI | normal | 19 | yes | EMIS |
| 1A2c | NMVOC | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2d | NMVOC | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2e | NMVOC | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2f | NMVOC | normal | 2 | no | GHGI | normal | 30 | yes | EMIS |
| 1A2gvii | NMVOC | normal | 1 | no | GHGI | normal | 34 | yes | UBA |
| 1A2gviii | NMVOC | normal | 2 | no | GHGI | normal | 30 | yes | EMIS |
| 1A3ai(i) | NMVOC | normal | 1 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 1A3aii(i) | NMVOC | normal | 1 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 1A3bi(fu) | NMVOC | normal | 1 | no | GHGI | normal | 52 | yes | UBA |
| 1A3bii(fu) | NMVOC | normal | 1 | no | GHGI | normal | 46 | yes | UBA |
| 1A3biii(fu) | NMVOC | normal | 1 | no | GHGI | normal | 22 | yes | UBA |
| 1A3biv(fu) | NMVOC | normal | 1 | no | GHGI | gamma | 400 | yes | UBA |
| 1A3bv(fu) | NMVOC | normal | 1 | no | GHGI | normal | 40 | yes | UBA |
| 1A3c | NMVOC | normal | 1 | no | GHGI | normal | 34 | yes | UBA |
| 1A3dii | NMVOC | normal | 1 | no | GHGI | normal | 34 | yes | UBA |
| 1A3ei | NMVOC | normal | 2 | no | GHGI | normal | 50 | yes | EMEP/EEA 2019 |
| 1A4ai | NMVOC | normal | 2 | no | GHGI | normal | 56 | yes | EMIS |
| 1A4aii | NMVOC | normal | 1 | no | GHGI | normal | 75 | yes | Sweden |
| 1A4bi | NMVOC | normal | 4 | no | GHGI | normal | 68 | yes | EMIS |
| 1A4bii | NMVOC | normal | 1 | no | GHGI | normal | 75 | yes | Sweden |
| 1A4ci | NMVOC | normal | 21 | no | GHGI | normal | 75 | yes | EMIS |
| 1A4cii | NMVOC | normal | 1 | no | GHGI | normal | 75 | yes | Sweden |
| 1A5b | NMVOC | normal | 1 | no | GHGI | normal | 34 | yes | UBA |
| 1B2ai | NMVOC | normal | 30 | no | | normal | 50 | yes | EMEP/EEA 2019 |
| 1B2aiv | NMVOC | normal | 30 | no | EMEP/EEA 2019 | normal | 47 | yes | EMIS |
| 1B2av | NMVOC | normal | 1 | no | EMEP/EEA 2019 | gamma | 40 | yes | EMIS |
| 1B2b | NMVOC | normal | 22 | no | EMIS | normal | 50 | yes | EMEP/EEA 2019 |
| 1B2c | NMVOC | normal | 22 | no | EMIS | gamma | 100 | yes | EMIS |
| 2A1 | NMVOC | normal | 2 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 2A2 | NMVOC | normal | 2 | no | GHGI | gamma | 500 | yes | EMEP/EEA 2019 |
| 2A5a | NMVOC | normal | 5 | no | EMIS | gamma | 500 | yes | EMEP/EEA 2019 |
| 2B10a | NMVOC | normal | 2 | no | GHGI | normal | 40 | yes | EMEP/EEA 2019 |
| 2C1 | NMVOC | normal | 2 | no | GHGI | gamma | 100 | yes | EMEP/EEA 2019 |
| 2C3 | NMVOC | normal | 5 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 2C7a | NMVOC | normal | 5 | no | EMIS | gamma | 200 | yes | EMEP/EEA 2019 |
| 2C7c | NMVOC | normal | 5 | no | EMIS | gamma | 100 | yes | EMEP/EEA 2019 |
| 2D3a | NMVOC | normal | 1 | no | EMIS | normal | 50 | no | EMIS |
| 2D3b | NMVOC | normal | 5 | no | EMIS | gamma | 100 | yes | EMEP/EEA 2019 |
| 2D3c | NMVOC | normal | 20 | no | EMIS | gamma | 100 | yes | EMEP/EEA 2019 |
| 2D3d | NMVOC | normal | 20 | no | EMIS | normal | 40 | yes | EMEP/EEA 2019 |
| 2D3e | NMVOC | normal | 40 | no | EMIS | normal | 50 | yes | EMEP/EEA 2019 |
| 2D3f | NMVOC | normal | 20 | no | EMIS | normal | 40 | yes | EMEP/EEA 2019 |
| 2D3g | NMVOC | normal | 30 | no | EMIS | gamma | 100 | yes | EMEP/EEA 2019 |
| 2D3h | NMVOC | normal | 20 | no | EMIS | normal | 40 | yes | EMEP/EEA 2019 |
| 2D3i | NMVOC | normal | 30 | no | EMEP/EEA 2019 | gamma | 180 | yes | EMEP/EEA 2019 |
| 2G | NMVOC | normal | 25 | no | EMIS | gamma | 200 | yes | EMEP/EEA 2019 |
| 2H1 | NMVOC | normal | 30 | no | EMEP/EEA 2019 | gamma | 200 | yes | EMEP/EEA 2019 |
| 2H2 | NMVOC | normal | 10 | no | EMEP/EEA 2019 | gamma | 100 | yes | EMEP/EEA 2019 |
| 2H3 | NMVOC | normal | 3 | no | EMIS | gamma | 200 | yes | EMEP/EEA 2019 |
| 3B1a | NMVOC | normal | 6 | no | GHGI | normal | 60 | yes | Schrade 2024 |
| 3B1b | NMVOC | normal | 6 | no | GHGI | normal | 70 | yes | Schrade 2024 |
| 3B2 | NMVOC | normal | 6 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 3B3 | NMVOC | normal | 6 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 3B4d | NMVOC | normal | 6 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 3B4e | NMVOC | normal | 6 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 3B4f | NMVOC | normal | 6 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 3B4gi | NMVOC | normal | 6 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 3B4gii | NMVOC | normal | 6 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 3B4giii | NMVOC | normal | 6 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 3B4giv | NMVOC | normal | 6 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 3B4h | NMVOC | normal | 6 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 3De | NMVOC | normal | 5 | no | GHGI (LULUCF) | gamma | 200 | yes | EMEP/EEA 2019 |
| 5A | NMVOC | normal | 10 | no | GHGI | normal | 50 | yes | EMIS |
| 5B1 | NMVOC | normal | 20 | no | Schleiss 2017 | normal | 100 | yes | EMIS |
| 5B2 | NMVOC | normal | 20 | no | EMIS | normal | 30 | yes | EMIS |
| 5C1a | NMVOC | normal | 50 | no | EMIS | normal | 50 | yes | EMIS |
| 5C1bi | NMVOC | normal | 30 | no | EMIS | normal | 30 | yes | EMIS |
| 5C1biii | NMVOC | normal | 30 | no | EMIS | normal | 30 | yes | EMIS |
| 5C1biv | NMVOC | normal | 20 | no | EMIS | normal | 20 | yes | EMIS |
| 5C1bv | NMVOC | normal | 5 | no | EMIS | normal | 30 | yes | EMIS |
| 5C2 | NMVOC | normal | 48 | no | EMIS | gamma | 156 | yes | EMIS |
| 5D1 | NMVOC | normal | 1 | no | EMIS | normal | 27 | yes | EMIS |
| 5D2 | NMVOC | normal | 10 | no | EMIS | normal | 20 | yes | EMIS |
| 5E | NMVOC | normal | 20 | no | EMIS | normal | 24 | yes | EMIS |
| 6A | NMVOC | normal | 30 | no | EMIS | normal | 50 | yes | EMIS |

Table A - 24 Input uncertainties for $SO_x$ for the year 2023, assigned to activity data (col. E) and emissions factors (col. F). For normal and gamma distributions, the given uncertainty is the standard deviation with a coverage factor of 2, expressed in percentage of the mean ((fu) means fuel used approach).

| A | B | E | | | | F | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year 2023 | | | | | | | | | |
| NFR code | Pollutant | Activity data uncertainty for a 95 % confidence | | | | Emission factor uncertainty for a 95 % | | | |
| | | Distribu-tion type | std. dev. % | Corr. | Ref. | Distribu-tion type | std. dev. % | Corr. | Ref. |
| 1A1a | SOx (as SO2) | normal | 10 | no | GHGI | normal | 22 | yes | EMIS |
| 1A1b | SOx (as SO2) | normal | 1 | no | GHGI | normal | 20 | yes | EMIS |
| 1A2a | SOx (as SO2) | normal | 2 | no | GHGI | normal | 15 | yes | EMIS |
| 1A2b | SOx (as SO2) | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2c | SOx (as SO2) | normal | 2 | no | GHGI | normal | 11 | yes | EMIS |
| 1A2d | SOx (as SO2) | normal | 2 | no | GHGI | normal | 14 | yes | EMIS |
| 1A2e | SOx (as SO2) | normal | 2 | no | GHGI | normal | 12 | yes | EMIS |
| 1A2f | SOx (as SO2) | normal | 2 | no | GHGI | normal | 19 | yes | EMIS |
| 1A2gvii | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A2gviii | SOx (as SO2) | normal | 2 | no | GHGI | normal | 19 | yes | EMIS |
| 1A3ai(i) | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A3aii(i) | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A3bi(fu) | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A3bii(fu) | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A3biii(fu) | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A3biv(fu) | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A3c | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A3dii | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A3ei | SOx (as SO2) | normal | 2 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A4ai | SOx (as SO2) | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A4aii | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A4bi | SOx (as SO2) | normal | 4 | no | GHGI | normal | 10 | yes | EMIS |
| 1A4bii | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A4ci | SOx (as SO2) | normal | 21 | no | GHGI | normal | 18 | yes | EMIS |
| 1A4cii | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1A5b | SOx (as SO2) | normal | 1 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 1B2aiv | SOx (as SO2) | normal | 30 | no | EMEP/EEA 2019 | normal | 47 | yes | EMIS |
| 1B2c | SOx (as SO2) | normal | 22 | no | EMIS | normal | 31 | yes | EMIS |
| 2A1 | SOx (as SO2) | normal | 2 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 2A2 | SOx (as SO2) | normal | 2 | no | GHGI | gamma | 500 | yes | EMEP/EEA 2019 |
| 2A5a | SOx (as SO2) | normal | 5 | no | EMIS | gamma | 500 | yes | EMEP/EEA 2019 |
| 2B5 | SOx (as SO2) | normal | 2 | no | GHGI | normal | 20 | yes | EMEP/EEA 2019 |
| 2B10a | SOx (as SO2) | normal | 2 | no | GHGI | normal | 40 | yes | EMEP/EEA 2019 |
| 2C1 | SOx (as SO2) | normal | 2 | no | GHGI | gamma | 100 | yes | EMEP/EEA 2019 |
| 2C3 | SOx (as SO2) | normal | 5 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 2C7c | SOx (as SO2) | normal | 5 | no | EMIS | gamma | 100 | yes | EMEP/EEA 2019 |
| 2G | SOx (as SO2) | normal | 25 | no | EMIS | gamma | 100 | yes | EMEP/EEA 2019 |
| 2H3 | SOx (as SO2) | normal | 3 | no | EMIS | gamma | 200 | yes | EMEP/EEA 2019 |
| 5B2 | SOx (as SO2) | normal | 20 | no | EMIS | normal | 100 | yes | EMIS |
| 5C1a | SOx (as SO2) | normal | 50 | no | EMIS | normal | 40 | yes | EMIS |
| 5C1bi | SOx (as SO2) | normal | 30 | no | EMIS | normal | 30 | yes | EMIS |
| 5C1biii | SOx (as SO2) | normal | 30 | no | EMIS | normal | 30 | yes | EMIS |
| 5C1biv | SOx (as SO2) | normal | 20 | no | EMIS | normal | 30 | yes | EMIS |
| 5C2 | SOx (as SO2) | normal | 48 | no | EMIS | gamma | 133 | yes | EMIS |
| 5D1 | SOx (as SO2) | normal | 1 | no | EMIS | normal | 37 | yes | EMIS |
| 5D2 | SOx (as SO2) | normal | 10 | no | EMIS | normal | 20 | yes | EMIS |
| 6A | SOx (as SO2) | normal | 30 | no | EMIS | normal | 50 | yes | EMIS |

Table A - 25 Input uncertainties for $NH_3$ for the year 2023, assigned to activity data (col. E) and emissions factors (col. F). For normal and gamma distributions, the given uncertainty is the standard deviation with a coverage factor of 2, expressed in percentage of the mean ((fu) means fuel used approach).

| A | B | E | | | | F | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year 2023 | | | | | | | | | |
| NFR code | Pollutant | Activity data uncertainty for a 95 % confidence | | | | Emission factor uncertainty for a 95 % | | | |
| | | Distribu-tion type | std. dev. % | Corr. | Ref. | Distribu-tion type | std. dev. % | Corr. | Ref. |
| 1A1a | NH3 | normal | 10 | no | GHGI | normal | 20 | yes | EMIS |
| 1A1b | NH3 | normal | 1 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2a | NH3 | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2b | NH3 | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2c | NH3 | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2d | NH3 | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2e | NH3 | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2f | NH3 | normal | 2 | no | GHGI | normal | 9 | yes | EMIS |
| 1A2gvii | NH3 | normal | 1 | no | GHGI | normal | 50 | yes | France |
| 1A2gviii | NH3 | normal | 2 | no | GHGI | normal | 9 | yes | EMIS |
| 1A3bi(fu) | NH3 | normal | 1 | no | GHGI | normal | 50 | yes | France |
| 1A3bii(fu) | NH3 | normal | 1 | no | GHGI | normal | 50 | yes | France |
| 1A3biii(fu) | NH3 | normal | 1 | no | GHGI | normal | 50 | yes | France |
| 1A3biv(fu) | NH3 | normal | 1 | no | GHGI | normal | 50 | yes | France |
| 1A3c | NH3 | normal | 1 | no | GHGI | normal | 50 | yes | France |
| 1A3dii | NH3 | normal | 1 | no | GHGI | normal | 50 | yes | France |
| 1A4ai | NH3 | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A4aii | NH3 | normal | 1 | no | GHGI | normal | 10 | yes | EMIS |
| 1A4bi | NH3 | normal | 4 | no | GHGI | normal | 10 | yes | EMIS |
| 1A4bii | NH3 | normal | 1 | no | GHGI | normal | 10 | yes | EMIS |
| 1A4ci | NH3 | normal | 21 | no | GHGI | normal | 10 | yes | EMIS |
| 1A4cii | NH3 | normal | 1 | no | GHGI | normal | 50 | yes | France |
| 1A5b | NH3 | normal | 1 | no | GHGI | normal | 50 | yes | France |
| 2B1 | NH3 | normal | 2 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 2B2 | NH3 | normal | 2 | no | GHGI | normal | 10 | yes | EMEP/EEA 2019 |
| 2B10a | NH3 | normal | 2 | no | GHGI | normal | 40 | yes | EMEP/EEA 2019 |
| 2C1 | NH3 | normal | 2 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 2C7c | NH3 | normal | 5 | no | EMIS | gamma | 500 | yes | EMEP/EEA 2019 |
| 2G | NH3 | normal | 25 | no | EMIS | normal | 40 | yes | EMEP/EEA 2019 |
| 2H2 | NH3 | normal | 10 | no | EMEP/EEA 2019 | gamma | 500 | yes | EMEP/EEA 2019 |
| 2H3 | NH3 | normal | 3 | no | EMIS | gamma | 200 | yes | EMEP/EEA 2019 |
| 2L | NH3 | normal | 25 | no | EMIS | normal | 100 | yes | EMEP/EEA 2019 |
| 3B1a | NH3 | normal | 6 | no | GHGI | normal | 29 | yes | INFRAS 2021 |
| 3B1b | NH3 | normal | 6 | no | GHGI | normal | 27 | yes | INFRAS 2021 |
| 3B2 | NH3 | normal | 6 | no | GHGI | normal | 87 | yes | INFRAS 2021 |
| 3B3 | NH3 | normal | 6 | no | GHGI | normal | 40 | yes | INFRAS 2021 |
| 3B4d | NH3 | normal | 6 | no | GHGI | normal | 65 | yes | INFRAS 2021 |
| 3B4e | NH3 | normal | 6 | no | GHGI | normal | 52 | yes | INFRAS 2021 |
| 3B4f | NH3 | normal | 6 | no | GHGI | normal | 68 | yes | INFRAS 2021 |
| 3B4gi | NH3 | normal | 6 | no | GHGI | normal | 82 | yes | INFRAS 2021 |
| 3B4gii | NH3 | normal | 6 | no | GHGI | normal | 86 | yes | INFRAS 2021 |
| 3B4giii | NH3 | normal | 6 | no | GHGI | normal | 93 | yes | INFRAS 2021 |
| 3B4giv | NH3 | normal | 6 | no | GHGI | normal | 85 | yes | INFRAS 2021 |
| 3B4h | NH3 | normal | 6 | no | GHGI | normal | 50 | yes | INFRAS 2021 |
| 3Da1 | NH3 | normal | 5 | no | GHGI | normal | 50 | yes | Kupper 2012 |
| 3Da2a | NH3 | normal | 6 | no | GHGI | normal | 21 | yes | INFRAS 2021 |
| 3Da2b | NH3 | normal | 6 | no | GHGI | normal | 50 | yes | Kupper 2012 |
| 3Da2c | NH3 | normal | 20 | no | Schleiss 2017 | normal | 50 | yes | Kupper 2012 |
| 3Da3 | NH3 | normal | 6 | no | GHGI | normal | 62 | yes | INFRAS 2021 |
| 5A | NH3 | normal | 10 | no | GHGI | normal | 50 | yes | EMIS |
| 5B1 | NH3 | normal | 20 | no | Schleiss 2017 | normal | 100 | yes | EMIS |
| 5B2 | NH3 | normal | 20 | no | EMIS | normal | 75 | yes | INFRAS 2014 |
| 5C1biv | NH3 | normal | 20 | no | EMIS | normal | 50 | yes | EMIS |
| 5C2 | NH3 | normal | 48 | no | EMIS | normal | 25 | yes | EMIS |
| 5D1 | NH3 | normal | 1 | no | EMIS | normal | 50 | yes | EMIS |
| 6A | NH3 | normal | 30 | no | EMIS | normal | 100 | yes | EMEP/EEA 2019 |

Table A - 26 Input uncertainties for PM2.5 for the year 2023, assigned to activity data (col. E) and emissions factors (col. F). For normal and gamma distributions, the given uncertainty is the standard deviation with a coverage factor of 2, expressed in percentage of the mean ((fu) means fuel used approach).

| A | B | E | | | | F | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year 2023 | | | | | | | | | |
| NFR code | Pollutant | Activity data uncertainty for a 95 % confidence | | | | Emission factor uncertainty for a 95 % | | | |
| | | Distribu-tion type | std. dev. % | Corr. | Ref. | Distribu-tion type | std. dev. % | Corr. | Ref. |
| 1A1a | PM2.5 | normal | 10 | no | GHGI | normal | 71 | yes | EMIS |
| 1A1b | PM2.5 | normal | 1 | no | GHGI | normal | 20 | yes | EMIS |
| 1A1c | PM2.5 | normal | 5 | no | EMIS | normal | 20 | yes | EMEP/EEA 2019 |
| 1A2a | PM2.5 | normal | 2 | no | GHGI | normal | 28 | yes | EMIS |
| 1A2b | PM2.5 | normal | 2 | no | GHGI | normal | 30 | yes | EMIS |
| 1A2c | PM2.5 | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2d | PM2.5 | normal | 2 | no | GHGI | normal | 33 | yes | EMIS |
| 1A2e | PM2.5 | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2f | PM2.5 | normal | 2 | no | GHGI | normal | 65 | yes | EMIS |
| 1A2gvii | PM2.5 | normal | 1 | no | GHGI | normal | 50 | yes | UBA/INFRAS |
| 1A2gviii | PM2.5 | normal | 2 | no | GHGI | normal | 65 | yes | EMIS |
| 1A3ai(i) | PM2.5 | normal | 1 | no | GHGI | normal | 30 | yes | UBA/INFRAS |
| 1A3aii(i) | PM2.5 | normal | 1 | no | GHGI | normal | 30 | yes | UBA/INFRAS |
| 1A3bi(fu) | PM2.5 | normal | 1 | no | GHGI | normal | 57 | yes | UBA/INFRAS |
| 1A3bii(fu) | PM2.5 | normal | 1 | no | GHGI | normal | 48 | yes | UBA/INFRAS |
| 1A3biii(fu) | PM2.5 | normal | 1 | no | GHGI | normal | 27 | yes | UBA/INFRAS |
| 1A3biv(fu) | PM2.5 | normal | 1 | no | GHGI | normal | 54 | yes | UBA/INFRAS |
| 1A3bvi(fu) | PM2.5 | normal | 1 | no | GHGI | normal | 50 | yes | UBA/INFRAS |
| 1A3c | PM2.5 | normal | 1 | no | GHGI | normal | 50 | yes | UBA/INFRAS |
| 1A3dii | PM2.5 | normal | 1 | no | GHGI | normal | 50 | yes | UBA/INFRAS |
| 1A3ei | PM2.5 | normal | 2 | no | GHGI | normal | 27 | yes | UBA/INFRAS |
| 1A4ai | PM2.5 | normal | 2 | no | GHGI | normal | 78 | yes | EMIS |
| 1A4bi | PM2.5 | normal | 4 | no | GHGI | normal | 76 | yes | EMIS |
| 1A4ci | PM2.5 | normal | 21 | no | GHGI | normal | 39 | yes | EMIS |
| 1A4cii | PM2.5 | normal | 1 | no | GHGI | normal | 80 | yes | EMIS |
| 1A5b | PM2.5 | normal | 1 | no | GHGI | normal | 50 | yes | UBA/INFRAS |
| 1B1a | PM2.5 | normal | 30 | no | EMEP/EEA 2019 | normal | 40 | yes | EMIS |
| 1B2c | PM2.5 | normal | 22 | no | EMIS | gamma | 237 | yes | EMEP/EEA 2019 |
| 2A1 | PM2.5 | normal | 2 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 2A2 | PM2.5 | normal | 2 | no | GHGI | gamma | 500 | yes | EMEP/EEA 2019 |
| 2A5a | PM2.5 | normal | 5 | no | EMIS | gamma | 500 | yes | EMEP/EEA 2019 |
| 2B5 | PM2.5 | normal | 2 | no | GHGI | gamma | 100 | yes | EMEP/EEA 2019 |
| 2B10a | PM2.5 | normal | 2 | no | GHGI | normal | 40 | yes | EMEP/EEA 2019 |
| 2C1 | PM2.5 | normal | 2 | no | GHGI | gamma | 125 | yes | EMEP/EEA 2019 |
| 2C3 | PM2.5 | normal | 5 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 2C7a | PM2.5 | normal | 5 | no | EMIS | gamma | 200 | yes | EMEP/EEA 2019 |
| 2C7c | PM2.5 | normal | 5 | no | EMIS | gamma | 500 | yes | EMEP/EEA 2019 |
| 2D3c | PM2.5 | normal | 20 | no | EMIS | gamma | 200 | yes | EMEP/EEA 2019 |
| 2D3i | PM2.5 | normal | 30 | no | EMEP/EEA 2019 | gamma | 500 | yes | EMEP/EEA 2019 |
| 2G | PM2.5 | normal | 25 | no | EMIS | gamma | 100 | yes | EMEP/EEA 2019 |
| 2H1 | PM2.5 | normal | 30 | no | EMEP/EEA 2019 | gamma | 200 | yes | EMEP/EEA 2019 |
| 2H2 | PM2.5 | normal | 10 | no | EMEP/EEA 2019 | gamma | 500 | yes | EMEP/EEA 2019 |
| 2H3 | PM2.5 | normal | 3 | no | EMIS | gamma | 200 | yes | EMEP/EEA 2019 |
| 2I | PM2.5 | normal | 10 | no | EMEP/EEA 2019 | gamma | 500 | yes | EMEP/EEA 2019 |
| 3B1a | PM2.5 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B1b | PM2.5 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B2 | PM2.5 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B3 | PM2.5 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B4d | PM2.5 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B4e | PM2.5 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B4f | PM2.5 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B4gi | PM2.5 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B4gii | PM2.5 | normal | 6 | no | GHGI | gamma | 300 | yes | |
| 3B4giii | PM2.5 | normal | 6 | no | GHGI | gamma | 300 | yes | |
| 3B4giv | PM2.5 | normal | 6 | no | GHGI | gamma | 300 | yes | |
| 3B4h | PM2.5 | normal | 6 | no | GHGI | gamma | 300 | yes | |
| 3De | PM2.5 | normal | 5 | no | GHGI (LULUCF) | gamma | 200 | yes | EMEP/EEA 2019 |
| 5A | PM2.5 | normal | 10 | no | GHGI | normal | 30 | yes | EMIS |
| 5B2 | PM2.5 | normal | 20 | no | EMIS | normal | 100 | yes | EMIS |
| 5C1a | PM2.5 | normal | 50 | no | EMIS | normal | 30 | yes | EMIS |
| 5C1bi | PM2.5 | normal | 30 | no | EMIS | normal | 30 | yes | EMIS |
| 5C1biii | PM2.5 | normal | 30 | no | EMIS | normal | 30 | yes | EMIS |
| 5C1biv | PM2.5 | normal | 20 | no | EMIS | normal | 34 | yes | EMIS |
| 5C1bv | PM2.5 | normal | 5 | no | EMIS | normal | 33 | yes | EMIS |
| 5C2 | PM2.5 | normal | 48 | no | EMIS | gamma | 156 | yes | EMIS |
| 5E | PM2.5 | normal | 20 | no | EMIS | normal | 30 | yes | EMIS |
| 6A | PM2.5 | normal | 30 | no | EMIS | normal | 40 | yes | EMIS |

Table A - 27 Input uncertainties for PM10 for the year 2023, assigned to activity data (col. E) and emissions factors (col. F). For normal and gamma distributions, the given uncertainty is the standard deviation with a coverage factor of 2, expressed in percentage of the mean ((fu) means fuel used approach).

| A | B | E | | | | F | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year 2023 | | | | | | | | | |
| NFR code | Pollutant | Activity data uncertainty for a 95 % confidence | | | | Emission factor uncertainty for a 95 % | | | |
| | | Distribu-tion type | std. dev. % | Corr. | Ref. | Distribu-tion type | std. dev. % | Corr. | Ref. |
| 1A1a | PM10 | normal | 10 | no | GHGI | normal | 71 | yes | EMIS |
| 1A1b | PM10 | normal | 1 | no | GHGI | normal | 20 | yes | EMIS |
| 1A1c | PM10 | normal | 5 | no | EMIS | normal | 20 | yes | EMEP/EEA 2019 |
| 1A2a | PM10 | normal | 2 | no | GHGI | normal | 28 | yes | EMIS |
| 1A2b | PM10 | normal | 2 | no | GHGI | normal | 30 | yes | EMIS |
| 1A2c | PM10 | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2d | PM10 | normal | 2 | no | GHGI | normal | 33 | yes | EMIS |
| 1A2e | PM10 | normal | 2 | no | GHGI | normal | 10 | yes | EMIS |
| 1A2f | PM10 | normal | 2 | no | GHGI | normal | 65 | yes | EMIS |
| 1A2gvii | PM10 | normal | 1 | no | GHGI | normal | 50 | yes | UBA/INFRAS |
| 1A2gviii | PM10 | normal | 2 | no | GHGI | normal | 65 | yes | EMIS |
| 1A3ai(i) | PM10 | normal | 1 | no | GHGI | normal | 30 | yes | UBA/INFRAS |
| 1A3aii(i) | PM10 | normal | 1 | no | GHGI | normal | 30 | yes | UBA/INFRAS |
| 1A3bi(fu) | PM10 | normal | 1 | no | GHGI | normal | 57 | yes | UBA/INFRAS |
| 1A3bii(fu) | PM10 | normal | 1 | no | GHGI | normal | 48 | yes | UBA/INFRAS |
| 1A3biii(fu) | PM10 | normal | 1 | no | GHGI | normal | 27 | yes | UBA/INFRAS |
| 1A3biv(fu) | PM10 | normal | 1 | no | GHGI | normal | 54 | yes | UBA/INFRAS |
| 1A3bvi(fu) | PM10 | normal | 1 | no | GHGI | normal | 50 | yes | UBA/INFRAS |
| 1A3c | PM10 | normal | 1 | no | GHGI | normal | 50 | yes | UBA/INFRAS |
| 1A3dii | PM10 | normal | 1 | no | GHGI | normal | 50 | yes | UBA/INFRAS |
| 1A3ei | PM10 | normal | 2 | no | GHGI | normal | 27 | yes | UBA/INFRAS |
| 1A4ai | PM10 | normal | 2 | no | GHGI | normal | 78 | yes | EMIS |
| 1A4bi | PM10 | normal | 4 | no | GHGI | normal | 76 | yes | EMIS |
| 1A4ci | PM10 | normal | 21 | no | GHGI | normal | 39 | yes | EMIS |
| 1A4cii | PM10 | normal | 1 | no | GHGI | normal | 80 | yes | EMIS |
| 1A5b | PM10 | normal | 1 | no | GHGI | normal | 50 | yes | UBA/INFRAS |
| 1B1a | PM10 | normal | 30 | no | EMEP/EEA 2019 | normal | 40 | yes | EMIS |
| 1B2c | PM10 | normal | 22 | no | EMIS | gamma | 237 | yes | EMEP/EEA 2019 |
| 2A1 | PM10 | normal | 2 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 2A2 | PM10 | normal | 2 | no | GHGI | gamma | 500 | yes | EMEP/EEA 2019 |
| 2A5a | PM10 | normal | 5 | no | EMIS | gamma | 500 | yes | EMEP/EEA 2019 |
| 2B5 | PM10 | normal | 2 | no | GHGI | gamma | 100 | yes | EMEP/EEA 2019 |
| 2B10a | PM10 | normal | 2 | no | GHGI | normal | 40 | yes | EMEP/EEA 2019 |
| 2C1 | PM10 | normal | 2 | no | GHGI | gamma | 125 | yes | EMEP/EEA 2019 |
| 2C3 | PM10 | normal | 5 | no | GHGI | gamma | 200 | yes | EMEP/EEA 2019 |
| 2C7a | PM10 | normal | 5 | no | EMIS | gamma | 200 | yes | EMEP/EEA 2019 |
| 2C7c | PM10 | normal | 5 | no | EMIS | gamma | 500 | yes | EMEP/EEA 2019 |
| 2D3c | PM10 | normal | 20 | no | EMIS | gamma | 200 | yes | EMEP/EEA 2019 |
| 2D3i | PM10 | normal | 30 | no | EMEP/EEA 2019 | gamma | 500 | yes | EMEP/EEA 2019 |
| 2G | PM10 | normal | 25 | no | EMIS | gamma | 100 | yes | EMEP/EEA 2019 |
| 2H1 | PM10 | normal | 30 | no | EMEP/EEA 2019 | gamma | 200 | yes | EMEP/EEA 2019 |
| 2H2 | PM10 | normal | 10 | no | EMEP/EEA 2019 | gamma | 500 | yes | EMEP/EEA 2019 |
| 2H3 | PM10 | normal | 3 | no | EMIS | gamma | 200 | yes | EMEP/EEA 2019 |
| 2I | PM10 | normal | 10 | no | EMEP/EEA 2019 | gamma | 500 | yes | EMEP/EEA 2019 |
| 3B1a | PM10 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B1b | PM10 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B2 | PM10 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B3 | PM10 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B4d | PM10 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B4e | PM10 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B4f | PM10 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B4gi | PM10 | normal | 6 | no | GHGI | gamma | 300 | yes | EMIS |
| 3B4gii | PM10 | normal | 6 | no | GHGI | gamma | 300 | yes | |
| 3B4giii | PM10 | normal | 6 | no | GHGI | gamma | 300 | yes | |
| 3B4giv | PM10 | normal | 6 | no | GHGI | gamma | 300 | yes | |
| 3B4h | PM10 | normal | 6 | no | GHGI | gamma | 300 | yes | |
| 3De | PM10 | normal | 5 | no | GHGI (LULUCF) | gamma | 200 | yes | EMEP/EEA 2019 |
| 5A | PM10 | normal | 10 | no | GHGI | normal | 30 | yes | EMIS |
| 5B2 | PM10 | normal | 20 | no | EMIS | normal | 100 | yes | EMIS |
| 5C1a | PM10 | normal | 50 | no | EMIS | normal | 50 | yes | EMIS |
| 5C1bi | PM10 | normal | 30 | no | EMIS | normal | 30 | yes | EMIS |
| 5C1biii | PM10 | normal | 30 | no | EMIS | normal | 30 | yes | EMIS |
| 5C1biv | PM10 | normal | 20 | no | EMIS | normal | 35 | yes | EMIS |
| 5C1bv | PM10 | normal | 5 | no | EMIS | normal | 33 | yes | EMIS |
| 5C2 | PM10 | normal | 48 | no | EMIS | gamma | 156 | yes | EMIS |
| 5E | PM10 | normal | 20 | no | EMIS | normal | 30 | yes | EMIS |
| 6A | PM10 | normal | 30 | no | EMIS | normal | 40 | yes | EMIS |

## A5.2 Uncertainty estimations: results from approach 1

Table A - 28 Uncertainty analysis of $NO_x$ emissions, approach 1, for 2023 and for the trend 1990-2023. The uncertainties are given considering a 95 % confidence interval and expressed as the distance from edge to mean, in percentage of the mean ((fu) means fuel used approach). AD: activity data; EF: emission factor; EM: emission; corr.: correlated.

| A | B | C | D | G | | H | | I | J | K | | L | | M | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFR | Pollutant | Emissions 1990 | Emissions 2023 | Emission combined uncertainty 2023 | | Category contribution to inventory variance 2023 | | Sensitivi-ty if corr. (type A) | Sensitivi-ty if not corr. (type B) | Contribution to inventory trend uncertainty from AD | | Contribution to inventory trend uncertainty from EF | | Contribution to inventory trend uncertainty from EM | |
| | | | | (-)% | (+)% | (-)% | (+)% | | | (-)% | (+)% | (-)% | (+)% | (-)% | (+)% |
| 1A1a | NOx (as NO2) | 6'279.37 | 2'266.58 | 21 | 21 | 1.084 | 1.084 | 0.001 | 0.016 | 0.228 | 0.228 | 0.024 | 0.024 | 0.052 | 0.052 |
| 1A1b | NOx (as NO2) | 494.17 | 338.32 | 20 | 20 | 0.021 | 0.021 | 0.001 | 0.002 | 0.004 | 0.004 | 0.025 | 0.025 | 0.001 | 0.001 |
| 1A1c | NOx (as NO2) | 0.01 | 0.04 | 21 | 21 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2a | NOx (as NO2) | 279.07 | 96.50 | 27 | 27 | 0.003 | 0.003 | 0.000 | 0.001 | 0.002 | 0.002 | 0.001 | 0.001 | 0.000 | 0.000 |
| 1A2b | NOx (as NO2) | 127.53 | 28.81 | 20 | 20 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.002 | 0.000 | 0.000 |
| 1A2c | NOx (as NO2) | 1'050.42 | 190.46 | 10 | 10 | 0.002 | 0.002 | 0.001 | 0.001 | 0.004 | 0.004 | 0.011 | 0.011 | 0.000 | 0.000 |
| 1A2d | NOx (as NO2) | 1'261.91 | 31.23 | 10 | 10 | 0.000 | 0.000 | 0.003 | 0.000 | 0.001 | 0.001 | 0.028 | 0.028 | 0.001 | 0.001 |
| 1A2e | NOx (as NO2) | 743.69 | 192.51 | 10 | 10 | 0.002 | 0.002 | 0.000 | 0.001 | 0.004 | 0.004 | 0.004 | 0.004 | 0.000 | 0.000 |
| 1A2f | NOx (as NO2) | 10'534.54 | 2'825.44 | 17 | 17 | 1.071 | 1.071 | 0.005 | 0.020 | 0.057 | 0.057 | 0.081 | 0.081 | 0.010 | 0.010 |
| 1A2gvii | NOx (as NO2) | 6'333.94 | 1'536.52 | 13 | 13 | 0.184 | 0.184 | 0.004 | 0.011 | 0.020 | 0.020 | 0.052 | 0.052 | 0.003 | 0.003 |
| 1A2gviii | NOx (as NO2) | 2'181.62 | 1'637.67 | 17 | 17 | 0.360 | 0.360 | 0.006 | 0.012 | 0.034 | 0.034 | 0.110 | 0.110 | 0.013 | 0.013 |
| 1A3ai(i) | NOx (as NO2) | 1'214.30 | 1'966.25 | 20 | 20 | 0.711 | 0.711 | 0.011 | 0.014 | 0.025 | 0.025 | 0.222 | 0.222 | 0.050 | 0.050 |
| 1A3aii(i) | NOx (as NO2) | 153.76 | 54.52 | 20 | 20 | 0.001 | 0.001 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A3bi(fu) | NOx (as NO2) | 43'748.48 | 15'009.57 | 38 | 38 | 150.796 | 150.796 | 0.003 | 0.107 | 0.194 | 0.194 | 0.129 | 0.129 | 0.054 | 0.054 |
| 1A3bii(fu) | NOx (as NO2) | 6'199.14 | 3'493.94 | 32 | 32 | 5.803 | 5.803 | 0.010 | 0.025 | 0.045 | 0.045 | 0.328 | 0.328 | 0.110 | 0.110 |
| 1A3biii(fu) | NOx (as NO2) | 29'630.57 | 3'029.17 | 18 | 18 | 1.368 | 1.368 | 0.048 | 0.022 | 0.039 | 0.039 | 0.870 | 0.870 | 0.758 | 0.758 |
| 1A3biv(fu) | NOx (as NO2) | 308.37 | 172.80 | 36 | 36 | 0.018 | 0.018 | 0.001 | 0.001 | 0.002 | 0.002 | 0.018 | 0.018 | 0.000 | 0.000 |
| 1A3c | NOx (as NO2) | 595.50 | 330.50 | 13 | 13 | 0.009 | 0.009 | 0.001 | 0.002 | 0.004 | 0.004 | 0.012 | 0.012 | 0.000 | 0.000 |
| 1A3dii | NOx (as NO2) | 1'054.73 | 898.19 | 13 | 13 | 0.063 | 0.063 | 0.004 | 0.006 | 0.012 | 0.012 | 0.051 | 0.051 | 0.003 | 0.003 |
| 1A3ei | NOx (as NO2) | 19.41 | 6.22 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ai | NOx (as NO2) | 5'139.32 | 2'831.98 | 16 | 16 | 0.949 | 0.949 | 0.008 | 0.020 | 0.045 | 0.045 | 0.128 | 0.128 | 0.018 | 0.018 |
| 1A4aii | NOx (as NO2) | 16.28 | 39.69 | 13 | 13 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.003 | 0.003 | 0.000 | 0.000 |
| 1A4bi | NOx (as NO2) | 11'636.07 | 3'464.39 | 14 | 14 | 1.004 | 1.004 | 0.003 | 0.025 | 0.129 | 0.129 | 0.037 | 0.037 | 0.018 | 0.018 |
| 1A4bii | NOx (as NO2) | 18.76 | 19.14 | 30 | 30 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.003 | 0.000 | 0.000 |
| 1A4ci | NOx (as NO2) | 388.54 | 379.41 | 37 | 37 | 0.089 | 0.089 | 0.002 | 0.003 | 0.081 | 0.081 | 0.053 | 0.053 | 0.009 | 0.009 |
| 1A4cii | NOx (as NO2) | 4'357.53 | 1'607.61 | 13 | 13 | 0.202 | 0.202 | 0.001 | 0.011 | 0.021 | 0.021 | 0.015 | 0.015 | 0.001 | 0.001 |
| 1A5b | NOx (as NO2) | 882.99 | 397.10 | 13 | 13 | 0.012 | 0.012 | 0.001 | 0.003 | 0.005 | 0.005 | 0.010 | 0.010 | 0.000 | 0.000 |
| 1B2c | NOx (as NO2) | 211.21 | 0.57 | 100 | 276 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.048 | 0.136 | 0.002 | 0.019 |
| 2A1 | NOx (as NO2) | 15.87 | 9.42 | 98 | 275 | 0.000 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.008 | 0.000 | 0.000 |
| 2A2 | NOx (as NO2) | 0.27 | 0.24 | 100 | 740 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 |
| 2A5a | NOx (as NO2) | 1.79 | 0.52 | 100 | 741 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2B2 | NOx (as NO2) | 82.78 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2B5 | NOx (as NO2) | 22.20 | 15.64 | 40 | 40 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.000 | 0.000 |
| 2B10a | NOx (as NO2) | 8.93 | 0.63 | 60 | 60 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| 2C1 | NOx (as NO2) | 245.46 | 131.32 | 50 | 50 | 0.020 | 0.020 | 0.000 | 0.001 | 0.003 | 0.003 | 0.018 | 0.018 | 0.000 | 0.000 |
| 2C3 | NOx (as NO2) | 17.41 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2C7c | NOx (as NO2) | NA | 1.42 | 74 | 122 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| 2G | NOx (as NO2) | 29.36 | 17.23 | 78 | 125 | 0.001 | 0.002 | 0.000 | 0.000 | 0.004 | 0.004 | 0.004 | 0.006 | 0.000 | 0.000 |
| 2H3 | NOx (as NO2) | 91.00 | 22.58 | 98 | 275 | 0.002 | 0.018 | 0.000 | 0.000 | 0.001 | 0.001 | 0.005 | 0.015 | 0.000 | 0.000 |
| 3B1a | NOx (as NO2) | 672.26 | 373.95 | 50 | 50 | 0.163 | 0.163 | 0.001 | 0.003 | 0.024 | 0.024 | 0.054 | 0.054 | 0.003 | 0.003 |
| 3B1b | NOx (as NO2) | 344.28 | 281.92 | 50 | 50 | 0.092 | 0.092 | 0.001 | 0.002 | 0.018 | 0.018 | 0.060 | 0.060 | 0.004 | 0.004 |
| 3B2 | NOx (as NO2) | 67.60 | 64.85 | 50 | 50 | 0.005 | 0.005 | 0.000 | 0.000 | 0.004 | 0.004 | 0.015 | 0.015 | 0.000 | 0.000 |
| 3B3 | NOx (as NO2) | 185.29 | 84.18 | 50 | 50 | 0.008 | 0.008 | 0.000 | 0.001 | 0.005 | 0.005 | 0.008 | 0.008 | 0.000 | 0.000 |
| 3B4d | NOx (as NO2) | 21.62 | 22.67 | 50 | 50 | 0.001 | 0.001 | 0.000 | 0.000 | 0.001 | 0.001 | 0.006 | 0.006 | 0.000 | 0.000 |
| 3B4e | NOx (as NO2) | 17.58 | 26.53 | 50 | 50 | 0.001 | 0.001 | 0.000 | 0.000 | 0.002 | 0.002 | 0.007 | 0.007 | 0.000 | 0.000 |
| 3B4f | NOx (as NO2) | 1.35 | 7.07 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.000 | 0.000 |
| 3B4gi | NOx (as NO2) | 7.19 | 9.38 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.002 | 0.000 | 0.000 |
| 3B4gii | NOx (as NO2) | 4.46 | 12.47 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.004 | 0.004 | 0.000 | 0.000 |
| 3B4giii | NOx (as NO2) | 0.44 | 0.54 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3B4giv | NOx (as NO2) | 0.84 | 1.23 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3B4h | NOx (as NO2) | 2.00 | 5.40 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.000 | 0.000 |
| 3Da1 | NOx (as NO2) | 1'205.08 | 609.12 | 100 | 100 | 1.702 | 1.702 | 0.001 | 0.004 | 0.031 | 0.031 | 0.148 | 0.148 | 0.023 | 0.023 |
| 3Da2a | NOx (as NO2) | 2'074.98 | 1'449.29 | 50 | 50 | 2.443 | 2.443 | 0.005 | 0.010 | 0.094 | 0.094 | 0.270 | 0.270 | 0.082 | 0.082 |
| 3Da2b | NOx (as NO2) | 87.01 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3Da2c | NOx (as NO2) | 14.76 | 122.27 | 102 | 102 | 0.071 | 0.071 | 0.001 | 0.001 | 0.025 | 0.025 | 0.083 | 0.083 | 0.008 | 0.008 |
| 3Da3 | NOx (as NO2) | 243.41 | 417.48 | 100 | 100 | 0.801 | 0.801 | 0.002 | 0.003 | 0.027 | 0.027 | 0.239 | 0.239 | 0.058 | 0.058 |
| 5A | NOx (as NO2) | 1.83 | 1.24 | 51 | 51 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5B2 | NOx (as NO2) | NA | 7.23 | 102 | 102 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.005 | 0.005 | 0.000 | 0.000 |
| 5C1a | NOx (as NO2) | 80.75 | 38.30 | 64 | 64 | 0.003 | 0.003 | 0.000 | 0.000 | 0.019 | 0.019 | 0.003 | 0.003 | 0.000 | 0.000 |
| 5C1bi | NOx (as NO2) | 9.75 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1biii | NOx (as NO2) | 22.50 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1biv | NOx (as NO2) | 114.00 | 42.53 | 54 | 54 | 0.002 | 0.002 | 0.000 | 0.000 | 0.009 | 0.009 | 0.002 | 0.002 | 0.000 | 0.000 |
| 5C1bv | NOx (as NO2) | 11.25 | 13.34 | 30 | 30 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.002 | 0.000 | 0.000 |
| 5C2 | NOx (as NO2) | 23.65 | 15.87 | 104 | 211 | 0.001 | 0.005 | 0.000 | 0.000 | 0.008 | 0.008 | 0.005 | 0.012 | 0.000 | 0.000 |
| 5D1 | NOx (as NO2) | 25.35 | 5.03 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5D2 | NOx (as NO2) | 0.23 | 1.13 | 14 | 14 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6A | NOx (as NO2) | 92.05 | 85.24 | 58 | 58 | 0.011 | 0.011 | 0.000 | 0.001 | 0.026 | 0.026 | 0.019 | 0.019 | 0.001 | 0.001 |
| Total | | | | | | 169.1 | 169.1 | | | | | | | 1.3 | 1.3 |
| Total | | 140'707.8 | 46'742.4 | Emissions 2023 uncertainty (%): | | 13.0 | 13.0 | | | Trend uncertainty (%): | | | | 1.1 | 1.1 |

Table A - 29 Uncertainty analysis of NMVOC emissions, approach 1, for 2023 and for the trend 1990-2023. The uncertainties are given considering a 95 % confidence interval and expressed as the distance from edge to mean, in percentage of the mean ((fu) means fuel used approach). AD: activity data; EF: emission factor; EM: emission; corr.: correlated.

| A | B | C | D | G | | H | | I | J | K | | L | | M | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFR | Pollutant | Emissions 1990 | Emissions 2023 | Emission combined uncertainty 2023 | | Category contribution to inventory variance 2023 | | Sensitivi-ty if corr. (type A) | Sensitivi-ty if not corr. (type B) | Contribution to inventory trend uncertainty from AD | | Contribution to inventory trend uncertainty from EF | | Contribution to inventory trend uncertainty from EM | |
| | | | | (-)% | (+)% | (-)% | (+)% | | | (-)% | (+)% | (-)% | (+)% | (-)% | (+)% |
| 1A1a | NMVOC | 320.80 | 187.05 | 34 | 34 | 0.008 | 0.008 | 0.000 | 0.001 | 0.009 | 0.009 | 0.012 | 0.012 | 0.000 | 0.000 |
| 1A1b | NMVOC | 6.95 | 2.99 | 20 | 20 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A1c | NMVOC | 2.13 | 6.18 | 21 | 21 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2a | NMVOC | 8.95 | 6.14 | 18 | 18 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2b | NMVOC | 53.62 | 5.52 | 19 | 19 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2c | NMVOC | 34.22 | 18.24 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2d | NMVOC | 29.90 | 3.35 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2e | NMVOC | 22.05 | 20.16 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| 1A2f | NMVOC | 596.56 | 421.87 | 30 | 30 | 0.032 | 0.032 | 0.001 | 0.001 | 0.004 | 0.004 | 0.028 | 0.028 | 0.001 | 0.001 |
| 1A2gvii | NMVOC | 1'331.50 | 256.93 | 34 | 34 | 0.015 | 0.015 | 0.000 | 0.001 | 0.002 | 0.002 | 0.007 | 0.007 | 0.000 | 0.000 |
| 1A2gviii | NMVOC | 294.30 | 116.53 | 30 | 30 | 0.002 | 0.002 | 0.000 | 0.000 | 0.001 | 0.001 | 0.005 | 0.005 | 0.000 | 0.000 |
| 1A3ai(i) | NMVOC | 247.46 | 127.04 | 50 | 50 | 0.008 | 0.008 | 0.000 | 0.000 | 0.001 | 0.001 | 0.011 | 0.011 | 0.000 | 0.000 |
| 1A3aii(i) | NMVOC | 58.81 | 30.49 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.003 | 0.000 | 0.000 |
| 1A3bi(fu) | NMVOC | 55'582.12 | 3'635.14 | 52 | 52 | 7.094 | 7.094 | 0.033 | 0.012 | 0.022 | 0.022 | 1.732 | 1.732 | 2.999 | 2.999 |
| 1A3bii(fu) | NMVOC | 4'868.98 | 131.94 | 46 | 46 | 0.007 | 0.007 | 0.004 | 0.000 | 0.001 | 0.001 | 0.162 | 0.162 | 0.026 | 0.026 |
| 1A3biii(fu) | NMVOC | 3'437.85 | 87.52 | 22 | 22 | 0.001 | 0.001 | 0.003 | 0.000 | 0.001 | 0.001 | 0.055 | 0.055 | 0.003 | 0.003 |
| 1A3biv(fu) | NMVOC | 5'736.73 | 826.68 | 100 | 599 | 1.345 | 48.222 | 0.002 | 0.003 | 0.005 | 0.005 | 0.190 | 1.136 | 0.036 | 1.291 |
| 1A3bv(fu) | NMVOC | 17'165.87 | 1'772.97 | 40 | 40 | 0.991 | 0.991 | 0.008 | 0.006 | 0.011 | 0.011 | 0.322 | 0.322 | 0.104 | 0.104 |
| 1A3c | NMVOC | 83.76 | 38.53 | 34 | 34 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.000 | 0.000 |
| 1A3dii | NMVOC | 1'640.55 | 388.66 | 34 | 34 | 0.034 | 0.034 | 0.000 | 0.001 | 0.002 | 0.002 | 0.001 | 0.001 | 0.000 | 0.000 |
| 1A3ei | NMVOC | 0.90 | 0.31 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ai | NMVOC | 1'329.00 | 873.24 | 56 | 56 | 0.471 | 0.471 | 0.002 | 0.003 | 0.007 | 0.007 | 0.105 | 0.105 | 0.011 | 0.011 |
| 1A4aii | NMVOC | 1'091.65 | 306.69 | 75 | 75 | 0.104 | 0.104 | 0.000 | 0.001 | 0.002 | 0.002 | 0.011 | 0.011 | 0.000 | 0.000 |
| 1A4bi | NMVOC | 10'056.33 | 2'346.74 | 68 | 68 | 5.026 | 5.026 | 0.000 | 0.008 | 0.042 | 0.042 | 0.019 | 0.019 | 0.002 | 0.002 |
| 1A4bii | NMVOC | 398.23 | 119.60 | 75 | 75 | 0.016 | 0.016 | 0.000 | 0.000 | 0.001 | 0.001 | 0.006 | 0.006 | 0.000 | 0.000 |
| 1A4ci | NMVOC | 235.07 | 255.12 | 78 | 78 | 0.078 | 0.078 | 0.001 | 0.001 | 0.026 | 0.026 | 0.050 | 0.050 | 0.003 | 0.003 |
| 1A4cii | NMVOC | 4'369.08 | 792.31 | 75 | 75 | 0.695 | 0.695 | 0.001 | 0.003 | 0.005 | 0.005 | 0.067 | 0.067 | 0.005 | 0.005 |
| 1A5b | NMVOC | 160.25 | 63.97 | 34 | 34 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.003 | 0.000 | 0.000 |
| 1B2ai | NMVOC | 0.02 | 0.01 | 58 | 58 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1B2aiv | NMVOC | 1'344.61 | 215.10 | 56 | 56 | 0.028 | 0.028 | 0.000 | 0.001 | 0.031 | 0.031 | 0.018 | 0.018 | 0.001 | 0.001 |
| 1B2av | NMVOC | 19'127.24 | 2'021.04 | 36 | 44 | 1.038 | 1.542 | 0.009 | 0.007 | 0.012 | 0.012 | 0.317 | 0.386 | 0.100 | 0.149 |
| 1B2b | NMVOC | 323.52 | 175.86 | 55 | 55 | 0.018 | 0.018 | 0.000 | 0.001 | 0.019 | 0.019 | 0.017 | 0.017 | 0.001 | 0.001 |
| 1B2c | NMVOC | 13.72 | 0.03 | 77 | 124 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| 2A1 | NMVOC | 41.25 | 24.49 | 98 | 275 | 0.001 | 0.009 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.014 | 0.000 | 0.000 |
| 2A2 | NMVOC | 0.69 | 0.63 | 100 | 740 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 |
| 2A5a | NMVOC | 4.59 | 1.34 | 100 | 741 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 |
| 2B10a | NMVOC | 608.61 | 15.18 | 40 | 40 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.018 | 0.018 | 0.000 | 0.000 |
| 2C1 | NMVOC | 1'053.60 | 187.83 | 74 | 122 | 0.038 | 0.103 | 0.000 | 0.001 | 0.002 | 0.002 | 0.017 | 0.028 | 0.000 | 0.001 |
| 2C3 | NMVOC | 56.57 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2C7a | NMVOC | 2.98 | 0.26 | 98 | 275 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2C7c | NMVOC | NA | 0.46 | 74 | 122 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2D3a | NMVOC | 8'866.55 | 6'506.75 | 50 | 50 | 20.834 | 20.834 | 0.015 | 0.022 | 0.031 | 0.031 | 1.560 | 1.560 | 2.434 | 2.434 |
| 2D3b | NMVOC | 4'895.00 | 2'700.00 | 74 | 122 | 7.826 | 21.384 | 0.005 | 0.009 | 0.065 | 0.065 | 0.379 | 0.627 | 0.148 | 0.398 |
| 2D3c | NMVOC | 2'430.00 | 365.45 | 76 | 124 | 0.153 | 0.402 | 0.001 | 0.001 | 0.035 | 0.035 | 0.055 | 0.092 | 0.004 | 0.010 |
| 2D3d | NMVOC | 40'731.00 | 8'285.92 | 45 | 45 | 27.018 | 27.018 | 0.005 | 0.028 | 0.795 | 0.795 | 0.211 | 0.211 | 0.676 | 0.676 |
| 2D3e | NMVOC | 11'731.23 | 1'566.25 | 64 | 64 | 1.979 | 1.979 | 0.004 | 0.005 | 0.300 | 0.300 | 0.215 | 0.215 | 0.136 | 0.136 |
| 2D3f | NMVOC | 910.00 | 60.60 | 45 | 45 | 0.001 | 0.001 | 0.001 | 0.000 | 0.006 | 0.006 | 0.022 | 0.022 | 0.001 | 0.001 |
| 2D3g | NMVOC | 27'503.97 | 3'184.68 | 80 | 126 | 12.634 | 31.496 | 0.012 | 0.011 | 0.458 | 0.458 | 0.864 | 1.431 | 0.957 | 2.257 |
| 2D3h | NMVOC | 20'353.80 | 3'617.41 | 45 | 45 | 5.150 | 5.150 | 0.004 | 0.012 | 0.347 | 0.347 | 0.176 | 0.176 | 0.151 | 0.151 |
| 2D3i | NMVOC | 5'470.21 | 1'932.86 | 100 | 245 | 7.416 | 44.128 | 0.002 | 0.007 | 0.278 | 0.278 | 0.198 | 0.503 | 0.117 | 0.331 |
| 2G | NMVOC | 22'431.61 | 6'315.50 | 101 | 277 | 79.935 | 599.996 | 0.003 | 0.021 | 0.757 | 0.757 | 0.296 | 0.834 | 0.661 | 1.268 |
| 2H1 | NMVOC | 554.99 | 181.31 | 102 | 277 | 0.068 | 0.496 | 0.000 | 0.001 | 0.026 | 0.026 | 0.016 | 0.044 | 0.001 | 0.003 |
| 2H2 | NMVOC | 1'413.07 | 1'416.69 | 74 | 122 | 2.184 | 5.917 | 0.004 | 0.005 | 0.068 | 0.068 | 0.269 | 0.445 | 0.077 | 0.202 |
| 2H3 | NMVOC | 156.00 | 38.70 | 98 | 275 | 0.003 | 0.022 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.001 | 0.000 | 0.000 |
| 3B1a | NMVOC | 6'412.83 | 6'584.61 | 60 | 60 | 31.065 | 31.065 | 0.017 | 0.022 | 0.203 | 0.203 | 1.024 | 1.024 | 1.090 | 1.090 |
| 3B1b | NMVOC | 5'121.56 | 7'441.23 | 70 | 70 | 53.838 | 53.838 | 0.021 | 0.025 | 0.230 | 0.230 | 1.472 | 1.472 | 2.219 | 2.219 |
| 3B2 | NMVOC | 66.79 | 69.04 | 98 | 275 | 0.009 | 0.071 | 0.000 | 0.000 | 0.002 | 0.002 | 0.018 | 0.049 | 0.000 | 0.002 |
| 3B3 | NMVOC | 1'126.15 | 770.22 | 98 | 275 | 1.121 | 8.856 | 0.002 | 0.003 | 0.024 | 0.024 | 0.165 | 0.465 | 0.028 | 0.217 |
| 3B4d | NMVOC | 37.02 | 49.60 | 98 | 275 | 0.005 | 0.037 | 0.000 | 0.000 | 0.002 | 0.002 | 0.013 | 0.038 | 0.000 | 0.001 |
| 3B4e | NMVOC | 120.39 | 205.58 | 98 | 275 | 0.080 | 0.631 | 0.001 | 0.001 | 0.006 | 0.006 | 0.059 | 0.165 | 0.003 | 0.027 |
| 3B4f | NMVOC | 8.64 | 49.21 | 98 | 275 | 0.005 | 0.036 | 0.000 | 0.000 | 0.002 | 0.002 | 0.016 | 0.044 | 0.000 | 0.002 |
| 3B4gi | NMVOC | 508.70 | 633.80 | 98 | 275 | 0.759 | 5.997 | 0.002 | 0.002 | 0.020 | 0.020 | 0.169 | 0.477 | 0.029 | 0.228 |
| 3B4gii | NMVOC | 366.34 | 1'144.35 | 98 | 275 | 2.474 | 19.549 | 0.004 | 0.004 | 0.035 | 0.035 | 0.350 | 0.986 | 0.124 | 0.973 |
| 3B4giii | NMVOC | 46.28 | 59.07 | 98 | 275 | 0.007 | 0.052 | 0.000 | 0.000 | 0.002 | 0.002 | 0.016 | 0.045 | 0.000 | 0.002 |
| 3B4giv | NMVOC | 129.27 | 215.88 | 98 | 275 | 0.088 | 0.696 | 0.001 | 0.001 | 0.007 | 0.007 | 0.061 | 0.172 | 0.004 | 0.030 |
| 3B4h | NMVOC | 3.60 | 4.37 | 98 | 275 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.003 | 0.000 | 0.000 |
| 3De | NMVOC | 481.06 | 453.28 | 98 | 275 | 0.388 | 3.066 | 0.001 | 0.002 | 0.011 | 0.011 | 0.112 | 0.315 | 0.013 | 0.099 |
| 5A | NMVOC | 405.68 | 123.02 | 51 | 51 | 0.008 | 0.008 | 0.000 | 0.000 | 0.006 | 0.006 | 0.004 | 0.004 | 0.000 | 0.000 |
| 5B1 | NMVOC | 105.05 | 175.20 | 102 | 102 | 0.063 | 0.063 | 0.001 | 0.001 | 0.017 | 0.017 | 0.051 | 0.051 | 0.003 | 0.003 |
| 5B2 | NMVOC | 49.57 | 1'146.82 | 36 | 36 | 0.336 | 0.336 | 0.004 | 0.004 | 0.110 | 0.110 | 0.115 | 0.115 | 0.025 | 0.025 |
| 5C1a | NMVOC | 516.80 | 245.09 | 71 | 71 | 0.059 | 0.059 | 0.000 | 0.001 | 0.059 | 0.059 | 0.020 | 0.020 | 0.004 | 0.004 |
| 5C1bi | NMVOC | 3.75 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1biii | NMVOC | 4.50 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1biv | NMVOC | 0.46 | 20.09 | 28 | 28 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.001 | 0.001 | 0.000 | 0.000 |
| 5C1bv | NMVOC | 1.20 | 0.37 | 30 | 30 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C2 | NMVOC | 25.19 | 16.91 | 104 | 211 | 0.001 | 0.003 | 0.000 | 0.000 | 0.004 | 0.004 | 0.003 | 0.008 | 0.000 | 0.000 |
| 5D1 | NMVOC | 0.51 | 0.10 | 27 | 27 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5D2 | NMVOC | 0.00 | 0.02 | 22 | 22 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5E | NMVOC | 28.00 | 60.00 | 31 | 31 | 0.001 | 0.001 | 0.000 | 0.000 | 0.006 | 0.006 | 0.004 | 0.004 | 0.000 | 0.000 |
| 6A | NMVOC | 202.98 | 166.12 | 58 | 58 | 0.018 | 0.018 | 0.000 | 0.001 | 0.024 | 0.024 | 0.020 | 0.020 | 0.001 | 0.001 |
| Total | | | | | | 272.6 | 947.7 | | | | | | | 12.2 | 17.4 |
| Total | | 294'960.8 | 71'290.2 | Emissions 2023 uncertainty (%): | | 16.5 | 30.8 | | | Trend uncertainty (%): | | | | 3.5 | 4.2 |

Table A - 30 Uncertainty analysis of $SO_x$ emissions, approach 1, for 2023 and for the trend 1990-2023. The uncertainties are given considering a 95 % confidence interval and expressed as the distance from edge to mean, in percentage of the mean ((fu) means fuel used approach). AD: activity data; EF: emission factor; EM: emission; corr.: correlated.

| A | B | C | D | G | | H | | I | J | K | | L | | M | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFR | Pollutant | Emissions 1990 | Emissions 2023 | Emission combined uncertainty 2023 | | Category contribution to inventory variance 2023 | | Sensitivi-ty if corr. (type A) | Sensitivi-ty if not corr. (type B) | Contribution to inventory trend uncertainty from AD | | Contribution to inventory trend uncertainty from EF | | Contribution to inventory trend uncertainty from EM | |
| | | | | (-)% | (+)% | (-)% | (+)% | | | (-)% | (+)% | (-)% | (+)% | (-)% | (+)% |
| 1A1a | SOx (as SO2) | 3'679.11 | 255.94 | 24 | 24 | 4.780 | 4.780 | 0.000 | 0.007 | 0.092 | 0.092 | 0.005 | 0.005 | 0.009 | 0.009 |
| 1A1b | SOx (as SO2) | 660.41 | 58.83 | 20 | 20 | 0.174 | 0.174 | 0.000 | 0.002 | 0.003 | 0.003 | 0.006 | 0.006 | 0.000 | 0.000 |
| 1A2a | SOx (as SO2) | 362.55 | 9.25 | 15 | 15 | 0.002 | 0.002 | 0.000 | 0.000 | 0.001 | 0.001 | 0.006 | 0.006 | 0.000 | 0.000 |
| 1A2b | SOx (as SO2) | 67.34 | 0.45 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| 1A2c | SOx (as SO2) | 1'187.10 | 62.95 | 11 | 11 | 0.062 | 0.062 | 0.001 | 0.002 | 0.005 | 0.005 | 0.006 | 0.006 | 0.000 | 0.000 |
| 1A2d | SOx (as SO2) | 3'238.01 | 0.56 | 14 | 14 | 0.000 | 0.000 | 0.006 | 0.000 | 0.000 | 0.000 | 0.083 | 0.083 | 0.007 | 0.007 |
| 1A2e | SOx (as SO2) | 1'077.50 | 3.75 | 12 | 12 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 | 0.023 | 0.023 | 0.001 | 0.001 |
| 1A2f | SOx (as SO2) | 3'530.25 | 1'299.67 | 19 | 19 | 77.035 | 77.035 | 0.027 | 0.033 | 0.094 | 0.094 | 0.506 | 0.506 | 0.265 | 0.265 |
| 1A2gvii | SOx (as SO2) | 370.66 | 2.67 | 10 | 10 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.006 | 0.006 | 0.000 | 0.000 |
| 1A2gviii | SOx (as SO2) | 3'533.86 | 260.22 | 19 | 19 | 3.090 | 3.090 | 0.000 | 0.007 | 0.019 | 0.019 | 0.002 | 0.002 | 0.000 | 0.000 |
| 1A3ai(i) | SOx (as SO2) | 99.68 | 137.22 | 10 | 10 | 0.239 | 0.239 | 0.003 | 0.004 | 0.006 | 0.006 | 0.033 | 0.033 | 0.001 | 0.001 |
| 1A3aii(i) | SOx (as SO2) | 24.94 | 4.65 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| 1A3bi(fu) | SOx (as SO2) | 1'618.97 | 34.55 | 10 | 10 | 0.015 | 0.015 | 0.002 | 0.001 | 0.002 | 0.002 | 0.021 | 0.021 | 0.000 | 0.000 |
| 1A3bii(fu) | SOx (as SO2) | 292.93 | 4.86 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.004 | 0.000 | 0.000 |
| 1A3biii(fu) | SOx (as SO2) | 1'842.88 | 8.70 | 10 | 10 | 0.001 | 0.001 | 0.003 | 0.000 | 0.000 | 0.000 | 0.032 | 0.032 | 0.001 | 0.001 |
| 1A3biv(fu) | SOx (as SO2) | 25.47 | 0.52 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A3c | SOx (as SO2) | 26.92 | 0.12 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A3dii | SOx (as SO2) | 64.88 | 0.49 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| 1A3ei | SOx (as SO2) | 0.28 | 0.05 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ai | SOx (as SO2) | 3'869.92 | 83.11 | 10 | 10 | 0.088 | 0.088 | 0.005 | 0.002 | 0.005 | 0.005 | 0.050 | 0.050 | 0.003 | 0.003 |
| 1A4aii | SOx (as SO2) | 1.61 | 0.05 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4bi | SOx (as SO2) | 10'354.85 | 207.08 | 11 | 11 | 0.610 | 0.610 | 0.014 | 0.005 | 0.028 | 0.028 | 0.138 | 0.138 | 0.020 | 0.020 |
| 1A4bii | SOx (as SO2) | 1.20 | 0.03 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ci | SOx (as SO2) | 335.80 | 51.09 | 28 | 28 | 0.252 | 0.252 | 0.001 | 0.001 | 0.039 | 0.039 | 0.012 | 0.012 | 0.002 | 0.002 |
| 1A4cii | SOx (as SO2) | 304.60 | 1.60 | 10 | 10 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.005 | 0.005 | 0.000 | 0.000 |
| 1A5b | SOx (as SO2) | 78.17 | 33.02 | 10 | 10 | 0.014 | 0.014 | 0.001 | 0.001 | 0.002 | 0.002 | 0.007 | 0.007 | 0.000 | 0.000 |
| 1B2aiv | SOx (as SO2) | 419.02 | 14.34 | 56 | 56 | 0.080 | 0.080 | 0.000 | 0.000 | 0.016 | 0.016 | 0.019 | 0.019 | 0.001 | 0.001 |
| 1B2c | SOx (as SO2) | 300.98 | 0.83 | 38 | 38 | 0.000 | 0.000 | 0.001 | 0.000 | 0.001 | 0.001 | 0.017 | 0.017 | 0.000 | 0.000 |
| 2A1 | SOx (as SO2) | 0.69 | 0.41 | 98 | 275 | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.003 | 0.000 | 0.000 |
| 2A2 | SOx (as SO2) | 0.01 | 0.01 | 100 | 740 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2A5a | SOx (as SO2) | 0.08 | 0.02 | 100 | 741 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2B5 | SOx (as SO2) | 625.20 | 197.85 | 20 | 20 | 1.976 | 1.976 | 0.004 | 0.005 | 0.014 | 0.014 | 0.078 | 0.078 | 0.006 | 0.006 |
| 2B10a | SOx (as SO2) | 168.00 | 40.01 | 40 | 40 | 0.321 | 0.321 | 0.001 | 0.001 | 0.003 | 0.003 | 0.028 | 0.028 | 0.001 | 0.001 |
| 2C1 | SOx (as SO2) | 144.04 | 13.11 | 74 | 122 | 0.117 | 0.320 | 0.000 | 0.000 | 0.001 | 0.001 | 0.005 | 0.008 | 0.000 | 0.000 |
| 2C3 | SOx (as SO2) | 696.30 | NO | NO | NO | NO | NO | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2C7c | SOx (as SO2) | NA | 0.02 | 74 | 122 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2G | SOx (as SO2) | 3.44 | 3.27 | 78 | 125 | 0.008 | 0.021 | 0.000 | 0.000 | 0.003 | 0.003 | 0.006 | 0.009 | 0.000 | 0.000 |
| 2H3 | SOx (as SO2) | 1.30 | 0.32 | 98 | 275 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.000 | 0.000 |
| 5B2 | SOx (as SO2) | NA | 1.09 | 102 | 102 | 0.002 | 0.002 | 0.000 | 0.000 | 0.001 | 0.001 | 0.003 | 0.003 | 0.000 | 0.000 |
| 5C1a | SOx (as SO2) | 24.23 | 11.49 | 64 | 64 | 0.068 | 0.068 | 0.000 | 0.000 | 0.021 | 0.021 | 0.010 | 0.010 | 0.001 | 0.001 |
| 5C1bi | SOx (as SO2) | 45.00 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1biii | SOx (as SO2) | 19.50 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1biv | SOx (as SO2) | 74.10 | 17.22 | 36 | 36 | 0.048 | 0.048 | 0.000 | 0.000 | 0.012 | 0.012 | 0.009 | 0.009 | 0.000 | 0.000 |
| 5C2 | SOx (as SO2) | 0.51 | 0.35 | 99 | 177 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 |
| 5D1 | SOx (as SO2) | 0.13 | 0.03 | 37 | 37 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5D2 | SOx (as SO2) | 0.00 | 0.01 | 22 | 22 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6A | SOx (as SO2) | 9.17 | 7.20 | 58 | 58 | 0.022 | 0.022 | 0.000 | 0.000 | 0.008 | 0.008 | 0.008 | 0.008 | 0.000 | 0.000 |
| Total | | | | | | 89.0 | 89.2 | | | | | | | 0.3 | 0.3 |
| Total | | 39'181.6 | 2'829.0 | Emissions 2023 uncertainty (%): | | 9.4 | 9.4 | | | Trend uncertainty (%): | | | | 0.6 | 0.6 |

Table A - 31 Uncertainty analysis of $NH_3$ emissions, approach 1, for 2023 and for the trend 1990-2023. The uncertainties are given considering a 95 % confidence interval and expressed as the distance from edge to mean, in percentage of the mean ((fu) means fuel used approach). AD: activity data; EF: emission factor; EM: emission; corr.: correlated.

| A | B | C | D | G | | H | | I | J | K | | L | | M | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFR | Pollutant | Emissions 1990 | Emissions 2023 | Emission combined uncertainty 2023 | | Category contribution to inventory variance 2023 | | Sensitivi-ty if corr. (type A) | Sensitivi-ty if not corr. (type B) | Contribution to inventory trend uncertainty from AD | | Contribution to inventory trend uncertainty from EF | | Contribution to inventory trend uncertainty from EM | |
| | | | | (-)% | (+)% | (-)% | (+)% | | | (-)% | (+)% | (-)% | (+)% | (-)% | (+)% |
| 1A1a | NH3 | 4.85 | 42.37 | 22 | 22 | 0.000 | 0.000 | 0.001 | 0.001 | 0.009 | 0.009 | 0.011 | 0.011 | 0.000 | 0.000 |
| 1A1b | NH3 | 0.01 | 0.01 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2a | NH3 | 0.00 | 0.00 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2b | NH3 | 0.11 | 0.00 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2c | NH3 | 0.02 | 0.01 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2d | NH3 | 0.02 | 0.00 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2e | NH3 | 0.02 | 0.01 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2f | NH3 | 147.02 | 168.44 | 9 | 9 | 0.001 | 0.001 | 0.001 | 0.002 | 0.007 | 0.007 | 0.007 | 0.007 | 0.000 | 0.000 |
| 1A2gvii | NH3 | 1.00 | 1.55 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| 1A2gviii | NH3 | 17.00 | 39.15 | 9 | 9 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.002 | 0.003 | 0.003 | 0.000 | 0.000 |
| 1A3bi(fu) | NH3 | 1'324.97 | 826.10 | 50 | 50 | 0.610 | 0.610 | 0.003 | 0.012 | 0.022 | 0.022 | 0.144 | 0.144 | 0.021 | 0.021 |
| 1A3bii(fu) | NH3 | 8.57 | 35.60 | 50 | 50 | 0.001 | 0.001 | 0.000 | 0.001 | 0.001 | 0.001 | 0.021 | 0.021 | 0.000 | 0.000 |
| 1A3biii(fu) | NH3 | 4.55 | 33.03 | 50 | 50 | 0.001 | 0.001 | 0.000 | 0.000 | 0.001 | 0.001 | 0.022 | 0.022 | 0.000 | 0.000 |
| 1A3biv(fu) | NH3 | 3.26 | 3.48 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| 1A3c | NH3 | 0.07 | 0.07 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A3dii | NH3 | 0.20 | 0.21 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ai | NH3 | 19.80 | 37.71 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.003 | 0.003 | 0.000 | 0.000 |
| 1A4aii | NH3 | 0.01 | 0.02 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4bi | NH3 | 153.12 | 55.96 | 11 | 11 | 0.000 | 0.000 | 0.001 | 0.001 | 0.004 | 0.004 | 0.009 | 0.009 | 0.000 | 0.000 |
| 1A4bii | NH3 | 0.01 | 0.01 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ci | NH3 | 2.88 | 8.44 | 23 | 23 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.004 | 0.001 | 0.001 | 0.000 | 0.000 |
| 1A4cii | NH3 | 0.76 | 0.82 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A5b | NH3 | 0.04 | 0.04 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2B1 | NH3 | 0.07 | 0.01 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2B2 | NH3 | 0.73 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2B10a | NH3 | 7.73 | NA | NA | NA | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2C1 | NH3 | 11.90 | 1.51 | 98 | 275 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.011 | 0.031 | 0.000 | 0.001 |
| 2C7c | NH3 | 9.19 | 8.16 | 100 | 741 | 0.000 | 0.013 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.011 | 0.000 | 0.000 |
| 2G | NH3 | 203.15 | 67.89 | 47 | 47 | 0.004 | 0.004 | 0.001 | 0.001 | 0.035 | 0.035 | 0.052 | 0.052 | 0.004 | 0.004 |
| 2H2 | NH3 | 132.33 | 49.36 | 100 | 741 | 0.009 | 0.478 | 0.001 | 0.001 | 0.010 | 0.010 | 0.077 | 0.571 | 0.006 | 0.326 |
| 2H3 | NH3 | 1.04 | 0.26 | 98 | 275 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.000 | 0.000 |
| 2L | NH3 | 2.38 | 3.69 | 103 | 103 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.003 | 0.003 | 0.000 | 0.000 |
| 3B1a | NH3 | 9'337.10 | 10'144.27 | 30 | 30 | 32.458 | 32.458 | 0.043 | 0.148 | 1.349 | 1.349 | 1.240 | 1.240 | 3.358 | 3.358 |
| 3B1b | NH3 | 5'190.92 | 7'241.49 | 28 | 28 | 14.441 | 14.441 | 0.047 | 0.106 | 0.963 | 0.963 | 1.273 | 1.273 | 2.549 | 2.549 |
| 3B2 | NH3 | 509.75 | 483.81 | 87 | 87 | 0.637 | 0.637 | 0.001 | 0.007 | 0.064 | 0.064 | 0.114 | 0.114 | 0.017 | 0.017 |
| 3B3 | NH3 | 6'965.04 | 4'735.68 | 41 | 41 | 13.157 | 13.157 | 0.009 | 0.069 | 0.630 | 0.630 | 0.375 | 0.375 | 0.537 | 0.537 |
| 3B4d | NH3 | 158.13 | 160.07 | 65 | 65 | 0.039 | 0.039 | 0.001 | 0.002 | 0.021 | 0.021 | 0.036 | 0.036 | 0.002 | 0.002 |
| 3B4e | NH3 | 256.31 | 393.78 | 52 | 52 | 0.152 | 0.152 | 0.003 | 0.006 | 0.052 | 0.052 | 0.149 | 0.149 | 0.025 | 0.025 |
| 3B4f | NH3 | 19.65 | 101.49 | 68 | 68 | 0.017 | 0.017 | 0.001 | 0.001 | 0.013 | 0.013 | 0.086 | 0.086 | 0.008 | 0.008 |
| 3B4gi | NH3 | 978.79 | 673.74 | 82 | 82 | 1.098 | 1.098 | 0.001 | 0.010 | 0.090 | 0.090 | 0.098 | 0.098 | 0.018 | 0.018 |
| 3B4gii | NH3 | 304.87 | 680.42 | 86 | 86 | 1.231 | 1.231 | 0.006 | 0.010 | 0.090 | 0.090 | 0.559 | 0.559 | 0.320 | 0.320 |
| 3B4giii | NH3 | 29.77 | 31.69 | 93 | 93 | 0.003 | 0.003 | 0.000 | 0.000 | 0.004 | 0.004 | 0.012 | 0.012 | 0.000 | 0.000 |
| 3B4giv | NH3 | 124.46 | 90.55 | 85 | 85 | 0.021 | 0.021 | 0.000 | 0.001 | 0.012 | 0.012 | 0.007 | 0.007 | 0.000 | 0.000 |
| 3B4h | NH3 | 14.55 | 42.62 | 50 | 50 | 0.002 | 0.002 | 0.000 | 0.001 | 0.006 | 0.006 | 0.023 | 0.023 | 0.001 | 0.001 |
| 3Da1 | NH3 | 4'258.83 | 2'250.67 | 50 | 50 | 4.571 | 4.571 | 0.015 | 0.033 | 0.232 | 0.232 | 0.758 | 0.758 | 0.628 | 0.628 |
| 3Da2a | NH3 | 34'567.08 | 20'191.26 | 22 | 22 | 70.303 | 70.303 | 0.094 | 0.295 | 2.685 | 2.685 | 1.984 | 1.984 | 11.146 | 11.146 |
| 3Da2b | NH3 | 1'169.36 | NO | NO | NO | NO | NO | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3Da2c | NH3 | 34.00 | 1'042.45 | 54 | 54 | 1.126 | 1.126 | 0.015 | 0.015 | 0.430 | 0.430 | 0.742 | 0.742 | 0.736 | 0.736 |
| 3Da3 | NH3 | 760.92 | 1'413.21 | 62 | 62 | 2.773 | 2.773 | 0.012 | 0.021 | 0.188 | 0.188 | 0.747 | 0.747 | 0.594 | 0.594 |
| 5A | NH3 | 615.79 | 186.65 | 51 | 51 | 0.032 | 0.032 | 0.004 | 0.003 | 0.039 | 0.039 | 0.211 | 0.211 | 0.046 | 0.046 |
| 5B1 | NH3 | 175.08 | 292.01 | 102 | 102 | 0.317 | 0.317 | 0.002 | 0.004 | 0.121 | 0.121 | 0.229 | 0.229 | 0.067 | 0.067 |
| 5B2 | NH3 | 10.28 | 245.32 | 78 | 78 | 0.130 | 0.130 | 0.003 | 0.004 | 0.101 | 0.101 | 0.260 | 0.260 | 0.078 | 0.078 |
| 5C1biv | NH3 | 5.70 | 2.02 | 54 | 54 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.002 | 0.000 | 0.000 |
| 5C2 | NH3 | 13.71 | 9.20 | 54 | 54 | 0.000 | 0.000 | 0.000 | 0.000 | 0.009 | 0.009 | 0.001 | 0.001 | 0.000 | 0.000 |
| 5D1 | NH3 | 89.98 | 128.83 | 50 | 50 | 0.015 | 0.015 | 0.001 | 0.002 | 0.003 | 0.003 | 0.043 | 0.043 | 0.002 | 0.002 |
| 6A | NH3 | 845.56 | 969.88 | 104 | 104 | 3.665 | 3.665 | 0.005 | 0.014 | 0.601 | 0.601 | 0.463 | 0.463 | 0.575 | 0.575 |
| Total | | | | | | 146.8 | 147.3 | | | | | | | 20.7 | 21.1 |
| Total | | 68'492.4 | 52'895.0 | Emissions 2023 uncertainty (%): | | 12.1 | 12.1 | | | Trend uncertainty (%): | | | | 4.6 | 4.6 |

Table A - 32 Uncertainty analysis of PM2.5 emissions, approach 1, for 2023 and for the trend 1990-2023. The uncertainties are given considering a 95 % confidence interval and expressed as the distance from edge to mean, in percentage of the mean ((fu) means fuel used approach). AD: activity data; EF: emission factor; EM: emission; corr.: correlated.

| A | B | C | D | G | | H | | I | J | K | | L | | M | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFR | Pollutant | Emissions 1990 | Emissions 2023 | Emission combined uncertainty 2023 | | Category contribution to inventory variance 2023 | | Sensitivi-ty if corr. (type A) | Sensitivi-ty if not corr. (type B) | Contribution to inventory trend uncertainty from AD | | Contribution to inventory trend uncertainty from EF | | Contribution to inventory trend uncertainty from EM | |
| | | | | (-)% | (+)% | (-)% | (+)% | | | (-)% | (+)% | (-)% | (+)% | (-)% | (+)% |
| 1A1a | PM2.5 | 781.83 | 46.09 | 72 | 72 | 0.282 | 0.282 | 0.005 | 0.002 | 0.024 | 0.024 | 0.347 | 0.347 | 0.121 | 0.121 |
| 1A1b | PM2.5 | 47.66 | 1.50 | 20 | 20 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.007 | 0.007 | 0.000 | 0.000 |
| 1A1c | PM2.5 | 4.64 | 13.44 | 21 | 21 | 0.002 | 0.002 | 0.000 | 0.000 | 0.003 | 0.003 | 0.009 | 0.009 | 0.000 | 0.000 |
| 1A2a | PM2.5 | 14.81 | 2.34 | 28 | 28 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| 1A2b | PM2.5 | 20.39 | 1.00 | 30 | 30 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.004 | 0.000 | 0.000 |
| 1A2c | PM2.5 | 40.77 | 5.17 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 | 0.002 | 0.000 | 0.000 |
| 1A2d | PM2.5 | 149.62 | 0.18 | 33 | 33 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.041 | 0.041 | 0.002 | 0.002 |
| 1A2e | PM2.5 | 25.68 | 1.11 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.000 | 0.000 |
| 1A2f | PM2.5 | 437.58 | 40.13 | 65 | 65 | 0.176 | 0.176 | 0.002 | 0.001 | 0.004 | 0.004 | 0.144 | 0.144 | 0.021 | 0.021 |
| 1A2gvii | PM2.5 | 728.86 | 384.17 | 50 | 50 | 9.531 | 9.531 | 0.008 | 0.014 | 0.026 | 0.026 | 0.400 | 0.400 | 0.160 | 0.160 |
| 1A2gviii | PM2.5 | 872.51 | 186.20 | 65 | 65 | 3.785 | 3.785 | 0.001 | 0.007 | 0.020 | 0.020 | 0.033 | 0.033 | 0.001 | 0.001 |
| 1A3ai(i) | PM2.5 | 92.39 | 14.12 | 30 | 30 | 0.005 | 0.005 | 0.000 | 0.001 | 0.001 | 0.001 | 0.008 | 0.008 | 0.000 | 0.000 |
| 1A3aii(i) | PM2.5 | 22.67 | 1.69 | 30 | 30 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.004 | 0.000 | 0.000 |
| 1A3bi(fu) | PM2.5 | 579.17 | 98.62 | 57 | 57 | 0.826 | 0.826 | 0.001 | 0.004 | 0.007 | 0.007 | 0.072 | 0.072 | 0.005 | 0.005 |
| 1A3bii(fu) | PM2.5 | 329.00 | 48.06 | 48 | 48 | 0.139 | 0.139 | 0.001 | 0.002 | 0.003 | 0.003 | 0.049 | 0.049 | 0.002 | 0.002 |
| 1A3biii(fu) | PM2.5 | 1'584.33 | 36.16 | 27 | 27 | 0.025 | 0.025 | 0.012 | 0.001 | 0.002 | 0.002 | 0.324 | 0.324 | 0.105 | 0.105 |
| 1A3biv(fu) | PM2.5 | 209.02 | 57.14 | 54 | 54 | 0.246 | 0.246 | 0.000 | 0.002 | 0.004 | 0.004 | 0.018 | 0.018 | 0.000 | 0.000 |
| 1A3bvi(fu) | PM2.5 | 689.50 | 958.18 | 50 | 50 | 59.290 | 59.290 | 0.029 | 0.035 | 0.064 | 0.064 | 1.472 | 1.472 | 2.171 | 2.171 |
| 1A3c | PM2.5 | 172.71 | 232.99 | 50 | 50 | 3.506 | 3.506 | 0.007 | 0.009 | 0.016 | 0.016 | 0.356 | 0.356 | 0.127 | 0.127 |
| 1A3dii | PM2.5 | 59.09 | 21.94 | 50 | 50 | 0.031 | 0.031 | 0.000 | 0.001 | 0.001 | 0.001 | 0.015 | 0.015 | 0.000 | 0.000 |
| 1A3ei | PM2.5 | 0.11 | 0.04 | 27 | 27 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ai | PM2.5 | 1'354.47 | 429.98 | 78 | 78 | 29.048 | 29.048 | 0.004 | 0.016 | 0.035 | 0.035 | 0.344 | 0.344 | 0.119 | 0.119 |
| 1A4bi | PM2.5 | 14'535.91 | 1'851.74 | 76 | 76 | 512.485 | 512.485 | 0.054 | 0.068 | 0.358 | 0.358 | 4.112 | 4.112 | 17.033 | 17.033 |
| 1A4ci | PM2.5 | 696.98 | 204.88 | 44 | 44 | 2.136 | 2.136 | 0.002 | 0.008 | 0.226 | 0.226 | 0.065 | 0.065 | 0.055 | 0.055 |
| 1A4cii | PM2.5 | 435.10 | 127.76 | 80 | 80 | 2.698 | 2.698 | 0.001 | 0.005 | 0.009 | 0.009 | 0.083 | 0.083 | 0.007 | 0.007 |
| 1A5b | PM2.5 | 86.95 | 44.87 | 50 | 50 | 0.130 | 0.130 | 0.001 | 0.002 | 0.003 | 0.003 | 0.046 | 0.046 | 0.002 | 0.002 |
| 1B1a | PM2.5 | 0.16 | 0.04 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1B2c | PM2.5 | 0.44 | 0.00 | 102 | 337 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 |
| 2A1 | PM2.5 | 240.48 | 142.77 | 98 | 275 | 5.032 | 39.899 | 0.003 | 0.005 | 0.015 | 0.015 | 0.315 | 0.889 | 0.100 | 0.790 |
| 2A2 | PM2.5 | 7.21 | 6.60 | 100 | 740 | 0.011 | 0.617 | 0.000 | 0.000 | 0.001 | 0.001 | 0.018 | 0.135 | 0.000 | 0.018 |
| 2A5a | PM2.5 | 102.21 | 97.86 | 100 | 741 | 2.478 | 135.560 | 0.003 | 0.004 | 0.025 | 0.025 | 0.274 | 2.029 | 0.076 | 4.117 |
| 2B5 | PM2.5 | 61.20 | 39.43 | 74 | 122 | 0.218 | 0.598 | 0.001 | 0.001 | 0.004 | 0.004 | 0.069 | 0.114 | 0.005 | 0.013 |
| 2B10a | PM2.5 | 7.86 | NA | NA | NA | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2C1 | PM2.5 | 817.90 | 6.81 | 84 | 158 | 0.008 | 0.030 | 0.007 | 0.000 | 0.001 | 0.001 | 0.556 | 1.051 | 0.309 | 1.104 |
| 2C3 | PM2.5 | 78.33 | NO | NO | NO | NO | NO | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2C7a | PM2.5 | 5.66 | 0.50 | 98 | 275 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.008 | 0.000 | 0.000 |
| 2C7c | PM2.5 | 1.53 | 1.40 | 100 | 741 | 0.001 | 0.028 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.029 | 0.000 | 0.001 |
| 2D3c | PM2.5 | 4.00 | 3.81 | 100 | 276 | 0.004 | 0.029 | 0.000 | 0.000 | 0.004 | 0.004 | 0.010 | 0.029 | 0.000 | 0.001 |
| 2D3i | PM2.5 | 12.00 | NA | NA | NA | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2G | PM2.5 | 512.78 | 327.02 | 78 | 125 | 16.718 | 42.810 | 0.008 | 0.012 | 0.425 | 0.425 | 0.568 | 0.941 | 0.504 | 1.066 |
| 2H1 | PM2.5 | 235.77 | 150.91 | 102 | 277 | 6.149 | 45.105 | 0.004 | 0.006 | 0.236 | 0.236 | 0.349 | 0.982 | 0.177 | 1.020 |
| 2H2 | PM2.5 | 187.99 | 166.06 | 100 | 741 | 7.190 | 390.390 | 0.005 | 0.006 | 0.086 | 0.086 | 0.453 | 3.352 | 0.212 | 11.241 |
| 2H3 | PM2.5 | 15.60 | 3.87 | 98 | 275 | 0.004 | 0.029 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.003 | 0.000 | 0.000 |
| 2I | PM2.5 | 216.08 | 47.23 | 100 | 741 | 0.582 | 31.577 | 0.000 | 0.002 | 0.025 | 0.025 | 0.008 | 0.062 | 0.001 | 0.004 |
| 3B1a | PM2.5 | 20.61 | 23.05 | 100 | 440 | 0.138 | 2.654 | 0.001 | 0.001 | 0.008 | 0.008 | 0.067 | 0.297 | 0.005 | 0.088 |
| 3B1b | PM2.5 | 18.26 | 22.19 | 100 | 440 | 0.128 | 2.461 | 0.001 | 0.001 | 0.007 | 0.007 | 0.066 | 0.292 | 0.004 | 0.085 |
| 3B2 | PM2.5 | 0.79 | 0.82 | 100 | 440 | 0.000 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.010 | 0.000 | 0.000 |
| 3B3 | PM2.5 | 9.57 | 6.35 | 100 | 440 | 0.010 | 0.202 | 0.000 | 0.000 | 0.002 | 0.002 | 0.015 | 0.067 | 0.000 | 0.005 |
| 3B4d | PM2.5 | 0.14 | 0.18 | 100 | 440 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.000 | 0.000 |
| 3B4e | PM2.5 | 3.94 | 6.73 | 100 | 440 | 0.012 | 0.227 | 0.000 | 0.000 | 0.002 | 0.002 | 0.021 | 0.094 | 0.000 | 0.009 |
| 3B4f | PM2.5 | 0.59 | 3.35 | 100 | 440 | 0.003 | 0.056 | 0.000 | 0.000 | 0.001 | 0.001 | 0.012 | 0.052 | 0.000 | 0.003 |
| 3B4gi | PM2.5 | 9.25 | 11.52 | 100 | 440 | 0.034 | 0.664 | 0.000 | 0.000 | 0.004 | 0.004 | 0.035 | 0.152 | 0.001 | 0.023 |
| 3B4gii | PM2.5 | 6.78 | 21.19 | 100 | 440 | 0.116 | 2.244 | 0.001 | 0.001 | 0.007 | 0.007 | 0.072 | 0.318 | 0.005 | 0.101 |
| 3B4giii | PM2.5 | 1.89 | 2.42 | 100 | 440 | 0.002 | 0.029 | 0.000 | 0.000 | 0.001 | 0.001 | 0.007 | 0.032 | 0.000 | 0.001 |
| 3B4giv | PM2.5 | 1.98 | 3.11 | 100 | 440 | 0.003 | 0.048 | 0.000 | 0.000 | 0.001 | 0.001 | 0.010 | 0.043 | 0.000 | 0.002 |
| 3B4h | PM2.5 | 0.24 | 0.09 | 100 | 440 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3De | PM2.5 | 47.48 | 44.87 | 98 | 275 | 0.498 | 3.942 | 0.001 | 0.002 | 0.012 | 0.012 | 0.122 | 0.345 | 0.015 | 0.119 |
| 5A | PM2.5 | 0.73 | 0.50 | 32 | 32 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5B2 | PM2.5 | NA | 0.06 | 102 | 102 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1a | PM2.5 | 465.12 | 220.58 | 58 | 58 | 4.270 | 4.270 | 0.004 | 0.008 | 0.574 | 0.574 | 0.126 | 0.126 | 0.345 | 0.345 |
| 5C1bi | PM2.5 | 0.47 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1biii | PM2.5 | 16.50 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1biv | PM2.5 | 14.25 | 2.98 | 39 | 39 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1bv | PM2.5 | 4.39 | 0.83 | 33 | 33 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C2 | PM2.5 | 64.43 | 43.25 | 104 | 211 | 0.520 | 2.146 | 0.001 | 0.002 | 0.108 | 0.108 | 0.096 | 0.215 | 0.021 | 0.058 |
| 5E | PM2.5 | 1.40 | 1.50 | 36 | 36 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.001 | 0.001 | 0.000 | 0.000 |
| 6A | PM2.5 | 4.42 | 4.69 | 50 | 50 | 0.001 | 0.001 | 0.000 | 0.000 | 0.007 | 0.007 | 0.005 | 0.005 | 0.000 | 0.000 |
| Total | | | | | | 668.5 | 1'330.0 | | | | | | | 21.7 | 40.1 |
| Total | | 27'172.2 | 6'224.0 | Emissions 2023 uncertainty (%): | | 25.9 | 36.5 | | | Trend uncertainty (%): | | | | 4.7 | 6.3 |

Table A - 33 Uncertainty analysis of PM10 emissions, approach 1, for 2023 and for the trend 1990-2023. The uncertainties are given considering a 95 % confidence interval and expressed as the distance from edge to mean, in percentage of the mean ((fu) means fuel used approach). AD: activity data; EF: emission factor; EM: emission; corr.: correlated.

| A | B | C | D | G | | H | | I | J | K | | L | | M | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFR | Pollutant | Emissions 1990 | Emissions 2023 | Emission combined uncertainty 2023 | | Category contribution to inventory variance 2023 | | Sensitivi-ty if corr. (type A) | Sensitivi-ty if not corr. (type B) | Contribution to inventory trend uncertainty from AD | | Contribution to inventory trend uncertainty from EF | | Contribution to inventory trend uncertainty from EM | |
| | | | | (-)% | (+)% | (-)% | (+)% | | | (-)% | (+)% | (-)% | (+)% | (-)% | (+)% |
| 1A1a | PM10 | 1'044.54 | 46.09 | 72 | 72 | 0.055 | 0.055 | 0.010 | 0.001 | 0.018 | 0.018 | 0.695 | 0.695 | 0.483 | 0.483 |
| 1A1b | PM10 | 47.66 | 1.50 | 20 | 20 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.009 | 0.009 | 0.000 | 0.000 |
| 1A1c | PM10 | 4.89 | 14.17 | 21 | 21 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.003 | 0.007 | 0.007 | 0.000 | 0.000 |
| 1A2a | PM10 | 20.53 | 2.61 | 28 | 28 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.004 | 0.000 | 0.000 |
| 1A2b | PM10 | 29.24 | 1.05 | 30 | 30 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.008 | 0.008 | 0.000 | 0.000 |
| 1A2c | PM10 | 40.77 | 5.17 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.003 | 0.000 | 0.000 |
| 1A2d | PM10 | 166.58 | 0.18 | 33 | 33 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 | 0.058 | 0.058 | 0.003 | 0.003 |
| 1A2e | PM10 | 25.68 | 1.11 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.000 | 0.000 |
| 1A2f | PM10 | 832.63 | 68.17 | 65 | 65 | 0.099 | 0.099 | 0.007 | 0.002 | 0.005 | 0.005 | 0.451 | 0.451 | 0.204 | 0.204 |
| 1A2gvii | PM10 | 2'173.23 | 2'366.27 | 50 | 50 | 70.673 | 70.673 | 0.042 | 0.065 | 0.118 | 0.118 | 2.093 | 2.093 | 4.393 | 4.393 |
| 1A2gviii | PM10 | 913.14 | 196.65 | 65 | 65 | 0.825 | 0.825 | 0.004 | 0.005 | 0.016 | 0.016 | 0.278 | 0.278 | 0.077 | 0.077 |
| 1A3ai(i) | PM10 | 102.65 | 14.12 | 30 | 30 | 0.001 | 0.001 | 0.001 | 0.000 | 0.001 | 0.001 | 0.021 | 0.021 | 0.000 | 0.000 |
| 1A3aii(i) | PM10 | 25.19 | 1.69 | 30 | 30 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.007 | 0.007 | 0.000 | 0.000 |
| 1A3bi(fu) | PM10 | 579.17 | 98.62 | 57 | 57 | 0.161 | 0.161 | 0.003 | 0.003 | 0.005 | 0.005 | 0.196 | 0.196 | 0.039 | 0.039 |
| 1A3bii(fu) | PM10 | 329.00 | 48.06 | 48 | 48 | 0.027 | 0.027 | 0.002 | 0.001 | 0.002 | 0.002 | 0.105 | 0.105 | 0.011 | 0.011 |
| 1A3biii(fu) | PM10 | 1'584.33 | 36.16 | 27 | 27 | 0.005 | 0.005 | 0.016 | 0.001 | 0.002 | 0.002 | 0.426 | 0.426 | 0.181 | 0.181 |
| 1A3biv(fu) | PM10 | 209.02 | 57.14 | 54 | 54 | 0.048 | 0.048 | 0.001 | 0.002 | 0.003 | 0.003 | 0.035 | 0.035 | 0.001 | 0.001 |
| 1A3bvi(fu) | PM10 | 2'045.83 | 2'609.72 | 50 | 50 | 85.963 | 85.963 | 0.050 | 0.072 | 0.130 | 0.130 | 2.494 | 2.494 | 6.236 | 6.236 |
| 1A3c | PM10 | 969.78 | 1'516.58 | 50 | 50 | 29.030 | 29.030 | 0.031 | 0.042 | 0.076 | 0.076 | 1.566 | 1.566 | 2.457 | 2.457 |
| 1A3dii | PM10 | 59.09 | 21.94 | 50 | 50 | 0.006 | 0.006 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 |
| 1A3ei | PM10 | 0.11 | 0.04 | 27 | 27 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ai | PM10 | 1'427.63 | 457.11 | 78 | 78 | 6.416 | 6.416 | 0.003 | 0.013 | 0.028 | 0.028 | 0.201 | 0.201 | 0.041 | 0.041 |
| 1A4bi | PM10 | 15'325.72 | 1'948.21 | 76 | 76 | 110.875 | 110.875 | 0.108 | 0.053 | 0.281 | 0.281 | 8.233 | 8.233 | 67.867 | 67.867 |
| 1A4ci | PM10 | 710.36 | 208.01 | 44 | 44 | 0.430 | 0.430 | 0.002 | 0.006 | 0.171 | 0.171 | 0.071 | 0.071 | 0.034 | 0.034 |
| 1A4cii | PM10 | 511.19 | 185.85 | 80 | 80 | 1.116 | 1.116 | 0.000 | 0.005 | 0.009 | 0.009 | 0.025 | 0.025 | 0.001 | 0.001 |
| 1A5b | PM10 | 286.52 | 261.49 | 50 | 50 | 0.863 | 0.863 | 0.004 | 0.007 | 0.013 | 0.013 | 0.207 | 0.207 | 0.043 | 0.043 |
| 1B1a | PM10 | 1.60 | 0.38 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1B2c | PM10 | 0.44 | 0.00 | 102 | 337 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 |
| 2A1 | PM10 | 374.35 | 222.25 | 98 | 275 | 2.384 | 18.898 | 0.002 | 0.006 | 0.017 | 0.017 | 0.208 | 0.587 | 0.044 | 0.345 |
| 2A2 | PM10 | 14.41 | 13.18 | 100 | 740 | 0.009 | 0.481 | 0.000 | 0.000 | 0.001 | 0.001 | 0.021 | 0.155 | 0.000 | 0.024 |
| 2A5a | PM10 | 302.32 | 347.67 | 100 | 741 | 6.114 | 334.409 | 0.006 | 0.010 | 0.067 | 0.067 | 0.633 | 4.689 | 0.406 | 21.991 |
| 2B5 | PM10 | 73.80 | 47.59 | 74 | 122 | 0.062 | 0.170 | 0.001 | 0.001 | 0.004 | 0.004 | 0.039 | 0.064 | 0.002 | 0.004 |
| 2B10a | PM10 | 17.07 | NA | NA | NA | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2C1 | PM10 | 1'485.46 | 10.46 | 84 | 158 | 0.004 | 0.014 | 0.015 | 0.000 | 0.001 | 0.001 | 1.292 | 2.441 | 1.669 | 5.957 |
| 2C3 | PM10 | 113.15 | NO | NO | NO | NO | NO | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2C7a | PM10 | 5.96 | 0.53 | 98 | 275 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.013 | 0.000 | 0.000 |
| 2C7c | PM10 | 3.06 | 2.78 | 100 | 741 | 0.000 | 0.021 | 0.000 | 0.000 | 0.001 | 0.001 | 0.004 | 0.032 | 0.000 | 0.001 |
| 2D3c | PM10 | 19.98 | 19.05 | 100 | 276 | 0.018 | 0.140 | 0.000 | 0.001 | 0.015 | 0.015 | 0.030 | 0.086 | 0.001 | 0.008 |
| 2D3i | PM10 | 24.00 | NA | NA | NA | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2G | PM10 | 588.38 | 398.75 | 78 | 125 | 4.858 | 12.441 | 0.005 | 0.011 | 0.387 | 0.387 | 0.347 | 0.574 | 0.270 | 0.479 |
| 2H1 | PM10 | 243.80 | 156.07 | 102 | 277 | 1.286 | 9.429 | 0.002 | 0.004 | 0.182 | 0.182 | 0.166 | 0.468 | 0.061 | 0.252 |
| 2H2 | PM10 | 310.39 | 308.26 | 100 | 741 | 4.842 | 262.932 | 0.005 | 0.008 | 0.120 | 0.120 | 0.517 | 3.826 | 0.281 | 14.651 |
| 2H3 | PM10 | 15.60 | 3.87 | 98 | 275 | 0.001 | 0.006 | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | 0.016 | 0.000 | 0.000 |
| 2I | PM10 | 864.32 | 187.64 | 100 | 741 | 1.794 | 97.420 | 0.004 | 0.005 | 0.073 | 0.073 | 0.400 | 2.964 | 0.165 | 8.788 |
| 3B1a | PM10 | 84.47 | 94.45 | 100 | 440 | 0.452 | 8.713 | 0.002 | 0.003 | 0.024 | 0.024 | 0.169 | 0.746 | 0.029 | 0.557 |
| 3B1b | PM10 | 74.85 | 90.95 | 100 | 440 | 0.419 | 8.079 | 0.002 | 0.002 | 0.023 | 0.023 | 0.170 | 0.749 | 0.029 | 0.561 |
| 3B2 | PM10 | 19.76 | 20.43 | 100 | 440 | 0.021 | 0.408 | 0.000 | 0.001 | 0.005 | 0.005 | 0.035 | 0.154 | 0.001 | 0.024 |
| 3B3 | PM10 | 213.16 | 142.62 | 100 | 440 | 1.030 | 19.869 | 0.002 | 0.004 | 0.036 | 0.036 | 0.165 | 0.728 | 0.029 | 0.531 |
| 3B4d | PM10 | 3.42 | 4.58 | 100 | 440 | 0.001 | 0.020 | 0.000 | 0.000 | 0.001 | 0.001 | 0.009 | 0.039 | 0.000 | 0.002 |
| 3B4e | PM10 | 6.20 | 10.58 | 100 | 440 | 0.006 | 0.109 | 0.000 | 0.000 | 0.003 | 0.003 | 0.022 | 0.099 | 0.001 | 0.010 |
| 3B4f | PM10 | 0.94 | 5.36 | 100 | 440 | 0.001 | 0.028 | 0.000 | 0.000 | 0.001 | 0.001 | 0.014 | 0.060 | 0.000 | 0.004 |
| 3B4gi | PM10 | 123.32 | 153.65 | 100 | 440 | 1.195 | 23.061 | 0.003 | 0.004 | 0.038 | 0.038 | 0.291 | 1.279 | 0.086 | 1.638 |
| 3B4gii | PM10 | 67.84 | 211.92 | 100 | 440 | 2.274 | 43.867 | 0.005 | 0.006 | 0.053 | 0.053 | 0.509 | 2.240 | 0.262 | 5.022 |
| 3B4giii | PM10 | 10.41 | 13.29 | 100 | 440 | 0.009 | 0.172 | 0.000 | 0.000 | 0.003 | 0.003 | 0.025 | 0.112 | 0.001 | 0.013 |
| 3B4giv | PM10 | 18.52 | 29.57 | 100 | 440 | 0.044 | 0.854 | 0.001 | 0.001 | 0.007 | 0.007 | 0.061 | 0.270 | 0.004 | 0.073 |
| 3B4h | PM10 | 0.50 | 0.80 | 100 | 440 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.007 | 0.000 | 0.000 |
| 3De | PM10 | 1'053.57 | 999.51 | 98 | 275 | 48.315 | 382.331 | 0.016 | 0.027 | 0.194 | 0.194 | 1.589 | 4.475 | 2.562 | 20.060 |
| 5A | PM10 | 0.73 | 0.50 | 32 | 32 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5B2 | PM10 | NA | 0.06 | 102 | 102 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1a | PM10 | 516.80 | 245.09 | 71 | 71 | 1.515 | 1.515 | 0.001 | 0.007 | 0.475 | 0.475 | 0.063 | 0.063 | 0.230 | 0.230 |
| 5C1bi | PM10 | 3.08 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1biii | PM10 | 24.00 | NO | NO | NO | NO | NO | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1biv | PM10 | 19.95 | 4.25 | 40 | 40 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.003 | 0.003 | 0.003 | 0.000 | 0.000 |
| 5C1bv | PM10 | 4.39 | 0.83 | 33 | 33 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| 5C2 | PM10 | 70.77 | 47.50 | 104 | 211 | 0.123 | 0.506 | 0.001 | 0.001 | 0.088 | 0.088 | 0.051 | 0.114 | 0.010 | 0.021 |
| 5E | PM10 | 2.80 | 3.00 | 36 | 36 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 | 0.002 | 0.002 | 0.000 | 0.000 |
| 6A | PM10 | 229.38 | 113.32 | 50 | 50 | 0.162 | 0.162 | 0.001 | 0.003 | 0.132 | 0.132 | 0.027 | 0.027 | 0.018 | 0.018 |
| Total | | | | | | 383.5 | 1'532.7 | | | | | | | 88.2 | 163.3 |
| Total | | 36'471.4 | 14'078.4 | Emissions 2023 uncertainty (%): | | 19.6 | 39.1 | | | Trend uncertainty (%): | | | | 9.4 | 12.8 |

## A5.3 Uncertainty estimations: results from approach 2

Numeric results of the uncertainty estimations using Monte Carlo simulations are summarised in the tables in Annex A5.3.1. In these tables, columns labelled A to J correspond exactly to columns A to J from Table 3.3, chp. 3, from the 2006 IPCC Guidelines (IPCC 2006).

Results of the sensitivity analysis between input emissions from each category and inventory emission are depicted by tornado plots in the figures in Annex A5.3.2 (see also discussion in chp. 1.7.3).

Distributions of inventory emissions obtained from the 500’000 Monte Carlo simulations are shown as histograms, for each pollutant, for the base year, the reporting year and the trend, in the figures in Annex A5.3.3.

## A5.3.1 Uncertainty estimations, approach 2, numeric results

Table A - 34 Uncertainty analysis of $NO_x$ emissions, approach 2, for 2023 and for the trend 1990-2023. Monte Carlo simulations were run 500'000 times. The reported uncertainties correspond to the borders of the narrowest 95.0 % confidence interval. Contributions to inventory trend (mean, uncertainties, columns I and J) are values normalised by the total inventory base year emission ((fu) means fuel used approach).

| A | B | C | D | E | | F | | G | | H | I | J | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFR | Pollutant | Emissions 1990 | Emissions 2023 | Activity data uncertainty 2023 | | Emission factor uncertainty 2023 | | Emission combined uncertainty 2023 | | Emission contri-bution to variance 2023 | Contri-bution to trend | Contribution to uncertainty of trend | |
| | | t | t | (-)% | (+)% | (-)% | (+)% | (-)% | (+)% | Fraction | % | (-)% | (+)% |
| 1A1a | NOx (as NO2) | 6'279.37 | 2'266.58 | 10 | 10 | 19 | 19 | 21 | 22 | 0.006 | -2.862 | 0.801 | 0.776 |
| 1A1b | NOx (as NO2) | 494.17 | 338.32 | 1 | 1 | 20 | 20 | 20 | 20 | 0.000 | -0.111 | 0.028 | 0.026 |
| 1A1c | NOx (as NO2) | 0.01 | 0.04 | 5 | 5 | 20 | 20 | 20 | 21 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2a | NOx (as NO2) | 279.07 | 96.50 | 2 | 2 | 27 | 27 | 27 | 27 | 0.000 | -0.130 | 0.039 | 0.039 |
| 1A2b | NOx (as NO2) | 127.53 | 28.81 | 2 | 2 | 20 | 20 | 20 | 20 | 0.000 | -0.070 | 0.017 | 0.017 |
| 1A2c | NOx (as NO2) | 1'050.42 | 190.46 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | -0.614 | 0.103 | 0.099 |
| 1A2d | NOx (as NO2) | 1'261.91 | 31.23 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | -0.878 | 0.146 | 0.142 |
| 1A2e | NOx (as NO2) | 743.69 | 192.51 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | -0.393 | 0.067 | 0.064 |
| 1A2f | NOx (as NO2) | 10'534.54 | 2'825.44 | 2 | 2 | 17 | 17 | 17 | 17 | 0.006 | -5.499 | 1.162 | 1.097 |
| 1A2gvii | NOx (as NO2) | 6'333.94 | 1'536.52 | 1 | 1 | 13 | 13 | 13 | 13 | 0.001 | -3.424 | 0.631 | 0.600 |
| 1A2gviii | NOx (as NO2) | 2'181.62 | 1'637.67 | 2 | 2 | 17 | 17 | 17 | 17 | 0.002 | -0.388 | 0.093 | 0.089 |
| 1A3ai(i) | NOx (as NO2) | 1'214.30 | 1'966.25 | 1 | 1 | 20 | 20 | 20 | 20 | 0.004 | 0.536 | 0.127 | 0.131 |
| 1A3aii(i) | NOx (as NO2) | 153.76 | 54.52 | 1 | 1 | 20 | 20 | 20 | 20 | 0.000 | -0.071 | 0.017 | 0.017 |
| 1A3bi(fu) | NOx (as NO2) | 43'748.48 | 15'009.57 | 1 | 1 | 38 | 38 | 39 | 38 | 0.892 | -20.272 | 5.396 | 5.662 |
| 1A3bii(fu) | NOx (as NO2) | 6'199.14 | 3'493.94 | 1 | 1 | 33 | 32 | 32 | 32 | 0.034 | -1.927 | 0.658 | 0.638 |
| 1A3biii(fu) | NOx (as NO2) | 29'630.57 | 3'029.17 | 1 | 1 | 18 | 18 | 18 | 18 | 0.008 | -18.952 | 3.598 | 3.580 |
| 1A3biv(fu) | NOx (as NO2) | 308.37 | 172.80 | 1 | 1 | 36 | 36 | 36 | 36 | 0.000 | -0.097 | 0.038 | 0.037 |
| 1A3c | NOx (as NO2) | 595.50 | 330.50 | 1 | 1 | 13 | 13 | 13 | 13 | 0.000 | -0.189 | 0.036 | 0.035 |
| 1A3dii | NOx (as NO2) | 1'054.73 | 898.19 | 1 | 1 | 13 | 13 | 13 | 13 | 0.000 | -0.112 | 0.025 | 0.023 |
| 1A3ei | NOx (as NO2) | 19.41 | 6.22 | 2 | 2 | 50 | 50 | 50 | 50 | 0.000 | -0.009 | 0.005 | 0.005 |
| 1A4ai | NOx (as NO2) | 5'139.32 | 2'831.98 | 2 | 2 | 16 | 16 | 16 | 16 | 0.006 | -1.646 | 0.340 | 0.335 |
| 1A4aii | NOx (as NO2) | 16.28 | 39.69 | 1 | 1 | 13 | 13 | 13 | 13 | 0.000 | 0.017 | 0.003 | 0.003 |
| 1A4bi | NOx (as NO2) | 11'636.07 | 3'464.39 | 4 | 4 | 13 | 13 | 13 | 14 | 0.006 | -5.830 | 1.082 | 1.052 |
| 1A4bii | NOx (as NO2) | 18.76 | 19.14 | 1 | 1 | 30 | 30 | 30 | 30 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ci | NOx (as NO2) | 388.54 | 379.41 | 21 | 21 | 30 | 30 | 36 | 37 | 0.001 | -0.006 | 0.084 | 0.084 |
| 1A4cii | NOx (as NO2) | 4'357.53 | 1'607.61 | 1 | 1 | 13 | 13 | 13 | 13 | 0.001 | -1.963 | 0.362 | 0.351 |
| 1A5b | NOx (as NO2) | 882.99 | 397.10 | 1 | 1 | 13 | 13 | 13 | 13 | 0.000 | -0.347 | 0.065 | 0.063 |
| 1B2c | NOx (as NO2) | 211.21 | 0.57 | 22 | 22 | 100 | 204 | 100 | 205 | 0.000 | -0.150 | 0.308 | 0.150 |
| 2A1 | NOx (as NO2) | 15.87 | 9.42 | 2 | 2 | 100 | 204 | 100 | 204 | 0.000 | -0.005 | 0.009 | 0.005 |
| 2A2 | NOx (as NO2) | 0.27 | 0.24 | 2 | 2 | 100 | 449 | 100 | 449 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2A5a | NOx (as NO2) | 1.79 | 0.52 | 5 | 5 | 100 | 448 | 100 | 448 | 0.000 | -0.001 | 0.004 | 0.001 |
| 2B2 | NOx (as NO2) | 82.78 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.059 | 0.010 | 0.009 |
| 2B5 | NOx (as NO2) | 22.20 | 15.64 | 2 | 2 | 40 | 40 | 40 | 40 | 0.000 | -0.005 | 0.002 | 0.002 |
| 2B10a | NOx (as NO2) | 8.93 | 0.63 | 2 | 2 | 60 | 60 | 60 | 61 | 0.000 | -0.006 | 0.004 | 0.004 |
| 2C1 | NOx (as NO2) | 245.46 | 131.32 | 2 | 2 | 50 | 50 | 50 | 50 | 0.000 | -0.081 | 0.042 | 0.042 |
| 2C3 | NOx (as NO2) | 17.41 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.012 | 0.025 | 0.012 |
| 2C7c | NOx (as NO2) | NA | 1.42 | 5 | 5 | 83 | 100 | 83 | 101 | 0.000 | 0.001 | 0.001 | 0.001 |
| 2G | NOx (as NO2) | 29.36 | 17.23 | 25 | 25 | 84 | 100 | 85 | 104 | 0.000 | -0.009 | 0.011 | 0.008 |
| 2H3 | NOx (as NO2) | 91.00 | 22.58 | 3 | 3 | 100 | 204 | 100 | 204 | 0.000 | -0.049 | 0.100 | 0.049 |
| 3B1a | NOx (as NO2) | 672.26 | 373.95 | 6 | 6 | 51 | 49 | 51 | 50 | 0.001 | -0.213 | 0.117 | 0.113 |
| 3B1b | NOx (as NO2) | 344.28 | 281.92 | 6 | 6 | 50 | 50 | 50 | 50 | 0.001 | -0.045 | 0.032 | 0.029 |
| 3B2 | NOx (as NO2) | 67.60 | 64.85 | 6 | 6 | 50 | 49 | 50 | 50 | 0.000 | -0.002 | 0.005 | 0.004 |
| 3B3 | NOx (as NO2) | 185.29 | 84.18 | 6 | 7 | 50 | 50 | 50 | 50 | 0.000 | -0.072 | 0.039 | 0.038 |
| 3B4d | NOx (as NO2) | 21.62 | 22.67 | 6 | 6 | 50 | 50 | 50 | 51 | 0.000 | 0.001 | 0.002 | 0.002 |
| 3B4e | NOx (as NO2) | 17.58 | 26.53 | 6 | 6 | 50 | 50 | 50 | 51 | 0.000 | 0.006 | 0.003 | 0.004 |
| 3B4f | NOx (as NO2) | 1.35 | 7.07 | 6 | 6 | 50 | 50 | 50 | 51 | 0.000 | 0.004 | 0.002 | 0.002 |
| 3B4gi | NOx (as NO2) | 7.19 | 9.38 | 6 | 7 | 49 | 50 | 50 | 50 | 0.000 | 0.002 | 0.001 | 0.001 |
| 3B4gii | NOx (as NO2) | 4.46 | 12.47 | 6 | 6 | 50 | 50 | 50 | 50 | 0.000 | 0.006 | 0.003 | 0.003 |
| 3B4giii | NOx (as NO2) | 0.44 | 0.54 | 6 | 6 | 50 | 50 | 50 | 51 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3B4giv | NOx (as NO2) | 0.84 | 1.23 | 6 | 6 | 50 | 50 | 51 | 50 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3B4h | NOx (as NO2) | 2.00 | 5.40 | 6 | 6 | 51 | 49 | 51 | 50 | 0.000 | 0.002 | 0.001 | 0.001 |
| 3Da1 | NOx (as NO2) | 1'205.08 | 609.12 | 5 | 5 | 100 | 100 | 101 | 100 | 0.010 | -0.424 | 0.434 | 0.427 |
| 3Da2a | NOx (as NO2) | 2'074.98 | 1'449.29 | 6 | 6 | 49 | 51 | 51 | 50 | 0.014 | -0.446 | 0.263 | 0.249 |
| 3Da2b | NOx (as NO2) | 87.01 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.062 | 0.063 | 0.063 |
| 3Da2c | NOx (as NO2) | 14.76 | 122.27 | 20 | 20 | 98 | 102 | 101 | 105 | 0.000 | 0.077 | 0.079 | 0.082 |
| 3Da3 | NOx (as NO2) | 243.41 | 417.48 | 6 | 6 | 99 | 101 | 100 | 100 | 0.005 | 0.124 | 0.127 | 0.130 |
| 5A | NOx (as NO2) | 1.83 | 1.24 | 10 | 10 | 50 | 50 | 51 | 52 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5B2 | NOx (as NO2) | NA | 7.23 | 20 | 20 | 101 | 99 | 102 | 104 | 0.000 | 0.005 | 0.005 | 0.005 |
| 5C1a | NOx (as NO2) | 80.75 | 38.30 | 50 | 50 | 40 | 40 | 61 | 67 | 0.000 | -0.030 | 0.036 | 0.034 |
| 5C1bi | NOx (as NO2) | 9.75 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.007 | 0.003 | 0.003 |
| 5C1biii | NOx (as NO2) | 22.50 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.016 | 0.007 | 0.007 |
| 5C1biv | NOx (as NO2) | 114.00 | 42.53 | 20 | 20 | 50 | 50 | 53 | 55 | 0.000 | -0.051 | 0.033 | 0.030 |
| 5C1bv | NOx (as NO2) | 11.25 | 13.34 | 5 | 5 | 30 | 30 | 30 | 31 | 0.000 | 0.001 | 0.001 | 0.001 |
| 5C2 | NOx (as NO2) | 23.65 | 15.87 | 48 | 48 | 100 | 156 | 100 | 167 | 0.000 | -0.006 | 0.018 | 0.011 |
| 5D1 | NOx (as NO2) | 25.35 | 5.03 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -0.015 | 0.002 | 0.002 |
| 5D2 | NOx (as NO2) | 0.23 | 1.13 | 10 | 10 | 10 | 10 | 14 | 14 | 0.000 | 0.001 | 0.000 | 0.000 |
| 6A | NOx (as NO2) | 92.05 | 85.24 | 30 | 30 | 50 | 50 | 56 | 60 | 0.000 | -0.005 | 0.029 | 0.028 |
| Total, Monte Carlo simulations | | 140'721.9 | 46'746.7 | | | | | 12.9 | 13.1 | 1.0 | -66.8 | 1.1 | 1.2 |
| Total, inventory | | 140'707.8 | 46'742.4 | | | | | | | | -66.8 | | |

Table A - 35 Uncertainty analysis of NMVOC emissions, approach 2, for 2023 and for the trend 1990-2023. Monte Carlo simulations were run 500'000 times. The reported uncertainties correspond to the borders of the narrowest 95.0 % confidence interval. Contributions to inventory trend (mean, uncertainties, columns I and J) are values normalised by the total inventory base year emission ((fu) means fuel used approach).

| A | B | C | D | E | | F | | G | | H | I | J | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFR | Pollutant | Emissions 1990 | Emissions 2023 | Activity data uncertainty 2023 | | Emission factor uncertainty 2023 | | Emission combined uncertainty 2023 | | Emission contribution to variance | Contribution to trend | Contribution to uncertainty of trend | |
| | | t | t | (-)% | (+)% | (-)% | (+)% | (-)% | (+)% | Fraction | % | (-)% | (+)% |
| 1A1a | NMVOC | 320.80 | 187.05 | 10 | 10 | 32 | 33 | 34 | 34 | 0.000 | -0.046 | 0.023 | 0.021 |
| 1A1b | NMVOC | 6.95 | 2.99 | 1 | 1 | 20 | 20 | 20 | 20 | 0.000 | -0.001 | 0.000 | 0.000 |
| 1A1c | NMVOC | 2.13 | 6.18 | 5 | 5 | 20 | 20 | 21 | 21 | 0.000 | 0.001 | 0.000 | 0.000 |
| 1A2a | NMVOC | 8.95 | 6.14 | 2 | 2 | 18 | 18 | 18 | 19 | 0.000 | -0.001 | 0.000 | 0.000 |
| 1A2b | NMVOC | 53.62 | 5.52 | 2 | 2 | 19 | 19 | 19 | 19 | 0.000 | -0.017 | 0.005 | 0.005 |
| 1A2c | NMVOC | 34.22 | 18.24 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | -0.005 | 0.001 | 0.001 |
| 1A2d | NMVOC | 29.90 | 3.35 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | -0.009 | 0.002 | 0.002 |
| 1A2e | NMVOC | 22.05 | 20.16 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | -0.001 | 0.000 | 0.000 |
| 1A2f | NMVOC | 596.56 | 421.87 | 2 | 2 | 30 | 30 | 30 | 30 | 0.000 | -0.060 | 0.024 | 0.023 |
| 1A2gvii | NMVOC | 1'331.50 | 256.93 | 1 | 1 | 34 | 34 | 34 | 34 | 0.000 | -0.369 | 0.157 | 0.147 |
| 1A2gviii | NMVOC | 294.30 | 116.53 | 2 | 2 | 30 | 30 | 30 | 30 | 0.000 | -0.061 | 0.024 | 0.023 |
| 1A3ai(i) | NMVOC | 247.46 | 127.04 | 1 | 1 | 50 | 50 | 50 | 50 | 0.000 | -0.041 | 0.023 | 0.022 |
| 1A3aii(i) | NMVOC | 58.81 | 30.49 | 1 | 1 | 50 | 50 | 50 | 50 | 0.000 | -0.010 | 0.006 | 0.005 |
| 1A3bi(fu) | NMVOC | 55'582.12 | 3'635.14 | 1 | 1 | 52 | 52 | 53 | 52 | 0.012 | -17.613 | 8.425 | 8.443 |
| 1A3bii(fu) | NMVOC | 4'868.98 | 131.94 | 1 | 1 | 46 | 45 | 46 | 45 | 0.000 | -1.628 | 0.842 | 0.809 |
| 1A3biii(fu) | NMVOC | 3'437.85 | 87.52 | 1 | 1 | 22 | 22 | 22 | 22 | 0.000 | -1.152 | 0.375 | 0.361 |
| 1A3biv(fu) | NMVOC | 5'736.73 | 826.68 | 1 | 1 | 100 | 390 | 100 | 390 | 0.036 | -1.556 | 6.060 | 1.556 |
| 1A3bv(fu) | NMVOC | 17'165.87 | 1'772.97 | 1 | 1 | 40 | 40 | 40 | 40 | 0.002 | -5.282 | 2.382 | 2.298 |
| 1A3c | NMVOC | 83.76 | 38.53 | 1 | 1 | 34 | 34 | 34 | 34 | 0.000 | -0.016 | 0.006 | 0.006 |
| 1A3dii | NMVOC | 1'640.55 | 388.66 | 1 | 1 | 34 | 34 | 34 | 34 | 0.000 | -0.431 | 0.179 | 0.175 |
| 1A3ei | NMVOC | 0.90 | 0.31 | 2 | 2 | 50 | 50 | 50 | 51 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ai | NMVOC | 1'329.00 | 873.24 | 2 | 2 | 56 | 56 | 56 | 56 | 0.001 | -0.157 | 0.098 | 0.093 |
| 1A4aii | NMVOC | 1'091.65 | 306.69 | 1 | 1 | 74 | 76 | 75 | 75 | 0.000 | -0.270 | 0.218 | 0.209 |
| 1A4bi | NMVOC | 10'056.33 | 2'346.74 | 4 | 4 | 68 | 68 | 69 | 67 | 0.008 | -2.641 | 1.884 | 1.835 |
| 1A4bii | NMVOC | 398.23 | 119.60 | 1 | 1 | 75 | 75 | 75 | 75 | 0.000 | -0.096 | 0.076 | 0.075 |
| 1A4ci | NMVOC | 235.07 | 255.12 | 21 | 21 | 74 | 76 | 78 | 79 | 0.000 | 0.007 | 0.028 | 0.030 |
| 1A4cii | NMVOC | 4'369.08 | 792.31 | 1 | 1 | 75 | 75 | 75 | 75 | 0.001 | -1.226 | 0.969 | 0.952 |
| 1A5b | NMVOC | 160.25 | 63.97 | 1 | 1 | 34 | 34 | 34 | 34 | 0.000 | -0.033 | 0.014 | 0.013 |
| 1B2ai | NMVOC | 0.02 | 0.01 | 30 | 30 | 49 | 51 | 57 | 60 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1B2aiv | NMVOC | 1'344.61 | 215.10 | 30 | 30 | 47 | 47 | 54 | 57 | 0.000 | -0.388 | 0.257 | 0.232 |
| 1B2av | NMVOC | 19'127.24 | 2'021.04 | 1 | 1 | 38 | 41 | 38 | 41 | 0.002 | -5.868 | 2.630 | 2.459 |
| 1B2b | NMVOC | 323.52 | 175.86 | 22 | 22 | 51 | 50 | 54 | 56 | 0.000 | -0.051 | 0.041 | 0.037 |
| 1B2c | NMVOC | 13.72 | 0.03 | 22 | 22 | 83 | 101 | 84 | 104 | 0.000 | -0.005 | 0.005 | 0.004 |
| 2A1 | NMVOC | 41.25 | 24.49 | 2 | 2 | 100 | 204 | 100 | 204 | 0.000 | -0.006 | 0.012 | 0.006 |
| 2A2 | NMVOC | 0.69 | 0.63 | 2 | 2 | 100 | 446 | 100 | 446 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2A5a | NMVOC | 4.59 | 1.34 | 5 | 5 | 100 | 447 | 100 | 446 | 0.000 | -0.001 | 0.005 | 0.001 |
| 2B10a | NMVOC | 608.61 | 15.18 | 2 | 2 | 40 | 40 | 40 | 40 | 0.000 | -0.204 | 0.096 | 0.093 |
| 2C1 | NMVOC | 1'053.60 | 187.83 | 2 | 2 | 83 | 101 | 83 | 100 | 0.000 | -0.298 | 0.307 | 0.251 |
| 2C3 | NMVOC | 56.57 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.019 | 0.040 | 0.019 |
| 2C7a | NMVOC | 2.98 | 0.26 | 5 | 5 | 100 | 204 | 100 | 204 | 0.000 | -0.001 | 0.002 | 0.001 |
| 2C7c | NMVOC | NA | 0.46 | 5 | 5 | 84 | 100 | 83 | 101 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2D3a | NMVOC | 8'866.55 | 6'506.75 | 1 | 1 | 50 | 50 | 50 | 50 | 0.035 | -0.807 | 1.928 | 1.906 |
| 2D3b | NMVOC | 4'895.00 | 2'700.00 | 5 | 5 | 84 | 100 | 83 | 101 | 0.024 | -0.752 | 0.774 | 0.630 |
| 2D3c | NMVOC | 2'430.00 | 365.45 | 20 | 20 | 84 | 100 | 84 | 103 | 0.000 | -0.709 | 0.754 | 0.605 |
| 2D3d | NMVOC | 40'731.00 | 8'285.92 | 20 | 20 | 40 | 40 | 44 | 46 | 0.046 | -11.071 | 5.366 | 5.032 |
| 2D3e | NMVOC | 11'731.23 | 1'566.25 | 40 | 40 | 49 | 50 | 62 | 66 | 0.003 | -3.481 | 2.532 | 2.284 |
| 2D3f | NMVOC | 910.00 | 60.60 | 20 | 20 | 40 | 40 | 44 | 46 | 0.000 | -0.292 | 0.151 | 0.145 |
| 2D3g | NMVOC | 27'503.97 | 3'184.68 | 30 | 30 | 83 | 100 | 85 | 106 | 0.038 | -8.140 | 8.028 | 6.675 |
| 2D3h | NMVOC | 20'353.80 | 3'617.41 | 20 | 20 | 40 | 40 | 44 | 46 | 0.009 | -5.738 | 2.901 | 2.776 |
| 2D3i | NMVOC | 5'470.21 | 1'932.86 | 30 | 30 | 100 | 183 | 100 | 187 | 0.042 | -1.198 | 2.280 | 1.197 |
| 2G | NMVOC | 22'431.61 | 6'315.50 | 25 | 25 | 100 | 204 | 100 | 206 | 0.552 | -5.166 | 9.714 | 5.166 |
| 2H1 | NMVOC | 554.99 | 181.31 | 30 | 30 | 100 | 202 | 100 | 206 | 0.000 | -0.128 | 0.273 | 0.128 |
| 2H2 | NMVOC | 1'413.07 | 1'416.69 | 10 | 10 | 83 | 101 | 83 | 102 | 0.007 | 0.001 | 0.082 | 0.084 |
| 2H3 | NMVOC | 156.00 | 38.70 | 3 | 3 | 100 | 203 | 100 | 203 | 0.000 | -0.040 | 0.082 | 0.040 |
| 3B1a | NMVOC | 6'412.83 | 6'584.61 | 6 | 6 | 60 | 60 | 60 | 60 | 0.053 | 0.059 | 0.217 | 0.230 |
| 3B1b | NMVOC | 5'121.56 | 7'441.23 | 6 | 6 | 69 | 71 | 70 | 71 | 0.091 | 0.796 | 0.597 | 0.641 |
| 3B2 | NMVOC | 66.79 | 69.04 | 6 | 6 | 100 | 204 | 100 | 204 | 0.000 | 0.001 | 0.003 | 0.004 |
| 3B3 | NMVOC | 1'126.15 | 770.22 | 6 | 6 | 100 | 203 | 100 | 203 | 0.008 | -0.122 | 0.252 | 0.122 |
| 3B4d | NMVOC | 37.02 | 49.60 | 6 | 6 | 100 | 204 | 100 | 204 | 0.000 | 0.004 | 0.004 | 0.009 |
| 3B4e | NMVOC | 120.39 | 205.58 | 6 | 6 | 100 | 204 | 100 | 204 | 0.001 | 0.029 | 0.029 | 0.061 |
| 3B4f | NMVOC | 8.64 | 49.21 | 6 | 6 | 100 | 204 | 100 | 204 | 0.000 | 0.014 | 0.014 | 0.029 |
| 3B4gi | NMVOC | 508.70 | 633.80 | 6 | 6 | 100 | 205 | 100 | 205 | 0.005 | 0.043 | 0.043 | 0.092 |
| 3B4gii | NMVOC | 366.34 | 1'144.35 | 6 | 6 | 100 | 204 | 100 | 204 | 0.017 | 0.267 | 0.267 | 0.550 |
| 3B4giii | NMVOC | 46.28 | 59.07 | 6 | 6 | 100 | 204 | 100 | 204 | 0.000 | 0.004 | 0.004 | 0.009 |
| 3B4giv | NMVOC | 129.27 | 215.88 | 6 | 6 | 100 | 204 | 100 | 204 | 0.001 | 0.030 | 0.030 | 0.061 |
| 3B4h | NMVOC | 3.60 | 4.37 | 6 | 6 | 100 | 204 | 100 | 204 | 0.000 | 0.000 | 0.000 | 0.001 |
| 3De | NMVOC | 481.06 | 453.28 | 5 | 5 | 100 | 203 | 100 | 204 | 0.003 | -0.010 | 0.028 | 0.013 |
| 5A | NMVOC | 405.68 | 123.02 | 10 | 10 | 50 | 50 | 51 | 51 | 0.000 | -0.097 | 0.056 | 0.055 |
| 5B1 | NMVOC | 105.05 | 175.20 | 20 | 20 | 100 | 100 | 101 | 104 | 0.000 | 0.024 | 0.026 | 0.031 |
| 5B2 | NMVOC | 49.57 | 1'146.82 | 20 | 20 | 30 | 30 | 35 | 37 | 0.001 | 0.378 | 0.157 | 0.169 |
| 5C1a | NMVOC | 516.80 | 245.09 | 50 | 50 | 50 | 50 | 67 | 73 | 0.000 | -0.093 | 0.121 | 0.105 |
| 5C1bi | NMVOC | 3.75 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.001 | 0.001 | 0.001 |
| 5C1biii | NMVOC | 4.50 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.002 | 0.001 | 0.001 |
| 5C1biv | NMVOC | 0.46 | 20.09 | 20 | 20 | 20 | 20 | 28 | 28 | 0.000 | 0.007 | 0.002 | 0.003 |
| 5C1bv | NMVOC | 1.20 | 0.37 | 5 | 5 | 30 | 30 | 30 | 31 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C2 | NMVOC | 25.19 | 16.91 | 48 | 48 | 100 | 156 | 100 | 168 | 0.000 | -0.003 | 0.009 | 0.006 |
| 5D1 | NMVOC | 0.51 | 0.10 | 1 | 1 | 27 | 27 | 27 | 27 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5D2 | NMVOC | 0.00 | 0.02 | 10 | 10 | 20 | 20 | 22 | 22 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5E | NMVOC | 28.00 | 60.00 | 20 | 20 | 24 | 23 | 30 | 31 | 0.000 | 0.011 | 0.006 | 0.006 |
| 6A | NMVOC | 202.98 | 166.12 | 30 | 30 | 49 | 51 | 57 | 60 | 0.000 | -0.013 | 0.031 | 0.028 |
| Total, Monte Carlo simulations | | 295'044.8 | 71'319.2 | | | | | 22.5 | 24.8 | 1.0 | -75.7 | 3.8 | 3.9 |
| Total, inventory | | 294'960.8 | 71'290.2 | | | | | | | | -75.8 | | |

Table A - 36 Uncertainty analysis of $SO_x$ emissions, approach 2, for 2023 and for the trend 1990-2023. Monte Carlo simulations were run 500'000 times. The reported uncertainties correspond to the borders of the narrowest 95.0 % confidence interval. Contributions to inventory trend (mean, uncertainties, columns I and J) are values normalised by the total inventory base year emission ((fu) means fuel used approach).

| A | B | C | D | E | | F | | G | | H | I | J | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFR | Pollutant | Emissions 1990 | Emissions 2023 | Activity data uncertainty 2023 | | Emission factor uncertainty 2023 | | Emission combined uncertainty 2023 | | Emission contri-bution to variance 2023 | Contri-bution to trend | Contribution to uncertainty of trend | |
| | | t | t | (-)% | (+)% | (-)% | (+)% | (-)% | (+)% | Fraction | % | (-)% | (+)% |
| 1A1a | SOx (as SO2) | 3'679.11 | 255.94 | 10 | 10 | 22 | 22 | 24 | 24 | 0.054 | -8.735 | 2.011 | 1.992 |
| 1A1b | SOx (as SO2) | 660.41 | 58.83 | 1 | 1 | 20 | 20 | 20 | 20 | 0.002 | -1.537 | 0.314 | 0.317 |
| 1A2a | SOx (as SO2) | 362.55 | 9.25 | 2 | 2 | 15 | 15 | 15 | 15 | 0.000 | -0.902 | 0.147 | 0.143 |
| 1A2b | SOx (as SO2) | 67.34 | 0.45 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | -0.171 | 0.020 | 0.020 |
| 1A2c | SOx (as SO2) | 1'187.10 | 62.95 | 2 | 2 | 11 | 11 | 11 | 11 | 0.001 | -2.871 | 0.358 | 0.350 |
| 1A2d | SOx (as SO2) | 3'238.01 | 0.56 | 2 | 2 | 14 | 14 | 14 | 14 | 0.000 | -8.268 | 1.173 | 1.184 |
| 1A2e | SOx (as SO2) | 1'077.50 | 3.75 | 2 | 2 | 12 | 12 | 12 | 12 | 0.000 | -2.743 | 0.367 | 0.358 |
| 1A2f | SOx (as SO2) | 3'530.25 | 1'299.67 | 2 | 2 | 19 | 19 | 19 | 19 | 0.865 | -5.692 | 1.063 | 1.044 |
| 1A2gvii | SOx (as SO2) | 370.66 | 2.67 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -0.940 | 0.109 | 0.109 |
| 1A2gviii | SOx (as SO2) | 3'533.86 | 260.22 | 2 | 2 | 19 | 19 | 19 | 19 | 0.035 | -8.354 | 1.528 | 1.530 |
| 1A3ai(i) | SOx (as SO2) | 99.68 | 137.22 | 1 | 1 | 10 | 10 | 10 | 10 | 0.003 | 0.096 | 0.012 | 0.012 |
| 1A3aii(i) | SOx (as SO2) | 24.94 | 4.65 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -0.052 | 0.006 | 0.006 |
| 1A3bi(fu) | SOx (as SO2) | 1'618.97 | 34.55 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -4.046 | 0.459 | 0.458 |
| 1A3bii(fu) | SOx (as SO2) | 292.93 | 4.86 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -0.736 | 0.086 | 0.085 |
| 1A3biii(fu) | SOx (as SO2) | 1'842.88 | 8.70 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -4.684 | 0.529 | 0.527 |
| 1A3biv(fu) | SOx (as SO2) | 25.47 | 0.52 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -0.064 | 0.008 | 0.007 |
| 1A3c | SOx (as SO2) | 26.92 | 0.12 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -0.068 | 0.008 | 0.008 |
| 1A3dii | SOx (as SO2) | 64.88 | 0.49 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -0.164 | 0.019 | 0.019 |
| 1A3ei | SOx (as SO2) | 0.28 | 0.05 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | -0.001 | 0.000 | 0.000 |
| 1A4ai | SOx (as SO2) | 3'869.92 | 83.11 | 2 | 2 | 10 | 10 | 10 | 10 | 0.001 | -9.670 | 1.046 | 1.048 |
| 1A4aii | SOx (as SO2) | 1.61 | 0.05 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -0.004 | 0.000 | 0.000 |
| 1A4bi | SOx (as SO2) | 10'354.85 | 207.08 | 4 | 4 | 10 | 10 | 11 | 11 | 0.007 | -25.902 | 2.464 | 2.424 |
| 1A4bii | SOx (as SO2) | 1.20 | 0.03 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -0.003 | 0.000 | 0.000 |
| 1A4ci | SOx (as SO2) | 335.80 | 51.09 | 21 | 21 | 18 | 18 | 28 | 28 | 0.003 | -0.727 | 0.234 | 0.222 |
| 1A4cii | SOx (as SO2) | 304.60 | 1.60 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -0.774 | 0.090 | 0.090 |
| 1A5b | SOx (as SO2) | 78.17 | 33.02 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | -0.115 | 0.014 | 0.014 |
| 1B2aiv | SOx (as SO2) | 419.02 | 14.34 | 30 | 30 | 47 | 47 | 54 | 57 | 0.001 | -1.034 | 0.584 | 0.569 |
| 1B2c | SOx (as SO2) | 300.98 | 0.83 | 22 | 22 | 31 | 31 | 37 | 39 | 0.000 | -0.766 | 0.297 | 0.286 |
| 2A1 | SOx (as SO2) | 0.69 | 0.41 | 2 | 2 | 100 | 204 | 100 | 204 | 0.000 | -0.001 | 0.001 | 0.001 |
| 2A2 | SOx (as SO2) | 0.01 | 0.01 | 2 | 2 | 100 | 446 | 100 | 447 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2A5a | SOx (as SO2) | 0.08 | 0.02 | 5 | 5 | 100 | 448 | 100 | 448 | 0.000 | 0.000 | 0.001 | 0.000 |
| 2B5 | SOx (as SO2) | 625.20 | 197.85 | 2 | 2 | 20 | 20 | 20 | 20 | 0.022 | -1.092 | 0.227 | 0.227 |
| 2B10a | SOx (as SO2) | 168.00 | 40.01 | 2 | 2 | 40 | 40 | 40 | 40 | 0.004 | -0.327 | 0.133 | 0.131 |
| 2C1 | SOx (as SO2) | 144.04 | 13.11 | 2 | 2 | 83 | 101 | 83 | 101 | 0.002 | -0.334 | 0.335 | 0.280 |
| 2C3 | SOx (as SO2) | 696.30 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -1.748 | 3.483 | 1.748 |
| 2C7c | SOx (as SO2) | NA | 0.02 | 5 | 5 | 83 | 101 | 83 | 101 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2G | SOx (as SO2) | 3.44 | 3.27 | 25 | 25 | 84 | 100 | 85 | 105 | 0.000 | 0.000 | 0.004 | 0.004 |
| 2H3 | SOx (as SO2) | 1.30 | 0.32 | 3 | 3 | 100 | 203 | 100 | 203 | 0.000 | -0.002 | 0.005 | 0.002 |
| 5B2 | SOx (as SO2) | NA | 1.09 | 20 | 20 | 99 | 101 | 101 | 104 | 0.000 | 0.003 | 0.003 | 0.003 |
| 5C1a | SOx (as SO2) | 24.23 | 11.49 | 50 | 50 | 40 | 40 | 62 | 66 | 0.001 | -0.033 | 0.039 | 0.036 |
| 5C1bi | SOx (as SO2) | 45.00 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.115 | 0.050 | 0.048 |
| 5C1biii | SOx (as SO2) | 19.50 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.050 | 0.022 | 0.021 |
| 5C1biv | SOx (as SO2) | 74.10 | 17.22 | 20 | 20 | 30 | 30 | 35 | 37 | 0.001 | -0.145 | 0.060 | 0.057 |
| 5C2 | SOx (as SO2) | 0.51 | 0.35 | 48 | 48 | 97 | 133 | 98 | 145 | 0.000 | 0.000 | 0.001 | 0.001 |
| 5D1 | SOx (as SO2) | 0.13 | 0.03 | 1 | 1 | 37 | 37 | 37 | 37 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5D2 | SOx (as SO2) | 0.00 | 0.01 | 10 | 10 | 20 | 20 | 22 | 23 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6A | SOx (as SO2) | 9.17 | 7.20 | 30 | 30 | 50 | 50 | 56 | 60 | 0.000 | -0.005 | 0.010 | 0.009 |
| Total, Monte Carlo simulations | | 39'184.1 | 2'829.0 | | | | | 9.5 | 9.4 | 1.0 | -92.8 | 0.6 | 0.6 |
| Total, inventory | | 39'181.6 | 2'829.0 | | | | | | | | -92.8 | | |

Table A - 37 Uncertainty analysis of $NH_3$ emissions, approach 2, for 2023 and for the trend 1990-2023. Monte Carlo simulations were run 500’000 times. The reported uncertainties correspond to the borders of the narrowest 95.0 % confidence interval. Contributions to inventory trend (mean, uncertainties, columns I and J) are values normalised by the total inventory base year emission ((fu) means fuel used approach).

| A | B | C | D | E | | F | | G | | H | I | J | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFR | Pollutant | Emissions 1990 | Emissions 2023 | Activity data uncertainty 2023 | | Emission factor uncertainty 2023 | | Emission combined uncertainty 2023 | | Emission contribution to variance 2023 | Contribution to trend | Contribution to uncertainty of trend | |
| | | t | t | (-)% | (+)% | (-)% | (+)% | (-)% | (+)% | Fraction | % | (-)% | (+)% |
| 1A1a | NH3 | 4.85 | 42.37 | 10 | 10 | 20 | 20 | 22 | 22 | 0.000 | 0.055 | 0.014 | 0.015 |
| 1A1b | NH3 | 0.01 | 0.01 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2a | NH3 | 0.00 | 0.00 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2b | NH3 | 0.11 | 0.00 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2c | NH3 | 0.02 | 0.01 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2d | NH3 | 0.02 | 0.00 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2e | NH3 | 0.02 | 0.01 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A2f | NH3 | 147.02 | 168.44 | 2 | 2 | 9 | 9 | 9 | 9 | 0.000 | 0.031 | 0.008 | 0.008 |
| 1A2gvii | NH3 | 1.00 | 1.55 | 1 | 1 | 50 | 49 | 50 | 49 | 0.000 | 0.001 | 0.000 | 0.000 |
| 1A2gviii | NH3 | 17.00 | 39.15 | 2 | 2 | 9 | 9 | 9 | 9 | 0.000 | 0.032 | 0.005 | 0.006 |
| 1A3bi(fu) | NH3 | 1'324.97 | 826.10 | 1 | 1 | 50 | 50 | 50 | 50 | 0.004 | -0.731 | 0.375 | 0.375 |
| 1A3bii(fu) | NH3 | 8.57 | 35.60 | 1 | 1 | 50 | 50 | 50 | 50 | 0.000 | 0.040 | 0.020 | 0.021 |
| 1A3biii(fu) | NH3 | 4.55 | 33.03 | 1 | 1 | 50 | 50 | 50 | 50 | 0.000 | 0.042 | 0.021 | 0.022 |
| 1A3biv(fu) | NH3 | 3.26 | 3.48 | 1 | 1 | 50 | 50 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A3c | NH3 | 0.07 | 0.07 | 1 | 1 | 51 | 50 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A3dii | NH3 | 0.20 | 0.21 | 1 | 1 | 50 | 50 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ai | NH3 | 19.80 | 37.71 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | 0.026 | 0.004 | 0.005 |
| 1A4aii | NH3 | 0.01 | 0.02 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4bi | NH3 | 153.12 | 55.96 | 4 | 4 | 10 | 10 | 11 | 11 | 0.000 | -0.142 | 0.026 | 0.025 |
| 1A4bii | NH3 | 0.01 | 0.01 | 1 | 1 | 10 | 10 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ci | NH3 | 2.88 | 8.44 | 21 | 21 | 10 | 10 | 23 | 24 | 0.000 | 0.008 | 0.003 | 0.003 |
| 1A4cii | NH3 | 0.76 | 0.82 | 1 | 1 | 50 | 50 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A5b | NH3 | 0.04 | 0.04 | 1 | 1 | 50 | 49 | 50 | 50 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2B1 | NH3 | 0.07 | 0.01 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2B2 | NH3 | 0.73 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.001 | 0.000 | 0.000 |
| 2B10a | NH3 | 7.73 | NA | NA | NA | NA | NA | NA | NA | 0.000 | -0.011 | 0.005 | 0.005 |
| 2C1 | NH3 | 11.90 | 1.51 | 2 | 2 | 100 | 204 | 100 | 204 | 0.000 | -0.015 | 0.031 | 0.015 |
| 2C7c | NH3 | 9.19 | 8.16 | 5 | 5 | 100 | 447 | 100 | 446 | 0.000 | -0.002 | 0.007 | 0.002 |
| 2G | NH3 | 203.15 | 67.89 | 25 | 25 | 40 | 40 | 46 | 49 | 0.000 | -0.198 | 0.118 | 0.109 |
| 2H2 | NH3 | 132.33 | 49.36 | 10 | 10 | 100 | 446 | 100 | 446 | 0.001 | -0.120 | 0.535 | 0.120 |
| 2H3 | NH3 | 1.04 | 0.26 | 3 | 3 | 100 | 203 | 100 | 203 | 0.000 | -0.001 | 0.002 | 0.001 |
| 2L | NH3 | 2.38 | 3.69 | 25 | 25 | 99 | 101 | 103 | 105 | 0.000 | 0.002 | 0.002 | 0.003 |
| 3B1a | NH3 | 9'337.10 | 10'144.27 | 6 | 6 | 29 | 29 | 30 | 29 | 0.221 | 1.183 | 1.352 | 1.384 |
| 3B1b | NH3 | 5'190.92 | 7'241.49 | 6 | 6 | 27 | 27 | 27 | 28 | 0.098 | 3.005 | 1.167 | 1.228 |
| 3B2 | NH3 | 509.75 | 483.81 | 6 | 6 | 87 | 87 | 87 | 88 | 0.004 | -0.038 | 0.088 | 0.072 |
| 3B3 | NH3 | 6'965.04 | 4'735.68 | 6 | 6 | 40 | 40 | 41 | 41 | 0.090 | -3.255 | 1.486 | 1.456 |
| 3B4d | NH3 | 158.13 | 160.07 | 6 | 6 | 65 | 64 | 65 | 65 | 0.000 | 0.003 | 0.023 | 0.024 |
| 3B4e | NH3 | 256.31 | 393.78 | 7 | 6 | 52 | 52 | 52 | 53 | 0.001 | 0.202 | 0.114 | 0.120 |
| 3B4f | NH3 | 19.65 | 101.49 | 6 | 6 | 68 | 68 | 68 | 69 | 0.000 | 0.120 | 0.084 | 0.084 |
| 3B4gi | NH3 | 978.79 | 673.74 | 6 | 6 | 82 | 82 | 82 | 82 | 0.007 | -0.447 | 0.394 | 0.379 |
| 3B4gii | NH3 | 304.87 | 680.42 | 6 | 6 | 86 | 85 | 87 | 86 | 0.008 | 0.551 | 0.488 | 0.483 |
| 3B4giii | NH3 | 29.77 | 31.69 | 6 | 6 | 93 | 93 | 93 | 94 | 0.000 | 0.003 | 0.005 | 0.006 |
| 3B4giv | NH3 | 124.46 | 90.55 | 6 | 6 | 85 | 86 | 85 | 86 | 0.000 | -0.050 | 0.048 | 0.044 |
| 3B4h | NH3 | 14.55 | 42.62 | 6 | 6 | 50 | 50 | 50 | 51 | 0.000 | 0.041 | 0.022 | 0.022 |
| 3Da1 | NH3 | 4'258.83 | 2'250.67 | 5 | 5 | 50 | 50 | 50 | 50 | 0.031 | -2.934 | 1.502 | 1.461 |
| 3Da2a | NH3 | 34'567.08 | 20'191.26 | 6 | 6 | 21 | 21 | 22 | 22 | 0.477 | -20.936 | 4.152 | 4.187 |
| 3Da2b | NH3 | 1'169.36 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -1.713 | 0.900 | 0.865 |
| 3Da2c | NH3 | 34.00 | 1'042.45 | 20 | 20 | 50 | 50 | 54 | 54 | 0.008 | 1.479 | 0.805 | 0.849 |
| 3Da3 | NH3 | 760.92 | 1'413.21 | 6 | 6 | 62 | 62 | 62 | 63 | 0.019 | 0.955 | 0.618 | 0.629 |
| 5A | NH3 | 615.79 | 186.65 | 10 | 10 | 50 | 50 | 51 | 51 | 0.000 | -0.629 | 0.346 | 0.331 |
| 5B1 | NH3 | 175.08 | 292.01 | 20 | 20 | 100 | 99 | 101 | 104 | 0.002 | 0.171 | 0.183 | 0.220 |
| 5B2 | NH3 | 10.28 | 245.32 | 20 | 20 | 76 | 74 | 76 | 80 | 0.001 | 0.345 | 0.270 | 0.279 |
| 5C1biv | NH3 | 5.70 | 2.02 | 20 | 20 | 50 | 50 | 53 | 55 | 0.000 | -0.005 | 0.003 | 0.003 |
| 5C2 | NH3 | 13.71 | 9.20 | 48 | 48 | 25 | 25 | 53 | 55 | 0.000 | -0.007 | 0.012 | 0.012 |
| 5D1 | NH3 | 89.98 | 128.83 | 1 | 1 | 50 | 50 | 50 | 50 | 0.000 | 0.057 | 0.030 | 0.030 |
| 6A | NH3 | 845.56 | 969.88 | 30 | 30 | 99 | 101 | 103 | 108 | 0.025 | 0.182 | 0.631 | 0.748 |
| Total, Monte Carlo simulations | | 68'496.6 | 52'898.5 | | | | | 12.2 | 12.1 | 1.0 | -22.7 | 4.8 | 4.9 |
| Total, inventory | | 68'492.4 | 52'895.0 | | | | | | | | -22.8 | | |

Table A - 38 Uncertainty analysis of PM2.5 emissions, approach 2, for 2023 and for the trend 1990-2023. Monte Carlo simulations were run 500'000 times. The reported uncertainties correspond to the borders of the narrowest 95.0 % confidence interval. Contributions to inventory trend (mean, uncertainties, columns I and J) are values normalised by the total inventory base year emission ((fu) means fuel used approach).

| A | B | C | D | E | | F | | G | | H | I | J | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFR | Pollutant | Emissions 1990 | Emissions 2023 | Activity data uncertainty 2023 | | Emission factor uncertainty 2023 | | Emission combined uncertainty 2023 | | Emission contribution to variance 2023 | Contribution to trend | Contribution to uncertainty of trend | |
| | | t | t | (-)% | (+)% | (-)% | (+)% | (-)% | (+)% | Fraction | % | (-)% | (+)% |
| 1A1a | PM2.5 | 781.83 | 46.09 | 10 | 10 | 70 | 72 | 71 | 73 | 0.000 | -2.844 | 2.530 | 2.297 |
| 1A1b | PM2.5 | 47.66 | 1.50 | 1 | 1 | 20 | 20 | 20 | 20 | 0.000 | -0.179 | 0.095 | 0.078 |
| 1A1c | PM2.5 | 4.64 | 13.44 | 5 | 5 | 20 | 20 | 21 | 21 | 0.000 | 0.034 | 0.015 | 0.018 |
| 1A2a | PM2.5 | 14.81 | 2.34 | 2 | 2 | 28 | 28 | 28 | 28 | 0.000 | -0.048 | 0.028 | 0.023 |
| 1A2b | PM2.5 | 20.39 | 1.00 | 2 | 2 | 30 | 30 | 30 | 30 | 0.000 | -0.075 | 0.044 | 0.036 |
| 1A2c | PM2.5 | 40.77 | 5.17 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | -0.138 | 0.070 | 0.055 |
| 1A2d | PM2.5 | 149.62 | 0.18 | 2 | 2 | 33 | 33 | 34 | 33 | 0.000 | -0.580 | 0.346 | 0.297 |
| 1A2e | PM2.5 | 25.68 | 1.11 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | -0.095 | 0.048 | 0.038 |
| 1A2f | PM2.5 | 437.58 | 40.13 | 2 | 2 | 65 | 65 | 66 | 64 | 0.000 | -1.540 | 1.291 | 1.170 |
| 1A2gvii | PM2.5 | 728.86 | 384.17 | 1 | 1 | 50 | 50 | 50 | 50 | 0.010 | -1.336 | 0.943 | 0.841 |
| 1A2gviii | PM2.5 | 872.51 | 186.20 | 2 | 2 | 65 | 65 | 64 | 66 | 0.004 | -2.653 | 2.219 | 1.962 |
| 1A3ai(i) | PM2.5 | 92.39 | 14.12 | 1 | 1 | 29 | 30 | 30 | 30 | 0.000 | -0.304 | 0.177 | 0.148 |
| 1A3aii(i) | PM2.5 | 22.67 | 1.69 | 1 | 1 | 30 | 30 | 30 | 30 | 0.000 | -0.081 | 0.048 | 0.039 |
| 1A3bi(fu) | PM2.5 | 579.17 | 98.62 | 1 | 1 | 57 | 57 | 57 | 57 | 0.001 | -1.861 | 1.429 | 1.283 |
| 1A3bii(fu) | PM2.5 | 329.00 | 48.06 | 1 | 1 | 48 | 48 | 48 | 48 | 0.000 | -1.091 | 0.775 | 0.666 |
| 1A3biii(fu) | PM2.5 | 1'584.33 | 36.16 | 1 | 1 | 27 | 27 | 27 | 27 | 0.000 | -6.004 | 3.348 | 2.778 |
| 1A3biv(fu) | PM2.5 | 209.02 | 57.14 | 1 | 1 | 53 | 54 | 53 | 55 | 0.000 | -0.589 | 0.444 | 0.389 |
| 1A3bvi(fu) | PM2.5 | 689.50 | 958.18 | 1 | 1 | 50 | 50 | 50 | 51 | 0.061 | 1.040 | 0.656 | 0.739 |
| 1A3c | PM2.5 | 172.71 | 232.99 | 1 | 1 | 51 | 49 | 50 | 50 | 0.004 | 0.234 | 0.148 | 0.169 |
| 1A3dii | PM2.5 | 59.09 | 21.94 | 1 | 1 | 50 | 50 | 50 | 50 | 0.000 | -0.144 | 0.104 | 0.091 |
| 1A3ei | PM2.5 | 0.11 | 0.04 | 2 | 2 | 28 | 27 | 27 | 27 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ai | PM2.5 | 1'354.47 | 429.98 | 2 | 2 | 78 | 78 | 78 | 78 | 0.030 | -3.553 | 3.273 | 3.065 |
| 1A4bi | PM2.5 | 14'535.91 | 1'851.74 | 4 | 4 | 76 | 76 | 76 | 76 | 0.530 | -44.700 | 16.943 | 20.511 |
| 1A4ci | PM2.5 | 696.98 | 204.88 | 21 | 21 | 39 | 39 | 44 | 45 | 0.002 | -1.908 | 1.358 | 1.142 |
| 1A4cii | PM2.5 | 435.10 | 127.76 | 1 | 1 | 80 | 80 | 79 | 81 | 0.003 | -1.188 | 1.167 | 1.044 |
| 1A5b | PM2.5 | 86.95 | 44.87 | 1 | 1 | 50 | 50 | 50 | 50 | 0.000 | -0.163 | 0.119 | 0.103 |
| 1B1a | PM2.5 | 0.16 | 0.04 | 30 | 30 | 40 | 40 | 49 | 51 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1B2c | PM2.5 | 0.44 | 0.00 | 22 | 22 | 100 | 244 | 100 | 245 | 0.000 | -0.002 | 0.004 | 0.002 |
| 2A1 | PM2.5 | 240.48 | 142.77 | 2 | 2 | 100 | 204 | 100 | 204 | 0.022 | -0.376 | 0.783 | 0.376 |
| 2A2 | PM2.5 | 7.21 | 6.60 | 2 | 2 | 100 | 446 | 100 | 446 | 0.000 | -0.002 | 0.010 | 0.002 |
| 2A5a | PM2.5 | 102.21 | 97.86 | 5 | 5 | 100 | 447 | 100 | 448 | 0.064 | -0.016 | 0.094 | 0.038 |
| 2B5 | PM2.5 | 61.20 | 39.43 | 2 | 2 | 83 | 101 | 84 | 100 | 0.000 | -0.084 | 0.095 | 0.074 |
| 2B10a | PM2.5 | 7.86 | NA | NA | NA | NA | NA | NA | NA | 0.000 | -0.031 | 0.020 | 0.017 |
| 2C1 | PM2.5 | 817.90 | 6.81 | 2 | 2 | 94 | 125 | 94 | 125 | 0.000 | -3.106 | 4.069 | 2.948 |
| 2C3 | PM2.5 | 78.33 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.302 | 0.635 | 0.302 |
| 2C7a | PM2.5 | 5.66 | 0.50 | 5 | 5 | 100 | 204 | 100 | 205 | 0.000 | -0.020 | 0.042 | 0.020 |
| 2C7c | PM2.5 | 1.53 | 1.40 | 5 | 5 | 100 | 446 | 100 | 446 | 0.000 | -0.001 | 0.002 | 0.001 |
| 2D3c | PM2.5 | 4.00 | 3.81 | 20 | 20 | 100 | 203 | 100 | 205 | 0.000 | -0.001 | 0.007 | 0.006 |
| 2D3i | PM2.5 | 12.00 | NA | NA | NA | NA | NA | NA | NA | 0.000 | -0.046 | 0.205 | 0.046 |
| 2G | PM2.5 | 512.78 | 327.02 | 25 | 25 | 84 | 100 | 84 | 105 | 0.031 | -0.717 | 1.091 | 0.730 |
| 2H1 | PM2.5 | 235.77 | 150.91 | 30 | 30 | 100 | 204 | 100 | 207 | 0.025 | -0.326 | 0.867 | 0.391 |
| 2H2 | PM2.5 | 187.99 | 166.06 | 10 | 10 | 100 | 446 | 100 | 446 | 0.184 | -0.081 | 0.416 | 0.108 |
| 2H3 | PM2.5 | 15.60 | 3.87 | 3 | 3 | 100 | 205 | 100 | 205 | 0.000 | -0.046 | 0.096 | 0.046 |
| 2I | PM2.5 | 216.08 | 47.23 | 10 | 10 | 100 | 447 | 100 | 448 | 0.015 | -0.623 | 2.806 | 0.623 |
| 3B1a | PM2.5 | 20.61 | 23.05 | 6 | 6 | 100 | 306 | 100 | 306 | 0.001 | 0.009 | 0.010 | 0.032 |
| 3B1b | PM2.5 | 18.26 | 22.19 | 6 | 7 | 100 | 305 | 100 | 305 | 0.001 | 0.015 | 0.015 | 0.047 |
| 3B2 | PM2.5 | 0.79 | 0.82 | 6 | 6 | 100 | 305 | 100 | 306 | 0.000 | 0.000 | 0.000 | 0.001 |
| 3B3 | PM2.5 | 9.57 | 6.35 | 6 | 6 | 100 | 306 | 100 | 306 | 0.000 | -0.012 | 0.039 | 0.012 |
| 3B4d | PM2.5 | 0.14 | 0.18 | 6 | 6 | 100 | 305 | 100 | 306 | 0.000 | 0.000 | 0.000 | 0.001 |
| 3B4e | PM2.5 | 3.94 | 6.73 | 6 | 6 | 100 | 306 | 100 | 306 | 0.000 | 0.011 | 0.011 | 0.033 |
| 3B4f | PM2.5 | 0.59 | 3.35 | 6 | 6 | 100 | 306 | 100 | 305 | 0.000 | 0.011 | 0.011 | 0.033 |
| 3B4gi | PM2.5 | 9.25 | 11.52 | 6 | 6 | 100 | 306 | 100 | 306 | 0.000 | 0.009 | 0.009 | 0.028 |
| 3B4gii | PM2.5 | 6.78 | 21.19 | 6 | 6 | 100 | 306 | 100 | 306 | 0.001 | 0.056 | 0.056 | 0.172 |
| 3B4giii | PM2.5 | 1.89 | 2.42 | 6 | 6 | 100 | 305 | 100 | 306 | 0.000 | 0.002 | 0.002 | 0.006 |
| 3B4giv | PM2.5 | 1.98 | 3.11 | 6 | 6 | 100 | 305 | 100 | 305 | 0.000 | 0.004 | 0.004 | 0.013 |
| 3B4h | PM2.5 | 0.24 | 0.09 | 6 | 6 | 100 | 308 | 100 | 308 | 0.000 | -0.001 | 0.002 | 0.001 |
| 3De | PM2.5 | 47.48 | 44.87 | 5 | 5 | 100 | 204 | 100 | 204 | 0.002 | -0.010 | 0.030 | 0.015 |
| 5A | PM2.5 | 0.73 | 0.50 | 10 | 10 | 30 | 30 | 31 | 32 | 0.000 | -0.001 | 0.001 | 0.001 |
| 5B2 | PM2.5 | NA | 0.06 | 20 | 20 | 101 | 100 | 102 | 104 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1a | PM2.5 | 465.12 | 220.58 | 49 | 51 | 30 | 30 | 58 | 59 | 0.005 | -0.947 | 1.220 | 1.084 |
| 5C1bi | PM2.5 | 0.47 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.002 | 0.001 | 0.001 |
| 5C1biii | PM2.5 | 16.50 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.064 | 0.042 | 0.036 |
| 5C1biv | PM2.5 | 14.25 | 2.98 | 20 | 20 | 34 | 34 | 39 | 40 | 0.000 | -0.044 | 0.029 | 0.025 |
| 5C1bv | PM2.5 | 4.39 | 0.83 | 5 | 5 | 33 | 33 | 34 | 33 | 0.000 | -0.014 | 0.008 | 0.007 |
| 5C2 | PM2.5 | 64.43 | 43.25 | 48 | 48 | 100 | 157 | 100 | 168 | 0.001 | -0.082 | 0.266 | 0.171 |
| 5E | PM2.5 | 1.40 | 1.50 | 20 | 20 | 30 | 30 | 35 | 37 | 0.000 | 0.000 | 0.002 | 0.002 |
| 6A | PM2.5 | 4.42 | 4.69 | 30 | 30 | 40 | 40 | 49 | 51 | 0.000 | 0.001 | 0.008 | 0.008 |
| Total, Monte Carlo simulations | | 27'152.2 | 6'220.6 | | | | | 30.6 | 30.8 | 1.0 | -76.6 | 5.1 | 6.3 |
| Total, inventory | | 27'172.2 | 6'224.0 | | | | | | | | -77.1 | | |

Table A - 39 Uncertainty analysis of PM10 emissions, approach 2, for 2023 and for the trend 1990-2023. Monte Carlo simulations were run 500'000 times. The reported uncertainties correspond to the borders of the narrowest 95.0 % confidence interval. Contributions to inventory trend (mean, uncertainties, columns I and J) are values normalised by the total inventory base year emission ((fu) means fuel used approach).

| A | B | C | D | E | | F | | G | | H | I | J | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFR | Pollutant | Emissions 1990 | Emissions 2023 | Activity data uncertainty 2023 | | Emission factor uncertainty 2023 | | Emission combined uncertainty 2023 | | Emission contribution to variance 2023 | Contribution to trend | Contribution to uncertainty of trend | |
| | | t | t | (-)% | (+)% | (-)% | (+)% | (-)% | (+)% | Fraction | % | (-)% | (+)% |
| 1A1a | PM10 | 1'044.54 | 46.09 | 10 | 10 | 71 | 71 | 72 | 71 | 0.000 | -2.829 | 2.379 | 2.179 |
| 1A1b | PM10 | 47.66 | 1.50 | 1 | 1 | 20 | 20 | 20 | 20 | 0.000 | -0.131 | 0.060 | 0.051 |
| 1A1c | PM10 | 4.89 | 14.17 | 5 | 5 | 20 | 20 | 21 | 21 | 0.000 | 0.026 | 0.011 | 0.012 |
| 1A2a | PM10 | 20.53 | 2.61 | 2 | 2 | 28 | 28 | 28 | 28 | 0.000 | -0.051 | 0.025 | 0.022 |
| 1A2b | PM10 | 29.24 | 1.05 | 2 | 2 | 30 | 30 | 30 | 30 | 0.000 | -0.080 | 0.041 | 0.036 |
| 1A2c | PM10 | 40.77 | 5.17 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | -0.101 | 0.042 | 0.036 |
| 1A2d | PM10 | 166.58 | 0.18 | 2 | 2 | 33 | 33 | 33 | 33 | 0.000 | -0.473 | 0.251 | 0.221 |
| 1A2e | PM10 | 25.68 | 1.11 | 2 | 2 | 10 | 10 | 10 | 10 | 0.000 | -0.070 | 0.029 | 0.024 |
| 1A2f | PM10 | 832.63 | 68.17 | 2 | 2 | 65 | 64 | 65 | 65 | 0.000 | -2.167 | 1.713 | 1.538 |
| 1A2gvii | PM10 | 2'173.23 | 2'366.27 | 1 | 1 | 50 | 50 | 50 | 50 | 0.079 | 0.546 | 0.328 | 0.370 |
| 1A2gviii | PM10 | 913.14 | 196.65 | 2 | 2 | 65 | 64 | 66 | 64 | 0.001 | -2.032 | 1.583 | 1.464 |
| 1A3ai(i) | PM10 | 102.65 | 14.12 | 1 | 1 | 30 | 30 | 30 | 30 | 0.000 | -0.252 | 0.128 | 0.113 |
| 1A3aii(i) | PM10 | 25.19 | 1.69 | 1 | 1 | 31 | 29 | 30 | 30 | 0.000 | -0.067 | 0.034 | 0.030 |
| 1A3bi(fu) | PM10 | 579.17 | 98.62 | 1 | 1 | 57 | 57 | 57 | 57 | 0.000 | -1.365 | 0.976 | 0.894 |
| 1A3bii(fu) | PM10 | 329.00 | 48.06 | 1 | 1 | 49 | 48 | 49 | 48 | 0.000 | -0.798 | 0.515 | 0.464 |
| 1A3biii(fu) | PM10 | 1'584.33 | 36.16 | 1 | 1 | 27 | 27 | 27 | 27 | 0.000 | -4.399 | 2.132 | 1.859 |
| 1A3biv(fu) | PM10 | 209.02 | 57.14 | 1 | 1 | 54 | 54 | 55 | 53 | 0.000 | -0.432 | 0.299 | 0.273 |
| 1A3bvi(fu) | PM10 | 2'045.83 | 2'609.72 | 1 | 1 | 50 | 50 | 50 | 50 | 0.096 | 1.597 | 0.934 | 1.027 |
| 1A3c | PM10 | 969.78 | 1'516.58 | 1 | 1 | 50 | 50 | 50 | 50 | 0.032 | 1.552 | 0.925 | 1.009 |
| 1A3dii | PM10 | 59.09 | 21.94 | 1 | 1 | 50 | 50 | 50 | 50 | 0.000 | -0.106 | 0.069 | 0.064 |
| 1A3ei | PM10 | 0.11 | 0.04 | 2 | 2 | 27 | 27 | 27 | 27 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1A4ai | PM10 | 1'427.63 | 457.11 | 2 | 2 | 79 | 77 | 79 | 77 | 0.007 | -2.743 | 2.442 | 2.271 |
| 1A4bi | PM10 | 15'325.72 | 1'948.21 | 4 | 4 | 76 | 76 | 75 | 77 | 0.123 | -35.449 | 16.897 | 19.269 |
| 1A4ci | PM10 | 710.36 | 208.01 | 21 | 21 | 40 | 38 | 43 | 45 | 0.000 | -1.427 | 0.927 | 0.818 |
| 1A4cii | PM10 | 511.19 | 185.85 | 1 | 1 | 80 | 80 | 81 | 79 | 0.001 | -0.923 | 0.849 | 0.796 |
| 1A5b | PM10 | 286.52 | 261.49 | 1 | 1 | 49 | 51 | 50 | 50 | 0.001 | -0.071 | 0.050 | 0.044 |
| 1B1a | PM10 | 1.60 | 0.38 | 30 | 30 | 40 | 40 | 48 | 51 | 0.000 | -0.003 | 0.002 | 0.002 |
| 1B2c | PM10 | 0.44 | 0.00 | 22 | 22 | 100 | 243 | 100 | 244 | 0.000 | -0.001 | 0.003 | 0.001 |
| 2A1 | PM10 | 374.35 | 222.25 | 2 | 2 | 100 | 203 | 100 | 203 | 0.011 | -0.429 | 0.881 | 0.429 |
| 2A2 | PM10 | 14.41 | 13.18 | 2 | 2 | 100 | 449 | 100 | 449 | 0.000 | -0.003 | 0.015 | 0.003 |
| 2A5a | PM10 | 302.32 | 347.67 | 5 | 5 | 100 | 446 | 100 | 446 | 0.169 | 0.121 | 0.121 | 0.539 |
| 2B5 | PM10 | 73.80 | 47.59 | 2 | 2 | 83 | 101 | 83 | 101 | 0.000 | -0.075 | 0.081 | 0.064 |
| 2B10a | PM10 | 17.07 | NA | NA | NA | NA | NA | NA | NA | 0.000 | -0.049 | 0.028 | 0.025 |
| 2C1 | PM10 | 1'485.46 | 10.46 | 2 | 2 | 94 | 125 | 94 | 125 | 0.000 | -4.120 | 5.180 | 3.887 |
| 2C3 | PM10 | 113.15 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.320 | 0.670 | 0.320 |
| 2C7a | PM10 | 5.96 | 0.53 | 5 | 5 | 100 | 204 | 100 | 204 | 0.000 | -0.015 | 0.032 | 0.015 |
| 2C7c | PM10 | 3.06 | 2.78 | 5 | 5 | 100 | 447 | 100 | 447 | 0.000 | -0.001 | 0.004 | 0.001 |
| 2D3c | PM10 | 19.98 | 19.05 | 20 | 20 | 100 | 204 | 100 | 206 | 0.000 | -0.003 | 0.027 | 0.023 |
| 2D3i | PM10 | 24.00 | NA | NA | NA | NA | NA | NA | NA | 0.000 | -0.068 | 0.302 | 0.068 |
| 2G | PM10 | 588.38 | 398.75 | 25 | 25 | 84 | 100 | 85 | 104 | 0.010 | -0.536 | 0.868 | 0.592 |
| 2H1 | PM10 | 243.80 | 156.07 | 30 | 30 | 100 | 204 | 100 | 207 | 0.006 | -0.248 | 0.661 | 0.295 |
| 2H2 | PM10 | 310.39 | 308.26 | 10 | 10 | 100 | 448 | 100 | 447 | 0.132 | -0.005 | 0.264 | 0.249 |
| 2H3 | PM10 | 15.60 | 3.87 | 3 | 3 | 100 | 205 | 100 | 205 | 0.000 | -0.033 | 0.070 | 0.033 |
| 2I | PM10 | 864.32 | 187.64 | 10 | 10 | 100 | 446 | 100 | 446 | 0.050 | -1.682 | 7.741 | 1.682 |
| 3B1a | PM10 | 84.47 | 94.45 | 6 | 6 | 100 | 306 | 100 | 305 | 0.005 | 0.028 | 0.030 | 0.095 |
| 3B1b | PM10 | 74.85 | 90.95 | 7 | 6 | 100 | 306 | 100 | 306 | 0.004 | 0.046 | 0.046 | 0.142 |
| 3B2 | PM10 | 19.76 | 20.43 | 6 | 6 | 100 | 306 | 100 | 307 | 0.000 | 0.002 | 0.008 | 0.012 |
| 3B3 | PM10 | 213.16 | 142.62 | 6 | 6 | 100 | 306 | 100 | 306 | 0.010 | -0.198 | 0.608 | 0.198 |
| 3B4d | PM10 | 3.42 | 4.58 | 6 | 6 | 100 | 306 | 100 | 305 | 0.000 | 0.003 | 0.003 | 0.010 |
| 3B4e | PM10 | 6.20 | 10.58 | 6 | 6 | 100 | 307 | 100 | 307 | 0.000 | 0.012 | 0.012 | 0.039 |
| 3B4f | PM10 | 0.94 | 5.36 | 6 | 6 | 100 | 305 | 100 | 306 | 0.000 | 0.013 | 0.013 | 0.039 |
| 3B4gi | PM10 | 123.32 | 153.65 | 6 | 6 | 100 | 305 | 100 | 306 | 0.012 | 0.085 | 0.085 | 0.264 |
| 3B4gii | PM10 | 67.84 | 211.92 | 6 | 6 | 100 | 307 | 100 | 307 | 0.023 | 0.409 | 0.409 | 1.268 |
| 3B4giii | PM10 | 10.41 | 13.29 | 6 | 6 | 100 | 305 | 100 | 306 | 0.000 | 0.008 | 0.008 | 0.025 |
| 3B4giv | PM10 | 18.52 | 29.57 | 6 | 6 | 100 | 307 | 100 | 307 | 0.000 | 0.031 | 0.031 | 0.097 |
| 3B4h | PM10 | 0.50 | 0.80 | 6 | 6 | 100 | 307 | 100 | 307 | 0.000 | 0.001 | 0.001 | 0.003 |
| 3De | PM10 | 1'053.57 | 999.51 | 5 | 5 | 100 | 204 | 100 | 204 | 0.224 | -0.149 | 0.460 | 0.236 |
| 5A | PM10 | 0.73 | 0.50 | 10 | 10 | 30 | 30 | 32 | 32 | 0.000 | -0.001 | 0.000 | 0.000 |
| 5B2 | PM10 | NA | 0.06 | 20 | 20 | 100 | 100 | 102 | 103 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5C1a | PM10 | 516.80 | 245.09 | 50 | 50 | 50 | 50 | 68 | 72 | 0.002 | -0.770 | 1.036 | 0.882 |
| 5C1bi | PM10 | 3.08 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.009 | 0.005 | 0.005 |
| 5C1biii | PM10 | 24.00 | NO | NO | NO | NO | NO | NO | NO | 0.000 | -0.068 | 0.041 | 0.036 |
| 5C1biv | PM10 | 19.95 | 4.25 | 20 | 20 | 35 | 35 | 40 | 41 | 0.000 | -0.045 | 0.027 | 0.024 |
| 5C1bv | PM10 | 4.39 | 0.83 | 5 | 5 | 33 | 33 | 33 | 34 | 0.000 | -0.010 | 0.005 | 0.005 |
| 5C2 | PM10 | 70.77 | 47.50 | 48 | 48 | 100 | 155 | 100 | 167 | 0.000 | -0.066 | 0.216 | 0.132 |
| 5E | PM10 | 2.80 | 3.00 | 20 | 20 | 30 | 30 | 36 | 36 | 0.000 | 0.001 | 0.002 | 0.003 |
| 6A | PM10 | 229.38 | 113.32 | 30 | 30 | 40 | 40 | 49 | 51 | 0.000 | -0.330 | 0.304 | 0.262 |
| Total, Monte Carlo simulations | | 36'472.5 | 14'074.3 | | | | | 27.8 | 30.9 | 1.0 | -60.7 | 10.5 | 12.2 |
| Total, inventory | | 36'471.4 | 14'078.4 | | | | | | | | -61.4 | | |

## A5.3.2 Uncertainty estimations, approach 2, sensitivity results

Results for the sensitivity analysis between emissions from each category and inventory emission are given as tornado plots, in Figure A - 5 to

Figure A - 10.

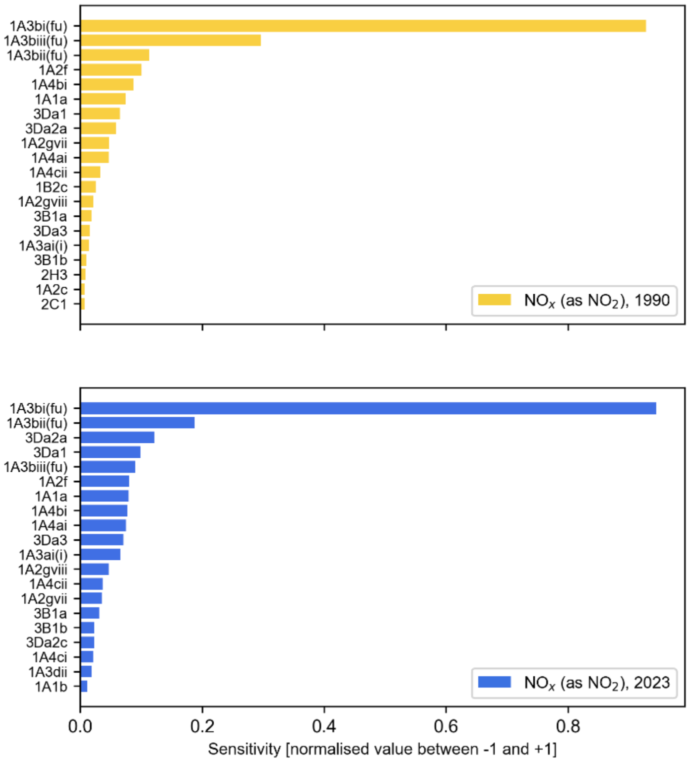


Figure A - 5 Results of the sensitivity analysis between emissions from each category and inventory emissions for $NO_x$, for the base year 1990 and the reporting year 2023 ((fu) means fuel used approach). Only the twenty categories ranked first are listed. See chp. 1.7 for details and compare also with Table 1-9 (results for the key category analysis approach 2, i.e. using uncertainties).

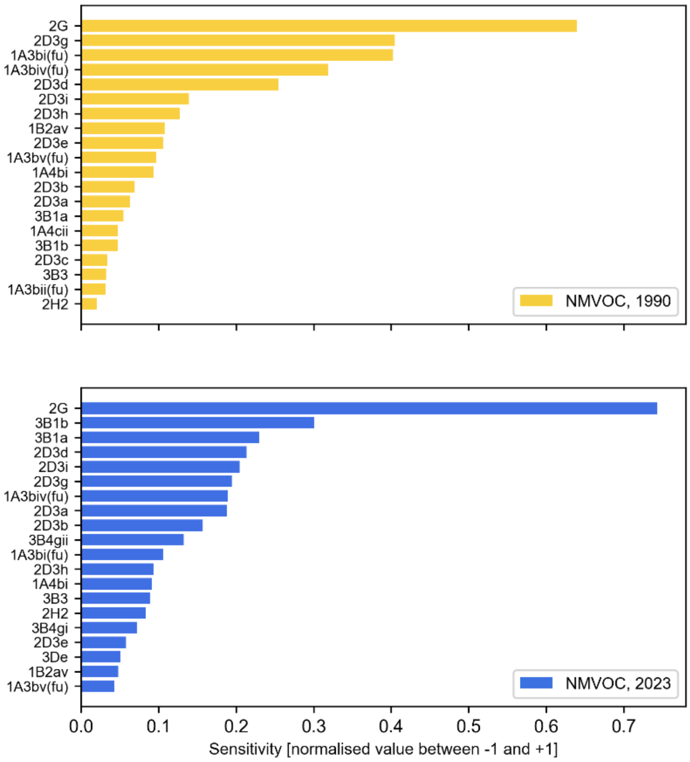


Figure A - 6 Results of the sensitivity analysis between emissions from each category and inventory emissions for NMVOC, for the base year 1990 and the reporting year 2023 ((fu) means fuel used approach). Only the twenty categories ranked first are listed. See chp. 1.7 for details and compare also with Table 1-9 (results for the key category analysis approach 2, i.e. using uncertainties).

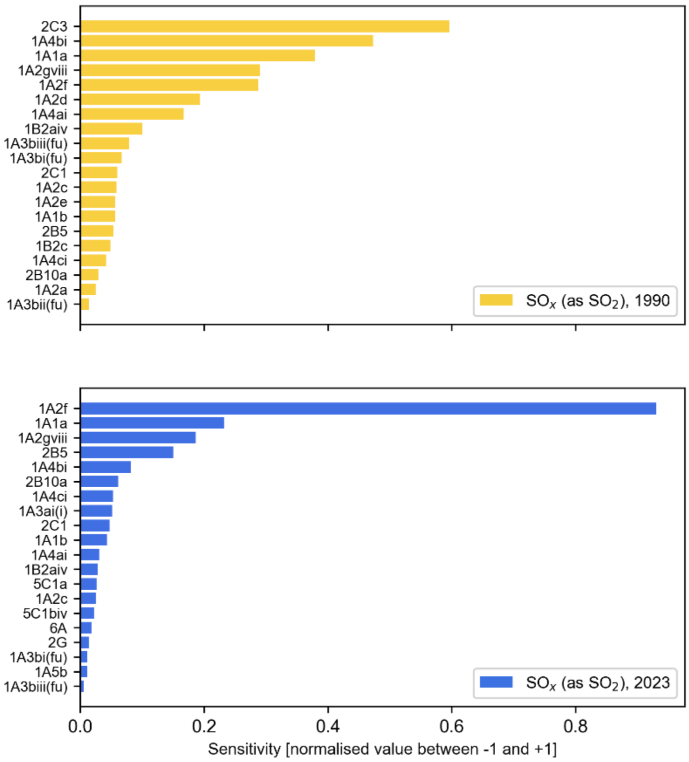


Figure A - 7 Results of the sensitivity analysis between emissions from each category and inventory emissions for $SO_x$ (expressed as $SO_2$ equivalents), for the base year 1990 and the reporting year 2023 ((fu) means fuel used approach). Only the twenty categories ranked first are listed. See chp. 1.7 for details and compare also with Table 1-9 (results for the key category analysis approach 2, i.e. using uncertainties).

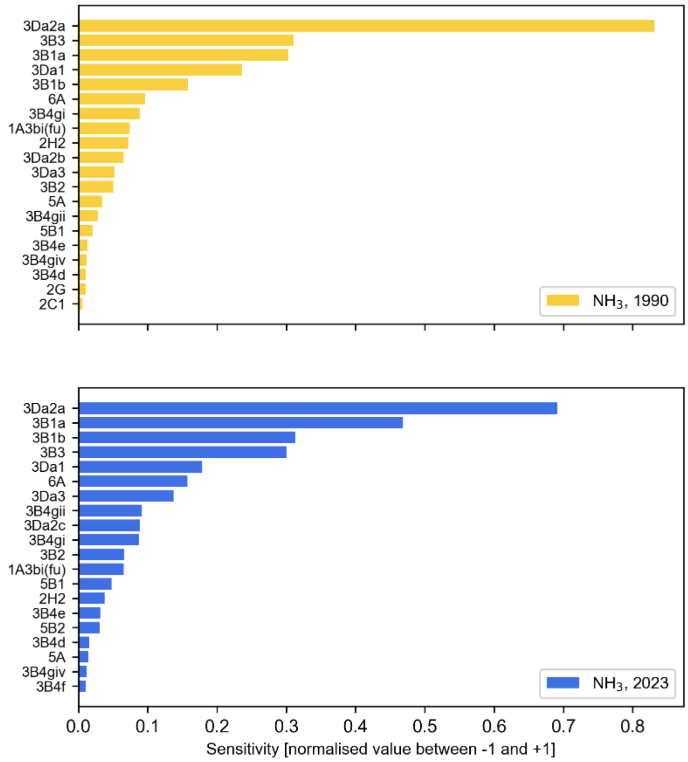


Figure A - 8 Results of the sensitivity analysis between emissions from each category and inventory emissions for $NH_3$, for the base year 1990 and the reporting year 2023 ((fu) means fuel used approach). Only the twenty categories ranked first are listed. See chp. 1.7 for details and compare also with Table 1-9 (results for the key category analysis approach 2, i.e. using uncertainties).

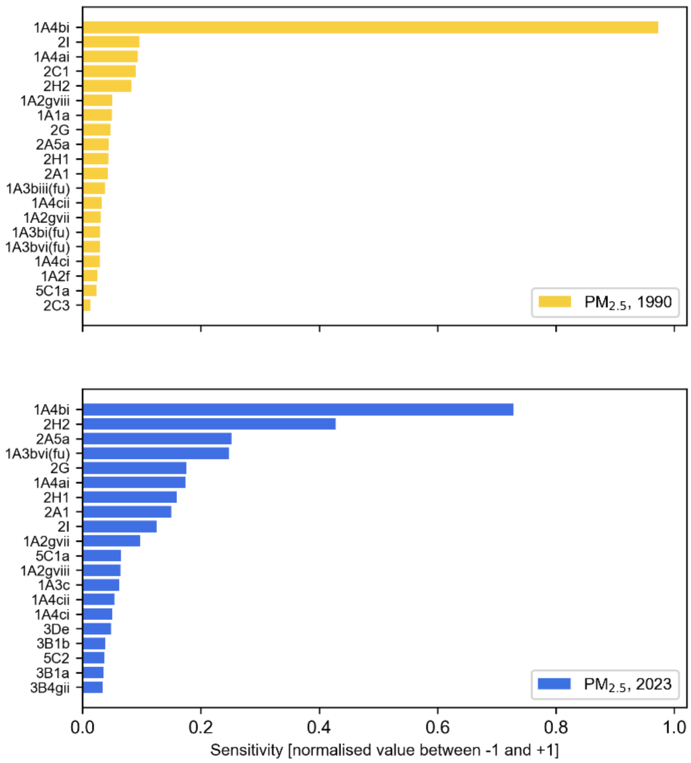


Figure A - 9 Results of the sensitivity analysis between emissions from each category and inventory emissions for PM2.5, for the base year 1990 and the reporting year 2023 ((fu) means fuel used approach). Only the twenty categories ranked first are listed. See chp. 1.7 for details and compare also with Table 1-9 (results for the key category analysis approach 2, i.e. using uncertainties).

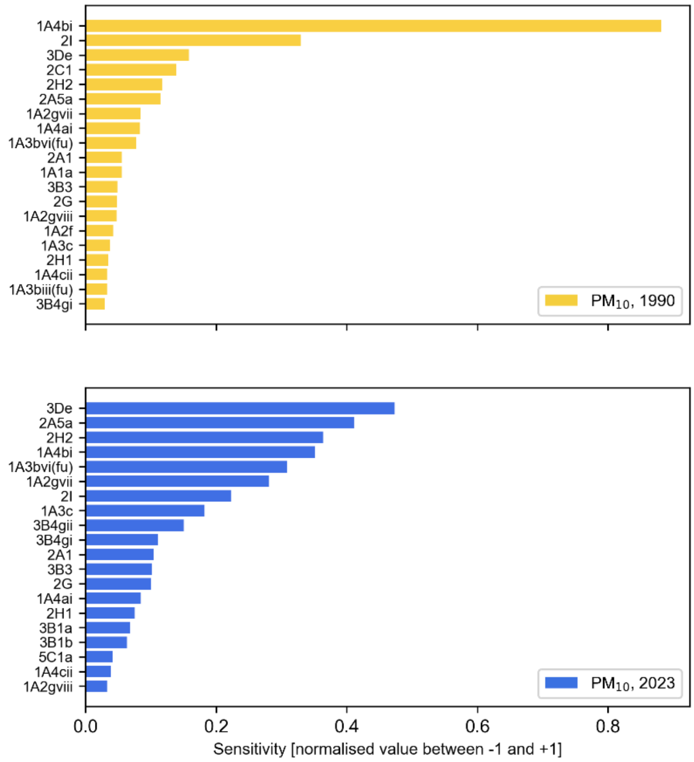


Figure A - 10 Results of the sensitivity analysis between emissions from each category and inventory emissions for PM10, for the base year 1990 and the reporting year 2023. Only the twenty categories ranked first are listed. See chp. 1.7 for details and compare also with Table 1-9 (results for the key category analysis approach 2, i.e. using uncertainties).

### A5.3.3 Uncertainty estimations, approach 2, generated distributions for inventory emissions

The following figures present the probability distributions generated by Monte Carlo simulations for each pollutant, for the base year, the reporting year and the trend. Each distribution is fitted using a continuous, normal probability density function, whose integral (or total area) has a value of one, by definition. Therefore, for variables with a large uncertainty, the probability values, depicted on the y-axis, can be very low.

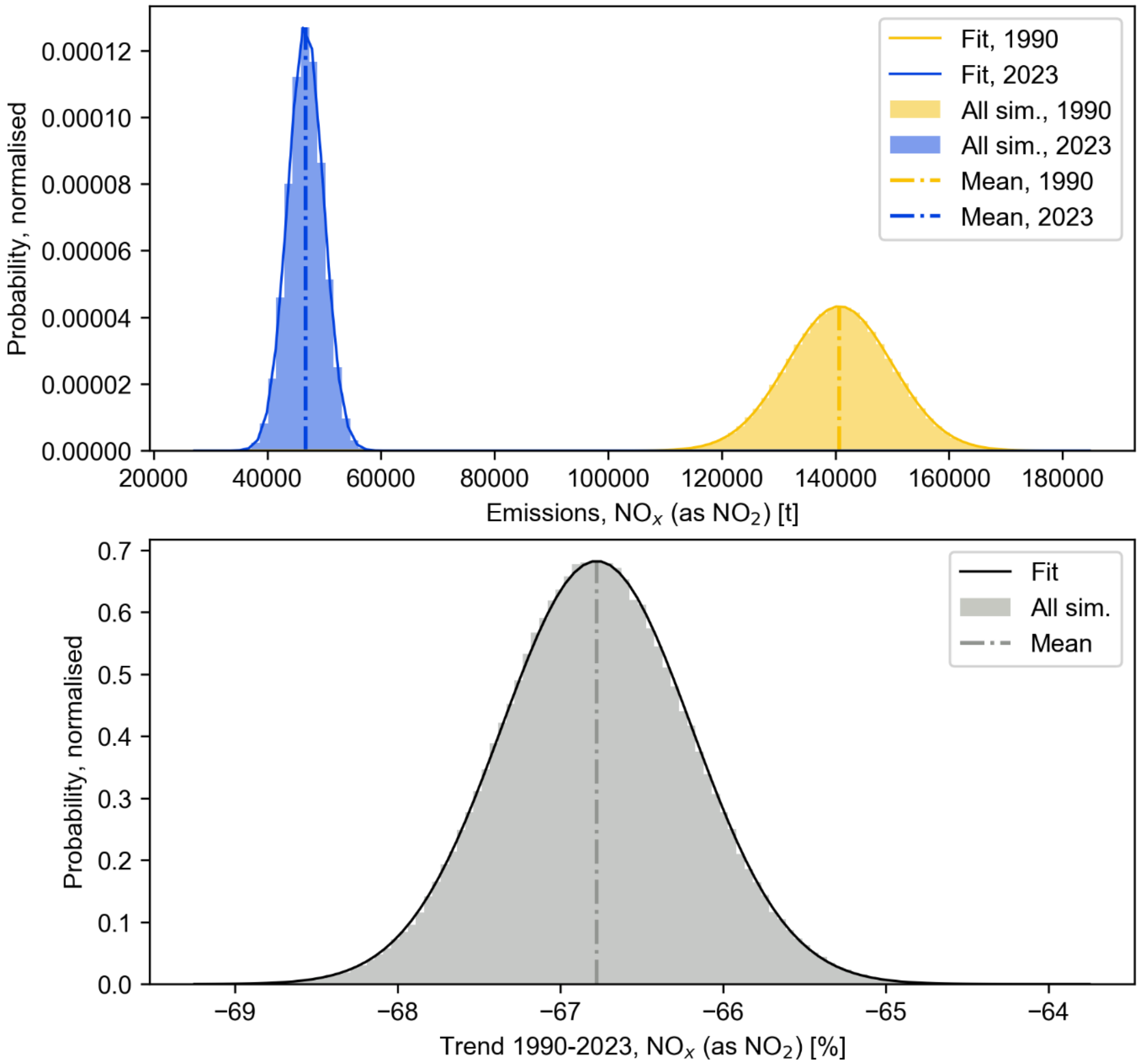


Figure A - 11 Monte Carlo simulations: Distributions obtained for the inventory mean emission for $NO_x$, for the base year 1990 (top panel, yellow), the reporting year 2023 (top panel, blue) and the trend 1990-2023 (bottom panel, grey). All sim.: all simulations (500’000 values for each distribution). Fit: fit of the distribution using a normal distribution. Mean: mean inventory emission obtained from the simulations.

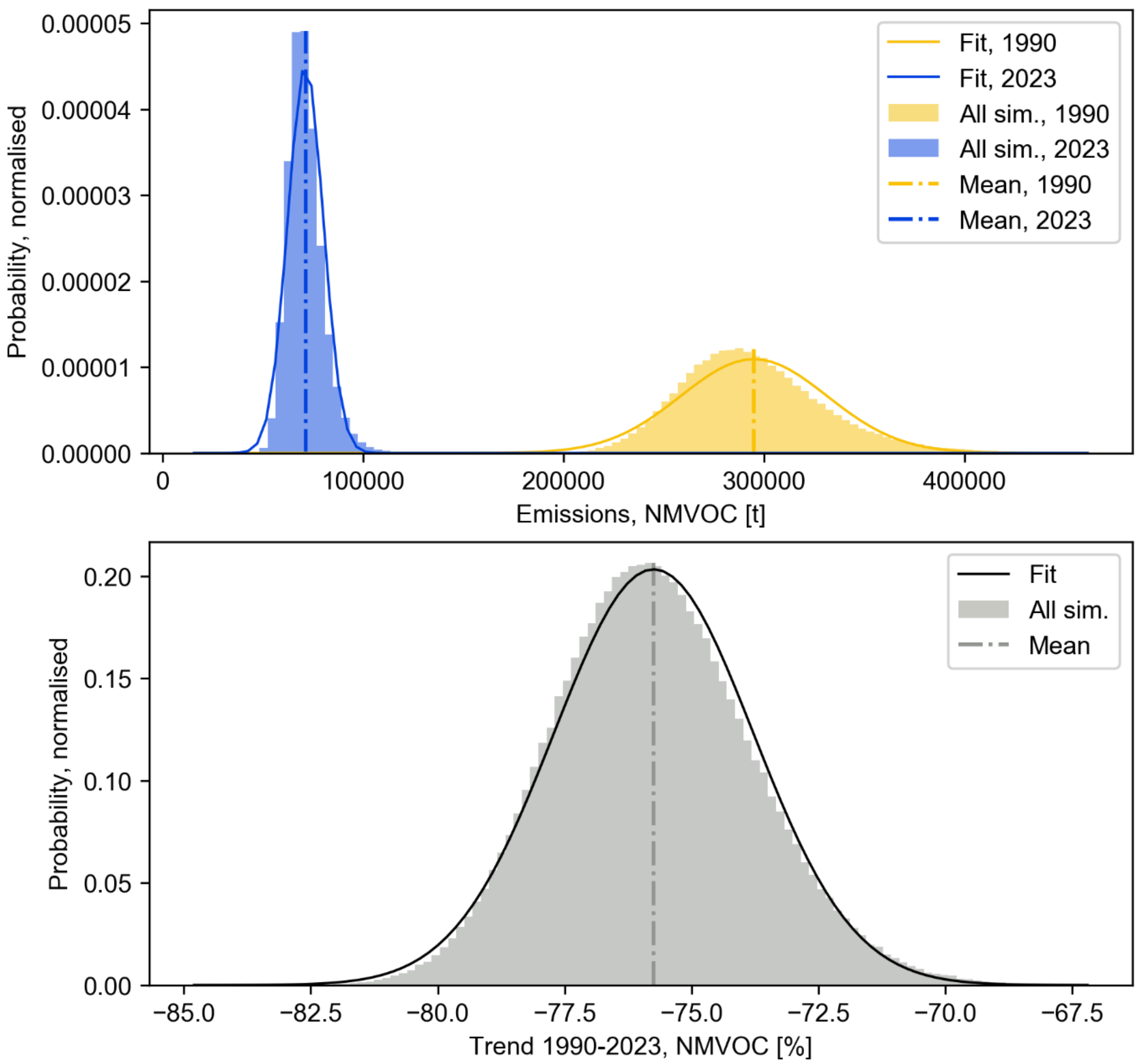


Figure A - 12 Monte Carlo simulations: Distributions obtained for the inventory mean emission for NMVOC, for the base year 1990 (top panel, yellow), the reporting year 2023 (top panel, blue) and the trend 1990-2023 (bottom panel, grey). All sim: all simulations (500'000 values for each distribution). Fit: fit of the distribution using a normal distribution. Mean: mean inventory emission obtained from the simulations.

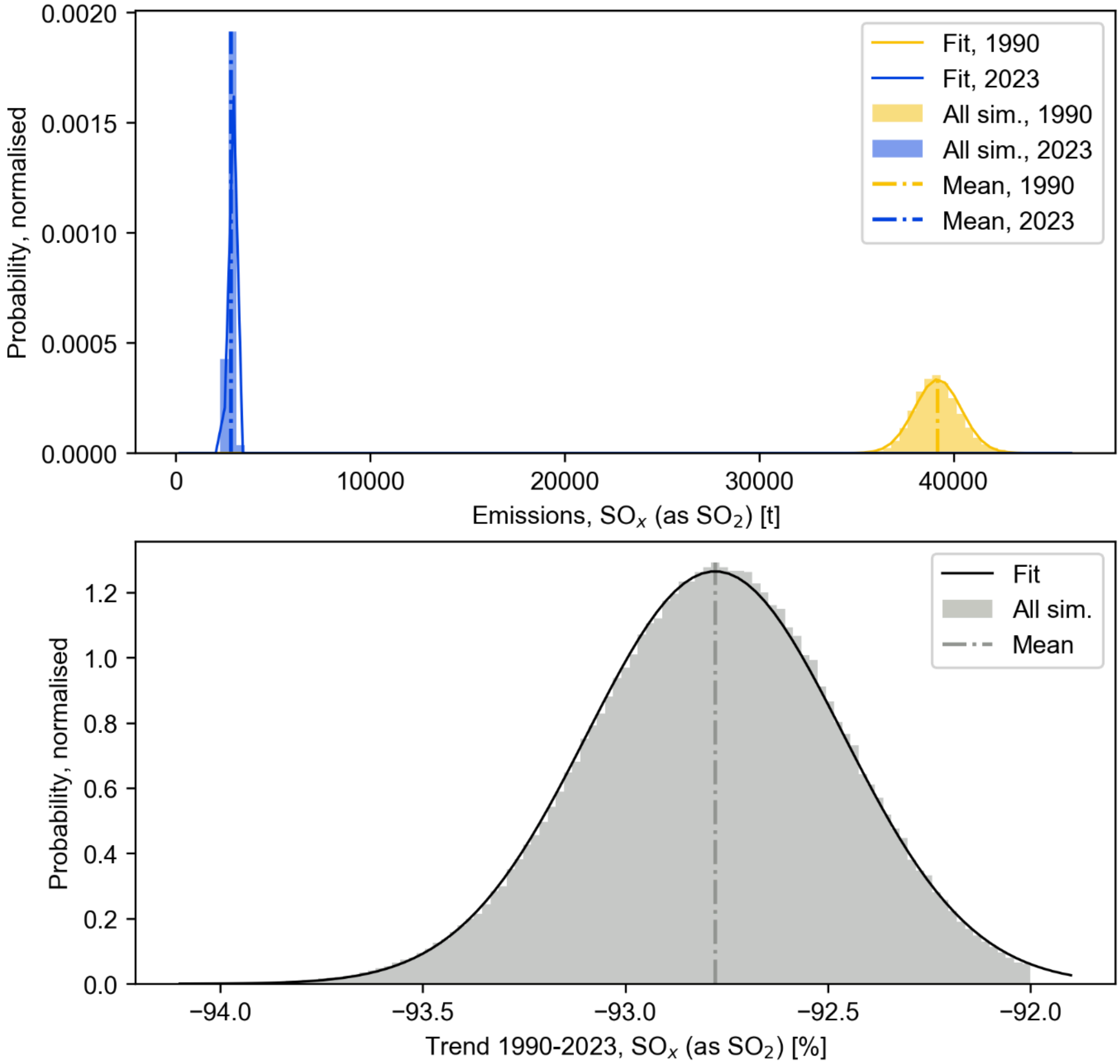


Figure A - 13 Monte Carlo simulations: Distributions obtained for the inventory mean emission for $SO_x$, for the base year 1990 (top panel, yellow), the reporting year 2023 (top panel, blue) and the trend 1990-2023 (bottom panel, grey). All sim: all simulations (500’000 values for each distribution). Fit: fit of the distribution using a normal distribution. Mean: mean inventory emission obtained from the simulations.

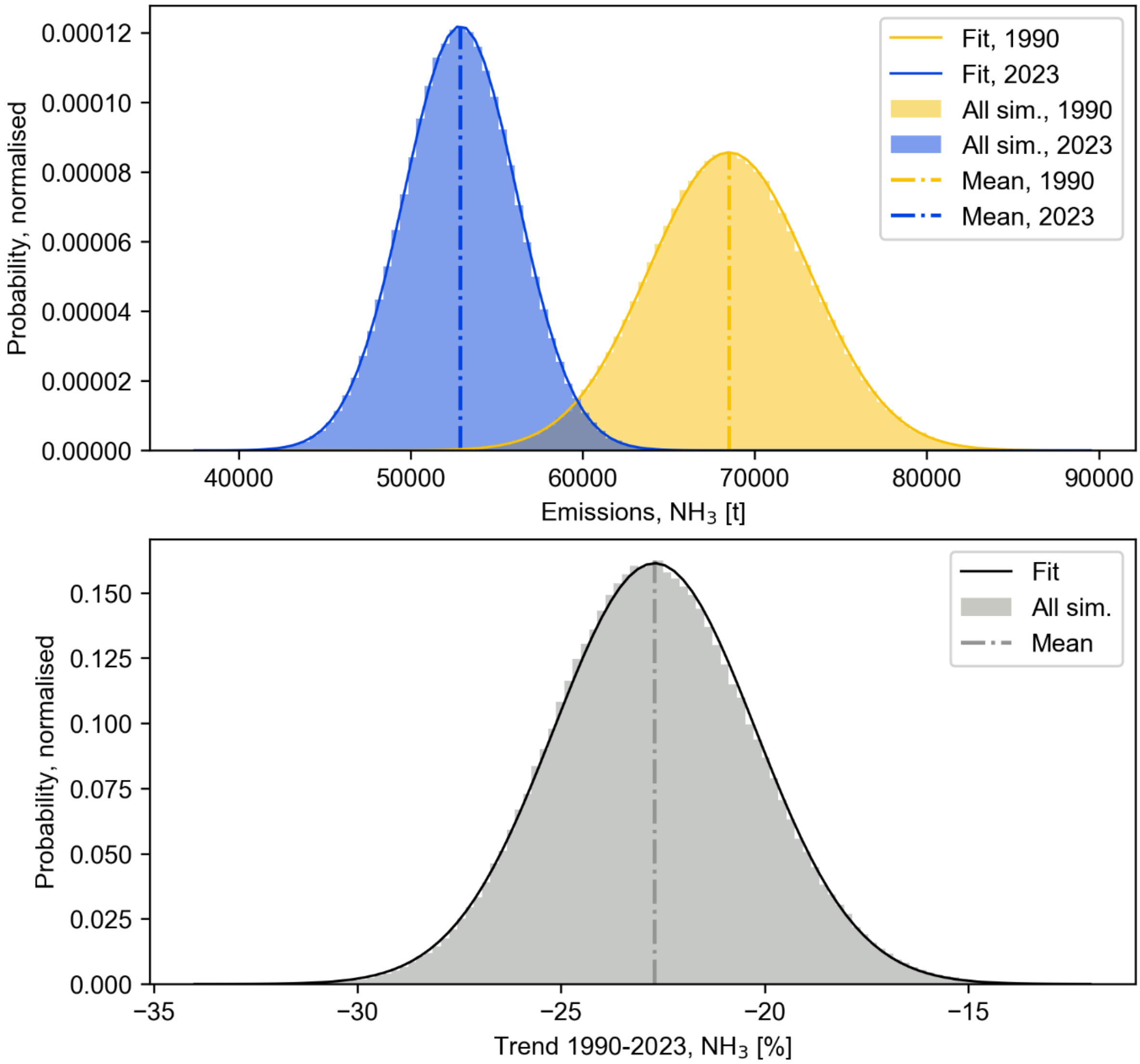


Figure A - 14 Monte Carlo simulations: Distributions obtained for the inventory mean emission for $NH_3$, for the base year 1990 (top panel, yellow), the reporting year 2023 (top panel, blue) and the trend 1990-2023 (bottom panel, grey). All sim: all simulations (500’000 values for each distribution). Fit: fit of the distribution using a normal distribution. Mean: mean inventory emission obtained from the simulations.

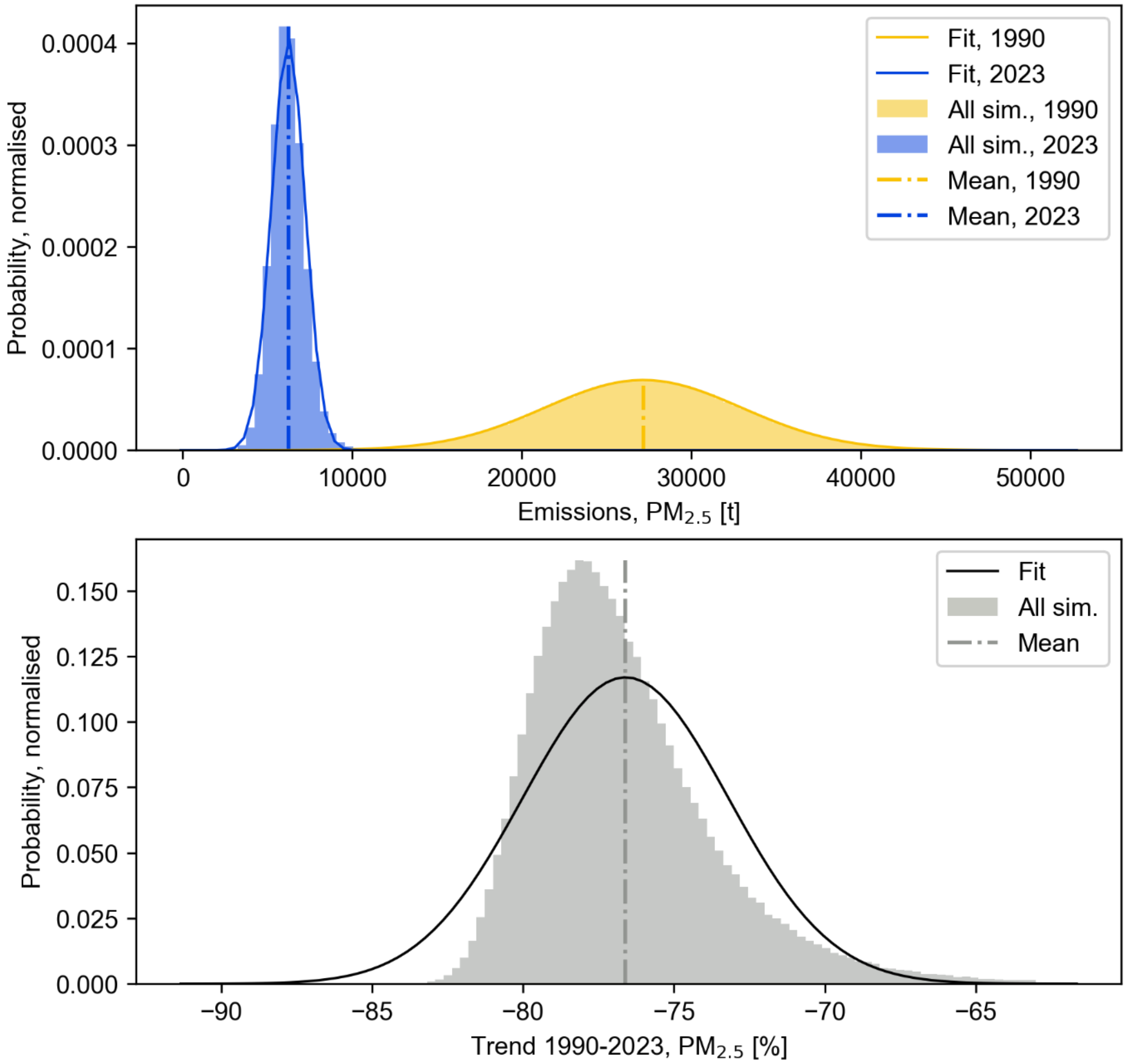


Figure A - 15 Monte Carlo simulations: Distributions obtained for the inventory mean emission for PM2.5, for the base year 1990 (top panel, yellow), the reporting year 2023 (top panel, blue) and the trend 1990-2023 (bottom panel, grey). All sim: all simulations (500'000 values for each distribution). Fit: fit of the distribution using a normal distribution. Mean: mean inventory emission obtained from the simulations.

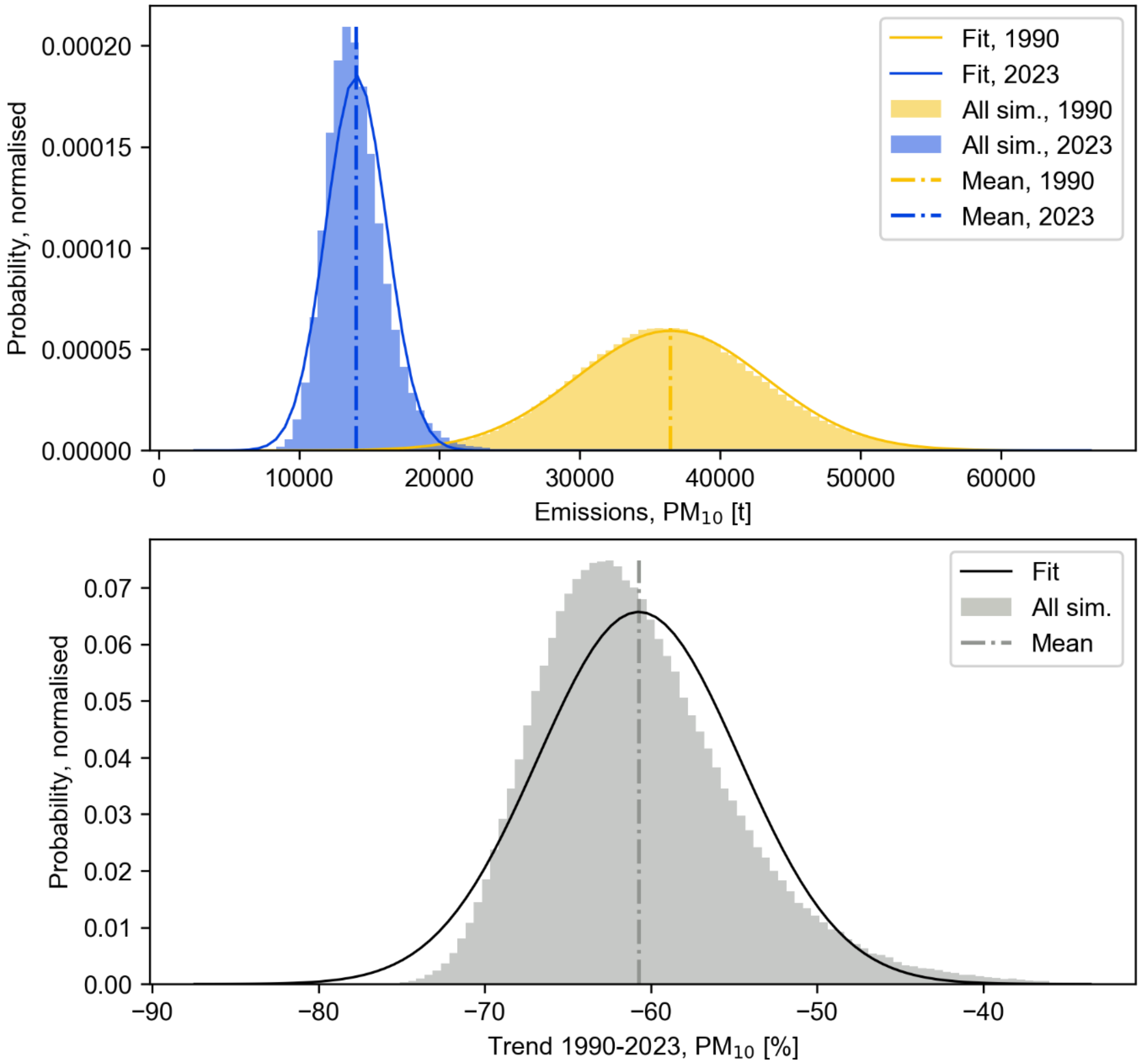


Figure A - 16 Monte Carlo simulations: Distributions obtained for the inventory mean emission for PM10, for the base year 1990 (top panel, yellow), the reporting year 2023 (top panel, blue) and the trend 1990-2023 (bottom panel, grey). All sim: all simulations (500'000 values for each distribution). Fit: fit of the distribution using a normal distribution. Mean: mean inventory emission obtained from the simulations.

# Annex 6 Summary information on condensables in PM

Table A - 40 Inclusion/exclusion of the condensable component from PM10 and PM2.5 emission factors.

| NFR codes | Source/sector name | PM emissions: the | | Emission factor 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. |
| 1A1a, 1A2gviii, 1A4ai/bi/ci | Wood energy combustion | X | | The emission factors of particulate matter from wood energy combustion comprise both the filterable and condensable fractions. |
| 1A2gvii, 1A3b-d, 1A4aii/bii/cii, 1A5 | Road transportation, Nonroad machinery and vehicles | X | | Considering the measuring procedure and the maximum temperature of 52°C, it can be assumed that PM condesables are also included in the measurements. The installed technology also plays a role in this context (gasoline engines with/without catalytic converter, diesel engines with/without particulate filter, etc.). |
| 1A4bi | Charcoal use, Bonfire | X | | The emission factor of particulate matter of these two source categories are based on default Tier-2 emission factor of the EMEP/EEA Guidebook 2019 (chp. 1A4, Table 3-39). These emission factor 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, PM2.5 and BC for 1990–2023 by pollutant and aggregated sectors

## A7.1 $NO_x$ emission time series

Table A - 41 $NO_x$ emissions by sector ((fu) means fuel used approach). The last column in the third part of the table indicates the relative trend.

| NOx | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 1(fu) | kt | 135 | 112 | 99 | 89 | 79 |
| 2 | kt | 0.52 | 0.34 | 0.36 | 0.34 | 0.40 |
| 3 | kt | 5.0 | 4.6 | 4.0 | 3.8 | 4.0 |
| 5 | kt | 0.29 | 0.21 | 0.18 | 0.16 | 0.15 |
| 6 | kt | 0.092 | 0.085 | 0.098 | 0.097 | 0.100 |
| Sum | kt | 141 | 117 | 104 | 94 | 83 |

| NOx | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 1(fu) | kt | 72 | 70 | 69 | 64 | 60 |
| 2 | kt | 0.38 | 0.35 | 0.31 | 0.33 | 0.30 |
| 3 | kt | 3.9 | 3.7 | 3.8 | 3.8 | 3.7 |
| 5 | kt | 0.15 | 0.15 | 0.14 | 0.14 | 0.12 |
| 6 | kt | 0.11 | 0.11 | 0.11 | 0.11 | 0.098 |
| Sum | kt | 77 | 75 | 73 | 69 | 65 |

| NOx | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 1(fu) | kt | 57 | 48 | 48 | 45 | 43 | -52 |
| 2 | kt | 0.26 | 0.25 | 0.27 | 0.25 | 0.20 | -41 |
| 3 | kt | 3.6 | 3.6 | 3.7 | 3.6 | 3.5 | -9.2 |
| 5 | kt | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | -22 |
| 6 | kt | 0.091 | 0.091 | 0.096 | 0.090 | 0.085 | -12 |
| Sum | kt | 61 | 52 | 52 | 49 | 47 | -50 |

## A7.2 NMVOC emission time series

Table A - 42 NMVOC emissions by sector ((fu) means fuel used approach). The last column in the third part of the table indicates the relative trend.

| NMVOC | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 1(fu) | kt | 130 | 85 | 63 | 44 | 31 |
| 2 | kt | 149 | 105 | 74 | 51 | 47 |
| 3 | kt | 14 | 14 | 14 | 16 | 17 |
| 5 | kt | 1.1 | 1.0 | 1.0 | 1.0 | 1.2 |
| 6 | kt | 0.20 | 0.19 | 0.21 | 0.20 | 0.18 |
| Sum | kt | 295 | 206 | 153 | 112 | 97 |

| NMVOC | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 1(fu) | kt | 23 | 21 | 20 | 19 | 18 |
| 2 | kt | 41 | 39 | 37 | 37 | 37 |
| 3 | kt | 18 | 18 | 18 | 18 | 18 |
| 5 | kt | 1.4 | 1.4 | 1.5 | 1.5 | 1.6 |
| 6 | kt | 0.20 | 0.20 | 0.20 | 0.21 | 0.18 |
| Sum | kt | 83 | 80 | 77 | 76 | 75 |

| NMVOC | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 1(fu) | kt | 18 | 16 | 16 | 15 | 15 | -65 |
| 2 | kt | 37 | 36 | 36 | 36 | 36 | -29 |
| 3 | kt | 18 | 18 | 18 | 18 | 18 | 12 |
| 5 | kt | 1.7 | 1.7 | 1.8 | 1.7 | 1.8 | 73 |
| 6 | kt | 0.17 | 0.16 | 0.17 | 0.17 | 0.17 | -18 |
| Sum | kt | 74 | 72 | 72 | 71 | 71 | -36 |

## A7.3 $SO_x$ emission time series

Table A - 43 $SO_x$ emissions by sector ((fu) means fuel used approach). The last column in the third part of the table indicates the relative trend.

| SOx | | 1990 | 1995 | 2000 | 2005 | 2010 | |
|---|---|---|---|---|---|---|---|
| 1(fu) | kt | 37 | 25 | 15 | 13 | 9.2 | |
| 2 | kt | 1.6 | 0.95 | 0.78 | 1.0 | 0.80 | |
| 3 | kt | NA | NA | NA | NA | NA | |
| 5 | kt | 0.16 | 0.080 | 0.062 | 0.063 | 0.063 | |
| 6 | kt | 0.0092 | 0.0092 | 0.0097 | 0.0094 | 0.0074 | |
| Sum | kt | 39 | 26 | 16 | 14 | 10 | |
| SOx | | 2014 | 2015 | 2016 | 2017 | 2018 | |
| 1(fu) | kt | 6.1 | 5.0 | 4.3 | 4.0 | 3.7 | |
| 2 | kt | 0.62 | 0.65 | 0.76 | 0.83 | 0.91 | |
| 3 | kt | NA | NA | NA | NA | NA | |
| 5 | kt | 0.066 | 0.070 | 0.058 | 0.045 | 0.031 | |
| 6 | kt | 0.0076 | 0.0073 | 0.0073 | 0.0078 | 0.0074 | |
| Sum | kt | 6.8 | 5.8 | 5.2 | 4.9 | 4.7 | |
| SOx | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
| 1(fu) | kt | 3.5 | 3.1 | 3.1 | 2.8 | 2.5 | -81 |
| 2 | kt | 0.81 | 0.52 | 0.47 | 0.35 | 0.26 | -75 |
| 3 | kt | NA | NA | NA | NA | NA | - |
| 5 | kt | 0.031 | 0.030 | 0.029 | 0.029 | 0.030 | -52 |
| 6 | kt | 0.0069 | 0.0068 | 0.0072 | 0.0072 | 0.0072 | -23 |
| Sum | kt | 4.3 | 3.7 | 3.6 | 3.2 | 2.8 | -80 |

## A7.4 $NH_3$ emission time series

Table A - 44 $NH_3$ emissions by sector ((fu) means fuel used approach). The last column in the third part of the table indicates the relative trend.

| NH3 | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 1(fu) | kt | 1.7 | 2.9 | 4.9 | 3.9 | 2.7 |
| 2 | kt | 0.37 | 0.32 | 0.40 | 0.35 | 0.21 |
| 3 | kt | 65 | 61 | 54 | 54 | 53 |
| 5 | kt | 0.91 | 0.85 | 0.91 | 0.93 | 0.89 |
| 6 | kt | 0.85 | 0.79 | 0.92 | 0.88 | 0.92 |
| Sum | kt | 68 | 65 | 62 | 60 | 58 |

| NH3 | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 1(fu) | kt | 1.7 | 1.5 | 1.4 | 1.4 | 1.3 |
| 2 | kt | 0.20 | 0.17 | 0.16 | 0.18 | 0.17 |
| 3 | kt | 52 | 52 | 51 | 51 | 51 |
| 5 | kt | 0.87 | 0.85 | 0.88 | 0.86 | 0.85 |
| 6 | kt | 1.0 | 1.1 | 1.0 | 1.0 | 0.97 |
| Sum | kt | 56 | 55 | 55 | 55 | 54 |

| NH3 | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 1(fu) | kt | 1.3 | 1.2 | 1.2 | 1.3 | 1.3 | -68 |
| 2 | kt | 0.17 | 0.15 | 0.14 | 0.15 | 0.13 | -63 |
| 3 | kt | 50 | 50 | 50 | 50 | 50 | -7.5 |
| 5 | kt | 0.89 | 0.88 | 0.90 | 0.86 | 0.86 | -6.9 |
| 6 | kt | 0.95 | 0.96 | 0.98 | 0.97 | 0.97 | 11 |
| Sum | kt | 54 | 53 | 54 | 53 | 53 | -11 |

## A7.5 PM2.5 emission time series

Table A - 45 PM2.5 emissions by sector ((fu) means fuel used approach). The last column in the third part of the table indicates the relative trend.

| PM2.5 | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 1(fu) | kt | 24 | 20 | 15 | 12 | 9.3 |
| 2 | kt | 2.5 | 2.0 | 1.4 | 1.3 | 1.4 |
| 3 | kt | 0.12 | 0.12 | 0.12 | 0.13 | 0.13 |
| 5 | kt | 0.57 | 0.46 | 0.43 | 0.38 | 0.36 |
| 6 | kt | 0.0044 | 0.0040 | 0.0042 | 0.0043 | 0.0044 |
| Sum | kt | 27 | 22 | 17 | 14 | 11 |

| PM2.5 | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 1(fu) | kt | 6.3 | 6.2 | 6.3 | 6.0 | 5.7 |
| 2 | kt | 1.3 | 1.2 | 1.2 | 1.2 | 1.2 |
| 3 | kt | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| 5 | kt | 0.34 | 0.34 | 0.33 | 0.32 | 0.31 |
| 6 | kt | 0.0050 | 0.0054 | 0.0053 | 0.0054 | 0.0049 |
| Sum | kt | 8.1 | 7.9 | 7.9 | 7.7 | 7.3 |

| PM2.5 | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 1(fu) | kt | 5.6 | 5.2 | 5.3 | 4.9 | 4.8 | -60 |
| 2 | kt | 1.1 | 1.1 | 1.2 | 1.2 | 0.99 | -26 |
| 3 | kt | 0.14 | 0.14 | 0.15 | 0.15 | 0.15 | 13 |
| 5 | kt | 0.30 | 0.29 | 0.29 | 0.27 | 0.27 | -28 |
| 6 | kt | 0.0047 | 0.0047 | 0.0049 | 0.0048 | 0.0047 | 8.8 |
| Sum | kt | 7.1 | 6.7 | 6.9 | 6.5 | 6.2 | -55 |

## A7.6 BC emission time series

Table A - 46 BC emissions by sector ((fu) means fuel used approach). The last column in the third part of the table indicates the relative trend.

| BC | | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|---|
| 1(fu) | kt | 5.7 | 5.1 | 4.1 | 3.5 | 2.5 |
| 2 | kt | 0.0063 | 0.0040 | 0.0027 | 0.0026 | 0.0016 |
| 3 | kt | NA | NA | NA | NA | NA |
| 5 | kt | 0.040 | 0.033 | 0.030 | 0.027 | 0.026 |
| 6 | kt | 0.00016 | 0.00016 | 0.00016 | 0.00015 | 0.000099 |
| Sum | kt | 5.7 | 5.1 | 4.1 | 3.5 | 2.6 |

| BC | | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 1(fu) | kt | 1.5 | 1.4 | 1.4 | 1.2 | 1.2 |
| 2 | kt | 0.0014 | 0.0013 | 0.0014 | 0.0014 | 0.0013 |
| 3 | kt | NA | NA | NA | NA | NA |
| 5 | kt | 0.024 | 0.024 | 0.023 | 0.023 | 0.022 |
| 6 | kt | 0.000098 | 0.000089 | 0.000088 | 0.000098 | 0.000089 |
| Sum | kt | 1.5 | 1.4 | 1.4 | 1.3 | 1.2 |

| BC | | 2019 | 2020 | 2021 | 2022 | 2023 | 2005-2023 (%) |
|---|---|---|---|---|---|---|---|
| 1(fu) | kt | 1.1 | 0.98 | 1.0 | 0.86 | 0.81 | -77 |
| 2 | kt | 0.0013 | 0.0014 | 0.0013 | 0.0013 | 0.0012 | -54 |
| 3 | kt | NA | NA | NA | NA | NA | - |
| 5 | kt | 0.022 | 0.021 | 0.021 | 0.020 | 0.019 | -27 |
| 6 | kt | 0.000075 | 0.000072 | 0.000081 | 0.000080 | 0.000078 | -47 |
| Sum | kt | 1.1 | 1.0 | 1.0 | 0.88 | 0.83 | -77 |