# Informative Inventory Report Sweden 2025

Submitted under
the Convention on Long-Range Transboundary Air Pollution

SWEDISH ENVIRONMENTAL
PROTECTION AGENCY

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# EXECUTIVE SUMMARY

## ES.1 Background information on the air pollutant emission inventory

Sweden has carried out inventories on air pollutants since the 1980's to meet the obligations of the United Nations Economic Commission for Europe Convention on Long-Range Transboundary Air Pollution (UNECE CLRTAP).

The inventory report of air pollutants for the year 2023 is prepared in accordance with the 2019 Reporting Guidelines and the CLRTAP's revised Gothenburg Protocol as agreed by the parties to the Convention in Geneva, 2012. The inventory report is annually submitted to the UNECE Secretariat and to the EEA.

This report constitutes Sweden's IIR 2025 (inventory data 2023) for anthropogenic emissions of air pollutants: NOx, CO, NMVOC, $SO_2$, $NH_3$, TSP, $PM_{10}$ and $PM_{2.5}$, BC, heavy metals and other metals, dioxins, HCB, PCBs and PAH1-4 covering the years from 1980 to 2023. The report contains methodology, data sources, uncertainties, the quality assurance and quality control (QA/QC) activities carried out, and trend analyses for many pollutants. Data on estimated emissions and corresponding activity data are provided in NFR tables. Thermal values and emission factors are provided in Annex 2. The report also shows how Sweden follows the guidelines to ensure the transparency, consistency, accuracy, comparability, and completeness of the reported emission data.

Emission estimates are mainly based on official Swedish statistics, e.g. quarterly fuel statistics, agricultural statistics, environmental reports from industry and emission factors (nationally developed factors as well as internationally recommended ones). Sweden uses the Guidelines for Estimating and Reporting Emission Data for reporting to the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019 and 2023[1] as methodological guidance. Sweden also uses methodologies in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories[2].

An internal review performed during 2016 of the use of confidential data in the inventory showed that additional data should be considered confidential compared to previous submissions in order to comply with the Public Access to Information and Secrecy Act of the Swedish law. When the confidentiality analysis showed that a certain category should be classified to protect data of one or more companies, the companies have been asked to give consent to publish the data. If the company declined or a consent could not be acquired, the data are considered confidential and marked using notation key 'C'. This has affected some sub-sectors in stationary combustion (NFR 1) and industrial processes and product use (NFR 2), which have

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[1] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019
https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023

[2] http://www.ipcc-nggip.iges.or.jp/public/2006gl/

been classified with the notation key Classified (C). Sweden is working continuously with improving the transparency of our reporting and strives to minimize the extent of confidentiality in inventory data.

# ES.2 Overview of source category emission estimates and trends

The main sources of air pollutants have been divided into the following sectors: energy, industrial processes and product use, agriculture and waste. No air pollutant emissions have been estimated for the land use, land use change and forestry sector.

Emissions of pollutants regulated in the amended Gothenburg Protocol ($SO_2$, NOx, $NH_3$, NMVOCs, $PM_{10}$, $PM_{2.5}$ and BC) have been reduced significantly since 1990. Other air pollutants, such as CO, poly aromatic hydrocarbons *(*PAH1-4), dioxins, HCB and priority heavy metals namely, cadmium (Cd), mercury (Hg) and lead (Pb) and other metals have also all been reduced since 1990.

Emission reduction of the air pollutants and heavy metals has been achieved through regulatory controls and application of better technologies in industry, energy, and transport sectors. Examples include switching from higher sulphur fuels to lower sulphur fuels, phasing out the use of leaded gasoline, catalytic converters on vehicles and other instruments such as the NOx-fee.

***Nitrogen oxides***

The estimated emissions of nitrogen oxides (NOx) were about 104 kt in 2023. The emissions have decreased by about 64% since 1990 and by about 4 % compared to the previous year.

The energy sector (NFR1) accounted 75% of the NOX emissions in which the transport was responsible for about 40% of the national total. The industrial processes and product use sector (NFR2) and the agriculture sector (NFR3) were responsible for about 23% and 12%, respectively. NOx emission from the waste sector (NFR5) is small. Emissions from the transport sector (NFR1A3) have declined by 75% since 1990 and by about 7% compared to the previous year mostly from road traffic. The reduction since 1990 is mainly due to the tightening of the EU road vehicle emission regulation standards.

Other important reasons for the general decline of NOx emissions are the increased use of district heating and the introduction of the NOx fee in 1992, which have resulted in a reduction of emissions from the manufacturing industries and construction (NFR1A2) and the energy industries sectors (NFR1A1).

***Sulphur dioxide***

Emissions of sulphur dioxide ($SO_2$) decreased from about 100 kt in 1990 to about 14 kt in 2023, a reduction of about 86%. Between 2022 and 2023 the emission decreased by about 2%. About 43% of the total $SO_2$ emission was derived from the energy sector. The remaining emissions (56%) were derived from the industrial processes and product use sector. $SO_2$ emission from the waste sector is very small.

Among the largest sources of $SO_2$ emission are metal industry (NFR2C), 28%, pulp and paper industry (2H1) and public electricity and heat production (NFR 1A1a) accounting for 21% and 16%, respectively. Manufacturing industries and construction (NFR 1A2) was responsible for about 16%. Transport (NFR 1A3) was a major source of $SO_2$ in early 1990's and now is responsible for about 3% of the total emission. Emission reduction of $SO_2$ was mainly due to a transfer from fuels with high sulphur content to low-sulphur fuels.

***Ammonia***

The total emissions of ammonia ($NH_3$) amounted to about 54 kt in 2023. Compared to emission levels in 1990, the emissions were about 19% lower in 2023. The agriculture sector was responsible for most of $NH_3$ emission in 2023, accounting to 90% of the total emissions. $NH_3$ is emitted from farm animals' dung and urine and the use of inorganic fertilizers. The rest of the emission originates mainly from pulp and paper industry and transport, mainly from urea in vehicles filters that release $HN_3$.

The main drivers for the reduced emission within the agriculture sector are declined animal population, reduced use of inorganic fertilizers and emission reduction measures within manure management.

***Non-methane volatile organic compounds (NMVOCs)***

In 2023, a total of about 138 kt of NMVOCs were emitted in Sweden. About 41% of the NMVOC emissions comes from the solvent use (NFR2D3). The total emissions of NMVOCs have decreased by about 62% since 1990 mainly from transport and solvent use. The main reason for the sharp decrease in the transport sector is improved vehicle fuel efficiency and the introduction of stricter emission standards in the EU-regulations for road vehicles. Between 2022 and 2023 the emission decreased by about 1%.

***Carbon monoxide***

The aggregated emissions of carbon monoxide (CO) have decreased from about 1.1 Mton in 1990 to about 267 kt in 2023, declined by 76%. Other energy sector (NFR1A4) was the largest source for CO emission, accounting for about 52% of the total emissions in 2023. Emissions have decreased by 39% since 1990.

In 2023, the transport sector (1A3) was responsible for 29% of the total emissions of CO. Emissions have decreased by about 91% since 1990, due to the introduction of catalytic converters in passenger cars and light duty vehicles.

***Particle Matter ($PM_{10}$ and $PM_{2.5}$)***

In 2023, the total emissions of $PM_{10}$ and $PM_{2.5}$ in Sweden were about 39 kt and 14 kt, respectively. Compared to 1990, the emissions have been reduced by about 46% and 68%, respectively. The transport sector was responsible for about 38% and 16%, respectively of the emission in 2023. The emission depends on total traffic work and also on the use of studded tires. Emission of particles from road abrasion and tires- and brake wear show an increasing trend due to increased volume of traffic. Residential and premises heating was also a large source of $PM_{2.5}$ emissions which accounted for about 30% of the total emissions in 2023. Emissions have declined by 66% since 1990 as district heating has become more common and that today's wood boilers are more effective in combustion than older ones.

***Black Carbon***

Emissions of back carbon (BC) have been reported for the years 2000 to 2023. The estimated emission was less than 2 kt in 2023 and declined by 70% since 2000. The largest single source of BC emission is other energy sectors (NFR1A4) accounting for 46% in which the use of wood for own heating of homes and premises is the biggest single source of soot emissions, accounts for approximately 36 percent of the emissions and have decreased by a half since 2000. The reduction is mainly due to a transition from wood combustion for residential and premises heating to district heating.

The transport sector (NFR1A3) accounted for about 28% of total BC emissions in 2023 where road traffic was the major contributor in the sector. Emissions from road transport have declined by about 79% since 2000 due to stricter exhaust requirements.

***Poly Aromatic Hydrocarbons***

The total emissions of poly aromatic hydrocarbons (PAH1-4) were about 6 tons in 2023. The emissions have been reduced by 68% since 1990. The largest source of emissions of PAH in Sweden is wood combustion in residential-, commercial and public premises- and agricultural and forestry and fishing heating, accounted for 76% of total emissions in 2023. Since 1990, emissions from this source decreased by 65% mainly due to a transition to district heating. The largest reduction of PAH1-4 emissions since 1990, about 82%, has been achieved in the industrial processes and product use sector (NFR2) due to the application of new technologies.

***Hexachlorobenzene***

The total emissions of hexachlorobenzene (HCB) were about 3.4 kg in 2023. Emissions have decreased by just under 80% since 1990. The largest single source of HCB emissions in 2023 was the electricity- and heat production (NFR1A1) which accounted for 29% followed by chemical Industry (NFR2B) and metal industry (NFR2C) 23% and 21% of the total emissions, respectively.

Emissions from electricity- and heat production have more than doubled (134%) since 1990, mainly due to increased use of biomass as a fuel. The largest increase of HCB in relative terms comes from the waste sector (incineration and open burning), which has increased by about 260% since 1990, due to increased combustion of hazardous waste.

***Priority Heavy Metals (Cd, Hg and Pb)***

In 2023, the estimated emissions of Cd in Sweden were about 500 kg, a decrease of 78% since 1990. The largest source in 2023 was the industrial processes and product use (NFR 2) accounted for 38% followed by public electricity- and heat production (NFR 1A1) and residential heating (NFR 1A4bi) which were accounted for 33% and 20%, respectively. The decreased emission from (NFR 2) by about more than 90% since 1990 is mainly due to better technologies applied in the metal industry.

In 2023, the estimated emissions of mercury (Hg) in Sweden were about 372 kg, a decrease of about 76% since 1990. The largest sources in 2023 were public electricity- and heat production (NFR1A1a) accounted for 37% of the total emission. Emissions from the industrial processes and product use have decreased by almost 82% since 1990, mainly due to application of better technologies in the metal industry. The waste sector is also a significant source of Hg emission which accounted for about 7% of the total emission in 2023.

The total emissions of lead (Pb) in Sweden were about 7 ton in 2023 and have decreased by 98% since 1990. The largest single source in 2023 was public electricity- and heat production (NFR1A1a) which was responsible for 33% followed by metal industry (NFR2C), 27% of the emission. The share of the transport sector was about 7% of the total emission in 2023 which has decreased by more than 99% since 1990 due to phasing out the use of leaded gasoline.

# 1 Introduction

Reporting of emission data to the Executive Body of the Convention on Long-range Trans-boundary Air Pollution (CLRTAP) is required in order to fulfil obligations regarding strategies and policies in compliance with the implementation of Protocols under the Convention. Parties should use the reporting procedures and are required to submit annual national emissions of $SO_2$, $NO_X$, NMVOC, CO and $NH_3$, particulate matter (PM), black carbon (BC), various heavy metals and POPs using the 2019 EMEP/EEA Air Pollutant Emission Inventory Guidebook[3].

This report constitutes Sweden's Informative Inventory Report (IIR) due by March 15, 2025. The report contains information on Sweden's inventories for all years from 1980 to 2023 including descriptions of methods, data sources, QA/QC activities carried out, and a trend analysis. The inventory accounts for anthropogenic emissions of $SO_2$, $NO_X$, $NH_3$, NMVOC, CO, BC, TSP, $PM_{10}$, $PM_{2.5}$, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PAH, PCBs, HCB and dioxins.

Emission estimates are mainly based on official Swedish statistics, e.g. quarterly fuel statistics, agricultural statistics, environmental reports from industry and emission factors (nationally developed factors as well as internationally recommended ones).

Sweden uses the Guidelines for Estimating and Reporting Emission Data for reporting to the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the 2019 and 2023 EMEP/EEA Air Pollutant Emission Inventory Guidebook as methodological guidance[4]. Data are also reported under the EU National Emissions Ceiling Directive on emission of air pollutants to the European Commission. Sweden also uses methodologies in accordance with the IPCC 2006 Guidelines for National Greenhouse Gas Inventories[5] and methods that are in general in line with Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories IPCC-NGGIP (Good Practice Guidance[6]).

## 1.1 Nord Stream gas leaks in the Swedish Exclusive Economic Zone (EEZ)

In September 2022, leaks were discovered in the Nord Stream gas pipelines in the Baltic Sea. The emissions occurred partially within Sweden's EEZ. The Swedish Environmental Protection Agency has conducted a legal assessment concerning whether the emissions should be included in the Swedish national inventory of greenhouse gas emissions and emissions of NMVOC in the Informative Inventory Report or not. The assessment is summarized in the Swedish national inventory of greenhouse gas emissions report submission 2024.

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[3] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019 and

[4] https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023

[5] http://www.ipcc-nggip.iges.or.jp/public/2006gl/

[6] http://www.ipcc-nggip.iges.or.jp/public/gp/english/

In conclusion, given the legal framework of UNCLOS, the emissions from the gas leaks in Nord Stream 1 and Nord Stream 2 in the Swedish EEZ, cannot be considered to have taken place in “offshore areas over which the country has jurisdiction” and the emissions should therefore not be included in the Swedish National Inventory Report and the Informative Inventory Report.

Neither do the provisions for specific issues concerning pipelines in the IPCC guidelines (primarily Section 8.2.1 [Coverage] of Volume 1) state that the emissions from Nord Stream 1 and Nord Stream 2 should be included in the Swedish National Inventory Report. There is no Swedish “national territory of the pipeline” as mentioned in Section 8.2.1. When the IPCC guidelines specify that offshore areas “may be an economic zone agreed upon with other countries”[7], the guidelines still state that such emissions should be allocated to the national territory of the pipeline.

## 1.2 Institutional arrangements

The national system is designed in compliance with UNFCCC decision 20/CP.7. Under the terms of Decision No. 280/2004/EC of the European Parliament and of the Council, the national system has to be in place by the end of 2005. The national system has to ensure the function of all the institutional, legal and procedural arrangements required to calculate emissions and removals of greenhouse gases.

The Swedish national system came into force on 1 January 2006 and its aim is to ensure that climate reporting to the secretariat of the Convention (UNFCCC) and the European Commission complies with specified requirements. This means, among other things,

- estimating and reporting anthropogenic GHG emissions and removals in accordance with the Kyoto Protocol,
- assisting Sweden in meeting its commitments under the Kyoto Protocol,
- facilitating the review of submitted information,
- ensuring and improving the quality of the Swedish inventory and
- guaranteeing that submitted data is officially approved.

The national system ensures annual preparation and reporting of the national inventory and of supplementary information in a timely manner and that the inventory fulfils all quality criteria, i.e. is transparent, accurate, consistent, comparable and complete.

The national system is, where applicable, used also for the reporting to the Convention on Long-Range Transboundary Air Pollution (CLRTAP) under the United Nations Economic Commission for Europe (UNECE) and under the EU National Emissions Ceiling Directive on emission of air pollutants to the European Commission.

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[7] Chapter 1.2 Volume 1, 2006 IPCC Guidelines.

### 1.2.1 Legal arrangements

The ordinance (2005:626) concerning climate reporting has been updated and enlarged to fulfil all the reporting requirements under the EU Monitoring Mechanism Regulation 525/2013/EC. The new ordinance 2014/1434 concerning climate reporting came into force and replaced the old ordinance the 29th of December 2014 and have been operational since the preparation of submission 2015.

The ordinance on climate reporting (OCR) describes the roles and responsibilities of the relevant government agencies in this area. The ordinance ensures that sufficient capacity is available for reporting. It also includes other improvements needed on the national level.

Supplemental to the new ordinance, formal agreements between the Swedish Environmental Protection Agency (Swedish EPA) and other concerned national agencies have been signed, listing in detail what is required regarding content and timetable from each agency.

Sweden also has legislation indirectly supporting climate reporting efforts by providing a basis for estimating greenhouse gas emissions and removals. Environmental reports are submitted under the Environmental Code (SFS 1998:808), and the Official Statistics Act (SFS 2001:99) imposes an obligation for large industries to submit annual data. In addition, government agencies in Sweden must comply by the Information and Secrecy Act (offentlighets- och sekretesslag) (SFS 2009:400).

The General Statistics Act (SFS 2001: 99) and the associated ordinance (2001:100) concerning official statistics impose an obligation on companies and other organizations to submit annual data. The data then serve as a basis for estimating greenhouse gas emissions and removals in several sectors.

There is legislation in Sweden that indirectly supports the work by providing a basis for the estimation of air pollutants. Under Chapter 26 Section 19 of the Environmental Code (1998:808), there is an obligation for annual environmental reports to be submitted for certain environmentally hazardous activities so that government agencies can undertake supervision.

The General Statistics Act (SFS 2001: 99) and the associated ordinance (2001:100) Concerning Official Statistics impose an obligation on companies and other organizations to submit annual data. The data then serve as a basis for estimating air pollutants in several sectors.

According to Directive 2003/87/EC and national Act (2004:1199) on emission trading, emission data for plants included in the emission trading system should be reported annually. These data are used as a supplementary source within this air pollutant inventory.

### 1.2.2 Institutional arrangements

Where applicable, the same institutional arrangements are used as for the Greenhouse gas inventory:

The illustration in Figure 1-1 and Table 1-1 and the associated text below describe in broad terms which organizations are involved in the work of compiling documentation for the yearly inventory report and for other reporting to the Convention on Long-Range Transboundary Air Pollution (CLRTAP) under the United Nations Economic Commission for Europe (UNECE) and under the EU National Emissions Ceiling Directive on emission of air pollutants to the European Commission.

Depending on the role of the government agencies in reporting activity, this responsibility may range for example from supplying data and producing emission factors/calorific values to carrying out calculations to estimate emissions or conducting a national peer review (in bold letters). In addition to what is described in the OCR, the Swedish EPA engages the SMED consortium as consultants with expert skills to conduct the inventory and reporting in the area of air pollutants.

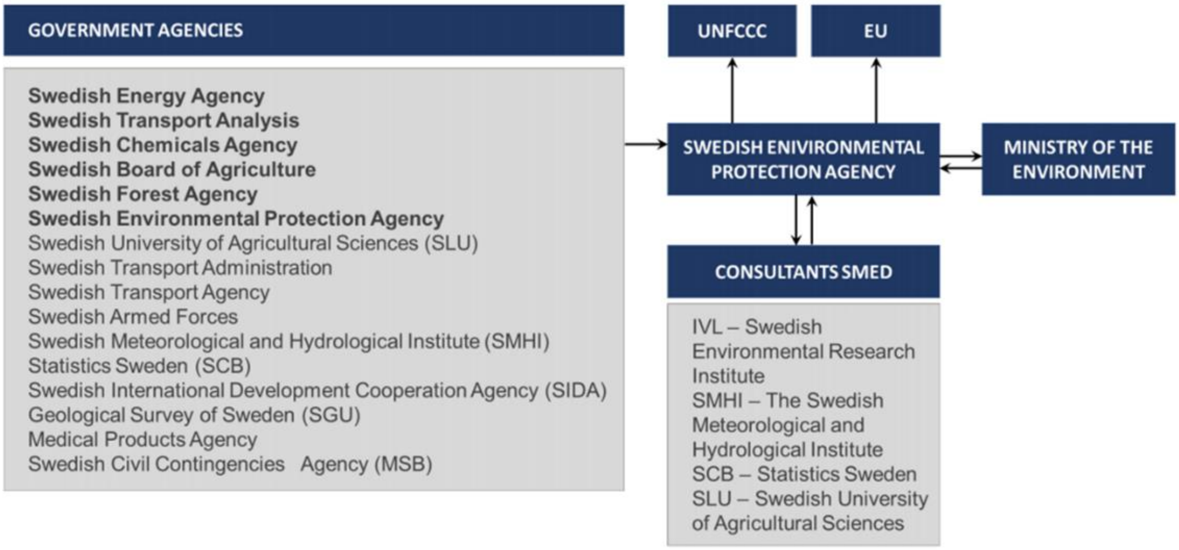

**Figure 1-1 . The Swedish national system.**

#### 1.2.2.1 RESPONSIBILITIES OF THE SWEDISH ENVIRONMENTAL PROTECTION AGENCY

The Swedish Environmental Protection Agency (Swedish EPA) is responsible for co-ordinating the activities for producing the inventory, maintaining the reporting system and also for the final quality control and quality assurance of the inventory. The Swedish EPA sends the inventory to Ministry of the Environment and – on behalf of the Ministry of the Environment and Energy – submits the inventory to the NEC directive/EU and to the CLRTAP/UNECE. Finally, the Swedish EPA is responsible for national publication of the air pollutants inventory.

#### 1.2.2.2 RESPONSIBILITIES OF NATIONAL AGENCIES

Table 1-1 below shows the responsibilities of the Swedish agencies according to the Ordinance concerning climate reporting.

**Table 1-1. Responsibilities according to the ordinance concerning climate reporting.**

| Sector | Data and documentation provided by | Peer review conducted by |
|---|---|---|
| **Energy** | Swedish Energy Agency, the Swedish Transport Administration, the Swedish Transport Agency, Transport Analysis, the Swedish Armed Forces. | Swedish Energy Agency (energy sector excluding transports)<br>Transport Analysis (transports) |
| **Industrial Processes and Product Use** | Swedish Chemicals Agency, Medical Products Agency. | The Swedish EPA ($CO_2$, $CH_4$ and $N_2O$)<br>Swedish Chemicals Agency |
| **Agriculture** | Swedish Board of Agriculture, Statistics Sweden (SCB). | The Swedish Board of Agriculture |
| **Land Use, Land-Use Change and Forestry Sector** | Swedish University of Agricultural Sciences (SLU), Statistics Sweden (SCB), the Swedish Forest Agency, the Swedish Meteorological and Hydrological Institute (SMHI), the Swedish Board of Agriculture, Swedish Civil Contingencies Agency (MSB), the Geological Survey of Sweden (SGU). | Swedish Forest Agency<br>The Swedish Board of Agriculture (agriculture related parts) |
| **Waste** | | The Swedish EPA |

#### 1.2.2.3 THE SMED CONSORTIUM

The Swedish EPA engages consultants with expert skills to conduct the inventory and reporting in the area of climate change. During the spring of 2005, the Swedish EPA completed a negotiated procurement of services under the terms of the Public Procurement Act. After procurement had been completed, a framework contract was signed with the consortium Swedish Environmental Emissions Data (SMED)[8], consisting of the Swedish Meteorological and Hydrological Institute (SMHI), Statistics Sweden (SCB), the Swedish University of Agricultural Sciences (SLU) and the Swedish Environmental Research Institute (IVL). The contract between the Swedish EPA and SMED runs for nine years and thus covered the whole first commitment period under the Kyoto Protocol. During 2014 the contract with the consortium SMED was prolonged for another period (2015 – 2022). In December 2022, the contract was then extended for another period (2023 to 2030). The structure of the consortium for the prolonged contract is a little bit different from since it is based on an agency agreement for the national agencies (SMHI, SCB and SLU) and a negotiated procurement of services under the terms of the Public Procurement Act for the IVL, this to be able to have the same setting for the consortium as during the former period.

SMED receives data and documentation from responsible authorities as described above and produces most of the data and documentation in the Swedish inventory. The regular inventory work is organized as a project involving all SMED organizations. The project is run by a project management team with one person from each organization. The SMHI is main responsible for production of gridded emission

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[8] http://www.smed.se/

data. SCB is main responsible for the energy sector, the agriculture sector and parts of the waste sector, but is also involved in industrial processes since these are closely connected to the energy sector. The SLU is responsible for the LULUCF sector. The IVL is main responsible for the industrial process and product use sector and also parts of the waste sector and energy sector.
On behalf of the Swedish EPA, SMED also conducts specific projects necessary for improving the inventory.

## 1.3 Inventory planning, preparation and management

The present Swedish air pollutant inventory was compiled according to the recommendations for inventories set out in the Guidelines for Estimating and Reporting Emission Data for reporting to the Convention on Long-Range Transboundary Air Pollution (CLRTAP[9]) and the 2019 and 2023 EMEP/EEA Air Pollutant Emission Inventory Guidebook as methodological guidance[10] and also the UNFCCC reporting guidelines in accordance with the Doha Amendment to the Kyoto Protocol (1/CMP.8), the IPCC 2006 Guidelines for National Greenhouse Gas Inventories, the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC GPG, 2000[11]). Data are reported in the updated NFR format.

The inventory of air pollutants for reporting to the UNECE (CLRTAP) is integrated with the greenhouse gas inventory (for reporting to the UNFCCC and EU). This assures effective use of resources and consistency between the reporting to the UNFCCC and to the CLRTAP.

### 1.3.1 Quality system

In order to fulfil the obligations of reporting, the Swedish EPA has set up a quality system as part of the national system. The structure of the quality system follows the PDCA cycle (Plan, Do, Check, Act) illustrated in Figure 1-2 below. This is an adopted model for how systematic quality and environmental management activity is to be undertaken according to international standards to ensure that quality is maintained and developed.

The quality system includes several procedures such as training of staff, inventory planning and preparation, QA/QC procedures, publication, data storage, and follow-up and improvements. All QA/QC procedures are documented in a QA/QC plan[12]. The QA/QC plan also includes a scheduled time frame describing the different stages of the inventory from its initial development to final reporting. The quality system ensures that the inventory is systematically planned, prepared and

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[9] http://www.ceip.at/fileadmin/inhalte/emep/2014_Guidelines/ece.eb.air.125_ADVANCE_VERSION_reporting_guidelines_2013.pdf

[10] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019 and
https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023

[11] http://www.ipcc-nggip.iges.or.jp/public/gp/english/

[12] Swedish EPA, National Greenhouse Gas and Air Pollutants Inventory System in Sweden

followed up in accordance with specified quality requirements so that the inventory is continuously developed and improved.

**Figure 1-2. Structure of the quality system.**

The responsibilities of the Swedish EPA and the other government agencies for the quality system are described in Ordinance (2014:1434) Concerning Climate Reporting. Under Section 3, the Swedish EPA and other government agencies which take part in the inventory work have to ensure that the methodologies applied in the reporting and inventories of emissions attain the quality required for it to be possible for Swedish air pollutant reporting to be done in the correct manner and with correct information.

The governments agencies have to have internal routines to plan, prepare, check and act/follow up the quality work and consult one another with the aim of developing and maintaining a coordinated quality system.

The responsibility of SMED to maintain and develop an internal quality system is described in the framework contract between the Swedish EPA and SMED. The SMED quality system is described in a detailed manual including several appendices.[13] It is updated annually and lists all quality control steps that must be undertaken during inventory work (Tier 1 and where appropriate Tier 2). It also includes descriptions of roles and responsibilities, of databases and models, work manuals for each NFR category and documented procedures for uncertainty and key source analyses, as well as procedures for handling and responding to UNECE’s review of the Swedish inventory. It also handles follow-up and improvement by procedures of non-conformity reporting and collection of improvement needs from all stages of the annual inventory cycle. This results in a planning document, which is used as a basis for planning and selecting further actions to improve the inventory.

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[13] Manual for SMED:s Quality System in the Swedish Air Emission Inventories, available at www.smed.se

The illustration in Figure 1-3 below shows a process description of the annual Swedish inventory for greenhouse gases which is largely applicable to the air pollutant inventory.

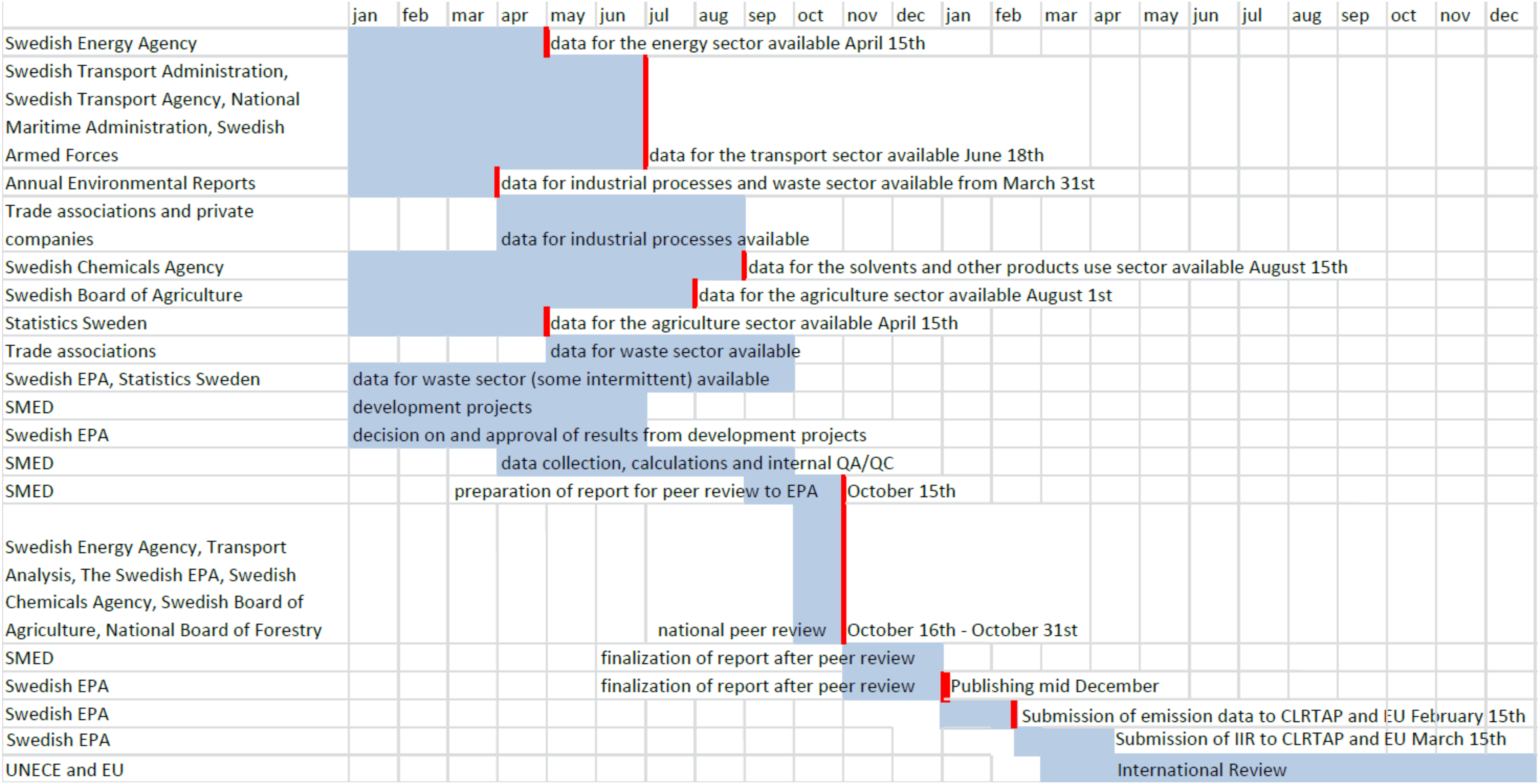

**Figure 1-3. Overview of inventory planning, preparation and management.**

### 1.3.2 Training, awareness and skills

Training, awareness and skills in air pollutant reporting are essential to maintain the level of quality required according to specified requirements. Skills are ensured for the Swedish EPA and the majority of the government agencies involved in the work by the government agency being the sector government agency with staff that have particular skills in different specialist areas.

Skills on the part of SMED are ensured in accordance with the requirements laid down in the framework contract between the Swedish EPA and the consultants. The levels of consultant’s skills are continuously reviewed.

### 1.3.3 Inventory planning (PLAN)

Planning of the inventory for submission in year x starts in the fall of year x-2 when the Swedish EPA gets the preliminary budget for year x-1. General priorities for the coming year are set by the Swedish EPA based on

- new international and national requirements, decisions and guidelines.
- recommendations from international review not yet implemented in the inventory.
- recommendations from national peer review not yet implemented in the inventory.
- key source analysis (focus on major sources).
- uncertainty analysis (focus on sources that contributes significantly to the uncertainty of the inventory).
- ideas from SMED and the Swedish EPA on how to improve quality and effectiveness of the inventory.

Priorities are distributed to SMED approximately in October. Based on the priorities and on detailed information in the list on suggestions on improvements (see section 1.2.8 below), SMED compiles a list of suggested development projects for the coming years. The list of suggested development projects is discussed between SMED and the Swedish EPA. During the winter the Swedish EPA decides on what projects should be initiated.

From January to June (approximately) SMED is working with development projects. Reports on the results and recommendations for implementation in the inventory are delivered to the Swedish EPA who then decides how these new methods/activity data/emission factors should be implemented in the inventory. In order to be able to implement results in the current inventory with sufficient QA/QC, the Swedish EPA has to decide on implementation in June.

From time to time, there is a need to change data provided by responsible authorities as discussed above. The Swedish EPA each year contacts responsible authorities and discusses needs for updates.

### 1.3.4 Inventory preparation (DO)

SMED gathers data and information from various government agencies, organisations and companies over the period from April to August with the aim of being able to carry out emission calculations. The calculations are performed in models, statistics programs and calculation programs in April to September. Over the period from September to October, the material is put together in a reporting format. A short description of data collection and processing for each sector is provided below. See sections 3-7 for a detailed description. Preparation of the inventory is documented in detailed work documentation, which serves as instructions for inventory compilers to ensure quality and consistency, and also serves as information in the national peer review process.

#### 1.3.4.1 ENERGY- STATIONARY COMBUSTION

**Energy industries**: Data from quarterly fuel statistics, a total survey conducted by Statistics Sweden at plant level and by fuel type. For some petroleum refining plants, data from the European Union Emission Trading Scheme (ETS) is used.

**Manufacturing industries**: Data is mainly from the quarterly fuel statistics, a sample survey conducted by Statistics Sweden. In some cases, data from the industrial Energy use in the manufacturing industry (ISEN) or ETS is used as a complement. All data is at plant level and by fuel type.

**Other sectors**: Data from official statistical reports prepared by Statistics Sweden at national level and by fuel type.

Activity data is multiplied by thermal values, mainly from Statistics Sweden, and emission factors provided by the Swedish Energy Agency and the Swedish EPA. Default emission factors from the EMEP/EEA 2016 and 2019 Guidebook are used to complement the national estimates.

#### 1.3.4.2 ENERGY- MOBILE COMBUSTION

Data on fuel consumption at national level and by fuel type is collected from Statistics Sweden and used in combination with emissions data and fuel data from the National Transport Administration, the Civil Aviation Administration and the Swedish Military. Activity data is multiplied by thermal values, mainly provided by Statistics Sweden, and emission factors provided by the responsible authorities. Default emission factors from the 2019EMEP/EEA Guidebook are used to complement the national estimates.

#### 1.3.4.3 ENERGY – FUGITIVE EMISSIONS

For handling of solid fuels, activity data from Statistics Sweden is used, together with national emission factors for coal and peat.

Emissions from coke production are partly compiled from the facilities' environmental reports, partly calculated via facility-specific activity data and default emission factors from the 2019 EMEP/EEA Guidebook.

For flaring in refineries and chemical industries, activity data from ETS are used for 2005 and later. In earlier years, data was collected through personal contacts with the facilities. Activity data from hydrogen production in oil refineries are taken from ETS and through personal contacts with the facilities, as well as from the facilities' environmental reports. Regular emission factors for stationary combustion are used.

Activity data for transfer losses of gasworks gas are taken from the environmental reports provided by the facilities. Data on venting and flaring of gas in the national gas transmission network (natural gas and biogas) is reported by the operator. Emission factors for stationary combustion are used for flaring. Losses of gas during transmission, storage, venting and distribution are estimated using a national method and national data on typical gas compositions.

Fugitive emissions from refineries and from storage of petroleum products at storage depots are mainly compiled from the facilities' environmental reports. Estimates of fugitive emissions from gasoline stations are calculated from fuel data provided by the National Road Administration.

#### 1.3.4.4 INDUSTRIAL PROCESSES AND PRODUCT USE

The reported data for industrial processes is mainly based on information from environmental reports. According to Swedish environmental legislation, operators performing environmentally hazardous activities that require a permit by law are required to compile and send an annual environmental report to their supervisory authority. The County Administrative Boards audit the data from the operators’ environmental reports.

The data in the environmental reports refer to emissions derived from plant specific measurements or estimates such as mass balances. The use of default emission factors is limited.

In some cases, when there are a large number of smaller companies within a specific sector, and all the environmental reports are not available, a combination of information available from environmental reports and production statistics at national level is used to estimate national emissions. Emission factors used are usually derived nationally based on available information from some facilities in a specific sector and applied to the national level. Default emission factors from the 2019 and 2023 EMEP/EEA and Guidebook are used to complement the national estimates.

Data used for estimating emissions from solvent and other product use are based on emission factors and national activity data obtained from the Products Register kept by the Swedish Chemicals Agency.

#### 1.3.4.5 AGRICULTURE

Data on livestock populations, crop areas, crop yields, sales of manure, manure management systems and stable periods are taken from official statistical reports published by the Swedish Board of Agriculture and Statistics Sweden. Some complementary information is collected from organisations and researchers, such as the Swedish Dairy Association, SLU and the Swedish Institute of Agricultural and Environmental Engineering. Default emission factors from the 2019 and 2023 EMEP/EEA Guidebooks are used to complement the national estimates.

#### 1.3.4.6 WASTE

Emissions reported for waste incineration are compiled from the facilities' annual environmental reports. Other reported data are mainly based on models and uses statistical sources as activity data and default emission factors from the 2019 and 2023 EMEP/EEA Guidebook.

### 1.3.5 QA/QC procedures and extensive review of emission inventory (CHECK)

#### 1.3.5.1 QUALITY CONTROL

Quality control is the check that is made during the inventory on different types of data, emission factors and calculations that have been made. The quality control takes place according to general requirements (Tier 1) which apply to all types of data used as support material for the reporting, and specific requirements for quality control (Tier 2) which are applied to certain types of data and/or emission sources. In this inventory, general Tier 1 QC measures, according to Table 6.1 in 2006 IPCC Guidelines (2006), have been carried out as follows:

- Transcription errors in data input
- Calculations are made correctly.
- Units and conversion factors are correct.
- Integrity of database files
- Consistency in data between source categories
- Time series consistency
- Correct movement of inventory data between processing steps
- Recalculations checked and documented.
- Completeness check
- Comparison of last submission's estimates to previous estimates
- Documentation of changes that may influence uncertainty estimates.

In addition, source specific Tier 2 QC procedures are carried out for several categories (Table 1-2).

QC activities are performed in line with the 2006 IPCC Guidelines. All QC measures performed are documented by SMED in work documentations and checklists for each NFR code or group of codes. When the reporting tables are completed by SMED, sector QC meetings are held between SMED and the Swedish EPA. During the meetings, emission data is analysed in terms of level, trend and changes compared to previous submission. Before delivery of the inventory to the Swedish EPA, the SMED quality coordinator performs the final quality control. The QC meetings and the SMED quality coordinator checks serve as both quality control and quality assurance in accordance with the 2006 IPCC guidelines. In addition, the validation tool RepDab[14] is used to check the format, completeness and internal consistency of the submission.

**Table 1-2. Source specific Tier 2 QC procedures carried out in the inventory.**

| CRT | | Action |
|---|---|---|
| 1A, 1B and parts of 2 | Energy amounts | Analysis of differences between the CRT sectoral and reference approach. In order to check activity data and EF, several quality control projects have been carried out over time comparing the inventory data with information from environmental reports and EU ETS data. |
| 2C1 | Iron and steel production | Activity data are checked with fuel combustion data in order to avoid double counting of emissions or omissions. Activity data is also compared to trade statistics. IEF are compared to IPCC default values. |

### 1.3.5.2 QUALITY ASSURANCE

The Swedish QA/QC system includes several QA activities outside the SMED QA/QC procedures. At the final stages of completion of the inventory, the Swedish EPA performs a peer review for each sector. In the 2025 submission, the Swedish EPA inventory compiler team for air pollutants consisted of four members.

The Swedish QA/QC system also includes national peer reviews by sectoral authorities prior to inventory submission. The peer review is defined in the Ordinance on Climate Reporting (2014:1434) and thus includes only review of greenhouse gases. However, most underlying data is the same for the estimation of greenhouse gases and air pollutions, and thus, the national reviews serve as quality improvements also for the air pollution reporting. The national reviews include all sectors and are conducted by a person who has not taken part in the inventory preparation. The Swedish EPA is responsible for coordinating the peer reviews. From the 2016 submission, the national peer review is conducted in two steps:

- *Annual national review*. The aim of the review is to check the robustness of the national system and to guarantee that politically independent emissions data is reported. The review is performed by sectoral authorities prior to submission.

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[14] http://www.ceip.at/check-your-inventory-repdab/

- *In-depth expert peer review*. Each year there is also an in-depth peer review of one sector or part of a sector. The choice of sector depends on the outcome of the results from the EU and UNFCCC reviews and if the national review has identified problems or other needs discovered by SMED or the Swedish EPA. The aim of the in-depth expert peer review is to improve the inventory data quality. The review is performed by sectoral authorities and other national and international experts.

The annual national review is organised as a yearly meeting. Before the meeting the sectoral authorities have reviewed the NIR in terms of the functionality of the national system and a general overview of methodology and statistics used (chapter 1), emission trends (chapter 2) and changes in methods, if changed (chapter 8). Thereafter the reviewers will provide feedback on whether they find the inventory reliable and independent, the trends are correct and the national system functional. Any recommendations for improvements are recorded in the list of suggested improvements described in section 1.3.8.

The in-depth expert peer review includes methodologies, models, activity data and emission factors. The reviewers also identify areas for improvement, which consolidates the basis for improvements in coming submissions. Results from the national peer review are documented in review reports. Recommendations from the review reports are collected to the list of suggested improvements described in section 1.3.8.

The UNECE secretariat administers an international peer review of Swedish reporting after submission approximately every fourth year. Recommendations from the review reports are collected to the list of suggested improvements described in section 1.3.8.

### 1.3.6 Finalization, publication and submission of the inventory

The Swedish Environmental Protection Agency informs the Ministry of the Environment and Energy about the air pollutants inventory report in mid-December. At the same time, the inventory is published nationally[15].

The Swedish EPA submits the inventory to the CLRTAP/UNECE and NEC Directive/European Commission on February 15th. Reported data in the submission of year X relates to emissions year X-2, in other words emissions which took place during 2023 are reported in early 2025.

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[15] www.naturvardsverket.se

### 1.3.7 Data storage

A system for handling emission data, entitled Technical Production System (TPS)[16], has been developed and was implemented for the first time in submission 2007. It supports data input from text files and Microsoft Excel sheets and provides different types of quality gateways. For instance, the system makes it possible for multiple users such as the SMED consortium and the national peer reviewers to view data, plot time series and make comparisons between different years and submissions. For all NFR categories and sub-categories, time series from 1990 (sometimes 1980) onwards of emission data, activity data, and implied emission factors where relevant can be presented. The system also allows for different types of data output, e.g. to the NFR tables or to plain MS Excel. Finally, TPS is used for data archiving of each submission. For access to the TPS, login with password is requested.

In addition to TPS, documentation, data and all calculations for each submission are stored at each organization’s servers and, for collective use and archiving, at two projects at Projectplace[17]. One project is for documents shared between Swedish EPA, other involved agencies and SMED and the other project is primarily for SMEDs use however the Swedish EPA also has access to a major part of the project. At Projectplace, all documents are stored in versions, in other words when documents are changed a new version is automatically created. This function ensures that important information is not lost and facilitates backtracking of changes. Login with password is requested for access to projects at Projectplace.

### 1.3.8 Follow-up and improvement (ACT)

Each year, all comments received from national and international reviews that are not already addressed, as well as ideas from SMED and the Swedish EPA, are compiled into a list for suggestions on improvements. From this list, development projects are formed each year as describes in section 1.2.3. All suggestions not implemented one year is kept on the list for next year.

Each year, the Swedish EPA follows up on delivered data from responsible agencies to ensure correct and appropriate data for next submission.

Development of TPS such as additional functions etc. is organized in a similar way as for the inventory: Ideas are compiled into a list, and from this list issues to be implemented are prioritized.

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[16] https://tps.naturvardsverket.se/

[17] www.projectplace.com

## 1.4 Key source categories

Key source categories are sources that together contribute with either 95% of the level or 95% of the overall trend of reported emissions in Sweden. In this inventory, key category analysis is carried out for both emission level and trend of the following pollutants: As, BC, Cd, CO, Cr, Cu, dioxins/furans, Hg, $NH_3$, Ni, NMVOC, $NO_X$, PAH 1-4, Pb, $PM_{2.5}$, $PM_{10}$, Se, $SO_2$, TSP and Zn. The level and the trend assessment are done with both the Approach 1 and the Approach 2 methods. A summary table of the identified key sources are given below within each NFR sector chapter. The complete results of the latest Swedish key source analysis are presented in Annex 1 (Tables A1-1 to A1-20) together with the methodology.

## 1.5 General uncertainty evaluation

To prioritise efforts and resources in subsequent years, expert judgments mainly by the inventory staff together with IPCC references on uncertainties in activity data and emission factors have been the basis for the IPCC Tier 1 uncertainty evaluation.

The complete results of the Swedish uncertainty analysis for 2023 are presented in Annex 1 together with the methodology. The summary table below (Table 1-3) shows the uncertainty for the total emissions together with the uncertainty for the trend for each substance. Tables A1-1 to A1-20 in Annex 1 provide a complete listing of uncertainties for all pollutants and source categories and include, along with estimated national emissions 1990 and 2023, uncertainties for activity data, emission factors and national emissions in 2023, and uncertainties for the trends 1990-2023. For several of the substances most of the total variance derives from only a limited number of sources. For example, 78.3% of the variance in total $NO_X$ emissions derives from the application of mineral fertilisers (Table A1-11). In general, estimated uncertainties are higher for emission factors than for activity data.

**Table 1-3. Summary of uncertainties in total inventory by pollutant in 2023 and trend uncertainties 1990-2023 (2000-2023 for Black Carbon, BC).**

| Pollutant | Uncertainty in total inventory 2023 (%) | Uncertainty introduced into the trend 1990-2023, (%) |
|---|---|---|
| As | 88.6 | 9.7 |
| Cd | 32.1 | 5.8 |
| CO | 20.2 | 6.7 |
| Cr | 40.8 | 4.3 |
| Cu | 58.3 | 20.6 |
| DIOX | 166 | 88.9 |
| Hg | 84.2 | 3.0 |
| $NH_3$ | 15.0 | 7.7 |
| Ni | 21.1 | 2.5 |
| NMVOC | 22.1 | 6.6 |
| $NO_X$ | 32.0 | 8.6 |
| PAH 1-4 | 678 | 18.6 |
| Pb | 25.6 | 0.5 |
| $PM_{2.5}$ | 23.2 | 2.9 |
| $PM_{10}$ | 35.0 | 5.0 |
| Se | 413 | 159 |
| $SO_2$ | 8.9 | 1.2 |
| TSP | 57.9 | 3.8 |
| Zn | 332 | 104 |
| BC | 109 | 18.5 |

# 1.6 General assessment of completeness

The Swedish inventory covers all air pollutants required and most relevant sources with some exceptions. The general completeness for each sector is discussed below.

Sources where pollutants have not yet been estimated, but may occur, include: 2C7d, Storage handling and transport of metal products; 2J, Production of POPs; 2K, Consumption of POPs and heavy metals; 3Da4, Crop residues applied to soils; 3Db, Indirect emissions from managed soils; 3Dd, Off-farm storage handling and transport of agricultural products.

For sources where PAH1-4 is estimated, usually benzo(a)pyrene is estimated separately but not always the other 3 specified PAH-substances due to lack of information. Therefore, national totals for the 4 specified PAH species in relation to PAH1-4 may be misleading.

In Table 1-4a and 1-4b those sources are listed that are not estimated in the Swedish emission inventory. For some of these, default emission factors are available in the EMEP/EEA Guidebook 2019. For each of the sources in Tables 1-4a and 1-4b, an explanation is given as to why emissions have not been estimated.

**Table 1-4a. Sources in the Swedish air pollutant inventory for which emissions have not been estimated – Main pollutants and particulates. Explanations are given below.**

| NFR Code | $NO_X$ | NMVOC | $SO_X$ | $NH_3$ | $PM_{2.5}$ | $PM_{10}$ | TSP | BC | CO |
|---|---|---|---|---|---|---|---|---|---|
| 1B1c | | | | NE (3) | | | | NE (3) | |
| 2C1b | | | | NE (3) | | | | | |
| 2C1c | | | | NE (3) | | | | | NE (3) |
| 2C7d | | | | | NE (1) | NE (1) | NE (1) | | |
| 11B | NE (4) | NE (4) | NE (4) | NE (4) | NE (4) | NE (4) | NE (4) | | NE (4) |

**Table 1-4b. Sources in the Swedish air pollutant inventory for which no emissions have been estimated – Heavy metals and POPs. Explanations are given below.**

| NFR Code | Pb | Cd | Hg | As | Cr | Cu | Ni | PCDD/ PCDF | PAH 1-4 | HCB | PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1B1c | | | | | | | | | NE (3) | NE (3) | NE (3) |
| 1B2A1 | NE (3) | NE (3) | NE (3) | NE (3) | NE (3) | NE (3) | NE (3) | | NE (3) | | |
| 1B2A4 | | | | | | | | | | NE (3) | NE (3) |
| 1B2C | | | | | | | | | | NE (3) | NE (3) |
| 2C1b | | | | | | | | | NE (2) | NE (3) | NE (2) |
| 2C1c | | | | | | | | | NE (2) | | |
| 2C7a | | | | | | | | | | | NE (1) |
| 2C7b | | | | | | | NE (1) | | | | |
| 2K | | | NE (2) | | | | | | | | NE (2) |

(1) Notation key should be IE (included in NFR 2), will be corrected in submission 2025.
(2) Default EF results in unreasonable emissions and is not applicable to Swedish conditions.
(3) Not possible to estimate with the country-specific methodology currently used.
(4) Source is not mandatory.

## 1.6.1 Energy

Estimated emissions are considered to be complete for most sources. There might still be some incompleteness with regard to in-house generated fuels in the chemical industry and in smaller companies.

Fugitive emissions, i.e. venting and flaring of liquid and gaseous fuels, are most likely not complete for smaller companies. However, all Swedish plants that flare gas and that are included in the European trading scheme for $CO_2$ from 2005, are included. For smaller plants, data might be reported in NFR1A instead of NFR1B. Hence lack of data on emissions from flaring is considered to be insignificant.

## 1.6.2 Industrial Processes and Product Use

For most sources, and particularly for the most important ones, the estimates are in accordance with the requirements concerning completeness as laid out in the EMEP/EEA Guidebook 2023, and in some cases EMEP/EEA Guidebook 2019. However, some exceptions do exist, mainly in terms of some heavy metal emissions and POPs from product use and consumption of POPs and heavy metals, where the default guidebook emission factors were judged inappropriate for Swedish conditions.

### 1.6.3 Agriculture

Emissions of $NO_X$ and $NH_3$ from crop residues are currently not estimated, the method in guidebook 2023 is not yet implemented. Except for that, all relevant agricultural emissions and sources are considered to be included in the inventory. For example, most of the country's horses do not belong to farms but are despite that included in the agricultural sector of the inventory. All sales of fertilizers are included, also quantities used in other sectors.

### 1.6.4 Waste

Emissions from incineration of Municipal Solid Waste (MSW) are included in 1A1a, as MSW is used for energy production. In NFR 5, emissions of some pollutants from hazardous waste incineration, cremation, landfill fires and garden burning/bonfires are included, but not completely. For hazardous waste incineration, emissions from one large plant are included, and there may be emissions from smaller plants that are not covered. The overall completeness for the waste sector is unknown, but the inventory can be considered as complete in terms of using the suggested methods in EMEP/EEA Guidebook 2019.

# 2 Explanation of key trends

## 2.1 Emissions of pollutants regulated in the amended Gothenburg Protocol

Emissions of pollutants regulated in the amended Gothenburg Protocol ($SO_2$, $NO_X$, $NH_3$, NMVOCs, $PM_{2.5}$ and BC) have been largely reduced since 1990 (Figure 2-1).

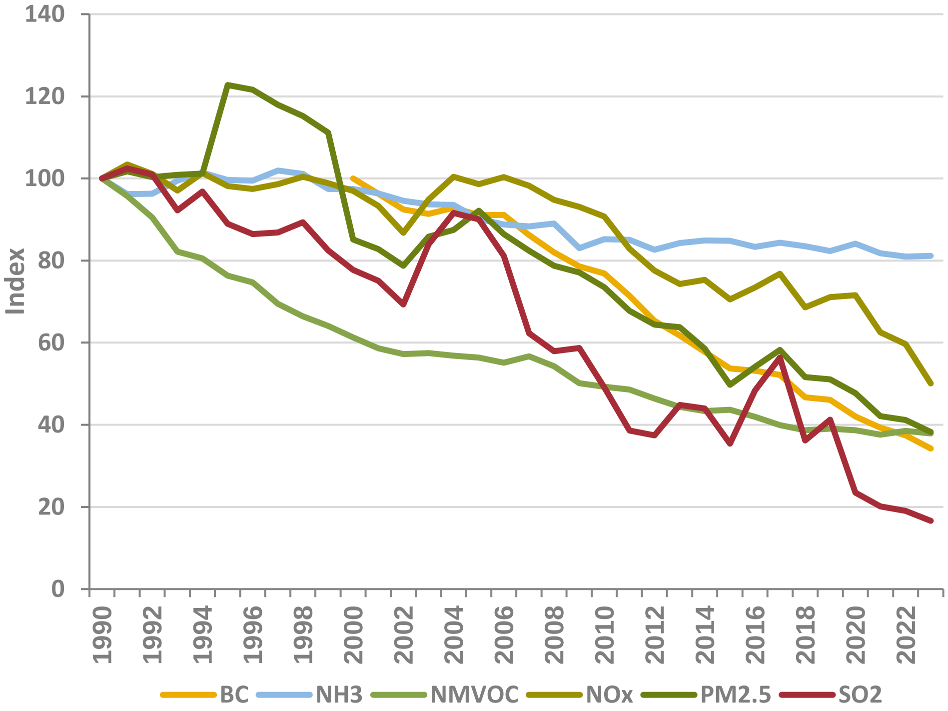

**Figure 2-1. Trends in emissions 1990-2023 for $NO_X$, $SO_2$, $NH_3$, NMVOC, $PM_{2.5}$ index-year 1990=100 and BC index year 2000=100.**

### 2.1.1 Nitrogen oxides ($NO_X$)

Swedish emissions of $NO_x$ amounted to about to about 104 kt in 2023. In total, emissions have decreased by 64% since 1990 and by 4% since 2022. The different sectors’ share of the $NO_x$ emissions in Sweden 2023 is shown in Figure 2-2.

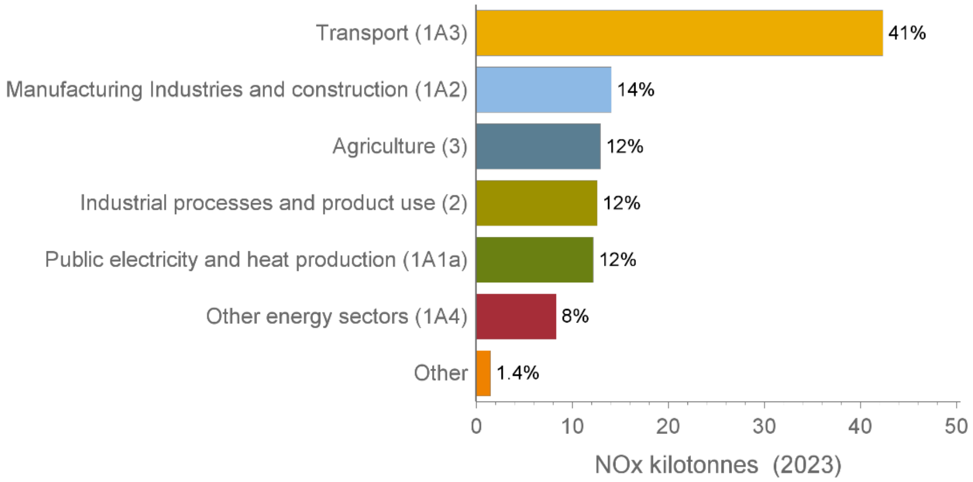

**Figure 2-2. Distribution of $NO_x$ emissions among major contributing sectors and sub-sectors in 2023.**

The largest source of $NO_x$ emissions in 2023 was the transport sector (NFR1A3), where emissions amounted to 40 kt, corresponding to 41% of the total. Emissions from the transport sector have been reduced by 75% since 1990 and by 7% since 2022. Since 1990 the stricter emission requirements for new vehicles during the period can explain the reduction.

$NO_x$ emissions from passenger cars (NFR1A3b) were 75% lower in 2023 compared to 1990 (Figure 2-3). $NO_x$ emissions from diesel passenger cars increased from 5 kt to 22 kt between 2005 and 2016. The last years, the emissions have decreased and was about 10 kt in 2023. The combination of increased use of diesel due to the political ambition to reduce $CO_2$ emissions from cars and the problems with the large discrepancies between Euro standards and real driving emissions (RDE) from diesel cars are the main reasons for this development. Emissions of $NO_x$ from gasoline cars as well as heavy-duty vehicles continue to decrease. Emissions from heavy duty vehicles were reduced by 16% between 2022 and 2023 and by 90% since 1990.

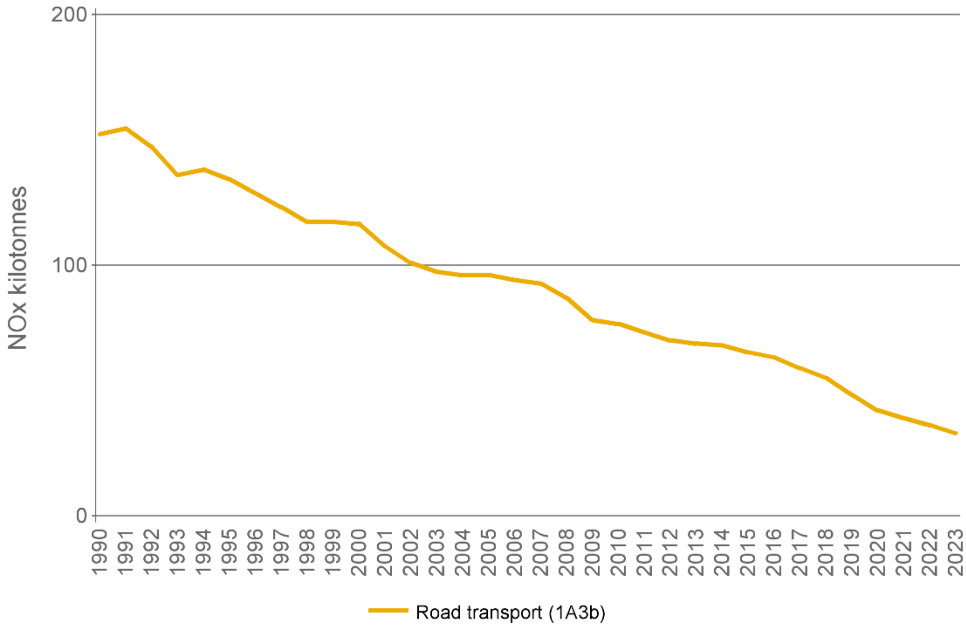

**Figure 2-3. Trend in $NO_X$ emissions from road transport (1A3b) 1990-2023.**

The second largest source of $NO_x$ emissions in 2023 was combustion in manufacturing industries and construction (NFR1A2) in which emissions were about 14 kt, corresponding to 14% of the total emissions. $NO_x$ emissions in the sector have been reduced by 63% since 1990 and decreased by 4% since 2022 (Figure 2-4).

Emissions of $NO_x$ from electricity and heat generation (NFR1A1a) amounted to 12 kt in 2023, corresponding to 12% of the total emissions. Emissions have varied during the period with decreasing emissions during the 1990’s and increasing emissions between 2000 and 2010 (Figure 2-4). To some extent emissions depend on temperature and precipitation resulting in higher emissions during 1996 and 2010 which were exceptionally cold years.

In 1992, a $NO_x$ fee was introduced where combustion plants (NFR1A1a and 1A2) with an output of more than 25 GWh per year are included. Since the introduction of the fee, $NO_x$ emissions per unit produced energy have been reduced to less than half. This is an important reason why emissions of $NO_x$ from combustion in manufacturing industries and construction and electricity and heat production have decreased despite increased energy production.

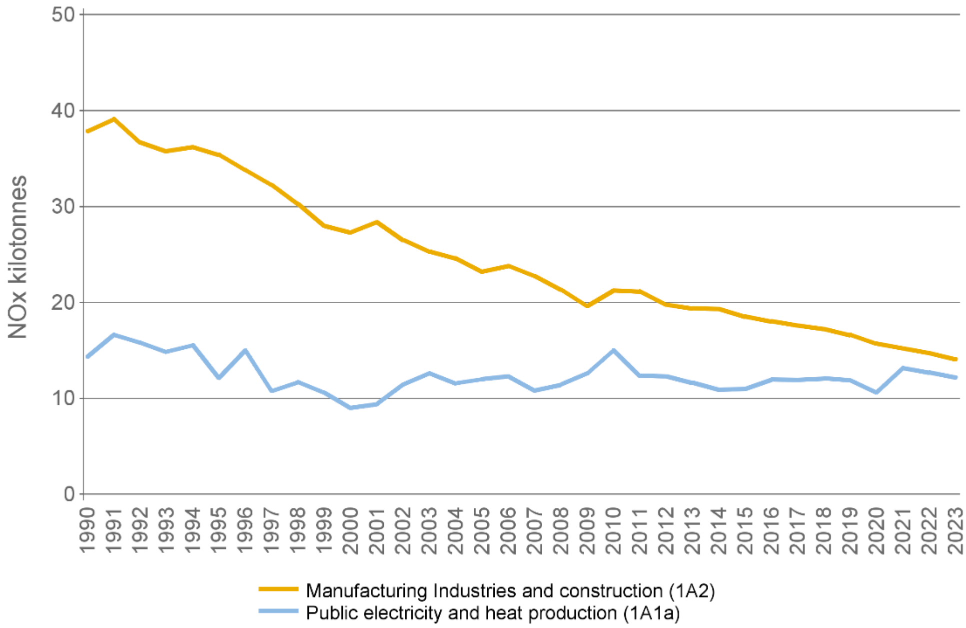

**Figure 2-4**. **Trends in emissions from public electricity and heat production and Manufacturing industries and construction 1990-2023.**

Emissions of $NO_x$ from other sectors (NFR1A4) were 8 kt, corresponding to 8% of the total emissions in 2023. These emissions have been reduced by 73% since 1990 due to expanded district heating and increased use of heat pumps that have replaced oil heaters.

Agriculture sector and industrial processes sector contributed 12% each of the total emissions of $NO_x$ in 2023. Emissions from industrial processes have decreased by 18% since 1990 and have stayed at the same level since 2010. The main part of the emissions originates from the pulp- and paper industry (NFR2H1).

### 2.1.2 Sulphur dioxide ($SO_2$)

Total emissions of $SO_2$ have decreased by 86% since 1990 and decreased by 2% since 2022 and amounted to 14.5 kt in 2023. The different sectors share of the $SO_2$ emissions in Sweden 2023is shown in Figure 2-5.

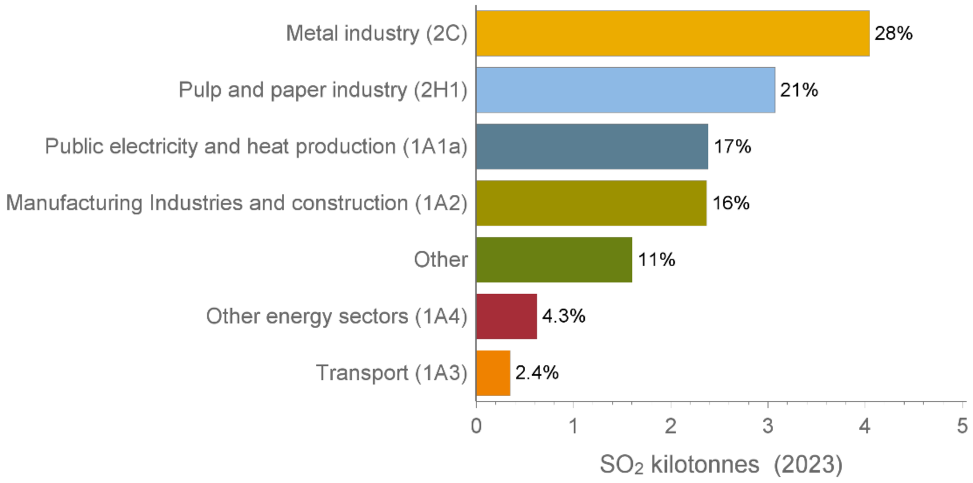

**Figure 2-5. Distribution of $SO_2$ emissions among major contributing sectors and sub-sectors in 2023.**

Industrial processes (NFR2) emitted 8 kt during 2023 and was the main contributor to the emissions of $SO_2$ (Figure 2-6). Processes within the metal industry (NFR2C) and pulp and paper industry (NFR2H1) generated 4 and 3.1 kt, corresponding to 28% and 21%, respectively in 2023. Since 2022 emissions from the metal industry have decreased by about 2 % and have overall been reduced by 58% since 1990. Emissions from the pulp and paper industry increased by about 11% since 2022 and decreased by 76% since 1990.

Emissions from combustion in manufacturing industries and construction (NFR1A2) amounted to 2.4 kt in 2023, corresponding to 16% of the total emissions. Emissions have been reduced by 88% since 1990. The main reason for the large reduction since 1990 was a cut-down in the use of oil in the sector and better pollution control.

Emissions from electricity and heat generation (NFRA1a) amounted to 2.4 kt, corresponding to about 17% in 2023. Emissions from the sector have been decreased by 84% since 1990 due to reduced use of coal and oil and pollution control. Between 2022 and 2023 emissions decreased by 13%.

Transport (NFR1A3) and other sectors (NFR1A4) amounted to 0.4 kt and 0.6 kt, corresponding to 2% and 4%, respectively in 2023. Emissions in these sectors have decreased by roughly 96% since 1990 due to reduced use of oil and reduced sulphur content in the oil used.

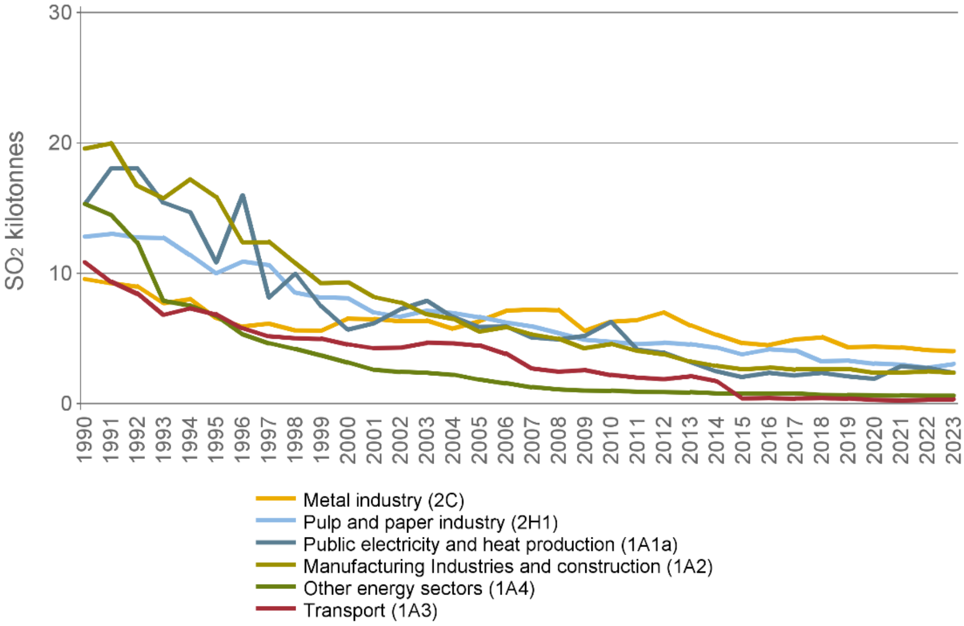

**Figure 2-6**. **Trends in $SO_2$ emissions from major sectors and subsectors 1990-2023.**

### 2.1.3 Ammonia ($NH_3$)

Total emissions of $NH_3$ in Sweden (54 kt) were about 19% lower in 2023 compared to 1990. Between 2022 and 2023 emissions increased slightly. The different sectors' share of the $NH_3$ emissions in 2023 is shown in Figure 2-7.

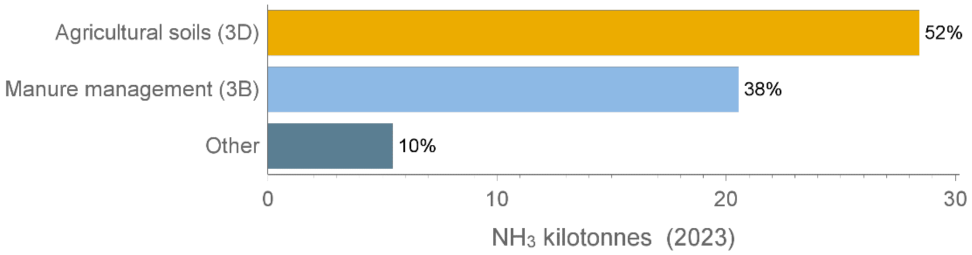

**Figure 2-7. Distribution of $NH_3$ emissions among major contributing sectors and subsectors in 2023.**

The agriculture sector (NFR3) was the main source for $NH_3$ emission in the inventory, amounted to about 49 kt or 90% of the emission in 2023. Ammonia is emitted from farm animals' dung and urine and during the spreading of animal manure and the use of inorganic fertilizers. Compared to emission levels in 1990, the emissions were about 19% lower in 2023.

Emissions from agriculture soils (NFR3D) were 28 kt in 2023 (Figure 2-8) and accounted for 52% of the sector's emissions. Within NFR3D, most of the emissions come from animal manure and inorganic fertilizers applied to soils. Emissions were about 21% and 34%, respectively lower in 2023 compared to 1990.

Manure management (NFR3B) contributed with about 21 kt or 38% of total emission of $NH_3$ in 2023. The main shares came from non-dairy cattle, 8.6 kt followed by dairy cattle, 3.6 kt. Emissions from manure management were about 20% lower in 2023 compared to 1990 due to a decline in number of animals, lesser use of inorganic fertilizers, and improvement of production within the sector.

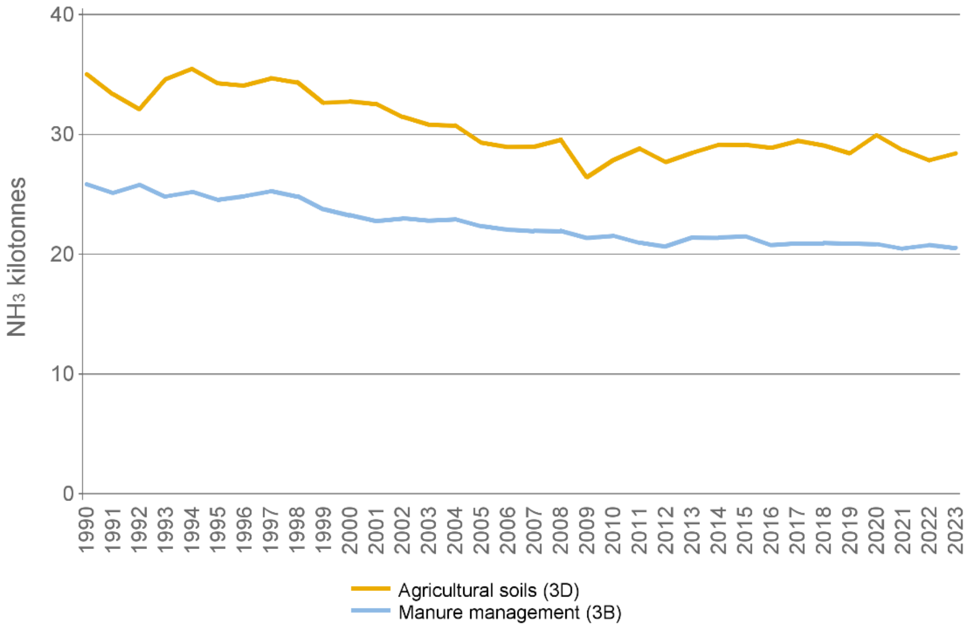

**Figure 2-8. Trend in $NH_3$ emissions from manure management (NFR3B) and Agricultural Soils (NFR3D) 1990-2023.**

### 2.1.4 NMVOC

Emissions of NMVOC which amounted to about 138 kt in 2023 have decreased by 62% since 1990 and decreased by 1% since 2022. The different sectors' share of the NMVOC emissions in Sweden 2023 is shown in Figure 2-9.

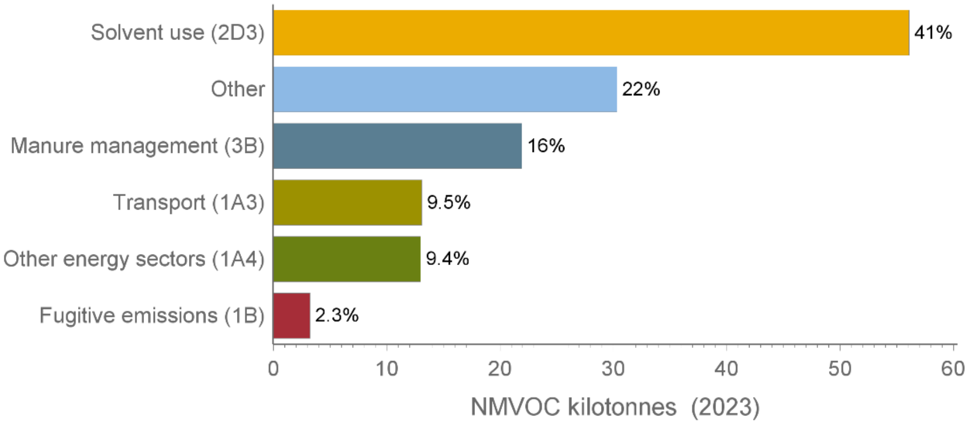

**Figure 2-9. Distribution of NMVOC emissions among major contributing sectors and subsectors in 2023. Emissions from the sabotaged NordStream pipeline in the Baltic Sea is not included in this figure.**

Emissions of NMVOC from solvent use (NFR2D3) were 56 kt in 2023 and it was the dominant source contributing 41% to total emissions. Emissions from solvent use have decreased by 38% since 1990 (Figure 2-10). Important reductions occurred from coating applications (in sector NFR2D3) where emissions decreased by 78% since 1990. Emissions from other non-specified (in sector NFR2D3) have more than doubled since 1990, from about 13 kt to 39 kt.

Emissions from the transport sector (NFR1A3) which accounted for 13 kt, corresponding to less than 10% of national totals in 2023, have decreased by 91% since 1990 and by about 2% since 2023. The main part of the reduction since 1990 stems from passenger cars (NFR1A3b) since the cars have become more energy efficient and with the introduction of new exhaust requirements. Emissions from gasoline evaporation (NFR1A3b) have been reduced by 95% from 45 kt to 2.3 kt per year since 1990, due to emission control measures.

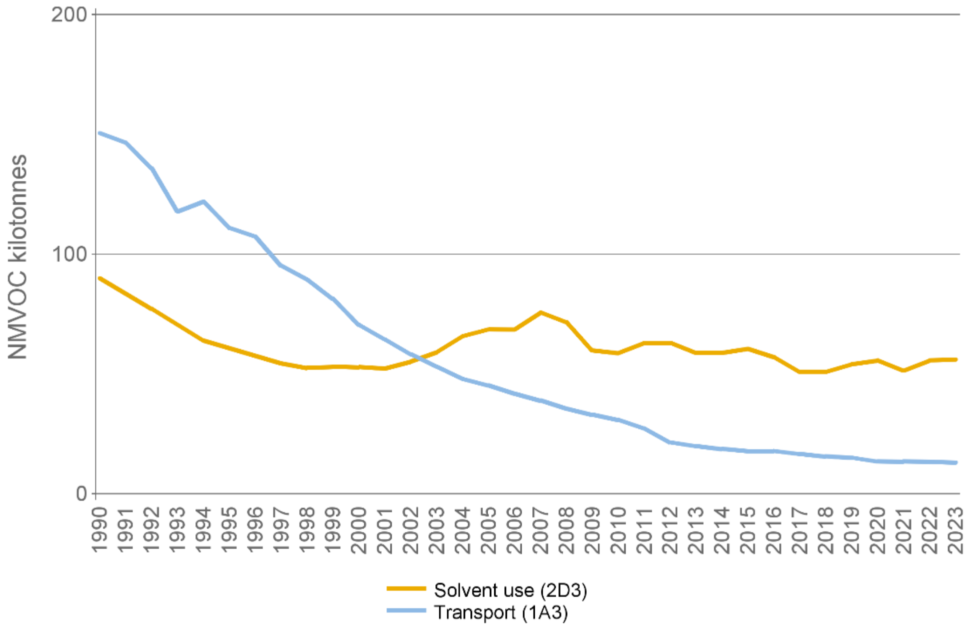

**Figure 2-10. Trends in NMVOC emissions from solvent use (2D3) and transport (1A3) 1990-2023.**

Emissions from other energy sectors (NFR1A4) amounted to 13 kt in 2023, corresponding to 9% to the total emissions. Since 1990 emissions have decreased by 55%. The main contribution, 9 kt or 6.6% of total emissions, comes from the residential sector (NFR1A4b) where the sources are combustion of biomass and the use of gasoline in gardening equipment.

Emissions of NMVOC from manure management (NFR3B) were 22 kt in 2023, corresponding to 16% of the total emission.

### 2.1.5 Particulate matter ($PM_{2.5}$)

Emissions of $PM_{2.5}$ were 14 kt in 2023 and have been reduced by 68% since 1990 and emissions in 2023 are almost comparable to 2022. The different sectors' share of the $PM_{2.5}$ emissions in Sweden 2023 is shown in Figure 2-11.

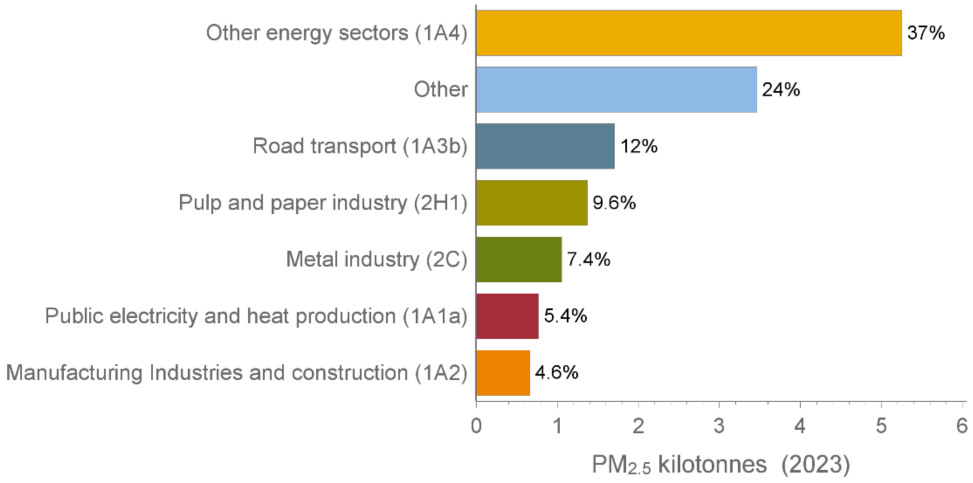

**Figure 2-11. Distribution of $PM_{2.5}$ emissions among major contributing sectors and subsectors in 2023.**

Other energy sectors (NFR1A4) were the largest source of $PM_{2.5}$ in 2023, accounting for 5 kt or 37% of total emissions (Figure 2-12). The main part of the emissions in the sector came from stationary biomass combustion in the residential sector (NFR1A4bi). Emissions from this sector, which have varied over the period, were 66% lower in 2023 compared to 1990.

Emissions from road transport (NFR1A3b), the second largest source of $PM_{2.5}$, amounted to 1.7 kt or 12% of total emissions in 2023. Emissions from road transport have decreased by 64% since 1990. The main reason for reductions since 1990 is stricter standards resulting in lower emissions from heavy goods vehicles (96% reduction since 1990) and buses (97% reduction since 1990). Specific emissions of $PM_{2.5}$ from diesel passenger cars have been reduced by over 86% since 1990. The emissions from automobile road abrasion, which depend on the total traffic work and the use of studded tires, increased with 95% between 1990 and 2023.

Emissions from combustion in manufacturing industries and construction (NFR1A2) were 0.7 kt in 2023, accounting for 4.6% of total emissions of $PM_{2.5}$. Emissions from the sector have been reduced by 86% since 1990. Most of the emissions in the sector originated from pulp, paper, and print (NFR1A2d) and other (NFR1A2g).

Emissions from electricity and heat generation (NFR1A1a) amounted to about 0.8 kt, accounting for 5% of total emissions in 2023. Emissions have decreased by 68% since 1990. The reason for the reduction is improved pollution control. Emissions in 2023 were 1% lower compared to 2022.

The pulp and paper (NFR2H1) and metal industries (NFR2C) are the two most important subsectors within industrial processes and product use (NFR2) where emissions were 1.4 and 1 kt, accounting for 10% and 7% of total emissions, respectively in 2023. In the metal industries there was a large reduction in emissions between 2013 and 2014 much of which can be explained by a new electro-filter at a large pellet plant. There has been a significant reduction, 78%, in emissions from the pulp and paper industry between 1990 and 2023.

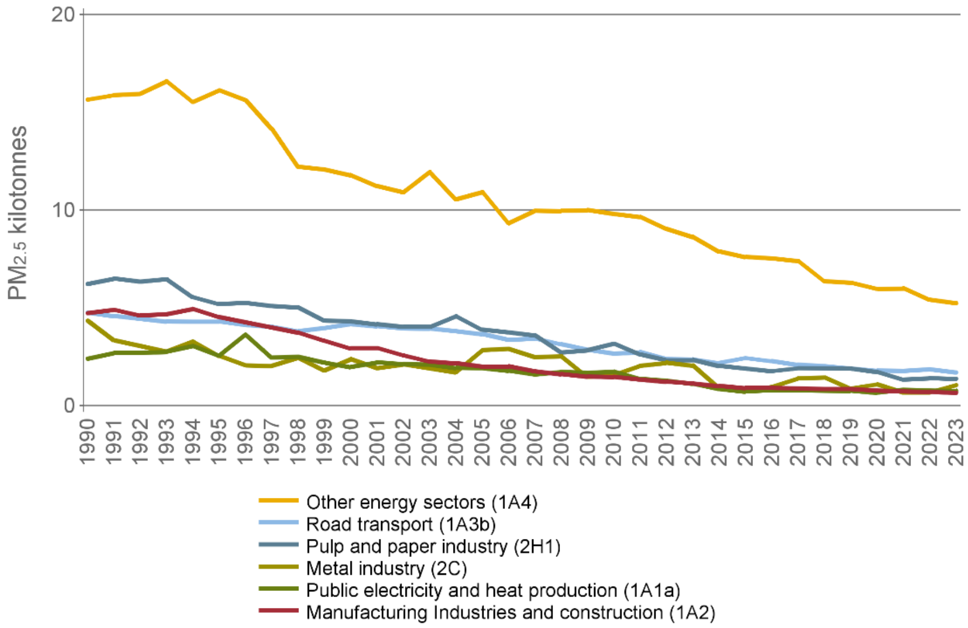

**Figure 2-12. Trends in $PM_{2.5}$ emissions from major sectors and subsectors 1990-2023.**

### 2.1.6 Black carbon (BC)

Total emissions of black carbon (BC) in Sweden 2023 amounted to 1.6 kt. Emissions have been reduced by 70% since 2000 and by 5% since 2022. The different sectors' share of the BC emissions in Sweden 2023 is shown in Figure 2-13.

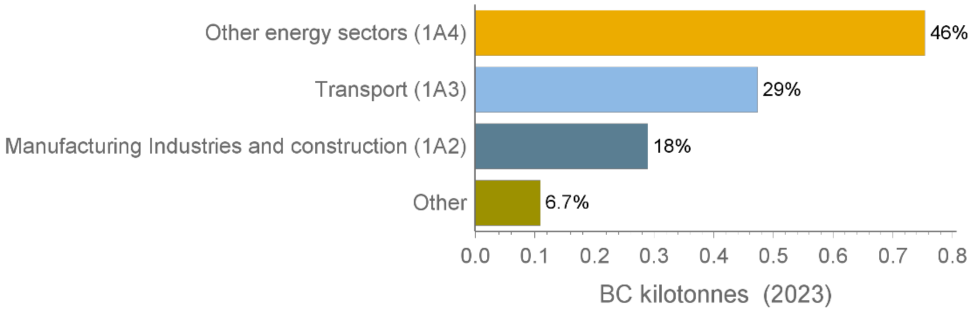

**Figure 2-13. Distribution of BC emissions among major contributing sectors and sub-sectors in 2023.**

The largest source of BC emissions in 2023, which amounted for 0.75 kt or 46% of the total emissions, was the other energy sectors (NFR1A4) (Figure 2-14). The main part, 0.62 kt, originates from stationary biomass combustion.

The second largest source of BC emissions is the transport sector (NFR1A3) amounted to 0.47 kt or 29% of the total emissions in 2023. The most important source was road transportation (NFR1A3b), contributing 0.38 kt or 79% of the emissions within the sector. Emissions from road transportation have been reduced by 81% since 2000 and the most important contribution to the reduction comes from heavy duty vehicles (96%) and passenger cars (89%). Emission reductions are a result of stricter exhaust requirements.

Emissions from combustion in manufacturing industries and construction (NFR1A2) were about 0.3 kt, amounted for 18% of the total emissions in 2023. Emissions were 72% lower in 2023 compared to 2000 mainly originated from off-road vehicles and other machinery (NFR1A2g).

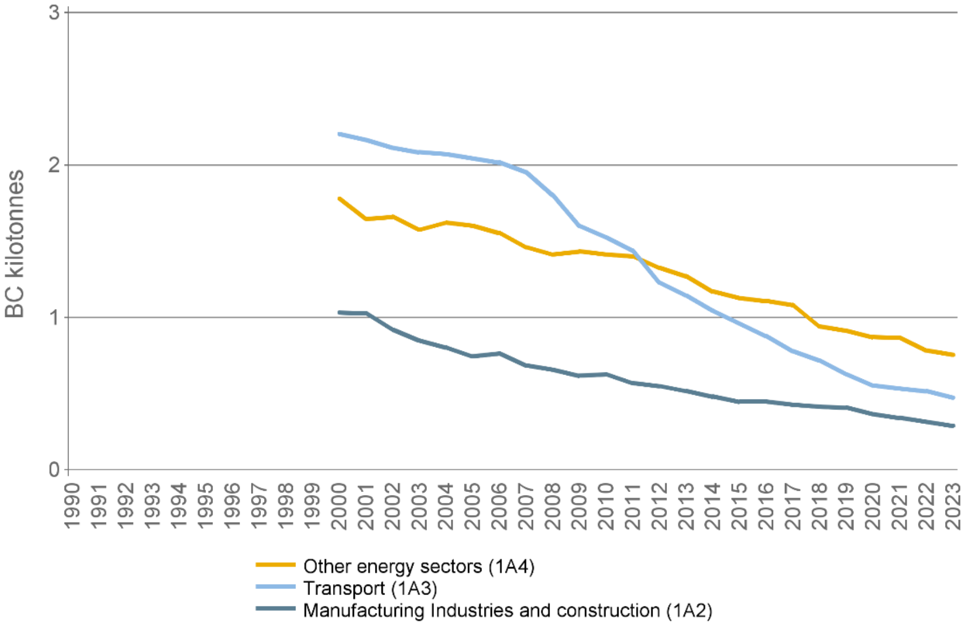

**Figure 2-14**. **Trends in BC emissions from major sectors and subsectors 2000-2023.**

## 2.2 CO, $PM_{10}$, PAH1-4, HCB & Dioxins

Emissions of CO, $PM_{10}$, PAH1-4, HCB and dioxins all show decreasing trends over the period (1990-2023). Emissions of these pollutants have been largely reduced but varied over the period (Figure 2-15).

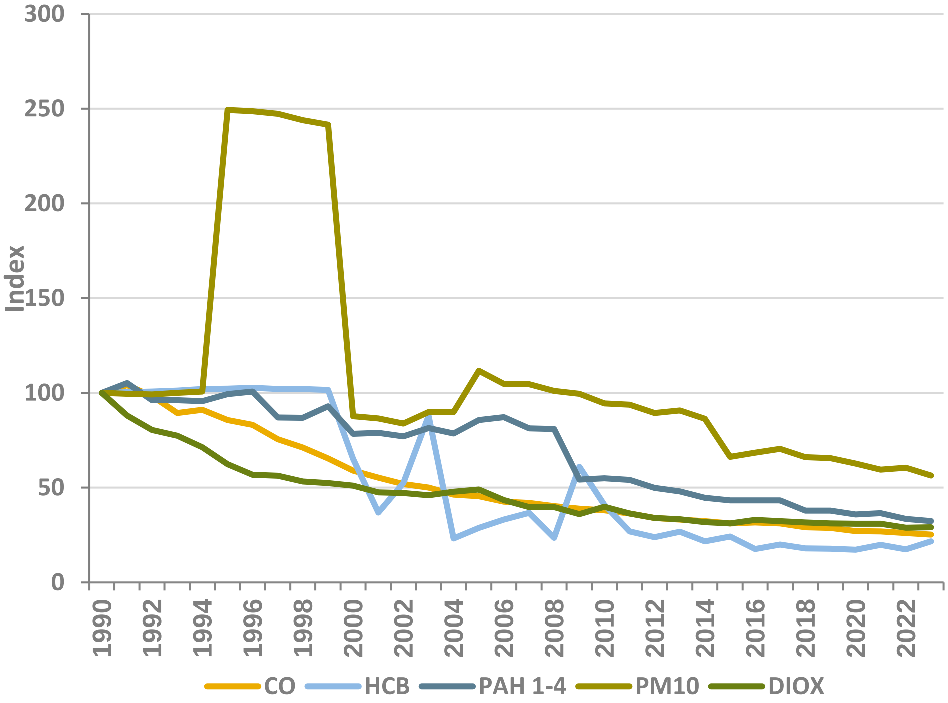

**Figure 2-15. Trends in emissions 1990-2023 for CO, $PM_{10}$, PAH1-4, HCB and dioxins. Index 1990=100.**

### 2.2.1 Carbon monoxide (CO)

The aggregated emissions of carbon monoxide (CO) have decreased from 1.1 Mt in 1990 to about 267 kt in 2023, a decline of 76%. The different sectors' share of the CO emissions in Sweden 2023 is shown in Figure 2-16.

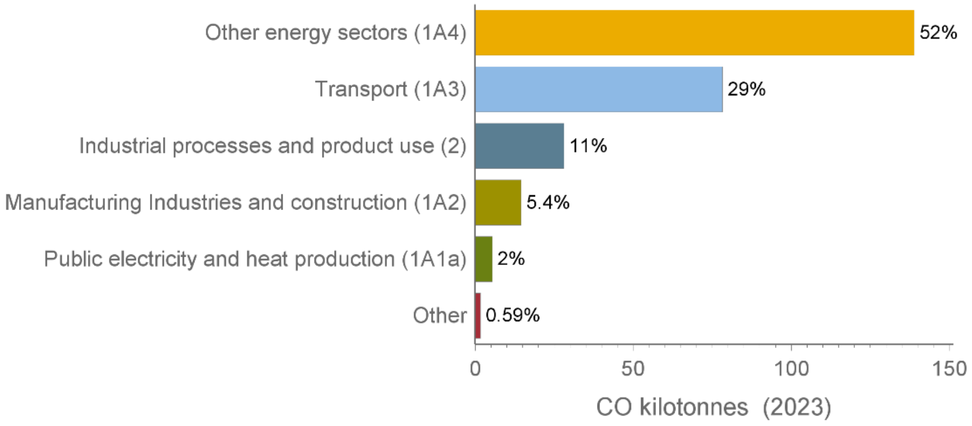

**Figure 2-16. Distribution of CO emissions among major contributing sectors and sub-sectors in 2023.**

Other energy sector (NFR1A4) was the largest source for CO emission, accounting for about 52% of the total emissions in 2023 (Figure 2-16). Most of the emission was derived from biomass combustion in residential stationary combustion, (NFR1A4bi). Emissions have been reduced by 39% since 1990.

In 2023, the transport sector (1A3) was responsible for 29% of the total emissions of CO. Emissions from the transport sector have decreased by 91% since 1990, the main reason being the introduction of catalytic converters in passenger cars and light duty vehicles. Emissions of CO from passenger cars have decreased by 93% and from light duty vehicles by 94% since 1990.

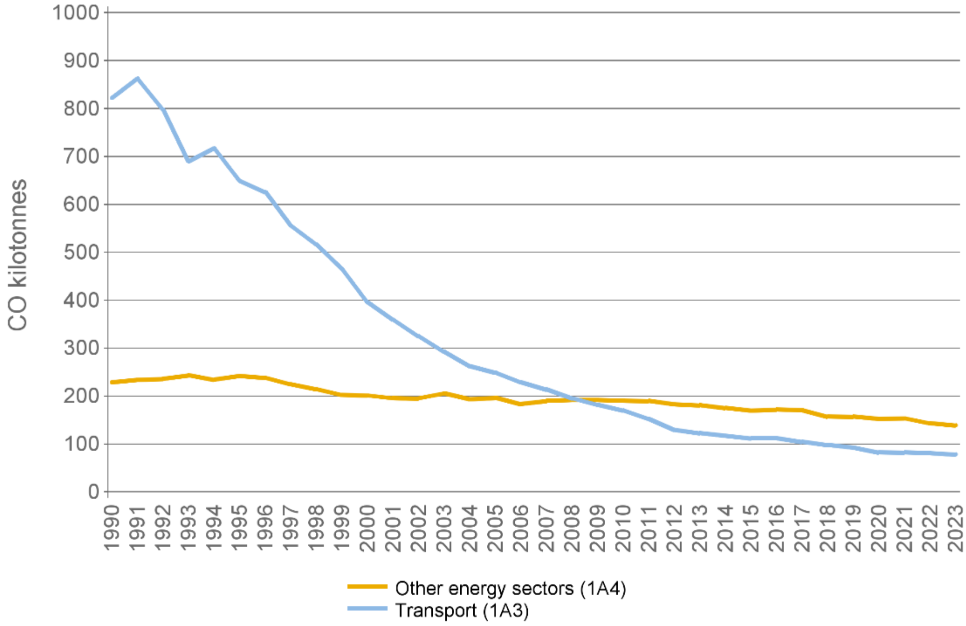

**Figure 2-17. Trends in CO emissions from other sectors (NFR1A4) and transport (NFR1A3) 1990-2023.**

Carbon monoxide emissions from the industrial processes and product use sector (NFR2) were about 32 kt in 2023 contributing with about 11% to the total. Emissions from NFR2 have increased by about 18% compared to 1990. The emissions were largely derived from aluminum industry (NFR2C3) and pulp and paper industry (NFR2H1) which have increased by about 49% and 21%, respectively since 1990.

Carbon monoxide emissions from electricity- and heat generation (NFR1A1a) and combustion within manufacturing industries and construction (NFR1A2) amounted to 5.4 and 14.5 kt, respectively or 2% and 5% of the total emission in 2023. Most of the emission in electricity- and heat generation is derived from biomass combustion which has increased by 850% since 1990. Within the manufacturing industries (NFR1A2) the emissions originated mainly from off-road vehicles and other machinery (1A2gvii).

### 2.2.2 Particulate matter ($PM_{10}$)

Emissions of $PM_{10}$ were about 39 kt in 2023 and have decreased by 47% since 1990. The aggregated emission in 2023 has decreased by 4% compared to 2022. The different sectors' share of the $PM_{10}$ emissions in Sweden 2023 is shown in Figure 2-18.

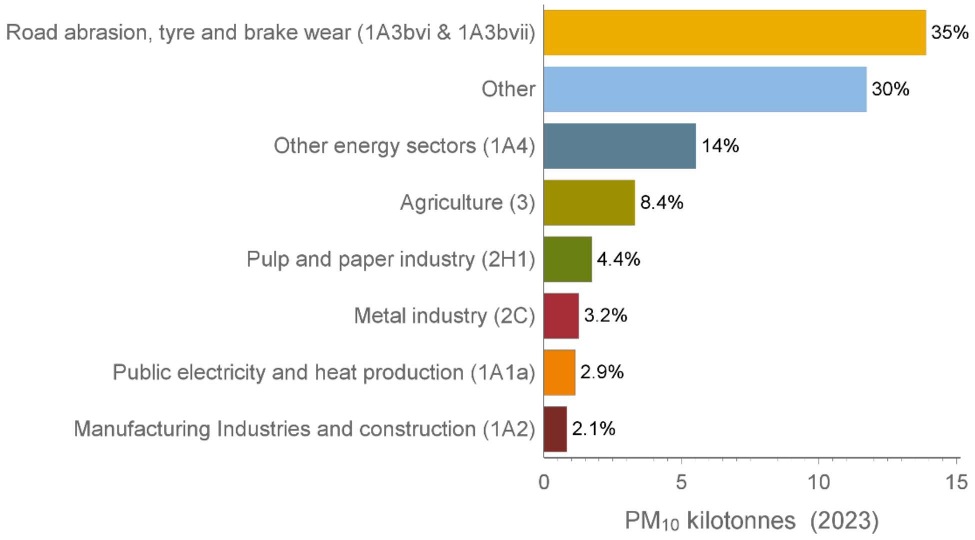

**Figure 2-18. Distribution of $PM_{10}$ emissions among major contributing sectors and subsectors in 2023.**

The main sources of $PM_{10}$ emissions in 2023 were automobile road abrasion, tyre, and brake wear (NFR1A3b), accounting for 14 kt or 35% % of the total emission in which the major part (94%) comes from automobile road abrasion. Emissions from automobile road abrasion, tyre, and brake wear were 95% higher in 2023 than in 1990. The magnitude of $PM_{10}$ emissions depends on total traffic work and the use of studded tires.

The second largest source of $PM_{10}$ emissions was Construction and Demolition (part of 2H3), accounting for 9.2 kt or 23% of the total emission in 2023. The emission from this sector have varied year to year with a peak between 1995 and 1999 due to extensive road construction.

Emissions from other energy sectors (NFR1A4) amounted to 5.5 kt or 14% of the total emissions in 2023. Most of the emissions are derived from using biomass in residential stationary combustion (NFR1A4bi) with a total of 5.3 kt. The aggregated emissions from NFR1A4 in 2023 decreased by 3% compared to 2022. Emissions in the sector have been reduced by 67% since 1990 due to increased proportion of district heating (Figure 2-19).

Emissions from the agriculture sector (NFR3) were 3.5 kt in 2023 or 8% of the national total. Manure management (NFR3B) and agricultural soils (NFR3D) contributed with about 1.4 and 2.1 kt, respectively.

The pulp and paper industry (NFR2H1) accounts for 1.7 kt, 4% of the national total in 2023. Emissions in the sector have been reduced by 80% since 1990. Large reductions in emissions have occurred in the metal industry (NFR2C), 77% since 1990, mainly due to installation of new flue gas treatment in pellets production (NFR2C1e).

Emissions of $PM_{10}$ from combustion in manufacturing industries and construction (NFR1A2) amounted to 0.8 kt in 2023 and have been reduced by 86% since 1990. Biomass combustion in pulp, paper, and print (NFR1A2d) contributed about 0.3 kt in 2023.

Emissions from public electricity- and heat production (NFR1A1a) were about 1.3 kt, or 3% of the total emissions in 2023. Emissions have decreased by 63% since 1990 mainly due to improved technology in large combustion plants (Figure 2-19).

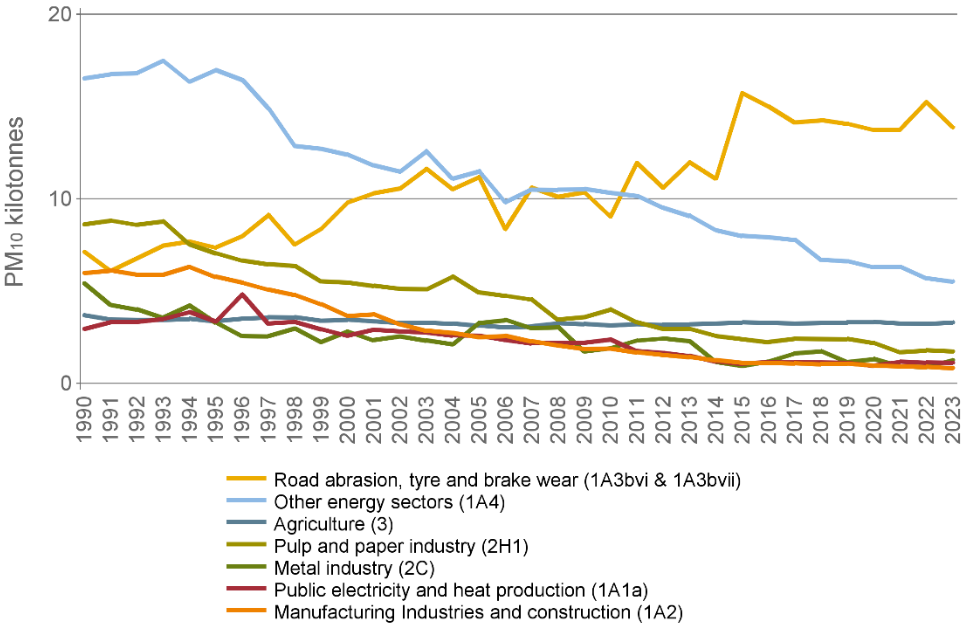

**Figure 2-19. Trends in $PM_{10}$ emissions from major sectors and subsectors 1990-2023.**

### 2.2.3 Poly Aromatic Hydrocarbons (PAH1-4)

Emissions of poly aromatic hydrocarbons (PAH1-4) were about 6 t in 2023. Emissions have been reduced by about 68% since 1990. Between 2022 and 2023 emissions decreased by 3%. The different sectors' share of the emissions of PAH1-4 in Sweden 2023 is shown in Figure 2-20.

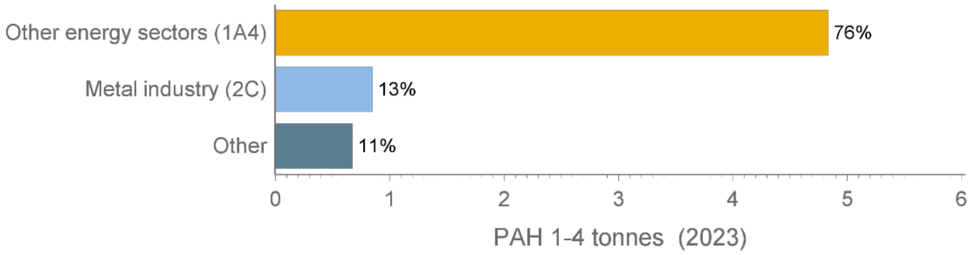

**Figure 2-20. Distribution of PAH1-4 emissions among major contributing sectors and subsectors in 2023.**

Other energy (NFR1A4) was the largest source of PAH1-4 and contributed with about 4.8 t or 76% of the total emissions in 2023. Most of the emission come from stationary combustion of solid biomass (NFR1A4b). Emissions from NFR1A4 are about 65% lower compared to 1990 (Figure 2-21). The rest of the emissions is derived from stationary combustion of biomass in agriculture, forestry, and fishing (NFR1A4ci) and commercial/Institutional (NFR1A4ai). Emission reduction in the sector is mainly due to increased proportion of district heating.

Metal industry (NFR2C) is also a significant source of PAH1-4 emissions and was responsible for 13% (or 0.9 t) of the emission in 2023. Between 1990 and 2023 emissions have been reduced by about 81% due to application of new technologies. Aluminium production (NFR2C3) was a key source of PAH1-4 emission in Sweden until 2008 and decreased strongly since then as all potlines operating the Söderberg technology were shut-down in 2008. This has resulted in emission reduction by more than 99% between 2008 and 2009 (Figure 2-21). In 2023, the emissions from aluminium production (NFR2C3) were about 14 kg.

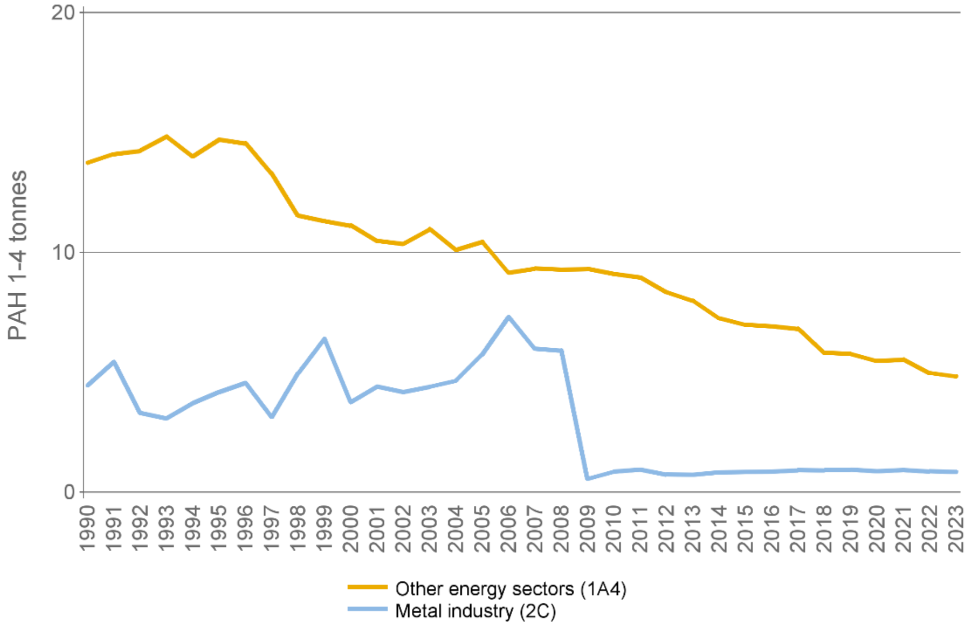

**Figure 2-21**. **Trends in PAH1-4 emissions from major sectors and subsectors 1990-2023.**

### 2.2.4 Hexachlorobenzene (HCB)

The total emissions of HCB in Sweden were about 3.4 kg in 2023. Emissions have decreased by about 80% since 1990. Between 2022 and 2023 emissions increased by 28%. The different sectors' share of the HCB emissions in 2023 is shown in Figure 2-22.

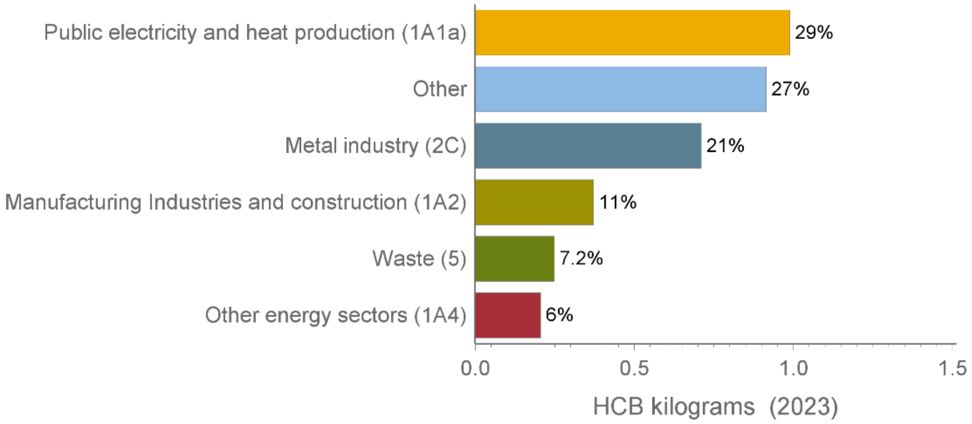

**Figure 2-22. Distribution of HCB emissions among major contributing sectors and subsectors in 2023.**

Emissions of HCB from public electricity- and heat production (NFR1A1a) amounted to about 1 kg in 2023 or about 29% of the total emission of which most of the emission was derived from biomass combustion. Emissions from NFR1A1a have more than doubled (134%) since 1990, mainly due to increased biomass combustion in the energy production plants and also as a result of increased combustion of waste. Emission in 2023 was about 3% lower compared to 2022 due to lower demand for district heating. The annual HCB emission depends, to some extent, on temperature and precipitation conditions in Sweden. For example, the observed emission peaks in 1996 and 2010 were particularly cold years (Figure 2-23).

Emissions of HCB from chemical Industry (NFR2B) were about 0.8 kg or 23% (under Other) followed by metal industry (NFR2C), 0.7 kg or 21% of the total in 2023. From metal industry, most of the emissions are derived from iron pellets production (NFR2C1e) which have largely increased since 1990 due to increased production. The economic recession between 2008 and 2009 is reflected by a dip in the emission trend.

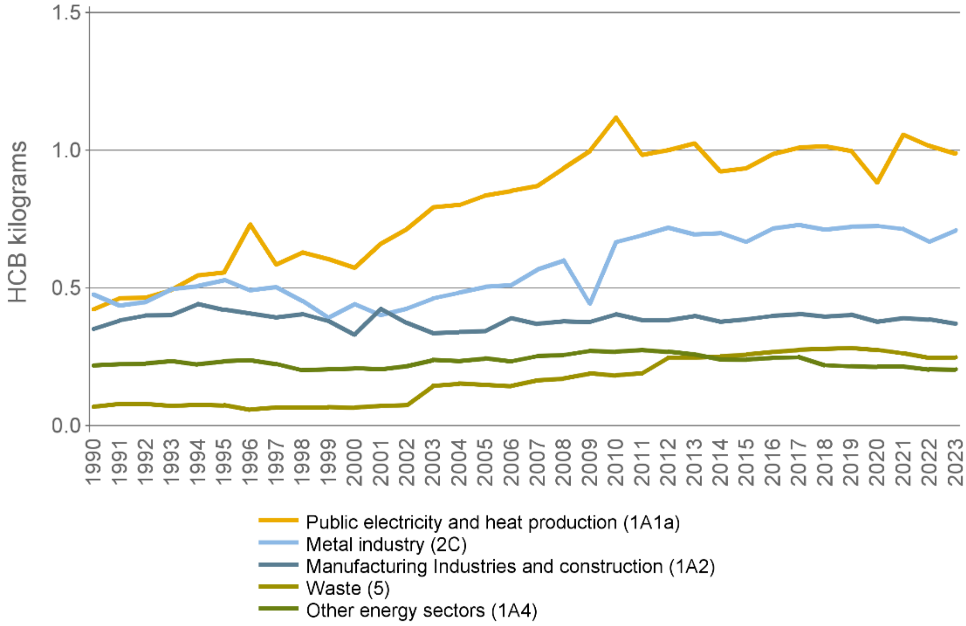

**Figure 2-23. Trends in HCB emissions from major sectors and subsectors 1990-2023.**

In 2023, combustion within the manufacturing industries and construction sector (NFR1A2) emitted about 0.37 kg or 11% of HCB of the total emission, mainly due to biomass combustion in pulp, paper and print (NFR1A2d) and other (NFR1A2g).

The waste sector (NFR5) is also a significant source of HCB emission and was responsible for about 0.25 kg or 7% of the total emission in 2023. Most of the emission derived from incineration of hazardous waste and open burning of waste too (NFR5C). Emissions have increased by about 260% since 1990 due to increased incineration of hazardous waste.

Emissions of HCB from Other Sectors (NFR1A4) were about 0.21 kg in or about 6% of the national total in 2023. Most of the emission within (NFR1A4) was derived from biomass combustion in residential stationary plants (NFR1A4bi). Emission levels in 2023 are comparable with those of 1990’s.

### 2.2.5 Dioxins - Polychlorinated dibenzodioxins and furans (PCDD/F)

The aggregated emissions of dioxins in Sweden were about 16 g I-Teq in 2023. Emissions have decreased by 71% since 1990. Compared to the previous year, emissions were about 2% higher in 2023. The share of different sectors' dioxins emissions in 2023 is shown in Figure 2-24.

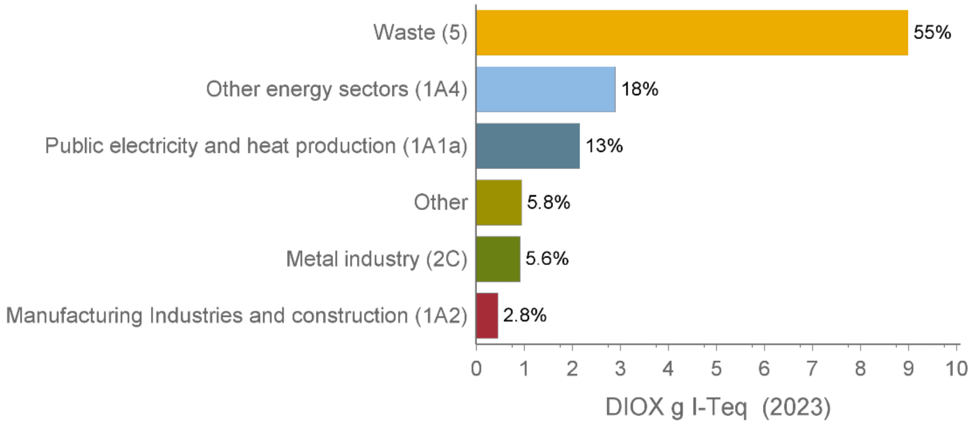

**Figure 2-24. Distribution of dioxin emissions among major contributing sectors and subsectors in 2023.**

Emissions of dioxins from the waste sector (NFR5) amounted to about 9 g I-Teq or about 55% of the total emission in 2023. Most of the emissions came from house- and car fires (NFR5E) and accounted for 49% of the national total. However, the uncertainty is quite high and needs to be improved. The rest of emissions within the sector came mainly from combustion of hazardous waste. Emissions from the waste sector have increased by about 4% since 1990.

The share of Other energy sectors (NFR1A4) amounted to about 2.9 g I-Teq or was 18% of the national emission in 2023. Emissions of dioxins from electricity- and heat production (NFR1A1a) amounted to about 2.1 g I-Teq or 13% of the national emission in 2023. Most of the emission is derived from biomass combustion. Emissions from NFR1A1a decreased by about 84% since 1990 due to improved technologies applied in the sector and revision of emission factors.

Emission of dioxins from the metal industry (NFR2C) were about 0.91 g I-Teq or about 6% of the national total in 2023. Since 1990, the emission decreased by more than 97% mainly from iron and steel production due to use of better technologies.

In 2023, about 0.45 g I-Teq or 3% of dioxins emission to air were derived from manufacturing industry and construction sector (NFR1A2), mostly due to biomass combustion in pulp, paper and print (NFR1A2d) and wood products (NFR1A2giv). Emissions from NFR1A2 have decreased by 79% since 1990, due to improved technologies applied, especially in pulp, paper and print.

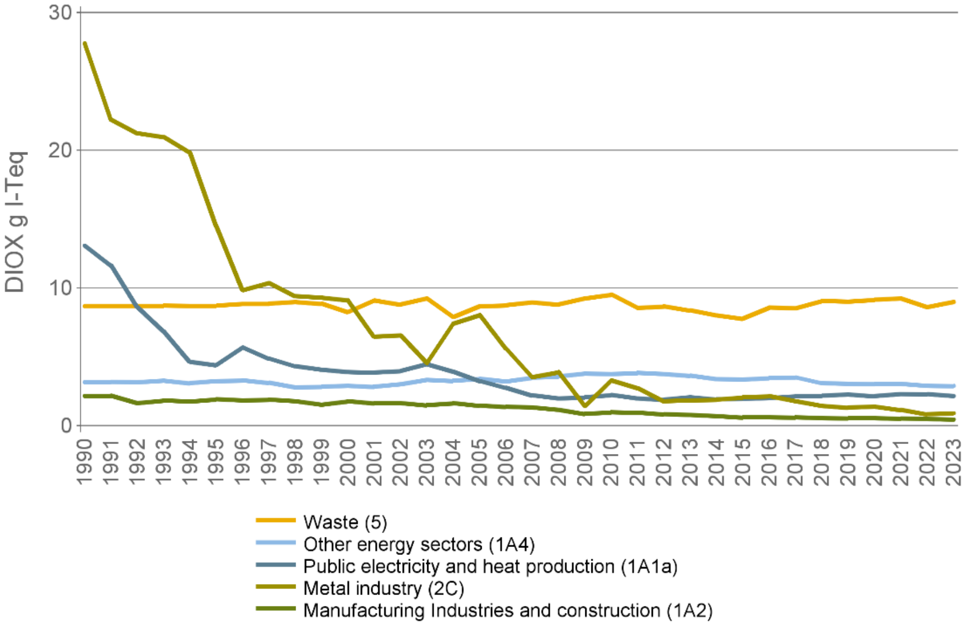

**Figure 2-25. Trends in dioxins emissions from major sectors and subsectors 1990-2023.**

## 2.3 Emissions of priority heavy metals

Emissions of cadmium (Cd), mercury (Hg) and lead (Pb) have all been reduced significantly since 1990 (Figure 2-26). The most significant reduction in emissions comes from Pb as it has been phased out from gasoline blends in the early 1990's. Since 1990, lead emissions have been reduced by about 98%. In the early 1990's Cd emissions were also heavily reduced by 78%, mainly due to efficient improvements in metal production. Hg emissions have been also reduced by nearly about 76% since 1990 mostly due to improvements in metal processing and waste incineration.

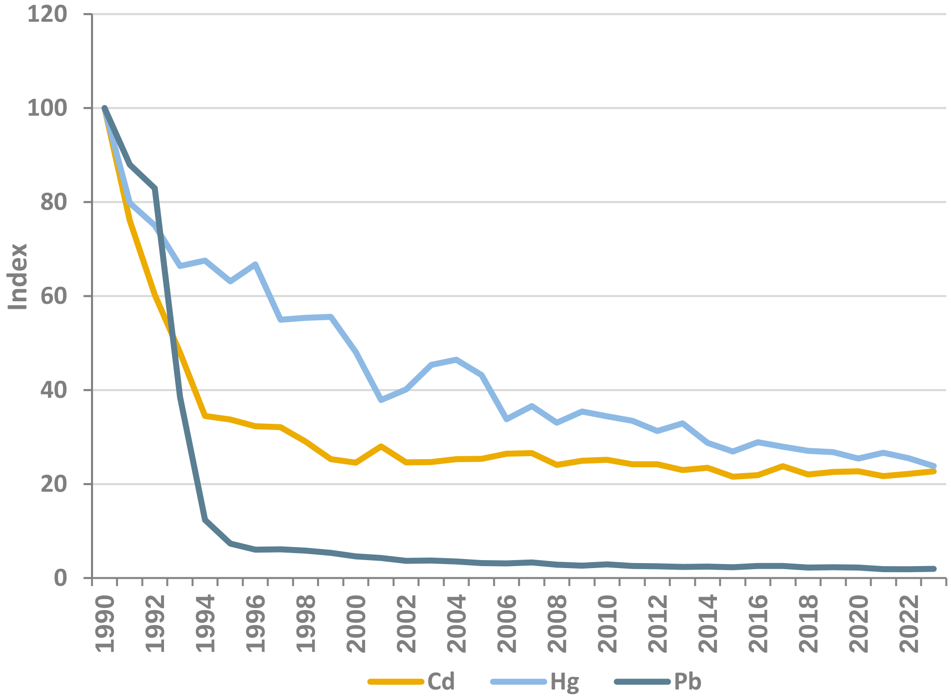

**Figure 2-26. Trends in emissions 1990-2023 for Cd, Hg and Pb. Index 1990=100.**

### 2.3.1 Cd

The aggregated emissions of Cd in Sweden were about 500 kg in 2023. Emissions have decreased by 78% since 1990. Compared to previous year, emissions were about 4% higher in 2023. Emission distribution of Cd between different sectors in 2023 is shown Figure 2-27.

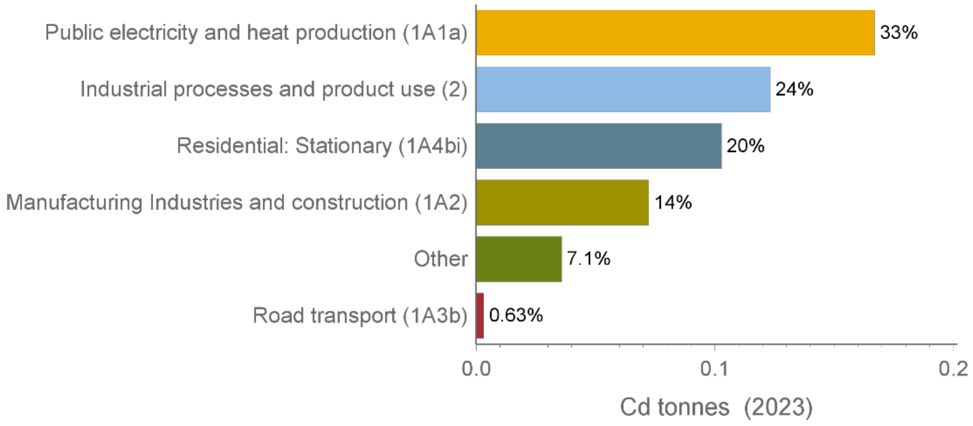

**Figure 2-27. Distribution of Cd emissions among major contributing sectors and sub-sectors in 2023.**

Electricity and heat production sector (NFR1A1a) was the largest source of Cd emissions and contributed with about 167 kg or 33% of the total emissions in 2023. Emissions from this source have increased by about 230% since 1990 due to increased amount of biomass combustion in the energy production (Figure 2-28). The amount of emission from this source depends to some extent on the weather condition and hence the demand on electricity and heat consumption. Year 1996 and 2010 were particularly cold which resulted in especially higher emissions for these years.

Stationary residential combustion (NFR1A4bi) was the second largest source of Cd emissions with a total of 100 kg in 2023, corresponding to about 20% of the total emissions. These emissions have decreased by 23% compared to levels in 1990.

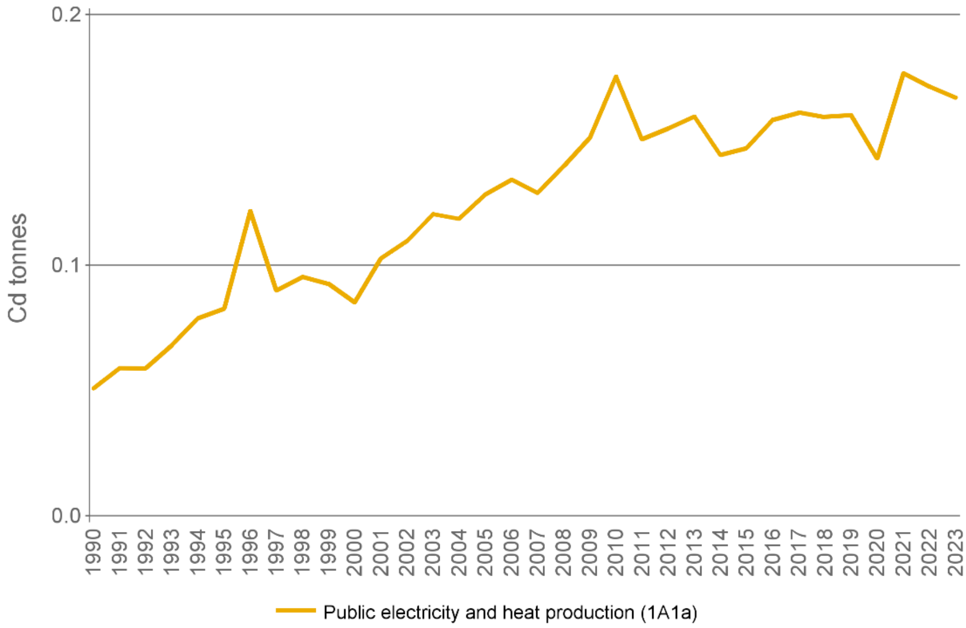

**Figure 2-28. Trend in Cd emissions from electricity and heat production (1A1a) 1990-2023.**

Emission of Cd from industrial processes and product use sector (NFR2) accounted for about 120 kg or 24% of the total emission in 2023. Most of these emissions were derived metal industry (NFR2C) and pulp and paper industry (NFR2H1) and accounted for 20% and 4%, respectively of total emissions. Emission trends from various industries are shown in (Figure 2-29). Emissions from industrial processes and product use have decreased by more than 94% since 1990.

Combustion in manufacturing industries and construction (NFR1A2) accounted for 14%, or about 72 kg, of total Cd emissions in 2023. Emissions from this source have decreased by 43% since 1990. Most of these emissions occurred in the pulp, paper and print industries (NFR1A2d). Emissions from combustion in manufacturing industries and construction have been relatively stable over the past twenty years.

Emissions from road traffic in the transport sector (NFR1A3b) accounted for less than 1% (about 5 kg) of the Cd emissions in 2023 and emissions have been almost stable since 1990.

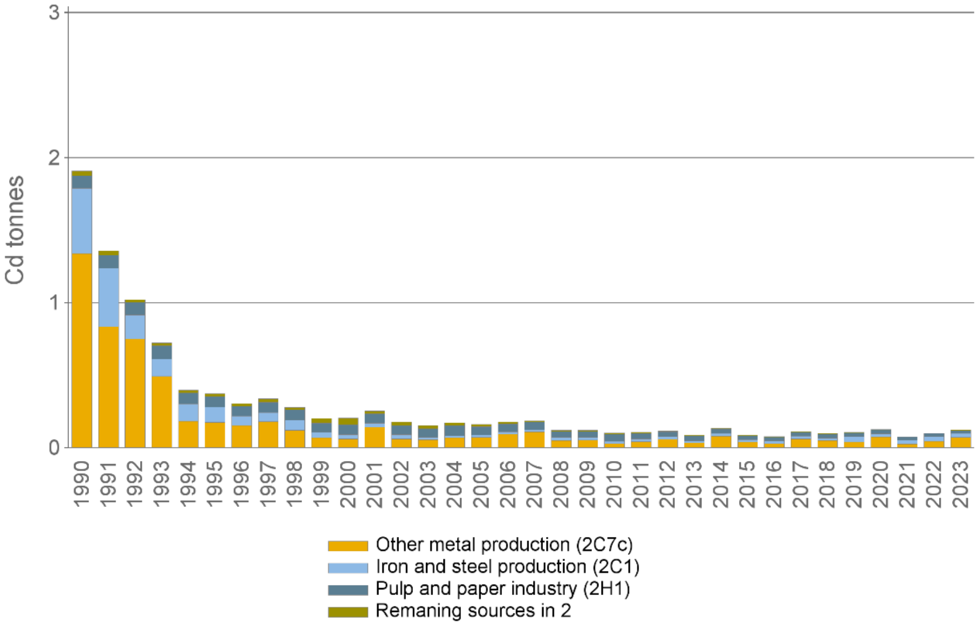

**Figure 2-29. Emissions of Cd from industrial processes and product use 1990-2023.**

### 2.3.2 Hg

Total emissions of Hg in Sweden were about 372 kg in 2023 and decrease by 76% since 1990. Emission distribution of Hg between different sectors in 2023 is shown in Figure 2-30.

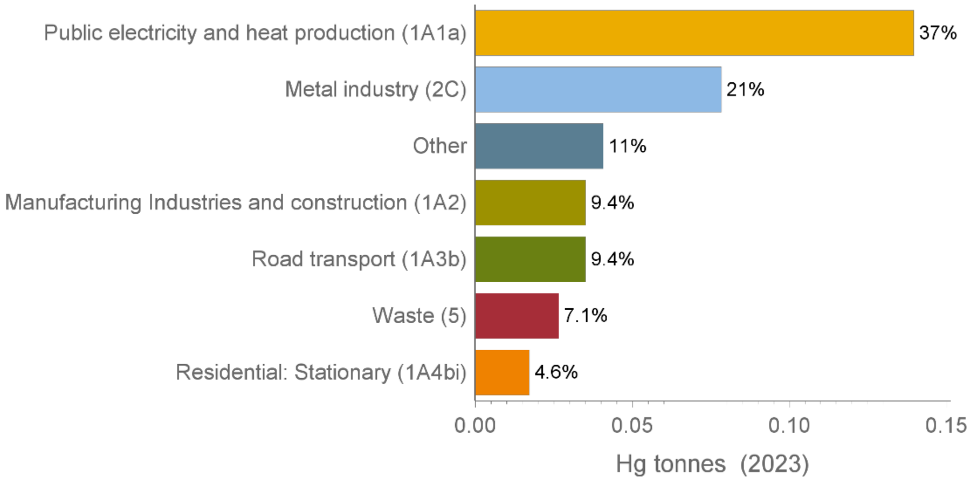

**Figure 2-30. Distribution of Hg emissions among major contributing sectors and sub-sectors in 2023.**

In 2023, about 37% (or 140 kg) of Hg emissions came from electricity and heat production (NFR1A1a). Most of the emission originated from biomass combustion. Hg emissions from this sector have decreased by about 71% since 1990 (Figure 2-31).

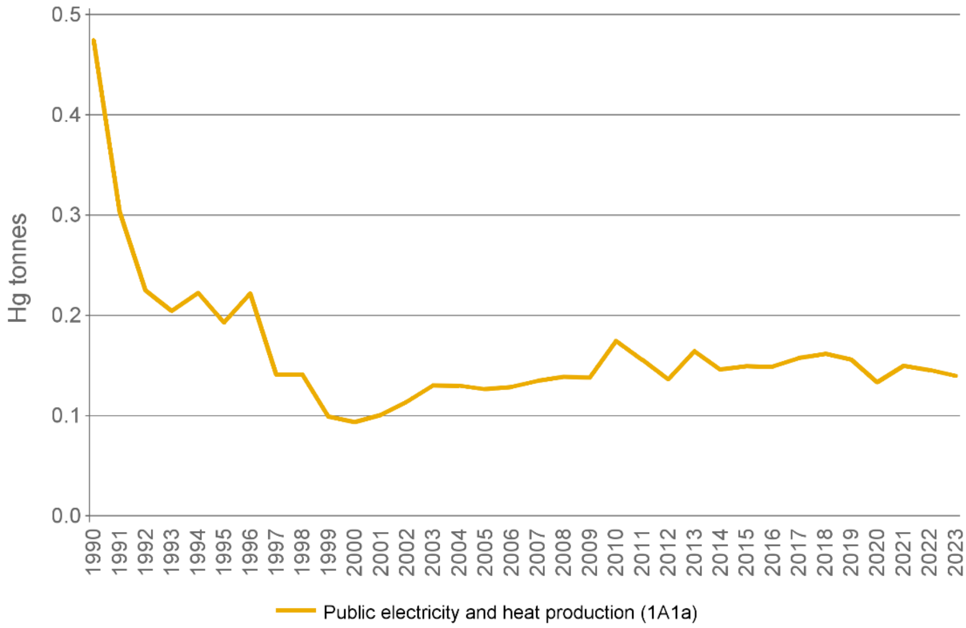

**Figure 2-31. Emissions of Hg in from public electricity and heat generation (1A1a) 1990-2023.**

Metal industry (NFR2C) accounted for 21% or about 78 kg of total Hg emissions in 2023. Emissions have been reduced by almost 85% since 1990 mainly due to improved technologies.

In 2023, about 9% (35 kg) of Hg emission came from combustion in manufacturing industries and construction (NFR1A2). Emissions have been reduced by more than a half since 1990 mostly from non-metallic minerals (NFR1A2f) and pulp, paper and print (NFR1A2d).

Emissions from road traffic in the transport sector (NFR1A3b) accounted for 9% (35 kg) of the Hg emissions in 2023. Most of the emission came from passenger cars accounting for about 23 kg. Emissions from transport sector have decreased by 19% since 1990.

Emission from the waste sector accounted for about 7% of the total emission in 2023, of which most of the emission came from crematories. Emissions in 2023 were 86% lower than in 1990 due to improved technologies applied in the incineration plants.

### 2.3.3 Pb

The total emissions of lead (Pb) in Sweden were about 7 t in 2023 and decreased by 98% since 1990. Emission distribution of Pb between different sectors in 2023 is shown in Figure 2-32.

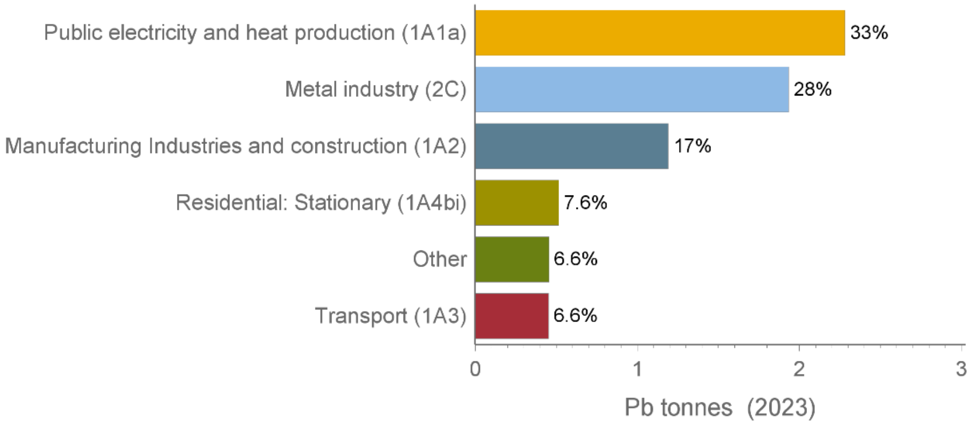

**Figure 2-32. Distribution of Pb emissions among major contributing sectors and subsectors in 2023.**

About 33% of the Pb emissions that come from public electricity and heat production (NFR1A1a) is mostly derived from biofuels combustion. These emissions have been reduced by 18% compared to emission levels in 1990, see Figure 2-35.

Emissions of Pb from metal industry (NFR2C) accounted for about 28% of the total emissions in 2023 and have been reduced by 97% since 1990 mainly due to improved technologies. Emissions from this sector were strongly reduced between 1990 and 1996 and since 2002 emissions have been leveled out with only slight variations between years, see Figure 2-33.

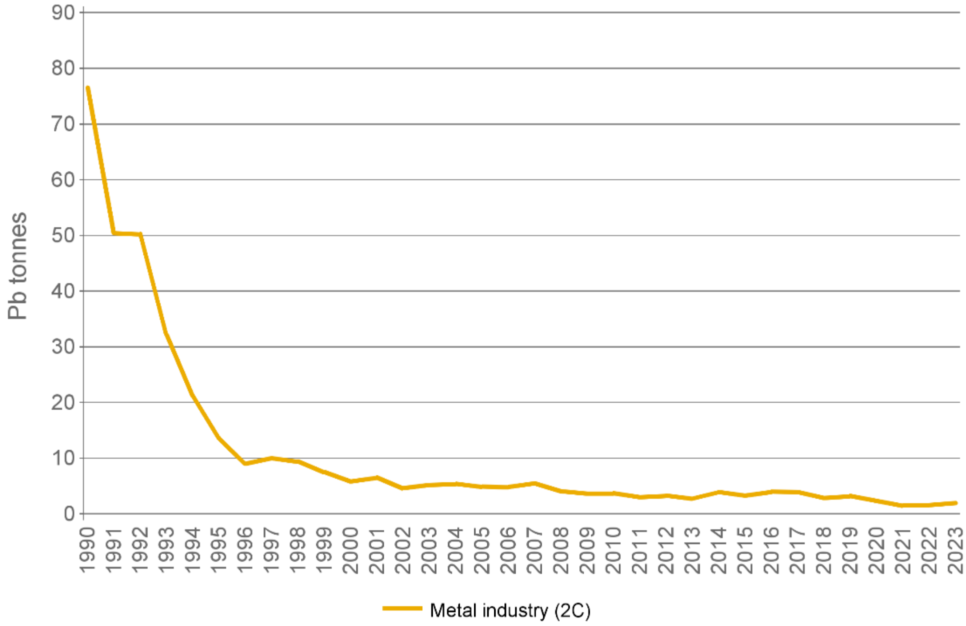

**Figure 2-33. Trend in emissions of Pb from Metal industry (2C) 1990-2023**.

Emissions from manufacturing industries and construction (NFR1A2) accounted for 17% of the Pb emissions in 2023. More than one-half of these emissions are derived from biomass combustion in pulp, paper and print industries (NFR1A2d). Since 1990, emissions from manufacturing industries and construction were reduced by 40%.

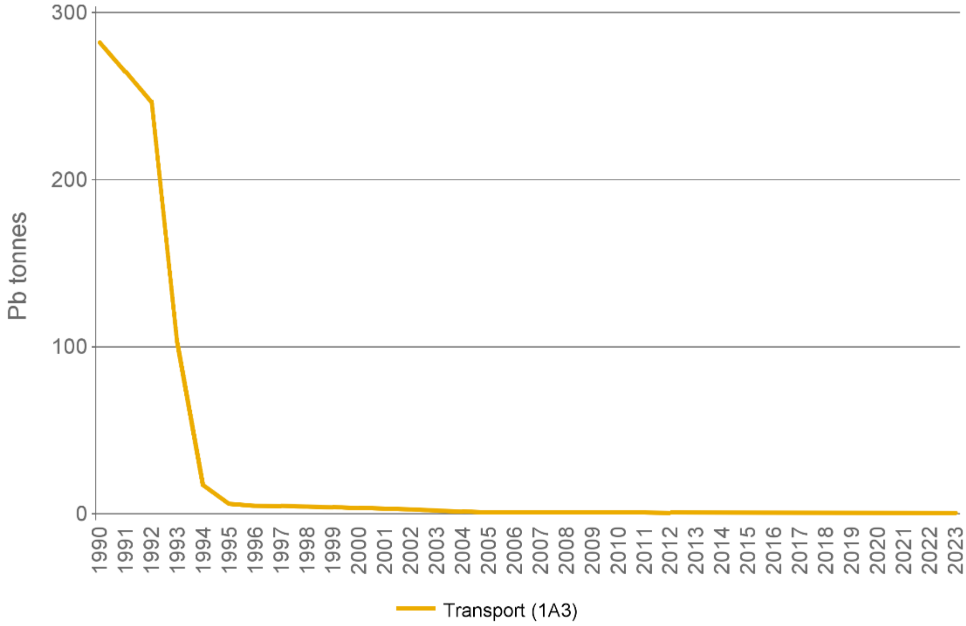

**Figure 2-34. Trend in emissions of Pb from transport (1A3) 1990-2023.**

The transport sector (NFR1A3) contributed with less than 7% of Pb emissions in 2023. Lead emission is derived from gasoline use for in transportation (NFR1A3b).

As Pb has been phased out from gasoline blends in the early 1990's, these emissions have been reduced by more than 99%. In 1990 emissions from road traffic amounted to about 270 t and in 2023 was about 0.3 t, see Figure 2-34.

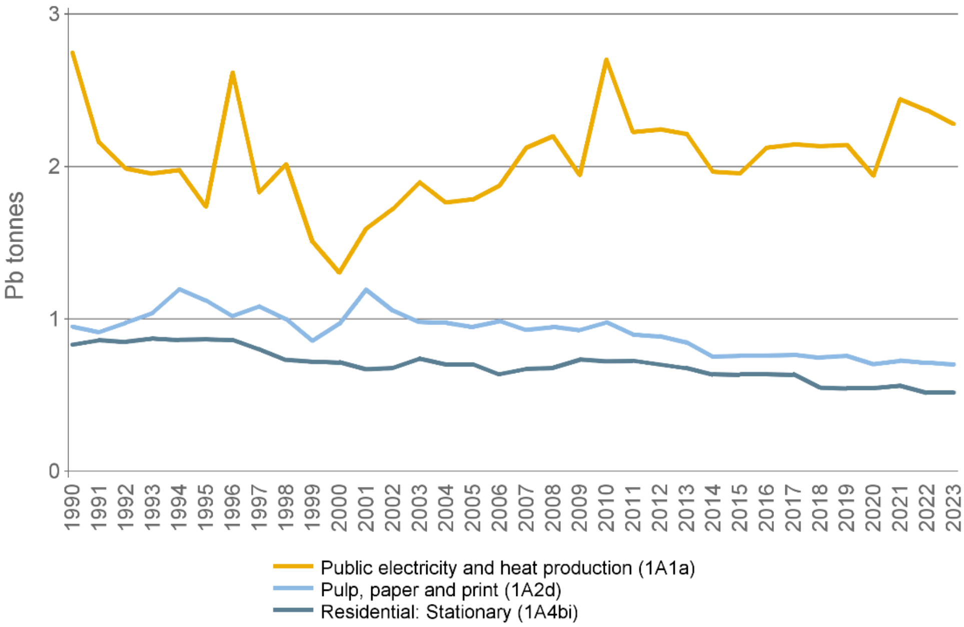

**Figure 2-35. Trends in emissions from public electricity (1A1a) and heat production, Pulp, paper and print (1A2d) and residential stationary (1A4bi) 1990-2023.**

In 2023, about 7% of Pb emissions came from the stationary residential heating (NFR1A4b) where most of the emission was derived from biomass combustion. Emissions have decreased by 38% since 1990 due to increased share of district heating.

# 3 Energy (NFR sector 1)

## 3.1 Overview

The energy sector includes emissions from fuel combustion (NFR1A) and fugitive emissions from fuel production and handling (NFR1B). Energy consumption per capita is high in Sweden compared to other OECD countries. This is because of the availability of natural resources such as forests and hydropower, which led to the early and rapid expansion of energy-intensive industries. Sweden’s geographical location, with low mean annual temperatures also explains the high demand for energy for heating.

## 3.2 Fuel combustion, NFR1A

Emissions from fuel combustion, NFR1A, are allocated to a number of subsectors.

NFR1A1 energy industries, e.g. public electricity and heat production plants, combustion activities within oil refineries, and combustion related to solid fuel production, i.e. coke ovens.

NFR1A2 manufacturing industries, combustion-related emissions in manufacturing industries and construction and working machinery within the construction sector allocated to this subsector. Emissions from working machinery within the construction sector are allocated to NFR1A2, but apart from that, NFR1A2 includes only stationary combustion.

NFR1A3, emissions from domestic transport include aviation, road traffic, railways and navigation.

NFR1A4, emissions from other sectors, include stationary and mobile sources in households, service, agriculture, forestry and fisheries.

NFR1A5, emissions from other combustion.

In addition, emissions from international aviation and international navigation (international bunkers) and multilateral operations, NFR1D, are not included in the national total.

Emissions from fuel combustion in Sweden are, if not specifically otherwise stated, determined as the product of fuel consumption, thermal value and emission factors (EF) as shown in the formula:

$\text{Emission}_{\text{fuel}} = \text{Fuel consumption}_{\text{fuel}} * \text{Thermal value}_{\text{fuel}} * \text{EF}_{\text{fuel}}$

Different tier methods are used for different sub-sectors as discussed in sections below. Activity data sources, thermal values and emission factors are described in detail in Annex 2.

Note that some fuel types are used in industrial processes rather than for energy purposes. This is the case for black liquor in the paper- and pulp industry and for coal and coke in the metal industry. Emissions from these fuels are thus accounted for under NFR2 and methods used are described in section 4.

## 3.2.1 Public electricity and heat production, NFR1A1a

### 3.2.1.1 SOURCE CATEGORY DESCRIPTION

Swedish production of electricity is characterized by large proportions of hydropower and nuclear energy. Sweden is also expanding its proportion of wind power, which is increasing every year. Wind power affects the electricity balance and is also affected by the weather. The power generated by wind power might need the use of reserve power in cases of limited wind. Only a small share of the electricity production is based on fuels used in conventional power plants. Public electricity and heat use vary between years, due to variations in ambient temperatures for instance. In addition, production of electricity based on fuels depends to a large extent on the actual weather conditions. Years with dry weather and cold winters have a significant effect on the use of fuel in electricity production since less electricity can be produced by means of hydropower and more electricity is needed for heating. The largest emissions from electricity production were thus in 1996, due to very dry and cold weather. The winters 2009/2010 and 2010/2011 were unusually cold, which lead to an increase in fuel consumption particularly in 2010. Liquid fuels and natural gas account for most of the increase, although the increase in natural gas use can to a large extent be explained by the fact that new gas fuelled facilities had been taken into operation. The use of solid fuels also increased substantially between 2009 and 2010, but in this case the explanation is the recovery from the dip in production in the iron and steel industry in 2009, which thus affected the amounts of energy gases sold to the public electricity and heat production plants.

In Sweden, electricity and district heating are used to a large extent to heat homes and commercial premises. Increased use of district heating since 1990 to heat homes and commercial/industrial premises has led to increased energy efficiency and thus lower emissions. Emissions of methane and nitrous oxide have increased from electricity and heat production because of the increased burning of biomass fuels.

Electricity is an important energy source in the manufacturing industry, where the most important industries are the pulp and paper and the steel industry.

The trend in fuel consumption in this sector varies depending on the production of hydroelectric power and variations in weather between years. The largest changes in fuel consumption are for biomass fuels, where the consumption has increased significantly, mainly due to increased district heating. Between 2013 and 2014, the consumption of natural gas in this sector decreased, which resulted in a notable decrease in emissions for this sector.

Production of district heating is currently to a large extent based on biomass and waste. There has been a shift from fossil fuels towards biomass since 1990. In 1990, 25% of fuels used were biomass including biogenic waste, and 6% was fossil waste. In 2023, 80% of all fuels used for district heating were biomass (including the biogenic fraction of waste), while waste (fossil fraction) accounted for 15%[18]. These proportions have been quite similar during the last six years.

Since 1990, there has been a large increase in the use of district heating from 89 PJ (1990) to 198 PJ (55.1 TWh 2023)[19] but, due to the more frequent use of biomass, greenhouse gas emissions from district heating were lower in 2023 than in 1990.

The number and distribution of Swedish power stations in 2023 are presented in Table 3-1**Fel! Bokmärket är inte definierat.**. Changes in the number of plants and their installed effect have been minor in the production of electricity, but due to growing wind power the number of plants in the electricity sector have increased.

**Table 3-1. Number and distribution of Swedish energy stations 2023.**

| Type of plants | Number of plants | Gross Production GWh | Gross Production TJ |
|---|---|---|---|
| Total power stations | 258 216 | 166 078 | 597 881 |
| Power generation not based on fuels | 258 033 | 103 583 | 372 899 |
| Wind power | 5 497 | 34 245 | 123 282 |
| Hydropower | 910 | 66 240 | 238 464 |
| Solar power | 251 626 | 3 098 | 11 153 |
| Power generation based on fuels | 183 | 62 495 | 224 982 |
| Nuclear power | 3 | 48 470 | 174 492 |
| Conv. thermal power | 180 | 14 025 | 50 490 |

A summary of the latest key source analysis is presented in Table 3-2.

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[18] All numbers are according to data used in the greenhouse gas inventory this submission. The proportions given are calculated for heat production, and may include plants in both 1.A1.A.ii and 1.A.1.A.iii

[19] Statistics Sweden/Swedish Energy Agency EN11SM 2001 (Electricity supply, district heating and supply of natural and gasworks gas 2023.).

**Table 3-2. Summary of Key Source Analysis (Approach 1). NFR category 1A1a is a Key Source in the 2023 national inventory regarding the level or trend of the following substances.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 1A1a | Biomass – *As, CO, Cd, Cr, Cu, Hg, NMVOC, NOx, Ni, PAH 1-4, PM10, PM2.5, Pb, SO2, Se, TSP, Zn* | Biomass – *As, Cd, Cr, Cu, Hg, NMVOC, NOx, Ni, PAH 1-4, PM10, PM2.5, SO2, Se, TSP, Zn* |
| | Gaseous – | Gaseous – |
| | Liquid – *Ni, SO2* | Liquid – *NOx, Ni, SO2, Se* |
| | Solid – *As* | Solid – As, *Cd, Cr, Cu, DIOX, Hg, NOx, PM10, PM2.5, SO2, Se, TSP* |
| | Other – *Cd, Hg, SO2* | Other – Cd, Hg, PM2.5, TSP |
| | Peat – | Peat– As, *Hg, NOx, Ni, PM10, PM2.5, SO2, Se, TSP* |

### 3.2.1.1 METHODOLOGICAL ISSUES

A combined Tier 2 and 3 methods is used. Activity data for emissions in NFR1A1a are taken from quarterly fuel statistics. For this sector, the quarterly fuel statistics is sent to all companies registered as IIC 40 according to databases used by Statistics Sweden and the response rate is almost 100%. This gives very good data to the inventory, accurate, complete and consistent and with very low uncertainties.

No emissions from the integrated iron and steel industry are allocated to NFR1A1a. However, emissions from steelwork gases sold to and combusted by ISIC 40 facilities are still allocated to NFR1A1a.

The reported emissions of particulate matter include the condensable fraction of particles.

Due to confidentiality reasons, TJ for Liquid and Gaseous fuels for 2023 years' emissions in 1A1a are reported as C in the NFR tables.

### 3.2.1.2 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

For the energy sector, the largest uncertainties come from activity data for the 1980's and from emission factors. The uncertainties for stationary combustion are in submission 2024 on fuel group aggregation level. The activity data uncertainties are relatively low, 2% all fuel groups except for other fossil fuels that are 3%. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group.

Activity data uncertainty is relatively low for all fuel groups. Emission factor uncertainty is for some fuel groups very high. The fuel groups and EF that have highest uncertainty are:

- Biomass for As, DIOX, HCB, PCB and Zn
- Other fuels for As, Cr, Cu, DIOX, Ni, Se, Zn, Cd
- Other fuels for HCB, PAH, PCB

- Peat for PCB
- Solid fuels for Cd, Cu, HCB, PCB, Se

See Annex 1 for more details regarding uncertainties for activity data and emissions.

#### 3.2.1.3 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Experts at the Swedish EPA conduct a review of the inventory estimates, methodologies and emissions factors used. The experts also identify areas of improvement, which constitute part of the basis for improvements in coming submissions.

All quality procedures according to the Swedish QA/QC plan (including the Manual for SMED’s Quality System in the Air Emission Inventories) have been implemented during the work with this submission.

All Tier 1 general inventory level QC procedures and all QC procedures listed in GPG section 8.1.7.4 applicable to this sector are used. The activity data has been subject to QA/QC procedures prior to the publishing of quarterly fuel statistics. In addition, the consumption of every type of fuel in the last year is checked and compared with previous years. If large variations are discovered for certain fuels, the consumption of these fuels is studied on facility level and if necessary, the staff responsible for the quarterly fuel survey is contacted for explanations. IEFs for all reported substances are calculated per fuel, substance and NFR-code and checked against the emission factors to make sure that no calculation errors have occurred when emissions were computed.

The time series for all revised data have been studied carefully in search for outliers and to make sure that levels are reasonable. Data has, when possible, been compared with information from companies’ legal environmental reports and/or other independent sources[20], [21]. Remarks in reports from the UNFCCC and CLRTAP/NEC reviews have been carefully read and taken into account.

#### 3.2.1.4 SOURCE-SPECIFIC RECALCULATIONS

No recalculation occurred in this sector in submission 2025.

#### 3.2.1.5 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan. In addition, see also chapter 1.2.5 QA/QC procedures and extensive review of emission inventory.

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[20] Backman & Gustafsson, 2006

[21] Nyström, 2007

### 3.2.2 Refineries, NFR1A1B

#### 3.2.2.1 SOURCE CATEGORY DESCRIPTION

Refineries process crude oil into a variety of hydrocarbon products such as gasoline and kerosene. During the refining process, dissolved gases are separated, some of which may be leaked or vented during processing. There are five refineries in Sweden. Three of these produce fuel products such as gasoline, diesel and heating oils. The other two mainly produce bitumen products and naphthenic special oils. One facility has a catalytic cracker; two facilities have hydrogen production plants and four of the facilities have sulphur recovery plants. The fuel consumption in this sector is mainly based on refinery gas, which is a by-product in the refining process. The use has increased due to higher demand of refined products.

A summary of the latest key source analysis is presented in Table 3-3.

**Table 3-3. Summary of Key Source Analysis (Approach 1). NFR category 1A1b is a Key Source in the 2023 national inventory regarding the level or trend of the following substances.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 1A1b | Liquid Fuels - *Cr, DIOX, NMVOC, NOx, Ni, PM2.5, SO2* | Liquid Fuels - *Cr, DIOX, NMVOC, Ni, PM10, PM2.5, SO2, TSP* |
| | Gaseous fuels– | Gaseous fuels– |

#### 3.2.2.2 METHODOLOGICAL ISSUES

The Tier 2 method is used. The statistics for NFR1A1b are based on a total of seven plants with the Swedish Standard Industrial Classification 192, petroleum refining. Five of these companies are real refineries which use more than 99% of the energy within the sector and thereby cause most of the emissions. The other two plants are oil companies, mainly involved in production of lubricating grease.

Activity data for the five refineries was collected directly from each company for 1990-1999, since the Energy use in the manufacturing industry (ISEN) and Quarterly fuel statistics (KvBr) did not account for all fuels produced within refineries during these years. The corresponding energy content of all fuels was also collected and individual thermal values were calculated for each operator and fuel. For 2000-2004, i.e. before the EU Emission Trading System (EU-ETS) was established, quarterly fuel statistics was used as the data quality was improved compared to the 1990’s and is considered to be sufficient for these years.

Data from the EU-ETS are used for four refinery plants for 2005 and 2007[22]. For the fifth plant, data from environmental reports were used due to lack of transparency in ETS data in the early years. In 2008 and later years, the quality of EU-ETS data is considered to be very high for all five of the refineries, and thus this is the

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[22] Backman & Gustafsson, 2006.

primary data source for the GHG inventory. However, most of the refineries report refinery gas and natural gas aggregated to the EU-ETS, and for these facilities, data from the environmental reports are used to allocate the proper amount of this fuel to gaseous fuels. Environmental reports are used for verification for all five refineries. For refinery gas, plant specific $CO_2$ emission factors reported to the EU-ETS[23] are used for 2008 and later, since they are considered to be more accurate than the older national emission factor. The $CO_2$ emission factors for refinery gas are generally quite stable for each of the refineries, but the differences between the refineries are large.

The reported emissions of particulate matter include the condensable fraction of particles.

Due to confidentiality reasons, reported emissions from the refineries under CRT 1B are included in 1A1b for 2021-2023. In addition, TJ for Liquid and Gaseous fuels for 2019-2023 years emissions in 1A1b are reported as C. Emissions of Se for the 1.A.1.b code are reported as C in the CRT-tables for 2023.

#### 3.2.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The use of so many different sources for this sector could of course lead to consistency problems. Data used in the inventory in earlier years has been analysed and no (significant) signs of inconsistency have been found. In recent years, environmental reports are used for verification.

Since all emissions from refineries are reported in NFR 1A1b from 2021 onwards due to confidentiality issues, the time series is not consistently reported at the NFR source category level. However, the collected emissions from refineries are consistently estimated throughout the time-series and total emissions from refineries for some of the estimated pollutants are shown in Figures 3-20 and 3-21, chapter 1.1.4 Refineries, NFR1B2a iv.

The assigned uncertainties are based on information directly from the facilities. These are updated regularly but not annually. The uncertainty of the activity data is around 1.5%, but the uncertainty of the NCV is unknown, so the total uncertainty for the activity data was judged to 10%. Activity data uncertainty for the 1990's is also estimated to 10%.

The uncertainties for stationary combustion are on fuel group aggregation level. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group. The uncertainty of the activity data for Liquid fuels is around 2%, but the uncertainty of

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[23] Technically, the emission factors are implied emission factors since amounts of fuel, NCV:s and emissions are reported.

the NCV is unknown, so the total uncertainty for the activity data was judged to 10%. The activity data for Gaseous Fuels is lower, 2%. Activity data uncertainty is relatively low for Gaseous fuels and higher for Liquid fuels. Emission factor uncertainty is for some fuels very high. The fuel groups and EF that have highest uncertainty is Liquid fuels for all emissions often larger than 100%. EF for As, CO and NMVOC are larger than 100%. See Annex 1 for more details regarding uncertainties for activity data and emissions.

#### 3.2.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In general, the same QA/QC procedures are used for NFR 1A1b as for 1A1a described above. For each of the five refineries, EU-ETS data for the latest year are verified against the refineries' legal environmental reports. During the national peer review, reviewers noted that gaseous fuels are reported as "NO" for 2003 and questioned if this is the correct notation key. Investigations of activity data files used in earlier submissions show that in 2001 to 2003, sweet gas (a by-product from the cryogen plant) was probably miscoded as natural gas in submission 2005. Data for 2003 has been revised in later submissions, i.e. sweet gas has been recoded as refinery gas. Environmental reports show that natural gas has been used in NFR 1A1b in 2004 and later, but not in 2003, and hence "NO" is considered to be the correct notation key for 2003. The environmental reports for 2001-2002 are no longer available, and hence there is not enough information to recode the natural gas reported in 2001 and 2002, even though it might be miscoded refinery gas.

#### 3.2.2.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2025 a correction of fugitive emissions from flaring of gas occurred for emissions of Cu for 2021 and BC, Hg, NOx, PM10, PM2.5 and TSP for 2022. The correction for Cu resulted in an increase of emissions with 0.015% (0.16g). The correction for 2022 resulted in decrease of emissions for all substances. The decrease in particle matter was the largest PM2.5 22.5% (0.016kt), TSP 14.1% (0,013kt) PM10 12.6% (0.01kt) all other substances decreased by less the 0.1% for 2022.

#### 3.2.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan. In addition, see also chapter 1.2.5 QA/QC procedures and extensive review of emission inventory.

## 3.2.3 Manufacture of solid fuels and other energy industries, NFR1A1c

### 3.2.3.1 SOURCE CATEGORY DESCRIPTION

This category includes emissions from two plants belonging to one company, producing coke to be used in blast furnaces for production of iron. The plants are integrated into the iron and steel production industry[24]. The trend is related to the amounts of iron and steel produced, and hence there was a dip in 2009. Since 2009, the production and the emissions have increased gradually, and in 2013 the emissions were about the same level as in the early 2000's.

A summary of the latest key source analysis is presented in Table 3-4.

**Table 3-4. Summary of key source analysis, NFR1A1c, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1A1c | *Solid fuels – NOx, PM2.5*<br>*$SO_2$* | *Solid fuels – TSP* |

### 3.2.3.2 METHODOLOGICAL ISSUES

The Tier 2 method is used. Emissions from fuel combustion in the manufacturing of solid fuels are reported under NFR1A1c, in line with IPCC Guidelines. This includes emissions from combustion in coke ovens in the iron and steel industry.

Activity data on coke production is taken from environmental reports.
Emissions of NMVOC and CO are estimated with the Tier 2 methodology with national emission factors. Estimates of emissions of $SO_2$ and $NO_X$ are available from environmental reports on an aggregate level, and these emissions are distributed over the different NFR codes (1A1c, 1A2a, 1B1c and 2C1, $SO_2$ also 2B5 and 1B1b) according to the activity data distribution.

Pollutants Cd, Hg, Pb, PCDD/F and PAHs are included under category 2C1. The emissions of POPs and heavy metals are included under category 2C1 because it is not possible to separate emissions between the IPPU and Energy sectors.

Activity data on combustion of coke oven gas and blast furnace gas in coke ovens is discussed in connection with other emissions from the iron- and steel industry in section 4.4 Metal production, NFR2C.

Since 1990, solid fuel consumption has increased slightly due to higher production of coke caused by higher demand of primary iron and steel. In 2009, however, solid fuel consumption decreased considerably due to lower production of coke, caused by a lower demand of primary iron and steel.

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[24] Fuel combustion in manufacturing of nuclear fuels was included in NFR 1A1c in previous submissions, but for confidentiality reasons the very small emissions from these facilities have been included in NFR 1A1aiii instead.

The reported emissions of particulate matter include the condensable fraction of particles.

### 3.2.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The time series is considered to be very consistent as all data on emissions from the coke producing plants has been collected directly from the facilities. The inter-annual variations in IEFs for solid fuels are caused by variations in the relative amounts of blast furnace gas and coke oven gas, respectively, between years. The composition of each gas is also quite variable, and this is another explanation to the fluctuating IEF’s. Solid fuel consumption decreased considerably in 2009 due to lower production of coke caused by lower demand of primary iron and steel. In 2010, the demand increased and thus the fuel consumption increased to about the same level as before 2009.

The uncertainties for stationary combustion are on fuel group aggregation level. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group. Activity data uncertainty is relatively low for most fuel types. Emission factor uncertainty is for some fuels very high. The fuel groups and EF that have highest uncertainty are:

- Liquid fuels for Cd, Cu, Hg, Pb, Se, Zn
- All fuels for Cr, Ni, PAH, $SO_2$, TSP and $PM_{10}$ and $PM_{2.5}$

See Annex 1 for more details regarding uncertainties for activity data and emissions.

### 3.2.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The estimation of emissions from coke production is based on carbon balance calculations and the methodology is thoroughly described in chapter 4.

The improvements in methodology and allocation of emissions from the integrated iron and steel industry in submission 2010 were made based on a study[25] carried out in 2008 looking at emissions from several industrial plants, including the two largest iron and steel plants in Sweden, where inventory data from submission 2008 was compared with data from environmental reports. In 2010, activity data and emission factors for the chemical industry and the most important metal foundries were verified against data from environmental reports in a similar study[26].

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[25] Skårman, T., Danielsson, H., Kindbom, K., Jernström, M., Nyström, A-K. 2008.

[26] Gustafsson, T., Nyström, A-K., Gerner, A., 2010

#### 3.2.3.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2025 there were revision of emissions of PM2.5 and PM10 emission for 2021 and PM2.5, PM10, TSP, NOx, and $SO_2$ emissions for 2022. The revision 2021 resulted in decreased PM2.5 emissions by 0.86% (0.22t) and increased PM10 emissions by 0.063% (0.024t). The revision in 2022 resulted in decreased emissions in PM10 44.76% (0.03kt), NOx 14.52% (0.052kt), $SO_2$ 2.63% (0.004kt) and increased emissions in PM2.5 24.76% (0.0054kt), TSP 7.23% (0.006kt).

#### 3.2.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan. In addition, see also chapter 1.3.5 QA/QC procedures and extensive review of emission inventory.

### 3.2.4 Iron and steel, NFR1A2a

#### 3.2.4.1 SOURCE CATEGORY DESCRIPTION

A limited number of industries account for the majority of industrial energy use, i.e. the pulp and paper industry, iron and steel works and the chemical industry together account for about 65% of the fuel used. Despite rising industrial production, oil consumption has fallen sharply since 1970. This has been possible due to increased use of electricity and improved energy efficiency.

In Sweden, there are three primary steel works that base their production on iron ore pellets producing either steel or iron powder. There are also 10 secondary steel plants producing steel based on scrap metal. In 2009, fuel consumption in the iron and steel industry fell sharply as a consequence of decreased production (2.8 Mt of steel) due to the global recession. In 2009, fuel consumption in the iron and steel industry fell sharply as a consequence of decreased production (2.8 Mt of steel) due to the global recession. In 2023, the production of raw steel was 4.3 Mt[27], and decreased with 3% compared to 2022. Emissions from iron and steel companies with less than 10 employees are allocated to NFR 1A2g because the model estimate of fuel consumption for these small companies is produced on an aggregate level and not separated by ISIC code.

The trend of the fuel combustion is increasing slightly since 1990 due to higher production of iron and steel products. In 2009 this trend was broken due to decreasing demand of iron and steel. In 2010, production and fuel consumption recovered to more “normal” levels.

A summary of the latest key source analysis is presented in Table 3-5.

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[27] The Swedish Steel Producers´ Association, 2024-01-25. Stålåret 2023 – en kort översikt. 2024. https://www.jernkontoret.se/sv/publicerat/stal-och-stalindustri/stalaret/

**Table 3-5. Summary of key source analysis, NFR1A2a, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1A2a | Liquid – *NOx, Ni, SO2* | Liquid – *Ni, SO2, Se* |
| | Solid – *SO2* | Solid – |

### 3.2.4.2 METHODOLOGICAL ISSUES

The Tier 2 method is used. During 2009, a new methodology was implemented for the two largest primary iron and steel works. Activity data for all other facilities is, if not otherwise stated, collected from Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 onwards, further described in Annex 1.

Emissions reported from primary steel works and other iron and steel works are reported in NFR 1A1c, 1A2a, 1B1b, 1B1c and 2C1 since some emissions arise from fuel combustion and some from reducing agents in the process. The text in this section is hence closely connected to the text in section 4.4 Metal production, NFR2C. NFR2C1 (iron and steel production). Fuel combustion has increased slightly since 1990 due to higher production of iron and steel products. However, there was a significant decrease in solid fuel consumption in 2009 due to lower production of coke, caused by a lower demand of primary iron and steel.

The reported emissions of particulate matter include the condensable fraction of particles.

For confidentiality reasons, selenium (Se) emissions are reported as C in the NFR-table for 2022.

#### *3.2.4.2.1 Primary iron and steel works*

In Sweden, there are two plants for integrated primary iron and steel production, i.e. basing their production on iron ore pellets. The integrated iron and steel production consist of material flows between coke oven, blast furnace and steelworks, and in one plant, rolling mill (see Figure 4.4.1 in section 4.4 Metal industry (NFR2C). Emissions from fuel combustion (oils, LPG and recovered energy gases, i.e. coke oven gas and blast furnace gas) used in the rolling mills and for in-house power and heat production are allocated to this sub-sector in accordance with the IPCC Guidelines.

#### *3.2.4.2.2 Secondary iron and steel works*

Except for the primary iron ore based iron and steel works, this sector includes emissions from for instance electric arc furnaces plants, iron ore pellet plants and iron powder plants. For these facilities, data on fuel consumption for energy purposes is from the quarterly fuel statistics. National NCVs and emission factors are used.

#### 3.2.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

For the two largest facilities, the time series is considered to be very consistent since the time series developed in 2009 was compiled in close cooperation with the facilities. For NFR1A2a in total, the time series is also considered to be consistent, despite the fact that the quarterly fuel survey is used for most years and the annual industrial energy survey for some years. The quarterly fuel survey data is weighted to cover the same population as the yearly industrial energy survey. A discussion on the reasons for changing data sources can be found in Annex 2.

The uncertainties for stationary combustion are on fuel group aggregation level. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group. Activity data uncertainty is relatively low for most fuel types. Emission factor uncertainty is for some fuels very high. The fuel groups and EF that have highest uncertainty are:

- Liquid fuels for As, Cd, Cr, Cu, $NH_3$, Ni, Pb, Se, Zn
- Biomass for As
- All fuels for DIOX, PAH, $PM_{10}$, $PM_{2.5}$ $SO_2$

See Annex 1 for more details regarding uncertainties for activity data and emissions.

#### 3.2.4.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In general, the same QA/QC procedures are used for NFR1A2a as for 1A1a described above. In addition to this, fuel consumption for the year t-2 is verified against the annual industrial energy survey on an aggregate level to check that the weight factors for the year t-1 are reasonable. For the two largest facilities, all data is collected directly from the company.

#### 3.2.4.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2025 there were revision of emissions of BC, PM2.5 and PM10 emission for 2021 and BC, PM2.5, PM10, TSP, NOx, and $SO_2$ emissions for 2022. The revisions for 2021 resulted in decreased emissions for BC 0.32% (0.015 t), PM2.5 0.39% (0.038 t) and increased emissions for PM10 1.2% (2.4 t). The revisions for 2022 resulted in decreased emissions for NOx and increased emissions for all other revised substances. NOx decreased by 6.7% (0.05 kt). $SO_2$ increased by 28.6% (0.069 kt), PM10 increased by 18.8% (0.002 kt), TSP 14,3% (0.027kt), PM2.5 2.6% (0.25 t), BC 1.06% (0.05 t).

#### 3.2.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan. In addition, see also chapter 1.3.5 QA/QC procedures and extensive review of emission inventory.

### 3.2.5 Non-Ferrous Metals, NFR1A2b

#### 3.2.5.1 SOURCE CATEGORY DESCRIPTION

This source category covers combustion-related emissions from seven aluminium producers (ISIC 27420), six copper producers (ISIC 27440) and five facilities producing various other metals. More detailed descriptions are given in section 4.4.

As for all subcategories to NFR1A2, for companies with less than 10 employees the Tier 2 method is used since country specific emission factors are used. Emissions from companies with less than 10 employees are allocated to NFR1A2g.

Fuel consumption shows a decreasing trend for the period 1990-2002, but from 2003 onwards, the inter-annual variations in fuel consumption for energy production are relatively small. In recent years, the copper producers account for 40-50% of the fuel consumption in 1.A.2.b and the aluminium producers account for 32-45%. The most common fuel is LPG (44-61% in recent years), followed by heating oils and natural gas.

A summary of the latest key source analysis is presented in Table 3-6.

**Table 3-6. Summary of key source analysis, NFR1A2b, according to approach 1.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 1A2b | Liquid – Ni | Liquid – |
| | Solid – | Solid – |

#### 3.2.5.2 METHODOLOGICAL ISSUES

The Tier 2 method is used. Activity data is taken from Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002 and from quarterly fuel statistics for 1997-1999 and 2003 and later. For more details on these surveys see Annex 2.

The reported emissions of particulate matter include the condensable fraction of particles.

For confidentiality reasons nickel (Ni) emissions are reported as C in the NFR-table for 2022.

#### 3.2.5.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As for NFR1A2a, time series consistency despite the changes in activity data source is discussed in Annex 2.

Activity data uncertainties are assigned by expert judgements by staff at the energy statistics department of Statistics Sweden. Emission factor uncertainties have been assigned by national experts on emissions from stationary combustion.

The uncertainties for stationary combustion are on fuel group aggregation level. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group. The uncertainty of AD and $CO_2$ is 5% for all fuel groups.

Activity data uncertainty is relatively low for most fuel types. Emission factor un certainty is for some fuels very high. The fuel groups and EF that have highest uncertainty are:

- Solid fuels for Zn
- Liquid fuels for all emissions
- All fuels for As, DIOX
- Other fuels for $PM_{10}$, $PM_{2.5}$, TSP

See Annex 1 for more details regarding uncertainties for activity data and emissions.

#### 3.2.5.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The same QA/QC procedures are used for NFR1A2b as for 1A2a described above. In addition to this, a detailed quality study of the non-ferrous metal industry was performed in 2010[28].

#### 3.2.5.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculation occurred in this sector in submission 2025.

#### 3.2.5.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan. In addition, see also chapter 1.3.5 QA/QC procedures and extensive review of emission inventory.

### 3.2.6 Chemicals, NFR1A2c

#### 3.2.6.1 SOURCE CATEGORY DESCRIPTION

The chemical industry produces a number of different products such as chemicals, plastics, solvents, petrochemical products etc. In total, around 50 plants are included, of which ten uses more than 90% of the energy according to the activity data used for emission calculations for this sector. The fuel consumption trend is increasing since 1990, especially for liquid fuels, mainly due to increased use within the basic plastic industry. For 2023, liquid fuels account for about 59% of the energy, solid fuels for 1%, gaseous fuels for 14%, other fossil fuels for 8% and biomass for 18%.

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[28] Skårman et.al, 2008.

As in other subcategories of NFR1A2, emissions from companies with less than 10 employees are allocated to NFR1A2g.

A summary of the latest key source analysis is presented in Table 3-7.

**Table 3-7. Summary of key source analysis, NFR1A2c, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1A2c | Biomass – | Biomass – |
| | Liquid – NOx | Liquid – Ni |
| | Other Fuels | Other Fuels |

### 3.2.6.2 METHODOLOGICAL ISSUES

The Tier 2 method is used. Activity data is, with exceptions mentioned below, collected from Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 and later. For more details on these surveys, and explanations of choice of data sources, see Annex 1.

Generally, plants classified as ISIC Division 24 according to ISIC Rev.3[29] in the Quarterly fuel statistics are included in this sector, as recommended in IPCC 2006 Guidelines.

In submission 2009, after careful studies of different data sources regarding activity data of consumption of other petroleum fuels in this sector, it was found that the fuel used is a by-product of the process in one facility, a gas that consists mainly of methane. Since no specific emission factors for methane and methane-based gas mixtures are available, emission factors for natural gas are used as these fuels are considered to have similar properties, but of course fuel consumption and emissions are still reported under liquid fuels. As natural gas contains around 90 molar per cent methane, the emission factors are considered to be accurate also for methane-rich gas mixtures of liquid origin.

In a development project in 2010[30], the activity data time series 1990-2008 for all fuel types and all facilities within the chemical industry were thoroughly reviewed. Reported emissions and activity data in NFR1 and 2 were analysed on facility level and verified against environmental reports, and when necessary, the facilities were contacted for explanations or complementary data. Most of the data reported in submission 2010 was concluded to be correct, and only a few revisions had to be made in submission 2011. A few erroneous activity data records were detected and

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[29] United Nations Statistics Division, 2010

[30] Gustafsson, T., Nyström, A-K.., Gerner, A., 2010: Riktad kvalitetskontrollstudie av utsläpp från kemiindustrin i Sveriges internationella rapportering. SMED report 2010 (in Swedish, quality control study of emissions from the chemical industry in Sweden’s international reporting)

revised. The errors include double-counting, input data errors and miscoding, e.g. biogenic ethanol that had been coded as natural gas or hydrogen coded as other petroleum fuels.

The project also resulted in revisions of a couple of emission factors. Emission factors for hydrogen, which were previously set equal to those of “other petroleum fuels” for all substances containing nitrogen, i.e. including $NH_3$, were corrected and set to zero for all substances except for $NO_X$.

The revision that had the largest impact on the emissions is the conclusion drawn that some (not all) of the natural gas consumption previously reported in NFR1A2c 2004 and onwards is actually used as feedstock and not for energy production, and hence no emissions from this activity should be reported in NFR1A2c.

Since submission 2020, all combustion of petrochemical by-products (i.e. the gas discussed above) is allocated to CRT 2. This allocation is made due to difficulties in separating emissions from processes from stationary combustion.

The reported emissions of particulate matter include the condensable fraction of particles.

In submission 2021, the combustion of carbide furnace gas was allocated to CRT 2B5 (IPPU sector), according to the results from a developing investigation[31] regarding improvements of the methods from carbide production, with the aim to increase consistency, completeness and accuracy of the reporting, and assures compliance with the 2006 IPCC Guidelines.

In submission 2023, the combustion of carbide furnace gas was reallocated to NFR 1A2c from 2B5 (IPPU sector), according to the results from a developing project regarding improvements of the allocation of stationary and process-based emissions between NFR 1 and 2[32].

For confidentiality reasons, the fuel consumption of liquid fuels, solid fuels, and other fossil fuels are reported as C in NFR-tables for emission year 2022.

### 3.2.6.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty in activity data is 1.5% (2012) and the emission factor uncertainty is assumed to be 10% based on the variation in plant specific values. The Activity data uncertainty for this fuel 2012 is as reported to the EU ETS. For the other fuels

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[31] Yaramenka, K., Danielsson, H., Josefsson Ortiz, C. 2020. Improvements in reporting of emissions from carbide production. SMED Report No 16 2020.

[32] Helbig, T., Yaramenka, K., Josefsson Ortiz, C., Guban, P. 2022. Omallokering för Borealis. SMED memorandum.

used and for all fuels for 1990, uncertainties are assigned by expert judgements by staff at the energy statistics department of Statistics Sweden.

The uncertainties for stationary combustion are revised on fuel group aggregation level. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group. The uncertainty of AD is 2-5% for all fuel groups except for Other Fossil Fuels that is 10%. Activity data uncertainty is relatively low for most fuel types. Emission factor uncertainty is for some fuels very high. The fuel groups and EF that have highest uncertainty are:

- Biomass for As
- Liquid As, Cr, Cu, Hg, Ni, Se, Zn
- Other fuels for As, Cr, Cu, Hg, Ni Pb, PAH
- Gaseous fuels for PAH, $PM_{10}$, $PM_{2.5}$

See Annex 1 for more details regarding uncertainties for activity data and emissions.

### 3.2.6.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In general, the same QA/QC procedures are used for NFR A2c as for 1A2a and 1A2b described above. For the largest plants in terms of emissions and fuel consumption, both environmental reports and ETS data are used for verification of the estimates based on Quarterly fuel statistics.

### 3.2.6.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculation occurred in this sector in submission 2025.

### 3.2.6.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan. In addition, see also chapter 1.3.5 QA/QC procedures and extensive review of emission inventory.

## 3.2.7 Pulp, Paper and Print, NFR1A2d

### 3.2.7.1 SOURCE CATEGORY DESCRIPTION

In 2021, there were 50 paper mill and pulp industry plants and 120 sawmills (production capacity >10 000 $m^3$/year) in Sweden. In total, they produced 8.9 Mt of paper, 19 $Mm^3$ of sawn timber and 11.7 Mt of pulp[33]. Since 1990, production has had an increasing trend, but not in the latest few years. There is no apparent trend in total fuel consumption since 1990, but the share of energy from biomass fuels has increased, from 82% of fuel consumption in 1990 to 96% in 2023 at the same time as liquid fuels has decreased from 15% of total fuel consumption in 1990 to 3.5% in 2023.  As for NFR 1.A.2 in general, emissions from companies with less than 10 employees are allocated to NFR 1A2g.

A summary of the latest key source analysis is presented in Table 3-8.

**Table 3-8. Summary of key source analysis, NFR1A2d, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | **Level** | **Trend** |
| 1A2d | Biomass – *As, Cd, Cr, Cu, Hg, NMVOC, NOx, Ni, PAH 1-4, PM10, PM2.5, Pb, SO2, Se, Zn* | Biomass – *Cd, NMVOC, NOx, PAH 1-4, PM10, PM2.5, SO2, Se, TSP, Zn* |
| | Liquid – *As, NOx, Ni, Pb, SO2* | Liquid – *NOx, Ni, PM10, PM2.5, SO2, Se* |
| | Solid Fuels – | Solid Fuels – DIOX, *Hg, SO2, Se* |
| | Other Fuels – | Other Fuels – PM10, PM2.5, TSP |

### 3.2.7.2 METHODOLOGICAL ISSUES

The Tier 2 method is used. Emissions from processes in the Pulp, paper and print industry are reported under NFR2H1, see section 4.6 Other industrial processes and product use, NFR2H.

Activity data is, if not otherwise stated, collected from Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 and later. For more details on these surveys see Annex 2. There is no apparent trend in fuel consumption since 1990.

During 2009, an investigation of emissions of $NO_X$, $SO_2$ and particulate matter from the pulp and paper industry was performed. A comparison between the total emissions from the facilities calculated with national emission factors and the corresponding emissions reported in the environmental reports of the corresponding facilities showed that the use of national emission factors leads to an overestimation of the emissions. In the environmental reports, however, emissions are not reported per fuel type, and hence it was not possible to develop revised emission fac-

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[33] The Swedish Forest Industries Federation, 2022-11-29. 2022. https://www.skogsindustrierna.se/skogsindustrin/skogsindustrin-i-korthet/fakta--nyckeltal/

tors per fuel. Instead, emissions of $NO_X$, $SO_2$ and particulate matter from fuel combustion in pulp and paper production facilities are enumerated with the same mean factors for all fuels:

$NO_X$: EM = 0.736*EF($NO_X$)*AD
$SO_2$ EM= 0.565*EF($SO_2$)*AD
TSP/$PM_{10}$/$PM_{2.5}$: EM=0.686* EF(TSP/$PM_{10}$/$PM_{2.5}$)*AD;

EM= emission
EF= national emission factor, specific for each substance
AD= activity data in TJ.

The availability of environmental reports for the years before 2000 is very limited, why the correction factors quoted above are used only for the years 2000 and later. The investigation, and hence the correction factors, applies to the pulp and paper industry only, and not to the printing works. Emissions from combustion of sulphur lyes are presently not reported in 1A2d as this activity has been considered as an industrial process.

The reported emissions of particulate matter include the condensable fraction of particles.

Due to confidentiality reasons:

- Activity data for liquid fuels and other fossil fuels are reported as C in NFR-tables in the NFR code 1.A.2.d for 2023.

### 3.2.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As for NFR1A2 in general, time series consistency despite the changes in activity data source is discussed in Annex 2. Activity data uncertainties are assigned by expert judgements made by persons in the energy statistics department at Statistics Sweden. Emission factor uncertainties have been assigned by national experts on emissions from stationary combustion.

The uncertainties for stationary combustion are on fuel group aggregation level. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group. The activity data uncertainty is lowest for Biomass and Other Fossil Fuels with 8-10%. The $N_2O$ emission factor uncertainty for wood is 40% and the $CO_2$ emission factor for Liquid Fuels is 5%.

Activity data uncertainty is relatively low for most fuel types. Emission factor uncertainty is for some fuels very high. The fuel groups and EF that have highest uncertainty are:

- Biomass for As
- Gaseous fuels for As
- Liquid As, Cd, Cr, Cu, DIOX, Hg, Ni, Se, Zn
- Other fuels for As, Cr, Cu, Hg, Ni, Pb, Zn
- All fuels for PAH, $PM_{10}$, $PM_{2.5}$, TSP

See Annex 1 for more details regarding uncertainties for activity data and emissions.

#### 3.2.7.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In general, the same QA/QC procedures are used for NFR1A2d as for 1A1a and 1A2a–c described above.

#### 3.2.7.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculation occurred in this sector in submission 2025.

#### 3.2.7.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission. Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan. In addition, see also chapter 1.2.5 QA/QC procedures and extensive review of emission inventory.

### 3.2.8 Food Processing, Beverages and Tobacco, NFR1A2e

#### 3.2.8.1 SOURCE CATEGORY DESCRIPTION

The food and drink industry is the fourth largest branch of industry measured as production value and number of employees. There are about 3000 companies, of which only around 650 have more than 10 employees[34]. The largest number of companies and employees are found in the bakery industry, but the most energy intensive branch is the sugar industry which accounts for about 25% of the fuel consumption in 1A2e. Dairies, breweries, producers of refined vegetable fats and potato products are other industries with significant fuel consumption (around 7-12% each of the fuel consumption in 1A2e). The total fuel consumption in the sector decreased from 1990 to 2023 by 60%. The percentage use of fossil fuels has been also decreasing from 98% in 1990 to 56% 2023. As for NFR 1A2 in general, emissions from companies with less than 10 employees are allocated to NFR 1A2g.

A summary of the latest key source analysis is presented in Table 3-9.

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[34] The Swedish Food Federation 2013-10-02

**Table 3-9. Summary of key source analysis, NFR1A2e, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1A2e | Biomass – | Biomass – |
| | Liquid – | Liquid – *NOx, Ni, SO2, Se* |
| | Other – | Other – |

### 3.2.8.2 METHODOLOGICAL ISSUES

The Tier 2 method is used. Activity data is collected from Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 and later. For more details on these surveys see Annex 2.

The fuel consumption varies between years and decreased steadily during the years 1998-2008. Since 2008, the total annual fuel consumption in this sector is stable.

The reported emissions of particulate matter include the condensable fraction of particles.
Due to confidentiality reasons activity data for liquid fuels and other fossil fuels are reported as C in NFR-tables in the NFR code 1.A.2.e for 2023

### 3.2.8.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As for NFR1A2 in general, time series consistency despite the changes in activity data source is discussed in Annex 2. The IEFs are slightly variable between years due to variations in fuel mix.

The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group. Emission factor uncertainties have been assigned by national experts on emissions from stationary combustion.

The uncertainties for stationary combustion were revised in submission 2020 and set on fuel group aggregation level. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group. Activity data uncertainty is 5% for all fuel groups except for Other Fossil Fuels which is 10%. $CO_2$ emission factor uncertainty varies between the fuel groups with highest for Other Fossil Fuels, 100%, 30% for Biomass and 5% for the other fuel groups. Activity data uncertainty is relatively low for most fuel types. Emission factor uncertainty is for some fuels very high. The fuel groups and EF that have highest uncertainty are:

- Biomass for As, DIOX
- Gaseous fuels for As
- Liquid As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn

- Other fuels for As, Cr, DIOX, Cu, Hg, Ni, Pb, Zn
- All fuels for PAH, $PM_{10}$, $PM_{2.5}$, TSP

See Annex 1 for more details regarding uncertainties for activity data and emissions.

### 3.2.8.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Generally, the same QA/QC procedures are applied for 1A2e as for other 1A2 categories described above.

### 3.2.8.5 SOURCE-SPECIFIC RECALCULATIONS

There was a reallocation in the sub-sector in submission 2025 affecting all submission years. Due to new information from a company in the sub-sector we reallocated solid fuel use to 2.H.2. The company has informed that solid fuels was used in the production processes but by mistake reported as combustion for all years 1990-2023. The recalculations resulted in lower emissions in this sub-sector.

### 3.2.8.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan. In addition, see also chapter 1.3.5 QA/QC procedures and extensive review of emission inventory.

## 3.2.9 Non-Metallic Minerals, NFR1A2f

### 3.2.9.1 SOURCE CATEGORY DESCRIPTION

This source category includes stationary combustion of fuels in non-metallic mineral industries (ISIC 26). Cement production accounts for a major part of the emissions.

A summary of the latest key source analysis is presented in Table 3-10.

**Table 3-10. Summary of key source analysis, NFR1A2f, according to approach 1.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 1A2f | Biomass – Cd | Biomass – |
| | Liquid – *Ni, SO2* | Liquid – *NOx, Ni, SO2* |
| | Solid – *As, Hg, NOx, SO2* | Solid – *DIOX, Hg, NOx, SO2, Se* |
| | Other – | Other – |

### 3.2.9.2 METHODOLOGICAL ISSUES

The tier 2 method is used for emissions from stationary combustion for NFR1A2f, because country-specific emission factors for the source category and fuel for each gas is used.

Activity data is collected from Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 and later. For 2008 and later, activity data for the three plants within the cement production industry is taken from the EU-ETS system, as this data source provides more detailed information on fuel types. The total amount of fuels combusted is consistent with the Quarterly fuel statistics (KvBr).

National emission factors are used. For more details on these surveys and emission factors see Annex 2.

All $NO_X$ emissions from cement production, including process emissions, are reported in NFR1A2f and reported as IE in NFR2A1. All other energy related emissions for this facility are reported in NFR1A2f.

The reported emissions of particulate matter include the condensable fraction of particles.

Due to confidentiality reasons, fuel consumption from solid fuels and other fossil fuels and emissions of hexachlorobenzene (HCB) are reported as C in NFR-tables for 2023.

#### 3.2.9.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As for NFR1A2 in general, time series are considered consistent despite the changes in activity data source as discussed in Annex 2. The IEFs are slightly variable between years due to variations in the fuel mix.

The uncertainties for stationary combustion are on fuel group aggregation level. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group. Activity data uncertainty is relatively low for most fuel types. Emission factor uncertainty is for some fuels very high. The fuel groups and EF that have highest uncertainty are:

- Biomass for As
- Gaseous fuels for As
- Liquid As, Cd, Cr, Cu, DIOX ox, Hg, Pb, Se, Zn
- Other fuels for As
- All fuels for DIOX, $PM_{10}$, $PM_{2.5}$, TSP

See Annex 1 for more details regarding uncertainties for activity data and emissions.

#### 3.2.9.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Generally, the same QA/QC procedures are applied for 1A2f as for other 1A2 categories described above. In some earlier submissions, extensive QA/QC and verification efforts have been made for the other sectors including the construction industry.

#### 3.2.9.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculation occurred in this sector in submission 2025.

#### 3.2.9.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan. In addition, see also chapter 1.3.5 QA/QC procedures and extensive review of emission inventory.

### 3.2.10 Other industries, NFR1A2g

#### 3.2.10.1 SOURCE CATEGORY DESCRIPTION

This source category is by nature heterogeneous, as both stationary and mobile emission sources are included. The stationary sources included are combustion within ISIC 10-37, except from the branches separately reported in 1A2a-1A2f, stationary combustion within all companies with less than 10 employees regardless of branch, and stationary combustion within the construction sector. The Quarterly fuel statistics (KvBr) is a cut-off survey including enterprises with ten or more employees. The estimation of emissions from enterprises with less than ten employees is based on activity data from the annual energy balances, i.e. a model estimate of aggregate fuel consumption in all small enterprises within the entire manufacturing industry. These emissions are reported in 1A2gviii.

The mobile emission source included in this sector is combustion by off-road vehicles and other machinery (working machinery) used in the construction and manufacturing industry. The emissions from this sector are reported in 1A2gvii.

In terms of stationary fuel combustion and emissions, two branches of industry are dominating: manufacturing of wood products (ISIC 20), and mining industry (ISIC 13). In ISIC 20, however, biomass fuels are dominating and hence the emissions of fossil $CO_2$ from this branch of industry are low. The construction industry also accounts for a significant share of fuel consumption and emissions. The fuel consumption varies between years, but for stationary combustion within 1A2g in total, it has decreased slightly since 1990. Liquid and biomass fuels account for most of the decrease.

Mobile combustion, i.e. working machinery, the consumption of liquid and biomass fuels was about 85% higher in 2023 than in 1990.

Emissions of PM$_{2.5}$ and NO$_x$ in 2023 have decreased by 70% and 67% compared to 1990 respectively. The emissions of NMVOC have decreased by 41% while emissions of CO have increased by 19% compared to 1990.

A summary of the latest key source analysis is presented in Table 3-11.

**Table 3-11. Summary of key source analysis, NFR1A2g, according to approach 1.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 1A2g vii | Biomass – CO, *Cu, NOx, PM2.5* | Biomass – *Cu, NOx* |
| | Liquid – *CO, Cd, Cu, NMVOC, NOx, PM10, PM2.5* | Liquid – *Cu, NOx, PM10, PM2.5, SO2, TSP* |
| | Other – | Other – |
| 1A2g viii | Biomass – *As, Cd, Cr, Hg, NOx, Ni, PM10, PM2.5, Pb, SO2, Se, Zn* | Biomass – *Cd, Cu, NMVOC, NOx, PAH 1-4, PM10, PM2.5, SO2, Se, TSP, Zn* |
| | Liquid – *NOx, Ni, SO2* | Liquid – NOx, Ni, *PM2.5, SO2, Se* |
| | Solid – *As, Cr, DIOX, Hg, NOx, Pb, SO2, Se* | Solid – *Hg, NOx, Se* |
| | Other – | Other – |

### 3.2.10.2 METHODOLOGICAL ISSUES

All consumption of motor gasoline and diesel oil, including low blended biofuel, in manufacturing industries and construction is allocated to mobile combustion while all other fuels (heating oils, natural gas etc.) are allocated to stationary combustion.

#### *3.2.10.2.1 Stationary combustion*

For emissions from stationary combustion, the Tier 2 method is used.
Emissions from stationary combustion in mining and quarrying and in the manufacturing of various products such as textiles, wearing apparel, leather, wood and wood products, rubber and plastics products, other non-metallic mineral products, fabricated metal products and manufacturing of different types of machinery, are calculated with activity data from the Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from the Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 and later. For more details on these surveys see Annex 2.

Emissions from all companies with less than 10 employees within the manufacturing industry are estimated and reported under NFR1A2g. Activity data are collected from the annual energy balances produced by Statistics Sweden[35]. The last emission year is estimated as a projection of the second last year by the trend from the quarterly energy balances, as the annual energy balances for the last emission year are not ready in time for the emission calculations. Emissions are minor and with current data not possible to separate on different industry sectors.

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[35] Statistics Sweden, EN20SM 1990-2008. See also Annex 2.

Emissions from stationary combustion in the construction industry are calculated with activity data from Statistics Sweden[36] in the same way as for small companies described above.

The fuel consumption varies between years, but has totally decreased slightly since 1990, especially the consumption of liquid and biomass fuels.

Since 2002, for one glassworks plant, it is no longer possible to separate combustion emissions of $SO_2$ from process emissions. The reason is that the facility has restructured its environmental report, and only reports emissions of $SO_2$ on an aggregate level. The median value for the share of process-related $SO_2$ missions of the total $SO_2$ emissions is 2% for the years 1990 - 2001. The emission data reported in the plants environmental report are considered to be more accurate than emissions calculated from fuel combustion with standard emission factors, and thus for practical reasons, all data that is available from environmental reports from this plant, namely $SO_2$ and $NO_X$, are reported in NFR2A7 and all other emissions are reported in NFR1A2F.

For 2008 and later, activity data for the three plants within the cement production industry is taken from the EU ETS system because the reporting of waste-like fuels to the Quarterly fuel statistics has shown to be partly incomplete for some years. In the CLRTAP stage 3 review of submission 2013 (and in earlier reviews) it was recommended that the emissions from the cement industry within NFR1A2f should be reported separately. This is however not possible, because data on emissions of $NO_X$, $SO_2$ and particulate matter from the cement industry are taken from environmental reports. In these reports, only the total emissions for each substance are reported, and it is not possible to isolate the combustion emissions. Because of this, all emissions of these substances from the cement industry are reported in NFR2A1. This means that the emissions reported under NFR1A2g in the NFR tables do not include combustion emissions from the cement industry. A table for the cement industry would hence show “IE” for the major pollutants.

The reported emissions of particulate matter include the condensable fraction of particles.

The fuel statistics for the last emission year, based on preliminary Energy Balance is not readily available in time for the emission calculations. As of submission 2022, the activity data is estimated with simple linear extrapolation at fuel type and year at total energy consumption level for ISIC 10-37 with less than 10 employees, construction industry and the Other sector (NFR 1A4)[37]. The estimated energy consumption is then distributed within the sectors according to the same fuel consump-

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[36] Statistics Sweden, EN20SM 1990-2008. See also Annex 2.

[37] Helbig, T. & Josefsson Ortiz, C. 2021. Uppdateringar av utsläppsberäkningar för småskalig biomassaeldning inom övrigsektorn (CRT/NFR 1A4) 2017-2021. SMED Rapport Nr 19 2021.

tion distribution as the previous year. For more detailed information about the extrapolation models and the effects on energy consumption of deviances from the models see Annex 2. The activity data for the last inventory year will be revised next coming submission, as the Energy Balance will then be published and definitive.

Due to confidentiality reasons activity data for solid fuels and liquid fuels and emissions from are reported as C in NFR-tables for 1.A.2.g.viii for 2023.

#### *3.2.10.2.2 Mobile combustion*

Emissions from mobile combustion in NFR1A2g ii refer to working machinery used in industry, including for example tractors, dumpers, mining trucks, cranes, excavators, generators and wheel loaders. A national model is used to estimate emissions from all working machinery used in Sweden and it is considered to correspond to Tier 3 for all emissions, except for $SO_2$ which is estimated according to Tier 2. The model is further explained in Annex 2.

Emissions from working machinery are also reported in NFR1A3e ii, 1A4a ii, 1A4b ii and 1A4c ii. See Table 3-12.

**Table 3-12. Distribution of emissions from off-road vehicles and other machinery.**

| Category | NFR | Definition IPCC Guidelines |
|---|---|---|
| **Industry** | 1A2g vii | Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc. |
| **Other** | 1A3e ii | Combustion emissions from all remaining transport activities including ground activities in airports and harbours, and off-road activities not otherwise reported under 1A4c ii or 1A2g vii. |
| **Commercial/ Institutional** | 1A4a ii | Garden machinery, e.g. lawn mowers and clearing saws, not used by private users, also tractors not used in industry ore forestry or agriculture. |
| **Residential** | 1A4b ii | All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts |
| **Agriculture, Forestry** | 1A4c ii | Emissions from mobile fuel combustion in agriculture and forestry, as for example loader-excavator, tractor, harvester, clearing saw etc. Highway agricultural transportation is excluded. |

### 3.2.10.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

#### *3.2.10.3.1 Stationary combustion*

As for NFR1A2 in general, time series consistency despite the changes in activity data source is discussed in Annex 2. As for other categories in NFR1A2, the IEFs vary slightly between years due to variations in fuel mix. In earlier submissions, the EC (European Commission) has asked for clarification of the drop in wood consumption in 2000 compared to earlier years. This issue has not been prioritized, but since the annual wood consumption 2001-2009 is considerably lower than in the 1990s, there is no reason to believe that the activity data for 2000 is incorrect.

The uncertainties for stationary combustion are on fuel group aggregation level. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group. Activity data uncertainty is relatively low for most fuel types. Emission factor uncertainty is for some fuels very high. The fuel groups and EF that have highest uncertainty are:

- Biomass for As
- Gaseous fuels for As
- Liquid As, Cd, Cr, Cu, DIOX, Hg, Pb, Se, Zn
- Other fuels for As
- All fuels for DIOX, $PM_{10}$, $PM_{2.5}$, TSP

See Annex 1 for more details regarding uncertainties for activity data and emissions.

#### *3.2.10.3.2 Mobile combustion*

No recalculations have been performed for emissions in the mobile sector for the eighties, and thus there are inconsistencies in time series between the eighties and later years. Time series from mobile combustion in NFR1A2gvii have been reviewed for later years and are considered to be consistent.

Uncertainties for activity data and emissions reported for working machinery in NFR1A2gvii can be seen in Annex 1 to the IIR.

### 3.2.10.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

### 3.2.10.5 SOURCE-SPECIFIC RECALCULATIONS

#### *3.2.10.5.1 Stationary combustion*

In submission 2025, there is a revision of activity data for year 2022 for ISIC 10-37 with less than 10 employees and the construction industry as the data was updated to the final energy balance statistics.

The largest percentage increase due to the access of the 2022 activity data was the emissions of CO with increase of 0.015 kt (1.75%) and largest decrease was of emission in Ni with decrease of 0.009Mg (-1.8%).

#### *3.2.10.5.2 Mobile combustion*

A development project[38] regarding annual machine operating hours was conducted during 2023. The project was conducted based on testing and inspection data from

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[38] Jerksjö, M. Genomsnittlig årlig driftstid för entreprenadmaskiner och traktorer. SMED PM 2024

the certified organisation Swedish machine testing. The project involved testing data from year 2019-2023 for machinery that is typically used in industry and construction (wheel loaders, excavators, dumpers and more). Included in the same project was also a study on operating hours of tractors. The study analysed the registered operating hours between change in ownership.
It was concluded that previously used machine hours were overestimated and thus the recalculations resulted in increased emissions throughout the time series.

An example of a notable change that was made in the non-road mobile machinery model was revising the operating hours for machine year 0 (the year a machine is brought into operation). The previous calculations assumed that a machine operates a full year during the calendar year when it is put into operation. The new model settings assume approximately half the operating time for many machine types.

For CO, NOx, $PM_{2.5}$ and NMVOC the recalculations resulted in significant decrease in emissions throughout the time series. The emissions of CO decreased by 2-8%, NOx by 8-13%, $PM_{2.5}$ by 7-14% and NMVOC by 6-11%.

#### 3.2.10.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 3.2.11 Civil Aviation, NFR1A3a i-ii

#### 3.2.11.1 SOURCE CATEGORY DESCRIPTION

Domestic aviation is defined as emissions from flights that depart and arrive in the same country. But when reporting air pollution according to the Long-Range Transboundary Air Pollution Convention (LRTAP), emissions from *both* national and international aviation during the LTO cycle[39] belong to the national totals. And emissions from *both* domestic and international aviation during the Cruise cycle[40] is reported separately as memo items and not included in national totals.

The national government administers 13 of 40 airports with regular and/or charted air traffic in Sweden, for which activity data is provided at present. The remaining 27 airports are private and/or administered by local governments[41].

In 2020, aviation suffered an unprecedented setback due to the covid-19 pandemic. In 2023, the industry has partly recovered in terms of total energy consumption. The energy consumption from the LTO cycle, from both national and international aviation, decreased by 18% between 1990 and 2023 but increased by 10% between

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[39] Landing and take-off.

[40] Cruise cycle: above 3000 feet.

[41] Transportstyrelsen, 2021a.

2022 and 2023. The energy consumption from the cruise cycle (national & international aviation) increased by 30% in 2023 compared to 1990 and by 9% between 2022 and 2023 (see Figure 3-1).

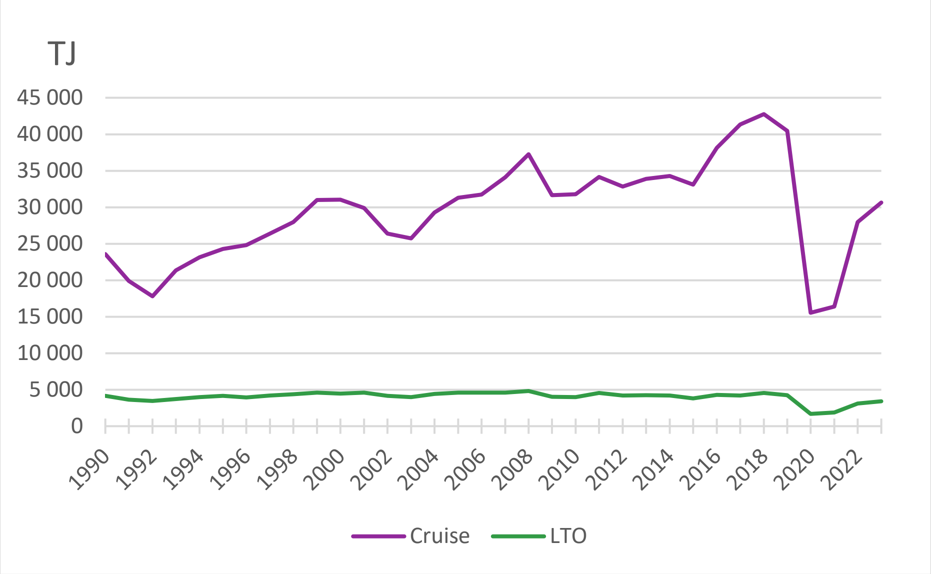

**Figure 3-1. Energy use by aviation 1990-2023: LTO & Cruise cycle (national and international aviation).**

Figures 3-2 and 3-3 show the emissions of $NO_x$ and CO, respectively, which decreased sharply between 2019 and 2020. In 2023 the emissions have increased again but are still well below pre-pandemic levels. The emissions of $NO_x$ from both national and international aviation and from the Cruise respectively LTO cycle have increased by 22% respectively decreased by 31% between 1990 and 2023, The total emissions of $NO_x$ increased by 9% between 2022 and 2023. The emissions of particles have increased in a similar fashion.

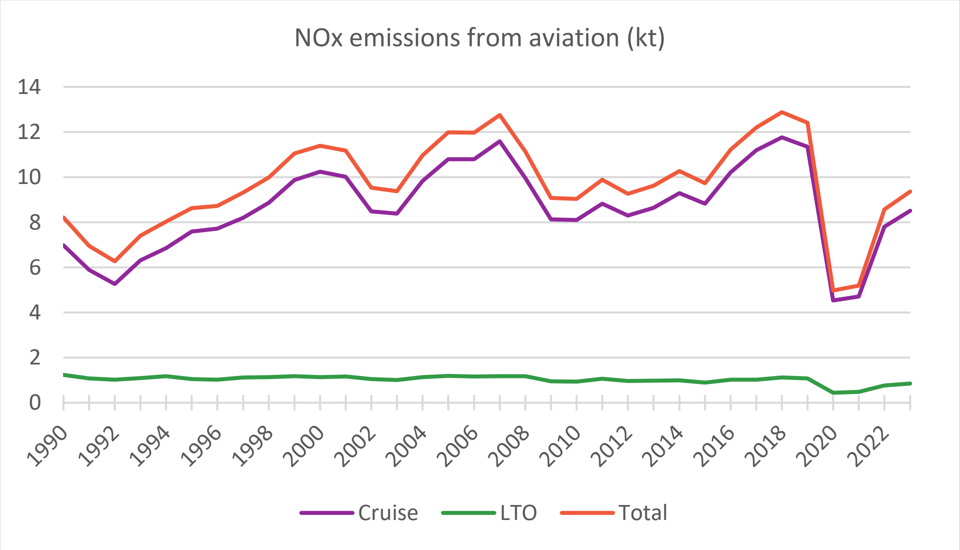

**Figure 3-2. $NO_x$ emission from cruise (national and international), LTO (national and international) and total emissions 1990-2023.**

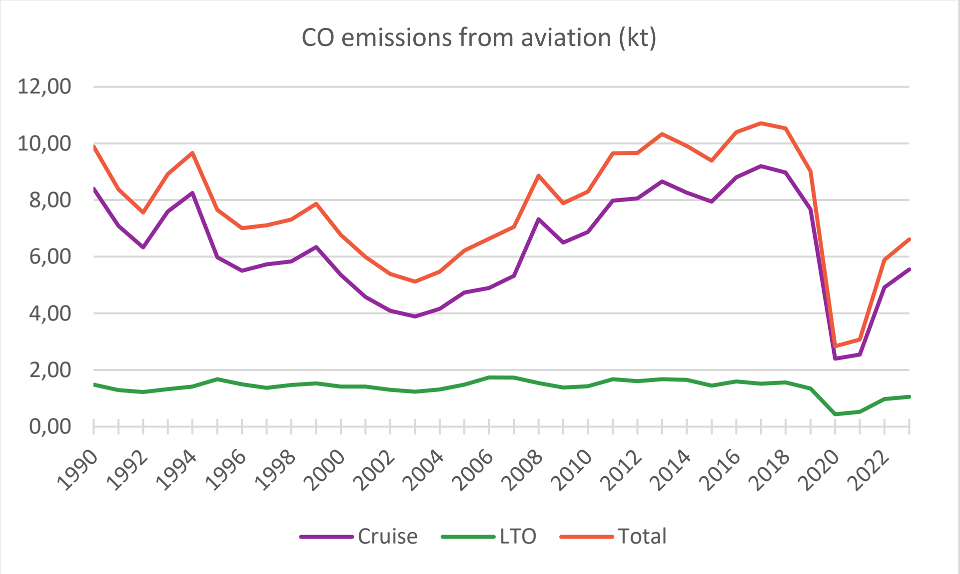

**Figure 3-3. CO emissions from cruise (national and international), LTO (national and international) and total emission 1990-2023.**

The decrease of CO between 2017 and 2019 is due to a transition from Boeing to Airbus planes. In 2023, the emissions of CO from the LTO phase have increased by 9% since 2022 and decreased by 29% since 1990. CO emissions from the cruise phase have increased by 13% since 2022 and decreased by 34% since 1990.

The emissions of NMVOC from the Cruise phase had a decreasing trend even before the covid-19 pandemic struck, which is a result of phasing out a specific type of airplane (MD-80/82) in recent years. The MD-80/82 was a major contributor to these gases. The emissions of NMVOC from the LTO phase have fluctuated for the whole time series and have decreased by 46% since 1990 and increased by 9% in the last year. The total emissions of NMVOC have declined by 68% since 1990 but increased by 10% between 2022 and 2023.

The emissions of $SO_2$ from the LTO phase have a fluctuating trend, while the emissions of $SO_2$ from the cruise phase have increased for the whole time series except during the corona pandemic, due to an increased fuel consumption by aviation. The emissions of $SO_2$ from LTO respectively the cruise phase have increased by 10% respectively 9% between 2022 and 2023. The emissions of Pb have a decreasing trend for both the Cruise and the LTO phase.

A summary of the latest key source analysis is presented in table 3-13.

**Table 3-13. Summary of key source analysis, NFR1A3a i-ii, according to approach 1.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 1A3a | Aviation Gasoline - *Pb* | |

### 3.2.11.2 METHODOLOGICAL ISSUES

Sweden uses Tier 2 to estimate emissions of $SO_2$ and Tier 3a to estimate the emissions of all other gases. Emissions from aviation used by agriculture and forestry are reported as civil aviation.

The Swedish Transport Agency (STAg) is responsible for reporting the emissions from aviation. But the fuel consumption and emissions published by STAg are calculated by the Swedish Defence Research Agency (FOI) by using an air emission model. STAg provides FOI statistics for the model regarding:

- Airport of departure and arrival
- Type of aircraft
- Number of flights
- Number of LTO cycles
- Number of passengers

A database with information regarding 200 different types of aircraft is also used. The emission data regarding different types of aircrafts in the database originates from “ICAO Engine Exhaust Emission Data Bank”. All this data is used to calculate emissions and the amount of combusted fuel for the whole flights as well as for aircraft movements below 3000 feet at the airports, the so called LTO cycle. FOI has written a report which describes their method for estimating the emission from aviation[42].

The model used to calculate the emissions from aviation underestimates the number of kilometres flown, as the model uses more direct flight routes in the calculations than the aircraft do in reality. As a result, the consumption of fuel and emissions are underestimated, and need to be adjusted to be in line with data on national delivery of aviation fuel from the monthly survey on supply and delivery of petroleum products from Statistics Sweden (see Annex 2). The results from the emission calculations are aggregated into four groups: domestic landing and take-off (LTO), domestic cruise, international LTO and international cruise.

The methodology for calculating national emissions is the same for all years with a few exceptions for earlier years. All emissions for 1990-1994 were calculated by

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[42] Mårtensson, T. Hasselrot, A. 2013. Calculation of exhaust emissions from air traffic. FOI R 3677 mSE.

SMED in cooperation with the STAg due to the lack of activity data. Emissions of CO for 1990-1994 were estimated by using the ratio between CO and $CO_2$ in 1995 (4.85% of $CO_2$ emissions). Emissions of $NO_X$ were calculated in a similar way. The mean value of the ratio between $NO_X$ and $CO_2$ emissions in 1995-2004 is used for 1990-1994 (4.03% of $CO_2$ emissions). Emissions of HC for 1990-1994 are calculated by extrapolation.

From 1995 and onwards, emissions of $SO_2$, $NO_X$, CO and HC are estimated by FOI as described above. The estimated emissions of HC are split into NMVOC and $CH_4$, based on the ratio given in EMEP/EEA Guidebook 2013. $N_2O$ emissions from LTO are estimated using information from STAg on the number of LTO cycles together with emission factors from EMEP/EEA guidebook 2013. Emissions of $N_2O$ from cruise are also based on emission factors from EMEP/EEA guidebook 2013 together with the fuel consumption for cruise activities as well as emissions of particles. The 2013 edition of the EMEP/EEA Guidebook is used in this context as the more recent editions are too complex in these calculations[43].

Due to the fact that the Swedish airports generally are smaller than international airports in other countries, taxi times are much shorter for domestic flights and climb-out and take-off times are often shorter as well. Hence, traffic from Swedish airports needs less fuel and give rise to less emissions compared to the International Civil Aviation Organization (ICAO) standards.[44] For international flights, ICAO standard taxi time has been used for the part of the LTO cycle occurring on international airports.[45]

The Swedish Transport Agency (STAg) includes the traffic from a number of non-governmental airports in their estimates from 2005 and from all Swedish airports from 2006. Since 2010 there is no separate reporting on emissions from governmental respectively private airports, instead a total is reported.

In 2006, the STAg responded to a governmental call to reduce the response burden on statistical compilations. As a result, private aviation as well as educational training flights are no longer covered in the STAg reports on fuel consumption and emissions from aviation as from 2007. However, as the estimated emissions from aviation are adjusted to match the delivered amount of aviation fuels, the emissions from private aviation as well as from educational training flights will consequently be included.

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[43] EMEP/EEA guidebook air pollutant emissions inventory guidebook.

[44] Gustafsson, 2005a. Comparative study of Swedish emission factors for aviation with the IPCC default factors. SMED report 2005.

[45] Näs, 2005.

#### 3.2.11.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Data on domestic and international bunker fuel in the Monthly fuel, gas and inventory statistics has been found to be of good quality (See Annex 1 to IIR for more information). Regarding time-series consistency, see the Methodology section.

#### 3.2.11.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The activity data has been subject to QA/QC procedures.

#### 3.2.11.5 SOURCE-SPECIFIC RECALCULATIONS

- In submission 2025, the monthly delivery statistics indicated a decrease in total fuel consumption. Since all other data (number of departures etc) indicated an increase, the decision was taken to extrapolate the total deliveries in 2022 with the percentual increase as calculated by the STAg.
- During 2024, Statistics Sweden performed a project aiming to investigate the validity of net calorific values and emission factors in the mobile energy subsector. As a result, the net calorific value and the $SO_2$ emission factor for fossil jet kerosene have been updated to be in line with the values used by the Swedish Defence Research Agency (FOI). The $SO_2$ emission factors for biojet have also been updated. Those two updates changes the distribution of fuel between national and international aviation, and slightly decreases the amount of $SO_2$ emitted.
- During the work with submission 2025, it was discovered that the consumption by the armed forces was included in the delivery statistics for the years 1990-2017. Since this consumption is now added at a later stage in the calculations, it was subtracted from the total deliveries. This update decreases the amount of fuel used in national aviation for those years.

#### 3.2.11.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 3.2.12 Road transport, NFR1A3b i-iv

#### 3.2.12.1 SOURCE CATEGORY DESCRIPTION

Road traffic is the dominating mode for transport of both goods and people and the Swedish citizens travelled approximately 65 000 million of km by car on Swedish roads in 2023 (Table 3-14). This is an increase by approximately 17% since 1990 and an increase by 0.3% since 2022. For all trucks (LCV & HGV) there has been an increase in number of travelled km by 96% since 1990 (Table 3-14). In 2019, the Swedish road network consisted of around 141,300 km of public roads[46].

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[46] Trafikverket, 2019. https://www.trafikverket.se/resa-och-trafik/vag/Sveriges-vagnat/

**Table 3-14. Millions of km driven by different kinds of vehicles[47].**

| Year | A-tractor cars | Passenger cars | LCV | HGV | Motorcycles | Buses |
|---|---|---|---|---|---|---|
| **1990** | 27 | 55 696 | 3 709 | 3 653 | 407 | 964 |
| **2000** | 18 | 58 555 | 4 574 | 4 310 | 648 | 917 |
| **2023** | 172 | 65 057 | 9 571 | 4 866 | 813 | 949 |

Road transport includes six vehicle categories: A-tractor cars, passenger cars, light commercial vehicles (LCV), heavy goods vehicles (HGV), buses and mopeds & motorcycles. The total number of trucks and passenger cars (in traffic) has increased by 126% respectively 38% since 1990[48] in contrast to the decreasing trend of air pollution.

The emissions of $NO_x$ have decreased by 78%, NMVOC have decreased by 94% and CO by 93% since 1990. This is mainly a result of the introduction of three-way catalytic converters for passenger cars and trucks.

The particle emissions also show a downward trend for all years (1990-2023) due to an increased usage of particle filters and the emissions of $SO_2$ have decreased as the sulphur content in fuel has been heavily restricted over the years.

Gasoline was previously the most common fuel used by road transportation, but as from 2011 the amount of diesel used by road traffic surpassed gasoline. The total consumption of gasoline has had a downward trend throughout the time series (see Figure 3-4). The increasing consumption of diesel by road traffic is primarily explained by a shift from gasoline cars to diesel cars, but also by an increased consumption of diesel by trucks. The total consumption of diesel by HGV and LCV corresponds to 54% of the total consumption of diesel by road traffic in 2023, while passenger cars consume around 44%. The total consumption of diesel by road traffic has, however, had a downward trend since 2015 due to an increased admixture of biofuels (see Figure 3-5).

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[47] Data from the road emission model HBEFA (Trafikverket).

[48] Trafa 2023

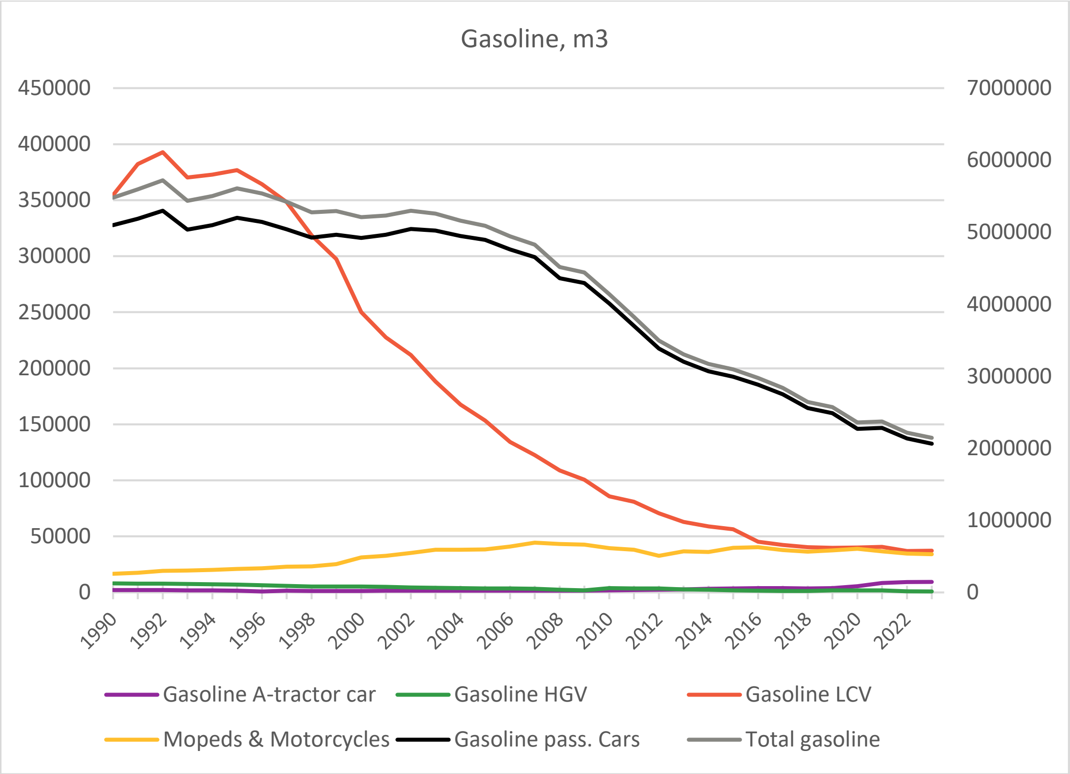

**Figure 3-4. Consumption of gasoline by vehicle type 1990-2023 (m$^3$). Passenger cars and total consumption are on the secondary y-axis.**

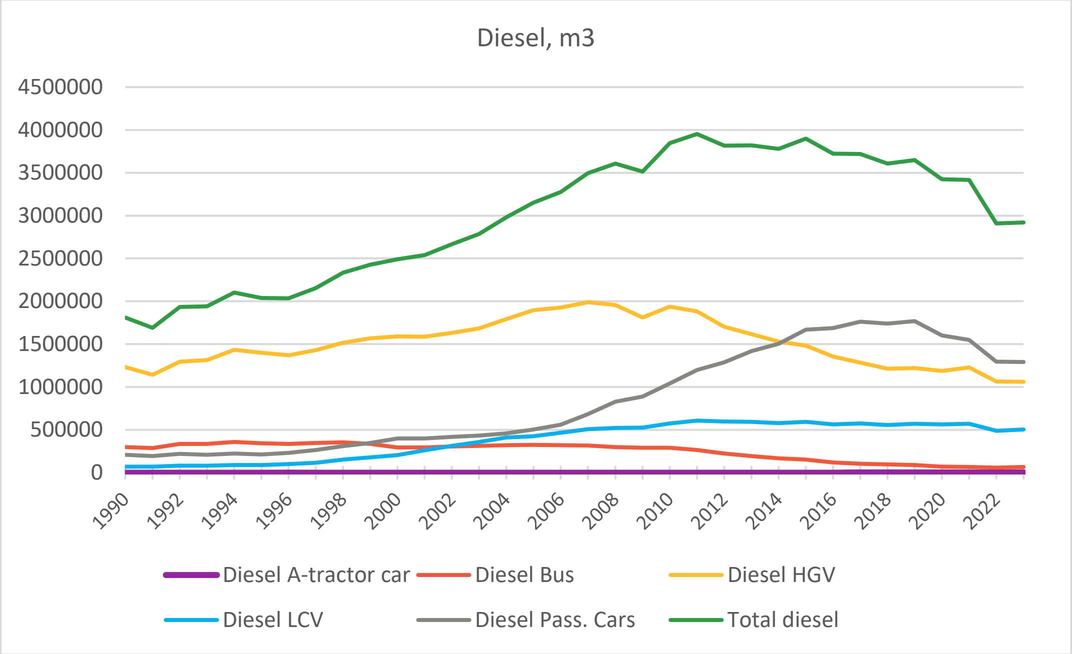

**Figure 3-5. Consumption of diesel by vehicle type 1990-2023 (m3).**

The total use of liquid biofuels (FAME/HVO and ethanol/ETBE) has increased vastly since 2003, when large-scale blending of ethanol into petrol began (Figure

3-7). Advantageous policy regulations and tax reliefs for biofuels initiated the increasing production and use of biofuels[49]. The amount of biogas used by road traffic has also increased greatly since it was introduced on the market and has doubled every other to every third year between 1998 and 2008. Since 2017 there is also a consumption of liquified natural gas (LNG) and liquified biogas (LBG). The use of LBG has increased rapidly and in 2023, it is the second most used gaseous fuel after CBG (Figure 3-6).

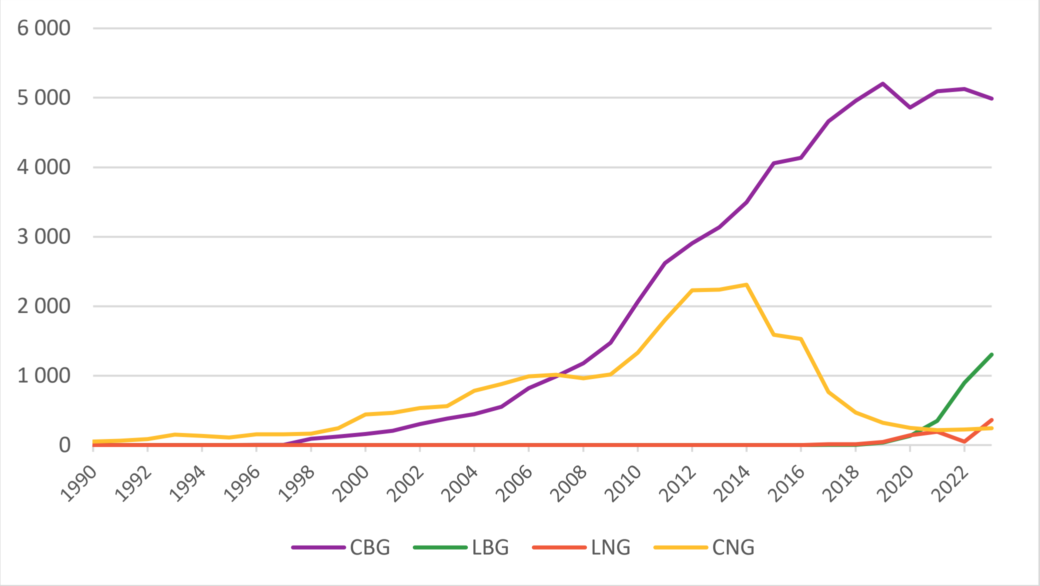

**Figure 3-6. Consumption of gaseous fuels 1990-2023 (TJ)**

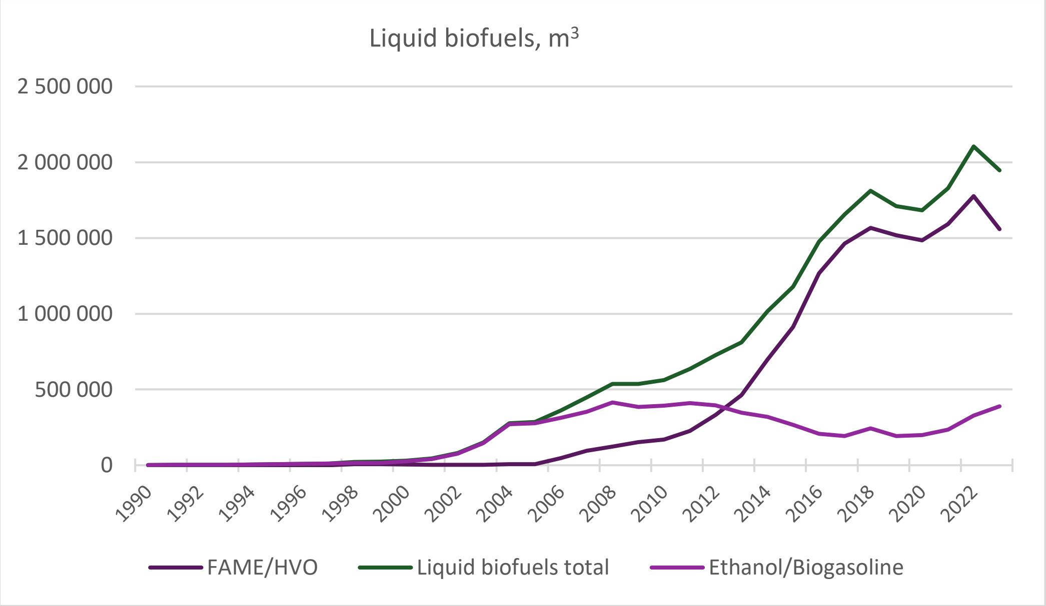

**Figure 3-7. Consumption of biofuels 1990-2023 (m$^3$).**

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[49] Swedish Energy Agency, 2013. Analys av marknaderna för biodrivmedel, tema fordonsgas. Report ES 201308.

The main part of ethanol used by road transportation in Sweden is used as a blending component for gasoline. Large-scale blending of ethanol into petrol began in 2003 and the total amount of ethanol used for road traffic nearly tripled between 2003 and 2011. Between 2012 and 2017, the amount of ethanol used by road traffic declined as a result of the shift from gasoline to diesel cars. In 2023 the amounts of ethanol used in road traffic have increased again with the introduction of E10 (see below).

During the years 2004-2021, just about all petrol sold in Sweden contained around 5% ethanol. In August 2021, Sweden raised this figure to 10% in order to achieve the national goal of a 70% GHG reduction from transport by 2030. As a result, the amount of ethanol used by road traffic is increasing again.

Ethanol is also used by ethanol buses and by E85 passenger cars (flexi fuel cars). The ethanol used by E85 cars increased until 2011 and then began to decline. The consumption of ethanol by buses follows the same trend (Figure 3-8).

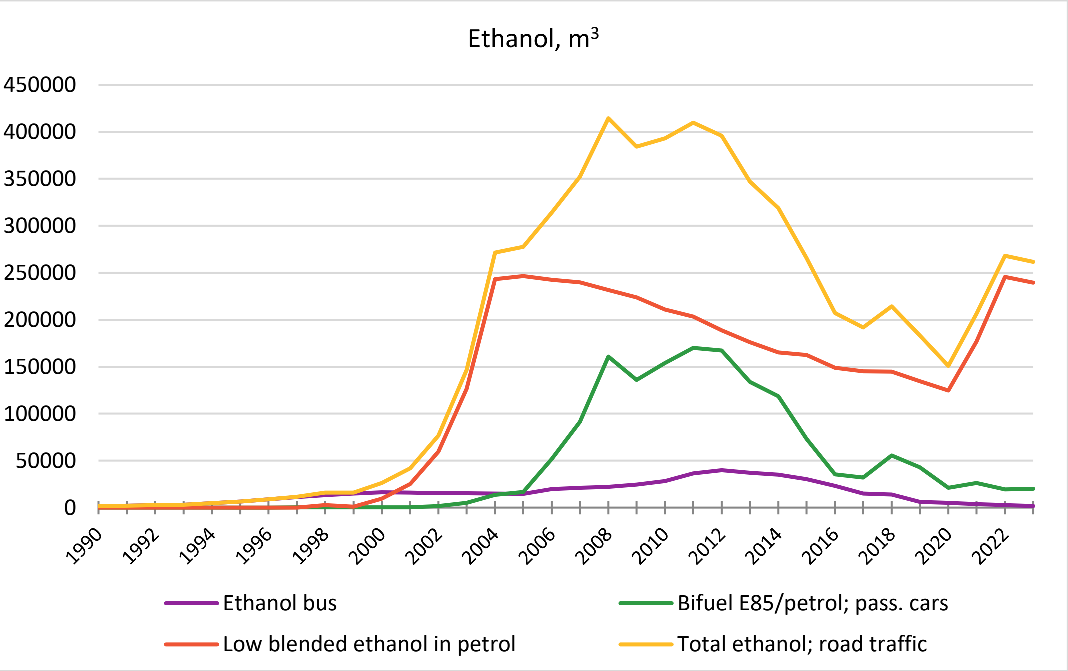

**Figure 3-8. Consumption of ethanol by road traffic 1990-2023 (m$^3$).**

Large-scale blending of FAME into diesel began in 2007 and of HVO in 2012. The amount of FAME/HVO used by road traffic increased by 32-51% per year 2011-2016, but the upward trend slowed down in 2018 and then turned in 2019. (Figure 3-9). After 2019 FAME/HVO has shown a fluctuating trend due to the corona pandemic and the Swedish reduction mandate. The sharp increase in biodiesel in 2011-2016 was mainly a result of a growing trend for diesel cars and a rising fraction of FAME/HVO blended into diesel.

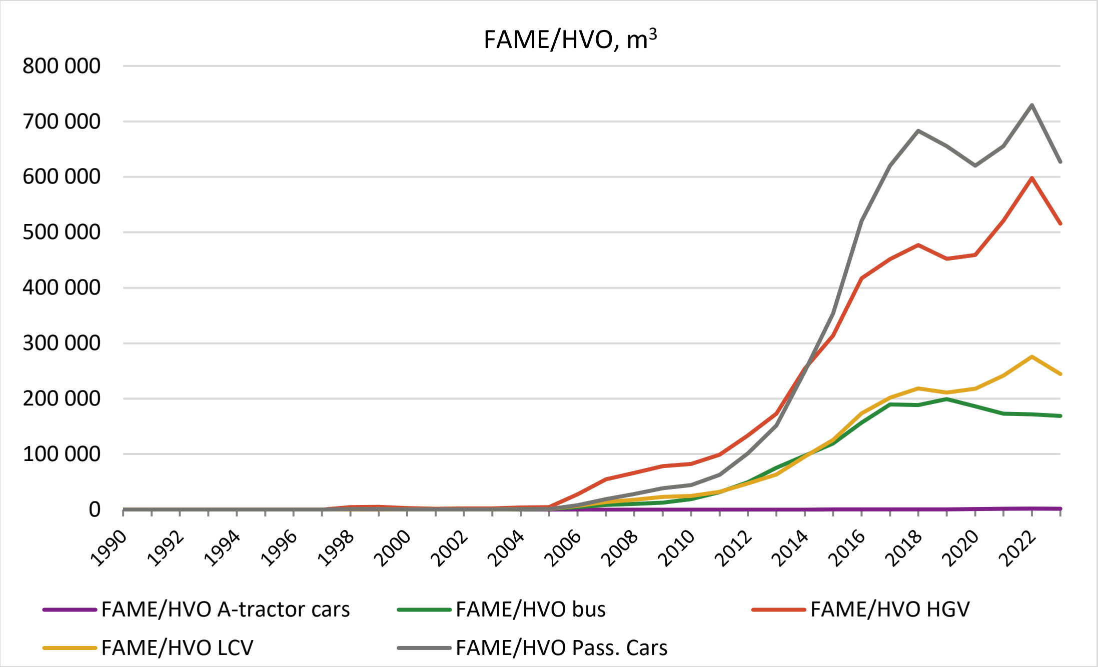

**Figure 3-9. Consumption of FAME/HVO by road traffic 1990-2023 (m$^3$).**

A summary of the latest key source analysis in presented in Table 3-15.

**Table 3-15. Summary of key source analysis, NFR1A3b i-v, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1A3b i | Biomass – *CO, Hg, NMVOC, NOx* | Biomass – *CO, NH3, NOx* |
| | Diesel oil – *CO, Hg, NOx, PM2.5* | Diesel oil – *NOx, PM10, PM2.5, SO2, TSP* |
| | Gasoline – *CO, DIOX, Hg, NH3, NMVOC, NOx* | Gasoline – *CO, DIOX, Hg, NH3, NMVOC, NOx, PM10, PM2.5, Pb, SO2* |
| 1A3b ii | Biomass – *NOx* | Biomass – *NOx* |
| | Diesel oil – *NOx, PM2.5* | Diesel oil – *NOx, PM10, PM2.5* |
| | Gasoline – CO | Gasoline – *CO, NMVOC, NOx, Pb* |
| 1A3b iii | Biomass – *CO, Hg, NOx* | Biomass – *NOx* |
| | Diesel oil – *CO, Hg, NOx, PM2.5* | Diesel oil – *CO, DIOX, NMVOC, NOx, PM10, PM2.5, SO2, TSP* |
| | Gasoline – | Gasoline – |
| 1A3b iv | Gasoline – *CO* | Gasoline – |
| 1A3b v | Gasoline evaporation – *NMVOC* | Gasoline evaporation – *NMVOC* |

Gasoline evaporation, automobile tyre and brake wear and automobile road abrasion are, beside combustion of fuel, also sources of air pollution caused by road traffic.

### 3.2.12.2 METHODOLOGICAL ISSUES

The road emission model HBEFA is used by the Swedish Transport Administration (STA) to estimate the fuel consumption and the emissions from road traffic. The fuel consumption estimated by HBEFA is however adjusted to be in line with national fuel statistics. For 1990-2017, data from the survey “Monthly fuel, gas and inventory statistics” was used for this purpose. A revised version of the survey was introduced in 2018, but uncertainties regarding the quality of the statistics were detected and data from the survey has not been used since 2017. As a result, data collected and reported according to the “Swedish fuel quality act”, regarding diesel, gasoline and liquid biofuels, has been used from 2018.[50]

In the monthly survey “Monthly fuel, gas and inventory statistics”, data is collected from all oil companies and other sellers who keep stocks of petroleum products and coal. The survey also collects stock data from companies with a large consumption of oil in the manufacturing industries and energy industries. As the same oil companies are obliged to collect and report fuel data under the “Swedish fuel quality act”, which is used for 2018-2022, the time series is still considered consistent. The amount of diesel and gasoline collected and reported by the monthly survey and the “Swedish fuel quality act” only differed around 1-2 percent. Therefore, despite the change of data source for 2018-2023, the activity data used in submission 2025 is considered to be consistent and of good quality.[51]

The fuel consumption and emissions are allocated by fuel type and the six vehicle categories: A-tractor cars, Passenger cars, Light commercial vehicles (LCV), Heavy goods vehicles (HGV), Buses and Mopeds & Motorcycles. The road traffic emission model HBEFA is updated yearly with new information regarding emission factors, vehicle fleet, composition of the fuel and the current traffic work. The HBEFA model is administrated by the Swedish Transport Administration (STA) and IVL Swedish Environmental Research Institute. More information can be found in IIR Annex 2.5.

Emissions of $SO_2$ are based on the fuel consumption per vehicle type and country specific thermal values and emission factors. The emission factors for $SO_2$ are based on the actual sulphur content for the different environmental classes of petrol and diesel fuel as from submission 2007. The thermal values and the country-specific emission factors for $SO_2$ are provided by Drivkraft Sverige[52].

The emissions of CO, $NO_X$, NMVOC, $NH_3$, Pb and particles from road traffic are estimated by HBEFA using a tier 3 methodology. The emissions of Cd, Hg, As, Cr, Cu, Ni, Se and Zn are estimated with default emission factors from EMEP/EEA Guidebook 2019. The reported emissions of particulate matter most likely include

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[50] Swedish Energy Agency 2015. Fuel quality act

[51] Eklund, V. et al. 2019. Analys och implementering av data från nya MåBra.

[52] Drivkraft Sverige 2021.The Swedish Industry Organisation for Sustainable and Innovative Mobility (Drivkraft Sverige) is a national industry organisation for fuel and biofuel producers and marketing companies and its members. https://drivkraftsverige.se/

the condensable fraction of particles. Emissions of PCB are estimated using default emission factors in table 3.84 and 3.85 in EMEP/EEA Guidebook 2019.

Activity data for natural gas is available from 1990, while reliable activity data for biogas exists from 1996 and ethanol and FAME from 1998. Thermal values for biogas have been taken from the Swedish Energy Agency, for ethanol from Drivkraft Sverige and for FAME from a SMED report from 2010[53].

The bottom-up estimations of the fuel consumption by HBEFA differ slightly from fuel consumption reported to the UNFCCC (based on fuel delivery). According to IPCC Guidelines, the inventory should only account for emissions from fuel purchased in Sweden compared to the STA, who aims to describe what is emitted on Swedish roads, regardless of where the fuel was bought or the nationality of the vehicles. An overview of the two different objectives is presented in Table 3-16.

**Table 3-16. Emissions from road transport reported by the STA and in the NFR.**

| Fuel bought in | Traffic on Swedish roads | Traffic in Sweden, not on roads | Traffic to/from other country | Traffic in other countries |
|---|---|---|---|---|
| Sweden | NFR1A3b i-iv<br>STA | NFR1A3b i-iv | NFR1A3b i-iv*<br>STA to the Swedish border | NFR1A3b i-iv<br>* |
| Other country | STA | Not reported | STA to the Swedish border | Not reported |

* Since the IPCC Guidelines do not consider international bunkers for road transportation, all emissions from road traffic and fuel bought in Sweden are considered to be domestic and thus reported under NFR1A3b.

Data on particle emissions are lacking for the years 1981-1984 as well as 1986 and are therefore interpolated.

From submission 2008 emissions of benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) were reported for 1A3b. As for dioxin, detailed data from the ARTEMIS model (submission 2008-2011) and HBEFA (from submission 2012) regarding yearly mileages (km x $10^6$) per vehicle category, Euro class and fuel category, have been used. The emission factors presented in table 3-80 and 3-81 in EMEP/EEA Guidebook have been used.

Emission factors presented by Westerholm et al. (2001)[54] are used for the calculations of PAHs from Swedish environmental classified diesel (MK1) used in Heavy duty vehicles. Emission factors for MK1 diesel in Passenger cars and Light duty vehicles are calculated using the relationship Passenger car/Heavy duty vehicle and

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[53] Paulrud et al. 2010. Uppdatering av klimatrelaterade emissionsfaktorer

[54] Westerholm et al., 2001. Comparison of Exhaust Emissions from Swedish Environmental Classified Diesel Fuel (MK1) and European Program on Emissions, Fuels and Engine Technologies (EPEFE) Reference Fuel: A Chemical and Biological Characterization, with Viewpoints on Cancer Risk

Light duty vehicle/Heavy duty vehicle in the EMEP-Corinair Guidebook and emission factors for Heavy duty vehicle according to Westerholm et al (2001)[54].

For MK1 diesel the emissions of benzo(k)fluoranthene are included in reported benzo(b)fluoranthene. All other emission estimates are based on emission factors in the EMEP-Corinair Guidebook. The emission factors used are shown in Table 3-17.

**Table 3-17. Emission factors used for estimations of PAH emissions from fuel combustion in NFR1 A 3 b i - iv.**

| | Gasoline | | Diesel | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Leaded | Un-leaded | Conventional | | | MK1 | | |
| | | | Passenger cars, Light duty vehicles | | Heavy duty vehicles | Passenger cars, Light duty vehicles | | Heavy duty vehicles |
| | | | Not DI | Direct injection | | Not DI | Direct injection | |
| Benzo(b)fluoranthene (µg/km) | 0.88 | 0.36 | 3.30 | 0.60 | 5.45 | 0.09 | 0.18 | 1.60 |
| Benzo(a)pyrene (µg/km) | 0.48 | 0.32 | 2.85 | 0.63 | 0.90 | 0.95 | 0.21 | 0.30 |
| Benzo(k)fluoranthene (µg/km) | 0.30 | 0.26 | 2.87 | 0.19 | 6.09 | | | |
| Indeno(1,2,3-cd)pyrene (µg/km) | 1.03 | 0.39 | 2.54 | 0.70 | 1.40 | 0.36 | 0.10 | 0.20 |

Time series per vehicle category are calculated for dioxin and PAH1-4 from 1980, but data for 1980 - 1989 are not updated in the NFR-tables. For the PAH calculations the share of diesel Passenger cars and diesel Light duty vehicles with direct injection must be estimated, since these emission factors differ from the emission factors for diesel vehicles without direct injection (Table 3-18). All heavy duty vehicles are assumed to have direct injection. Also, the share of MK1 diesel of the total amount of diesel used has to be known (Table 3-18).

**Table 3-18. Distribution of vehicles with respect to fuel type and injection system.**

| | Gasoline | | Without direct injection | | With direct injection | | Diesel type | |
|---|---|---|---|---|---|---|---|---|
| Year | Leaded | Un-leaded | Passenger cars | Light duty vehicles | Passenger cars | Light duty vehicles | MK1 | MK3 |
| 1980-1985 | 100% | 0% | 100% | 100% | 0% | 0% | 0% | 100% |
| 1990 | 50% | 50% | 100% | 100% | 0% | 0% | 0% | 100% |
| 1995 | 0% | 100% | 67% | 100% | 33% | 0% | 66% | 34% |
| 2000 | 0% | 100% | 30% | 45% | 70% | 55% | 94% | 6% |
| 2005 | 0% | 100% | 6% | 20% | 94% | 80% | 98% | 2% |
| 2010 | 0% | 100% | 0% | 4% | 100% | 96% | 99% | 1% |
| 2013- | 0% | 100% | 0% | 0% | 100% | 100% | 99% | 1% |

### 3.2.12.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

For the energy sector, the largest uncertainties come from activity data for the 1980's and from emission factors. No recalculations have been performed for emissions in the mobile sector for the eighties, and thus there are inconsistencies in time series between the eighties and later years.

Activity data for gasoline, diesel and natural gas is available from 1990, while reliable activity data for biogas exists from 1996, for ethanol from 1998, for FAME from 1999 and for HVO from 2012.

One important basic parameter for the HBEFA model is vehicle-km, which is calculated through another model. This second model is based on the mileage driven by the vehicle noted at time of MOT (annual testing of the vehicle). A passenger car which goes through the MOT in the beginning of 2023, has done most of the mileage in 2022. If the development of traffic is without interruption, this issue is not a problem for the calculations. However, if a sudden event occurs, such as a drop in the economy, it will not show as clearly in the development of the vehicle mileage as in statistics on fuel consumption.

In 2018 a revised version of the survey "monthly fuel, gas and inventory statistics" was introduced, but uncertainties regarding the quality of the statistics were identified and the data from the survey was consequently not used for 2018. As a result, data collected and reported according to the "Swedish fuel quality act", regarding diesel, gasoline and biofuels, is used from 2018 onwards[55]. See section 3.2.12.2 for more information.

See Annex 1 for more details regarding uncertainties for activity data and emissions.

### 3.2.12.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All Tier 1 general inventory level QC procedures and all QC procedures applicable to this sector are used. The activity data has been subject to QA/QC procedures. In addition to this, the consumption of every type of fuel in the last year is checked and compared with previous years. If large variations are discovered for certain fuels, responsible staff is contacted for an explanation. IEFs are calculated per fuel, substance and NFR-code and checked against the emission factors to make sure that no calculation errors have occurred when emissions were computed.

### 3.2.12.5 SOURCE-SPECIFIC RECALCULATIONS

#### *3.2.12.5.1 Updates in the HBEFA road emission model*

For submission 2025, the following updates have been made to the HBEFA road model:

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[55] https://www.energimyndigheten.se/en/sustainability/sustainable-fuels/fuel-quality-act/

- The method for allocating passenger car traffic activity (vehicle-km) across vehicle technologies (gasoline, diesel, flex-fuel gasoline/E85, natural gas, electric and plug-in gasoline/diesel hybrid) was updated. Total traffic activity for passenger cars remains unchanged. This affects HBEFA-calculated emissions and energy use for 2000-2022 for passenger cars. The resulting change in energy use for passenger cars ranges between a 5% decrease and a 3% increase for gasoline, an 8% decrease and a 5% increase for diesel, and a 1% to 44% increase for natural gas/biogas. These changes influenced all the emissions from passenger cars, which can be seen below. The allocation of traffic activity as a function of vehicle age has been updated for gasoline and diesel passenger cars and LCVs. The update affects HBEFA-calculated emissions and energy use for 2016-2022. The resulting change in energy use from passenger cars and LCVs ranges from a 0.7-1.7% increase for gasoline and a 0.1-0.2% increase for diesel. All pollutants are affected by this change, which can be seen below, but the largest changes are in HC, CO and NMVOC emissions.

- The combined change in emissions from the previously listed recalculations are (in share of total emissions in road transport):
    - NOX: -1.1%-2.5%
    - NH3: -1.1%-2.7%
    - NMVOC: -1.3%-10.6%
    - PM2.5: -1.5%-1.7%
    - BC: -1.8%-1.7%
    - CO: -1.1%-8.8%

#### *3.2.12.5.2 Updates outside of the HBEFA road emissions model*

- The method for calculating emissions of dioxins and furans has changed in submission 2025. Previously, an emission factor based on fuel consumption was used. The new method uses emission factors based on mileage and also takes Euro class and vehicle type into account. The mileage by Euro class and vehicle type is acquired from the road emission model HBEFA. This change has had a substantial effect on the calculated emissions of dioxins and furans throughout the time series (See fig 3.10 below).
- The net calorific value for biogasoline has been updated for 2020-2022. Before the update, the value was 31.71 GJ/m$^3$ for all years, but after the update the value is 32.15, 31.57, 31.71 and 31.96 respectively, for the years 2020, 2021, 2022 and 2023.
- FAME and HVO as well as ethanol and biogasoline were previously aggregated in the emission calculations. From submission 2025 they are handled as separate fuel types.
- Changes in the model for working machinery has resulted in a larger allocation of diesel and to some extent gasoline, to road traffic.

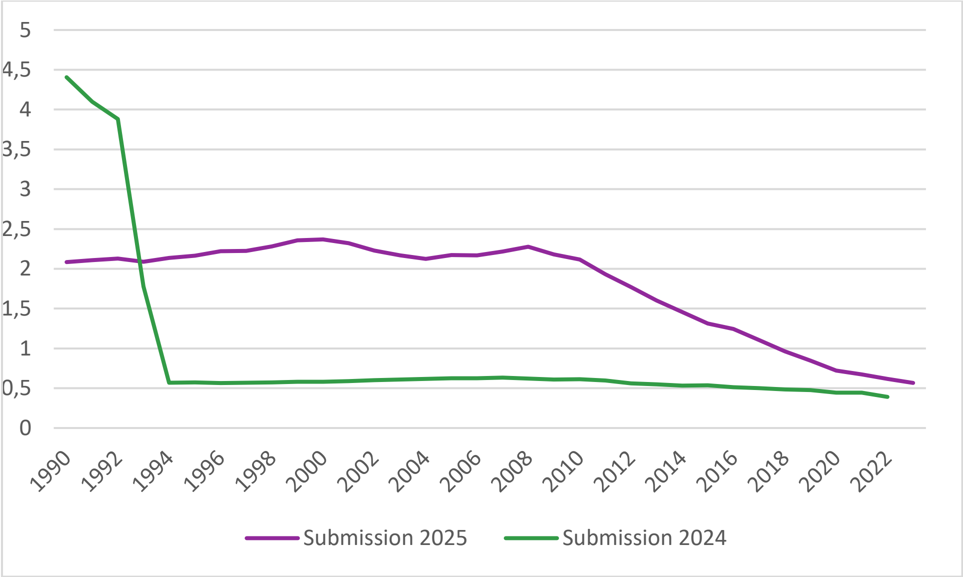

**Fig 3.10 Dioxins and furans from road traffic in submission 2024 and submission 2025, measured in grams I-TEQ.**

#### 3.2.12.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 3.2.13 Automobile tyre and brake wear, NFR1A3b vi, and automobile road abrasion, NFR1A3b vii

#### 3.2.13.1 SOURCE CATEGORY DESCRIPTION

Emissions from road traffic originate not only from exhaust gases but also from the wear on road, tyres, and brakes. Some particles are emitted directly into the air while others are dispersed from the road surface.

A summary of the latest key source analysis is presented in Table 3-19.

**Table 3-19. Summary of key source analysis, NFR1A3b vi-vii, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1A3b vi | Automobile tyre and brake wear– *Cd, Cu, PM10, PM2.5, Pb, TSP, Zn* | Automobile tyre and brake wear– *Cu, PM10, PM2.5, TSP, Zn* |
| 1A3b vii | Automobile road abrasion – *TSP, PM10, PM2.5* | Automobile road abrasion – *TSP, PM10, PM2.5* |

#### 3.2.13.2 METHODOLOGICAL ISSUES

Emissions of non-exhaust particles from road traffic have up to submission 2025 been estimated with emission factors based on the Swedish Meteorological and

Hydrological Institute (SMHI)'s air quality system SIMAIR[56]. In 2023, Sweden started working on a model to improve estimations of separated emissions from tyre wear, brake wear, road abrasion or resuspended particles.

From submission 2025, the NORTRIP model[57] is used to estimate emissions from non-exhaust particles. The model has been developed through a series of Nordic collaborative projects to provide a more detailed description of non-exhaust emissions that better suit the Nordic road conditions. The model can also calculate emissions of PM2.5 and PM10 from direct emissions of particles produced by tyre wear, road wear and brake wear separately, as well as suspension of particles, which originate from retention on the roads under wet conditions, by traffic and from wind-blown processes.

In the model, retention of particles to the road surface is only calculated on the creation process of the particle. Retended particles on the road surface may be washed away by rain, removed from the road by snow plowing, or road sweeping, suspended to the air. Once retained particles are suspended to the air, they are removed from the model and can no longer be retained to the road surface and resuspended. No other particles than those created from wear processes on the car or road surface are ever retained on the road surface in these calculations. This capability is required for national reporting of emissions to the EU according to the EMEP/EEA air pollutant emission inventory guidebook. Figure 3-10 shows a schematic outline of the NORTRIP emission model.

Meteorological data is one of the required inputs to the NORTRIP model. In the Swedish calculations, meteorological data from Copernicus European Regional Reanalysis system [58](CERRA) is used for the years 1990 - 2014, and Mesoscale Analysis (MESAN)[59] for the years 2015 - 2023. Global radiation, which is required input to NORTRIP, is not included in MESAN and is included from CERRA even for years after 2015 when available and from the STRÅNG model[60] for the rest of the years.

Road network data including information on mileage from the Swedish Transport Administration is used in the Swedish calculations. For the period 1990 to 2016, the physical description and layout of the road network is based on the Swedish Transport Administration's road network from 2015. From 2017 to 2019, the road network from 2018 is employed, and from 2019 to 2023, the network from 2021 is utilized. All the major types of roads are included in all the representations of the road network used. The traffic on major roads is modelled by the

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[56] https://www.smhi.se/tema/simair

[57] Denby et al., 2012

[58] https://climate.copernicus.eu/copernicus-regional-reanalysis-europe-cerra

[59] (Häggmark et al., 1999)

[60] https://strang.smhi.se/

SAMPERS[61]/EMME[62] traffic model. The traffic model assimilates traffic flow measurements gathered by the Transport Administration during a 7–10-year period preceding the simulation in order to simulate a base year in the period. Base year traffic is then scaled by factors calculated separately for light and heavy vehicles as well as several classifications of roads according to statistics from traffic counts gathered during that particular year. For minor roads, traffic volumes are calculated by the SAMPERS demand model. The model is based on estimated transportation needs in various geographical areas and are allocated to the smallest roads through a simple scheme according to the classification of the roads for which traffic flows are not yet modelled by EMME in the area.

The mass balance for the retained particles, snow and water on the road is calculated. An important model assumption is that the retained particles on the road can be suspended once and only once into the atmosphere under favourable conditions. An important factor influencing the magnitude of both retention and suspension of the particles is the road moisture content. Moisture is calculated in the model using available meteorological data sampled from the meteorological reanalysis at one pair of coordinates for each municipality.

Another important model assumption is that there is no deposition of previously suspended particles back onto the road, such that the deposition term in the mass balance equation in the model is set to zero.

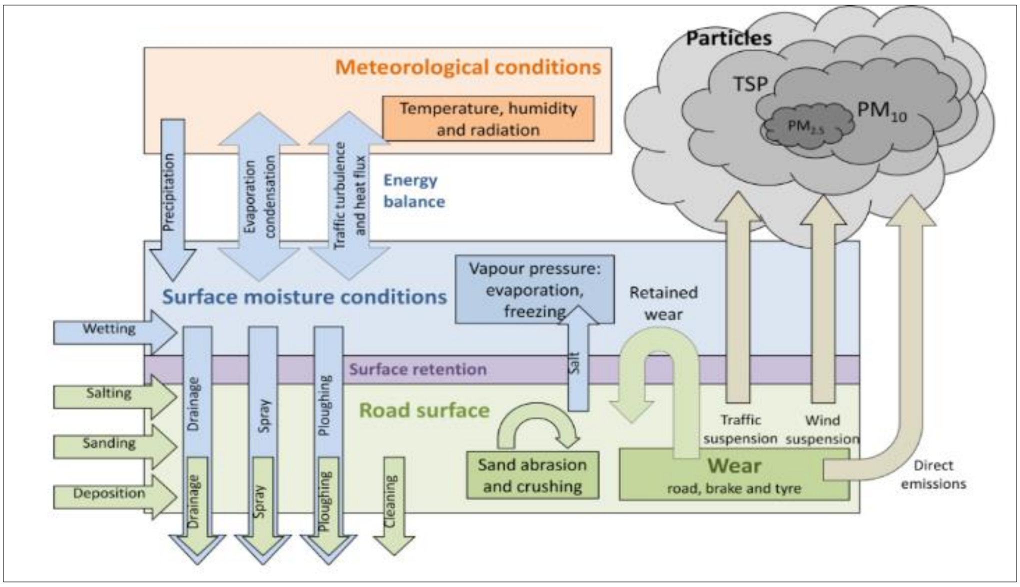

**Figure 3-11. Schematic outline of the NORTRIP emission model (Denby et al., 2012).**

The NORTRIP model calculates emissions for a road hour by hour over a full year. To run Nortrip on each road in the road network would require a very large number of calculations, and extensive calculations would then be performed on numerous

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[61] https://bransch.trafikverket.se/tjanster/system-och-verktyg/Prognos--och-analysverktyg/Sampers/

[62] https://bransch.trafikverket.se/tjanster/system-och-verktyg/Prognos--och-analysverktyg/Emme/

roads with low traffic in the national road database even though those roads individually do not affect the total emissions to a large extent.

In order to achieve higher efficiency in emission calculations for the whole road network, Segersson and Bennet (2023) have developed a Swedish methodology to minimize the number of roads needed to be calculated and emission factors calculated for a road can be applied on many other roads that share the same or similar characteristics.

The calculations are divided into municipalities. For each municipality, meteorological data is extracted at the coordinates of its city hall and the same meteorological data is used for all the calculations done within the same municipality.

A combination of road parameters is used to generate a list of possible roads within each municipality. These road parameters describe various road characteristics and thus affect wear emissions and calculated emission factors. In case of a need for re-analysis, a routine has been established allowing the possibility to generate the same set of road parameters and increasing traceability. Calculations of emission factors are only performed on the list of possible roads for every municipality, and emission factors are saved accordingly.

Key road parameters include:

- Traffic variations
- Posted speed limit
- Road category
- Congestion profile (tyre changing periods, type of pavement material and driving cycle)
- Proportion of heavy traffic
- Proportion of studded tyres
- Annual average daily traffic (AADT) in intervals of 1000 vehicles.

Studies have shown that calculated emissions deviate slightly from direct proportionality to annual average daily traffic (AADT) due to the impact of traffic which dries the road surface. Therefore, in the parameter setup for the calculations, the AADT is divided into bins of 1000 vehicles per day. Within this range, emissions are nearly proportional to traffic flow and the emissions for each road are proportionally scaled with the emission factor estimated using that value. Test calculations have shown this simplification to have an impact less than one percent on the calculated emissions from road wear.

In order to use correctly applied pre-calculated emission factors in the total emission calculations, a mapping is created between the list of possible roads and all the roads in the road network in each municipality.

For every road link, emissions are calculated through:

$$Emission_{\substack{road\\link}} = Emission\ Factor_{\substack{a\ possible\ road\\with\ similar\\characteristics}} \times \frac{AADT_{\substack{road\\link}} \times Length_{\substack{road\\link}}}{AADT_{\substack{a\ possible\\road\ with\ similar\\characteristics}}}$$

Yearly national total emissions are calculated through summation of all the emissions calculated for all the road links in the road network:

$$Total\ emission = \sum Emission_{\substack{road \\ link}}$$

### 3.2.13.2.1 *Particle emissions from Tyre and brake wear and road abrasion, NFR1A3b vi and 1A3bvii*

Emission factors for PM10 for the years 2008-2014 have been calculated using the national model, for previous years and following years, averages of 2008-2014 have been used. TSP and PM2.5 emissions have been estimated based on the PM10 emission factor according to the EMEP/EEA Guidebook 2013 and other literature. As the modelled PM10 emissions include both tyre and brake wear and road abrasion, the emission sources have been separated by assuming a constant emission factor for tyre and brake wear of 10 mg vkm−1, according to literature values[63]. The PM2.5 emission factor is calculated as 0.2 times the PM10 emission factor. This factor is based on measurements from a Swedish street. The TSP emission factor is calculated using the relationship between TSP and PM10 presented in the EMEP/EEA Guidebook 2013 (0.76 for tyre and brake wear and 0.5 for road abrasion).

### 3.2.13.2.2 *PAH emissions from Tyre and brake wear, NFR1A3b vi*

The emission factors used for the calculations of PAH emissions from tyre wear and brake wear are as presented in the EMEP/EEA air pollutant emission inventory guidebook (detailed methodology). The emission factors used for the PAH calculations are presented in Table 3-20.

**Table 3-20. Emission factors used for PAH emission calculations in 1A3b vi.**

| | **Emission factors, TYRE WEAR (ppm wt.)** | | | | **Emission factors, BRAKE WEAR (ppm wt.)** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Benzo(a) pyrene** | **Benzo(b) fluoranthene** | **Benzo(k) fluoranthene** | **Indeno (1,2,3-cd) pyrene** | **Benzo(a) pyrene** | **Benzo(b) fluoranthene** | **Benzo(k) fluoranthene** | **Indeno (1,2,3-cd) pyrene** |
| All vehicle categories | 3.9 | - | - | - | 0.74 | 0.42 | 0.62 | - |

### 3.2.13.2.3 *Metal emissions from Tyre and brake wear, NFR1A3b vi*

In a report from 2006[64], the mean metal concentrations in retread and non-retread tyre tread rubber are presented. As almost all tyres used on heavy duty vehicles are retread tyre tread rubber[64] and emissions calculated for heavy duty vehicles are

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[63] Omstedt, G., Bringfelt, B. and Johansson, C., 2005: A model for vehicle-induced non-tailpipe emissions of particles along Swedish roads, Atmospheric Environment, 39, 6088–6097

[64] Hjortenkrans et al. 2006. Metallemission från trafiken i Stockholm – Däck. (in Swedish, results from a study on metal emissions from tyre wear)

based on an emission factor representing retread tyre tread rubber. For all other vehicle categories, the calculations are based on emission factors for non retread tyre tread rubber (Table 3-21).

**Table 3-21. Emission factors used for metal emission calculations from tyre wear in 1A3b vi.**

| | Emission factors, TYRE WEAR, (mg/kg) | | | | | |
|---|---|---|---|---|---|---|
| **Vehicle category** | **Pb** | **Cd** | **Cr** | **Cu** | **Ni** | **Zn** |
| Passenger cars | 9.4 | 1.1 | 1.7 | 8.6 | 3.2 | 9 400 |
| Light duty vehicles | 9.4 | 1.1 | 1.7 | 8.6 | 3.2 | 9 400 |
| Heavy duty vehicles* | 9.5 | 0.86 | 1.3 | 7.4 | 2.9 | 12 000 |
| Mopeds & Motorcycles | 9.4 | 1.1 | 1.7 | 8.6 | 3.2 | 9 400 |

* retread tyres

In the same report, the [65] the metal content in both branded brake linings and those from independent suppliers was also examined. A similar study was made in the late 1990s[66] and the results show that there is a clear reduction of the Pb and Zn content in both branded linings and linings from independent suppliers in the later study from 2006. Also for Cu the metal content in linings from independent suppliers from 2005[67] is much lower than in 1998[68]. For branded linings the results is the contrary, the Cu content in linings from 2005 is higher compared to linings from 1998. For the brake linings metal emission calculations the same assumption as both Hjortenkrans[67] and Westerlund[68] is made; 40% of the traffic volume is related to new vehicles using branded linings and 60% to older vehicles using linings from independent suppliers. For Pb, Cu and Zn the emission factors used are based on results presented by Westerlund[68] for the years 1980 - 1998, and on results presented by Hjortenkrans[67] for 2005 and onwards. The emission factors for 1999 - 2004 are interpolated. For Cd the same emission factor is set for the whole time series[65].

The emission factors used for calculating metal emissions from tyre wear and brake wear are presented in Table 3-22.

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[65] Hjortenkrans et al. 2006. Metallemission från trafiken i Stockholm – Bromsbelägg. (in Swedish, results from a study on metal emissions from brake linings)

[66] Westerlund, K.-G. 2001. Metal Emissions from Stockholm Traffics Wear of Brake Linings; Reports from SLB-analys, 2:2001; Environment and Health Protection Administration in Stockholm: Stockholm. 2001.

[67] Hjortenkrans et al. 2006. Metallemission från trafiken i Stockholm – Bromsbelägg. (in Swedish, results from a study on metal emissions from brake linings)

[68] Westerlund, K.-G. 2001. Metal Emissions from Stockholm Traffics Wear of Brake Linings; Reports from SLB-analys, 2:2001; Environment and Health Protection Administration in Stockholm: Stockholm. 2001.

**Table 3-22. Emission factors used for metal emission calculations from brake wear in 1A3b vi.**

| Vehicle category | Emission factors, BRAKE WEAR, branded (ppm wt.) | | | | Emission factors, BRAKE WEAR, independent (ppm wt.) | | | |
|---|---|---|---|---|---|---|---|---|
| | Pb | Cd | Cu | Zn | Pb | Cd | Cu | Zn |
| 1980 - 1998 | 13854 | 2.6 | 105070 | 20164 | 11381 | 0.445 | 61615 | 12447 |
| 1999 | 12090 | 2.6 | 108631 | 21855 | 9783 | 0.445 | 52835 | 11340 |
| 2000 | 10327 | 2.6 | 112193 | 23546 | 8185 | 0.445 | 44055 | 10233 |
| 2001 | 8563 | 2.6 | 115754 | 25237 | 6587 | 0.445 | 35275 | 9127 |
| 2002 | 6800 | 2.6 | 119316 | 26927 | 4989 | 0.445 | 26495 | 8020 |
| 2003 | 5037 | 2.6 | 122877 | 28618 | 3391 | 0.445 | 17715 | 6913 |
| 2004 | 3273 | 2.6 | 126439 | 30309 | 1793 | 0.445 | 8935 | 5807 |
| 2005 - | 1510 | 2.6 | 130000 | 32000 | 195 | 0.445 | 155 | 4700 |

### 3.2.13.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

For road traffic data, there is a lack of older road network data prior to 2015, which introduces uncertainties in traffic for earlier emission years. For these years, only a broad-scale downsizing of traffic has been performed, providing accurate total emissions across road types and vehicle classes but with greater uncertainties at a finer regional scale. Before 2005, there are also significant uncertainties regarding the use of studded tyres at a regional level in Sweden, as data available for this period is very limited. Estimates have been made based on the best possible assessment of historical trends.

The updated methodology to modelling by NORTRIP calculations are completely new. NORTRIP has been shown together with dispersion modelling in street canyon to capture the yearly mean of measurement result from station measuring PM10 from all 18 dataset of 7 stations within 35% (Denby et al. 2012). Stojiljkovic et al. (2019) showed larger difference on one occasion. In both studies both measurements and dispersion modelling are involved in the comparison which makes it hard to distinguish the uncertainties in each part. In a pre-study to the changed methodology by Segersson and Bennet (2023), 5 places with both street canyon and urban background stations were studied. There, the background values were significant enough that the local street contribution was not possible to isolate in order to validate the emission calculation.

NORTRIP has a wide range of parameters which are more or less certain and have large impact on the results. Some of them are activity data for the simulation while others are principally constants that will be gradually improved by validation studies in laboratory as well as in field. While input parameters are not the same but rather improved since the Denby et al. (2012) study, the model itself is thought to be better than 35% in individual runs, provided good quality input data.

The traffic intensity over all roads is also modelled with assimilation of all traffic counts performed by the Swedish transport administration during several years. Those may be uncertain at individual roads without traffic counts and is believed to be the activity data with the largest contribution to the overall uncertainty.

Simplifications done by calculating all roads in one municipality in one spot and some less important data such as surrounding buildings simplified was investigated by comparisons on some roads and found to give rise to far smaller errors than the uncertainties in the emission and traffic intensity modeling.

#### 3.2.13.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Evaluation of the simplified methodology has been done on four selected municipalities.

Three simplifications of type roads, where the type roads deviate from the methodology in the pre-study, have been made as follows:

1. The meteorology is from a selected coordinate in each municipality.
2. The share of heavy traffic is rounded off to two decimal places.
3. the AADT differs up to 500 from the real value and emissions are then scaled proportionally with the AADT from the type road.

To evaluate the impact of the above simplifications on the results, we have made four test runs each in each in four selected Swedish municipalities: Falköping, Kiruna, Lund and Norrköping. These four test runs (a-d) have been made with the assumptions:

a) Without simplified methodology. With an AADT interval of 10 vehicles/day[69] and without rounding of the share of heavy traffic.

b) Simplification in AADT (3 above). The relative emission difference between test run a and b in percent is shown in Table 3-23 under column ‘simpl. AADT’.

c) Simplification in Heavy Traffic (2 above). The relative emission difference between test run a and c in percent is shown in Table 3-23 under column ‘simpl. heavy traffic’.

d) Both simplifications (2 and 3 above). The relative emission difference between test runs a and d in percent is shown in Table 3-23 under column ‘both simpl.’.

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[69] For technical reasons bins of 10 was chosen instead of exact numbers, but the remaining error of such small bins is thought to be much smaller that the used bin size 1000.

**Table 3-23: Emission difference of PM2.5 and PM10 (% difference) caused by different methodology simplifications in Falköping, Kiruna, Lund and Norrköping.**

| **Falköping** | **PM2.5** | | | **PM10** | | |
|---|---|---|---|---|---|---|
| | simpl. AADT | simpl. heavy traffic | both simpl. | simpl. AADT | simpl. heavy traffic | both simpl. |
| Total non-exhaust | +0.37 | +0.12 | +0.48 | +0.50 | +0.07 | +0.59 |
| Tyre and brake wear | +0.24 | +0.16 | +0.40 | +0.30 | +0.15 | +0.45 |
| Tyre wear | +0.32 | +0.00 | +0.32 | +0.32 | +0.00 | +0.32 |
| Brake wear | +0.23 | +0.14 | +0.37 | +0.29 | +0.00 | +0.29 |
| Road wear | +0.54 | +0.05 | +0.59 | +0.57 | +0.05 | +0.62 |

| **Kiruna** | **PM2.5** | | | **PM10** | | |
|---|---|---|---|---|---|---|
| | simpl. AADT | simpl. heavy traffic | both simpl. | simpl. AADT | simpl. heavy traffic | both simpl. |
| Total non-exhaust | +0.34 | +0.00 | +0.34 | +0.56 | +0.00 | +0.56 |
| Tyre and brake wear | +0.15 | +0.00 | +0.15 | +0.00 | +0.00 | +0.00 |
| Tyre wear | +0.00 | +0.00 | +0.00 | +0.00 | +0.00 | +0.00 |
| Brake wear | +0.16 | +0.00 | +0.16 | +0.00 | +0.00 | +0.34 |
| Road wear | +0.69 | +0.00 | +0.62 | +0.66 | +0.00 | +0.66 |

| **Lund** | **PM2.5** | | | **PM10** | | |
|---|---|---|---|---|---|---|
| | simpl. AADT | simpl. heavy traffic | both simpl. | simpl. AADT | simpl. heavy traffic | both simpl. |
| Total non-exhaust | -0.10 | -0.01 | -0.12 | -0.16 | -0.01 | -0.17 |
| Tyre and brake wear | -0.02 | -0.02 | -0.05 | -0.08 | -0.00 | -0.08 |
| Tyre wear | -0.15 | -0.00 | -0.15 | -0.15 | -0.00 | -0.15 |
| Brake wear | -0.03 | -0.03 | -0.03 | -0.00 | -0.00 | -0.00 |
| Road wear | -0.19 | -0.00 | -0.19 | -0.18 | -0.00 | -0.19 |

| **Norrköping** | **PM2.5** | | | **PM10** | | |
|---|---|---|---|---|---|---|
| | simpl. AADT | simpl. heavy traffic | both simpl. | simpl. AADT | simpl. heavy traffic | both simpl. |
| Total non-exhaust | +0.05 | -0.00 | +0.05 | +0.08 | -0.01 | +0.07 |
| Tyre and brake wear | +0.01 | +0.01 | +0.02 | +0.04 | +0.00 | +0.04 |
| Tyre wear | +0.00 | -0.00 | +0.00 | +0.00 | -0.00 | +0.00 |
| Brake wear | +0.01 | +0.01 | +0.03 | +0.00 | +0.00 | +0.00 |
| Road wear | +0.09 | -0.01 | +0.08 | +0.09 | -0.01 | +0.08 |

The municipalities are selected to be geographically dispersed and are of different sizes. Kiruna is the largest municipality in Sweden in the north. Falköping has less through traffic and smaller typical roads, while Lund is slightly larger and has more typical roads. Norrköping has a larger share of heavy traffic and more through traffic. The results for the test runs are shown in Table 3-23. Emission differences between the different test runs are negligible compared to emissions from the test run without simplified methodology and show that these simplifications are good to use for the whole country.

It is evident from the recalculated results that the inter-annual variation is larger than in previous submissions. To find an explanation for this a test was made where one year with exceptionally high emissions, 2015, was recalculated with the meteorological time series of all parameters shifted back two years from 2017 while all other input was the original 2015. The study showed that all three sources (tyre, break and road wear) were decreasing in the southern part of the country where most population and traffic is concentrated with the alternative meteorology, making the total emissions for the whole country rather similar to the emissions calculated for 2017 summarized in Table 3-24. This is a strong indication that the major explanation for the inter-annual variation is the meteorological conditions during the year.

**Table 3-24: Comparisons between the total emissions for the country between the years 2015, 2017 and the test calculation of 2015 using meteorology from 2017.**

| | PM10 [ton/year] | PM2.5 [ton/year] | PM10 [ton/year] | PM2.5 [ton/year] |
|---|---|---|---|---|
| Year | Road wear | Road wear | Tyre & brakewear | Tyre & brakewear |
| 2015 | 14,333.00 | 1,147.00 | 1,402.00 | 337.00 |
| 2015 with 2017 meteorology | 12,943.48 | 1,035.48 | 1,316.87 | 324.30 |
| 2017 | 12,779.00 | 1,022.00 | 1,370.00 | 337.00 |

#### 3.2.13.5 SOURCE-SPECIFIC RECALCULATIONS

Emissions from automobile road abrasion, tyre and brake wear were recalculated for all years, using new methodology in submission 2025. The recalculation is done using the NORTRIP emission model. This recalculation has had a profound impact on all emissions associated with road abrasion and tyre and brake wear and can not easily be described here in detail. Generally, emissions of all PM categories from road abrasion are lower after the recalculation. The emissions of metals from tyre and brake wear have increased most years with the noteworthy exceptions of cupper and lead, which have both decreased. The emissions of PM and BC from tyre & brake wear has also increased after the recalculation.

#### 3.2.13.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 3.2.14 Railways, NFR1A3c

#### 3.2.14.1 SOURCE CATEGORY DESCRIPTION

The majority of all railway traffic in Sweden runs on electricity. Only a small part runs on diesel fuel and the emissions related to the use of electricity for railway should not be included in this sector. Production of electricity is accounted for in NFR1A1A, regardless of where it’s consumed. The energy use by railways is very small compared to the total transport sector. A summary of the latest key source analysis is presented in Table 3-25.

**Table 3-25. Summary of key source analysis, NFR1A3c according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1A3c | Liquid Fuels – $NO_x$ | Liquid Fuels – *NOx* |

### 3.2.14.2 METHODOLOGICAL ISSUES

Both Tier 1 and Tier 2 methods are used to estimate emissions from diesel. The Swedish Transport Administration (STA) estimates the emissions of $SO_2$, $NO_X$, NMVOC and CO from railways, which are based on the consumption of diesel by railways[70] and default as well as country specific emission factors. The emission factors are described below.

The estimated diesel consumption is based on a survey carried out by the Swedish Transport Administration on behalf of the Swedish Energy Agency. The survey is a total survey and based on approximately 30 respondents for passenger traffic and rail infrastructure.

Emissions of $SO_2$ are based on country-specific thermal values and the actual sulphur content for diesel fuel. The threshold limits for CO, NMVOC and $NO_x$ are used as emission factors for all emissions from engines that comply with the EU emission standards Stage IIIA and Stage IIIB.71 For engines introduced before the implementation of EU emissions standards, the emission factors from EMEP/EEA guidebook 2019 are used to estimate emissions of CO, NMVOC and $NO_x$.

The conversion of g/kWh to g/litre is based on the fuel consumption factors in Table 3-5 in the EMEP/EEA Guidebook 2019 and a diesel density of 816 g / litre. The same density is used for all years.

The emissions of $NH_3$ and particles are estimated with tier 1 emission factors from EMEP/EEA Guidebook 2019.

### 3.2.14.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The emissions for NFR1A3c are associated with low uncertainties. The estimate of diesel consumption based on the survey is considered to be of very high quality.

Uncertainties for activity data and emissions can be seen in Annex 1 to the IIR

### 3.2.14.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All Tier 1 general inventory level QC procedures and all QC procedures applicable to this sector are used. The activity data has been subject to QA/QC procedures.

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[70] Energimyndigheten 2021b. Swedish Official Statistics Notifications EN0118 SM 1701.

[71] Dieselnet 2021. http://www.dieselnet.com/standards/eu/nonroad.php#rail

#### 3.2.14.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculation occurred in this sector in submission 2025.

#### 3.2.14.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 3.2.15 Navigation, NFR1A3d ii

#### 3.2.15.1 SOURCE CATEGORY DESCRIPTION

Domestic navigation is defined as emissions from liquid fuels purchased and used in Sweden by commercial ships and leisure boats and the emissions from LNG used by commercial ships between Swedish ports. The energy consumption by domestic navigation including leisure boats increased by 0.2% between 2022 and 2023 and has increased by 59% since 1990.

An amendment to Directive 2012/33/EU[72] introduced a mandatory sulphur content of no more than 0.10% in fuels used by navigation in sulphur control areas (SECA) from the 1'st of January 2015[,73]. In 2012 a decrease of the consumption of heavy fuel oils with a high level of sulphur could be noticed. However, with the introduction of hybrid fuels on the market, i.e. heavy fuel oils with a reduced sulphur content, the consumption of residual fuel oils didn't continue to decrease as anticipated.

The Baltic Sea is a NECA zone where ships above 500 GT with a certain engine output and built after the 1st of January 2021 need to comply with IMO Tier III $NO_X$ emission standards. As more Tier III compliant ships navigate Swedish waters, the emission factor for $NO_X$ has been gradually reduced in recent years. This is the reason why Sweden's $NO_X$ IEF is low in an international context.

From 2018, a shift from residual fuel oils to LNG (liquid natural gas) can be noticed (see Figure 3-12). The consumption of LNG started already in 2016, but in 2016-2017, the consumption of LNG could not be separated from the consumption of heavy fuel oil due to the lack of detailed data.

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[72] Directive 2012/33/EU of the European Parliament and of the Council of 21 November 2012 amending Council Directive 1999/32/EC as regards the Sulphur content of marine fuels.

[73] Directive 2016/802 of the European council of 11th of May 2016. https://eur-lex.europa.eu/eli/dir/2016/802

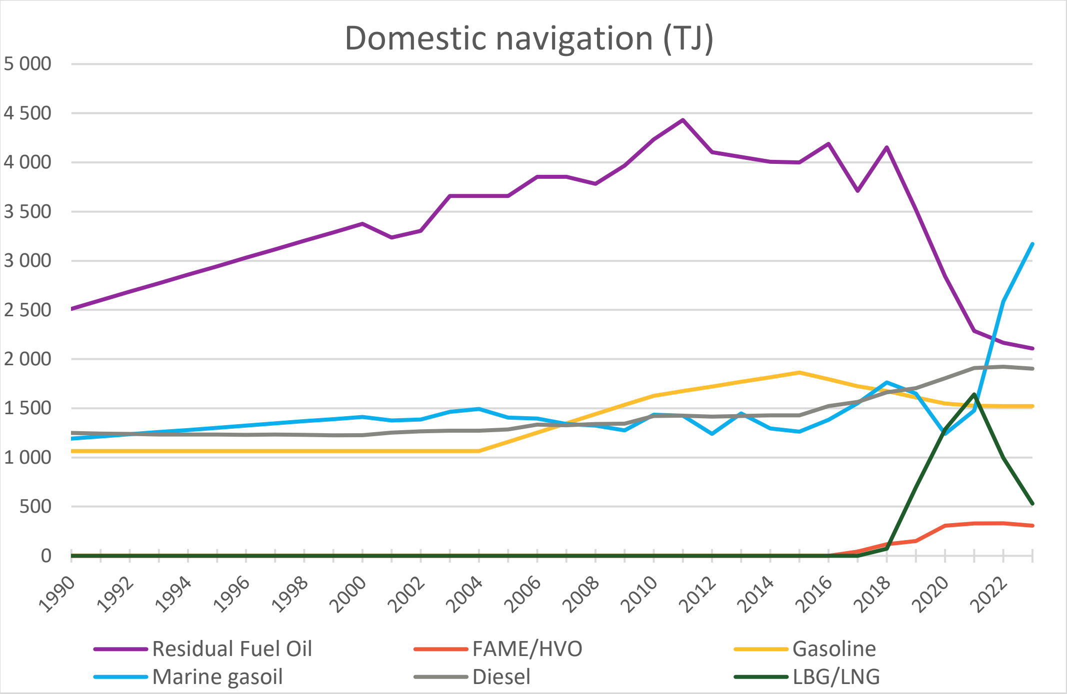

**Figure 3-12. Fuel consumption by domestic navigation and fuel type (including leisure boats) 1990-2023 (TJ).**

A summary of the latest key source analysis is presented in Table 3-26.

**Table 3-26. Summary of key source analysis, NFR1A3d ii, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | **Level** | **Trend** |
| 1A3d ii | Gas/diesel oil – *CO, Cu, NMVOC, NOx, Ni, PM10, PM2.5, SO2, TSP* | Gas/diesel oil – *NOx, SO2* |
| | LNG – | LNG – |
| | Residual oil – *As, NOx, Ni, PM10, PM2.5, SO2* | Residual oil – *As, NOx, Ni, PM10, PM2.5, SO2, TSP* |

### 3.2.15.2 METHODOLOGICAL ISSUES

This source category covers domestic navigation and leisure boats. Domestic navigation is defined as emissions from gasoline, diesel oil, FAME, HVO, marine gasoil and residual fuel oil purchased and used in Sweden and LNG used by commercial ships in Sweden. Emissions from fuels that are purchased in Sweden but used between a Swedish port and the first foreign port are reported separately as international bunker emissions. The allocation of emissions from navigation is summarized in Table 3-27.

**Table 3-27. Reporting of emissions from navigation, according to the Good Practice Guidance.**

| Fuel bought in | Traffic between Swedish harbours | Traffic between Swedish and international harbours | Traffic between two international harbours |
|---|---|---|---|
| Sweden | Domestic, 1A3d ii | International bunkers, 1A3d i (i) | International bunkers, 1A3d i (i) |
| Other country | Not included | Not included | Not included |

As from submission 2020, the fuel consumption by domestic commercial shipping is based[74] on a methodology called Shipair as well as a maritime survey. Shipair was developed by the Swedish meteorological and hydrological institute (SMHI) and the model collects AIS data (Automatic Identification System) for ships which move between Swedish harbours. AIS data is used by ships to continuously transmit their identity and position information and consequently shows how the ships move between different ports. Information regarding the ships, such as size, engine power and type of vessel is also collected by the model and enables Shipair to estimate the amount of energy used by the ships. Shipair uses the fuel allocation method described in the 4th IMO GHG study[75] to decide what fuel a ship is using. If data is lacking, Shipair, assumes that ships with a gross tonnage larger than 6000 in the Shipair database run on residual fuel oil.

Beside the Shipair model, the energy consumption from domestic navigation is based on a survey[76] of the largest shipping actors in domestic navigation, except for cargo ships[77]. The survey collects information regarding the fuel consumption by fuel type.

The consumption of FAME and HVO by navigation was added for 2017-2020 in submission 2022. This consumption was included in fossil diesel in previous submissions.

The consumption of LNG (liquid natural gas) by navigation was first included in submission 2021 for the year 2019. The data is based on a survey which aims to map the consumption of LNG by both national and international navigation[78]. The emission factors for LNG are based on a study from 2020.[79]

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[74] Excluding leisure boats.

[75] https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Fourth%20IMO%20GHG%20Study%202020%20-%20Full%20report%20and%20annexes.pdf

[76] Energimyndigheten 2021c. EN0118, Transportsektorns energianvändning. Energianvändning inrikes sjöfart 2021

[77] The difference between the energy consumption estimated by Shipair and from the survey is assumed to be the energy consumption by cargo ships.

[78] Eklund, et al. 2020. Sjöfartens förbrukning av LNG.

[79] Hult, C. et al. 2020. Emission factors for methane engines on vehicles and ships

The Swedish Maritime Administration (SMA) provided the emission factors for NOx, CO, NMVOC and $SO_2$ in 2005-2015. As from 2016, this is the responsibility of the Swedish Transport Agency (STA) in accordance with the Swedish climate legislation.

The emissions of $NO_x$, CO, NMVOC, $SO_2$, metals, particles and PAH are estimated according to Tier 2 as the emission factors take into account the distribution of engine types and fuel types. The emission factors for $NO_x$, $NH_3$, PM, BC, $SO_2$ (diesel only) and CO (diesel and marine gasoil only) were updated in submission 2022, in accordance with a SMED study from 2021[80]. In submission 2023 the emission factor for $SO_2$ from gasoline and diesel was harmonised with the values reported annually in accordance with the EU fuel quality directive for all shipping including leisure boats. Emission factors for metals from residual fuel oil were updated by the Swedish Environmental Research Institute (IVL) in submission 2018.

Emission factors take into account the use of abatement measures in Swedish domestic navigation, most notably selective catalytic reduction to reduce $NO_x$ emission[81]. The emission model for shipping is based on emission factors split by fuel type, engine type and use of abatement equipment. The engine types are slow speed diesel engine, medium speed diesel engine, high speed diesel engine, steam turbine and gas turbine as well as dual fuel engines for LNG. Thus, the emission factors used vary between the different engine/fuel combinations and also with engine age (especially for $NO_x$ with the different Tiers). In addition, the use of abatement measures is considered, such as SCR for $NO_x$ and scrubbers giving a further complexity in the emission factor matrix. Further, the split on engine types and age, fuel types and use of abatement equipment for the relevant ships (national and international) is then obtained from data on ships entering Swedish ports. These factors are all considered to produce the usable emission factors.

There have been four surveys of recreational boats since 1990; in 2004, 2010, 2015 and 2020[82]. The surveys have been reviewed and the fuel consumption estimated in four different studies[83, 84,85,86]. The fuel consumption between the surveys is estimated by interpolation.

Emissions of $SO_2$ from leisure boats are based on the fuel consumption and the same thermal values and emission factors as for civil road traffic regarding both

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[80] Fridell et al., 2021. Revised emission factors for shipping.

[81] Cooper and Gustafsson, 2004.

[82] Transportstyrelsen 2021b. https://www.transportstyrelsen.se/sv/sjofart/Fritidsbatar/Statistik-och-fakta--fritidsbatar/batlivsundersokningen/

[83] Gustafsson, 2005b.

[84] Eklund V. 2014. Justering av småbåtars bränsleförbrukning.

[85] Fridell, E., Mawdsley, I., Wisell T. 2017.

[86] Energimyndigheten, 2021a.

gasoline and diesel. The emissions of CO from leisure boats are based on the estimated fuel consumption and emission factors provided and updated by the Swedish Environmental Research Institute (IVL) in submission 2018[87]. Emission factors for $NO_x$, NMVOC, $NH_3$, particles and BC from both gasoline and diesel leisure boats were updated in submission 2023 based on a study in 2022[88]. The emissions from gasoline leisure boats also depend on the ratio between 2-stroke and 4-stroke engines and the ratio used is based on a study from 2005[89] and 2017[90]. The studies indicate that the share of 4-stroke engines is increasing over time. Based on information from the periodical publication "Fakta om Båtlivet i Sverige", the ratio has been determined for the years 2003, 2009 and 2015 and the ratio for 1990 has been estimated. For the years in between, the ratio has been interpolated, assuming that the change towards 4 stroke engines is gradual. The ratio for 2016 and 2017 is assumed to be the same as for 2015.

Emissions of particles from leisure boats have been estimated with the assumption that leisure boats generate the same amount of emissions per energy unit as for gasoline-run off road vehicles and other machinery for households[91]. For commercial and other ships, particle emissions from MGO are assumed to be below size 2.5 µm.

### 3.2.15.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Before submission 2020, the fuel consumption by domestic navigation was based on the "Monthly fuel, gas and inventory statistics" survey and showed fluctuations for which it has been difficult to find natural explanations.[92] In submission 2020, the methodology for both national and international navigation was revised. The new methodology is based on the Shipair model and a maritime survey and is explained in section 3.2.15.2.

Uncertainties for activity data and emissions reported for domestic navigation in NFR1A3d can be seen in Annex 1 to the IIR.

The first year covered by the Shipair method is 2013. For the years before that, data has been extra- or interpolated with different methodologies. The method depends on what data was available for each shipping company and is either constant, interpolation or a moving average.

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[87] Fridell, E., Mawdsley, I., Wisell T. 2017.

[88] Wisell, T. 2022.

[89] Gustafsson, Tomas. 2005b. Update of gasoline consumption and emissions from leisure boats in Sweden 1990-2003 for international reporting. SMED Report No 73 2005.

[90] Fridell, E., Mawdsley, I., Wisell T. 2017.

[91] Kindbom and Persson. 1999

[92] Statistic Sweden. Monthly fuel, gas and inventory statistics. EN31SM.

#### 3.2.15.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All Tier 1 general inventory level QC procedures and all QC procedures applicable to this sector are used. The activity data has been subject to QA/QC procedures.

#### 3.2.15.5 SOURCE-SPECIFIC RECALCULATIONS

- Data on the consumption of LNG by domestic and international navigation has been collected through a survey to shipping companies in 2020-2024.
- In submission 2025 a large proportion of the shipping companies failed to respond to the survey, lowering the credibility of the result. Consequently, survey data was only used for the years 2018-2020 in submission 2025. A new method has been implemented to estimate the LNG consumption for 2021-2023. The new method uses the energy consumption by LNG ships calculated by Shipair and assumes the same LNG/MGO ratio as for the dual fuel LNG vessels with the highest LNG consumption in domestic navigation. Back testing for previous years has revealed that the results differ by less than 5% from the results in the survey.
- Shipair can’t calculate the energy consumption for international navigation and therefore LNG in international navigation still relies on the survey. For 2021-2022, consumption of the companies that failed to respond was extrapolated with the percentual change of other shipping companies. For 2023, those companies used for extrapolation also failed to respond and the consumption was instead assumed to be the same as for 2022.
- Due to updates of the monthly fuel deliveries, the total amount of marine gasoil and residual fuel oil have decreased somewhat for the year 2022. This change only affects international navigation.

#### 3.2.15.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 3.2.16 Other transportation, NFR1A3e

#### 3.2.16.1 SOURCE CATEGORY DESCRIPTION

Emissions reported under NFR1A3e refer to emissions from combustion of natural gas for pipeline transport (1A3ei), off-road vehicles and other machinery (1A3eii). Examples of working machinery included in this sector are machinery used in ports and airports as well as snow groomer machines used in ski resorts. In any given year, 10-33% of the fuel consumption by working machinery is reported in NFR1A3eii. The consumption of diesel (including low blended biofuel) by working machinery has decreased between 2005 and 2016 and since then. Emissions of $PM_{2.5}$ and $NO_x$ in 2023 have decreased by 93% and 83% compared to 1990. The emissions of NMVOC and CO have decreased by 93% and 89% respectively.

A summary of the latest key source analysis is presented in Table 3-28.

**Table 3-28. Summary of key source analysis, NFR1A3e ii, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1A3e ii | *Diesel oil - NOx* | *Diesel oil – CO, NOx, PM10, PM2.5, TSP* |

### 3.2.16.2 METHODOLOGICAL ISSUES

#### *3.2.16.2.1 Pipeline Transport (1A3ei)*

The annual amount of transported natural gas in pipelines in Sweden is known for the whole reporting period 1990-2023. The amount of combusted natural gas for pipeline transport of natural gas in Sweden is only known for 2013 and for the following years, but not for 1990-2012. According to a national expert at Swedegas, the annual amount of natural gas used for pipeline transport is directly proportional to the total natural gas in the pipelines (about 0.12% in 2013). Based on data for 2013, annual amounts of natural gas for combustion at pipeline transport were estimated for 1990-2012. The increase in the emissions in 2010 is a result of an increase in the import of natural gas due to a cold winter.

Annual national calorific values and national emission factors are applied to estimate the emissions of CO, NMVOC, $NO_x$ and $SO_2$. The emission factors used are the same as used for stationary combustion of natural gas in sector 1A4a[93].

#### *3.2.16.2.2 Mobile combustion (1A3eii)*

A national model is used to estimate emissions from all working machinery used in Sweden and it is considered to correspond to Tier 3 for all emissions, except for $SO_2$ which are estimated according to Tier 2. The model is further explained in Annex 2.[94]

The consumption of gasoline and diesel, estimated by the model for off-road vehicles, is adjusted with regard to low-blended biofuel. The fuel consumption is also modified with a residual of gasoline and diesel. This residual arises as the volume of gasoline and diesel allocated to different sectors through a top-down approach is compared to the total volume of the gasoline and diesel consumed according to a bottom-up estimate. See Annex 2 for more information regarding the allocation of fuels for mobile combustion[95].

### 3.2.16.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

No recalculations have been performed for emissions in the mobile sector for the eighties, and thus there are inconsistencies in time series between the eighties and later years. Time series from mobile combustion in NFR1A3e ii have been reviewed for later years and are considered to be consistent.

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[93] Eklund, V. 2018. Beräkning av NOx, $SO_2$, NMVOC, $NH_3$ och $PM_{2.5}$ från Pipeline Transport.

[94] Annex 2: 1.6 Methodology for off-road vehicles and working machinery

[95] See Annex 2. chapter “1.4 Allocation of fuels for mobile combustion” for more information.”

The fuel and emission estimates of working machinery are based on a model that takes into consideration the emission regulations according to EU legislation in g/kWh, the differences between regulation and value measured at certification, the transient use[96], the emission deterioration with age and the differences between certification fuel and Swedish diesel of type “MK1”. The model does not consider market fluctuations.

Uncertainties for activity data and emissions reported for working machinery in NFR1A3e ii can be seen in Annex 1 to the IIR

#### 3.2.16.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The model for working machinery was implemented the first time in submission 2009. During 2010 the model underwent a second verification. Activity data and emissions factors were reviewed in 2012 and 2013. Time series are checked for consistency and recalculations are verified every year.

#### 3.2.16.5 SOURCE-SPECIFIC RECALCULATIONS

A development project[97] regarding annual machine operating hours was conducted during 2023. The project was conducted based on testing and inspection data from the certified organisation Swedish machine testing. The project involved testing data from year 2019-2023 for common NRMM such as wheel loaders, excavators, dumpers and more. Included in the same project was also a study on operating hours of tractors. The study analysed the registered operating hours between change in ownership. It was concluded that previously used machine hours were overestimated and thus the recalculations resulted in increased emissions throughout the time series.

An example of a notable change that was made in the non-road mobile machinery model was revising the operating hours for machine year 0 (the year a machine is brought into operation). The previous calculations assumed that a machine operates a full year during the calendar year when it is put into operation. The new model settings assume approximately half the operating time for many machine types.

For CO, NOx, $PM_{2.5}$ and NMVOC the recalculations resulted in significant decrease in emissions throughout the time series. The emissions of CO decreased by 2-10%, NOx by 5-10%, $PM_{2.5}$ by 7-14% and NMVOC by 5-14%.

Sweden has not been able to update the amount of gas burnt for pipeline transport for two years. In submission 2025 however, Sweden has received updated data for 2021 and 2022 along with data for 2023.

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[96] The difference between static test cycle and real use of the machine.

[97] Jerksjö, M. Genomsnittlig årlig driftstid för entreprenadmaskiner och traktorer. SMED PM 2024

#### 3.2.16.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 3.2.17 Commercial/institutional, NFR1A4a

#### 3.2.17.1 SOURCE CATEGORY DESCRIPTION

This category includes stationary combustion for heating of premises used for commercial and institutional activities as well as emissions from working machinery used in these activities.

##### *3.2.17.1.1 Stationary combustion*

The activity data for the last emission year (2023), is the same as for 2022, as the annual energy balances are not published at the time when the emission calculations have to be finalized. Since 1990, the total consumption of fuels for heating of premises has decreased significantly due to the increased use of district heating. In the early 1990s, the total annual fuel consumption in this sector was around 35000 TJ, and in 2022 it was around 6 300 TJ. Liquid fuels account for most of the decrease. The share of liquid fuels in 1990 was about 95% and the corresponding share in 2022 was about 21%.

A summary of the latest key source analysis is presented in Table 3-29.

##### *3.2.17.1.2 Mobile combustion*

The mobile emission source included in this sector is combustion by off-road vehicles and other machinery (working machinery), for example gardening machines for professional use, wheel loaders, excavators and tractors that are not used in industry, farming or forestry. The emissions from this sector are reported in 1A4aii.

The fuel consumption from working machinery in 1A4aii represent around 8-14% of the fuel consumption from all working machinery and has increased by 58% since 1990. While the consumption of diesel (including low blended biofuel) has shown an increasing trend up until 2019, the consumption of gasoline (including low blended biofuel) fluctuates in later years.

Emissions of $PM_{2.5}$ and $NO_x$ in 2023 have decreased by 52% and 55% compared to 1990. The emissions of NMVOC and CO have decreased by 58% and 13% respectively.

A summary of the latest key source analysis is presented in Table 3-29.

**Table 3-29. Summary of key source analysis, NFR1A4a, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1A4a | Biomass – *CO, Cd, NOx, PM2.5* | Biomass – *PM2.5* |
| | Gasoline - *CO* | Gasoline - *NMVOC* |
| | Liquid fuels - *NOx, PM2.5* | Liquid fuels - *NOx, Ni, PM10, PM2.5, SO2, Se, TSP* |

### 3.2.17.2 METHODOLOGICAL ISSUES

### *3.2.17.2.1 Stationary combustion*

For stationary combustion within NFR1A4a, all activity data and emission factors are on national level by fuel type and estimated emissions are therefore considered to correspond to Tier 2. The data source for activity data is the annual energy balance, which for this sector is mainly based on premises statistics that is further described in in Annex 2. Since submission 2020, biomass activity data and emission factors are separated into traditional and modern small scale combustion technology for the whole time series[98]. Activity data for the latest emission year is preliminary as the annual energy balances are not published at the time when the emission calculations have to be finalized.

The reported emissions of particulate matter include the condensable fraction of particles.

The activity data and emission factors for $CH_4$, CO and NMVOC from biomass combustion within 1.A.4.a are separated into modern and traditional combustion technology for the whole time series in order to capture the phasing-out of old technology[99]. The revision is described more in detail in Annex 2.

The activity data for the last emission year (2023), is the same as for 2022, as the annual energy balances are not published at the time when the emission calculations have to be finalized.

Since 2002, and in particular since 2004, the consumption of biomass fuels has increased in this sector. This is partly explained by the general shift from liquid to biomass fuels in recent years. However, a study carried out in 2013 had shown that the fuel consumption estimate used in the national energy balance and the emission inventory is more complete than the data reported to Eurostat.

Every year, there are revisions in the annual energy balances for years t-2 and t-3, that is, data published in 2010 contain revisions in fuel consumption in 2007 and

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[98] Helbig, T. Kindbom, K. Jonsson, M. 2019. Uppdatering av nationella emissionsfaktorer för övrig sektor. SMED rapport no 12 2019.

[99] Helbig, T., Kindbom, K. Jonsson, M. 2019. Uppdatering av nationella emissionsfaktorer för övrig sektor. SMED rapport no 12 2019.

2008. These, sometimes large, revisions in the annual energy balances lead to large revisions of GHG inventory data as well as for air pollutants. In submission 2016, activity data and hence also emissions have been revised for 2012 and 2013.

In submission 2010 it was noted that the consumption of biomass, liquid fuels and gaseous fuels within this sector was higher in 2007 than in 2006 and 2008. In submission 2011, the activity data for 2007 and 2008 were revised as described above. The fuel consumption in 2007 is still relatively high. The input data to the energy balances for this sector has not been available for analysis. However, the activity data uncertainty is high in this sector and the time series 1990-2013 shows that inter-annual variations in total fuel consumption can be high.

### *3.2.17.2.2 Mobile combustion*

Emissions from mobile combustion in NFR1A4a refer mainly to gardening machines for professional use and tractors that are not used in industry, farming or forestry. A national model is used to estimate emissions from all working machinery used in Sweden and it is considered to correspond to Tier 3 for all emissions, except for $SO_2$ which is estimated according to Tier 2. The model is further explained in Annex 2.

Emissions from working machinery are also reported in NFR1A2g vii, 1A3e ii, 1A4b ii and 1A4c ii. See Table 3-30.

**Table 3-30. Distribution of emissions from off-road vehicles and other machinery.**

| Category | NFR | Definition IPCC Guidelines |
|---|---|---|
| **Industry** | 1A2g vii | Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc. |
| **Other** | 1A3e ii | Combustion emissions from all remaining transport activities including ground activities in airports and harbours, and off-road activities not otherwise reported under 1A4c ii or 1A2g vii. |
| **Commercial/ Institutional** | 1A4a ii | Garden machinery, e.g. lawn mowers and clearing saws, not used by private users, also tractors not used in industry ore forestry or agriculture. |
| **Residential** | 1A4b ii | All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts |
| **Agriculture, Forestry** | 1A4c ii | Emissions from mobile fuel combustion in agriculture and forestry, as for example loader-excavator, tractor, harvester, clearing saw etc. Highway agricultural transportation is excluded. |

### *3.2.17.2.3 Verification of Estimation models and allocation methods for fuel in the other sectors*

In submission 2005 and earlier, there were large uncertainties in estimation models and allocation methods for fuel in the Other sectors and NFR1A2f, construction. In 2005, a study was performed by SMED, aiming at identifying and analysing the methods and models applied for each sub-sector and determine whether they were in line with the IPCC guideline recommendations.[100] In addition, each fuel was traced back to its original source in order to determine whether it had been correctly allocated on stationary and mobile combustion.

The results from the study show good agreement with IPCC guideline recommendations. All fuels but biomass had little or no changes in methodologies, and where changes occurred, no significant inconsistencies in fuel consumption time series were detected. However, for biomass, several significant inconsistencies were identified leading to recalculations of activity data and emissions in NFR1A4a and 1A4b[101]. Due to these recalculations there are obvious inconsistencies between the national energy balances and the national emission inventory data.

Furthermore, all fuels proved to be correctly allocated on stationary and mobile combustion. In the Swedish air emission inventory, this means that all diesel oil and gasoline reported under Other sectors in the energy balances are used by mobile combustion, while all the other fuels are related to stationary combustion.

### 3.2.17.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

#### *3.2.17.3.1 Stationary combustion*

The large activity data uncertainty in the stationary combustion is due to the use of data from the annual energy balances. The uncertainties for stationary combustion are on fuel group aggregation level. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group.
Activity data uncertainty is relatively low for most fuel types. Emission factor uncertainty is for some fuels very high. The fuel groups and EF that have highest uncertainty are:

- Biomass for As, Cd, Cu, HCB, PAH, PCB
- All fuels for Dioxin
- Liquid fuels for Cu, Hg, Cr
- Solid fuels for HCB, PCB

See Annex 1 for more details regarding uncertainties for activity data and emissions.

#### *3.2.17.3.2 Mobile combustion*

No recalculations have been performed for emissions in the mobile sector for the eighties, and thus there are inconsistencies in time series between the eighties and

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[100] Gustafsson, et al. 2005.

[101] Paulrud et al. 2005.

later years. Time series from mobile combustion in NFR1A4aii have been reviewed for later years and are considered to be consistent.

Uncertainties for activity data and emissions reported for working machinery in NFR1A4b ii can be seen in Annex 1 to the IIR.

### 3.2.17.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In submission 2005 and earlier, there were large uncertainties in estimation models and allocation methods for fuel in the other sectors. In 2005, a study was performed by SMED, aiming at identifying and analysing the methods and models applied for each sub-sector and determine whether they were in line with the IPCC guideline recommendations[102]. In addition, each fuel was traced back to its original source in order to determine whether it had been correctly allocated on stationary and mobile combustion.

The results from the study show good agreement with IPCC guideline recommendations. All fuels but biomass had little or no changes in methodologies, and where changes occurred, no significant inconsistencies in fuel consumption time series were detected. However, for biomass, several significant inconsistencies were identified leading to recalculations of activity data and emissions in NFR1A4a and 1A4b[103]. Due to these recalculations there are obvious inconsistencies between the national energy balances and the national emission inventory data for years before 2005. Furthermore, all fuels proved to be correctly allocated on stationary and mobile combustion. All diesel oil and gasoline reported under Other sectors in the energy balances is allocated to mobile combustion, while all the other fuels are related to stationary combustion.

### 3.2.17.5 SOURCE-SPECIFIC RECALCULATIONS

#### *3.2.17.5.1 Stationary combustion*

In submission 2025 there is a revision of activity data for the year 2022 for the sector as the data was updated to the final energy balance statistics.

All emissions decreased due to the recalculations. The largest decrease was in PCB, HCB and dioxin emissions for 2022. The decrease of PCB, HCB and dioxin emissions was 22% (0.021g, 1.8g and 0.025g respectively) in 2022.

#### *3.2.17.5.2 Mobile combustion*

A development project[104] regarding annual machine operating hours was conducted during 2023/2024. The project was conducted based on testing and inspec-

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[102] Gustafsson, et al. 2005.

[103] Paulrud et al. 2005.

[104] Jerksjö, M. Genomsnittlig årlig driftstid för entreprenadmaskiner och traktorer. SMED PM 2024

tion data from the certified organisation Swedish machine testing. The project involved testing data from year 2019-2023 for various machines used in the commercial sector. Included in the same project was also a study on operating hours of tractors. The study analysed the registered operating hours between change in ownership. As a result of the project the operating hour during “machine year 0” was revised by up to 50% for many machines as the previous emission calculations assumed that a machine would manage a full year of operation time during the year its was registered/sold. The more reasonable approach is that the average machine manage half a year in operation during year 0.

The project resulted in adjusted machine hours for tractors, wheel loaders, front loaders and other machinery used in the commercial sector. Previous machine hours were overestimated and thus the recalculations resulted in decreased emissions throughout most the time series.

For CO, NOx, $PM_{2.5}$ and NMVOC the recalculations resulted in decrease in emissions throughout the time series. The emissions of CO were revised by -1% to +0,1%, $NO_x$ -3% to - 13%, $PM_{2.5}$ by - 7% to +1% and NMVOC by -4% to +1.

#### 3.2.17.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 3.2.18 Residential, NFR1A4b

#### 3.2.18.1 SOURCE CATEGORY DESCRIPTION

In this category both stationary and mobile combustion occur.

#### *3.2.18.1.1 Stationary combustion*

The activity data for the last emission year (2023), is the same as for 2022, as the annual energy balances are not published at the time when the emission calculations have to be finalized. Stationary combustion of fuels within residential decreased by 69% between 1990 and 2022, mainly due to a continuous increase in district heating use[105]. In recent years, the use of heat pumps has also increased significantly[106]. Most of this change occurred before 2006; however, the use of heating oils is still decreasing while combustion of wood, wood chips and pellets has increased in recent years. In 2009-2010, fuel consumption increased due to the cold winters these years, especially in 2010. Despite this, the consumption of heating oil continued to decrease while consumption of wooden fuels and natural gas increased quite considerably. Emissions of $CO_2$, $CH_4$ and $N_2O$ from the use of charcoal are included in this source category.

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[105] Swedish Energy Agency. Yearly Energy Balances.

[106] Swedish Energy Agency. Yearly Energy Balances.

### *3.2.18.1.2 Mobile combustion*

Mobile combustion in NFR1A4bii refer to gardening machines used in households e.g. lawn mowers, hedged cutters, clearing saws and more. Snow mobiles and all-terrain vehicles not used for professional purposes are also allocated to NFR1A4bii. The emissions of CO, NMVOC, $NH_3$ and particles arise mainly from combustion of gasoline. This also applies to emissions of $NO_x$ after 2009.

Emissions of $PM_{2.5}$ and NMVOC in 2023 have decreased by 42% and 24% compared to 1990. The emissions of $NO_x$ and CO have increased by 19% and 16% compared to 1990.

A summary of the latest key source analysis is presented in Table 3-32.

**Table 3-32. Summary of key source analysis, NFR1A4b, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1A4b | Biomass – *As, CO, Cd, Cr, DIOX, Hg, NMVOC, NOx, Ni, PAH 1-4, PM10, PM2.5, Pb, SO2, Se, TSP, Zn* | Biomass – *CO, DIOX, NMVOC,PAH 1-4, PM10, PM2.5, Se, TSP, Zn* |
| | Liquid fuels – *CO, NMVOC, NOx, PM2.5* | Liquid – CO, Cd, Cu, Hg, NMVOC, NOx, Ni, PM10, PM2.5, SO2, Se, TSP |

### 3.2.18.2 METHODOLOGICAL ISSUES

### *3.2.18.2.1 Stationary combustion*

The main data source is the annual energy balances. One- and two-dwellings statistics, Holiday cottages statistics and Multi-dwellings statistics are used as complementary data sources to get more details on biomass combustion. Biomass fuel consumption for heating residences is surveyed on the three most common combustion technologies: boiler, stoves and open fireplaces. Since 1998 biomass activity data is separated on wood logs, pellets/briquettes and wood chips/saw dust. Historical biomass data has been estimated by inter- and extrapolation. As of submission 2019, biomass activity data and emission factors for boilers and stoves are separated into traditional and modern small-scale combustion technology for the whole time series[107].

Estimation models and allocation methods for fuel in the Other sectors, as well as the use of preliminary data for stationary combustion in the Other sectors as discussed in section 3.2.17 also applies to NFR1A4b.

Emissions arising from the use of charcoal are estimated using national statistics and default 2006 IPCC guidelines EFs.

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[107] Helbig, T., Gustafsson, T., Kindbom, K. Jonsson, M. 2018. Uppdatering av nationella emissionsfaktorer för övrig sektor (CRF/NFR 1A4). SMED rapport no 13 2018.

The reported emissions of particulate matter include the condensable fraction of particles. The emission factors were updated in submission 2019 from being based on measurements in hot flue gases to being based on measurements in diluted flue gases. The measurement method is described in Kindbom et al. 2017[108].

The activity data for the last emission year (2022), is the same as for 2021, as the annual energy balances are not published at the time when the emission calculations have to be finalized. The activity data for the last inventory year will be revised next coming submission, as the Energy Balance will then be published and definitive.

### *3.2.18.2.2 Mobile combustion*

Emissions from mobile machinery used in households are included in NFR1A4bii. Machines included here are mainly different types of gardening machines e.g. lawn movers, hedge cutters and chain saws as well snow mobiles and all-terrain vehicles used by households, while emissions from gardening machines for professional use are reported in 1A4aii. Emissions from tractors not used in forestry, agriculture or industry are also reported in 1A4bii as well as emissions from generator sets and mobile freezers and chillers. A national model is used to estimate most emissions from working machinery used in Sweden and is considered to correspond to Tier 3 for all emissions, except $SO_2$ which is estimated according to Tier 2. The model is further explained in Annex 2.

Emissions from working machinery are also reported in NFR1A2g vii, 1A3e ii, 1A4a ii and 1A4c ii. See Table 3-33.

**Table 3-33. Distribution of emissions from off-road vehicles and other machinery.**

| Category | NFR | Definition IPCC Guidelines |
|---|---|---|
| **Industry** | 1A2g vii | Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc. |
| **Other** | 1A3e ii | Combustion emissions from all remaining transport activities including ground activities in airports and harbours, and off-road activities not otherwise reported under 1A4c ii or 1A2g vii. |
| **Commercial/ Institutional** | 1A4a ii | Garden machinery, e.g. lawn mowers and clearing saws, not used by private users, also tractors not used in industry ore forestry or agriculture. |
| **Residential** | 1A4b ii | All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts |
| **Agriculture, Forestry** | 1A4c ii | Emissions from mobile fuel combustion in agriculture and forestry, as for example loader-excavator, tractor, harvester, clearing saw etc. Highway agricultural transportation is excluded. |

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[108] Kindbom, K.; Mawdsley, I.; Nielsen, O.; Saarinen, K.; Jónsson, K. and Aasestad, K., (2017): *Emission factors for SLCP emissions from residential wood combustion in the Nordic countries. Improved emission inventories of Short Lived Climate Pollutants (SLCP)*. TemaNord 2017:570

### 3.2.18.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

#### *3.2.18.3.1 Stationary combustion*

The activity data and emission factor uncertainties for stationary combustion are 20% and 1% respectively. The large activity data uncertainty is due to the use of input data from the annual energy balances.

The time series for NFR1A4b is considered to be consistent as there have not been any major changes in methodology or input data to the energy balances that affect this category.

The uncertainties for stationary combustion are on fuel group aggregation level. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group. Activity data uncertainty is relatively low for most fuel types. Emission factor uncertainty is for some fuels very high. The fuel groups and EF that have highest uncertainty are:

- Biomass for As, Cd, Cr, Cu, HCB, PAH, PCB, Zn
- Liquid fuels for Cd, Cr, Ni, PAH, Pb, Se, $SO_2$ and Zn
- Other fuels for $PM_{10}$, $PM_{2.5}$

See Annex 1 for more details regarding uncertainties for activity data and emissions.

#### *3.2.18.3.2 Mobile combustion*

No recalculations have been performed for emissions in the mobile sector for the eighties, and thus there are inconsistencies in time series between the eighties and later years. Time series from mobile combustion in NFR1A4b ii have been reviewed for later years and are considered to be consistent.

Uncertainties for activity data and emissions reported for working machinery in NFR1A4b ii can be seen in Annex 1 to the IIR.

### 3.2.18.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All quality procedures according to the Swedish QA/QC plan (including the Manual for SMED’s Quality System in the Air Emission Inventories) have been implemented during the work with this submission.

### 3.2.18.5 SOURCE-SPECIFIC RECALCULATIONS

#### *3.2.18.5.1 Stationary combustion*

In submission 2025 there is a revision of activity data for the year 2022 for the sector as the data was updated to the final energy balance statistics. Updated activity data was acquired for charcoal for 2020, 2021, 2022.

The new activity data for charcoal resulted in increase of CO, NMVOC, $SO_2$ and NOx emissions for 2020:CO: 0.19 kt (0.03%), NMVOC: 0.003 kt (0.04%), $SO_2$:

0.001 kt (0.025%) NOx: 0.003 kt (0.09%), for 2021 CO: 1.7 kt (2.4%), NMVOC: 0.02 kt (0.3%), $SO_2$:0.01 kt (2.1%), NOx: 0.02 kt (0.8%).
The revised activity data for 2022 resulted in decreased emissions. The largest decrease was in $SO_2$ emissions 0.05kt (10.4%).

#### *3.2.18.5.2 Mobile combustion*

A development project[109] regarding annual machine operating hours was conducted during 2023/2024. The project was conducted based on testing and inspection data from the certified organisation Swedish machine testing. The project involved testing data from year 2019-2023 for some of the machinery used in the residential sector. Included in the same project was also a study on operating hours of tractors. The study analysed the registered operating hours between change in ownership.

The project resulted in adjusted machine hours for tractors, wheel loaders, front loaders and other machinery used in the commercial sector. Previous machine hours were overestimated and thus the recalculations resulted in decreased emissions throughout most the time series. In particular tractors used in the residential sector was heavily overestimated for older machine models.

For CO, NOx, $PM_{2.5}$ and NMVOC the recalculations resulted in decrease in emissions throughout the time series.

The emissions of CO were reduced by 2-5%, $NO_x$ by 3-24%, $PM_{2.5}$ by 15-25% and NMVOC by 6-10%. The large decrease in $NO_x$ and $PM_{2.5}$ is mainly due to
a decrease in operating hours for older tractors (diesel) used in residential sector. Since most of the tractor stock in the residential sector consist of older machines, the effect of revising the operating hours becomes significant.

#### 3.2.18.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 3.2.19 Agriculture/Forestry/Fisheries, NFR1A4c

#### 3.2.19.1 SOURCE CATEGORY DESCRIPTION

This category includes emissions from stationary combustion for heating purposes and mobile combustion in working machinery within agriculture and forestry, and fishing vessels. The structure of the agricultural sector in Sweden is described in chapter 6. Changes in use of liquid and gaseous fuels in agriculture, fishing and forestry have been small since 1990. Due to availability of better data for the period 2003 and later years, there is a shift in the time series for biomass.

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[109] Jerksjö, M. Genomsnittlig årlig driftstid för entreprenadmaskiner och traktorer. SMED PM 2024

The consumption of both gasoline and diesel (including low blended biofuels) by working machinery used in agriculture and forestry has an overall increasing trend. Despite the smaller share of gasoline used by working machinery in NFR1A4cii, the largest share of the emissions of CO and NMVOC stem from the combustion of gasoline. The emissions of CO from gasoline have an increasing trend compared to the emissions of CO from diesel, which have a decreasing trend. The emissions of NMVOC from diesel also have a decreasing trend.

Most of the emissions of particles and $NO_X$ from working machinery arise from the combustion of diesel (including biofuel) but have a decreasing trend. Emissions of $PM_{2.5}$ and $NO_x$ in 2023 have decreased by 86% and 80% compared to 1990 respectively. The emissions of NMVOC have decreased by 32% while emissions of CO have increased by 44% compared to 1990.

For stationary combustion the activity data for the last emission year (2023), is the same as for 2022, as the annual energy balances are not published at the time when the emission calculations have to be finalized. Combustion of solid fuels for stationary combustion within this sector has decreased substantially since 1990.

A summary of the latest key source analysis is presented in Table 3-35.

**Table 3-35. Summary of key source analysis, NFR1A4c i, according to approach 1.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 1A4c i | Biomass – *CO, Cd, Cu. DIOX, NMVOC, NOx, PAH 1-4, PM10, PM2.5, Pb, SO2, Se, TSP, Zn* | Biomass – *Cu, PAH 1-4, PM10, PM2.5, Se, TSP* |
| | Marine gasoil – NOx | Marine gasoil – NOx, SO2 |
| | Gasoline – CO | Gasoline – |
| | Liquid – *CO, Cd, Cu, NMVOC, NOx, Ni, PM2.5, PM2.5* | Liquid – *Cu, NMVOC, NOx, Ni, PM10, PM2.5, SO2, TSP* |
| | Solid – | Solid – *SO2, TSP* |

### 3.2.19.2 METHODOLOGICAL ISSUES

In this sector both stationary and mobile combustion occur.

#### *3.2.19.2.1 Stationary combustion*

The activity data for the last emission year (2023), is the same as for 2022, as the annual energy balances are not published at the time when the emission calculations have to be finalized. For stationary combustion, all activity data is on national level by fuel type and estimated emissions are therefore considered to correspond to Tier2. Activity data is based on models and results from a survey from 1985 repeated in 2007 (see Other statistics from Statistics Sweden in Annex 2). Activity data for other biomass was revised for the time series between 1990 and 2004 according to Josefsson Ortiz & Helbig (2021)[110]. The energy consumption of other biomass for this sector had an abrupt start in 2002, which was not credible.

Estimation models and allocation methods for fuel in the Other sectors, as well as the use of preliminary data for stationary combustion in the Other sectors as discussed in section 3.2.17, Commercial/institutional, NFR1A4a also applies to NFR1A4c. Biomass activity data and emission factors are separated into traditional and modern small scale combustion technology for the whole time series[111].

The reported emissions of particulate matter include the condensable fraction of particles.

#### *3.2.19.2.2 Mobile combustion*

Mobile combustion in NFR1A4cii refers to working machinery used in agriculture (e.g. tractors and combine harvesters), forestry (e.g. forwarders and harvesters) and fisheries. A national model is used to estimate emissions from all land based working machinery used in Sweden, considered to correspond to Tier 3 for all emissions, except $SO_2$ which is estimated according to Tier 2. The model is further explained in Annex 2.

Emissions from Fisheries, NFR1A4ciii, were first reported in submission 2006. The estimated fuel consumption is based on a survey on energy consumption within the fishing industry by Statistics Sweden[112] together with data on the Swedish fishing fleet's total installed effect in kW from the Swedish Agency for Marine and Water Management (SwAM). The estimated fuel consumption provided by Statistics Sweden refers to 2005, and for the previous and following years the fuel consumption is estimated by adjusting the 2005 value according to the development in total installed effect. From submission 2025, there is also a correction factor to accommodate two later surveys of fuel consumption by the fishing fleet. The fuel consumption by fisheries has decreased by 73% since 1990 and by 0.05% between 2022 and 2023.

The emissions factors used to estimate emissions from Fisheries are based on a SMED study from 2005[113], producing emission factors for $SO_2$, $NO_X$ and NMVOC, for 1990-2004. As from 2005, the estimates are based on the same consumption estimate and emission factors as for 2004.

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[110] Josefsson Ortiz, C. & Helbig, T. 2021. Revidera bränsleförbrukning i övrig sektor 1990-2002. SMED Memorandum 2021.

[111] Helbig, T. Kindbom, K. Jonsson, M. 2019. Uppdatering av nationella emissionsfaktorer för övrig sektor. SMED rapport no 12 2019.

[112] Statistics Sweden, 2006 ENFT0601.

[113] Cooper et al., 2005a. Emission factors, fuel consumption and emission estimates for Sweden's fishing fleet 1990-2004.

Emissions from fisheries are derived under the assumption that the fishing fleet operates using medium speed engines running on marine gasoil. The emission abatement technologies used by the fleet (e.g. Selective Catalytic Reduction (SCR) for $NO_X$ reduction) is assumed to be negligible. As in navigation, the values for PM10 and PM2.5 from fishing boats are the same. This is because all particles generated from combustion of marine gasoil are assumed to be small enough to fit in the smaller category.

Emissions from working machinery are also reported in NFR1A2g vii, 1A3e ii, 1A4a ii and 1A4b ii. See Table 3-36.

**Table 3-36. Distribution of emissions from off-road vehicles and other machinery.**

| Category | NFR | Definition IPCC Guidelines |
|---|---|---|
| **Industry** | 1A2g vii | Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc. |
| **Other** | 1A3e ii | Combustion emissions from all remaining transport activities including ground activities in airports and harbours, and off-road activities not otherwise reported under 1A4c ii or 1A2g vii. |
| **Commercial/ Institutional** | 1A4a ii | Garden machinery, e.g. lawn mowers and clearing saws, not used by private users, also tractors not used in industry ore forestry or agriculture. |
| **Residential** | 1A4b ii | All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts |
| **Agriculture, Forestry** | 1A4c ii | Emissions from mobile fuel combustion in agriculture and forestry, as for example loader-excavator, tractor, harvester, clearing saw etc. Highway agricultural transportation is excluded. |

### 3.2.19.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

#### *3.2.19.3.1 Stationary combustion*

The sharp increase in use of biomass in stationary combustion in 2003 is due to a revision in submission 2009, where improved data was used for 2003 and later years. There is no information available to improve data from 2002 and earlier years. Emissions in 1990 are considered to be of a sufficient quality as they are based on the 1985 survey mentioned above, which was reasonably recent in 1990. The time series for liquid, solid and gaseous fuels are considered to be consistent. Solid fuels have not been used in this sector since 2000.

The uncertainties for stationary combustion are on fuel group aggregation level. The uncertainty values are assigned by staff at Swedish Statistics and are based on expert judgements made on fuel type that were aggregated to fuel group. Activity data uncertainty is relatively low for most fuel types. Emission factor uncertainty is for some fuels very high. The fuel groups and EF that have highest uncertainty are:

- Biomass for As, Cd, Cu, DIOX, HCB, PAH, PCB

- Liquid fuels for Cd, Cr, Cu, Ni, PAH, Pb, Se and Zn
- Solid fuels for As, DIOX, HCB, PAH, $SO_2$, Zn

See Annex 1 for more details regarding uncertainties for activity data and emissions.

#### *3.2.19.3.2 Mobile combustion*

No recalculations have been performed for emissions in the mobile sector for the eighties, and thus there are inconsistencies in time series between the eighties and later years. The time series from mobile combustion in NFR1A4c ii have been reviewed for later years and are considered to be consistent.

Uncertainties for activity data and emissions reported for working machinery in NFR1A4cii can be seen in Annex 1 to the IIR.

### 3.2.19.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In submission 2021, AD from the Energy balances were revised for biomass 2013 to 2018 all fuels. In addition, the preliminary consumption for liquid fuel in 2018 in submission 2020 was revised.

The largest effect of submission 2021 recalculations was in Ni emissions. The emissions decreased with -35% (0.07 t Ni) and decreased with -2.5% (0.005 t Ni) in 2017 between submission 2020 and 2021 in the sector.

During the 2021 NECD inventory review the EEA pointed out that emission ratios for CO/BC and CO/$NO_x$ are outside the 95% confidence interval for 2018 and 2019 when compared to other Member States. This is due to most CO emissions (about 90%) being accounted for by professionally used chainsaws/clearing saws and snow mobiles/ATVs. Compared to other Nordic countries, a lot of snow mobiles and ATVs are operated in agriculture, reindeer herding and forestry. Chainsaws and snow mobiles/ATVs run on gasoline engines which cause relatively little emissions of BC and $NO_x$ compared to CO. Emissions of CO are calculated based on the EMEP/EEA guidebook.

### 3.2.19.5 SOURCE-SPECIFIC RECALCULATIONS

#### *3.2.19.5.1 Stationary combustion*

In submission 2025 there is a revision of activity data for the year 2022 for the sector as the data was updated to the final energy balance statistics. The revised activity data resulted in increased emission for all substances.
The largest effects due to recalculations in submission 2025, was for nickel (Ni) emissions. The increase of Ni emissions was 44.3% (35.45 kg) in 2022.

### *3.2.19.5.2 Mobile combustion*

A development project[114] regarding annual machine operating hours was conducted during 2023/2024. The project was conducted based on testing and inspection data from the certified organisation Swedish machine testing. The project involved testing data from year 2019-2023 for machinery that is typically used in industry and construction (wheel loaders, excavators, dumpers and more). Included in the same project was also a study on operating hours of tractors. The study analysed the registered operating hours between change in ownership.

The project resulted in adjusted machine hours for tractors, wheel loaders, front loaders and other machinery used in the commercial sector. Previous machine hours were overestimated and thus the recalculations resulted in decreased emissions throughout most the time series.

For CO, NOx, $PM_{2.5}$ and NMVOC the recalculations resulted in decrease in emissions throughout the time series. The emissions of CO decreased by 6-13%, NOx by 11-26%, $PM_{2.5}$ by 20-33% and NMVOC by 5-13%. The larger decrease in $NO_x$ and $PM_{2.5}$ is partly due to a significant decrease in operating hours for older tractors (diesel) used in agriculture and forestry. Since most of the tractor stock in these sectors consist of older machines, the effect of revising the operating hours becomes significant. When looking at snow mobiles and all-terrain vehicles the decrease is about 7-13%.

The fuel consumption in the fishing fleet is calculated by adjusting fuel consumption data from 2005 with the installed effect in the fishing fleet. In 2018 and 2023, new data has been published which indicates that this method overestimates the fuel consumption. Thus, a correction factor which indicates the consumption per installed effect has been introduced into the calculations. This correction factor has been calculated for the known points, i e 2005, 2017 and 2022. The values between the known points have then been interpolated and finally the consumption as per the 2005 extrapolation method has been multiplied with the correction factor (Fig 3-13).

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[114] Jerksjö, M. Genomsnittlig årlig driftstid för entreprenadmaskiner och traktorer. SMED PM 2024

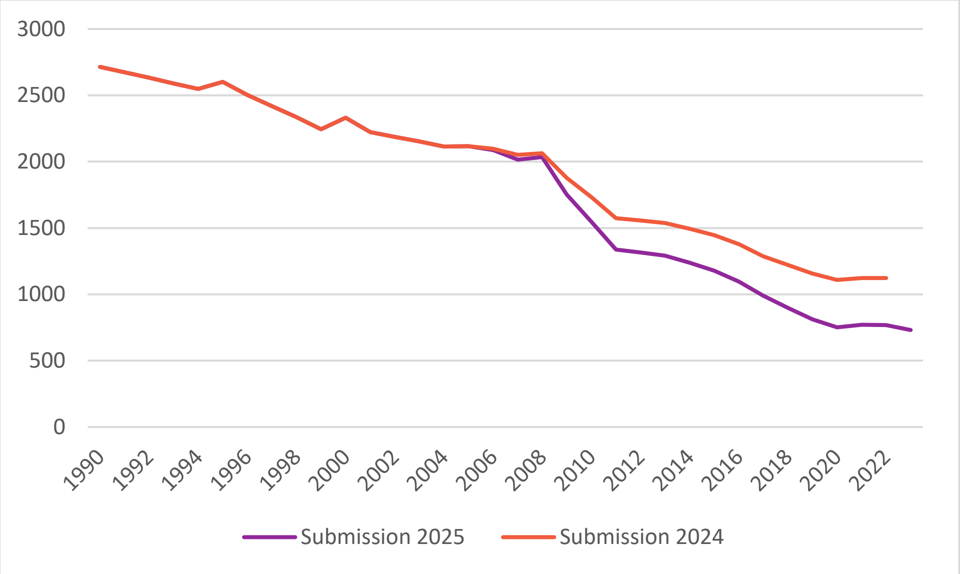

**Fig 3-13. Energy consumption (TJ) 1990-2023 by the fishing fleet in submission 2024 and submission 2025.**

#### 3.2.19.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 3.2.20 Other stationary combustion, NFR1A5a

No emissions are reported in this category.

### 3.2.21 Other mobile combustion, NFR1A5b

#### 3.2.21.1 SOURCE CATEGORY DESCRIPTION

NFR1A5b includes emissions from military transports, which are reported as included elsewhere (IE) in submission 2024.

### 3.2.22 Memo Items International bunkers, 1D, NFR1A3ai and 1A3dii

#### 3.2.22.1 SOURCE CATEGORY DESCRIPTION

This sector includes emissions from bunker fuels, e.g., fuel bought in Sweden and used for international aviation and international navigation.

International Aviation is defined as emissions from flights that depart in one country and arrive in a different country. However, “Cruise emissions” from *both* domestic and international aviation should be reported separately as a memo item in NFR1A3ai and are not included in national totals. This applies according to the Long-Range Transboundary Air Pollution Convention (LRTAP). And emissions from *both* national and international aviation during the “LTO cycle” belong to the national totals.

International navigation is defined as fuels bought in Sweden, by Swedish or foreign registered ships, and used for transports to non-Swedish destinations, but excludes consumption by fishing vessels. In the case of LNG, international navigation is defined as fuel used from a port within Sweden to a port outside Sweden. Emissions from international navigation are not included in the national total but are instead reported separately as a memo item in NFR1A3di.

A summary of the latest key source analysis is presented in Table 3-37.

**Table 3-37. Summary of key source analysis, NFR1D according to approach 1.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 1D International Aviation | Jet kerosene – NOx | Jet kerosene – |

### 3.2.22.2 METHODOLOGICAL ISSUES

International bunkers from aviation and navigation are defined as fuels bought in Sweden, by Swedish or foreign-registered airplanes or ships, and used for transport to non-Swedish destinations. Emissions from bunker fuels is reported separately as a memo item in NFR1A3ai respectively 1A3di. The division on international and domestic fuels for navigation is based on AIS data as from submission 2020. In previous submissions it was based on information from the monthly survey on supply and delivery of petroleum products[115]. More information regarding the change of methodology for navigation can be found in section 3.2.15.2.

#### *3.2.22.2.1 INTERNATIONAL AVIATION, NFR1A3A I*

International Aviation is defined as emissions from flights that depart in one country and arrive in a different country. However, “Cruise emissions” from *both* domestic and international aviation should be reported separately as a memo item in NFR1A3ai and not included in national totals. This applies according to the Long-Range Transboundary Air Pollution Convention (LRTAP). Emissions from *both* national and international aviation during the “LTO cycle” belong to the national totals.

The fuel consumption and emissions from both national and international aviation are calculated by the Swedish Defence Research Agency (FOI) by using an estimation model and data provided by Swedish Transport Agency (STAg) regarding:

- Airport of departure and arrival
- Type of aircraft
- Number of flights
- Number of passengers

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[115] Statistic Sweden. http://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Energi/Tillforsel-och-anvandning-av-energi/Manatlig-bransle--gas--och-lagerstatistik/

- International or domestic flight

A database with information regarding 200 different types of aircraft is also used. The emission data regarding different types of aircrafts in the database originates from “ICAO Engine Exhaust Emission Data Bank”. All this data is used to calculate emissions and amounts of burnt fuel for total flight time as well as for aircraft movements below 3000 feet at the airports, the so called LTO cycle. The FOI has in a published report described their method for estimating the emission from aviation[116].

Due to the fact that the Swedish airports generally are smaller than international airports in other countries; taxi times are much shorter for domestic flights and climb-out and take-off times are often shorter as well compared to the International Civil Aviation Organization (ICAO) standards that the IPCC guidelines follow[117]. The traffic from Swedish airports consumes as a result less fuel and gives rise to less emission. The estimated fuel consumption and emissions are adjusted to match the statistics on delivered amount of aviation fuels from Statistics Sweden (see Annex 2).

The results from the emission calculations are aggregated into four groups; domestic landing and take-off (LTO), domestic cruise, international LTO and international cruise. The aggregation is based on estimated emissions from the LTO cycle & Cruise reported by STAg *and* the national/international (bunker) fuel consumption from the monthly survey on supply and delivery of petroleum products from Statistics Sweden.

The emissions of $NO_X$ from the cruise phase peaked first in 2007 and then increased until 2017. The emissions of $NO_x$ from the Cruise cycle increased by 57% between 1990 and 2019. Due to the covid-19 pandemic however, the $NO_x$ emissions from international aviation decreased by 63% between 2019 and 2020. In 2023, $NO_x$ emissions have increased significantly from the previous year, Thus, in 2023 the $NO_x$ emissions were 22% higher than in 1990 (see Figure 3-18).

The emissions of CO fluctuate a lot but was at its lowest in 2003. After a steady increase, the emissions of CO from the cruise phase peaked in 2017. The decreasing trend since 2017 is due to a transition from Boeing to Airbus planes. Between 2019 and 2020, CO emissions decreased by 71% due to the covid-19 pandemic. In 2021-2022 the CO emissions have increased again but in 2023 they are still 34% lower than in 1990.

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[116] Mårtensson, T. & Hasselrot, A., 2013. Calculation of exhaust emissions from air traffic. FOI R 3677 mSE.

[117] Gustafsson, 2005a. Comparative study of Swedish emission factors for aviation with the IPCC default factors. SMED report 2005.

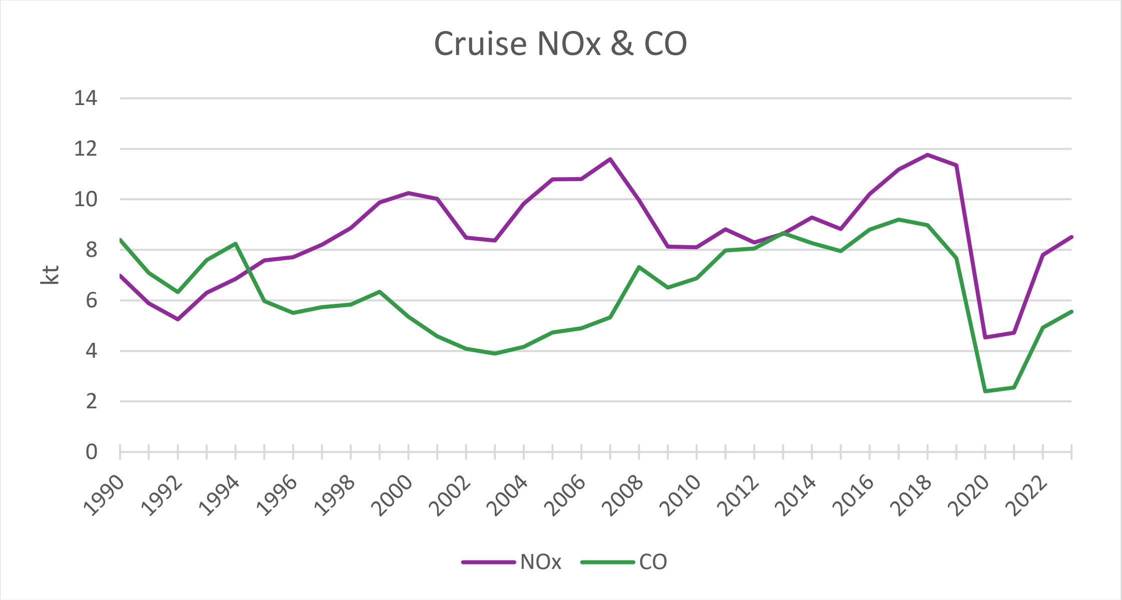

**Figure 3-18. Emissions of $NO_x$ and CO from the cruise phase for aviation (CRF 1A3a & 1D) 1990-2023.**

The emissions of NMVOC fluctuate but show a decreasing trend over time since 1990. In recent years this is the result of phasing out the MD-80/82 aircraft model. The emissions of Pb have decreased noticeably for the whole period, as leaded gasoline has been phased out (see Figure 3-19 below). The emissions of Pb originate from the cruise phase in national aviation, since no aviation gasoline is used for international aviation.

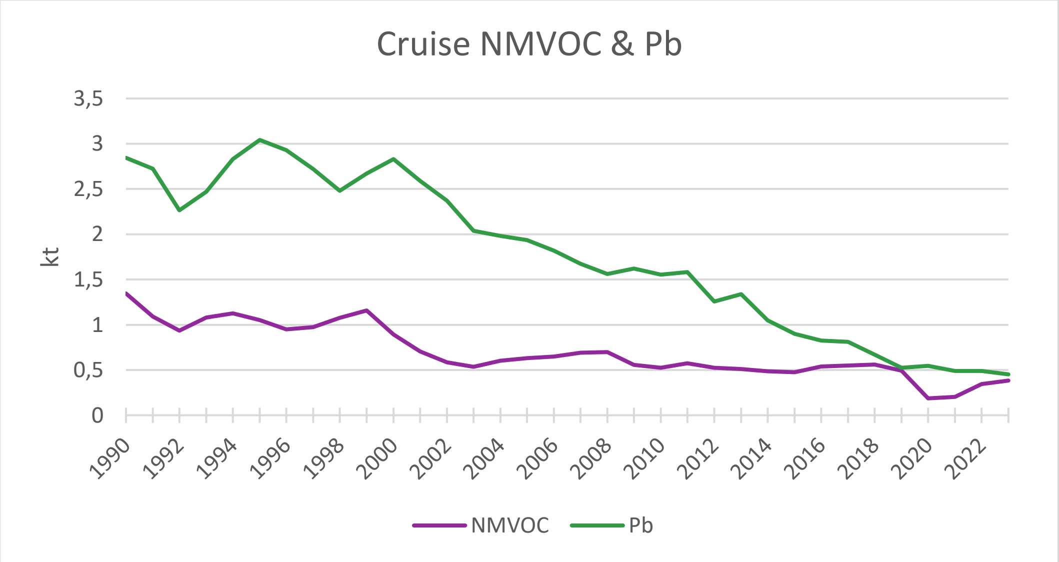

**Figure 3-19. Emissions of NMVOC and Pb from the cruise phase for aviation (CRF 1A3a & 1D) 1990-2023**

### *3.2.22.2.2 INTERNATIONAL NAVIGATION, NFR1A3D I*

International bunkers from navigation are defined as fuels bought in Sweden, by Swedish or foreign-registered ships and used for transport from Swedish destinations to non-Swedish destinations but excludes consumption by fishing vessels. But LNG is often bunkered from vessels off the coast and therefore never enters the national delivery statistics. Therefore, the LNG used between a port in Sweden and a foreign port is defined as international even though it's not bunkered in Sweden. Emissions from international bunkers navigation are not included in the national total but instead reported separately as a memo item in NFR1A3di. The division on international and domestic fuels is based on information from the monthly survey on supply and delivery of petroleum products.

The emissions from international navigation are estimated applying Tier 2 methodology. The fuel consumption for international navigation has in previous submissions been based on the monthly survey on supply and delivery of petroleum products[118]. But it has been problematic for fuel suppliers to separate fuel distributed to national respectively international navigation. As the monthly survey of fuel supply statistics was revised in 2018, the reported fuel for national and international navigation was merged in the survey and represent as from 2018 the total fuel supply for navigation.

As a result, the fuel consumption by international navigation is estimated as the difference between the total supply of fuel for navigation in the monthly survey of fuel supply statistics and the estimated energy consumption for national navigation. The result from using the new methodology is a slightly lower consumption of fuel for international navigation.

The above-described adjustments in the monthly fuel survey[119] has resulted in a change of methodology and the Shipair model is used to estimate the fuel consumption from domestic shipping as from submission 2020. The Shipair model is developed by the Swedish meteorological and hydrological institute (SMHI) and collects AIS[120] data from ships, which transmit their identity and position information. The AIS data shows how the ships move between Swedish ports. Information regarding the ships, such as size, engine power and type of vessel is also collected. This enables the Shipair model to estimate the amount of energy needed for the ships to move and the amount of fuel consumed. Shipair uses the fuel allocation method described in the 4th IMO GHG study[121] to decide if the ship is using

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[118] Statistic Sweden. Monthly fuel, gas and inventory statistics. See annex 2 for more information regarding different surveys.

[119] Monthly oil survey on supply and delivery of petroleum products

[120] Automatic Identification System

[121] https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Fourth%20IMO%20GHG%20Study%202020%20-%20Full%20report%20and%20annexes.pdf

a light or heavy fuel oil. If data is lacking, Shipair, assumes that ships with a gross tonnage larger than 6000 in the Shipair database run on residual fuel oil.

Beside the Shipair model, the energy consumption from domestic navigation is based on information collected from the largest shipping actors for national navigation, with the exception for cargo ships.[122] Information regarding the fuel consumption is collected by fuel type and is used to distribute the light fuel oils from Shipair into marine gas oil, diesel, petrol etc. The difference in the amount of fuel estimated by Shipair and in the survey, is assumed to be the fuel consumption by cargo ships. For 2018- 2023, data on LNG consumption is collected from shipping actors for both domestic and international navigation. This is done because most LNG is bunkered from ships at sea and therefore does not show up in Swedish statistics.

#### 3.2.22.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The fuel consumption by international navigation was in previous submissions based on the the “Monthly fuel, gas and inventory statistics” survey.

Uncertainties for activity data and emissions reported for domestic navigation in NFR1A3d can be seen in Annex 1 to the IIR.

#### 3.2.22.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 3.2.22.5 SOURCE-SPECIFIC RECALCULATIONS

- During 2024, Statistics Sweden performed a project aiming to investigate the validity of net calorific values and emission factors in the mobile energy subsector. As a result, the net calorific value for fossil jet kerosene has been updated from 35.28 to 34.85 GJ/m$^3$, the emission factor for $CO_2$ from fossil and biogenic jet kerosene was updated from 78.5 to 73.45 ton/TJ and emission factor for $SO_2$ from fossil and biogenic jet kerosene was updated from 0.0236 to 0.0232 ton/TJ. This update was performed in order to align the emission factors of SMED with those used by the Swedish Defence Research Agency (FOI) in their emission model for aviation.
- In submission 2025, the monthly fuel deliveries indicated that the amount of delivered jet kerosene had decreased compared to 2022. Since most other indicators, such as number of flights and passengers indicated increasing air traffic, it was decided that the monthly fuel deliveries can’t be relied on for the year 2023. As a result, the fuel consumption for aviation was extrapolated from year 2022 to 2023 with the same percentual increase as the fuel consumption estimated by FOI.
- The fuel consumed by the armed forces between 1990 and 2017 has by mistake been included twice in previous emission estimations and this was corrected in submission 2025.

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[122] Eklund, V. et al. 2019. Analys och implementering av data från nya MåBra.

- Due to updates in the monthly fuel deliveries, the amounts of residual fuel oil and marine gasoil in 2022 has decreased somewhat.

#### 3.2.22.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

# 3.3 Fugitive emissions from solid fuels and oil and natural gas, NFR1B

## 3.3.1 Coal mining and handling, NFR1B1a

### 3.3.1.1 SOURCE CATEGORY DESCRIPTION

There are no coal mines in Sweden and hence no fugitive emissions from coal mines occur. However, emissions from handling of imported coal are reported in NFR1B1a from submission 2025 onwards. A summary of the latest key source analysis is presented in Table 3-38.

**Table 3-38. Summary of key source analysis, NFR1B1a, according to approach 1.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 1B1a | - | - |

### 1.1.1.1 METHODOLOGICAL ISSUES

No production of coal occurs in Sweden, however emissions from the amount of imported coal (and small amounts of exported coal) is included in NFR1B1a for the first time in submission 2025.

### 1.1.1.2 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions are mostly expert estimates. Uncertainties for particulate emissions from handling of imported coal are ± 900% based on emission factor uncertainties in the EMEP/EEA Guidebook 2023. More detailed information is to be found in Annex 1.

### 1.1.1.3 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

### 1.1.1.4 SOURCE-SPECIFIC RECALCULATIONS

In submission 2025, particle emissions from handling of coal were re-allocated from NFR1B1c to NFR1B1a in response to recommendations during the NECD review of the 2023 and 2024 submission. As a result, 0.01-0.03 kt TSP, 0.006-0.01 kt PM10 and 0.0006-0.001 kt PM2.5 were added in NFR1B1a for the years 1990-2022. In addition to re-allocating emissions, emission factors from EMEP/EEA Guidebook 2023 were applied where previously emission factors suggested in a

CEPMEIP project from 2001 were used, resulting in a decrease of TSP emissions by 0.3-0.5 kt, PM10 emissions by 0.1-0.2 kt and PM2.5 emissions by 0.01-0.02 kt for 1.B.1 as a whole.

#### 1.1.1.5 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 3.3.2 Solid fuel transformation, NFR1B1b

#### 3.3.2.1 SOURCE CATEGORY DESCRIPTION

NFR1B1b includes emissions of $SO_2$, $HN_3$, NMVOC, $NO_x$, Se and PAH from quenching and extinction at coke ovens. Particle emissions, also occurring from coke production, are allocated to NFR1A1c (industrial combustion).

From submission 2025, also fugitive emissions of CO and NOx from charcoal production are reported in NFR1B1b.

A summary of the latest key source analysis is presented in Table 3-39.

**Table 3-39. Summary of key source analysis, NFR1B1b, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1B1b | *Coke production - Se* | - |

#### 3.3.2.2 METHODOLOGICAL ISSUES

Information on $SO_2$ emissions is retrieved from the companies’ environmental reports and direct communication. PAH emissions from quenching and extinction at coke ovens are reported based on the measurement data from the environmental reports.

Estimated emissions of NMVOC, $NO_x$, $NH_3$ and Se from coke production are based on emission factors from EMEP/EEA Guidebook 2023 and applied to activity data. Activity data, produced amount of coke (Mton), has been acquired from the annual environmental reports for the two facilities producing coke (2001 and onwards), and for the earlier years – estimated via amounts of treated coking coal and the coke/coal ratio of 0.79, based on the data for the later years.

Fugitive emissions of particles from handling of coke have not been included since these emissions are included in the reporting of particle emissions from the industrial facilities that produce coke. These emissions are thus reported “IE”. Separate calculations based on statistics on coke and petroleum coke, using emission factors for handling of coal from CEPMEIP results in a rough estimate of 300 t TSP/year. The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e., not in diluted flue gases.

Emissions of As, Hg and dioxin occurring during coke production are reported in NFR2C1.

Emissions of CO and $NO_x$ from charcoal production have been estimated in submission 2025 using FAO statistics[123] as activity data, and default emission factors specified in EMEP/EEA Guidebook 2023.

### 3.3.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR1B1b are displayed in Annex 1. Uncertainties for $SO_2$ and PAH are expert estimates; emission factor uncertainties for NMVOC, $NO_x$, $NH_3$, Se, and CO are calculated based on the intervals in the EMEP/EEA Guidebook 2023.

### 3.3.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The improvements in methodology and allocation of emissions from the integrated iron and steel industry in submission 2010 were made based on a study[124] carried out in 2008 looking at emissions from several industrial plants, including the two largest iron and steel plants in Sweden, where inventory data from submission 2008 was compared with data from environmental reports.

### 3.3.2.5 SOURCE-SPECIFIC RECALCULATIONS

Addition on fugitive emissions of CO and NOx from charcoal production in submission 2025 resulted in emission increase by up to 0.66 kt CO and 0.0002 kt NOx annually.

Correction of amount of PAH-4 in environmental reporting for 2022 at one facility resulted in emission increase for PAH-4 (0.0019 t), benzo(a)pyrene (0.0004 t), benzo(b)fluoranthene (0.0008 t), benzo(k)fluoranthene (0.0004 t), and Indeno(1,2,3-cd)pyrene (0.0003 t).

### 3.3.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

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[123] FAOSTAT, Forestry Production and Trade, https://www.fao.org/faostat/en/#data/FO
[124] Skårman, T., Danielsson, H., Kindbom, K., Jernström, M., Nyström, A-K. 2008.

## 3.3.3 Other, NFR1B1c

### 1.1.1.6 SOURCE CATEGORY DESCRIPTION

NFR1B1c includes emissions from flaring of coke oven gas at coke ovens handling ($NO_X$, CO, NMVOC, $SO_2$, TSP, $PM_{10}$ and $PM_{2.5}$) and particle emissions from handling of peat (TSP, $PM_{10}$ and $PM_{2.5}$). A summary of the latest key source analysis is presented in Table 3-40.

**Table 3-40. Summary of key source analysis, NFR1B1c, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1B1c | - | - |

### 3.3.3.1 METHODOLOGICAL ISSUES

### *3.3.3.1.1 Flaring of coke oven gas*

NFR 1B1 is not really designed to include flaring, but since NFR1B2 only refers to liquid and gaseous fuels, it is not possible to report flaring from coke oven gas, blast furnace gas and steel converter gas in NFR 1B2.

The emissions from flaring of coke oven gas (COG – by-product gas at the integrated iron and steel plants) are calculated with Tier 2, i.e., with activity data directly from the plants, in the same way as for emissions from stationary combustion. All emissions, with the exception of $SO_2$, are calculated with the same emission factors as for stationary combustion because no other information is available for COG flaring in particular (emission numbers in the environmental reports are given for the coke ovens in total, including both flaring and industrial combustion of COG). For $SO_2$, one facility provides the emissions from COG flaring, whereas for the other total emissions from COG are distributed between NFR codes using the fuel amounts allocated to each code. The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e., not in diluted flue gases.

Reported activity data is amounts of flared COG (Mton). The amounts vary considerably between years, and during some years (2009, 2015) they were unusually high, resulting in increasing emissions. According to environmental reports[125], COG is flared when the production is temporarily stopped because of urgent needs of reparation of equipment or other maintenance measures.

### *3.3.3.1.2 Handling of solid fuels*

Particulate emissions from handling of peat have been calculated for all years since 1980. Emission factors used for handling of exported and imported peat are those

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[125] SSAB, 2008, 2009, 2015

suggested in the CEPMEIP-project[126]. The TSP emission factor is 0.15 kg/t where $PM_{10}$ constitutes 40% and $PM_{2.5}$ 4% of the total particulate emissions. The same emission factors have been used for the entire time series.

Peat production occurs in Sweden and from submission 2011 particulate emissions from production of milled peat is included in the estimates of particle emissions. Activity data (as $m^3$ produced peat) is available from official statistics from 1980 and onwards and is divided in peat used for energy purposes and peat used for agricultural purposes. Furthermore, there are different methods for peat production. Most particle emissions arise from the production of milled peat.

Production data from official statistics divide peat used for energy purposes in milled peat and other types of peat. However, this split is not used when reporting production data for peat used for agriculture purposes. Milled peat is mostly used for energy purposes, but some may also be used for agricultural purposes, hence the production data for milled peat may be underestimated.

The TSP emission factors used for milled peat production are from Nuutinen *et. al.* (2007)[127] and the share of $PM_{10}$ and $PM_{2.5}$ are from Tissari *et. al.* (2006)[128]. There are different methods that can be used when harvesting milled peat and the size of the particle emissions depends on which method is used. Since no information is available about the share between the different methods in Sweden an average emission factor is used, Table 3-41. Particle emissions are made up of only filterable particles since they origin from non-combustion processes.

**Table 3-41. Particle emission factors for milled peat production.**

| | Particle emission factors (g/$m^3$) for peat production | | |
|---|---|---|---|
| **Harvesting method** | **TSP** | **$PM_{10}$** | **$PM_{2.5}$** |
| HAKU method | 0.09 | 0.042 | 0.030 |
| Mechanical collector | 0.14 | 0.066 | 0.046 |
| Pneumatic collector | 0.12 | 0.056 | 0.039 |
| **Average** | **0.12** | **0.055** | **0.039** |

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[126] CEPMEIP, 2001. TNO. http://www.mep.tno.nl/wie_we_zijn_eng/organisatie/kenniscentra/centre_expertise_emissions_assessment.html

[127] Nuutinen, J., Yli-Pirilä, P., Hytönen, K., Kärtevä, J., 2007, Turvetuotannon poly- ja melupäästöt sekä vaikutukset lähialueen ilmanlaatuun, Symo

[128] Tissari, J. M., Yli-Tuomi, T., Raunemaa, T. M., Tiitta, P. T., Nuutinen J. P., Willman, P. K., Lehtinen, K. E. J., Jokiniemi, J. K., 2006, Fine particle emissions from milled peat production, Boreal Environmental research 11:283-293, Helsinki 30 August 2006

#### 3.3.3.2 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Time series reported in NFR1B1c have been reviewed in later years and is considered to be consistent. Uncertainties for emissions are mostly expert estimates. For COG flaring, uncertainties in activity data are high since the amount of flared gas are not measured as carefully as combusted gas (this statement is true for any plant). Uncertainties for particulate emissions from handling of solid fuels are ± 20% and based on expert judgement. More detailed information is to be found in Annex 1.

#### 3.3.3.3 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 3.3.3.4 SOURCE-SPECIFIC RECALCULATIONS

For flaring of COG, the following recalculations are made in submission 2025:

- $SO_2$ emissions in environmental report of one facility for 2022 was corrected, resulting in 0.0002 kt emission decrease.
- Emissions of PM10 and PM2.5 were recalculated for the entire timeseries. Particle fraction distribution between NFR categories was revised, resulting in annual emission changes by -0.00003 – +0.00004 kt for PM10, and by -0.00001 – +0.00003 kt for PM2.5.

Handling of solid fuels: In submission 2025, particle emissions from handling of coal were re-allocated from NFR1B1c to NFR1B1a in response to recommendations during the NECD review of the 2023 and 2024 submission. As a result, emissions in NFR1B1c were reduced by 0.3-0.5 kt TSP, 0.1-0.2 kt PM10 and 0.1-0.2 kt PM2.5 for the years 1990-2022.

Furthermore, a small update of activity data from official statistics in Sweden has been made for the year of 2022 in submission 2025. The changes resulted in a small increase in TSP, $PM_{10}$ and $PM_{2.5}$ emissions.

#### 3.3.3.5 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 3.3.4 Oil – exploration, production, transport, NFR1B2a i

#### 3.3.4.1 SOURCE CATEGORY DESCRIPTION

No exploration or production occurs in Sweden, and thus “NO” is reported for NFR1B2ai. Up until submission 2024, emissions from hydrogen production at refinery facilities were reported in NFR1B2ai. In submission 2025, these emissions have been reallocated to NFR 1B2aiv.

#### 3.3.4.2 SOURCE-SPECIFIC RECALCULATIONS

In submission 2025, emissions from hydrogen production at refineries have been re-allocated to NFR 1B2aiv.

### 3.3.5 Refineries, NFR1B2a iv

#### 3.3.5.1 SOURCE CATEGORY DESCRIPTION

There are five refinery facilities in Sweden. Emissions from refineries reported in NFR1B2a iv include:

- Fugitive emissions of NMVOC from the total refinery area (occur at all five facilities);
- $SO_2$ emissions from desulphurisation (occur at four facilities);
- Emissions from catalyst regeneration and make-up coke combustion (occur at three facilities) – NMVOC, $NH_3$, PAH, CO, $NO_x$, dioxin, $SO_2$, TSP, $PM_{10}$, $PM_{2.5}$, BC, and from submission 2020 – also heavy metals (Ni, Cr, Zn, Cu, Cd, Hg, and As).
- Emissions from hydrogen production at refinery facilities – $NO_X$, CO, NMVOC, $SO_2$, $NH_3$, TSP, $PM_{10}$ and $PM_{2.5}$, BC, and dioxin.

A summary of the latest key source analysis is presented in Table 3-42.

**Table 3-42. Summary of key source analysis, NFR1B2a according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1B2a i,iv,v | *Oil – NMVOC* | *Oil – NMVOC, SO2* |

#### 3.3.5.2 METHODOLOGICAL ISSUES

Sweden estimates emissions by using the Tier 2 method. The Tier 2 method requires data at plant level and Sweden uses data provided by the refineries in their annual environmental reports. Emissions are reported from catalyst regeneration and make-up coke combustion, desulphurization, from the storage and handling of oil, and from hydrogen production plants at refineries.

For 2021 onwards, all emissions from refineries, including 1B2a iv refining/storage, and 1B2c venting and flaring at refineries, and the relevant activity data are included in the reporting under the category NFR1A1b (petroleum refining) due to confidentiality issues.

##### *3.3.5.2.1 Catalyst regeneration*

Since submission 2009, emissions from catalytic cracking and combustion of make-up coke in refineries are reallocated from the energy sector to NFR1B2a iv (hence the combustion is not carried out for energy purposes). This was based on a study performed by SMED[129]. The cracking reactions produce some carbonaceous

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[129] Skårman, T., Danielsson, H., Kindbom, K., Jernström, M., Nyström, A-K. 2008. Fortsättning av riktad kvalitetskontrollstudie av utsläpp från industrin i Sveriges internationella rapportering. SMED Report 2008

material (referred to as *coke*) that deposits on the catalyst and very quickly reduces the catalyst reactivity. The catalyst is regenerated by burning off the deposited coke. Combustion of cracker coke occurs at three facilities. At one of the facilities, there is a large fluidized catalytic cracker (FCC), which contributes to over 95% of all the emissions from catalyst regeneration and make-up coke combustion.

**Particle emissions** from FCC have been obtained from the company's environmental reports from 2010 onwards (for $PM_{2.5}$, an assumption was made that it constitutes 85% of $PM_5$ specified in the environmental reports). These particles do not origin in the combustion processes but represent fine catalyst mass. The particle size distributions for 1990-2009 have been estimated with expert judgement. The assumed size distribution is 95% of TSP for $PM_{10}$, and 85% - for $PM_{2.5}$. BC emissions are estimated with a standard share specified in the EMEP/EEA Guidebook 2023. The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e., not in diluted flue gases. Particle emissions from the other two facilities where catalyst regeneration occur are estimated with implied emission factors calculated for FCC. Amounts of make-up coke are taken from the company's reporting to the EU ETS system.

**CO emissions** from FCC are estimated based on the total facility's CO emissions (as specified in the environmental report) and the relative input of cracker feedstock to the total material input to the refinery processes. Implied emission factor calculated for FCC is further used to estimate CO emissions from the other two facilities with coke combustion and catalyst regeneration processes.

**$NO_x$, $SO_2$ and heavy metal emissions** from FCC are taken from the facility's environmental reports. Emissions of heavy metals are reported by the facility for the years from 2000, and for the earlier period estimated with implied emission factors and amounts of burnt make-up coke. For the other two facilities, default emission factors from the EMEP/EEA Guidebook 2023 are used for $NO_x$, and FCC-based implied emission factors – for $SO_2$ and for heavy metals. Emissions of heavy metals (Ni, Cr, Zn, Cu, Cd, Hg, and As) from refinery processes are reported starting from submission 2020.

Other emissions are calculated with the plant-specific activity data and either national emission factors (**PAH, dioxin**) or default emission factors specified in the EMEP/EEA Guidebook 2023 for the catalyst regeneration stage (**$NH_3$, NMVOC).**

In 2020, combustion of cracker coke was significantly lower than in 2019, which resulted in the decrease of all emissions by ~70% compared to 2019. This is because FCC was out of operation most part of the year. In 2021-2022, combustion of cracker coke was back to normal operation conditions, and the emission increased.

### *3.3.5.2.2 Desulphurization*

Emissions of **$SO_2$ from desulphurization** significantly decreased after 1994 and were between 0.18 and 0.50 Gg during 1995-2022.

### *3.3.5.2.3 Fugitive NMVOC emissions*

**Fugitive emissions of NMVOC** from refineries include emissions from the process area as well as emissions from the refinery harbors when loading tankers. The estimates of NMVOC are mainly based on reported data from the facilities' environmental reports and older reports from the Swedish EPA[130],[131],[132],[133] and Statistics Sweden[134]. The total numbers in the environmental reports most often cover NMVOC emissions from both evaporation (fugitive emissions) and flaring (NFR 1B2c) – fugitive emissions are thus calculated by subtracting flaring emissions from the totals for the entire time-series. For certain years, where emission data is missing, implied emission factors (emissions per tonne crude oil) are used.

Activity data reported is amount of processed crude oil (Mg), specified in the facilities’ environmental reports.

### *3.3.5.2.4 Hydrogen production at refineries*

Since the 1980s, one of the Swedish refineries has had hydrogen production. In 2006, another refinery took a hydrogen plant into operation. Two other refineries launched hydrogen production facilities recently – one started production in 2019, another one in 2020.

The Tier 2 method is used to estimate emissions. Activity data is amount of feedstock used for hydrogen production (e.g., naphta, LNG), as reported to the EU ETS for three of four facilities. One of the plants does not report amounts of feedstock - a mixture of butane, off-gas from one of the refinery units, and LNG. Instead, to calculate CO2 emissions reported to the EU ETS, the facility uses amounts of so called ‘PSA (pressure swing adsorption) gas’ - energy-poor off-gas from the hydrogen production unit. PSA gas is a good proxy for activity data for this particular plant with a complicated feedstock structure; however, it is not a feedstock. For calculation of emissions other than CO2, the amounts of feedstocks at this facility for the entire time series have been estimated based on the ratio amount of LNG used as feedstock / corresponding amount of PSA gas during 2014-2019. Neither the exact amounts of the other two feedstocks nor the relations between the different feedstock amounts are known.

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[130] Swedish EPA, 1990.

[131] Swedish EPA, 1994a.

[132] Swedish EPA, 1994b.

[133] Swedish EPA. 1995.

[134] Statistics Sweden. 1996 Emissions to air in Sweden of volatile organic compounds (VOC) 1988 and 1994.

Emissions are calculated with plant-specific activity data and national emission factors. Due to lack of specific emission factors, “other petroleum fuels” emission factors are used for naphtha, and emission factors for refinery gas are used for the mixture of gases at the facility that reports amounts of PSA gas to the EU ETS. For two of three facilities, emissions of NOx and TSP are taken from the facilities’ environmental reports.

Within a development project during 2018-2019[135], efforts were made to investigate whether alternative emission factors can be used instead of currently used national emission factors for stationary combustion. The project work, performed in close cooperation with the refineries, resulted in better accounting of information available in environmental reports (often based on continuous measurements) in the emission inventories. In particular, NOx emission factor for LNG/natural gas as feedstock was revised with respect to available (measurement) data. However, no relevant emission factors specific for hydrogen production were found in the literature.

The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e., not in diluted flue gases.

The emissions of SO2 from hydrogen production ended in 2011 when naphtha was no longer used as a raw material in the production.

#### 3.3.5.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR1B2a iv are displayed in Annex 1. Uncertainties are mostly expert estimates.

Since all emissions from refineries are reported in NFR 1A1b from 2021 onwards due to confidentiality issues, the time series is not consistently reported at the NFR category level. However, the collected emissions from refineries are consistently estimated throughout the time-series, and total emissions from refineries for some of the pollutants are shown below in Figures 3-20 – 3-21.

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[135] Yaramenka, K., Kindbom, K., Helbig, T. 2019. Improvements in the reporting of fugitive emissions (CRF and NFR 1B), Phase II. SMED Report No 8 2019.

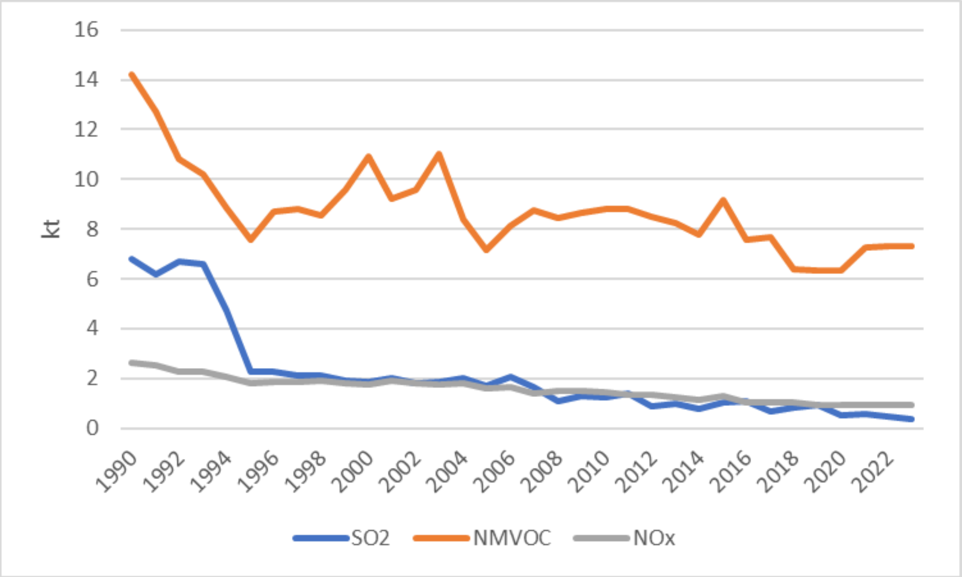

**Figure 3-20. Total emissions from refineries (1A1b, 1B2aiv and venting and flaring at refineries in 1B2c) for SO2, NMVOC and NOx for the whole period for refineries.**

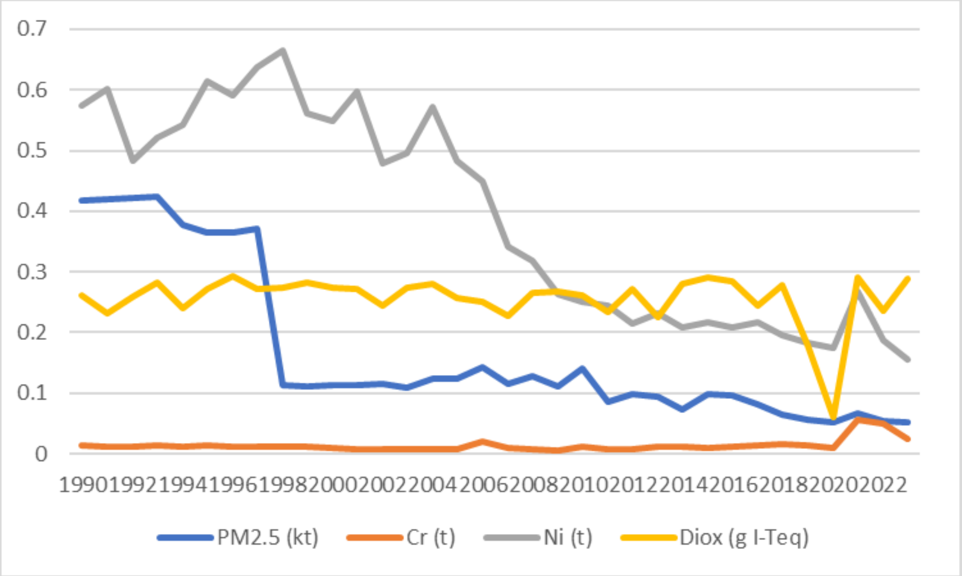

**Figure 3-21. Total emissions from refineries (1A1b, 1B2aiv and venting and flaring at refineries in 1B2c) for PM2.5, Cr, Ni and Dioxin for the whole period for refineries.**

### 3.3.5.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

### 3.3.5.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2025, emissions from hydrogen production plants at refineries were re-allocated from NFR1B2ai to NFR1B2aiv.

#### 3.3.5.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 3.3.6 Fuel handling and distribution, NFR1B2a v

#### 3.3.6.1 SOURCE CATEGORY DESCRIPTION

NFR1B2a v includes fugitive emissions of NMVOC from the storage of oil products (oil depots) and from fuel handling and distribution (gasoline, diesel, jet fuels).

Previous submissions did only include gasoline handling but from submission 2025 onwards diesel and jet fuels are included.

A summary of the latest key source analysis is presented in Table 3-43.

**Table 3-43. Summary of key source analysis, NFR1B2a, according to approach 1.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 1B2a i,iv,v | Oil – NMVOC | Oil – NMVOC, SO2 |

#### 3.3.6.2 METHODOLOGICAL ISSUES

##### *3.3.6.2.1 Gasoline stations*

The calculation of the NMVOC time series for fugitive emissions from gasoline distribution is based on methods given by EMEP/EEA Guidebook 2023 which in turn refers to Concawe[136]. The fugitive emissions, which mainly consist of evaporation losses, arise from three sources at the fuel stations: drip and spill when refueling, refueling of vehicles and refueling of fuel tanks.

The emission calculations are based on the following parameters and data sources:

-Volume gasoline ($m^3$). Data is obtained from Statistics Sweden.
-Emission factors taken from EMEP/EEA Guidebook 2023.
-True vapour pressure (kPa). Calculated based on equation in Concawe 2019. TVP is depending on the vapour pressure and annual average temperature.
-Abatement factors (vapour recovery rate). Gathered from the Swedish Transportation administration TSFS 2016:36 and the EU directive 94/63/EG.

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[136] Concawe 2019 report no. 4/19. Air pollutant emission estimation methods for E-PRTR reporting by refineries.

Since the vapour recovery controls was not fully implemented until 1994 the emissions are significant higher 1990-1994 compared to the rest of the time series. Table 3-44 lays out the development of technical installations during 1990-1994.

**Table 3-44. Fraction of gasoline stations with technical measures installed.**

| Year | Large gas stations >2000 m³ | Small gas stations |
|---|---|---|
| 1988 – 1990 | 0% | 0% |
| 1991 | 50% | 0% |
| 1992 | 75% | 25% |
| 1993 | 100% | 75% |
| 1994 - | 100% | 100% |

### *3.3.6.2.2 Oil depots*

Calculated fugitive emissions of NMVOC from the storage of oil products have been obtained from SPI[137] or from the environmental reports of the oil depots. The calculations are based on the amount of gasoline handled in the depots.

The calculations cover the years 1990 and onwards and are based on methods given by Concawe 85/54[138] for the years 1990-2006 and on Concawe 03/07[139] for the years 2007 and onwards. More than 30 depots have been considered during later years. Gas recovery systems and the recovered amount of gas have been considered in the calculations. For five depots the reported NMVOC emissions are based on emission measurements in the depot areas and not on calculations based on the amount gasoline handled in the depots. For some years, for which no data was provided, emissions were by using interpolation.

### *3.3.6.2.3 Handling of other fuels*

Other fuels include diesel, jet kerosene and jet gasoline. The emission calculations are based on Tier 1 methods from 2019 Refinement[140]. The calculation method is based on volume of handled fuel multiplied by emission factors for the different fuels. Data on the volumes of fuel are obtained from Statistics Sweden.

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[137] Per Brännström, 2009-, personal communication; Leif Ljung -2009, personal communications

[138] Concawe, 1986, Hydrocarbon emissions from gasoline storage and distribution systems, Report No 85/54.

[139] Concawe Report No. 3/07, Air pollutant emission estimation methods for E-PRTR reporting by refineries

[140] 2019 Refinement Volume 2, Chapter 4 Fugitive emissions, 1B2av Distribution of Oil products (pp 60-61).

**Table 3-45. Estimated fugitive emissions of NMVOC (kt) from storage at depots, gasoline stations and handling of other fuels.**

| Year | Fugitive emissions of NMVOC at depots Gg | Fugitive emissions of NMVOC at gasoline stations, Gg | Fugitive emissions of other fuels |
|---|---|---|---|
| 1990 | 2.48 | 11.6 | 0.55 |
| 1995 | 1.93 | 2.80 | 0.41 |
| 2000 | 2.07 | 2.61 | 0.14 |
| 2005 | 2.31 | 2.68 | 0.16 |
| 2010 | 2.23 | 2.21 | 0.19 |
| 2015 | 2.03 | 1.69 | 0.21 |
| 2020 | 1.58 | 1.35 | 0.20 |
| 2021 | 1.43 | 1.37 | 0.21 |
| 2022 | 1.64 | 1.34 | 0.21 |
| 2023 | 1.34 | 1.33 | 0.20 |

### 3.3.6.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Time series reported in NFR 1B2a v have been reviewed in later years and are considered to be consistent. Uncertainties for NMVOC emissions reported in NFR 1B2a v are ± 75% and based on Guidebook Quality Rating C. More detailed information is to be found in IIR Annex 1.

### 3.3.6.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

### 3.3.6.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2025, fugitive NMVOC emissions from gasoline stations have been recalculated from 1990 onwards. Estimates are based on methods given by EMEP/EEA Guidebook 2023 which refers to an updated method provided in Concawe 2019 (previous source Concawe 1988).

The calculated emissions decreased by approximately 18% throughout the time series due to implementation of the new method. The decrease is about 0,3-0,6 kt NMVOC per year throughout the time series, with the exception for the first part of the time series 1990-1994 when the emissions were considerably higher due to lack of vapour recovery installations.

In addition, fugitive NMVOC emissions from handling of other fuels than gasoline have been added in submission 2025, adding 0.14 to 0.55 kt NMVOC to the source category.

#### 3.3.6.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 3.3.7 Transmission and distribution of natural gas and gasworks gas – fugitive emissions, 1B2b

#### 3.3.7.1 SOURCE CATEGORY DESCRIPTION

NFR1B2b includes fugitive emissions of NMVOC from transmission and storage of natural gas and biogas (1B2b iv) and from distribution of natural gas, biogas and gasworks gas (1B2b v). A summary of the latest key source analysis is presented in Table 3-46.

**Table 3-46. Summary of key source analysis, NFR1B2b, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1B2b | - | - |

#### 3.3.7.2 METHODOLOGICAL ISSUES

In 2013, a national method for estimating fugitive emissions of natural gas and gasworks gas was developed[141]. Emission of NMVOC from this subsector were for the first time reported in submission 2014.

#### *3.3.7.2.1 Transmission and storage of natural gas NFR1B2b iv*

Emission estimates for gas transmission and storage are based on information provided by Swedegas, the operator of the gas transmission pipeline and storage in Sweden.

The Swedish network for gas storage and transmission includes several different types of facilities: metering and regulation stations (M/R stations), compressor stations, ramification stations, valve stations, pig launcher & receiver stations, and a storage facility. According to Swedegas[142], many of the facilities are combined, e.g., valves located close to M/R stations. To enable biogas transmission in the network, two compressor stations were put into operation in 2014 – one combined with M/R station and one stand-alone facility. The stand-alone facility was taken out of operation in 2020.

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[141] Jerksjö M., Gerner A., Wängberg I. 2013

[142] Bjur & Lindsjö, 2016

In 2016, the method for estimating the emissions from the gas transmission network was revised since new measurements of methane emissions became available[143]. Methane leakage rates per hour have been measured at all major types of facilities. Estimated emission factors (see Table 3-47 below) have been applied to the number of facilities of each type.

**Table 3-47. Method for estimation of gas leakage from the national gas transmission network.**

| Facility typ.e | $CH_4$ EF g/hour | Number of facilities in 2022 | Comment |
|---|---|---|---|
| M/R station | 91 | 43 | Number of facilities is known for the whole time series |
| Storage | 200 | 1 | In operation since 2006 |
| M/R + compressor station | 222 | 1 | In operation since 2014 |
| Valve station | 30 | 26 | For the years 1990-2014, the number of facilities is assumed to be in direct proportion to the network's length (320 km in 1990, 620 km in 2017) |
| Pig launcher & receiver station | 300 | 9 | |
| Ramification station | 30 | 39 | |

Methane emissions have been further calculated to NMVOC emissions by using parameters shown in Table 3-48. Information on gas composition was obtained from Swedegas and constitutes average values from the period 2006 to 2012.

**Table 3-48. Composition and physical properties of natural gas.**

| Property | Unit | Value |
|---|---|---|
| Methane content in natural gas | % by weight | 78.6 |
| NMVOC content in natural gas | % by weight | 19.0 |
| Density of natural gas | kg/Nm$^3$ | 0.817 |
| Density of methane | kg/Nm$^3$ | 0.716 |

As explained above, emissions of NMVOC are based on the amount of the different facility types within the national gas transmission network.

Emissions that are controlled and associated with regular network maintenance work rather than with uncontrolled gas leakage are reported in the sector *NFR1B2c Venting and flaring*.

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[143] Jerksjö, M., Salberg, H. 2016. Mätningar av metanläckage längs svenska naturgasnätets stamledning, IVL report C202 (in cooperation with Fluxsense)

### *3.3.7.2.2 Natural gas distribution 1B2b v*

There are three types of gas networks for distribution of gas in Sweden.

1. The gas network for distribution of natural gas (since 2016 mixed with biogas)
2. Local biogas distribution network
3. Gasworks gas distribution network.

The gas network for distribution of natural gas is connected to the national transmission pipeline via M/R stations as mentioned above and had a total length of 2620 km in year 2012. This network delivers natural gas to the end users, which are industries or municipalities which in turn use the gas for energy production, to feed their town gas networks, etc. There are about 40 small local distribution networks for biogas in Sweden[144]. The total length was 146 km in 2012. The biogas is of similar quality as natural gas and is distributed in similar distribution pipes as natural gas.

Most of the gasworks gas networks use natural gas and their distribution system has been modernized and considered to be of the same standard as the distribution system for natural gas. However, the gasworks gas networks in Stockholm and Gothenburg (the two largest cities in Sweden) are different. These networks consist to a large part of old pipes with considerable high leaking rate. Between 1990 and 2011, a facility in Stockholm produced gasworks gas from cracking light petroleum. In 2011, they started to use a mixture of natural gas and air. The city of Gothenburg produced gasworks gas of a similar quality as that in Stockholm during the period 1990 – 1993. In 1993, the city of Gothenburg shifted to a mixture of natural gas and air. Activity data in terms of leakage of gasworks gas has been obtained from the gasworks gas distributor in Stockholm for the years 2002-2012. For earlier years, only production data is available, and the average relation of leakage to production has been used to estimate leakage for the years 1990-2001. The emissions of NMVOC have been calculated with data on chemical composition of gas from cracking and natural gas/air mixture. The methodology is described in Jerksjö et al[145].

Since no measurement on fugitive methane emissions from distribution of gas has been made in Sweden, emission factors found in the literature were compared and examined. Information on the Swedish gas network was collected by contacting the operators. Based on this information an emission factor obtained from a Dutch investigation (Wikkerlink 2006[146]) was chosen. The emission factor is the result of an

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[144] Jerksjö, M., Gerner, A., Wängberg, I. 2013. Development of method for estimating emissions of methane, NMVOC and carbon dioxide from natural gas, biogas and town networks in Sweden. SMED Report No: 121, 2013.

[145] Jerksjö, M., Gerner, A., Wängberg, I. 2013. Development of method for estimating emissions of methane, NMVOC and carbon dioxide from natural gas, biogas and town networks in Sweden. SMED Report No: 121, 2013.

[146] Wikkerlink. 2006.

evaluation of data from measurements of gas leaks at several places in the Netherlands and is equal to 120 $Nm^3$ methane per km distribution line. According to net operators of new or renewed Swedish networks for natural gas, the networks in Sweden are of similar standard and design as those in the Netherlands. The Dutch emission factor is considered to be valid for pipes made from PVC and polyethylene, etc., and can be used as an average value covering different pressure regimes. The emission factor from the Dutch study was adopted for estimating the methane emissions from Swedish gas networks 1. (Natural gas) and 2. (Biogas) and also gas networks in cities with new or renewed distribution systems.

Data on gas mixtures, sources of activity data and emission factors used for emission calculations in NFR1B2b v for each gas distribution network are summarized in Table 3-49.

**Table 3-49. Summary of method for calculating emissions from Swedish gas distribution networks.**

| Gas distribution networks | Natural gas* | Local biogas | Gasworks gas – Stockholm |
|---|---|---|---|
| Gas mixture used | Natural gas | Biogas of similar quality as natural gas | Mixture of natural gas and air. Until 2011 – gasworks gas and mixture of natural gas and air |
| Source of activity data | Gas distribution companies | Grönmij. 2009 | Stockholm gas environmental reports |
| Type of activity data | km length | km length | $Nm^3$ gas leakage |
| Emission factor for NMVOC | No emission factors are used. Emissions are calculated based on estimated methane emissions and the content of $CO_2$ and NMVOC in the natural gas. | | No emission factors are used. Emissions are calculated based on the content of NMVOC in the gas mixtures considered |

* Including a number of city gas distribution networks, for instance Gothenburg gas distribution network since 2011.

The gas distribution networks in Stockholm and Gothenburg constitute of both old and new or re-lined pipes. The old pipes have a relatively high leaking rate. During 1990 to January 2011 gasworks gas (i.e. from cracking of light petroleum) was produced and distributed in the Stockholm gas network. In January 2011 one started to use a mixture of natural gas and air. The city of Gothenburg produced gasworks gas of a similar quality as that in Stockholm during the period 1990 – 1993. In 1993, the city of Gothenburg shifted to a mixture of natural gas and air and since the beginning of 2011, pure natural gas.

The fugitive emissions from distribution of gasworks gas in Stockholm and Gothenburg have been estimated from statistics on production of gasworks gas and natural gas air mixtures and leakage rates from Stockholm Gas. The content of NMVOC in gasworks gas and natural gas air mixture is shown in Table 3-50.

Table 3-50. NMVOC content in gasworks gas.

| Property | Unit | Value |
|---|---|---|
| NMVOC in gasworks gas | kg/Nm$^3$ | 0.04 |
| NMVOC in natural gas air mixture | kg/Nm$^3$ | 0.08 |

#### *3.3.7.2.3 Post-meter emissions 1B2B6*

Fugitive emissions of NMVOC from natural gas leakage in industry, households and commercial appliances and gas vehicles were, are reported for the first time in submission 2025. This is a small emission source of NMVOC as the main emission from natural gas leakage is methane. In submission 2025, a complete timeseries is reported for all emission segments.

Leakage sources in the three segments are:
**Industry** - Leakage from internal piping
**Appliances** - Leakage from house piping and natural gas appliances such as furnaces, water heaters, stoves and ovens, and barbecues/grills.
**Gas vehicles** - Leakage from dead volumes during fuelling, emptying of gas cylinders of high-pressure interim storage units, for execution of pressure tests and relaxation of residual pressure from vehicles' gas tanks, or decommissioning.

Tier 1 emission factors used for the different segments are presented in the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (see Table 3-51).

Table 3-51 NMVOC emission factors for the post-meter segment.

| Segment | NMVOC | Units of measure |
|---|---|---|
| Leakage at industrial plants and power stations. | 0.03 | Tonnes/million m3 gas consumed |
| Appliances in commercial and residential sector | 1.0*10^-4 | Tonnes/appliance |
| Natural gas-fueled vehicles | 9.3*10^-6 | Tonnes/car |

The reported emissions from post-meter leakage in industry, appliances and from gas vehicles during 2023 was 0.015 kt NMVOC. For most years in the time series the calculated emissions are within the span 0.015-0.025 kt NMVOC.

### 3.3.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

*Gas transmission*: The associated emission uncertainty is ±50% according to expert estimates. More detailed information is to be found in IIR Annex 1.

*Gas distribution*: Fugitive emissions from the distributing network in Stockholm constitute 80 – 90% of the total emissions from gas distribution in Sweden. The emission data from the Stockholm distribution network is based on measurements provided by the operator and the associated uncertainty is estimated to ± 50%. The total uncertainty concerning distribution of gas in Sweden is largely influenced by the contribution from the gas network in Stockholm and is thus likewise estimated to ± 50%. More detailed information is to be found in IIR Annex 1.

*Post-meter emissions*: The associated emission uncertainty is ±60% based on expert judgement. More detailed information is to be found in IIR Annex 1

#### 3.3.7.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 3.3.7.5 SOURCE-SPECIFIC RECALCULATIONS

New sources reported in 1b2b4 and 1b2b6 (Fugitive leakage emissions from LNG terminals, industry, gas vehicles, appliances in residential and commercial sector. For most years in the time series the newly calculated emissions for 1b2b6 are within the span 0.015-0.025 kt NMVOC. New sources added in 1b2b4 (LNG terminals) only concern $CO_2$ and $CH_4$ and are therefore not reported in IIR.

#### 3.3.7.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 3.3.8 Venting and flaring, NFR1B2c

#### 3.3.8.1 SOURCE CATEGORY DESCRIPTION

NFR1B2c includes emissions of NMVOC from gas venting as well as emissions from flaring of gas and/or oil products at refineries and during the national gas network maintenance ($NO_X$, CO, NMVOC, $SO_x$, $NH_3$, TSP, $PM_{10}$, $PM_{2.5}$, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, Se, PAH and dioxin). A summary of the latest key source analysis is presented in Table 3-52.

**Table 3-52. Summary of key source analysis, NFR1B2c, according to approach 1.**

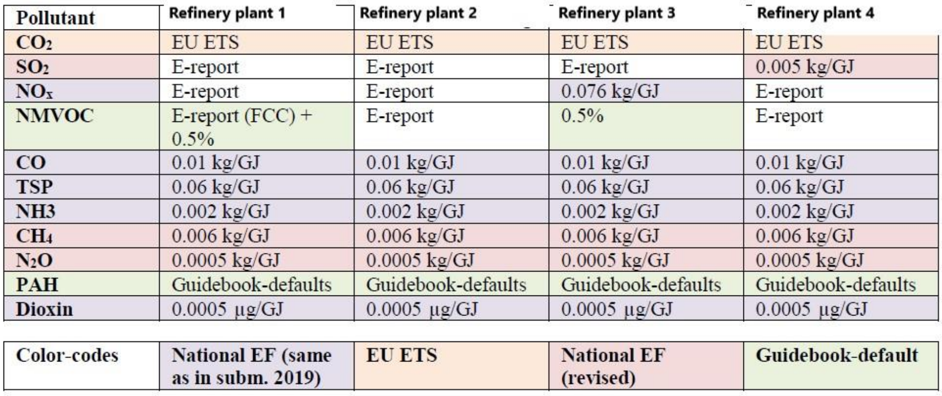
| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 1B2c | - | *SO2* |

#### 3.3.8.2 METHODOLOGICAL ISSUES

For flaring of oil products and refineries during 1990-2004, activity data has been collected directly from the plant operators. For 2005 and onwards, activity data is mainly taken from the EU ETS system. Plant specific net calorific values are used when available. The reported activity data are amounts of flared gas mixture in TJ.

The same emission factors are used as for stationary combustion if no other emission factors or emissions are available. The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e. not in diluted flue gases.

Within a development project during 2018-2019[147], flaring at refineries was investigated in detail. Efforts were made to find alternative emission factors to be used instead of national emission factors for stationary combustion. The project work, performed in close cooperation with the refineries, resulted in better accounting of facility-specific information available in environmental reports (often based on measurements) in the emission inventories. This data, where available, is prioritized in the inventory overestimates made with national emission factors for stationary combustion ("E-report" in Figure 3-23).



| Pollutant | Refinery plant 1 | Refinery plant 2 | Refinery plant 3 | Refinery plant 4 |
|---|---|---|---|---|
| **$CO_2$** | EU ETS | EU ETS | EU ETS | EU ETS |
| **$SO_2$** | E-report | E-report | E-report | 0.005 kg/GJ |
| **$NO_x$** | E-report | E-report | 0.076 kg/GJ | E-report |
| **NMVOC** | E-report (FCC) + 0.5% | E-report | 0.5% | E-report |
| **CO** | 0.01 kg/GJ | 0.01 kg/GJ | 0.01 kg/GJ | 0.01 kg/GJ |
| **TSP** | 0.06 kg/GJ | 0.06 kg/GJ | 0.06 kg/GJ | 0.06 kg/GJ |
| **NH3** | 0.002 kg/GJ | 0.002 kg/GJ | 0.002 kg/GJ | 0.002 kg/GJ |
| **$CH_4$** | 0.006 kg/GJ | 0.006 kg/GJ | 0.006 kg/GJ | 0.006 kg/GJ |
| **$N_2O$** | 0.0005 kg/GJ | 0.0005 kg/GJ | 0.0005 kg/GJ | 0.0005 kg/GJ |
| **PAH** | Guidebook-defaults | Guidebook-defaults | Guidebook-defaults | Guidebook-defaults |
| **Dioxin** | 0.0005 µg/GJ | 0.0005 µg/GJ | 0.0005 µg/GJ | 0.0005 µg/GJ |

| | | | | |
|---|---|---|---|---|
| **Color-codes** | **National EF (same as in subm. 2019)** | **EU ETS** | **National EF (revised)** | **Guidebook-default** |

**Figure 3-23. Methodology of the reporting of emissions from flaring at refineries**

The emission factor for NMVOC from stationary combustion (implying 0.01% unburnt hydrocarbons) was replaced with the default emission factor from the EMEP/EEA Guidebook 2019 (no changes in the 2023 Guidebook version) for refinery gas flaring, implying 0.5% unburnt hydrocarbons. Other improvements include revision of estimates made for the years 1990-2004 and better accounting of facility-specific shares of refinery gas, natural gas, LNG, sulphur-rich gases and hydrogen in the flared gas mixture. Emissions of dioxin are based on the national emission factors for stationary combustion. Emissions of PAH and heavy metals (Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, Se), based on the default emission factors from the EMEP/EEA Guidebook 2023. The subcategory also includes occasional emissions from venting and flaring of natural gas during a network inspection at Swedegas. Network inspection conducted once in eight years (sometimes more often) requires so called piggning – emptying M/R stations, which means release of certain amounts of natural gas. A larger part of the released gas is flared but some is

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[147] Yaramenka, K., Kindbom, K., Helbig, T. 2019. Improvements in the reporting of fugitive emissions (CRF and NFR 1B), Phase II. SMED Report No 8 2019.

vented. From the years 2014 estimated amounts of gas vented during the inspections have been obtained from the operator. For the years 2006, 1998 and 1990 estimates were made based on the relation of the amount of vented gas to the number of M/R stations in 2014-2015. Emissions of NMVOC from piggning are well below 0.1 t.

Beside piggning operations, there is certain amount of gas annually vented to the atmosphere (earlier reported as diffuse emissions) from M/R stations – between 11 and 13 $Nm^3$ gas per station for recent years, or about 0.1 ton NMVOC in total per year. Much higher and much more varying venting emissions come from the storage facility (put into operation in 2006) – from 0.1 to 17 t NMVOC per year, depending on how well the compressor worked. In 2013 the compressor failure[148] resulted in particularly high emissions.

#### 3.3.8.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Estimates of emissions from natural gas venting are provided by the operator. The associated uncertainty is ± 50% according to expert estimates. The activity data uncertainty for flaring of different fuels at refineries and other industrial facilities is as reported to EU ETS and is estimated to ±17.5%. For gas and oil flaring, the total emission uncertainties are affected by uncertainties in the emission factors, which are the same as for industrial combustion. More detailed information is to be found in IIR Annex 1.

Since all emissions from refineries are reported in NFR 1A1b from 2021 onwards due to confidentiality issues, the time series is not consistently reported at the NFR category level. However, the collected emissions from refineries are consistently estimated throughout the time-series and total emissions from refineries for some of the estimated pollutants are shown in Figures 3-20 and 3-21, chapter 1.1.4 Refineries, NFR1B2a iv.

#### 3.3.8.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The coherence between environmental reports and ETS data is checked when possible, and when differences occur, the facilities are contacted for verification.

#### 3.3.8.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculation occurred in this sub-sector in submission 2025.

#### 3.3.8.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

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[148] Hellström 2013-2015

### 3.3.9 Other fugitive emissions from energy production, NFR1B2d

No other fugitive emissions from energy production are reported by Sweden.

# 4 Industrial processes and product use (NFR sector 2)

## 4.1 Overview

For Sweden, the most important industries within the industrial sector have historically been base industries such as mining, iron and steel industry and pulp and paper industry. Other important industries when considering emissions from industrial processes include the cement industry, primary aluminum production and processes in the chemical industry.

Generally, three sources of information concerning activity and emission data for the industrial process sector have been used:

- Emission data as reported annually by facilities in legally required environmental reports to the authorities (see Annex 4).
- National production statistics or similar information at national level.
- Plant specific data collected by direct contacts with facilities.

The use of emission factors in the Swedish inventory for industrial processes is limited and, when used, they are nationally derived or specific for a facility. Where there are a large number of companies within a specific sector, and when all environmental reports are not available, a combination of information from environmental reports and production statistics on the national level, are used to estimate the sector's emissions on a national scale.

Emissions of $PM_{10}$ and $PM_{2.5}$ are in many cases calculated as a fraction of TSP. An overview of the fractions that are used within the sector are included in Annex 3.2.

Sweden’s emission inventory is in general in accordance with EMEP/ EEA Air Pollutant Emission Inventory Guidebook 2023[149], 2006 IPCC Guidelines[150], and the Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution[151].

## 4.2 Mineral products, NFR2A

Reported emissions include estimates for cement production (NFR2A1), lime production (NFR2A2), glass production (NFR2A3), Quarrying and mining of minerals

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[149] The EMEP/EEA Guidebook: http://www.eea.europa.eu/themes/air/emep-eea-air-pollutant-emission-inventory-guidebook/emep

[150] 2006 IPCC Guidelines for National Greenhouse Gas Inventories http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

[151] UNECE 2015, Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution. ECE/EB.AIR/128.

other than coal (NFR2A5a), Construction and demolition (NFR2A5b) and Other mineral products (NFR2A6). Emissions from the source category Storage, handling and transport of mineral products (NFR2A5c) have not been separated from the relevant mineral chapter and are included in respective source category, 2A1, 2A2, 2A3 or 2A5.

### 4.2.1 Cement production, NFR2A1

#### 4.2.1.1 SOURCE CATEGORY DESCRIPTION

Cement production occurred during 2023 at two facilities in Sweden (owned by one company), with one being dominant. One smaller facility owned by the same company shut down in 2019. Emission data is taken from environmental reports and by direct contacts with the facilities. Calculation methods have been discussed with the industry. Cement production quantity in 2023 is classified and hence not shown in this section.

The summary of the latest key source assessment is presented in Table 4.2.1.

**Table 4.2.1. Summary of key source analysis, NFR2A1, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2A1 | *PM2.5, $SO_2$* | *PM10, PM2.5, SO2, TSP* |

#### 4.2.1.2 METHODOLOGICAL ISSUES

All three cement-producing facilities (owned by one company) are covered in the reported estimates and the emissions have been estimated based on direct information from the company or from environmental reports. $NO_X$ emissions originate mainly from fuel combustion and less from industrial processes. Therefore, IE is reported for NOx in NFR 2A1, and emissions are reported in NFR 1A2f.

$SO_2$ emissions are allocated to industrial processes. For 2020, the largest company reported a revised method to estimate $SO_2$ emissions, which resulted in considerably higher emissions of $SO_2$ in 2020 than in previous years. Thus, for years prior to 2020 $SO_2$ is estimated using the old method, resulting in that reported data for $SO_2$ for year 2020 is not comparable to earlier years. Emissions of $SO_2$ have decreased substantially since 1990.

Reported emissions of TSP, $PM_{10}$ and $PM_{2.5}$ from 2010 onwards are substantially lower than average emissions in the 2000’s. The decreased emissions are due to the installation of a new dust filter at the largest site in 2010. The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e., not in diluted flue gases. BC emissions are reported for 2000 onwards and are calculated as a fraction of $PM_{2.5}$ according to EMEP/EEA Guidebook 2023.

$NH_3$ emissions arise partly due to the selective non-catalytic reduction (SNCR) of $NO_X$ where $NH_3$ is injected and partly from the raw material. Emissions have been included for the years that such an SNCR has been installed at respective plant. To ensure double reporting does not occur, reported emissions in the energy sector are subtracted from total $NH_3$ emissions reported by the company. There is a substantial variation in $NH_3$ emissions over the time series, which is due to variations in ammonia slip and the fact that emissions in the energy sector are subtracted from the total as reported by the company.

Emissions of heavy metals, PAH1-4 and dioxins from the fuels used are calculated based on Quarterly fuel statistics and reported in the energy sector (NFR1A2f).

Table 4.2.2 gives an overview of the allocation of pollutants from cement production.

**Table 4.2.2. Allocation of pollutants from cement production.**

| Pollutant | NFR |
|---|---|
| NOX | 1A2f |
| NMVOC | 1A2f |
| $SO_2$ | 2A1 |
| $NH_3$ | 2A1 and 1A2f |
| $PM_{2.5}$ | 2A1 |
| $PM_{10}$ | 2A1 |
| TSP | 2A1 |
| BC | 2A1 |
| CO | 1A2f |
| Metals | 1A2f |
| PAH1-4 | 1A2f |

### 4.2.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions are based on expert judgement. Assessed uncertainties for $SO_2$ and $NH_3$ are ± 20% and ± 400%, respectively. For TSP, $PM_{10}$ and $PM_{2.5}$, uncertainties are estimated to ± 30% each. More information is given in IIR Annex 1.

Time series for cement production reported in NFR2A1 has been reviewed in later years and are considered to be consistent.

### 4.2.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

### 4.2.1.5 SOURCE-SPECIFIC RECALCULATIONS

During submission 2025, small recalculations have been performed for particle emissions (all fractions) in 2021-2022, due to data corrections in the facilities' environmental reports. Increase in emissions for 2021: 0.00022 kt TSP, 0.00020 kt

PM10, 0.0018 kt PM2.5, 0.000005 kt BC. Decrease in emissions for 2022: 0.0011 kt TSP, 0.0010 kt PM10, 0.0009 kt PM2.5, 0.00003 kt BC.

$NH_3$ emissions have been recalculated for the years from 1997 onwards, as earlier performed revision of the method for estimating $NH_3$ in the energy has now been included in the calculation of emissions reported in NFR2A1; the recalculation resulted in the increase of annual $NH_3$ emissions by up to 0.002 kt.

#### 4.2.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 4.2.2 Lime production, NFR2A2

#### 4.2.2.1 SOURCE CATEGORY DESCRIPTION

In Sweden, quicklime, hydraulic lime and dolomite lime is produced at a number of facilities, owned by a few companies. Produced lime is, for instance, used in blast furnaces, in sugar and carbide production and in the pulp and paper industry to bind impurities and purify the produced material. The production of lime has increased since 1990 (about 440 kt) and peaked in 2005 (about 730 kt). In 2009 there was a large decrease in lime production due to the global economic recession. In 2017 and 2018, there was an increase in production compared to years 2014-2016, with quantities of around 625 kt, but slightly lower compared to years 2010-2013. Lime production in 2021 summed up to an amount of around 500 kt. Lime production 2022 onwards is classified and hence not shown in this section.

Emissions of $SO_2$, particulate matter and BC from lime production are reported in NFR2A2.

The summary of the latest key source assessment is presented in Table 4.2.3.

**Table 4.2.3. Summary of key source analysis, NFR2A2, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2A2 | *PM2.5, $SO_2$* | *PM10, PM2.5, $SO_2$* |

#### 4.2.2.2 METHODOLOGICAL ISSUES

Emissions of $SO_2$ from 1990 have been estimated for production of quick lime. The estimations from quick lime production are calculated using emission factors presented in environmental reports by one of the producers[152]. The emission factor provided by the lime producer is substantially higher for 2008 than for earlier years. This resulted in an increase of reported $SO_2$ emissions for 2008 compared to earlier years. However, in 2009 the reported $SO_2$ emissions were again on the same

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[152] Nordkalk, http://www.nordkalk.com

level as before 2008 due to less use of lime. For 2009-2023 the emission factor for 2008 has been used for the estimation of emissions of $SO_2$ due to lack of more recent information in the environmental reports.

Emissions of $SO_2$ from quick lime production intended for the pulp and paper industry are, as in earlier submissions, not included in the estimates reported in NFR2A2 but are reported in NFR2H1. $SO_2$ emissions from quick lime production within carbide production are from submission 2015 onwards included in NFR2A2.

Emissions of particles from lime production within conventional lime and sugar industries have been estimated using emission factors presented in environmental reports by one of the producers and the size fractions ($PM_{10}$ and $PM_{2.5}$) are based on expert judgement. The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e., not in diluted flue gases.

For particle emissions from quicklime production within carbide production, emissions are obtained from the company's environmental report.

BC emissions are included as of submission 2015 and are calculated as a fraction of $PM_{2.5}$ according to EMEP/EEA Guidebook 2023.

From 2005 onwards, facility-specific EU ETS data is used for activity data estimations, where the amount of burnt lime is calculated based on $CO_2$ emissions. In previous submissions, statistics from the Swedish Lime Association have been used for activity data for the entire time series, however, the statistics have not been produced in time, resulting in the need of an alternative data source. In a study carried out in 2015[153] different data sources were compared, and it was concluded that EU ETS data is the more reliable one. For 1990-2004, statistics from the Swedish Lime Association is used for activity data. Although different data sources are used over the time series, it was concluded that both sources provide similar results, and the time series can be considered consistent.

#### 4.2.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions are based on expert judgement. Assessed uncertainty for $SO_2$ is ± 20% and ± 50% for TSP, $PM_{10}$ and $PM_{2.5}$. More information is given in IIR Annex 1.

Time series from lime production reported in NFR code 2A2 have been reviewed in later years and are consistent.

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[153] Mawdsley, I. 2015. Change of activity data for lime production

### 4.2.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Activity data reported in NFR2A2 has been compared with national statistics from Statistics Sweden[154] and from the Swedish Lime Industry[155]. The comparison (Figure 4.2.1) shows that national statistics from Statistics Sweden are more irregular but for early years the coherence is good. The differences are especially high in 1998, 1999 and from 2004 and onwards. Comparison between reported activity data and activity data from the Swedish Lime Industry shows good compliance and only has small differences for a few years. National statistics are based on national surveys mainly aiming at collecting data for economic statistics. In these surveys not all facilities are included and for those the produced amounts are estimated, which might lead to over- or underestimations of, in this case, produced amounts of lime. This leads to larger fluctuations and higher uncertainties in the national statistics from Statistics Sweden compared to data from the Swedish Lime Association and the Swedish Lime Industry. In a study conducted in 2013[156], Gustafsson and Gerner concluded that national statistics from Statistics Sweden would likely result in overestimated emissions, as imported quantities are likely included in the data. In 2015 a review of NFR2A2 was made, where different data sources were compared and where it was determined that the best available data source for this source code is the EU ETS. The main reason being that the EU ETS data is verified by an accredited person and that the data from the Swedish Lime Association often arrive too late for the ordinary reporting timeline. As part of the QA / QC procedures, a comparison is made annually between activity data from the different data sources (EU-ETS, Statistics Sweden, the Swedish Lime Association) (Figure 4.2.1).

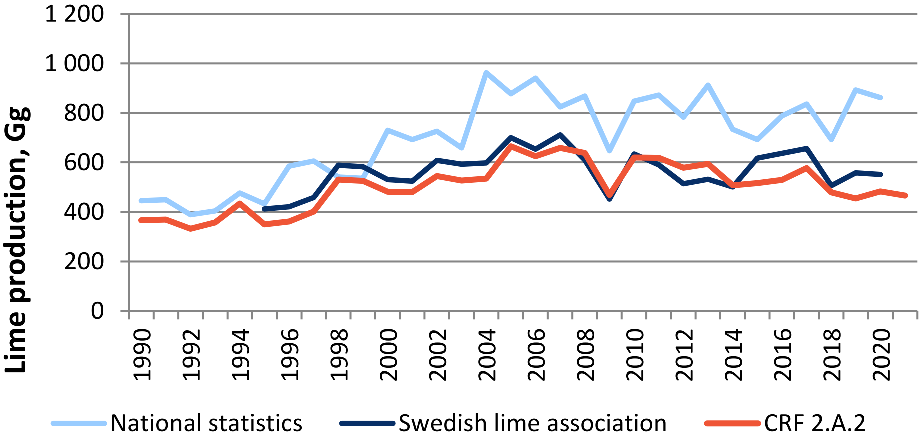

**Figure 4.2.1 National total on produced amount of lime according to data from Statistics Sweden, the Swedish Lime Association and reported data in NFR2A2.**

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[154] Statistics Sweden. Data from the Industrial production database: www.scb.se

[155] Swedish Lime Association and The Swedish Lime Industry, Svenska Kalkföreningen, personal communication

[156] Gustafsson, T., Gerner A. 2013. Verification of activity data for lime production.

#### 4.2.2.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations were made during submission 2025.

#### 4.2.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 4.2.3 Glass production, NFR2A3

#### 4.2.3.1 SOURCE CATEGORY DESCRIPTION

In Sweden there is one facility for container glass production and several small facilities for manual glass production. The only float glass producer ceased production in 2013. In addition, emissions from one glass wool producer are included. From glass wool production, emissions of $NH_3$, NMVOC, particulate matter and BC are reported.

From the float glass production, the total emissions of $SO_2$ and $NO_X$ from the glass furnace are allocated to NFR2A3 since a separation in energy related and process related emissions is not possible. From the container glass production, $SO_2$ emissions originating from the raw material and small amounts of NMVOC are reported. Emissions of Cu, Se and Ni from the float glass and container glass production are reported.

The only producer of float glass shut down in 2013. The shut-down resulted in very low emissions for 2013 as this is the only source of $NO_X$ emissions in NFR2A3. Also, total emissions of $SO_2$ in 2A3 decreased to a small extent in 2013-2014 due to the ceased production of float glass. In 2014, $NO_X$ emissions in 2A3 are reported "NA".

Emissions of particulate matter have been reported from the production of container and manual glass for the period 1990-2013, whereas particle emissions from float glass production are reported for the time period 1990–2012 until production shut down. BC emissions are reported for glass and glass wool production for year 2000 onwards and heavy metals from glass production are reported 1990-2023. The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e., not in diluted flue gases.

No data regarding CO, dioxin, PAH and HCB emissions are available, and the time series from 1990 and onwards are thus reported NE, in accordance with EMEP/EEA Guidebook 2023.

All other emissions from the glass production facilities originate from combustion for energy purposes and are allocated to the Energy sector (NFR1). A summary of the latest keys source assessment is presented in Table 4.2.4.

**Table 4.2.4. Summary of key source analysis, NFR2A3, according to approach 1.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 2A3 | *Ni, SO2, Se* | *As, NH3, PM10, PM2.5, Se, TSP* |

#### 4.2.3.2 METHODOLOGICAL ISSUES

The emission data sources for glass production are mixed. Some data derives from reports from the Swedish EPA, and some have been received from the companies' environmental reports or from data bases containing data from the environmental reports. For earlier years in the time series emission data are from national reporting to HELCOM and from the Swedish EPA[157]. Data for missing years and parameters have been estimated or interpolated.

Emission factors for Ni, Se and Cu are obtained from EMEP/EEA Guidebook 2023 and applied to activity data. Activity data, produced amounts of float and container glass, has been collected from the annual environmental reports for the two major producers. Information on the quantities of glass wool produced has also been taken from the annual environmental reports. There are also small manual glass-producing facilities for which no activity data are provided. Amounts of produced container glass, flat glass, crystal glass and glass wool are attributed to different processes, which means that it is not relevant to sum up and report these data as activity data. Activity data for NFR2A3 are therefore reported as not applicable, NA, in CRF. In Table 4.2.5 produced amounts of container glass, flat glass and glass wool, taken from the annual environmental reports, are presented together with estimated amounts of glass produced at small manual glass-producing facilities.

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[157] Bjärborg, 1998.

**Table 4.2.5. Glass production in Sweden, ton.**

| Year | Float glass | Container glass, large facilities | Manual glass production | Glass wool |
|---|---|---|---|---|
| 1990 | 223 672 | 126 257 | 6 120 | 94 486 |
| 1995 | 262 171 | 101 878 | 6 120 | 53 400 |
| 2000 | 275 830 | 109 861 | 6 120 | 49 358 |
| 2005 | 273 144 | 125 477 | 6 070 | 54 091 |
| 2010 | 219 837 | 148 112 | 5 150 | 49 218 |
| 2011 | 245 176 | 160 016 | 5 120 | 48 403 |
| 2012 | 200 150 | 157 423 | 4 920 | 45 350 |
| 2013 | 0 | 155 231 | 4 770 | 44 073 |
| 2014 | 0 | 157 795 | 4 500 | 46 721 |
| 2015 | 0 | 156 206 | 4 500 | 44 105 |
| 2016 | 0 | 139 055 | 4 500 | 58 479 |
| 2017 | 0 | 172 012 | 4 500 | 60 697 |
| 2018 | 0 | 176 333 | 4 500 | 51 264 |
| 2019 | 0 | 175 771 | 4 500 | 59 170 |
| 2020 | 0 | 164 906 | 4 500 | 49 461 |
| 2021 | 0 | 175 263 | 4 500 | 57 261 |
| 2022 | 0 | 185 475 | 4 500 | 57 151 |
| 2023 | 0 | 163 078 | 4 500 | 47 536 |

Manual glass production used to be an important source of lead emissions. In the early 1990's emissions of lead from the production of manual glass represented roughly 80% of the total reported lead emission from glass production. Ten years later, the manual glass production adds up to only around 10% of the lead emissions from glass production. This reduction is probably due to the reduced production of lead crystal glass. Today no lead is used in the production of manual glass.

### 4.2.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions are based on the Guidebook 2023, Guidebook Quality Rating C or D or E and expert judgement. More detailed information is to be found in IIR Annex 1.

Time series from glass production reported in NFR2A3 have been reviewed in later years and are consistent.

### 4.2.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

### 4.2.3.5 SOURCE-SPECIFIC RECALCULATIONS

Minor change in AD for year 2022. Resulted in minor emission changes: + 0.0004 kt for Se, + 0.00007 kt for Ni and 0.000002 kt for Cu.

#### 4.2.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 4.2.4 Quarrying and mining of minerals other than coal, NFR2A5a

#### 4.2.4.1 SOURCE CATEGORY DESCRIPTION

Reported emissions include estimates for quarrying and mining of minerals other than coal. Emissions from four iron ore mines, located near three pellets plants, are reported in NFR2C1 as the emissions from these mines are presented in the environmental reports together with the emissions from the pellet production. The number of metal ore mines in operation varies between years but a total of 16 mines are included in emissions reported in NFR2A5a. Particulate emissions from limestone quarrying, crushing and grinding are also included in NFR2A5a.

The dominating source for emissions of particulate matter in NFR2A5a are limestone quarrying, crushing and grinding. These emissions are based on national statistics on the amount quarried limestone and emission factors. The use of mining explosives causes emissions of mainly nitrogen oxides, $NO_X$[158]. Ore dressing plants are the dominating source of heavy metals. Data on emissions of $NO_X$, particulate matter and heavy metals from metal ore mining are mainly collected from the companies' environmental reports to the authorities.

The summary of the latest key source assessment is presented in Table 4.2.6.

**Table 4.2.6 Summary of key source analysis, NFR2A5a, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2A5a | *PM10, PM2.5, TSP* | *Hg* |

#### 4.2.4.2 METHODOLOGICAL ISSUES

$NO_X$ emissions originating from the use of mining explosives are only reported for the years 2002 - 2023 due to lack of data for earlier years. Emissions of particulate matter and metals are reported for the whole time period.

#### 4.2.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions of TSP, $PM_{10}$, $PM_{2.5}$ are based on expert judgement. Assessed uncertainties are ± 49%, ± 49% and ± 50%, respectively.

Uncertainties for emissions for $NO_X$ and metals are based on Guidebook Quality ratings C and D. Uncertainty for $NO_X$, Pb, Cd, Hg, As, Cu, Ni and Zn are ± 100%, ± 50%, ± 100%, ± 1000%, 100%, ± 50%, ± 50% and ± 50%, respectively.

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[158] Wieland, 2004.

More information is given in IIR Annex 1.

Time series from quarrying and mining of minerals other than coal reported in NFR code 2A5a have been reviewed in later years and are consistent.

#### 4.2.4.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 4.2.4.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations were made during submission 2025.

#### 4.2.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 4.2.5 Construction and demolition, NFR2A5b

#### 4.2.5.1 SOURCE CATEGORY DESCRIPTION

Reported emissions include estimates for construction and demolition (2A5b). Emissions of particles from construction work are reported. Emissions from road construction is being reported for the first time in submission 2024. The basis for the calculations is national data on construction activity (buildings) and national data on land use (road area). Emission factors from EMEP/EEA Guidebook 2023 are used[159]. During the last five years the emissions from road construction makes up about 80% of the total particle emissions in NFR2A5b even if the total affected area of road construction is similar to that of construction of buildings.

No data concerning the NMVOC emissions are available, and the time series from 1990 and onwards is thus reported NE, in accordance with EMEP/EEA 7. A summary of the latest key source assessment is presented in Table 4.2.7.

**Table 4.2.7. Summary of key source analysis, NFR 2A5b, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2A5b | *PM10, PM2.5, TSP* | *PM10, PM2.5, TSP* |

#### 4.2.5.2 METHODOLOGICAL ISSUES

At present, there are no surveys relating to particulate emissions from individual large point sources that would make it possible to estimate particulate emissions from Construction and demolition using a higher tier level method (Tier 3). There

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[159] The EMEP/EEA Guidebook: http://www.eea.europa.eu/themes/air/emep-eea-air-pollutant-emission-inventory-guidebook/emep

is also currently no country-specific information that could be used to estimate particle emissions from Construction and Demolition (NFR2A5b).

*Houses and non-residential constructions*

The data chosen as a basis for the particle emission estimates from construction work are national statistics on building permits for housing and non-residential buildings (in $m^2$)[160], 1996 - 2023, and economic statistics on annual investments in construction-related activities[161], 1990 - 1995. As only information on economic investments used for construction work are available for the years 1990 - 1995 this information had to be transformed into a unit where emission factors can be used. For the calculations of the time series of emissions before 1996, the economic information was normalised to the 1995 level, and the costs per square meter was assumed to be constant between 1990 and 1995.

The data is divided into three sub-groups; houses (detached single family, detached two family and single family terraced), apartments (all types) and non-residential construction (all construction except residential construction and road construction).

Emission factors used for calculations of particulate matter from construction activities are all found in the EMEP/EEA Guidebook 2023[162]. Since submission 2020 the Tier 1 default approach from EMEP/EEA Guidebook 2023 has been used to calculate emissions from construction and demolition. To calculate the emissions properly, it is necessary to use the “footprint area” or “the area affected by construction” and not only the area given by the building permit. This is because the construction work expands well outside the boundaries of the complete building. The affected area is calculated by multiplying the area ($m^2$) approved in the building permit with conversion factors stated in the EMEP/EEA Guidebook 2023.

*Road Construction*

The activity data for this category is the total area ($m^2$) affected by road construction. The data source chosen as a basis for the particle emission estimates from road construction work is the national report *Land use Sweden* that is produced every fifth year by Statistics Sweden[163]. The report includes an updated overview.

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[160] Statistics Sweden. http://www.scb.se. Housing and construction, Statistics on building permits for housing and non-residential buildings

[161] The Swedish Construction Federation. http://www.bygg.org. Personal communication

[162] The EMEP/EEA Guidebook: http://www.eea.europa.eu/themes/air/emep-eea-air-pollutant-emission-inventory-guidebook/emep

[163] Statistics Sweden, www.scb.se. Land use in Sweden, statistics on total land use area dedicated to road infrastructure.

of the total amount of land use (hectares of road area) that is being dedicated to road infrastructure. The average amount of newly constructed road area per year is simply calculated by comparing the total amount of road infrastructure area in newest land use report with the previous one.

Emission factors and other parameters used for calculations of particulate matter from road construction activities are found in the EMEP/EEA Guidebook 2023[164].

The calculations assume that the road area which includes ditches and safety zone is a fair and conservative assumption of the total area that is affected by construction work (machine and mass transportation often occur outside the future road surface). The alternative would be to use carriageway area but by using this area the total area affected is probably underestimated. The difference in using the total road area compared to carriageway is about 40% more surface.

During 1995-1999 a significant peak in emission can be seen. This corresponds to the land use reports which states a much larger amount of land dedicated to road infrastructure in year 2000 onwards compared to the earlier years. During the last 20 years the amount of newly constructed road amounts to 1 300-3 500 hectares per year without. The method of measuring and calculating the land use dedicated to road infrastructure was enhanced during 2010 by Statistics Sweden which is why the last four reports is believed to have higher accuracy than the ones before.

Apart from the emission factors for particles the parameters *average construction time, soil moisture, soil silt content* and *control efficiencies* all have a significant impact on the calculated particle emissions. These parameters are in reality varying depending on the scale of the road construction and part of the country the projects are being situated. For the calculations the duration of the construction work, control efficiencies and soil silt content have been selected according to standard factors in Guidebook 2023. The average construction time is set to 1 year, soil silt content to 20% and the control efficiency to 50% (meaning 50% of the road project use measures to reduces particle pollution such as watering the surface). The soil moisture factor is calculated based on national temperature and precipitation statistics.

#### 4.2.5.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

*Houses and non-residential constructions*

Uncertainties for emissions of TSP, $PM_{10}$, $PM_{2.5}$ are calculated with the EF from EMEP/EEA Guidebook 2023 (upper and lower). Assessed uncertainties for TSP are ± 146%, $PM_{10}$ are ± 145% and for $PM_{2.5}$ are ± 151%. Time series from construction work reported in NFR code 2A5b have been reviewed in later years and are consistent.

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[164] The EMEP/EEA Guidebook: http://www.eea.europa.eu/themes/air/emep-eea-air-pollutant-emission-inventory-guidebook/emep

*Road Construction*

Uncertainties for emissions of TSP, $PM_{10}$, $PM_{2.5}$ are calculated with the EF from EMEP/EEA Guidebook 2023 (upper and lower). Assessed uncertainties for TSP are ± 160%, $PM_{10}$ and $PM_{2.5}$ are ± 200%.

#### 4.2.5.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 4.2.5.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculation occurred during submission 2025.

#### 4.2.5.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 4.2.6 Storage, handling and transport of mineral products, NFR2A5c

Emissions from the source category Storage, handling and transport of mineral products, NFR2A5c, have not been separated from the relevant mineral chapter and are included in respective source category, 2A1, 2A2, 2A3 or 2A5.

### 4.2.7 Other mineral products, NFR2A6

#### 4.2.7.1 SOURCE CATEGORY DESCRIPTION

Reported emissions include estimates for other mineral products (2A6). In the source category other mineral products, emissions from battery manufacturing and mineral wool production are reported. Under NFR2A6 “Other mineral products” emissions from battery manufacturing and mineral wool production are reported.

A summary of the latest key source assessment is presented in Table 4.2.8.

**Table 4.2.8. Summary of key source analysis, NFR 2A6, according to approach 1.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 2A6 | *PM2.5* | *Cd, PM10, PM2.5, TSP* |

#### *4.2.7.1.1 Mineral wool production*

Mineral wool has been produced at approximately 2-5 different facilities during the time period 1990-2013. Presently, glass and mineral wool production occurs at two facilities run by one company.

#### *4.2.7.1.2 Batteries manufacturing*

There is currently one battery producing facility in Sweden. This battery producer of nickel–cadmium batteries previously used iso-propanol in their processes, which gave rise to emissions of NMVOC. The process was changed in 1998 and, since then, no NMVOC emissions occur from this source. Before 2000 another two battery producing facilities were included of which one was emitting NMVOC until 1991. Emissions of lead, cadmium and nickel are reported for the time period from 1990 and onwards.

In 2021, construction of a new battery factory was ongoing, where in the future there will be production of lithium-ion batteries and recycling of batteries. There has been only minor production at the plant in 2022 and no emissions are yet reported from the factory.

### 4.2.7.2 METHODOLOGICAL ISSUES

#### *4.2.7.2.1 Mineral wool production*

For mineral wool production, the reported emission data on NMVOC consists of the sum of formaldehyde and phenol.

The data on particulate emissions from mineral wool production provided for the 1990´s and 2000 - 2022 are primarily based on measurements whereas for earlier years, estimates made by the companies are based on known circumstances influencing emissions. Concerning the particle emissions, only the TSP emissions were provided by industry, and the fractions of TSP as $PM_{10}$ and $PM_{2.5}$ were calculated from emission factors for production of glass fibers provided in the CEPMEIP study[165].

#### *4.2.7.2.2 Batteries manufacturing*

The time series from 1990 - 2000 is based on emission data representing three individual facilities. From 2000 there is only one active facility. Between 1988 and 1991 reported NMVOC represents emissions from two facilities. From 1992 to 1998 only NMVOC from one facility is included. This manufacturer of nickel–cadmium batteries used isopropanol in their processes, which gave rise to emissions of NMVOC. The process was changed in 1998 and, since then, no NMVOC emissions occur from this source. The heavy metal emissions from the battery manufacture nowadays originate from one facility producing nickel-cadmium batteries. For some years information on emissions is not available, and data has been interpolated.

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[165] CEPMEIP, 2001. TNO. http://www.mep.tno.nl/wie_we_zijn_eng/organisatie/kenniscentra/centre_expertise_emissions_assessment.html

#### 4.2.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions of NMVOC, $NH_3$, TSP, $PM_{10}$, $PM_{2.5}$ from Mineral Wool Production are based on Guidebook Quality Rating D, E and expert judgements. Assessed uncertainties for are ± 400%, ± 400%, ± 49%, ± 49% and ± 50%, respectively. Uncertainties for emissions for metals are based on Guidebook Quality Rating C, D and expert judgement. Uncertainties for Pb, Cd, Hg, As, Cr, Cu, Ni and Zn are ± 50%, ± 100%, 1000%, ± 100%, ± 100%, ± 50%, ± 50% and ± 50%, respectively.

Uncertainties for emissions of NMVOC, Cd, Ni, Pb from Batteries manufacturing are based on Guidebook Quality Rating D, C and expert judgements. Uncertainties for NMVOC, Cd, Ni and Pb are ± 200%, ± 100%, ± 50% and ± 50%, respectively.

More information is given in IIR Annex 1.

Time series from construction work reported in NFR code 2A6 have been reviewed in later years and are consistent.

#### 4.2.7.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 4.2.7.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations were performed during submission 2025.

#### 4.2.7.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

# 4.3 Chemical industry, NFR2B

## 4.3.1 Ammonia production, NFR2B1

#### 4.3.1.1 SOURCE CATEGORY DESCRIPTION

There is an annual production of about 5 Gg of ammonia in Sweden, according to UN statistics[166]. This is however not intentionally produced but is a by-product in one chemical industry producing various chelates and chelating agents, such as EDTA, DTPA and NTA[167]. Emissions from this industry are included in NFR code 2B5. Ammonia production, 2B1, is thus reported as NO in the NFR-tables.

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[166] UN. Commodity Production Statistical Database. Department of Economic and Social Affairs, Statistics Division, as referred in FCCC Synthesis and Assessment report 2002 Part I.

[167] Kindbom, 2004.

#### 4.3.1.2 METHODOLOGICAL ISSUES

Emission data on $NO_X$ and $NH_3$ originating from the nitric acid production has been obtained directly from the facilities and from official statistics. Emissions for all years, except 1991-1993, are as reported from the facilities. The reduction of the reported $NO_X$ emissions in 2001 and 2002, compared to earlier years, is a result of one facility being shut down in late 2000 and a second one during 2001. The higher level of $NO_X$ emissions in year 2004 is a result of a long-lasting leakage of $NO_X$ from one of the production units at the active facility. During year 2007 catalytic abatement was installed at one of the production units at the active facility and as a result the emissions of $NO_X$ and $NH_3$ were reduced compared to previous years. According to the company the increased $NH_3$ emissions in 2010-2014 is a result of prioritizing low $NO_X$ emissions. $NH_3$ is used as a reducing agent in the de-$NO_X$ catalyst and hence lower $NO_X$ implies more injected $NH_3$. $NH_3$ that do not react in the catalyst is emitted to the air. From 2007 emissions are continuously measured in one of the two production lines, from 2011 emissions are continuously measured in both production lines.

Documentation has been received from the facility concerning production data, production capacity and abatement measures, used emission factors and the method used for estimating emissions as well as uncertainty in emission estimates and measurements. However, this information is confidential.

#### 4.3.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Time series from industrial processes reported in NFR codes 2A-2H have been reviewed in later years and are consistent.

#### 4.3.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Experts at the Swedish EPA conduct a review of the inventory, estimates, methodology and emissions factors used. The experts also identify areas of improvement, which constitute part of the basis for improvements in coming submissions.

All quality procedures according to the Swedish QA/QC plan (Manual for SMED's Quality System in the Air Emission Inventories, Kindbom et al. 2005) have been implemented during the work with this submission.

All Tier 1 general inventory level QC procedures and some specific Tier 2 QC procedures, listed in Good Practice Guidance section 8, have been performed and are documented in checklists.

The time series for all revised data have been studied carefully in search for outliers and to make sure that levels are reasonable. Data has, when possible, been compared with information in environmental reports and/or other independent sources. Remarks in reports from the UNFCCC and CLRTAP/NEC reviews have been carefully read and considered.

According to the Good Practice Guidance, the method of calculating emissions at facilities should be documented. This is currently not done in most cases and will be improved in the future.

#### 4.3.1.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been made.

#### 4.3.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are currently planned.

### 4.3.2 Nitric acid production, NFR2B2

#### 4.3.2.1 SOURCE CATEGORY DESCRIPTION

Production of nitric acid has taken place at three facilities in Sweden. One of these was shut down late 2000, and a second one was shut down during 2001. Therefore, there is currently only one facility producing nitric acid in Sweden. Data on emissions have been obtained directly from the facilities and from official statistics.

A summary of the latest key source assessment is presented in Table 4.3.1.

**Table 4.3.1. Summary of key source analysis, NFR2B2, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2B2 | - | $NO_X$ |

#### 4.3.2.2 METHODOLOGICAL ISSUES

Emission data on $NO_X$ and $NH_3$ originating from the nitric acid production has been obtained directly from the facilities and from official statistics. Emissions for all years, except 1991-1993, are as reported from the facilities. The reduction of the reported $NO_X$ emissions in 2001 and 2002, compared to earlier years, is a result of one facility being shut down in late 2000 and a second one during 2001. The higher level of $NO_X$ emissions in year 2004 is a result of a long-lasting leakage of $NO_X$ from one of the production units at the active facility. During year 2007 catalytic abatement was installed at one of the production units at the active facility and as a result the emissions of $NO_X$ and $NH_3$ were reduced compared to previous years. According to the company the increased $NH_3$ emissions from 2010 and onwards is a result of prioritizing low $NO_X$ emissions. $NH_3$ is used as a reducing agent in the de-$NO_X$ catalyst and hence lower $NO_X$ implies more injected $NH_3$. $NH_3$ that does not react in the catalyst is emitted to the air. From 2007 emissions are continuously measured in one of the two production lines, from 2011 emissions are continuously measured in both production lines. During 2019 a new production line was taken into operation. In connection with that, the oldest production line, with the highest emissions, was shut down.

Documentation has been received from the facility concerning production data, production capacity and abatement measures, used emission factors and the method used for estimating emissions as well as uncertainty in emission estimates and measurements. However, this information is confidential.

#### 4.3.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Time series from industrial processes reported in NFR codes 2A-2H have been reviewed in later years and are consistent. Uncertainties for emissions are based on information from the company. Assessed uncertainties for $NO_X$ and for $NH_3$ are ± 5%. More information is given in IIR Annex 1.

#### 4.3.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 4.3.2.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been performed in submission 2025.

#### 4.3.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are currently planned.

### 4.3.3 Adipic acid production, NFR2B3

No production of adipic acid occurs in Sweden, and thus NO is reported for NFR2B3.

### 4.3.4 Caprolactam, glyoxal and glyoxylic acid production (NFR2B4)

#### 4.3.4.1 SOURCE CATEGORY DESCRIPTION

No production of caprolactam, glyoxal or glyoxylic acid occurs in Sweden, and thus NO is reported for NFR2B3.

### 4.3.5 Carbide production, NFR2B5

#### 4.3.5.1 SOURCE CATEGORY DESCRIPTION

Carbide production occurs at only one facility in Sweden. Emissions of TSP, $PM_{10}$, $PM_{2.5}$ and BC are reported from carbide production and estimates are based on information from the company. The distribution of particulates between TSP, $PM_{10}$ and $PM_{2.5}$ has been determined by expert judgement.
Silicon carbide production does not occur in Sweden.

A summary of the latest key source assessment is presented in Table 4.3.2.

**Table 4.3.2. Summary of key source analysis, NFR2B5, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2B5 | *PM2.5* | - |

#### 4.3.5.2 METHODOLOGICAL ISSUES

The time series of particle emissions from carbide production are considered complete and consistent in methodology. TSP, $PM_{10}$, $PM_{2.5}$ and BC emissions from carbide production are included and the dominating part of reported emissions arises from flaring of carbide oven gas. The amount of TSP from flaring is reported by the company. The partitioning of particles between TSP, $PM_{10}$ and $PM_{2.5}$ has been done by expert judgement after discussions with the carbide producing company and the emitted mass of $PM_{10}$ and $PM_{2.5}$ are estimated to constitute 90% and 80% of the total TSP emission, respectively. Particle emissions from quicklime production in the carbide industry are included in NFR2A2. Emissions from flaring are allocated to 2B5 together with all other emissions from carbide production.

Amounts of produced carbide and used carbide (the latter are used for reporting of $CO_2$ emissions from the same category) are attributable to different processes with different emission factors, meaning that summarizing them in a one set of activity data would not be relevant. Activity data is therefore reported as not applicable, NA.

#### 4.3.5.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Time series from industrial processes reported in the NFR code 2B5 have been reviewed in later years and are consistent. Uncertainties for NFR2B5 are displayed in Annex I.

#### 4.3.5.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 4.3.5.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been performed in submission 2025.

#### 4.3.5.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are currently planned.

### 4.3.6 Titanium dioxide production, NFR2B6

No production of titanium dioxide occurs in Sweden, and thus NO is reported for NFR2B6.

### 4.3.7 Soda ash production, NFR2B7

In 2004[168] a study was carried out to collect data on soda ash use and calculate $CO_2$ emissions. From this study it became clear that no production of soda ash occurs in Sweden and is hence reported as NO in NFR2B7.

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[168] Nyström, A-K. 2004. $CO_2$ from the use of soda ash. SMED report 61 2004.

## 4.3.8 Other chemical industry, NFR2B10a

### 4.3.8.1 SOURCE CATEGORY DESCRIPTION

This sub-category includes various chemical industries, such as sulphuric acid production, the pharmaceutical industry, production of base chemicals for plastic industry, various organic and inorganic chemical productions, and other non-specified chemical production, which is not covered elsewhere. Approximately 70 larger industrial facilities are included in the emission estimates. Emissions of $NO_X$, CO, NMVOC, $SO_2$, $NH_3$ and TSP are reported. From submission 2020 onwards, emissions of $PM_{2.5}$, $PM_{10}$ and BC from 18 plants are included in the inventory. Emissions from organic chemical processes include cracking and graphite production, inorganic chemical processes include production of carbon black, phosphate fertilizers, NPK and PVC. Also, emissions from production of base plastics such as PE and styrene are included. It is possible that some emissions of NMVOC reported in NFR2B10 should be reported in NFR2D3g (e.g. pharmaceutical industries), but since it has been difficult to make the distinction clear between process emissions and solvent use, all NMVOC emissions from these facilities are included in NFR2B10.

The mercury emissions reported originate from the chloralkali and the sulphuric acid industries. The dioxin emissions reported in 2001 originate from three facilities, in 2002 from four, and for 2003 from six facilities. Due to lack of information about emissions in earlier years, dioxin emissions are reported NE (Not Estimated) for 1980 – 2000.

From some chemical processes, emissions of Se, As and PAH may occur, according to EMEP/EEA Guidebook 2023 (e.g., arsenic from production of PVC and phosphate fertilizers). Data on these emissions are not available, and the time series from 1990 and onwards are thus reported NE.

Time series for HCB emissions has been included to the inventory as a result of a development project[169]. These emissions occur at one facility within inorganic chemical production and have significantly (by more than 90%) decreased between 1990 and 2016.

A summary of the latest key source assessment is presented in Table 4.3.3.

**Table 4.3.3. Summary of key source analysis, NFR2B10a, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2B10 | Hg, NMVOC, NOx, Pb, SO2 | Hg, NH3, NMVOC, SO2 |

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[169] Hagström, P. 2017, SMED memorandum on HCB emissions from Swedish industrial processes

### 4.3.8.2 METHODOLOGICAL ISSUES

The primary information on emissions of $NO_X$, CO, NMVOC, $SO_2$, $NH_3$ and TSP are as reported by the companies in their environmental reports. A total of approximately 70 facilities are included, but not all of them report on all emissions. The time series have been reviewed and is considered to be consistent.

From submission 2020 onwards, emissions of TSP, $PM_{10}$ and $PM_{2.5}$, and BC from 18 plants are included in the inventory. For six inorganic chemical processes, emission factors are based on particulate fractions as in EMEP/EEA Guidebook 2023 and applied to TSP emissions reported by facilities. Activity data on production of PVC and carbon black is obtained from the facilities' environmental reports. Activity data on production of phosphate fertilizers was obtained from FAOSTAT[170] for 1990-1995 and from Statistics Sweden database for 1996 onwards. TSP from one organic process (cracking) is obtained from the plant's environmental report and emission factors from EMEP/EEA Guidebook 2023 are used to calculate emissions of the remaining particle fractions. Particle emissions from the remaining plants and processes are calculated based on production data and Tier 1 emission factors or Tier 2 emissions factors where applicable (e.g. styrene production). Particle emissions in this source category come from many different processes and for most of these processes it is not known whether the condensable component is included in the particle emission estimate.

Mercury emissions reported in 2B10a originate from processes in the chloralkali industry and from sulphuric acid production. Reported emissions of mercury were derived from information in the SMP database, from the industries' environmental reports or unpublished earlier estimates[171].

Hardly any information on dioxin emissions from the chemical industry has been available. There is only information on dioxin emissions available from a few facilities from 2001. In submission 2020, complete time series have been created by extrapolation.

The $SO_2$ emissions reported in 2B10a decreased dramatically in 2004 in comparison to earlier years. This is due to that in December 2003 one facility for production of viscose staple fiber was shut down. The yearly $SO_2$ emissions from this facility represented between 8 and 20% of the totally reported $SO_2$ emission in NFR2 – Industrial Processes, 1990 - 2003. In 2007 the CO-emissions were very low from one facility producing PVC. $NH_3$ emissions decreased since 2007 due to that one facility are working on replacing $NH_3$ in the production process.

In 2010, emissions in this sub-category were reviewed as part of a quality control project carried out by SMED on behalf of the Swedish EPA, aiming at increasing

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[170] FAOSTAT http://faostat3.fao.org

[171] Levander, 1989.

the quality and reducing the uncertainties of the emissions of the most important substances from chemicals industries in Sweden[172]. Emissions reported in the environmental reports were compared to plant-specific data. Significant discrepancies were investigated, and recommendations were provided on feasible improvements for submission 2011 as well as recommendations on further investigations[173].

Overall, the QC-project showed that total reported emissions from the chemical industries in the Swedish inventory are in coherence with the emission data reported by the plants.

#### 4.3.8.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR2B10a are displayed in Annex I.

Time series for various chemical industries reported in NFR code 2B10a have been reviewed in later years and are considered to be consistent.

In submission 2025 a defect heat exchanger at one facility led to elevated emissions of HCB and dioxins from 2022 to 2023 by 1 900% and 413%, respectively.

#### 4.3.8.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Emissions reported in the plant-specific environmental reports are carefully studied annually to retrieve the most appropriate data.

#### 4.3.8.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2025 updated activity data regarding 2022 resulted in a minor increase in emissions of NMVOC.

#### 4.3.8.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are currently planned.

### 4.3.9 Storage, handling and transport of chemical products, NFR2B10b

Emissions from the source category Storage, handling and transport of chemical products, NFR2B10b, have not been separated from the relevant chemical production chapter and are included in respective source category, 2B1, 2B2, 2B5 or 2B10a.

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[172] Swedish EPA. 2010.

[173] Most recommendations on further investigations refer to the energy sector

# 4.4 Metal production, NFR2C

## 4.4.1 Iron and steel production NFR2C1

### 4.4.1.1 SOURCE CATEGORY DESCRIPTION

Processes that are included in this category are primary and secondary iron and steel production, direct reduced iron production, iron ore mining, dressing, sintering and iron ore pellets production. Emissions from iron and steel foundries are also reported I NFR 2C1. The summary of the latest key source assessment is presented in Table 4.4.1.

**Table 4.4.1. Summary of key source analysis, NFR2C1, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2C1 | As, CO, Cd, Cr, Cu, DIOX, Hg, NOx, Ni, PAH 1-4, PM10, PM2.5, Pb, SO2, Se, TSP, Zn | As, Cd, Cr, Cu, DIOX, Hg, Ni, PAH 1-4, PM10, PM2.5, Pb, SO2, Se, TSP, Zn |

In Sweden, there are two primary iron and steel facilities equipped with blast furnaces, producing iron and steel products from virgin materials, one plant producing iron sponge and iron powder using direct reduction of iron ore pellets, and about ten secondary steel plants equipped with electric arc furnaces, producing iron and steel products from scrap and direct reduced iron. Included are also emissions from one facility using a shaft furnace process to produce stainless steel from recovered flue gas dust and other waste products, and one foundry using a cupola furnace for melting cast iron. In total, there are approximately 20 different facilities included in the different estimates. Processes occurring besides the primary processes and secondary steel production are rolling mills, pickling and other refinement processes. Emissions from four iron ore mines and from three facilities producing pellets in Sweden are reported in 2C1. Emissions from one sinter producing facility are reported in 2C1 until 1995, when the production closed down.

#### *4.4.1.1.1 Primary iron and steel production*

There are two plants in Sweden that produce pig iron and steel as part of their integrated coke ovens, blast furnaces and steel converters. The basis of the production is iron ore pellets.

#### *4.4.1.1.2 Secondary iron and steel production*

There are about ten secondary steel plants equipped with electric arc furnaces, producing iron and steel products from scrap and direct reduced iron. One of the facilities is using a shaft furnace process to produce stainless steel from recovered flue gas dust and other waste products. Emissions from one foundry using a cupola furnace for melting cast iron is also included.

#### *4.4.1.1.3 Direct reduced iron*

There is one plant in Sweden which produces iron sponge and iron powder using direct reduction of iron ore pellets.

#### *4.4.1.1.4 Sinter*

Emissions from a sinter producing facility are also included in NFR2C1 between 1990 and 1995, when the production closed down.

#### *4.4.1.1.5 Pellet*

Emissions from four iron ore mines and three facilities producing pellets in Sweden are reported in NFR2C1.

#### *4.4.1.1.6 Other*

Emissions from nine iron and steel foundries in Sweden are reported in NFR2C1.

### 4.4.1.2 METHODOLOGICAL ISSUES

Process emissions arising from reducing agents in the primary steel works and secondary iron and steel works are reported in NFR2C1. As the plants also generate emissions from fuel combustion (NFR1A1c and NFR1A2a) and fugitive emissions (NFR1B1b and NFR1B1c) the text in this section is closely connected to the text in the energy section.

In the Swedish inventory, emissions from primary iron and steel production and secondary steel production are estimated separately but reported together under 2C1 iron and steel production. In 2C1 also emissions from four major iron ore mines and three facilities producing pellets in Sweden are included.

#### *4.4.1.2.1 Primary iron and steel production*

Two plants reported in this sector are primary iron and steel producing plants as part of integrated coke ovens, blast furnaces and steel converters. The primary purpose of the use of coal and coke in the blast furnace is to secure oxidation and to act as reducing agents, and the associated emissions are reported as industrial processes from iron and steel production in NFR2C1, according to the 2006 IPCC Guidelines.

Figure 4.4.1 gives an overview of the input and output materials, the carbon flows between the different processes (plant stations), and the $CO_2$-emitting sources. Note that for non-$CO_2$ emissions, the different emission sources may vary considerably. The flow chart is however giving a general introduction to the two integrated iron and steel production plants in Sweden.

In the coke ovens (battery), coking coal is turned into coke through dry distillation. During the process, coke oven gas (COG) and by-products are formed. The coke oven gas is purified through several procedures and used as fuel in other plant stations, but smaller amounts are also flared. Produced amounts of coke are fed into the blast furnace together with injection coal to act as reduction agent when pig iron is produced from iron ore pellets. Limestone is added to extract slag and other by-products from the pig iron. Besides pig iron and by-products, blast furnace gas (BFG) is produced in the process. The main use for the blast furnace gas is to heat the cowpers (and in one plant used in the coke oven), but some excess gas is released through flaring.

In the steelworks, pig iron is transformed into various qualities of steel depending on the demand. Dolomite, pig iron, carbide, etc., are added depending on the different metallurgic processes. LD-gas is produced in the steel converter and used as fuel or flared. Some steel is treated in the rolling mills where LPG and different oils are used as fuel.

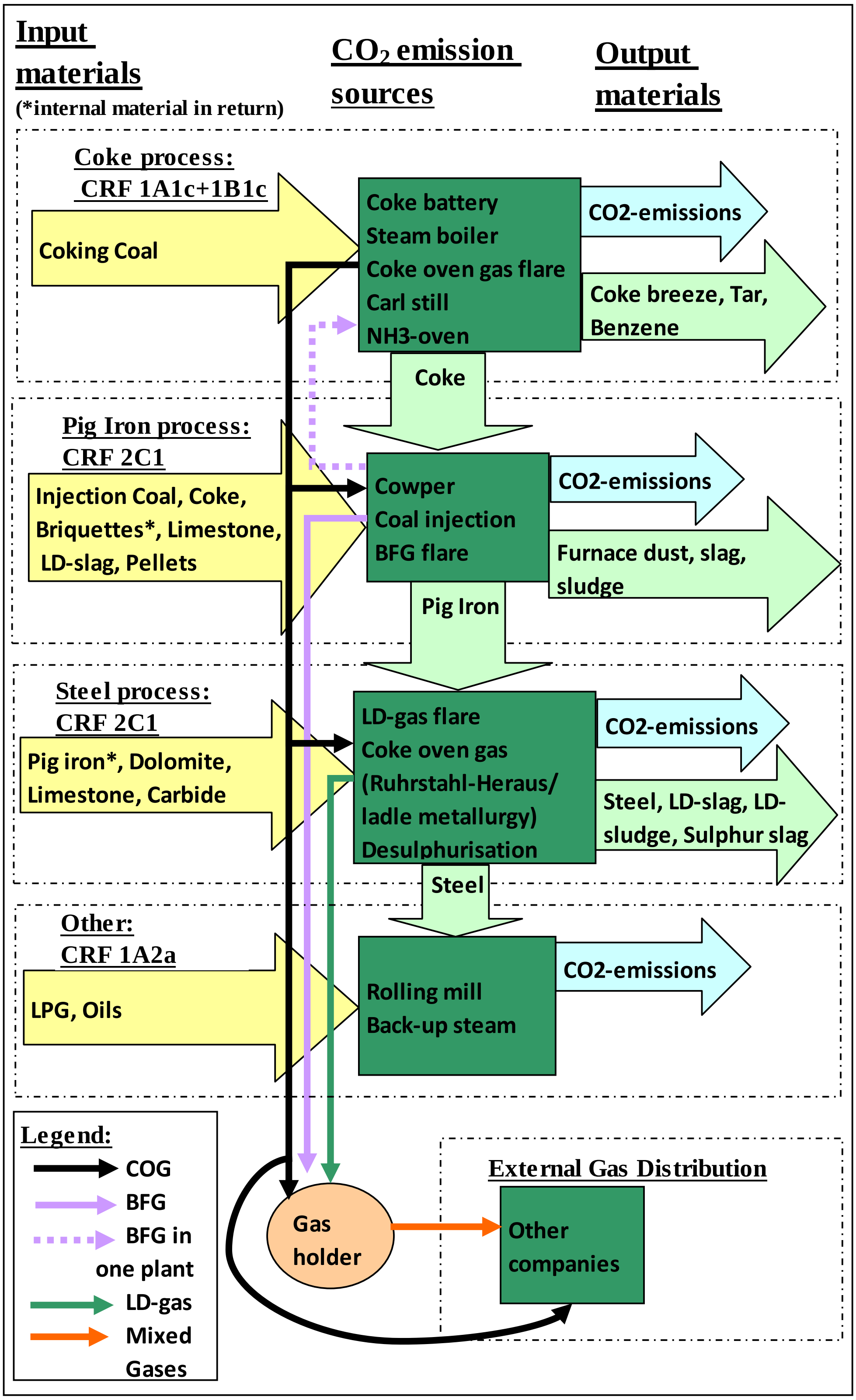

**Figure 4.4.1. Carbon flow chart of integrated primary iron and steel plants in Sweden. CRF = NFR.**

Considerable amounts of energy gases (coke oven gas, blast furnace gas and LD-gas) from the different processes are collected in a gas holder and sold to external consumers (mainly in NFR1A1a electricity and heat production). These amounts of gases and their associated emissions are allocated to the source category where they are consumed and thus not accounted for in the iron and steel production. This is in line with the 2006 IPCC Guidelines[174] where allocation of emissions from delivered gases is described. During the whole process from raw material to final product, emissions are released.

From 2003 onwards, the plant specific annual environmental reports consist of plant station data on consumed amounts of energy gases (coke oven gas, blast furnace gas and LD-gas) and other fuels, emissions of $NO_X$, $SO_2$, several heavy metals, TSP and dioxin (one plant only), but lack information on emissions of NMVOC, CO and some heavy metals. In previous submissions, time series for several pollutants ($NO_X$, $SO_2$, NMVOC and CO) were based on information from various sources (e.g. Statistics Sweden and environmental reports). As of submission 2010, the inventory reporting of all emissions is based on information from the environmental reports and some additional information from direct contact with the plants. In order to achieve consistent time series and to estimate emissions of missing pollutants, different IPCC splicing techniques were applied.

Emissions of $NO_X$, $SO_2$ and TSP are derived from the environmental reports and direct contact with the plants for the entire time series. The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e., not in diluted flue gases. The allocation of both plants' total emissions of $NO_X$, $SO_2$ and TSP on plant stations and consequently NFR category is presented in Table 4.4.2 for the year 2023.

**Table 4.4.2. Allocation of NOx, $SO_2$ and TSP emissions for 2023 in integrated primary iron and steel production.**

| NFR | Plant station | $NO_X$ emissions (kt) | $SO_2$ emissions (kt) | TSP emissions (kt) |
|---|---|---|---|---|
| 1A1c | Coke Oven | 0.39 | 0.12 | 0.11 |
| 1A2a | Combustion in Rolling Mills + Power and Heat Production | 0.28 | 0.27 | 0.02 |
| 1B1b | $SO_2$ from quenching and extinction at coke ovens | - | 0.02 | - |
| 1B1c | Flare in Coke Oven (COG) | 0.003 | 0.01 | 0.0001 |
| 2B10a | Sulphuric acid production | - | 0.01 | - |
| 2C1 | Blast Furnace + Steelworks (including Flaring of BFG and LD-gas) | 0.15 | 0.52 | 0.21 |
| **Total** | | **0.82** | **0.94** | **0.33** |

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[174] See 2006 IPCC Guidelines: Volume 3: Industrial Processes and Product Use, Box 1.1 (page 1.8)

NMVOC and CO emissions are estimated based on consumed amounts (including flared amounts) of energy gases multiplied by country specific emission factors (see Annex 2). Emissions of NMVOC and CO from coke oven gas, blast furnace gas and LD-gas in the blast furnace and steel converter are allocated to NFR2C1. Consumed amounts of different energy gases and other fuels 1990-2002 are derived by applying the Good Practice Guidance surrogate method using the average values 2003-2007 and $CO_2$ emissions as the surrogate parameter.

Inventory emissions of heavy metals and dioxin are mostly obtained from the environmental reports, except for selenium, which is included for the first time in submission 2016. Emissions of selenium are calculated using default emission factor from EMEP/EEA Guidebook 2023. In some cases, especially for the early 1990's and for one of the plants, information on heavy metal emissions is lacking and thus estimated by extrapolation using IEF and TSP as a surrogate parameter. Emissions of heavy metals and dioxin are all reported under NFR2C1 although they comprise both process-related emissions and emissions originating in the energy sector (CRF 1.A.1.c).

The PM size fractioning has been made according to reported emissions of $PM_{10}$ and $PM_{2.5}$ from one of the plants. From submission 2015, BC emissions are also reported from year 2000, calculated as a fraction of $PM_{2.5}$, according to the EMEP/EEA Guidebook 2023.

Reported activity data are amounts of pig iron produced (Mt).

### *4.4.1.2.2 Secondary iron and steel production*

For reported emissions from secondary iron and steel production, the companies' environmental reports are the main source of information. $NO_X$, NMVOC and $SO_2$ emissions emitted from electric arc furnaces are reported in 2C1. $NO_X$ emissions may also arise from pickling and acid regeneration and NMVOC emissions may arise from rolling mills. These sources are also included in the estimates.

The estimated TSP emissions are based on information from the different facilities. TSP data for missing years have been interpolated. The PM size fractioning has been made according to EMEP/EEA Guidebook 2023. BC emissions are reported from secondary iron and steel production from 2000 onwards. Emissions are calculated as a fraction of $PM_{2.5}$ according to EMEP/EEA Guidebook 2023.

The estimated metal emissions from secondary iron and steel processes are based on produced amount of steel, published by the trade association[175], and emission factors, for the years 1990 - 2000. The emission factors used are based on compiled information from older trade specific reports made by the Swedish EPA for some years during the 1990's. Emission factors have been calculated for Cd, Cr, Cu, Hg,

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[175] The Swedish Steel Producers Association. http://www.jernkontoret.se.

Ni, Pb and Zn. For years where the Swedish EPA did not provide trade specific reports, or when the trade was not fully covered in the reports, data has been interpolated. Data on As emissions from iron and steel production is somewhat uncertain since reported data are scarce. From 2001 and onwards the emissions are mainly derived from the companies' environmental reports. For years when information is missing in the environmental reports, emissions are estimated using IEF for earlier years and production volumes or amounts of particles emitted.

Dioxin emissions have been compiled for the whole time series. According to the USEPA[176], dioxin emissions from steel production are strongly dependent on several parameters, likely to vary between steel plants. Whether steel is produced from primary metals or from scrap metal is one very important factor, with the latter giving much higher dioxin emissions. Since the emission factors vary widely depending on several process factors, no straightforward calculations using an emission factor were made when compiling a time series of national dioxin emissions from the iron and steel industry. Instead, the estimates for the time period 1990 - 2000 are based on a combination of information concerning production data for scrap-based steel, results from dioxin measurements, earlier estimates and expert judgement in co-operation with the trade association[177]. From 2001 the information concerning the dioxin emissions were derived from the companies' environmental reports.

PAH1-4 and PCB emissions are calculated based on national figures on produced amount of steel and emission factors from EMEP/EEA Guidebook 2023.

Emissions from flaring of pilot fuel, that occur at several facilities, are also included. The emissions from flaring of pilot gas are calculated based on estimated constant fuel amounts, periodically checked with the facilities. This affected emissions from 1990 of NOx, NMVOC, CO, $NH_3$ and dioxin.

#### *4.4.1.2.3 Direct reduced iron*

For emissions estimates for the producer of iron ore-based iron powder, almost all reported emissions are obtained from the plant's environmental reports and are verified by collecting and comparing the carbon contents in the amounts of coke, anthracite and output material. To be consistent with calculations of emissions from production of pig iron, limestone used in the production is included in the emissions from the production of iron powder in NFR2C1. Reported activity data is produced amount of direct-reduced iron (iron sponge). For estimation of $PM_{10}$, $PM_{2.5}$ and BC emissions, the same Tier 1 fractions of TSP or $PM_{2.5}$ as in EMEP/EEA Guidebook 2023 are used. The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e., not in diluted flue gases.

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[176] U.S. Environmental Protection Agency, 1997.

[177] The Swedish Steel Producers Association. http://www.jernkontoret.se.

Emissions of Se, HCB and PCB are reported, calculated with default Tier 1 emission factors from the EMEP/EEA Guidebook 2023.

### *4.4.1.2.4 Sinter*

During 1990-1995 a sinter plant was in operation at one of the integrated primary iron and steel plants. $SO_2$ from the sulphur content in the ore were considered to be emitted from the facility. Also, particles, heavy metals, dioxin, PAH1-4, PCB and HCB are reported for the facility. The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e., not in diluted flue gases.

### *4.4.1.2.5 Pellet*

There are currently four major iron ore mines closely connected to three facilities producing iron ore pellets reported in NFR2C1e. Emissions considered are $SO_2$ from the sulphur content in the ore, and $NO_X$, emitted as a result of the use of explosives. The use of mining explosives also causes emissions of carbon monoxide, CO. No data concerning the CO emissions are available and the time series from 1990 is thus reported NE[178]. Particulate matter, metals, dioxins, PAH, HCB and PCB are reported for the time period from 1990. Emissions of particles from mining are not reported separately anymore but are reported together with particle emissions from sorting plants and from enrichment plants.

The figures are mainly based on data reported by the companies in their environmental reports. For years with missing data figures have been interpolated or estimated, using expert judgement in cooperation with industry. For distributing the emission of particulates between TSP, $PM_{10}$ and $PM_{2.5}$ for mining activities, the same ratio has been used as the ones presented in EMEP/EEA Guidebook 2023 ($PM_{10}$ = 50% of TSP, $PM_{2.5}$ = 7% of TSP, NFR2A5a, Table 3.2). The distribution of particulates from pellets production are for one of the facilities based on information presented in their environmental report ($PM_{10}$ = 85% of TSP, $PM_{2.5}$ = 80% of TSP). For the other two facilities $PM_{10}$ and $PM_{2.5}$ are 100% of TSP. BC emissions are reported from submission 2015 and are calculated as a fraction of $PM_{2.5}$ according to EMEP/EEA Guidebook 2023. The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e. not in diluted flue gases.

PAH1-4, PCB, HCB and Se emissions from iron ore pellets production are based on produced amounts and emission factors from EMEP/EEA Guidebook 2019/2023.

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[178] Wieland, 2004

The reported emissions of dioxins are for 1990 – 2001, based on emission factors provided by the company. The emission factors are generally higher in the early 90s and lower in later years. For 2002 onwards, data on dioxin emissions provided by the companies are reported.

**Metal emissions**[179]

As far as possible, the facilities reported metal emissions in their annual environmental reports have been used, but the between year variation was in some cases so large that adjustments have been made to reported emissions.

The ratio between emissions of metals and dust from pellet plants (Implied emission factor, IEF) has been calculated for all metals, except for mercury and selenium. Since mercury emissions occur mainly in the gas phase and not bound to particles, IEF for mercury has instead been calculated as the ratio between emissions of mercury and the amounts of pellets produced. Selenium emissions are, as before, estimated using the default factor from the EMEP/EEA Guidebook 2023 since selenium has not been measured by the company.

To find out if there are outliers among calculated IEF:s, Kruskal-Wallis Test and Box-and-Whisker plot has been used. For the years IEF:s falls out as outliers, the average IEF for the years 2011-2020 has been used to estimate the emissions.

For all metals except copper, zinc and mercury, emissions for the years before 2006 has been estimated using the mean IEF for the period 2006 - 2010 and reported dust data. For copper, zinc and mercury, the emissions for 1990 – 2010 has instead been estimated using the average IEF for 2011 – 2020 and dust and production data, respectively.

For the years and metals after 2011, where the company did not report emissions in its environmental reports, missing data have been replaced by estimated emissions using the mean IEF for 2011 – 2020 and the amount of dust emitted from the pellet plants or, for mercury, pellet production.

The method is based on reporting metal emissions as much as possible in accordance with what the company reports in its environmental reports and only replacing reported data when the Implied emission factor falls out as outlier.

### *4.4.1.2.6 Other*

Process related emissions from most foundries consist of NMVOCs, particulate matter and heavy metals. NMVOC emissions come from organic binder used to hold together molds and cores as well as black used to provide a nice surface of the goods. Particle and metal emissions come from melting, casting and finishing. Most of the foundries report emissions of particulate matter in their annual environmental reports. In a couple of cases, however, the reported emissions have not been reported as annual quantities, and in these cases the TSP emissions have instead been calculated with an emission factor of 0.2 t/kt of the amount of castings produced, based on the emissions of other plants. The PM size fractioning has been

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[179] Danielsson & Mawdsley, 2022

made according to EMEP/EEA Guidebook 2023. BC emissions are reported from 2000 onwards. Emissions are calculated as a fraction of $PM_{2.5}$ according to EMEP/EEA Guidebook 2023. Reported metals are Pb, Cd, Hg, As, Cr, Cu, Ni, Zn. Data for missing years have been interpolated.

#### 4.4.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Time series from industrial processes reported in NFR codes 2C1 has been reviewed in later years and are consistent.

Uncertainties for NFR2C1 are displayed in Annex 1.

Primary iron and steel plants *(including direct reduced iron production):* Uncertainties are mostly expert estimates, except for Se, PCB and HCB, for which the emission factor uncertainties are calculated based on the intervals in the EMEP/EEA Guidebook 2023.

#### 4.4.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 4.4.1.5 SOURCE-SPECIFIC RECALCULATIONS

##### *4.4.1.5.1 Primary iron and steel plants:*

In submission 2025, emissions of particles (all fractions) were recalculated for the entire timeseries. Particle fraction distribution between NFR categories was revised, resulting in annual emission changes by up to +0.05 kt for TSP, by -0.02 – +0.56 kt for PM10, by -0.002 – +0.36 kt for PM2.5, and by -0.0006 – +0.004 kt for BC within NFR2C1b.

Correction of amount of combusted BFG in 2022 and correction of total TSP emissions during the same year resulted in decrease of emission calculated from amount of combusted BFG (by 0.01 kt CO, 0.002 kt NMMVOC) and increase of emissions calculated from amount of emitted TSP (by 0.001 t Cr, 0.00001 t Cu, 0.002 t Ni).

Correction of values in the facilities’ environmental reports resulted in emission reductions of NOx (by 0.02 kt) and $SO_2$ (by 0.01 kt) in 2022.

##### *4.4.1.5.2 Secondary iron and steel production:*

In submission 2025, small corrections of values from environmental reports were conducted, resulting in emission changes in 2021 (reduction of TSP by 0.004 kt, PM10 by 0.004 kt, PM2.5 by 0.003 kt and BC by 0.00001 kt) and 2022 (reduction of TSP by 0.00005 kt, PM10 by 0.00004 kt, PM2.5 by 0.00003 kt and BC by 0.0000001 kt, and NOx increase by 0.00001 kt).

#### *4.4.1.5.3 Direct reduced iron:*

No source-specific recalculations have been performed in submission 2025.

#### *4.4.1.5.4 Sinter*

No source-specific recalculations have been performed in submission 2025.

#### *4.4.1.5.5 Pellet*

Recalculations were made for year 2022 for one of the mines and was resulting in minor changes in calculated TSP, PM2.5 and PM10 emissions, with a decrease in emissions ranging from -0.19 to -0.94 %.

#### *4.4.1.5.6 Other*

Recalculations were made for year 2022 for one of the foundries and was resulting in minor changes in calculated TSP, PM2.5 and PM10 emissions, with an increase in emissions with 0.74 %.
Recalculations were also made for year 2021 for one of the foundries and was resulting in minor changes in calculated NMVOC emissions, with a decrease in emissions with -2.3 %.

### 4.4.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

## 4.4.2 Ferroalloy production NFR2C2

### 4.4.2.1 SOURCE CATEGORY DESCRIPTION

Ferroalloy production is reported for only one facility in Sweden. There is also ferroalloy production at another plant, but since the main production at this facility is of iron and steel, these emissions are reported in NFR2C1, Iron and steel production.

A summary of the latest key source assessment is presented in Table 4.4.3.

**Table 4.4.3. Summary of key source analysis, NFR2C2, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2C2 | *Cr, Zn* | *Cr* |

### 4.4.2.2 METHODOLOGICAL ISSUES

Emission data for $SO_2$ and $NO_X$ has been obtained directly from the company for all years. Production of ferrosilicon leads to larger emissions of $SO_2$ compared to production of ferrochromium. From 2005 the production of ferrosilicon has been much reduced and during 2008 – 2011 and from 2014 there has not been any ferrosilicon production at all. This led to a distinct decrease in $SO_2$ emissions during these years. In 2012 the production of ferrosilicon was relatively large compared to adjacent years, which resulted in high emissions of $SO_2$. Also, emissions of $NO_X$ were higher in 2012 compared to years with no ferrosilicon production. In 2013 only small amounts of ferrosilicon was produced, resulting in lower emissions of $SO_2$ and $NO_X$ compared to 2012. Higher sulphur concentrations in the raw materials used have resulted in increased emissions of $SO_2$ in 2012, 2018 and 2020.

TSP emissions for 1990-1999 have been calculated based on activity data provided by the company and emission factors derived from reported emissions of TSP in the company's environmental reports in later years. The calculated average emission factor has been used for all years during the 1990's and was doubled for the period 1980-1989, as suggested by the company experts. From 2000, data on TSP emissions from the company's environmental report were used. $PM_{2.5}$ emissions are estimated from $PM_{10}$ according to relationship in Guidebook 2023. Emissions of BC are estimated from $PM_{2.5}$ according to relationship in Guidebook 2023.

Metals emitted to air from ferroalloy production are primarily Cr, Pb, Ni and Zn. Chromium emission have been reported in the environmental reports to the emission database from 1992. The chromium (Cr) emissions in the database and the activity data obtained from the company have been used to derive emission factors. The average emission factor for 1992-1994 was used for 1990-1991. Zinc and lead emissions have only been sporadically reported to the database during the 1990's. In order to estimate emissions of Zn and Pb, information from older Swedish EPA reports were combined with the reported data on emissions to calculate emission factors for the 1990's. Emissions of Ni from ferroalloys production has been derived from the company's environmental reports or by information from the producer for the years 2003 – 2014. For earlier years no data is available and Ni emissions are hence reported NE (Not Estimated) for the time period 1990 – 2002.

Reported activity data are amounts of carbon in coke and electrode materials (kt).

#### 4.4.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Time series from industrial processes reported in NFR codes 2C2 have been reviewed in later years and are consistent.

Uncertainties for NFR2C2 are displayed in Annex 1.

#### 4.4.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 4.4.2.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations are performed in submission 2025.

#### 4.4.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are currently planned.

### 4.4.3 Aluminium production, NFR2C3

#### 4.4.3.1 SOURCE CATEGORY DESCRIPTION

The process related emissions included in this category comes from primary aluminium production, secondary aluminium production, formerly reported in NFR2C7, and also from four aluminium foundries.

A summary of the latest key source assessment is presented in Table 4.4.4.

**Table 4.4.4. Summary of key source analysis, NFR2C3, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2C3 | *CO, SO2* | *PAH 1-4, PM10, TSP* |

#### *4.4.3.2.1 Primary aluminium production*

There is one facility that produces primary aluminium in Sweden. The facility consists of two plants. One of the potlines (plant 1) includes 56 closed Prebake cells (CWPB), each of 150 kA. The other plant (plant 2) consisted of 262 cells and, until the beginning of 2008, operated three Prebake cells and 259 open cells with Söderberg anodes (VSS). The Söderberg anodes were produced in an electrode pulp factory at the facility.

In 2008 a project was started to convert the Söderberg ovens to ovens with Prebake cells. All pot-lines operating the Söderberg technology were shut-down by December 2008. By the end of December 2009, 120 of a total of 262 cells in plant 2 had been converted to the Prebake technology and the conversion to Prebake cells continued under 2010. In the beginning of December 2010 242 Prebake cells in plant 2 were in operation. At the end of December 2010, a power outage lead to big disturbances in plant 2 leading to both increased emissions and major production problems. On January 7, 120 Prebake cells were shut down as a direct result of the power outage. At the end of June 2011 all Prebake cells in plant 2 were restarted and in operation.

PAHs emissions occur in Söderberg plants due to the self-baking anode. Emissions of PAHs during the electrolysis process are small for Prebake plants but from submission 2018 these emissions are calculated from 2009 and onwards using emission factors emissions presented in EMEP/EEA Guidebook 2023.

#### *4.4.3.2.1 Secondary aluminium production and aluminium foundries*

In Sweden there is one facility that produces secondary aluminium. In submissions prior to 2023 emissions from this facility were reported in NFR2C7c. In submission 2023 also emissions from four aluminium foundries are included in NFR2C3.

### 4.4.3.2 METHODOLOGICAL ISSUES

#### *4.4.3.2.1 Primary aluminium production*

Primary aluminium production takes place in one facility, where historically both the Prebake and the Söderberg technologies have been used. All pot-lines operating the Söderberg technology were shut-down by December 2008.

The time series of emissions compiled for primary aluminium production include emissions of $NO_X$, CO, NMVOC and $SO_2$, particulate matter and PAH. Reported production statistics and emissions data are based on information in the environmental reports or received directly from the company.

From submission 2019 emissions of dioxin from aluminium production are reported as NE since no emission factors for dioxin regarding primary aluminium production are available in EMEP/EEA Guidebook 2023.

Emissions of $NO_X$ have been calculated from production statistics using emission factors defined by Swedish EPA[180]. NMVOC emissions have been calculated from reported emissions of tar, assuming that 70% of the tar is emitted as NMVOC[166]. Closing down the Söderberg ovens also ended the need for anode production in late 2008. The shutdown of the anode production ended the tar emissions which meant that also the NMVOC emissions fell sharply. From 2009 and onwards, emissions of NMVOC are reported NE since no emission factor is specified in the EMEP / EEA Guidebook. CO emissions were reported for the first time in submission 2008 and are for 2002 - 2020 as reported in the company's environmental reports. For the period 1990 - 2001 the CO emissions are calculated using production statistics and emission factor provided by the company as also the $SO_2$ emissions, 1990 - 2005. For 2006 - 2020 $SO_2$ is as reported by the company in their environmental reports.

The elevated $SO_2$ emission in 2012 is primarily due to high sulphur content in delivered anodes. The desulfurization of flue gases in the flue gas treatment facilities was not sufficiently efficient. In 2014 the $SO_2$ emissions were lower than previous year due to improved abatement technology. The improved abatement technology is also shown in low $SO_2$ emissions from 2015. Also the CO emissions were higher for 2012 compared to previous years. The reason for this is, according to the company, that a new calculation method has been used from 2012 and onwards.

Information concerning production statistics and emissions of TSP and benzo(a)pyrene (BaP) were provided by industry, and only a few missing years have had to be interpolated. The reported emissions also include particulate matter from the foundry located at the site of the primary production plant. The particle size fractions of $PM_{10}$ and $PM_{2.5}$ have been assumed for the whole time period, as given in

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[180] Ahmadzai, H. Swedish EPA. Personal communication. 2000.

the CEPMEIP project[181] for primary aluminium production. For particulate matter from the foundry the same particle size fractions of $PM_{10}$ and $PM_{2.5}$ have been used. The assumption is thus that $PM_{10}$ constitutes 95% and $PM_{2.5}$ 43% of the reported TSP emissions.

Emissions of benzo(a)pyrene and "PAH" have been reported from the facility as far back as 1984. It is not known which compounds are included in the term "PAH". In 1984 and 1986, benzo(a)pyrene emissions occurred from plant 1 and 2. From 1987 until 2008, emissions occurred only from plant 2, which represents the production of Söderberg anodes and anode baking in the so-called Söderberg ovens. Emissions of PAHs during the electrolysis process are small for Prebake plants but to submission 2018 these emissions are calculated from 2009 and onwards using emission factors emissions presented in EMEP/EEA Guidebook 2023. For 1990 – 2008 emissions of benzo(a)pyrene are as reported by the facility and emissions of benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-de)pyrene are calculated based on information in EMEP/EEA Guidebook 2023.
According to UNEP[182] primary production of aluminium has no significant emissions of dioxins to air. This was confirmed by measurements made at the facility in the late 1970´s and early 1980´s. The measurements in the early 1980´s showed no detectable amounts.

#### *4.4.3.2.1 Secondary aluminium production and aluminium foundries*

Reported emission data are mainly based on information in the facilities environmental reports. For the years where data is missing for individual facilities, extrapolation has been used to make the time series complete.
For secondary aluminium production emissions of $NO_X$, $SO_2$, CO, particulate matter, As, Cd, Hg, Pb, Zn, dioxin and HCB are reported.
HCB is formed when using hexachloroethane (HCE) to remove hydrogen bubbles from molten aluminum in secondary aluminum production. A general ban on the use in the manufacture or processing of non-ferrous metals was introduced at EU level on 1 January 1998. HCB is reported from 1990 to 1997 using production data and emission factor from Toda (2005)[183].
For aluminium foundries emissions of NMVOC, particulate matter, Cd, Cr, Cu, Ni, Pb and Zn are reported.

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[181] CEPMEIP, 2001. TNO. http://www.mep.tno.nl/wie_we_zijn_eng/organisatie/kenniscentra/centre_expertise_emissions_assessment.html

[182] UNEP, 2001. Standardized Toolkit for Identification and Quantifications of Dioxin and Furan Releases. http://www.chem.unep.ch/pops/pdf/toolkit/toolkit.pdf

[183] Toda, E. 2005. POPs and heavy metals emission inventory of Japan.

#### 4.4.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

##### *4.4.3.2.1 Primary aluminium production*

Uncertainties for emissions are based on Guidebook Qualiaty Ratings. Uncertainty for $SO_2$, $NO_X$, NMVOC and particulate matter are ± 30%, ± 50%, ± 75%, and ± 40%, respectively, and ± 100% for CO and PAH1-4.

##### *4.4.3.2.1 Secondary aluminium production and aluminium foundries*

Uncertainties for CO, $SO_2$, $NO_X$ and NMVOC are ± 100%, ± 30%, ± 50%, ± 100%, respectively. Uncertainty for particulate matter is ± 40%, for dioxin ± 2900% and for HCB ± 1000%
Uncertainty for As is ± 50% and for Hg ± 20%. For other reported metals is the uncertainty ± 100%.

More information is given in IIR Annex 1. Time series reported in NFR code 2C3 have been reviewed in later years and are consistent.

#### 4.4.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 4.4.3.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations are performed in submission 2025.

#### 4.4.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

### 4.4.4 Magnesium production, NFR2C4

No production of magnesium occurs in Sweden, and thus NO is reported for NFR2C4.

### 4.4.5 Lead, Zinc, Copper and Nickel production, NFR2C5, 2C6, 2C7a and 2C7b

Production of lead, zinc, copper and nickel does occur in Sweden. However, since Swedish non-ferrous metal smelters produce several metals in the same process, emissions cannot be separated and are all included in NFR2C7c Other metal production. Thus IE is reported in NFR2C5, 2C6, 2C7a and 2C7b.

### 4.4.6 Other metal production, NFR2C7c

#### 4.4.6.1 SOURCE CATEGORY DESCRIPTION

This sub-category includes emission estimates from one large smelter producing different non-ferrous metals such as copper, lead, zinc etc., one metal recycling company mainly producing lead and seven smaller smelters of various kinds. Emissions from two foundries that produce castings in brass and bronze are also included. Emissions of particulate matter have been obtained from the large smelter from 1980, for one facility from 1985 and for most of the smaller smelters from 1990. Time series of metal emissions are reported from 1990 and includes also the smaller facilities. In the dioxin time series reported emissions from the large smelter, from the metal recycling company and from two smaller smelters are included.

A summary of the latest key source assessment is presented in Table 4.4.5.

**Table 4.4.5. Summary of key source analysis, NFR2C7c, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2C7c | *As, Cd, Cu, DIOX, Hg, Ni, Pb, SO2, Zn* | *As, Cd, Cu, DIOX, Hg, PM10, PM2.5, Pb, SO2, TSP, Zn* |

### 4.4.6.2 METHODOLOGICAL ISSUES

Choice of data source for reporting can cause confidentiality issues, especially if only one or a few facilities emissions are reported in the NFR code. Therefore, Sweden chooses to report facilities that produce primary and secondary non-ferrous metals, except aluminium, together in NFR 2C7c.

The reported emissions of $SO_2$ mainly originate from the sulphur content in the raw materials used in the large non-ferrous smelter, but also represent emissions from the metal recycling company and from one of the smaller smelters. Reported $NO_X$ in 2C7c represents the same facilities. The $SO_2$ and $NO_X$ time series are considered complete and consistent.

At the large smelter, a variety of processes occur, including both primary and secondary processes, and a number of products are produced. This facility has a long history of submitting environmental reports to the authorities, why emission estimates for all substances were readily available, except for the size fractions of emitted particulate matter. Emission factors for $PM_{10}$ and $PM_{2.5}$, as fractions of emitted TSP, have for the period before 1995 been assigned by expert judgement, in cooperation with company experts. Fractions range from 60 to 95% for $PM_{10}$ from 1990 until 2003 and from 30 to 80% for $PM_{2.5}$ during the same period of time. The suggested emission factors according to CEPMEIP[184], valid for 1995, correspond to a value of 90% for $PM_{10}$ and 80% for $PM_{2.5}$. For the years after 2003 the emission factors for $PM_{10}$ and $PM_{2.5}$ are the same as for 2003.

Emissions of particulate matter and metals from ten secondary non-ferrous metal smelters and two foundries have been compiled. Emissions of TSP and metals, except chrome from the large smelter and nickel from one secondary copper production facility, are reported in the inventory as reported by the companies in environmental reports, and further into an emission database. The data in the database are

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[184] CEPMEIP, 2001. TNO. http://www.mep.tno.nl/wie_we_zijn_eng/organisatie/kenniscentra/centre_expertise_emissions_assessment.html

for early years not complete and consistent, and several instances of missing values have had to be interpolated in order to complete the time series. Emissions of $PM_{10}$ and $PM_{2.5}$ are calculated by applying particle size fractions implied by Tier 2 emissions factors given in EMEP/EEA guidebook 2023. The applied particle size fraction applied for a plant therefore depends on the type of metal production of the plant.

Primary non-ferrous metal production is not associated with major dioxin emissions to air. From secondary processes, however, dioxin emissions are known to occur. Dioxin emissions from the large smelter, from the metal recycling company and from two smaller smelters are included for the whole time series, 1990 – 2023.

Emissions of PCB from the large smelter, one small smelter and the metal recycling plant are reported using the EF from EMEP/EEA Guidebook 2023.

Chrome and nickel emissions from copper production are reported from submission 2016 onwards according to Table 4.4.6 below. For the primary copper production facility, nickel emissions are obtained from environmental reports from 1999 onwards and chrome emissions are calculated based on the EMEP/EEA Guidebook 2023 and information from the facility operator regarding abatement efficiency. For one secondary copper production facility, nickel emissions are based on EMEP/EEA Guidebook 2023 with assumptions on applied abatement and chrome is reported as NE due to the lack of Tier 2 emissions factor. Activity data is acquired from the facilities' environmental reports. For two smaller smelters, almost all emission data are obtained from the environmental reports and interpolated/extrapolated to cover the period 1990-2014.

**Table 4.4.6. Cr and Ni emissions from copper production (NFR2C7c) at four major facilities in Sweden – sources and emission factors used.**

| Facility | Type of production | Emissions of Ni | | Emissions of Cr | |
|---|---|---|---|---|---|
| | | Source | EF, g/Mg copper | Source | EF, g/Mg copper |
| 1 | Primary | Emissions from environmental reports available from 1999 onwards, extrapolation for earlier years | | Facility production data and default EF from Guidebook 2023 | 0.315 (98.5% abatement efficiency according to facility operator) |
| 2 | Secondary | Facility production data and default EF from Guidebook 2023 | 1.3E-05 (abatement with 99.99% efficiency assumed) | Not estimated | No default Tier II EF in the Guidebook 2023 |
| 3 | Secondary | Emissions from environmental reports available for 2014+extrapolation | | Emissions from environmental reports available for 2008-2014+extrapolation | |
| 4 | Secondary | Emissions from environmental reports available for 2003-2008+extrapolation | | Emissions from environmental reports available for 2006 and 2008 + interpolation/extrapolation | |

#### 4.4.6.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Time series from industrial processes reported in NFR codes 2C7c have been reviewed in later years and are consistent. Uncertainties for NFR2C7c are displayed in Annex 1.

#### 4.4.6.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 4.4.6.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed in submission 2025.

#### 4.4.6.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are currently planned.

### 4.4.7 Storage, handling and transport of metal products, NFR2C7d

Emissions from the source category Storage, handling and transport of metal products, NFR2C7d, have not been separated from the relevant metal production chapter and are included in respective source category, 2C1, 2C2, 2C3 or 2C7c.

## 4.5 Other solvent and product use, NFR2D3

A summary of the latest key source assessment is presented in Table 4.5.1.

**Table 4.5.1. Summary of key source analysis, NFR2D3, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2D3 | *NMVOC* | *NMVOC* |

### 4.5.1 Road paving with asphalt, NFR2D3b

#### 4.5.1.1 SOURCE CATEGORY DESCRIPTION

In this source category, emissions from road paving with asphalt are included. Due to confidentially reasons emissions from asphalt roofing (NFR2D3c) are reported together with emissions from road paving.

Large changes have occurred in asphalt paving technology over the last decade, with a gradual change towards use of water-based emulsions instead of solvent-containing bitumen solutions. Industry representatives estimated that the naphtha content in the solutions used for road paving varied within the interval 17- 50% during 2002-2014. In this inventory, NMVOC and particles emitted in the process of asphalt paving of roads are included. CO emissions have not been estimated due to lack of information and reported NE in accordance with EMEP/EEA Guidebook 2023.

### 4.5.1.2 METHODOLOGICAL ISSUES

NMVOC emission estimates for the late 1980s and early 1990s are taken from investigations and inventories made in the early 1990s. Data from 2002-2008 has been calculated based on information from the asphalt producers on the average amount of solvent (naphtha) in the mixtures used for road paving. The producers have also provided figures on the total amount of road paving mixtures delivered in Sweden. It is assumed that all solvents in the solvent-based bitumen are emitted when used. In the calculations, emissions from imported solvent-based bitumen are not included. The amount of imported solvent-based bitumen is most likely very small. Emissions of NMVOC reported for the years in mid- and late 1990s were interpolated. For the years 2009 - 2023, data on amount of road paving mixtures has been calculated based on national statistics[185] on the amount of petroleum bitumen used for asphalt products, the assumption that 85% of the bitumen for asphalt is allocated to road construction[186] and the emission factor for NMVOC in EMEP/EEA Guidebook 2023. The method change was needed as the previous data source, used from 1990-2008, didn’t provide full coverage of the bitumen industry as new bituminous mixes and emulsifiers were introduced to the market.

Particle emissions from road paving with asphalt are reported from submission 2016 onwards. Activity data for 1990-2008 is obtained from asphalt statistics[187] and by statistics Sweden from 2009 onwards. Emissions factors are obtained from EMEP/EEA Guidebook 2023. According to the Guidebook, there are two main types of asphalt production technologies – batch mix and drum mix technologies – with different emission factors for particle fractions. Both technologies are applied in Sweden, but the exact proportion is not known. In particle emissions calculations, it is assumed that 50% of all the asphalt is produced with batch mix technology and another 50% with drum mix technology. Based on personal communication with branch representatives[188], it is also assumed that all the facilities use fabric filters to catch major part of the particles.

Reported activity data are amounts of produced asphalt in kt.

### 4.5.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions are based on expert judgement. Assessed uncertainties for emissions, from Road paving with asphalt and Asphalt roofing, of CO, NMVOC, TSP, $PM_{10}$ and $PM_{2.5}$ are ± 216%, ± 191%, ± 109%, ± 97%, and ± 100%, respectively. More information is given in IIR Annex 1.

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[185] Statistics Sweden, Yearly data on total amount of petroleum bitumen used for asphalt production.

[186] National asphalt pavement association and European asphalt pavement association 2011, The asphalt pavement industry- A global perspective 3rd edition. https://web.achive.org/web/20140107203855/http://www.asphaltpavement.org/images/stories/GL_101_Edition_3.pdf available 2024-11-03

[187] Asphalt in figures http://www.eapa.org/asphalt.php available 2016-10-15

[188] Jan Wikström and Lorentz Lundqvist, NCC Roads AB

Time series from road paving with asphalt reported in NFR code 2D3b have been reviewed in later years and are consistent.

#### 4.5.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC has been performed.

#### 4.5.1.5 SOURCE-SPECIFIC RECALCULATIONS

During submission 2025 a project was carried out with the purpose to find a new source of activity data for Road Paving from year 2010 onwards since the old source did not provide either statistics over produced amount of asphalt or bitumen emulsions. Recalculations were made from year 2010 onwards and was resulting in minor changes in calculated emissions ranging from -0,1 kt to + 0.04 kt NMVOC.

#### 4.5.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are currently planned.

### 4.5.2 Asphalt roofing, NFR2D3c

#### 4.5.2.1 SOURCE CATEGORY DESCRIPTION

In this source category, emissions from asphalt roofing are included. Due to confidentially reasons emissions from asphalt roofing are reported together with emissions from road paving (NFR2D3b).

Emissions to air linked to the asphalt roofing industry consist mainly of particles, CO and non-methane volatile organic compounds (NMVOC), which are emitted from asphalt storing tanks and blowing stills, as well as from coater-mixer tanks and coaters. Since the end of the 1990’s there have only been two companies in Sweden producing asphalt-saturated felt. Production and emission data provided by the manufacturers have been used for developing emission factors for estimations of the NMVOC and particle emissions. CO emissions are estimated with the default emission factors from EMEP/EEA Guidebook 2023. No measurements or estimations on Ni, Pb, Cd or Cr emissions have been performed by the industry and are consequently reported NE for the whole time-series, in accordance with EMEP/EEA Guidebook 2023.

#### 4.5.2.2 METHODOLOGICAL ISSUES

Data on the total Swedish production of asphalt-saturated felt was provided by the producing companies. Emission factors for NMVOC and particles are based on measurements and calculations made by the manufacturers[189]. The NMVOC emissions from the production of asphalt-saturated felt originate from the felt saturation and coating processes. In submission 2018 new information and measurements

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[189] Danielsson, 2004.

from both companies were presented leading to new calculations of NMVOC emissions for the whole time series. The new information also showed that no NVMOC emissions came from leakage from the asphalt storage tanks. The NMVOC and TSP emissions, 1990-2008, for one company are calculated by emission factors based on measurements in 2009. The NMVOC and TSP emissions for 2009-2022 are based on measurements. For the other company the NMVOC emissions, 1990-2015, are calculated by an emission factor based on the measurements in 2016. The factor used for estimating the TSP emission for the other company includes particles emitted from the mineral surfacing process as well as from storage and handling of the mineral products (0.005 kg/Mg) and are based on data from 1997. Emission factors for CO are obtained from EMEP/EEA Guidebook 2023. CO emissions from Swedish production of asphalt-saturated felt are reported from submission 2016 onwards. The notation key for activity data is C (classified). However, emissions from asphalt roofing are reported in 2D3 Road paving with asphalt due to confidentially reasons.

#### 4.5.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions are based on expert judgement. Assessed uncertainties for emissions, from Road paving with asphalt and Asphalt roofing, of CO, NMVOC, TSP, $PM_{10}$ and $PM_{2.5}$ are ± 216%, ± 191%, ± 109%, ± 97%, and ± 100%, respectively. More information is given in IIR Annex 1.

Time series from asphalt roofing have been reviewed in later years and are considered to be consistent.

#### 4.5.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No SOURCE-specific QA/QC has been performed.

#### 4.5.2.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations in submission 2025.

#### 4.5.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are currently planned.

### 4.5.3 Solvent use, NFR2D3a, NFR2D3d, NFR2D3e, NFR2D3f, NFR2D3g, FR2D3h and NFR2D3i

#### 4.5.3.1 SOURCE CATEGORY DESCRIPTION

Use of solvents and products containing solvents result in emissions of non-methane volatile organic compounds (NMVOC). The model used for estimating the NMVOC emissions reported in the various solvent use categories is described in more detail in Annex 3.1 and is fully described in Skårman et al., 2016[190].

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[190] Skårman et al., 2016. Swedish method for estimating emissions from Solvent Use. Further development of the calculation model. SMED report 192.

Emission estimates reported for solvent use in NFR2D3 include emissions from the source groups NFR2D3a “Domestic solvent use” (all domestic use except use of coatings), NFR2D3d “Coating applications” (industrial coating, domestic coating, non-industrial coating), NFR2D3e “Degreasing” (use of degreasing in industry), NFR2D3f “Dry cleaning” (non-domestic dry cleaning), NFR2D3g “Chemical product use” (vehicle industry, rubber industry, paint industry, textile industry, leather industry), NFR2D3h “Printing” (printing industry) and NFR2D3i “Other solvent and product use” (all other use of solvents).

NMVOC emissions from asphalt blowing are included in NFR 1B2A4 as this process step occurs at Swedish refineries that produce bitumen for the market. Emissions are not possible to separate from other NMVOC emissions from the plant. For other emissions from asphalt blowing, the Guidebook EFs are judged to be too uncertain to be used as these lack references and would result in fairly high emissions.

Emissions of NMVOC from solvents and products containing solvents have decreased by 28% from 90 kt NMVOC in 1990 to 56 kt NMVOC in 2023. This can largely be explained by the reduced use of solvents in coating application due to a shift to water-based paints.

NMVOC emissions from “Coating applications” (NFR2D3d) have decreased by 77% from 35 kt NMVOC in 1990 to about 8 kt NMVOC in 2023. The largest source of NMVOC from solvents reported in NFR2D3 is, in later years, NFR2D3i “Other product and solvent use”. In this sub-sector an increase of emitted NMVOC from 1990 (13 kt) to 2023 (39 kt) can be observed.

#### *4.5.3.1.1 NFR2D3a “Domestic solvent use”*

Domestic solvent use is a moderate source of NMVOC but increases over time. This increase, starting in 2002, is due to an increased use of the product groups “washer fluid”, “degreasing agents”, “diluents and thinners” and “ignition fluids”. However, a decrease in emissions from the use of ignition fluids and diluents and thinners can be seen for later years.

Two different emission factors are used for NFR2D3a “Domestic solvent use” for the whole time series:

- Diluted 0.275 (product groups that are used diluted in water)
- Not diluted 0.95 (product groups that are not used diluted in water)

The separation between diluted and not diluted products is a new approach compared to the old calculation model.

#### *4.5.3.1.2 NFR2D3d “Coating applications”*

Coating applications is a moderate source of NMVOC and has decreased over time. Coating in industry is the dominating source, followed by domestic coating, and that non-industry coating is of less importance. Emissions of NMVOC from coating application have decreased for the whole time series from 1990. The decrease is both due to reduced use of paints containing solvents and more efficient abatement technologies as indicated in available environmental reports. Water based paints and coatings and an increased use of high-solid formulas (increased proportion of solid mass) are the two main reasons for the steady decline. The sharp decline in emissions from 2009 onwards is most likely due to the sharpened legislations that were implemented in Sweden (and the EU) during this time.

#### *4.5.3.1.3 NFR2D3e "Degreasing"*

Degreasing within the industry is a minor source of NMVOC and has decreased over time. The estimates are based on abatement efficiency factors given in EMEP/EEA Guidebook and the distribution between different abatement technologies has been based on information available in the GAINS-model (scenario: EGEO_Baseline_CLE) for 1995, 2000, 2005 and 2010. Emissions of NMVOC have decreased from 1990, mainly due to a decreased use of degreasing products, but also a shift in technology, i.e. lower emission factors for the later years.

#### *4.5.3.1.4 NFR2D3f "Dry cleaning"*

Dry cleaning is a minor source of NMVOC. The time series for emissions of NMVOC from dry cleaning has decreased from 1990 mainly due to less use of dilution and thinner products. The general emission trend has been declining from the times series start but during 1997 the emissions, related to usage of dilutants and thinners, did decrease significantly. This year was followed by an increase in emission that was in line with the original trend. No specific reason for the trend anomalies has been found but the product register that the Swedish chemical agency holds confirms the product quantities used during these years.

#### *4.5.3.1.5 NFR2D3g "Chemical product use"*

Chemical product use is a minor source of NMVOC. The vehicle industry is the predominant source of emissions for chemical product use. The emissions are decreasing over time. The decrease during the 90's is both due to reduced solvent content in used products, as well as more efficient abatement technologies according to information available in environmental reports for the rubber and vehicle industry. The largest sources in Chemical product use are:

- Vehicle industry
- Rubber industry
- Paint industry
- Textile and leather industry

#### *4.5.3.1.6 NFR2D3h "Printing industry"*

Printing industry is a minor source of NMVOC. A steady decrease in the emissions of NMVOC from 1990 depends on a reduced use of solvent products within the industry as well as a technology shift. Year 2008 and 2017 deviates from the general trend as the calculated emissions these years shows a significant increase compared to years before and after. Statistics from the Swedish chemical agency shows that the quantities of products in the printing segment almost doubled during 2008, mainly to a major increase in the segment "dilutants and thinners". Concerning 2017, increasing quantities in the segment "paints" is the reason for the sharp increase. Why these segments were increasing during these years is not certain but since Sweden implemented new legislations 2009 to tighten the control of NMVOC (affecting dilutants used in the printing industry) a possible reason is that producing companies wanted to sell their stocks of dilutants and thinners to the greatest possible extent before the new legislations came into force.

#### *4.5.3.1.7 NFR2D3i "Other solvent and product use"*

Other solvent and product use is a major source of NMVOC and has, with the exception from a few years, increased from 1990 to 2023. The increased emissions for the activity are mainly due to a greater use of the product groups preservatives, refrigerants, metal mordants/etchants and coolant agents. From 2002, these products account for between around 40% to around 70% of reported emissions.

### 4.5.3.2 METHODOLOGICAL ISSUES

Activity data regarding all solvent use sub-categories for year 1995 and onwards has been obtained from the Product register at the Swedish Chemicals Agency.

The Products Register does not provide reliable data for the period 1990-1994 for most industry categories. Data from reported time series compiled in a dedicated study on NMVOC emissions carried out by SMED in 2002 (Kindbom et. al, 2004) has been used for the estimations of emissions for 1990 for most sources. Exceptions are the emissions for 1990 for NFR2D3e "Degreasing", "Vehicle industry" (included in NFR2D3g) and NFR2D3i "Other solvent and product use". The 1990 emissions for "Degreasing" have been calculated with activity data from the GAINS-model and emission factors from EMEP/EEA. The 1990 emissions for the "Vehicle industry" are based on the information that the number of produced vehicles was around 22% lower in 1990 than in 1995, and this information has been used to calculate the NMVOC emissions for 1990. The 1990 emissions for "Other product and solvent use" are based on the correlation between GDP (gross domestic product) (Ekonomifakta, 2016) and emissions from 1995 to 2013. From known GDP for 1990 and the mathematical function for the correlation between emissions and GDP, emissions of NMVOC have been calculated.

The emissions for 1991-1994 have been interpolated based on the available information for1990 and the known data for 1995.

In submission 2020, the model used for estimating NMVOC emissions has been updated[191]. Up until submission 2019, emissions have been calculated over a running average of three years. From submission 2020 on, emissions from solvent use are distributed over three consecutive years based on the assumption that products containing solvents are seldomly used entirely within the same year they have been purchased. More detailed information about the methodology update is given in IIR Annex 3.1.4.

Emission factors given in the literature, for example the EMEP/EEA Guidebook 2023, EU legislations, and other countries IIR´s, have been compiled and included in the model. The used emission factors are presented in Annex 3.1. The model has been developed in order to enable to test different datasets of emission factors. Two emission factors have been developed for each activity; one for solvents used as raw material and one for the remaining quantities. The emission factors for raw material have been set to 0.001 for all SNAP codes, since most of the solvents will end up in the product and will not be emitted during production.

Sweden reports NA for mercury for NFR2D3a since applying the default emission factor of 5.6 mg Hg/capita from the EMEP/EEA Guidebook 2023would result in emissions of 56.8 kg. Compared to the national total emissions of 0.41 t, this would lead to an increase of emissions by 14%. Sweden estimates emissions to be much lower since fluorescent tubes are handled as electronic waste with hazardous components and are collected and treated according to a national directive enforced in 2014. 97% of households in Sweden consider returning electronic waste to recycling sites as important according to a study conducted within a project aiming to improve the emission inventory carried out in 2017. If Sweden was to estimate Hg emissions from this source, national statistics that are not readily available, has to be compiled in the future.

A new emission factor for products used diluted in water or removed with water has been introduced in the new model for NFR 2D3a and 2D3i. The new emission factor is set to 0.275 and it has been calculated as average of 0.05 and 0.5 according to the information in the EMEP/EEA Guidebook 2023 for NFR 2D3a section 3.2.4. In the previous estimates these products were not treated separately and consequently the emission factor of 0.95 was used also for water diluted products. Activity data and emission factors for the individual SNAP codes 060412i (not diluted), 060412i (not diluted, raw material), 060412ii (diluted) and 060412ii (diluted, raw material) are given in Annex 3.1.

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[191] Helbig, T., Danielsson, H. Uppdatering av utsläppsberäkningen i lösningsmedelmodellen, SMED memorandum, 2019.

The country specific emission factors have been developed in order to adjust to the old time series 1990-2001, developed by SMED in 2002 (Kindbom et. al., 2004). However, for some activities, errors have been identified in previously reported data for 1990, and consequently those emissions have been corrected. Furthermore, application techniques, available information in the environmental reports for specific industries, as well as other pathways of release (e.g. water), have been considered when developing the country specific emission factors.

#### 4.5.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Reported time series are considered to be consistent, except for the current year where activity data for the previous year has been applied for emission calculations. This practice has been questioned by the ERT several times. The reason for Sweden to apply activity data with a delay of one year is due to the fact that activity data from the Product Register is not provided in sufficient time data to be able to perform the calculations and report in a timely manner. Sweden is undertaking efforts to receive data earlier and hence being able to report emissions accordingly.

Uncertainties for NMVOC emissions for NFR2D3a, NFR2D3d, NFR2D3e, NFR2D3f, NFR2D3e, NFR2D3f, NFR2D3h and NFR2D3i are ± 25% for years 1990-1994 and ± 15% for 1995 and onwards. More detailed information is to be found in IIR Annex 1.

The uncertainties have been discussed and assigned in co-operation with the Swedish Chemicals Agency. Uncertainty estimates for the emission factors were estimated by expert judgement. Information available in environmental reports, in the GAINS model and in the EMEP/EEA Guidebook has been taken into account when developing the emission factors.

#### 4.5.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 4.5.3.5 SOURCE-SPECIFIC RECALCULATIONS

Activity data from the Swedish Chemicals Agency is only available with a one-year-delay. In submission 2025 activity data for 2022 is updated.

The effect of the updates per NFR is presented in Table 4.5.2.

**Table 4.5.2. The effect of the updates in the solvent use model (NFR2D3a, NFR2D3d, NFR2D3e, NFR2D3f, NFR2D3e, NFR2D3f, NFR2D3h and NFR2D3) on NMVOC emissions in 2022, emission difference in kt.**

| | NFR 2D3a | NFR 2D3d | NFR 2D3e | NFR 2D3f | NFR 2D3g | NFR 2D3h | NFR 2D3i | Total |
|---|---|---|---|---|---|---|---|---|
| 2022 | -0.29 | -1.5 | -0.0001 | -0.01 | -0.35 | -0.01 | 7.37 | 5.21 |

#### 4.5.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

## 4.6 Other product use, NFR2G4

### 4.6.1 Source category description

NFR2G4 includes emissions from tobacco smoking and use of fireworks.

#### 4.6.1.1 TOBACCO SMOKING

Emissions of $NO_X$, CO, NMVOC, $NH_3$, TSP, $PM_{10}$, $PM_{2.5}$, BC, Ni, Zn, Ni, Dioxin, and individual PAHs from tobacco smoking calculated using emission factors from EMEP/EEA Guidebook 2023. For calculation of emissions of Pb, Cd, Hg, As, Cr and Cu from tobacco smoking, emission factors presented in the Norwegian IIR submission 2015 are used.

#### 4.6.1.2 FIREWORKS

Emissions of $NO_X$, $SO_X$, CO, TSP, $PM_{10}$, $PM_{2.5}$, As, Cd, Cr, Cu, Hg, Ni and Zn from use of fireworks are calculated using emission factors from EMEP/EEA Guidebook 2023.
A summary of the latest key source assessment is presented in Table 4.6.1.

**Table 4.6.1. Summary of key source analysis, NFR2G, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2G4 | *Cu, Ni, PM10, PM2.5* | PM2.5 |

### 4.6.2 Methodological issues

Emissions of $NO_X$, $SO_X$, NMVOC, $NH_3$, CO, particles, BC, most heavy metals, dioxins and PAH from tobacco smoking and use of fireworks are included in NFR2G4. Emissions from tobacco smoking are based on activity data from official statistics on sold amounts of tobacco for the whole time series from 1990. Activity data include only “legal” purchases of tobacco products in Sweden; products that are purchased through tax-free and cross-border trading are not included. For fireworks, activity data is based on national statistics available at Statistics Sweden’s website on imported and exported amounts of fireworks. No significant production of fireworks occurs in Sweden. Emission factors from EMEP/EEA Guidebook 2023 are used for estimates of emissions from fireworks. The emission factors for particles are the default factors from EMEP/EEA Guidebook, which does not specify whether the condensable component is included or not.

Emission factors and activity data for the two sources are listed in Table 4.6.2 and in Table 4.6.3. In Table 4.6.4 the corresponding emissions are shown. Emissions of

CO, as well as activity data for later years, are reported as confidential in order not to disclose confidential information in other source categories.

**Table 4.6.2. Emission factors for tobacco smoking and use of fireworks.**

| Pollutant | Tobacco smoking | | Fireworks | |
|---|---|---|---|---|
| | Emission factor | Reference | Emission factor | Reference |
| $NO_X$ | 1.8 kg/ton | EMEP/EEA 2019 | 0.26 kg/ton | EMEP/EEA 2019 |
| $SO_X$ | NE | - | 3.02 kg/ton | EMEP/EEA 2019 |
| CO | 55.1 kg/ton | EMEP/EEA 2019 | 7.15 kg/ton | EMEP/EEA 2019 |
| NMVOC | 4.84 kg/ton | EMEP/EEA 2019 | NE | - |
| $NH_3$ | 4.15 kg/ton | EMEP/EEA 2019 | NA | - |
| TSP | 27 kg/ton | EMEP/EEA 2019 | 109.83 kg/ton | EMEP/EEA 2019 |
| $PM_{10}$ | 27 kg/ton | EMEP/EEA 2019 | 99.92 kg/ton | EMEP/EEA 2019 |
| $PM_{2.5}$ | 27 kg/ton | EMEP/EEA 2019 | 51.94 kg/ton | EMEP/EEA 2019 |
| BC | 0.45% of $PM_{2.5}$ | EMEP/EEA 2019 | NA | - |
| Pb | 0.05 g/ton | Norwegian IIR, 2015 | NE | - |
| Cd | 0.1 g/ton | Norwegian IIR, 2015 | 1.48 g/ton | EMEP/EEA 2019 |
| Hg | 0.1 g/ton | Norwegian IIR, 2015 | 0.057 g/ton | EMEP/EEA 2019 |
| As | 0.159 g/ton | Norwegian IIR, 2015 | 1.33 g/ton | EMEP/EEA 2019 |
| Cr | 0.354 g/ton | Norwegian IIR, 2015 | 15.6 g/ton | EMEP/EEA 2019 |
| Cu | 0.152 g/ton | Norwegian IIR, 2015 | 444 g/ton | EMEP/EEA 2019 |
| Ni | 2.7 g/ton | EMEP/EEA 2019 | 30 g/ton | EMEP/EEA 2019 |
| Zn | 2.7 g/ton | EMEP/EEA 2019 | 260 g/ton | EMEP/EEA 2019 |
| Dioxin | 0.1 ug/ton | EMEP/EEA 2019 | NA | - |
| B(a)P | 0.111 g/ton | EMEP/EEA 2019 | NA | - |
| B(b)F | 0.045 g/ton | EMEP/EEA 2019 | NA | - |
| B(k)F | 0.045 g/ton | EMEP/EEA 2019 | NA | - |
| I(1,2,3-cd)P | 0.045 g/ton | EMEP/EEA 2019 | NA | - |

**Table 4.6.3. Activity data for tobacco smoking and use of fireworks.**

| Year | Amount consumed tobacco ton | Amount used fireworks ton |
|---|---|---|
| 1990 | 8 475 | 987 |
| 1995 | 6 688 | 1 696 |
| 2000 | 5 599 | 2 581 |
| 2005 | 5 719 | 2 347 |
| 2010 | 4 324 | 1 778 |
| 2011 | 4 417 | 1 653 |
| 2012 | 4 154 | 1 405 |
| 2013 | 3 993 | 1 564 |
| 2014 | 4 068 | 1 576 |
| 2015 | 3 863 | 1 341 |
| 2016 | 3 826 | 1 326 |
| 2017 | 3 649 | 1 245 |
| 2018- | C | C |

**Table 4.6.4a. Emissions from tobacco smoking.**

| | Tobacco smoking | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | NO$_X$, ton | CO, ton | NMVOC, ton | NH$_3$, ton | TSP, ton | PM$_{10}$, ton | PM$_{2.5}$, ton | BC, ton | Pb, kg | Cd, kg | Hg, kg | As, kg | Cr, kg | Cu, kg | Ni, kg | Zn, kg | Dioxin, mg | B(a)P, kg | B(b)F, kg | B(k)F, kg | I(1,2,3-cd)P, kg |
| 1990 | 15 | 467 | 41 | 35 | 229 | 229 | 229 | | 0.42 | 0.85 | 0.85 | 1.3 | 3.0 | 1.3 | 23 | 23 | 0.85 | 0.94 | 0.38 | 0.38 | 0.38 |
| 1995 | 12 | 369 | 32 | 28 | 181 | 181 | 181 | | 0.33 | 0.67 | 0.67 | 1.1 | 2.4 | 1.0 | 18 | 18 | 0.67 | 0.74 | 0.30 | 0.30 | 0.30 |
| 2000 | 10 | 308 | 27 | 23 | 151 | 151 | 151 | 0.68 | 0.28 | 0.56 | 0.56 | 0.89 | 2.0 | 0.85 | 15 | 15 | 0.56 | 0.62 | 0.25 | 0.25 | 0.25 |
| 2010 | 7.8 | 238 | 21 | 18 | 117 | 117 | 117 | 0.53 | 0.22 | 0.43 | 0.43 | 0.69 | 1.5 | 0.66 | 12 | 12 | 0.43 | 0.48 | 0.19 | 0.19 | 0.19 |
| 2015 | 7.0 | 213 | 19 | 16 | 104 | 104 | 104 | 0.47 | 0.19 | 0.39 | 0.39 | 0.61 | 1.4 | 0.59 | 10 | 10 | 0.39 | 0.43 | 0.17 | 0.17 | 0.17 |
| 2016 | 6.9 | 211 | 19 | 16 | 103 | 103 | 103 | 0.46 | 0.19 | 0.38 | 0.38 | 0.61 | 1.4 | 0.58 | 10 | 10 | 0.38 | 0.42 | 0.17 | 0.17 | 0.17 |
| 2017 | 6.6 | 201 | 18 | 15 | 99 | 99 | 99 | 0.44 | 0.18 | 0.36 | 0.36 | 0.58 | 1.3 | 0.55 | 9.9 | 9.9 | 0.36 | 0.40 | 0.16 | 0.16 | 0.16 |
| 2018 | 6.4 | C | 17 | 15 | 97 | 97 | 97 | 0.43 | 0.18 | 0.36 | 0.36 | 0.57 | 1.3 | 0.54 | 9.7 | 9.7 | 0.36 | 0.40 | 0.16 | 0.16 | 0.16 |
| 2019 | 6.3 | C | 17 | 14 | 94 | 94 | 94 | 0.42 | 0.17 | 0.35 | 0.35 | 0.55 | 1.2 | 0.53 | 9.4 | 9.4 | 0.35 | 0.39 | 0.16 | 0.16 | 0.16 |
| 2020 | 6.0 | C | 16 | 14 | 91 | 91 | 91 | 0.41 | 0.17 | 0.34 | 0.34 | 0.53 | 1.2 | 0.51 | 9.1 | 9.1 | 0.34 | 0.37 | 0.15 | 0.15 | 0.15 |
| 2021 | 5.8 | C | 16 | 13 | 87 | 87 | 87 | 0.39 | 0.16 | 0.32 | 0.32 | 0.51 | 1.1 | 0.49 | 8.7 | 8.7 | 0.32 | 0.32 | 0.14 | 0.14 | 0.14 |
| 2022 | 5.9 | C | 16 | 13 | 88 | 88 | 88 | 0.39 | 0.16 | 0.33 | 0.33 | 0.52 | 1.2 | 0.49 | 8.8 | 8.8 | 0.33 | 0.36 | 0.15 | 0.15 | 0.15 |
| 2023 | 5.4 | C | 15 | 13 | 82 | 82 | 82 | 0.37 | 0.15 | 0.30 | 0.30 | 0.48 | 1.1 | 0.46 | 8.2 | 8.2 | 0.30 | 0.34 | 0.14 | 0.14 | 0.14 |

**Table 4.6.4b. Emissions from the use of fireworks.**

| | Use of fireworks | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | $NO_X$, ton | $SO_X$, ton | CO, ton | TSP, ton | $PM_{10}$, ton | $PM_{2.5}$, ton | Cd, kg | Hg, kg | As, kg | Cr, kg | Cu, kg | Ni, kg | Zn, kg |
| 1990 | 0.26 | 3.0 | 7.1 | 108 | 99 | 51 | 1.5 | 0.056 | 1.3 | 15 | 438 | 30 | 257 |
| 1995 | 0.44 | 5.1 | 12 | 186 | 169 | 88 | 2.5 | 0.097 | 2.3 | 26 | 753 | 51 | 441 |
| 2000 | 0.67 | 7.79 | 18 | 283 | 258 | 134 | 3.8 | 0.147 | 3.4 | 40 | 1146 | 77 | 671 |
| 2005 | 0.61 | 7.09 | 17 | 258 | 235 | 122 | 3.5 | 0.134 | 3.1 | 37 | 1042 | 70 | 610 |
| 2010 | 0.46 | 5.37 | 13 | 195 | 178 | 92 | 2.6 | 0.101 | 2.4 | 28 | 789 | 53 | 462 |
| 2015 | 0.35 | 4.05 | 9.6 | 147 | 134 | 70 | 2.0 | 0.076 | 1.8 | 21 | 595 | 40 | 349 |
| 2016 | 0.34 | 4.00 | 9.5 | 146 | 132 | 69 | 2.0 | 0.076 | 1.8 | 21 | 589 | 40 | 345 |
| 2017 | 0.32 | 3.8 | 8.9 | 137 | 124 | 65 | 1.8 | 0.071 | 1.7 | 19 | 553 | 37 | 324 |
| 2018 | 0.29 | 3.35 | C | 122 | 111 | 58 | 1.6 | 0.063 | 1.5 | 17 | 492 | 33 | 288 |
| 2019 | 0.28 | 3.24 | C | 118 | 107 | 56 | 1.6 | 0.061 | 1.4 | 17 | 476 | 32 | 279 |
| 2020 | 0.19 | 2.17 | C | 79 | 72 | 37 | 1.1 | 0.041 | 1.0 | 11 | 320 | 22 | 187 |
| 2021 | 0.12 | 1.40 | C | 51 | 46 | 24 | 0.7 | 0.026 | 0.6 | 7 | 206 | 14 | 121 |
| 2022 | 0.33 | 3.83 | C | 139 | 127 | 66 | 1.9 | 0.072 | 1.7 | 20 | 563 | 38 | 330 |
| 2023 | 0.26 | 3.04 | C | 111 | 101 | 52 | 1.5 | 0.057 | 1.3 | 16 | 448 | 30 | 262 |

Generally, emissions from tobacco smoking have decreased during the years. Emissions from the use of fireworks show an increasing trend during the years 1990 to 2007. The reported emissions for 2008 – 2022 have decreased compared to 2007 since fewer fireworks were imported.

### 4.6.3 Uncertainties and time-series consistency

Uncertainties for all estimates based on EF from EMEP/EEA Guidebook 2023 are based on information on upper/lower EFs. For other estimates, Guidebook Quality Rating D is used. More information is given in IIR Annex 1.

Time series from tobacco smoking and use of fireworks reported in NFR code 2G4 have been reviewed in later years and are consistent.

Uncertainties for NFR2G4 are displayed in Annex 1.

### 4.6.4 Source-specific QA/QC and verification

No source-specific QA/QC or verification is performed.

### 4.6.5 Source-specific recalculations

Minor recalculations were performed in submission 2025 as a result of updated activity data for 2022.

### 4.6.6 Source-specific planned improvements

No major improvements are currently planned.

## 4.7 Pulp and paper industry, NFR2H1

### 4.7.1 Source category description

NFR2H1 includes emissions from pulp and paper.

The pulp and paper industry in Sweden is an important source of industrial process emissions. Emissions from 44 individual pulp and paper facilities are included in the inventory. Of those, six facilities only have energy related emissions which are reported in NFR1A2d. Of the facilities included with process related reported in NFR2H1 one shut down in 2004, two in 2008 and one in 2012. For 2023, emissions from 23 individual pulp and paper facilities are included in emissions reported in NFR2H1. The Kraft process (sulphate) dominates in Sweden but there are also emissions from sulphite facilities and facilities that are mainly CTMP (Chemo Thermo Mechanical Pulp) or TMP (Thermo Mechanical Pulp) facilities reported in NFR2H1.

Reported emissions from the pulp and paper industry are for $SO_2$, $NO_X$ and TSP based on information in the companies' environmental reports, while other air pollutants are calculated using nationally derived emission factors.

A summary of the latest key source assessment is presented in Table 4.7.1.

**Table 4.7.1. Summary of key source analysis, NFR2H1, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2H1 | *As, CO, Cd, Cr, Hg, NH3, NMVOC, NOx, Ni, PM10, PM2.5, Pb, SO2, TSP* | *Cd, Cu, NH3, Ni, PM10, PM2.5, SO2, TSP* |

### 4.7.2 Methodological issues

Reported $SO_2$, $NO_X$ and TSP emissions from the pulp and paper industry are primarily based on information on production (Figure 4.7.1) and emissions in the companies' environmental reports. The industrial organisation within this sector has for several years co-operated closely with its members in developing sector-specific methods of measuring and calculating emissions, which have resulted in high-quality emissions data. The condensable component of the particle emissions is most likely excluded since emission factors/estimates in general are based on measurements in the flue stack, i.e., not in diluted flue gases.

The emission factors that are used for the other pollutants are derived from national measurements and from international literature. The reported emissions of NMVOC do not include terpenes.

In submission 2023, $NH_3$ emissions were recalculated for the whole timeseries based on new information compiled by the Swedish Forest Industries on the practice of leading smelt dissolver gases to the recovery boiler[192]. Prior to submission 2023, it was assumed that 200 g $NH_3$/ton pulp was emitted from the smelt dissolving process at all sulphur plants. However, at a number of plants, the gases from the smelt dissolver are led to the recovery boiler, thus avoiding these $NH_3$ emissions. In addition, it was noted that $NH_3$ emissions from the causticizing process are only relevant if the plant does not have a modern collection system for non-condensable gases in place. The overall $NH_3$ emission factor was adjusted to account for these practices.

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[192] Mawdsley, I. 2022. Revision of emission factors for process-related emissions from the Swedish pulp and paper industry. SMED PM 2022-06-07

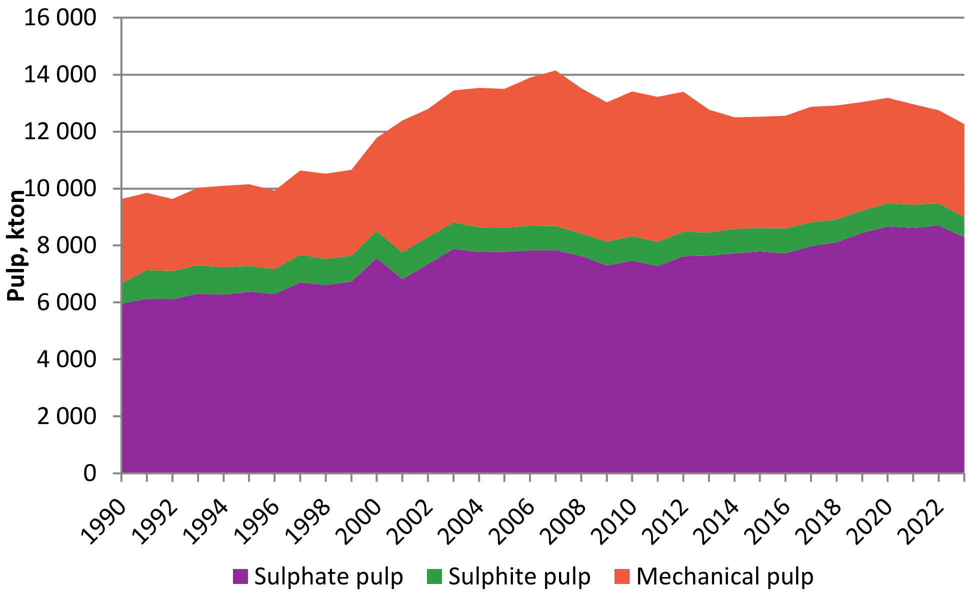

**Figure 4.7.1 Production of pulp in Sweden 1990-2023 in kton.**

### 4.7.3 Uncertainties and time-series consistency

Uncertainties for emissions are based on Guidebook Quality Ratings and expert judgement. For TSP, PM, $NH_3$ as well as heavy metals information from a national good practice guidance project is taken into account. More detailed information is to be found in IIR Annex 1.

Time series from industrial processes for pulp and paper industries reported in NFR codes 2H1 have been reviewed in later years and are consistent.

### 4.7.4 Source-specific QA/QC and verification

No source-specific QA/QC or verification is performed.

### 4.7.5 Source-specific recalculations

In submission 2025, NOx emissions have been recalculated for 2002-2022, as earlier calculation templates at one of the facilities have been considered incorrect. The recalculation resulted in annual emission decrease by up to 0.1 kt.

Correction in the amounts of flared LPG at one of the facilities resulted in slight decrease (by up to 0.005%, compared to submission 2024) of emissions of BC, CO, NH3, and NOx and in 2022.

### 4.7.6 Source-specific planned improvements

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

# 4.8 Food and beverages industry, NFR2H2

## 4.8.1 Source category description

NFR2H2 includes emissions from the food and beverages industry. The food and drink industry is a moderate source of NMVOC in Sweden. The industry consists of beer, wine and liquor producers, bread, sugar, yeast and margarine and solid cooking fat producers, coffee roasters and animal feed producers.

A summary of the latest key source assessment is presented in Table 4.8.1.

**Table 4.8.1. Summary of key source analysis, NFR2H2, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2H2 | *NMVOC* | |

## 4.8.2 Methodological issues

Estimations of NMVOC emissions are based on activity data from different official statistics. For wine the estimation of NMVOC emissions is based on data on sold amount[193] together with figures on import and export[194]. NMVOC emissions from beer production are based on the Swedish annual total production of beer[195]. NMVOC emissions originating from the production of liquors, bread, sugar, yeast, margarine and solid cooking fat, coffee roasters and animal feeds are all based on statistics from Statistics Sweden[194]. For the NMVOC emission estimations emission factors presented in Table 4.8.2 are applied. Emission factors used in 2.H.2 are mainly from the EMEP/EEA Emission Inventory Guidebook 2023. Sweden assumes that abatement equipment reduces the emissions by 90%.

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[193] Systembolaget. Försäljningsstatistik. http://www.systembolaget.se

[194] Statistics Sweden. http://www.scb.se. Data from the Industrial production database.

[195] Bryggeriföreningen. http://sverigesbryggerier.se

**Table 4.8.2. NMVOC emission factors for the reported production activities in NFR2H2 - Food and drink. Sweden assumes that abatement equipment reduces the emissions by 90%.**

| Production activity | Emission factor | Unit | Reference EF (footnote) |
|---|---|---|---|
| Liquors | 0.6 | kg/1000 litres | EF based on emission and activity data from one producer, 2001 |
| Wine | 0.08 | kg/1000 litres | EMEP/EEA Guidebook 2023 |
| Beer | 0.035 | kg/1000 litres | EMEP/EEA Guidebook 2023 |
| Bread (sponge dough) | 0.45 | kg/Mg | EMEP/EEA Guidebook 2023 |
| Bread (white) | 0.45 | kg/Mg | EMEP/EEA Guidebook 2023 |
| Bread (wholemeal and light rye) | 0.45 | kg/Mg | EMEP/EEA Guidebook 2023 |
| Bread (dark rye) | 0.45 | kg/Mg | EMEP/EEA Guidebook 2023 |
| Cakes | 0.1 | kg/Mg | EMEP/EEA Guidebook 2023 |
| Biscuits | 0.1 | kg/Mg | EMEP/EEA Guidebook 2023 |
| Breakfast cereals | 0.1 | kg/Mg | EMEP/EEA Guidebook 2023 |
| Sugar | 1 | kg/Mg | EMEP/EEA Guidebook 2023 |
| Yeast | 1.8 | kg/Mg | EF from Finlands inventory |
| Margarine and solid cooking fats | 1 | kg/Mg | EMEP/EEA Guidebook 2023 |
| Coffee roasting | 0.055 | kg/Mg | EMEP/EEA Guidebook 2023 |
| Animal feed | 0.1 | kg/Mg | EMEP/EEA Guidebook 2023 |

### 4.8.3 Uncertainties and time-series consistency

Uncertainties for emissions are based on Guidebook 2023. Assessed uncertainties for NMVOC are ± 200%. More information is given in IIR Annex 1.

Time series from industrial processes for food and beverages industries reported in NFR codes 2H2 have been reviewed in later years and are consistent.

### 4.8.4 Source-specific QA/QC and verification

No source-specific QA/QC or verification is performed.

### 4.8.5 Source-specific recalculations

Minor recalculations were performed in submission 2025 because of updated activity data for 2021-2022.

### 4.8.6 Source-specific planned improvements

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

# 4.9 Wood processing, NFR2I

## 4.9.1 Source category description

TSP emissions from wood processing are included for the first time in submission 2016. Emissions from production of plywood, MDF boards and fiber boards are included in NFR2I Wood processing. The number of companies, as well as the amount of produced wood products have decreased over the time series, with 18 companies in 1990 producing around 670 kt to three companies since 2016, producing around 440 kt.

A summary of the latest key source assessment is presented in Table 4.9.1.

**Table 4.9.1. Summary of key source analysis, NFR2I, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 2I | *TSP* | |

## 4.9.2 Methodological issues

Activity data is retrieved from Trä- och Möbelföretagen[196], a Swedish trade organisation for wood and furniture products. For the years 1991-1999, production quantities are interpolated as there is no available data for those years. Reported activity data are amounts of wood products in kt.

TSP emissions are calculated using activity data and the emission factor from EMEP/EEA Guidebook 2023. Particle emissions are made up of only filterable particles since they origin from non-combustion processes.

## 4.9.3 Uncertainties and time-series consistency

The time series reported in the NFR code 2I has been reviewed and is consistent. Uncertainties for emissions of TSP are ± 900%. More detailed information is to be found in IIR Annex 1.

## 4.9.4 Source-specific QA/QC and verification

No source-specific QA/QC or verification is performed.

## 4.9.5 Source-specific recalculations

As data was not available in time for submission, emissions for 2022 have been updated in submission 2025. Emissions of TSP decreased therefore by about 0.01 kt.

## 4.9.6 Source-specific planned improvements

No major improvements are currently planned.

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[196] http://www.tmf.se/english_1/about_tmf_1

## 4.10 Production of POPs, NFR2J

To the knowledge of the Swedish inventory compilers, there is no production of POPs in Sweden. Thus, no emissions are reported from the source category NFR2J.

## 4.11 Consumption of POPs and heavy metals, NFR2K

Emissions from consumption of POPs and heavy metals are not included in the Swedish emission inventory. Calculations have been made using default emission factors from the EEA/EMEP Guidebook 2016 (same as in Guidebook 2023), however resulting emissions were judged to be unreasonably high for Swedish conditions[197].

## 4.12 Other production, consumption, storage, transportation or handling of bulk products, NFR2L

No other production, consumption, storage, transportation or handling of bulk products occur in Sweden; thus, no emissions are reported in NFR2L.

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[197] Yaramenka, K., Mawdsley, I., Gustafsson, T. 2014. Utveckling av rapportering till CLRTAP NFR 1B, 2 och 5 map EMEP Guidebook, steg 1. SMED rapport nr 161 2014 (available in Swedish)

# 5 Agriculture (NFR sector 3)

## 5.1 Overview

In the agriculture sector, emissions of $NH_3$, NMVOC, $NO_X$ and particulate matter (TSP, $PM_{10}$ and $PM_{2.5}$) are reported. The general trend for all emissions is a continuous decline. One of the driving forces to this is a decreasing agricultural sector in Sweden, which has resulted in a decrease of agriculture land and decreasing livestock populations. Over the past 50 years, the agriculture in Swedish has undergone radical structural changes and rationalisations. One fifth of the Swedish arable land cultivated in the 1950s is no longer farmed. Closures have mainly affected small holdings and those remaining are growing larger. Livestock farmers predominately engage in milk production and the main crops grown in Sweden are grain and fodder crops. The decrease of total agricultural land area has continued since Sweden joined the European Union in 1995, but the acreages of land for hay and silage has increased. From 1990 there has been a steady decrease in the number of dairy cows. However, milk yield per head has increased.

Field burning of crop residues is prohibited in Sweden[198]. Dispensation can be given for pest control reasons only. According to an inquiry sent out by the Swedish Board of Agriculture, field burning only occurs to a very limited extent in Sweden and therefore notation key NO is used for emission from 3F Field burning of crop residues.

## 5.2 Manure management, NFR 3B

### 5.2.1 Source category description

Manure management and housing of livestock give rise to emissions of ammonia, NMVOC, $NO_X$ and particulate matters. Emissions of ammonia derive from storage, handling and application of stable manure. Emissions from application of manure are calculated here but reported under sector 3D. NMVOC emissions from animal husbandry originate from feed, especially silage, degradation and decomposition of feed in the rumen and in the manure. In the Swedish inventory, emissions of NMVOC from manure management from dairy cattle is the main contributor. Nitric oxide is formed through biological oxidation (i.e. nitrification) of ammonia or ammonium by aerobic bacteria. Nitric oxide is emitted from the surface layers of stored manure, during application of manure to soil and from deposition of excreta during grazing. The same processes also result in emissions of nitrous oxide ($N_2O$). These emissions are accounted for in the reporting to the UNFCCC. Housing of livestock causes emissions of particulate matter. The emissions originate mainly from feed but bedding materials such as straw or wood shavings can also give rise to airborne particulates.

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[198] SJVFS 2018:40, §15

A summary of the latest key source assessment is presented in Table 5-1.

**Table 5-1. Summary of key source analysis, NFR 3B, according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 3B1 Dairy cattle | *NH3, NMVOC, PM10, PM2.5* | *NH3, NMVOC* |
| 3B1 Non-dairy cattle | *NH3, NMVOC, PM10, PM2.5, TSP* | *NH3* |
| 3B3 Swine | *NH3, PM10, TSP* | *NH3, TSP* |
| 3B4 Fur-bearing animals | | *NH3* |
| 3B4 Horses | *NH3, NMVOC* | *NH3* |
| 3B4 Poultry | *NH3, NMVOC, PM10, PM2.5, TSP* | *NH3, PM10, TSP* |
| 3B4 Sheep | *NH3* | *NH3* |

## 5.2.2 Methodological issues

### 5.2.2.1 ACTIVITY DATA

One of the main sources of activity data used in the agriculture inventory is the sample survey “Use of fertilisers and animal manure in agriculture”[199]. This survey has been performed by Statistics Sweden every second year until 2013 and every third year thereafter. The latest was for 2022. In this survey data was collected from 5 149 agricultural holdings, in the 2019 survey data was collected from 5 150 holdings. Detailed information about the design of the survey can be found in the report series MI 30 SM[200]. It is from this survey we receive data on the distribution of different manure management systems (solid manure, liquid manure and deep litter) for each animal type (Table 5-5 to Table 5-7), design of containers for liquid manure and urine (if filled from above or underneath the manure surface, if it has cover and what type, Table 5-10), time and method of manure application, timespan before mulching of manure and data on stable periods (Table 5-4). Since dairy cattle regularly are stabled at night, and also spend time in the stable during milking, the data on stable periods is combined with the assumption that 38% of the dairy cattle manure is produced in the stable during the grazing period. Data on anaerobic digestion of manure come from the Swedish Energy Agency[201] (Table 5-8 and Table 5-9).

Another important source of activity data is the farm register from the Swedish Board of Agriculture. From this register, data on livestock population is obtained for most animal categories (Table 5-2). As for submission 2022, the annual average population is calculated for swine categories with shorter life span than one year, and the time series has been updated from 1990. Input data for this method is slaughter statistics. For other swine categories, the farm registry is used. Other sources are used for slaughter chicken, horses, reindeers, and furred animals. Concerning horses, the farm register underestimates the number of horses because only

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[199] Statistics Sweden, report series MI 30 SM.

[200] http://www.scb.se/mi1001

[201] Swedish Energy Agency. Produktion och användning av biogas och rötrester.

horses on farms are included in the sampling frame (i.e. not horses for leisure activities). Three separate surveys[202] have estimated total number of horses in Sweden in 2004, 2010 and 2016. These estimates are used in the inventory instead. To estimate the number of slaughter chickens we use the Swedish official slaughter statistics together with timespan between production rounds to estimate the average annual population. The number of minks is provided by the Swedish Furred Animals Association.

Data on manure and nitrogen excretion for different animals are compiled by the Swedish board of agriculture and based on nutrient balance calculations. The underlying data are based on a variety of sources. The data for the most significant animal groups (i.e. cattle and swine) are from public reports produced by the Swedish Board of Agriculture. Some of the data for the less significant animal groups are based on expert opinions. Data on milk yield for dairy cows, which affects the amount of nitrogen and manure excreted, is obtained from the Swedish board of agriculture (Table 5-3).

**Table 5-2. Population size of different animal groups (1000s heads).**

| Year | Dairy cows | Non-Dairy Cattle | | | | Swine | | | | Sheep | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Suckler cows | Heifers | Bulls and steers | Calves | Sow | Pig for meat production | Piglet | Boar | Sheep | Lamb |
| 1990 | 576 | 75 | 337 | 206 | 524 | 221 | 1 286 | 844 | 8.6 | 162 | 244 |
| 1995 | 482 | 157 | 370 | 226 | 542 | 237 | 1 310 | 855 | 7.6 | 195 | 266 |
| 2000 | 428 | 167 | 365 | 224 | 500 | 202 | 1 155 | 630 | 4.2 | 198 | 234 |
| 2005 | 393 | 177 | 327 | 200 | 508 | 185 | 1 093 | 599 | 2.7 | 222 | 249 |
| 2010 | 348 | 197 | 322 | 191 | 479 | 154 | 977 | 487 | 2.3 | 273 | 292 |
| 2015 | 340 | 184 | 311 | 178 | 467 | 140 | 852 | 425 | 1.5 | 289 | 306 |
| 2020 | 303 | 207 | 301 | 179 | 462 | 130 | 867 | 433 | 1.4 | 263 | 238 |
| 2021 | 302 | 210 | 298 | 178 | 465 | 128 | 874 | 436 | 1.5 | 272 | 252 |
| 2022 | 297 | 213 | 302 | 180 | 458 | 126 | 880 | 439 | 1.6 | 264 | 245 |
| 2023 | 296 | 210 | 300 | 180 | 459 | 111 | 848 | 423 | 1.6 | 264 | 222 |

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[202] Swedish Board of Agriculture, report series JO 25 SM http://www.scb.se/jo0107

**Table 5-2. (continued).**

| Year | Horses | Goats | | Other | | Poultry | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Horse | Goat | Kid | Reindeer | Fur-bearing animals | Laying hen | Turkey | Chicken | Slaughter Chicken |
| 1990 | 316 | 2.8 | 2.8 | 253 | 297 | 6 400 | 122 | 2 200 | 4 476 |
| 1995 | 316 | 2.8 | 2.8 | 221 | 254 | 6 100 | 122 | 1 800 | 7 055 |
| 2000 | 316 | 2.8 | 2.8 | 261 | 276 | 5 700 | 122 | 1 700 | 7 896 |
| 2005 | 323 | 3.7 | 3.7 | 250 | 290 | 5 100 | 122 | 1 700 | 8 453 |
| 2010 | 363 | 5.2 | 5.2 | 250 | 180 | 6 061 | 130 | 1 647 | 9 159 |
| 2015 | 363 | 6.8 | 6.8 | 240 | 210 | 7 571 | 156 | 1 842 | 11 044 |
| 2020 | 356 | 7.5 | 7.5 | 240 | 200 | 8 403 | 130 | 2 420 | 12 696 |
| 2021 | 356 | 7.9 | 7.9 | 240 | 125 | 6 363 | 132 | 2 390 | 13 305 |
| 2022 | 356 | 8 | 8 | 240 | 135 | 7 919 | 133 | 1 722 | 12 986 |
| 2023 | 356 | 7.8 | 7.8 | 240 | 100 | 7 717 | 131 | 2 700 | 12 586 |

**Table 5-3. Activity data used for estimating the emissions from dairy cattle.**

| Year | Total milk delivered* (kt) | Average fat content (%) | Average protein content (%) | Yield per cow, kg ECM/yr | Feed intake (MJ/day) |
|---|---|---|---|---|---|
| 1990 | 3 432 | 4.31 | 3.36 | 6 503 | 270.8 |
| 1995 | 3 243 | 4.33 | 3.34 | 7 352 | 291.2 |
| 2000 | 3 297 | 4.18 | 3.28 | 8 240 | 309.8 |
| 2005 | 3 163 | 4.25 | 3.38 | 8 734 | 319.6 |
| 2010 | 2 862 | 4.23 | 3.41 | 8 928 | 320.7 |
| 2015 | 2 933 | 4.25 | 3.42 | 9 401 | 329.9 |
| 2020 | 2 773 | 4.23 | 3.51 | 9 997 | 344.5 |
| 2021 | 2 782 | 4.26 | 3.51 | 10 118 | 347.4 |
| 2022 | 2 765 | 4.25 | 3.5 | 10 216 | 349.8 |
| 2023 | 2 819 | 4.26 | 3.53 | 10 485 | 356.4 |

* Including on farm consumption.

Table 5-4. Livestock grazing periods (percent).

| Year | Dairy cattle | Suckler cows | Heifers | Bulls and steers | Calves | Swine | Sheep, Goats | Reindeer | Horses | Poultry |
|---|---|---|---|---|---|---|---|---|---|---|
| 1990 | 24.8 | 48.3 | 45.8 | 36.7 | 35.0 | NO | 50 | 100 | 50 | NO |
| 1995 | 24.8 | 48.3 | 45.8 | 36.7 | 35.0 | NO | 50 | 100 | 50 | NO |
| 2000 | 24.8 | 51.7 | 49.2 | 36.7 | 36.7 | NO | 50 | 100 | 50 | NO |
| 2005 | 26.1 | 58.9 | 53.7 | 30.2 | 36.6 | NO | 50 | 100 | 50 | NO |
| 2010 | 25.0 | 54.1 | 51.7 | 26.4 | 31.4 | NO | 50 | 100 | 50 | NO |
| 2015 | 24.5 | 52.1 | 49.7 | 18.6 | 31.7 | NO | 50 | 100 | 50 | NO |
| 2020 | 25.3 | 57.4 | 52.7 | 23.9 | 35.7 | NO | 50 | 100 | 50 | NO |
| 2021 | 25.3 | 57.4 | 52.7 | 23.9 | 35.7 | NO | 50 | 100 | 50 | NO |
| 2022 | 25.0 | 56.7 | 51.8 | 24.9 | 34.1 | NO | 50 | 100 | 50 | NO |
| 2023 | 25.0 | 56.7 | 51.8 | 24.9 | 34.1 | NO | 50 | 100 | 50 | NO |

Table 5-5. Liquid waste management systems (percent).

| Year | Dairy cattle | Suckler cows | Heifers | Bulls and steers | Calves | Pigs for meat production | Other swine | Sheep, goats, horses, reindeer and fur-bearing | Laying Hens, Chickens | Slaughter Chickens, Turkeys |
|---|---|---|---|---|---|---|---|---|---|---|
| 1990 | 22.6 | 15.5 | 16.3 | 19.0 | 19.5 | 44.0 | 44.0 | 0.0 | 25.0 | 0.0 |
| 1995 | 30.6 | 21.0 | 22.0 | 25.8 | 26.5 | 63.0 | 63.0 | 0.0 | 25.0 | 0.0 |
| 2000 | 39.0 | 12.5 | 13.2 | 16.4 | 16.4 | 80.5 | 25.8 | 0.0 | 25.0 | 0.0 |
| 2005 | 50.8 | 5.9 | 19.6 | 22.5 | 18.9 | 91.3 | 31.8 | 0.0 | 20.8 | 0.0 |
| 2010 | 57.1 | 11.2 | 22.3 | 28.6 | 16.8 | 91.3 | 60.4 | 0.0 | 12.0 | 0.0 |
| 2015 | 60.4 | 10.0 | 24.9 | 31.4 | 16.1 | 81.4 | 49.7 | 0.0 | 30.1 | 0.0 |
| 2020 | 63.8 | 9.8 | 24.0 | 36.6 | 16.9 | 78.3 | 45.6 | 0.0 | 5.6 | 3.2 |
| 2021 | 63.7 | 9.7 | 24.0 | 36.5 | 16.8 | 77.8 | 45.4 | 0.0 | 5.6 | 3.2 |
| 2022 | 64.2 | 9.8 | 23.4 | 35.8 | 18.3 | 75.3 | 49.4 | 0.0 | 9.9 | 0.0 |
| 2023 | 63.6 | 9.7 | 23.2 | 35.5 | 18.1 | 72.3 | 47.4 | 0.0 | 9.9 | 0.0 |

**Table 5-6. Solid waste management systems (percent).**

| Year | Dairy cattle | Suckler cows | Heifers | Bulls and steers | Calves | Pigs for meat production | Other swine | Sheep, goats | Reindeer | Fur-bearing animals | Horses | Laying Hens, Chickens | Slaughter Chickens, Turkeys |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1990 | 51.9 | 28.9 | 30.3 | 35.5 | 36.4 | 54.0 | 45.0 | 50.0 | 0.0 | 100.0 | 33.0 | 55.0 | 87.3 |
| 1995 | 43.8 | 23.4 | 24.5 | 28.7 | 29.4 | 35.0 | 26.0 | 50.0 | 0.0 | 100.0 | 33.0 | 55.0 | 87.3 |
| 2000 | 35.3 | 28.0 | 29.5 | 36.7 | 36.7 | 18.0 | 67.0 | 50.0 | 0.0 | 100.0 | 33.0 | 55.0 | 87.3 |
| 2005 | 22.4 | 19.0 | 16.7 | 27.2 | 22.8 | 6.2 | 45.6 | 50.0 | 0.0 | 100.0 | 33.0 | 72.6 | 87.3 |
| 2010 | 16.4 | 20.1 | 15.2 | 25.8 | 22.0 | 5.2 | 30.4 | 50.0 | 0.0 | 100.0 | 33.0 | 88.0 | 87.3 |
| 2015 | 10.8 | 19.9 | 11.9 | 25.3 | 16.1 | 3.4 | 36.0 | 50.0 | 0.0 | 100.0 | 33.0 | 64.6 | 87.3 |
| 2020 | 5.1 | 10.3 | 7.9 | 10.6 | 11.9 | 2.3 | 23.8 | 50.0 | 0.0 | 100.0 | 33.0 | 90.9 | 69.6 |
| 2021 | 5.1 | 10.3 | 7.9 | 10.6 | 11.9 | 2.3 | 23.8 | 50.0 | 0.0 | 100.0 | 33.0 | 90.9 | 69.6 |
| 2022 | 4.7 | 11.0 | 7.7 | 11.8 | 10.6 | 3.0 | 13.5 | 50.0 | 0.0 | 100.0 | 33.0 | 86.0 | 61.0 |
| 2023 | 4.7 | 11.0 | 7.7 | 11.7 | 10.6 | 3.0 | 13.5 | 50.0 | 0.0 | 100.0 | 33.0 | 86.0 | 61.0 |

**Table 5-7. Deep litter waste management systems (percent).**

| Year | Dairy cattle | Suckler cows | Heifers | Bulls and steers | Calves | Pigs for meat production | Other swine | Sheep, goats, reindeer, Fur-bearing animals | Horses | Laying Hens, Chickens | Slaughter Chickens, Turkeys |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1990 | 0.8 | 7.2 | 7.6 | 8.9 | 9.1 | 2.0 | 11.0 | 0.0 | 2.0 | 20.0 | 13 |
| 1995 | 0.8 | 7.2 | 7.6 | 8.9 | 9.1 | 2.0 | 11.0 | 0.0 | 2.0 | 20.0 | 13 |
| 2000 | 0.8 | 7.7 | 8.1 | 10.1 | 10.1 | 1.0 | 7.0 | 0.0 | 2.0 | 20.0 | 13 |
| 2005 | 0.4 | 16.0 | 9.8 | 19.9 | 21.6 | 1.3 | 22.1 | 0.0 | 2.0 | 6.6 | 13 |
| 2010 | 0.8 | 14.5 | 10.5 | 18.8 | 29.5 | 0.9 | 7.4 | 0.0 | 2.0 | 0.0 | 13 |
| 2015 | 0.9 | 17.1 | 11.9 | 22.4 | 34.5 | 1.5 | 6.0 | 0.0 | 2.0 | 5.3 | 13 |
| 2020 | 1.0 | 21.3 | 13.3 | 25.6 | 33.5 | 1.0 | 19.8 | 0.0 | 2.0 | 3.6 | 27 |
| 2021 | 1.0 | 21.2 | 13.3 | 25.6 | 33.5 | 1.0 | 19.8 | 0.0 | 2.0 | 3.6 | 27 |
| 2022 | 0.9 | 21.1 | 14.7 | 24.0 | 34.6 | 1.9 | 24.1 | 0.0 | 2.0 | 4.1 | 39 |
| 2023 | 0.9 | 21.1 | 14.7 | 23.9 | 34.5 | 1.9 | 24.1 | 0.0 | 2.0 | 4.1 | 39 |

**Table 5-8. On-farm anaerobic digestion treatment and composting systems (percent). Affects only cattle, swine and horses.**

| Year | Anaerobic digestion in on-farm digesters | | | | | | | | | Composting |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Dairy cattle** | Suckler cows | Heifers | Bulls and steers | Calves | **Non-Dairy cattle** | Pigs for meat production | Other swine | **Swine** | **Horses** |
| 1990 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.0 |
| 1995 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 15.0 |
| 2000 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.1 | 15.0 |
| 2005 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.4 | 0.1 | 0.3 | 15.0 |
| 2010 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.8 | 0.6 | 0.8 | 15.0 |
| 2015 | 1.2 | 0.3 | 0.6 | 0.8 | 0.5 | 0.5 | 4.7 | 2.9 | 4.2 | 15.0 |
| 2020 | 1.7 | 0.5 | 0.8 | 1.2 | 0.7 | 0.7 | 6.6 | 3.8 | 5.9 | 15.0 |
| 2021 | 2.0 | 0.5 | 0.9 | 1.4 | 0.9 | 0.9 | 7.6 | 4.5 | 6.8 | 15.0 |
| 2022 | 2.7 | 0.7 | 1.2 | 1.8 | 1.2 | 1.1 | 9.9 | 6.5 | 9.1 | 15.0 |
| 2023 | 3.0 | 0.8 | 1.3 | 2.1 | 1.4 | 1.3 | 11.9 | 7.8 | 10.9 | 15.0 |

**Table 5-9. Anaerobic digestion treatment in co-digesters (percent). These fractions of the manure are for storage accounted in the waste sector.**

| Year | Anaerobic digestion in co-digesters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Dairy cattle** | Suckler cows | Heifers | Bulls and steers | Calves | **Non-Dairy cattle** | Pigs for meat production | Other swine | **Swine** |
| 1990 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1995 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2000 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.4 | 0.1 | 0.3 |
| 2005 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.9 | 0.3 | 0.7 |
| 2010 | 0.5 | 0.1 | 0.2 | 0.3 | 0.2 | 0.2 | 1.8 | 1.2 | 1.6 |
| 2015 | 2.2 | 0.6 | 1.1 | 1.5 | 1.0 | 1.0 | 8.9 | 5.5 | 8.0 |
| 2020 | 3.0 | 0.8 | 1.4 | 2.1 | 1.3 | 1.3 | 11.9 | 6.9 | 10.6 |
| 2021 | 2.9 | 0.8 | 1.3 | 2.0 | 1.3 | 1.3 | 11.3 | 6.6 | 10.1 |
| 2022 | 2.6 | 0.7 | 1.2 | 1.8 | 1.2 | 1.1 | 9.8 | 6.4 | 9.0 |
| 2023 | 2.8 | 0.8 | 1.2 | 1.9 | 1.3 | 1.2 | 10.9 | 7.2 | 10.0 |

**Table 5-10. Design of containers for liquid manure and urine respectively, filled from above or underneath the manure surface, uncovered of type of cover (percentage of livestock units). A 0 (zero) means that the data is below 0.5 percent.**

| | Liquide manure | | | | | | | | Urine | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Filled from underneath | | | | Filled from above | | | | Filled from underneath | | | | Filled from above | | | |
| Year | Uncovered | Roof | Floating crust | Other cover | Uncovered | Roof | Floating crust | Other cover | Uncovered | Roof | Floating crust | Other cover | Uncovered | Roof | Floating crust | Other cover |
| | Dairy cattle | | | | | | | | Dairy cattle | | | | | | | |
| 2005 | 2 | 2 | 92 | 0 | 0 | - | 3 | - | 3 | 16 | 62 | 6 | 4 | 5 | 3 | 1 |
| 2007 | 1 | 1 | 95 | 0 | - | - | 3 | - | 5 | 21 | 58 | 9 | 3 | 2 | 2 | 1 |
| 2009 | 2 | 1 | 95 | 0 | - | - | 2 | 0 | 5 | 24 | 51 | 8 | 2 | 2 | 6 | 2 |
| 2011 | 2 | 1 | 95 | - | 0 | 0 | 2 | - | 6 | 17 | 54 | 10 | 1 | 5 | 4 | 2 |
| 2013 | 1 | 2 | 94 | 0 | 0 | - | 2 | - | 4 | 22 | 56 | 7 | 1 | 5 | 4 | 0 |
| 2016 | 2 | 1 | 92 | 0 | 0 | 0 | 3 | - | 4 | 28 | 45 | 8 | 2 | 5 | 6 | 2 |
| 2019 | 2 | 1 | 94 | 0 | 0 | - | 3 | - | 9 | 19 | 51 | 7 | 3 | 6 | 4 | 1 |
| 2022 | 2 | 2 | 95 | 0 | 0 | - | 1 | - | 11 | 20 | 63 | 4 | 2 | - | - | - |
| | Suckler cows | | | | | | | | Suckler cows | | | | | | | |
| 2005 | - | 3 | 79 | - | 6 | - | 12 | - | 2 | 30 | 52 | 2 | 2 | 8 | 1 | 2 |
| 2007 | - | 9 | 72 | - | 1 | - | 18 | - | 4 | 26 | 44 | 12 | 5 | 4 | 5 | 1 |
| 2009 | 3 | 1 | 88 | - | 0 | - | 7 | - | 3 | 34 | 37 | 8 | 6 | 7 | 4 | 1 |
| 2011 | 5 | 2 | 79 | 0 | 1 | 0 | 13 | - | 6 | 18 | 52 | 5 | 4 | 7 | 5 | 3 |
| 2013 | 0 | 5 | 87 | 0 | 3 | 0 | 6 | 0 | 4 | 26 | 49 | 6 | 4 | 4 | 7 | 1 |
| 2016 | 3 | 3 | 80 | - | 0 | 0 | 13 | - | 7 | 23 | 33 | 8 | 3 | 16 | 10 | 1 |
| 2019 | 3 | 0 | 87 | 0 | 1 | 0 | 9 | 0 | 8 | 23 | 43 | 8 | 2 | 9 | 5 | 2 |
| 2022 | 6 | 1 | 90 | 1 | 0 | - | 3 | - | 10 | 28 | 47 | 12 | 2 | 1 | - | - |
| | Heifers | | | | | | | | Heifers | | | | | | | |
| 2005 | 2 | 1 | 92 | 0 | 0 | - | 4 | - | 4 | 20 | 59 | 6 | 3 | 5 | 3 | 1 |
| 2007 | 1 | 2 | 93 | 0 | 0 | - | 4 | - | 4 | 26 | 52 | 8 | 2 | 4 | 3 | 1 |
| 2009 | 3 | 2 | 91 | 1 | 0 | - | 3 | 0 | 5 | 27 | 47 | 8 | 4 | 3 | 5 | 1 |
| 2011 | 2 | 1 | 92 | - | 1 | 0 | 4 | - | 4 | 20 | 50 | 6 | 2 | 8 | 6 | 4 |
| 2013 | 2 | 1 | 92 | 0 | 0 | 0 | 4 | - | 8 | 22 | 51 | 6 | 5 | 4 | 4 | 1 |
| 2016 | 2 | 1 | 91 | 0 | 1 | 0 | 5 | - | 5 | 24 | 44 | 8 | 3 | 9 | 5 | 1 |
| 2019 | 2 | 2 | 91 | 0 | 0 | 0 | 5 | 0 | 6 | 25 | 47 | 5 | 3 | 8 | 5 | 1 |
| 2022 | 2 | 2 | 94 | 0 | 0 | - | 1 | - | 8 | 29 | 54 | 8 | 2 | - | - | - |
| | Bulls and steers | | | | | | | | Bulls and steers | | | | | | | |
| 2005 | 4 | 4 | 87 | - | 0 | - | 5 | - | 1 | 31 | 54 | 4 | 1 | 5 | 3 | 1 |
| 2007 | 3 | 2 | 90 | 0 | 0 | 0 | 4 | - | 5 | 26 | 53 | 5 | 2 | 7 | 1 | 1 |
| 2009 | 2 | 2 | 89 | 1 | 0 | - | 6 | - | 4 | 26 | 48 | 9 | 4 | 4 | 3 | 3 |
| 2011 | 1 | 1 | 92 | - | 0 | 0 | 5 | 0 | 1 | 16 | 56 | 5 | 4 | 6 | 9 | 2 |
| 2013 | 3 | 3 | 88 | - | 1 | - | 5 | - | 1 | 13 | 76 | 3 | 2 | 1 | 3 | 1 |
| 2016 | 2 | 2 | 89 | 0 | 1 | 1 | 6 | - | 3 | 19 | 43 | 15 | 2 | 13 | 5 | 1 |
| 2019 | 2 | 2 | 91 | 0 | 1 | 0 | 4 | 0 | 5 | 13 | 44 | 20 | 7 | 5 | 5 | 1 |
| 2022 | 3 | 2 | 94 | 1 | 0 | - | 2 | - | 7 | 27 | 57 | 6 | 1 | 2 | - | - |
| | Calves | | | | | | | | Calves | | | | | | | |
| 2005 | 3 | 1 | 91 | 0 | 0 | - | 5 | - | 3 | 22 | 57 | 6 | 4 | 5 | 2 | 1 |
| 2007 | 1 | 3 | 91 | 0 | 1 | - | 5 | - | 4 | 27 | 49 | 9 | 3 | 3 | 4 | 1 |
| 2009 | 4 | 1 | 90 | 0 | 0 | - | 3 | - | 5 | 28 | 46 | 7 | 3 | 5 | 4 | 2 |
| 2011 | 3 | 1 | 91 | - | 1 | 0 | 4 | - | 2 | 21 | 54 | 5 | 4 | 8 | 5 | 2 |
| 2013 | 3 | 3 | 91 | - | 1 | 0 | 2 | - | 3 | 28 | 49 | 6 | 5 | 2 | 6 | 1 |
| 2016 | 3 | 1 | 87 | 0 | 1 | 0 | 8 | - | 4 | 28 | 38 | 8 | 4 | 10 | 8 | 1 |
| 2019 | 3 | 2 | 89 | 0 | 1 | 0 | 5 | 0 | 8 | 19 | 51 | 5 | 3 | 8 | 5 | 1 |
| 2022 | 3 | 2 | 93 | 1 | 0 | - | 1 | - | 8 | 25 | 53 | 10 | 3 | 1 | 1 | - |

| Year | Liquide manure | | | | | | | | Urine | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Filled from underneath | | | | Filled from above | | | | Filled from underneath | | | | Filled from above | | | |
| | Uncovered | Roof | Floating crust | Other cover | Uncovered | Roof | Floating crust | Other cover | Uncovered | Roof | Floating crust | Other cover | Uncovered | Roof | Floating crust | Other cover |
| | Sows and Boars | | | | | | | | Sows and Boars | | | | | | | |
| 2005 | 4 | 2 | 89 | - | 3 | 1 | 1 | - | - | 16 | 74 | 6 | 0 | 0 | 3 | - |
| 2007 | 2 | 5 | 88 | 2 | - | - | 3 | - | - | 16 | 77 | 6 | - | 0 | 0 | - |
| 2009 | 2 | 6 | 91 | 1 | - | - | 1 | - | 2 | 21 | 59 | 13 | - | 1 | 3 | - |
| 2011 | 8 | 2 | 89 | - | - | - | 2 | - | - | 18 | 68 | 2 | - | 2 | 10 | 1 |
| 2013 | - | 6 | 91 | 1 | 0 | - | 1 | - | - | 19 | 76 | 4 | - | 1 | - | - |
| 2016 | 1 | 21 | 77 | - | 0 | - | 1 | - | 3 | 37 | 42 | 15 | - | 2 | - | - |
| 2019 | 1 | 7 | 83 | - | - | 2 | 7 | - | 1 | 12 | 66 | 21 | - | - | - | - |
| 2022 | 1 | 15 | 82 | 0 | 0 | - | 2 | - | - | 25 | 52 | 23 | 0 | - | - | - |
| | Pigs for meat production | | | | | | | | Pigs for meat production | | | | | | | |
| 2005 | 1 | 5 | 91 | 0 | 1 | 1 | 1 | 0 | - | 10 | 86 | 4 | - | - | - | - |
| 2007 | 2 | 3 | 88 | 5 | - | - | 3 | - | - | 36 | 49 | 11 | 1 | 3 | - | - |
| 2009 | 1 | 7 | 90 | 1 | - | - | 1 | - | - | 4 | 82 | 10 | - | 3 | - | 1 |
| 2011 | 2 | 7 | 89 | 1 | - | 0 | 1 | - | - | 10 | 80 | - | - | 9 | - | - |
| 2013 | 0 | 10 | 85 | 0 | 3 | 0 | 1 | - | - | 51 | 39 | 10 | - | - | - | - |
| 2016 | 1 | 17 | 79 | 1 | 0 | 0 | 2 | - | - | - | 61 | 24 | - | 15 | - | - |
| 2019 | 1 | 15 | 77 | 1 | - | - | 6 | - | - | 14 | 77 | 9 | - | - | - | - |
| 2022 | 3 | 16 | 77 | 2 | 1 | 0 | 1 | - | - | 4 | 68 | 27 | 0 | - | - | - |
| | Poultry | | | | | | | | | | | | | | | |
| 2005 | - | 7 | 81 | 2 | 6 | - | 4 | - | | | | | | | | |
| 2007 | 5 | 33 | 40 | 3 | - | - | 19 | - | | | | | | | | |
| 2009 | - | 7 | 70 | - | 17 | - | 6 | - | | | | | | | | |
| 2011 | - | 12 | 56 | 7 | 4 | 2 | 19 | - | | | | | | | | |
| 2013 | - | 8 | 44 | - | - | 19 | 29 | - | | | | | | | | |
| 2016 | - | 19 | 56 | - | 3 | 17 | 5 | - | | | | | | | | |
| 2019 | 3 | 0 | 57 | 14 | - | 19 | 6 | - | | | | | | | | |
| 2022 | - | 27 | 69 | - | - | 4 | - | - | | | | | | | | |

### 5.2.2.2 EMISSIONS OF AMMONIA (TIER 2) AND EMISSIONS OF NITRIC OXIDE

To estimate the emission of ammonia from 1990 to 2004, and the emission of $NO_X$ for the complete time series, Sweden uses a slightly modified version of the default tier 2 model described in the EMEP/EEA guidebook 2023. The ammonia emissions from 2005 and onwards are instead estimated with a country specific model (described in detail below). The main modification of the tier 2 model is that we use total N instead of TAN to estimate the emissions from livestock housing and manure storage. The reason is that the country specific emissions factors we use are developed in that way. The emission factors we use in the tier 2 model are the same as in the country specific model but here aggregated to match the calculation level used in the default model (e.g. aggregated to different animal categories instead of different application methods as we use in the CS model). The rationale for not using the default emission factors is that the climate in Sweden is considerable cooler then the European average and this has a profound effect on the average annual ammonia emission factors[203].

The default tier 2 methodology for both ammonia and NOx follows the same stepwise procedure from the guidebook. This methodology is utilized for all the livestock categories described in Tables 5-2 and 5-3. To ensure consistency with the greenhouse gas inventory, the same parameters are used in both inventories. The manure management systems taken into account are liquid systems, solid systems, deep litter, anaerobic digesters and composting. The digesters are divided into on-farm digesters and co-digesters. Emissions from on-farm digesters are allocated to the agriculture sector while emissions from co-digesters are during storage accounted for in the waste sector while emissions during livestock housing are accounted for in the agriculture sector. Emissions during application of digest from co-digesters are also accounted in the agriculture sector as other organic fertilisers.

**Step 1**

By using the annual nitrogen excretion rates (Table 5-13) combined with the distribution of different manure management systems (MMS) (Tables 5-5 to 5-8) and stable periods (Table 5-4) we calculate the amount of total-N that is excreted in the stables and on the grazing grounds.

I.e. $m_{hous\_\mathit{MMS}\_N}$ and $m_{graz\_N}$.

**Step 2**

Here we calculate the $NH_3$-N emissions from the livestock housings by multiplying the amount of excreted nitrogen with the emission factor for all the different manure management systems (Table 5-11).

$E_{hous\_\mathit{MMS}\_}NH_3\text{-}N = m_{hous\_\mathit{MMS}\_N} \times EF_{hous\_\mathit{MMS}}$

**Step 3**

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[203] Swedish Institute of Agricultural and Environmental Engineering (JTI) 2002

In this step, we estimate the amount of total-N in the manure that remains after the livestock housing emissions. This estimate the amount of N stored in the different manure management systems.

$m_{storage\_MMS\_N} = m_{hous\_MMS\_N} - E_{hous\_MMS\_}NH_3\text{-}N$

**Step 4**

Here we estimate the nitrogen emissions that occur from emissions of $NH_3$ as well as $NO_X$ during storage. In Sweden, no manure is spread directly without being stored before application so this shortens the calculations slightly compared to the guidebook. The emission factors used can be seen in table 5-12. To estimate the emissions of $NO_X$ we have used the default solid manure emission factors for solid manure, deep litter and compost (1%). For liquid manure and digestate we have used the default EF for slurry (0.01%). These values are used together with the country specific values of the proportion of total N that is ammoniacal nitrogen (TAN) (Table 5-13).

$E_{storage\_MMS\_}NH_3\text{-}N = m_{storage\_MMS\_N} \times EF_{NH3}$

$E_{storage\_MMS\_}NO\text{-}N = m_{storage\_MMS\_N} \times TAN_{MMS} \times EF_{NOx}$

**Step 5**

In this step, we calculate the amount of N that is available for application on agricultural soil. That is, subtracting the amount of nitrogen lost during storage.

$m_{applic\_MMS\_N} = m_{storage\_MMS\_N} – (E_{storage\_MMS\_}NH_3\text{-}N + E_{storage\_MMS\_}N_2O\text{-}N + E_{storage\_MMS\_}NO_X\text{-}N + E_{storage\_MMS\_}N_2\text{-}N)$

**Step 6**

Emissions of ammonia from application of manure are estimated. First, the available total N is translated to amount of TAN, because the country specific emission factors we use are expressed as fraction of TAN lost as ammonia (Table 5-13).

$E_{applic\_MMS\_}NH_3\text{-}N = m_{applic\_MMS\_N} \times TAN_{MMS} \times EF_{Applic\_MMS}$

**Step 7**

The emissions of $NO_X$ from application of manure are estimated based on total amount of nitrogen in manure applied to agricultural soils. The emissions are reported under NFR category 3.D. The emission factor used is the default one from the guidebook.

$EM_{applic\_NO2} = \sum (m_{applic\_MMS\_N}) \times 0.04$

**Step 8**

Here we calculate the emissions of ammonia from grazing (although reported under NFR 3D). See Table 5-16 for the emission factors.

$E_{graz\_}NH_3\text{-}N = m_{graz\_N} \times EF_{grazing}$

**Step 9**
In this final step, the different emissions are aggregated to the relevant NFR categories and converted to the mass of the specific compounds.

*Reported per animal (m) in 3B, manure management (emissions from animal manure treated in co-digesters are included in housings and excluded during storage)*

$$EM_{3.B.m\_}NH_3 = \sum (E_{hous\_MMS\_}NH_3\text{-}N + E_{storage\_MMS\_}NH_3\text{-}N) \times 17/14$$

$$EM_{3.B.m\_}NO_2 = \sum (E_{storage\_MMS\_}NO\text{-}N) \times 46/14$$

*Reported as a sum for all animals in 3Da2a, animal manure applied to soils (including emissions from animal manure digestate from on-farm digester and excluding animal manure digestate from co-digesters which is included in emissions from other organic fertilizers)*

$$EM_{3.D.a.2.a\_}NH_3 = \sum (E_{applic\_MMS\_}NH_3\text{-}N) \times 17/14$$

*Reported as a sum for all animals in 3Da3, urine and dung deposited by grazing animals*

$$EM_{3.D.a.3\_}NH_3 = E_{graz\_}NH_3\text{-}N \times 17/14$$

### 5.2.2.3 EMISSIONS OF AMMONIA (COUNTRY SPECIFIC MODEL)

Additionally, Sweden has developed a country specific methodology to estimate emissions of ammonia from agriculture. The methodology[204,205,206] was developed in collaboration between the Swedish EPA, Statistics Sweden, the Swedish Board of Agriculture, Swedish University of Agricultural Sciences and the Swedish Institute of Agricultural and Environmental Engineering. Several of the questions to the farmers in the Statistics Sweden's field investigation among farmers are designed to provide this model with relevant and accurate activity data. It is only possible to use the model from 2005 and onwards. The reason being that before this year it is not possible to acquire the detailed micro data from the Statistics Sweden's field investigation among farmers that is needed as activity data in the model. However, when 2005 is Sweden's base year for ammonia reduction commitments in the EU national emission ceilings directive (NEC) and the Gothenburg protocol this is the most important part of the time series. Hence, the only available alternative strategy, i.e. to use the default tier 2 model for the complete time series, would result in a less accurate monitoring of these commitments.

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[204] Swedish Environmental Protection Agency 1997

[205] Swedish Institute of Agricultural and Environmental Engineering (JTI) 2002

[206] Swedish Board of Agriculture 2023: Nya emissionsfaktorer vid beräkning av kväveförluster från stallar

The Swedish method estimates the emissions separately from all four stages of the manure handling chain: livestock housing, storage, manure application and grazing. The emission factors that describe the share of nitrogen lost as ammonia during the different stages of the manure handling are developed by the Swedish University of Agricultural Sciences, the Swedish Board of Agriculture and the Swedish Institute of Agricultural and Environmental Engineering (JTI)[207,208]. The main difference between the country specific model and the tier 2 model is that the former considers more variables when estimating the emissions from storage and application of manure. For example, whether the manure is stored with or without a roof (and if so, type of roof), application method as well as timespan between application and mulching.

The calculations are carried out as:

$$NH_3\text{-}N_{Hous} = D \times N_1 \times P \times EF_1$$
$$NH_3\text{-}N_{Storage} = D \times N_2 \times P \times (1 - EF_1) \times EF_2$$
$$NH_3\text{-}N_{Application} = D \times N_3 \times P \times (1 - EF_1) \times (1 - EF_2) \times EF_3$$
$$NH_3\text{-}N_{Grazing} = D \times N_1 \times (1 - P) \times EF_4$$

Where, D = number of animals, P = stable period, $N_1$ = yearly production of nitrogen per type of animal, $EF_1$ = nitrogen emissions during livestock housing (fraction of total nitrogen content), $N_2$ = nitrogen per type of animal after ventilation losses of $NH_3$-N, $EF_2$ = nitrogen emissions during storage (fraction of total nitrogen content), $N_3$ = nitrogen per type of animal after ventilation and storage losses of $NH_3$-N, $N_2O$-N, $NO_X$-N and $N_2$-N, $EF_3$ = nitrogen emissions during application of animal manure (fraction of ammonium nitrogen content) and $EF_4$ = nitrogen emissions during grazing (fraction of total nitrogen content). In Tables 5-11 and 5-14 to 5-16 all the emission factors used in the calculations are presented. For cattle and laying hen the $EF_1$ for housing differs depending on the housing system (Table 5-11). For cattle with liquid manure a higher EF is used for loose housing and a lower for tie stalls, and a higher EF is used for laying hens in floor system than for cage systems. Since 1990 the portion of cattle kept in loose hosing, and laying hens in floor systems have increased in Sweden, which means that gradually higher $EF_1$ is used over time.

The ammonia emissions per animal from 3B manure management are then calculated as:

$$NH_3 = (NH_3N_{Ventilation} + NH_3N_{Storage}) \times {}^{17}/_{14}$$

Ammonia emissions from application of manure and grazing are also calculated with this methodology but instead reported under 3D, crop production and agricul-

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[207] Swedish Institute of Agricultural and Environmental Engineering (JTI) 2002

[208] Swedish Board of Agriculture 2023: Nya emissionsfaktorer vid beräkning av kväveförluster från stallar

tural soils. Concerning grazing, the length of the grazing periods for cattle are obtained from the field investigation among farmers, while the grazing period is fixed to 6 months for horses, sheep and goats, and to 12 months for reindeers.

**Table 5-11. Emission factors (EF1) used to calculate emissions of ammonia during housing (% of total N) in both the tier 2 and the country specific model.**

| Animal category | EF solid manure1) | EF liquid manure1) | EF deep litter1) | EF digesters2) | EF composting3) |
|---|---:|---:|---:|---:|---:|
| Cattle | 4% | 6%/4%4) | 7% | 7% | - |
| Sow, Pigs for meat production and Boar | 12% | 12% | 12% | 17% | - |
| Piglet | 6% | 6% | 6% | 6% | - |
| Sheep5) | 11% | - | 11% | - | - |
| Goats5) | 11% | - | 11% | - | - |
| Horses | 4% | - | 15% | - | 4% |
| Laying hens | 10%/3%6) | 10%/3%6) | 10% | - | - |
| Chickens | 10% | 10% | 10% | - | - |
| Slaughter Chickens | 6% | 6% | 6% | - | - |
| Turkeys | 10% | 10% | 10% | - | - |
| Fur-bearing animals | 12% | - | - | - | - |

1) Swedish Board of Agriculture 2023: Nya emissionsfaktorer vid beräkning av kväveförluster från stallar. 2) Same as for liquid manure. 3) Same as for solid manure. 4) Loose housing / Tie stalls. 5) EF include lamb / kid. 6) Floor system / Cage.

**Table 5-12. Emission factors used to calculate emissions of ammonia from manure storage (% of total N) in the tier 2 model.**

| Animal category | EF solid manure* | EF liquid manure* | EF deep litter* | EF digesters** | EF composting*** |
|---|---:|---:|---:|---:|---:|
| Dairy Cows | 18% | 3% | 30% | 2.75% | - |
| Suckler cows | 17% | 3% | 30% | 2.75% | - |
| Heifers | 18% | 3% | 30% | 2.75% | - |
| Bulls and steers | 17% | 3% | 30% | 2.75% | - |
| Calves | 18% | 3% | 30% | 2.75% | - |
| Sows | 18% | 4% | 30% | 2.75% | - |
| Boars | 18% | 4% | 30% | 2.75% | - |
| Pigs for meat production | 18% | 4% | 30% | 2.75% | - |
| Piglets | 18% | 4% | 30% | 2.75% | - |
| Sheep | 25% | - | - | - | - |
| Goats | 25% | - | - | - | - |
| Horses | 25% | - | 33% | - | 0.25% |
| Laying hens | 12% | 4% | 20% | - | - |
| Turkeys | 20% | - | 20% | - | - |
| Chickens | 12% | 4% | 20% | - | - |
| Slaughter Chickens | 5% | - | 5% | - | - |
| Fur-bearing animals | 30% | - | - | - | - |
| Reindeer* | - | - | - | - | - |

* This EF:s are based on the same EF:s as in the country specific model but here aggregated to match the calculation level used in the tier 2 model. See paragraph 5.2.2.2.
** Default EF:s from EMEP/EEA Guidebook 2019. *** Same as for solid manure.

**Table 5-13. Nitrogen excretion, proportion of TAN and emission factors (% of TAN) used for ammonia emissions from application of manure in the tier 2 model.**

| Animal groups | Nitrogen kg/year/head | TAN in liquid manure and digestate | TAN in solid manure and compost | TAN in deep litter | EF for application of liquid manure and digestate | EF for application of solid manure and compost | EF for application of deep litter |
|---|---|---|---|---|---|---|---|
| Dairy Cows* (Milk production 6,000 kg/yr) | 97 | 60% | 51% | 10% | 33% | 38% | 41% |
| Dairy Cows* (Milk production 8,000 kg/yr) | 117 | | | | | | |
| Dairy Cows* (Milk production 10,000 kg/yr) | 137 | | | | | | |
| Suckler cows | 63 | 60% | 52% | 10% | 32% | 39% | 46% |
| Heifers | 47 | 60% | 51% | 10% | 32% | 38% | 47% |
| Bulls and steers | 47 | 60% | 52% | 10% | 32% | 39% | 46% |
| Calves | 28 | 60% | 51% | 10% | 33% | 39% | 47% |
| Sows** | 22.5 | 70% | 51% | 10% | 30% | 35% | 48% |
| Boars | 13 | 70% | 51% | 10% | 29% | 34% | 46% |
| Pigs for meat production** | 10.8 | 70% | 51% | 10% | 29% | 35% | 44% |
| Piglets | 1.2 | 70% | 51% | 10% | 29% | 35% | 48% |
| Sheep | 14 | 25% | 25% | - | - | 43% | - |
| Goats | 13 | 25% | 25% | - | - | 43% | - |
| Horses | 48 | 24% | 25% | 10% | - | 43% | 47% |
| Laying hens | 0.60 | 75% | 60% | 40% | 29% | 40% | 56% |
| Turkeys | 0.69 | 40% | 40% | 40% | | 39% | 39% |
| Chickens | 0.22 | 75% | 60% | 40% | 30% | 41% | 56% |
| Slaughter Chickens | 0.29 | 40% | 40% | 40% | - | 41% | 41% |
| Fur-bearing animals | 4.59 | 100% | 100% | - | - | 40% | - |
| Reindeer*** | 5.4 | - | - | - | - | - | - |

*For dairy cows the nitrogen excretion is estimated from milk production. **Due to a more intense swine production the nitrogen production for sows and pigs for meat production was updated in 2002. For the years prior to 2002, the values 18.5 and 9.5 kg are used. *** From the Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories with a typical animal mass for reindeer of 64 kg.

**Table 5-14. Emission factors (EF2) used to calculate emissions of ammonia from storage (% of total N) in the country specific model.**

| Type of manure, handling | Cattle | Swine | Sheep/goats/horses | Laying hens/ chicken | Slaughter chicken | Turkeys | Fur-bearing animals |
|---|---|---|---|---|---|---|---|
| Liquid manure, uncovered | | | | | | | |
| Filled from underneath | 6% | 8% | | 8% | | | |
| Filled from above | 7% | 9% | | 9% | | | |
| Liquid manure, covered | | | | | | | |
| Filled from underneath: | | | | | | | |
| Roof | 1% | 1% | | 1% | | | |
| floating crust | 3% | 4% | | 4% | | | |
| Other | 2% | 2% | | 2% | | | |
| Filled from above: | | | | | | | |
| Roof | 1% | 1% | | 1% | | | |
| floating crust | 4% | 5% | | 5% | | | |
| Other | 3% | 3% | | 3% | | | |
| Urine, uncovered | | | | | | | |
| Filled from underneath | 37% | 37% | | | | | |
| Filled from above | 40% | 40% | | | | | |
| Urine, with cover | | | | | | | |
| Filled from underneath: | | | | | | | |
| Roof | 5% | 5% | | | | | |
| floating crust | 17% | 17% | | | | | |
| Other | 10% | 10% | | | | | |
| Filled from above: | | | | | | | |
| Roof | 5% | 5% | | | | | |
| floating crust | 20% | 20% | | | | | |
| Other | 12% | 12% | | | | | |
| Solid manure | 20% | 20% | 25% | 12% | | | 30% |
| Deep litter manure | 30% | 30% | 33% | 20% | 5% | 20% | |
| Anaerobic digesters* | 2.75% | 2.75% | | | | | |
| Composting** | | | 25% | | | | |

Except for digesters and composting all EF:s are from the report "Swedish Institute of Agricultural and Environmental Engineering 2002: Översyn av statistiska centralbyråns beräkningar av ammoniakavgången i jordbruk, JTI, 2002.
** Default EF:s from EMEP/EEA Guidebook 2019. *** Same EF as for solid manure.

**Table 5-15. Emission factors (EF3) used to calculate emissions of ammonia from spreading (% of TAN) in the country specific model.**

| Tillage timing | Spreading strategy | Season | EF solid manure, deep litter and compost | EF urine | EF liquid manure, slurry and digestate |
|---|---|---|---:|---:|---:|
| Immediately | Broadcast | Early autumn | 20% | 15% | 5% |
| Immediately | Trailing hoses | Early autumn |  | 10% | 3% |
| Mulching within 4 h | Broadcast | Early autumn | 35% | 23% | 18% |
| Mulching within 4 h | Trailing hoses | Early autumn |  | 18% | 9% |
| Mulching within 5-24 h | Broadcast | Early autumn | 50% | 30% | 30% |
| Mulching within 5-24 h | Trailing hoses | Early autumn |  | 25% | 15% |
| After 24 hours or no mulching on unseeded ground | Broadcast | Early autumn | 70% | 45% | 70% |
| After 24 hours or no mulching on unseeded ground | Trailing hoses | Early autumn |  | 30% | 40% |
| Immediately | Broadcast | Late autumn | 10% | 10% | 5% |
| Immediately | Trailing hoses | Late autumn |  | 4% | 3% |
| Mulching within 4 h | Broadcast | Late autumn | 15% | 15% | 8% |
| Mulching within 4 h | Trailing hoses | Late autumn |  | 11% | 4% |
| Mulching within 5-24 h | Broadcast | Late autumn | 20% | 20% | 10% |
| Mulching within 5-24 h | Trailing hoses | Late autumn |  | 18% | 5% |
| After 24 hours or no mulching on unseeded ground | Broadcast | Late autumn | 30% | 25% | 30% |
| After 24 hours or no mulching on unseeded ground | Trailing hoses | Late autumn |  | 25% | 15% |
| After 24 hours or no mulching on unseeded ground | Broadcast | Winter | 20% | 40% | 30% |
| After 24 hours or no mulching on unseeded ground | Trailing hoses | Winter |  | 30% | 20% |
| Immediately | Broadcast | Spring | 15% | 8% | 10% |
| Immediately | Trailing hoses | Spring |  | 7% | 5% |
| Mulching within 4 h | Broadcast | Spring | 33% | 14% | 15% |
| Mulching within 4 h | Trailing hoses | Spring |  | 14% | 8% |
| Mulching within 5-24 h | Broadcast | Spring | 50% | 20% | 20% |
| Mulching within 5-24 h | Trailing hoses | Spring |  | 20% | 10% |
| After 24 hours or no mulching on pasture | Broadcast | Spring | 70% | 35% | 40% |
| After 24 hours or no mulching on pasture | Trailing hoses | Spring |  | 25% | 30% |
| Immediately | Shallow injection | Spring |  | 8% | 15% |
| After 24 hours or no mulching on grain | Broadcast | Spring | 70% | 11% | 20% |
| After 24 hours or no mulching on grain | Trailing hoses | Spring |  | 10% | 15% |
| After 24 hours or no mulching on pasture | Broadcast | Summer | 90% | 60% | 70% |
| After 24 hours or no mulching on pasture | Trailing hoses | Summer |  | 40% | 50% |
| Immediately | Shallow injection | Summer |  | 15% | 30% |
| After 24 hours or no mulching on grain | Broadcast | Summer | 90% | 10% | 20% |
| After 24 hours or no mulching on grain | Trailing hoses | Summer |  | 10% | 7% |

All EF:s are from the report “Swedish Institute of Agricultural and Environmental Engineering 2002: Översyn av statistiska centralbyråns beräkningar av ammoniakavgången i jordbruk, JTI, 2002.

**Table 5-16. Emission factors (EF4) used to calculate emissions of ammonia from grazing animals (% of total N) in both the tier 2 and the country specific model.**

| Animal category | EF Grazing |
|---|---:|
| Cattle | 8% |
| Horses | 8% |
| Sheep | 4% |
| Goats | 4% |
| Reindeer | 4% |

Statistics Sweden. 1998. Beräkningsunderlag och metodik till “Utsläpp till luft av ammoniak 1997”.

### 5.2.2.4 NON-METHANE VOLATILE ORGANIC COMPOUNDS (NMVOCS)

The emissions of NMVOC from manure management are estimated with the tier 2 methods described in the EMEP/EEA guidebook 2019. The emissions are calculated as the sum of six different sources:

- from feeding of silage
- from silage stores
- from housing (feeding beside silage)
- from outdoor manure stores
- from manure application (reported in 3D)
- from sewage sludge application (reported in 3D)
- from grazing animals (reported in 3D)

The calculation methodology differs slightly between cattle and other animals. For cattle the methodology is based on feed intake, instead of excreted volatile substance as for the other animals. That is, the factor $MJ\_{_i}$ is replaced with kg $VS\_{_i}$ (kg volatile solids excreted).

The emissions from cattle for the different subcategories are calculated as:

Feeding of silage:

$$E_{NMVOC,silage\_feeding\_i} = AAP\_{_i} \times MJ\_{_i} \times X_{house\_i} \times EF_{NMVOC,silage\_feeding\_i} \times Frac_{silage\_i}$$

Silage stores:

$$E_{NMVOC,silage\_store\_i} = E_{NMVOC,silage\_feeding\_i} \times Frac_{silage\_store}$$

Housing (feeding beside silage):

$$E_{NMVOC,house\_i} = AAP\_{_i} \times MJ\_{_i} \times X_{house\_i} \times EF_{NMVOC,house\_i}$$

Outdoor manure stores:

$$E_{NMVOC,manure\_store\_i} = E_{NMVOC,house\_i} \times (E_{NH3,storage\_i} / E_{NH3,house\_i})$$

Finally, the total emission of NMVOC reported in 3B, manure management, is:

$$\sum_i \left[ E_{NMVOC,silage_{feeding_i}} + E_{NMVOC,silage_{store_i}} + E_{NMVOC,house_i} + E_{NMOC,manure_{store_i}} \right]$$

where;

$AAP\_{_i}$ is the annual average population of animal *i*, $MJ\_{_i}$ is the annual gross feed intake for animal *i*. The estimated gross feed is country-specific and the same ones as used in the reporting of greenhouse gases to the UNFCCC. $X_{\mathrm{house\_i}}$ is country specific data on the share of time an animal *i* spends in the animal house in a year. The value is corrected for that part of the manure is deposited in the stables also during the grazing period when dairy cows return to the stables for milking. $\mathrm{Frac}_{\mathrm{silage\_store}}$ is the share of the emission from the silage store compared to the emission from the feeding table in the barn. The default tentative value of 0.25 from the guidebook is used. The emission factors used are from the EMEP/EEA guidebook 2019. $E_{\mathrm{NH3,storage\_}i}$, $E_{\mathrm{NH3,house\_}i}$ and $E_{\mathrm{NH3,appl\_}i}$ are the emissions of ammonia from storage of manure, stables and application of manure for animal category *i*, respectively. The values are taken from the Swedish ammonia inventory.

When no country specific emission factors on emissions of NMVOC exists in Sweden the default emission factors from the EMEP/EEA guidebook 2019are used. See Table 5-17 for a list of the factors used in the calculations of NMVOC from manure management.

**Table 5-17. Parameters and emission factors used for estimating emissions of NMVOC from manure management.**

| **Source** | **Feed intake (MJ/day)** | **Fraction silage feeding** | **Silage feeding (kg NMVOC/MJ feed intake)** | **Housing (kg NMVOC/MJ feed intake)** |
|---|---|---|---|---|
| Dairy cows | * | 0.76 | 0.0002002 | 0.0000353 |
| Suckler cows | 217.0 | 0.59 | 0.0002002 | 0.0000353 |
| Bulls and steers | 165.5 | 0.63 | 0.0002002 | 0.0000353 |
| Heifers | 143.9 | 0.81 | 0.0002002 | 0.0000353 |
| Calves | 91.5 | - | 0.0002002 | 0.0000353 |
| **Source** | **Feed intake (kg VS /day)** | **Fraction silage feeding** | **Silage feeding (kg NMVOC/kg VS excreted)** | **Housing (kg NMVOC/kg VS excreted)** |
| Sows and boars | 0.69 | - | - | 0.007042 |
| Pigs for meat production | 0.37 | - | - | 0.001703 |
| Piglets | 0.04 | - | - | 0.001703 |
| Sheep | 0.4 | 0.68 | 0.01076 | 0.001614 |
| Horses | 2.13 | 1 | 0.01076 | 0.001614 |
| Goats | 0.3 | 0.67 | 0.01076 | 0.001614 |
| Laying hens and chickens | 0.02 | - | - | 0.005684 |
| Slaughter chickens | 0.01 | - | - | 0.009147 |
| Turkeys | 0.07 | - | - | 0.005684 |
| Reindeers | 0.39 | - | - | 0.001614 |
| Fur-bearing animals | 0.14 | - | - | 0.005684 |

* see table 5-3.

#### 5.2.2.5 PARTICULATE MATTER

The default tier 1 methodology from the EMEP/EEA guidebook 2023 is used for all animal categories. Only housed animals are included in the calculation. All used emission factors are presented in Tables 5-18 and 5-19.

**Table 5-18. Tier 1 emission factors used to estimate the emissions from cattle and swine (kg/AAP/year).**

| Substance | Dairy cows | Suckler cows | Steers and bulls | Heifers | Calves | Pigs for meat production | Piglets | Sows | Boars |
|---|---|---|---|---|---|---|---|---|---|
| TSP | 1.38 | 0.59 | 0.59 | 0.59 | 0.34 | 1.05 | 0.27 | 0.62 | 0.62 |
| $PM_{10}$ | 0.63 | 0.27 | 0.27 | 0.27 | 0.16 | 0.14 | 0.05 | 0.17 | 0.17 |
| $PM_{2.5}$ | 0.41 | 0.18 | 0.18 | 0.18 | 0.1 | 0.006 | 0.002 | 0.01 | 0.01 |

**Table 5-19. Tier 1 emission factors used to estimate emissions from other animals (kg/AAP/year).**

| Substance | Sheep | Horses | Goats | Poultry (layers) | Poultry (broilers) | Poultry (turkeys) | Fur-bearing animals |
|---|---|---|---|---|---|---|---|
| TSP | 0.14 | 0.48 | 0.14 | 0.19 | 0.04 | 0.11 | 0.018 |
| $PM_{10}$ | 0.06 | 0.22 | 0.06 | 0.04 | 0.02 | 0.11 | 0.008 |
| $PM_{2.5}$ | 0.02 | 0.14 | 0.02 | 0.003 | 0.002 | 0.02 | 0.004 |

### 5.2.3 Uncertainties and time-series consistency

As described above it was not possible to apply the Swedish country specific ammonia model for the years before 2005. To minimize the time series break between the default tier 2 model (1990-2004) and the country specific model (2005 and onwards) we use the country specific emission factors also in the tier 2 model. However, when the emissions are estimated on different levels in the two models, it was necessary to aggregate the country specific emission factors so to be able to use them in the tier 2 model. For example, the Swedish model use much more disaggregated emissions factors for application of animal manure (i.e. Table 5-14). From these we have calculated weighted country specific averages that fit the default tier 2 model (i.e. Table 5-12).

Between 1995 and 1996 there was an increase in the number of sows by 13%. The reason for this sudden increase was that as from this year also uncovered gilts are included in the group. Due to more intense swine production, the nitrogen production for sows and pigs for meat production were updated in 2002. Since no estimate on the number of horses exists before 2004, the value for 2004 is used for all preceding years.

The calculations are to a large degree based on data collected from farmers in Statistics Sweden's sample survey on the use of fertilisers and animal manure in agriculture; the estimations from this survey are associated with statistical uncertainties. Hence, all results must be considered with caution regarding the uncertainty in the input data. The emission factors are also encumbered with significant uncertainties. The emission factor uncertainties are likely larger than the activity data uncertainties. We estimate the uncertainty for the activity data for a specific emission category in 3B to be ca 20%. The uncertainty for the different emission factor are estimated as: $NH_3$ 50%, NMVOC 200%, $NO_X$ 80%. PM 150%-200%.

### 5.2.4 Source-specific QA/QC and verification

Annual increase or decrease is verified for the whole time series for all sub sources to decide that all annual changes are reasonable. We compare the times series for the emission with the time series for the activity data to confirm that they agree. We conduct regular meetings with the different authorities that provide activity data to the inventory to ensure that the quality of the data is of satisfactory quality and that they in turn use appropriate QC methods.

### 5.2.5 Source-specific recalculations

In this submission the emission factors for particulate matters from cattle and swine is updated in accordance with the EMEP/EEA Guideline and the emission factors for ammonia during housing in accordance with an update in the country specific method. These corrections have an impact on their respective emissions.

The total effect of the recalculations in 3.B entailed a decrease in $NH_3$ for 1990 of 2.9 % (-0.75 kt) and for the two most recent recalculated years entailed a decrease of 5.2 % and 5.4 % (-1.1 and -1.2 kt) respectively for year 2021 and 2022.

### 5.2.6 Source-specific planned improvements

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

## 5.3 Crop production and agricultural soils, NFR 3D

### 5.3.1 Source category description

From the subsector, “crop production and agricultural soils”, Sweden report emissions of ammonia, NMVOC, $NO_X$ and particulate matters. The most significant source of ammonia is emissions from application of animal manure. Other sources of ammonia are the use of inorganic fertilisers, grazing animals, applications of sewage sludge and use of other organic fertilisers. The same sources also give rise to emissions of nitric oxide. Emissions of NMVOC from crop can arise to attract pollinating insects, eliminate waste products or as a means of losing surplus energy. Factors that can influence the emissions of NMVOC include temperature and light intensity, plant growth stage, water stress, air pollution and senescence. The main source from crop production in Sweden is emissions from ley. Particulate matters are emitted during production of crops, and the main sources are soil cultivation and crop harvesting. These emissions originate from the operation of tractors and other machinery and are thought to consist of a mixture of organic fragments from the crops, soil minerals and organic matter.

A summary of the latest key source assessment is presented in Table 5-20.

**Table 5-20. Summary of key source analysis, NFR 3D, according to approach 1.**

| **NFR** | **Key Source Assessment** | |
|---|---|---|
| | **Level** | **Trend** |
| 3Da1 Inorganic N fertilizers | *NH3, NOx* | *NH3, NOx* |
| 3Da2a Animal manure applied to soils | *NH3, NMVOC, NOx* | *NH3, NMVOC* |
| 3Da2b Sewage sludge applied to soils | *NH3* | *NH3* |
| 3Da2c Other organic fertilizers applied to soils | *NH3, NOx* | *NH3* |
| 3Da3 Urine and dung deposited by grazing animals | *NH3, NOx* | |
| 3Dc Farm-level agricultural operations | *PM10, PM2.5* | *PM10* |
| 3De Cultivated crops | *NMVOC* | |

## 5.3.2 Methodological issues

### 5.3.2.1 ACTIVITY DATA

To estimate the emissions of ammonia and nitric oxide, data on applied nitrogen is needed for a number of different sources. To ensure consistency with the greenhouse gases inventory the same data are used in both inventories. The data on total nitrogen content in different types of mineral fertilisers are from the Statistic Sweden's sales statistics in Sweden. Application of sludge and nitrogen content in sludge are collected intermittently by Statistics Sweden and the Swedish EPA from sewage treatment plants. The nitrogen content in other organic fertilisers applied to soils is estimated from Statistics Sweden's survey on "Use of fertilisers and animal manure in agriculture" excluding substrate from manure. Nitrogen content in applied animal manure is estimated as the amount remaining after livestock housing and storage emissions calculated above in category 3B. The nitrogen content from animal manure digestate from on-farm digesters are included in animal manure whereas animal manure digestate from co-digester are, at this state, included in other organic fertilisers.

The formula used to calculate N content in animal manure applied to soils ($F_{AM}$) is:

$$F_{AM} = \sum_{T} N_T \times Nex_T \times (1 - Frac_{LossMS}) \times (1 - Frac_{PRP}) \times (1 - Frac_{co\text{-}digesters})$$

Where $N_T$ is the number of heads of livestock in category $T$ in Sweden, $Nex_T$ is the annual average excretion of N per head of category $T$, $Frac_{LossMS}$ is the amount of N lost before application. $Frac_{PRP}$ is the fraction of the nitrogen in pasture, range and paddock manure, and $Frac_{co\text{-}digesters}$ is the fraction of manure treated in co-digesters. The amount of nitrogen in grazing manure is also calculated above under 3B.

To estimate emissions of particulate matter and NMVOC from crop production, statistics on crop areas is needed. This statistics is produced by the Swedish Board of Agriculture[209].

Emission of hexachlorobenzene (HCB) is estimated from pesticides that have HCB as an impurity or by-product. In Sweden one active substance, Pecloram, contains HCB, it is in used since 2011, se Table 5-21.

**Table 5-21. Annual sale of active substance, picloram (ton).**

| Year | Picloram |
|---|---|
| 1990 | 0.0 |
| 1995 | 0.0 |
| 2000 | 0.0 |
| 2005 | 0.0 |
| 2010 | 0.0 |
| 2015 | 0.6[a)] |
| 2020 | 1.7 |
| 2021 | 2.0 |
| 2022 | 2.0[b)] |
| 2023 | 2.0[b)] |

Statistics on picloram are from Swedish Chemicals Agency, https://www.kemi.se/en/statistics/quantities-of-sold-pesticides.

a) Assumed values using linear alteration.

b) Data from 2021 is reused.

### 5.3.2.2 EMISSIONS OF AMMONIA

For a methodological description of the emissions from application of manure and grazing animals, see paragraph 5.2.2.2 and 5.2.2.3 above. To estimate the ammonia emissions from mineral fertilisers we have used the default tier 2 methodology from the EMEP/EEA guidebook 2023. The amount of nitrogen that volatilise as ammonia differs between different types of fertilisers[210] (Table 5-22). The total amount of nitrogen in sold ammonia-emitting products are shown in Table 5-25 (Amount of nitrogen in inorganic fertilizers).

To estimate the emissions from the relatively small sources, sewage sludge and other organic fertilisers, we have used the average nitrogen loss from application of animal manure as an approximation.

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[209] Swedish Board of Agriculture, JO 10-series

[210] EMEP/EEA air pollutant emission inventory guidebook 2023

**Table 5-22. Emissions of ammonia from different fertiliser types.**

| Fertiliser | Volatilised as ammonia ($g\ NH_3/kg\ N$) |
|---|---:|
| Anhydrous ammonia | 20 |
| Ammonium nitrate (AN) | 24 |
| Ammonium phosphate | 84 |
| Ammonium sulphate (AS) | 84 |
| Calcium ammonium nitrate (CAN) | 24 |
| Ammonium solutions (AN) | 87 |
| NK mixtures | 24 |
| NP mixtures | 84 |
| NPK mixtures | 84 |
| Other straight N compounds | 84 |
| Urea | 195 |

### 5.3.2.3 EMISSIONS OF NON-METHANE VOLATILE ORGANIC COMPOUNDS (NMVOCS)

As described in the guidebook, the estimated emissions of NMVOC from housing are used as the basis for estimating the emissions from manure application. See above in paragraph 5.2.3.3, for a description of how $E_{NMVOC,house}$ is calculated.

Emissions from animal manure applied to soils (3Da2a):

$$E_{NMVOC,appl\_i} = E_{NMVOC,house\_i} \times (E_{NH3,appl\_i} / E_{NH3,house\_i})$$

For emissions from application of sewage sludge no methodology is described in the guidebook. As an approximation of the NMVOC emissions, we have used the same emission factor as for manure from pasture, range and paddock and assume the same volatile solid content as for swine.

Emissions from sewage sludge applied to soils (3Da2b):

$$E_{NMVOC,Sludge} = N_{sludge} \times Frac_{VS\_swine} \times EF_{NMVOC,graz}$$

Emissions from urine and dung deposited by grazing animals (3Da3):

$$E_{NMVOC,graz\_i} = AAP_{\_i} \times MJ_{\_i} \text{ (or kg } VS_{\_i}) \times (1- \chi_{house\_i}) \times EF_{NMVOC,graz\_i}$$

To estimate the emissions from crop production we have used the tier 2 method described in the 2019 guidebook. Country specific data have been used (see Table 5-23) in combination with the default parameters found in table 3.3 in the EMEP/EEA Guidebook 2019 (Table 5-24 below). Concerning grass there is a temperature effect in the model. The emissions are assumed to increase if the temperature is above 25 °C. Data from the Swedish Meteorological and Hydrological Institute indicate that this occurs on average 20 days per year in Sweden. However, when the default EFs describe the emissions per hour, we have assumed that the temperature is above 25 °C half the time on these days.

**Table 5-23. Activity data used to estimate emissions of NMVOC from crops production.**

| | Yield | | | | Normalised fraction | | | | Weighted EF, kg NMVOC/ha/ year |
|---|---|---|---|---|---|---|---|---|---|
| Year | Wheat | Rye | Rape | Grass | Wheat | Rye | Rape | Grass | |
| 1990 | 5 451 | 3 873 | 2 252 | 5 989 | 0.24 | 0.05 | 0.09 | 0.62 | 0.47 |
| 1995 | 5 053 | 4 420 | 1 899 | 4 448 | 0.18 | 0.03 | 0.06 | 0.73 | 0.34 |
| 2000 | 5 080 | 4 610 | 2 559 | 4 429 | 0.28 | 0.02 | 0.03 | 0.67 | 0.33 |
| 2005 | 5 447 | 4 516 | 2 298 | 4 046 | 0.25 | 0.01 | 0.05 | 0.69 | 0.33 |
| 2010 | 4 608 | 4 174 | 2 337 | 4 697 | 0.25 | 0.02 | 0.07 | 0.67 | 0.35 |
| 2015 | 6 171 | 5 426 | 3 501 | 5 209 | 0.29 | 0.01 | 0.06 | 0.64 | 0.44 |
| 2020 | 6 123 | 5 217 | 3 178 | 5 094 | 0.29 | 0.02 | 0.06 | 0.63 | 0.43 |
| 2021 | 5 407 | 4 797 | 2 991 | 5 245 | 0.30 | 0.02 | 0.06 | 0.62 | 0.42 |
| 2022 | 5 998 | 5 307 | 3 090 | 4 819 | 0.29 | 0.01 | 0.08 | 0.62 | 0.43 |
| 2023 | 4 622 | 4 338 | 2 284 | 4 747 | 0.31 | 0.02 | 0.07 | 0.60 | 0.37 |

**Table 5-24. Parameters and emission factors used to estimate emissions of NMVOC from grazing.**

| Source | Grazing (kg NMVOC/ MJ feed intake) |
|---|---|
| Dairy cows | 0.0000069 |
| Beef cows | 0.0000069 |
| Steers and bulls | 0.0000069 |
| Heifers | 0.0000069 |
| Calves | 0.0000069 |
| Sows and boars | - |
| Pigs for meat production and piglets | - |
| Sheep | 0.00002349 |
| Horses | 0.00002349 |
| Goats | 0.00002349 |
| Laying hens and chickens | - |
| Slaughter chickens | - |
| Turkeys | - |
| Reindeers | 0.00002349 |
| Fur-bearing animals | - |

### 5.3.2.4 NITROGEN OXIDES

The estimate of $NO_X$ emissions from crop production and agricultural soils are based on the default tier 1 methodology when no tier 2 methodology yet exists in the guidebook.

To estimate these emissions the annual sum of all nitrogen applied to soil is required. That is, the sum of all applied nitrogen in: inorganic fertilisers, animal manure, sewage sludge, other organic fertilisers and excreta from grazing animals

(Table 5-25). This value is multiplied with the default tier 1 emission factor of 0.04 kg of $NO_2$[211] per kg of fertiliser-N applied.

**Table 5-25. Amount of nitrogen applied from different sources (t/year).**

| Year | Amount of nitrogen in animal manure applied to soils (including animal manure digestate from on-farm digester) | Amount of nitrogen in animal manure digestate from co-digester applied to soils | Amount of nitrogen in urine and dung deposited by grazing animals | Amount of nitrogen in inorganic fertilizers | Amount of nitrogen in sewage sludge applied to soils | Amount of nitrogen in other organic fertilisers applied to soils (excluding animal manure digestate from co-digesters) |
|---|---|---|---|---|---|---|
| 1990 | 77 744 | . | 42 901 | 224 500 | 1 180 | 1 700 |
| 1995 | 81 138 | . | 45 323 | 198 300 | 2 304 | 1 700 |
| 2000 | 76 763 | 102 | 45 921 | 189 400 | 1 758 | 1 800 |
| 2005 | 76 037 | 243 | 46 313 | 161 568 | 1 053 | 1 834 |
| 2010 | 74 889 | 466 | 44 107 | 168 000 | 2 224 | 2 921 |
| 2015 | 74 114 | 2 201 | 42 002 | 190 200 | 2 802 | 5 966 |
| 2020 | 70 921 | 2 909 | 43 811 | 215 171 | 4 799 | 6 974 |
| 2021 | 70 241 | 2 735 | 43 963 | 195 036 | 4 966 | 6 900 |
| 2022 | 71 274 | 2 506 | 43 470 | 184 852 | 5 285 | 8 066 |
| 2023 | 70 805 | 2 645 | 43 494 | 184 027 | 4 831 | 8 195 |

### 5.3.2.5 PARTICULATE MATTER

Emissions from agricultural crop operations are estimated with the tier 2 method. Emission factors are presented in Table 5-26. Activity data are statistics on crop areas and data on agricultural crop operations. The frequency of soil cultivation, harvesting, cleaning and drying has been set to one time per year for all crops except for grass for hay making. For this category, soil cultivation is assumed to take place every third year and harvest on average 2.4 times per year. Average number of harvests is estimated based on the survey “Nitrogen and phosphorus balances for agricultural land”[212].

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[211] In the EMEP/EEA Guidebook 2019

[212] Statistics Sweden MI40SM series

**Table 5-26. Tier 2 emission factors used to estimate emissions from crop production (kg/ha/year).**

| Substance | Crop operation | Winter wheat | Spring wheat | Winter rye | Triticale | Mixed grain | Winter barley | Spring barley | Oats | Pasture ground | Other crops | Ley |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $PM_{10}$ | Soil cultivation | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| | Harvesting | 0.49 | 0.49 | 0.37 | 0.37 | 0.37 | 0.41 | 0.41 | 0.62 | NA | NA | 0.25 |
| | Cleaning | 0.19 | 0.19 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.25 | NA | NA | 0 |
| | Drying | 0.56 | 0.56 | 0.37 | 0.37 | 0.37 | 0.43 | 0.43 | 0.66 | NA | NA | 0 |
| $PM_{2.5}$ | Soil cultivation | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 |
| | Harvesting | 0.02 | 0.02 | 0.015 | 0.015 | 0.015 | 0.016 | 0.016 | 0.025 | NA | NA | 0.01 |
| | Cleaning | 0.009 | 0.009 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.0125 | NA | NA | 0 |
| | Drying | 0.168 | 0.168 | 0.111 | 0.111 | 0.111 | 0.129 | 0.129 | 0.198 | NA | NA | 0 |

#### 5.3.2.6 HEXACHLOROBENZENE

Emissions of HCB are estimated with the tier 1 default approach. Activity data are statistics on annual sales of active substances and proposed maximum concentration (impurity factor) of 50 mg/kg from guidebook 2019. In Sweden two active substances are in use that have impurity of HCB, picloram and tefluthrin but tefluthrin is used in such a way that it is not emission-relevant. The amount of HCB emissions from picloram is computed using the data on annual sale multiplied with the proposed impurity factor. The emission factor is set to 1 (100%) as all HCB appears to volatilize during the first 24 hours according to guidebook 2019.

### 5.3.3 Uncertainties and time-series consistency

There was a decrease in the amount of sold fertilisers in 2009. The reason was an overconsumption in 2008 due to a dropped tax on fertilisers. The sales of fertilisers in 2020 increased compared to the year before, since there were no fertilisers remaining in stock. In 2019 there were, on the contrary, fertilisers that remained in stock from the draught year of 2018. The crop production was at a high level in both 2019 and 2020. Statistics on the use of sewage sludge has been published irregularly and in different reports, and the time series for the earlier years in the time series has been created through interpolation/extrapolation and certain assumptions. Gradually the quality of the data has increased and is now of adequate quality.

We estimate the uncertainty interval for the activity data for a specific emission category in 3D is 20%-35%. Uncertainty intervals for the different emission factor are estimated as: $NH_3$ 50%, NMVOC 200%, $NO_X$ 80%-400%. PM 150%-200%.

### 5.3.4 Source-specific QA/QC and verification

Annual increase or decrease is verified for the whole time series for all sub sources to decide that all annual changes are reasonable. We compare the times series for the emission with the time series for the activity data to confirm that they agree. Every year we ask experts from the Swedish board of agriculture to conduct expert peer reviews of the methods used. Regular meetings are held with the authorities that provide activity data to the inventory to ensure that the quality of the data is of satisfactory quality and that they in turn use appropriate QC methods.

### 5.3.5 Source-specific recalculations

In this submission the emission factors for ammonia from inorganic fertilizers were updated according to EMEP/EEA Guideline 2023. This has a large effect on the total ammonia emissions.

The total effect of the recalculations in 3.D for 1990 entailed an increased $NH_3$ emissions of 26 % (7.3 kt) for 1990 and for the two most recent recalculated years entailed an increase of 18 and 16 % (4.3 and 3.7 kt) respectively for year 2021 and 2022.

### 5.3.6 Source-specific planned improvements

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

# 6 Waste (NFR sector 5)

## 6.1 Overview

Emission estimates from the waste sector include emissions from solid waste disposal on land, biological treatment of waste, waste-water handling, incineration of hazardous waste (including cremation) and various types of fires such as landfill fires, house and car fires, bonfires and open burning of garden waste. Combustion of municipal waste is accounted for in the energy sector, since it is used as fuel for energy production. Emission estimates also include emissions from sludge spreading (mechanical dewatering of digested sludge) and pets.

## 6.2 Solid waste disposal on land, NFR 5A

This category includes Solid waste disposal on land (NFR 5A).

### 6.2.1.1 SOURCE CATEGORY DESCRIPTION

Sweden is reporting of emissions of NMVOC, TSP, $PM_{10}$ and $PM_{2.5}$. Emissions of $NH_3$, Hg and CO are reported as not estimated (NE). Other emissions are reported as not applicable (NA).

A summary of the latest key source assessment is presented in Table 6-1.

**Table 6-1. Summary of key source analysis, NFR 5A, according to approach 1.**

| NFR | Key Source Assessment 2022 | |
|---|---|---|
| | Level | Trend |
| 5A | - | - |

### 6.2.1.2 METHODOLOGICAL ISSUES

#### *6.2.1.2.1 Emission factors*

Tier 1 default emission factors from the EMEP/EEA Emission Inventory Guidebook 2019 are used for NMVOC, TSP, $PM_{10}$ and $PM_{2.5}$. See further information in Table 6-2 below.

**Table 6-2. Emission factors used for NFR 5A Solid waste disposal on land.**

| Pollutant | Value | Unit | 95% confidence interval | | Reference |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| NMVOC | 5.65 | g/$m^3$ landfill gas | 1.81 | 10.86 | UK inventory (2004) |
| TSP | 0.463 | g/Mg waste | 0.006 | 2.21 | US EPA (2006) |
| $PM_{10}$ | 0.219 | g/Mg waste | 0.003 | 1.05 | US EPA (2006) |
| $PM_{2,5}$ | 0.033 | g/Mg waste | 0.0004 | 1.16 | US EPA (2006) |

#### *6.2.1.2.2 Activity data*

The activity data used for NFR 5A Solid waste disposal on land is presented in Table 6-3 below.

**Table 6-3. Activity data used for NFR 5A Solid waste disposal on land.**

| Year | Emission of landfill gas ($m^3$) (AD used for NMVOC) | Deposited waste at landfills for municipal solid waste, industries with internal landfills and landfills for other than household waste (t, wet weight) (AD used for TSP, PM$_{10}$ and PM$_{2.5}$) |
|---|---|---|
| 1990 | 382 927 526[1] | 10 484 000[3] |
| 1991 | 388 770 022[1] | 10 254 000[3] |
| 1992 | 388 918 341[1] | 10 024 000[3] |
| 1993 | 375 910 398[1] | 9 794 000[3] |
| 1994 | 360 464 775[1] | 9 512 800[3] |
| 1995 | 359 543 542[1] | 8 721 600[3] |
| 1996 | 356 474 428[1] | 8 380 400[3] |
| 1997 | 352 992 295[1] | 8 029 200[3] |
| 1998 | 347 228 887[1] | 8 028 000[3] |
| 1999 | 332 390 334[1] | 8 101 250[3] |
| 2000 | 321 949 542[1] | 7 624 500[3] |
| 2001 | 316 104 850[1] | 7 387 750[3] |
| 2002 | 295 282 713[1] | 6 891 000[3] |
| 2003 | 278 479 652[1] | 6 061 000[3] |
| 2004 | 275 632 045[1] | 3 666 000[2] |
| 2005 | 256 357 191[1] | 3 120 000[3] |
| 2006 | 246 175 768[1] | 2 573 000[2] |
| 2007 | 224 165 142[1] | 3 197 000[3] |
| 2008 | 192 977 000[1] | 3 820 000[2] |
| 2009 | 180 279 458[1] | 3 567 000[3] |
| 2010 | 168 059 356[1] | 3 314 000[2] |
| 2011 | 153 615 503[1] | 3 211 000[3] |
| 2012 | 139 583 496[1] | 3 108 000[2] |
| 2013 | 128 942 540[1] | 3 401 000[3] |
| 2014 | 116 171 471[1] | 3 693 000[2] |
| 2015 | 104 749 833[1] | 4 295 000[3] |
| 2016 | 94 656 775[1] | 4 897 000[2] |
| 2017 | 87 685 448[1] | 4 512 000[3] |
| 2018 | 80 368 844[1] | 4 127 000[2] |
| 2019 | 70 236 928[1] | 4 270 500[3] |
| 2020 | 63 393 894[1] | 4 414 000[2] |
| 2021 | 54 705 898[1] | 4 414 000[3] |
| 2022 | 50 831 638[1] | 4 414 000[3] |
| 2023 | 46 866 835[1] | 4 414 000[3] |

Data sources: 1) Sweden's reporting on greenhouse gases to UNFCCC, submission 2025,
2) Sweden's reporting to the Commission in accordance with the Waste Statistic Regulation,
3) Statistical sources in combination with estimates or extrapolated/interpolated data.

For the calculations of the emissions of NMVOC, emission data on methane from solid waste disposal on land reported to UNFCCC is used. To transform the data on methane emissions into data on landfill gas emissions, the following assumptions are made:

1 kg methane = 1.3937 1 Nm$^3$ methane
Methane content in landfill gas = 50%

For TSP, $PM_{10}$ and $PM_{2.5}$, activity data are used on deposited waste at:
1. landfills for municipal solid waste that deposit household waste,
2. industries with internal landfills and
3. landfills for other than household waste (construction and demolition waste, industrial waste, slags, ashes and sludges)

The source of the activity data on deposited waste 1990-2018 is a study[213] that was carried out in 2021.

#### 6.2.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The used uncertainties are presented below.

**NMVOC**
Emission factor:
1.81-10.86 $g/m^3$ landfill gas
(Default).

Activity data "Emission of landfill gas":
± 64% (1990),
± 55% (2023),
(Expert judgement).

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[213] SMED (Sundqvist & Szudy), 2021

**TSP, $PM_{10}$ and $PM_{2.5}$**
Emission factor TSP:
0.006-2.21 g/Mg waste
(Default).

Emission factor $PM_{10}$:
0.003-1.05 g/Mg waste
(Default).

Emission factor $PM_{2.5}$:
0.0004-0.16 g/Mg waste
(Default).

Activity data “Deposited waste at landfills for municipal solid waste”:
± 15% (1990),
± 10% (2023),
(Expert judgement).

The time series in the waste sector are calculated consistently. When statistics are not produced annually, interpolation and extrapolation have been necessary tools for imputation.

#### 6.2.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 6.2.1.5 SOURCE-SPECIFIC RECALCULATIONS

Recalculations have been done for NMVOC from NFR 5A Solid waste disposal on land for the years 2011-2013 and 2018-2022. The reasons for the recalculations were:
-implementation of newly published[214] activity data on landfilled waste for the year 2022,
-implementation of newly available[215] estimates on DOC values for year 2020,
-interpolations of the activity data and DOC values above,
-revision of data on collection of landfill gas for some landfills for the years 2011-2013, 2018 and 2020-2022. The emission estimates changed by between -0.41% and 0.30%.

#### 6.2.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

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[214] Swedish EPA, 2024

[215] SMED (Sundqvist & Szudy), 2020

# 6.3 Biological treatment of waste, NFR 5B

This category includes Composting (NFR 5B1) and Anaerobic digestion at biogas facilities (NFR 5B2). Emissions from both composting and anaerobic digestion at biogas facilities are estimated and reported.

## 6.3.1 Composting, NFR 5B1

### 6.3.1.1 SOURCE CATEGORY DESCRIPTION

Sweden is reporting of emissions of $NH_3$ (from covered composting and windrow composting) and CO (from windrow composting). Emissions of $NO_X$, NMVOC, TSP, $PM_{10}$, $PM_{2.5}$ and BC are reported as not estimated (NE). Other emissions are reported as not applicable (NA).

A summary of the latest key source assessment is presented in Table 6-4.

**Table 6-4. Summary of key source analysis, NFR 5B1, according to approach 1.**

| NFR | Key Source Assessment 2022 | |
|---|---|---|
| | Level | Trend |
| 5B1 | - | *NH3* |

### 6.3.1.2 METHODOLOGICAL ISSUES

### *6.3.1.2.1 Emission and abatement factors used*

When composting food waste and household waste in Sweden, the composting process is normally covered. Tier 2 default emission factors from the EMEP/EEA Emission Inventory Guidebook 2019 are used for $NH_3$ from compost production (covered composting) – see Table 6-5.

**Table 6-5. Emission factor used for NFR 5B1 Composting (covered composting).**

| Pollutant | Value | Unit | 95% confidence interval | | Reference |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| $NH_3$ | 0.24 | kg/Mg organic waste | 0.1 | 0.7 | Guidebook (2019) |

The abatement factor from the EMEP/EEA Emission Inventory Guidebook 2019 is used in from year 2005. From year 1994 to 2005, this factor is estimated to be gradually increasing from zero to the default factor due to reflect an increasing degree of practicing abatement techniques. See further in Table 6-6 below.

**Table 6-6. Abatement factor used for NFR 5B1 Composting (covered composting).**

| Abatement technology | Pollutant | Efficiency | 95% confidence interval | | Reference |
|---|---|---|---|---|---|
| | | Default value | Lower | Upper | |
| Biofilter | $NH_3$ | 90% | 70% | 97% | Guidebook (2019) |

Tier 2 default emission factors from the EMEP/EEA Emission Inventory Guidebook 2019 are used for $NH_3$ and CO (from windrow composting of garden and park waste). See further in Table 6-7 below.

**Table 6-7. Emission factors used for NFR 5B1 Composting (windrow composting)**

| Pollutant | Value | Unit | 95% confidence interval | | Reference |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| CO | 0.56 | kg/Mg waste | 0.05 | 1 | Boldrin et al. (2009) |
| $NH_3$ | 0.66 | kg/Mg waste | 0.05 | 1 | Boldrin et al. (2009) |

### *6.3.1.2.2 Activity data used*

Activity data on composted waste (covered composting and windrow composting) is used for emissions of CO and $NH_3$. The data (see Table 6-8) has been compiled and published by the association Swedish Waste Management (RVF/Avfall Sverige).

**Table 6-8. Activity data used for NFR 5B1 Composting.**

| Year | Composted waste* (t, wet weight) (AD used for $NH_3$ from covered composting) | Composted waste* (t, wet weight) (AD used for CO and $NH_3$ from windrow composting of garden and park waste) |
|---|---|---|
| 1990 | **50 000**[1] | **20 000**[1] |
| 1991 | 44 940 | 60 460 |
| 1992 | 39 880 | 100 920 |
| 1993 | 34 820 | 141 380 |
| 1994 | 29 760 | 181 840 |
| 1995 | **24 700**[2] | **222 300**[2] |
| 1996 | 43 350 | 197 650 |
| 1997 | **62 000**[3] | **173 000**[3] |
| 1998 | 72 333 | 185 167 |
| 1999 | 82 667 | 197 333 |
| 2000 | **93 000**[4] | **197 000**[4] |
| 2001 | 102 492 | 193 271 |
| 2002 | **111 984**[5] | **189 546**[5] |
| 2003 | **108 745**[5] | **273 215**[5] |
| 2004 | **99 950**[5] | **289 430**[5] |
| 2005 | **234 640**[6] | **225 190**[6] |
| 2006 | **248 230**[7] | **204 160**[7] |
| 2007 | **261 450**[8] | **253 840**[8] |
| 2008 | **278 000**[9] | **290 700**[9] |
| 2009 | **284 940**[10] | **345 560**[10] |
| 2010 | **297 180**[11] | **269 030**[11] |
| 2011 | **257 110**[12] | **432 990**[12] |
| 2012 | **246 680**[13] | **312 150**[13] |
| 2013 | **211 260**[14] | **317 210**[14] |
| 2014 | **197 140**[15] | **270 780**[15] |
| 2015 | **208 430**[16] | **209 910**[16] |
| 2016 | **181 047**[17] | **295 091**[17] |
| 2017 | **152 744**[18] | **297 618**[18] |
| 2018 | **137 191**[19] | **214 564**[19] |
| 2019 | **123 114**[20] | **231 716**[20] |
| 2020 | **128 104**[21] | **245 696**[21] |
| 2021 | **115 037**[22] | **228 655**[22] |
| 2022 | **100 546**[23] | **230 295**[23] |
| 2023 | **107 262**[24] | **168 818**[24] |

*Data in bold are compiled, other data is extrapolated or interpolated.

1) Swedish Association of Waste Management 1990, 2) Swedish EPA 1995, 3) Swedish Association of Waste Management 1998, 4) Swedish Association of Waste Management 2001, 5) Swedish Association of Waste Management 2005, 6-24) Swedish Waste Management 2006-2024

## 6.3.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The used uncertainties are presented below.

#### $NH_3$ (from covered composting)

Emission factor:
0.1-0.7 kg/Mg organic waste
(Default).

Abatement factor:
70%-97%
(Default).

Activity data “Composted waste”:
± 15% (1990),
± 10% (2023),
(Expert judgement).

**$NH_3$ and CO (from windrow composting)**
Emission factor ($NH_3$):
0.05-1 kg/Mg waste
(Default).

Emission factor (CO):
0.05-1 kg/Mg waste
(Default).

Activity data “Composted waste”:
± 20% (1990),
± 15% (2023),
(Expert judgement).

The time series in the waste sector are calculated consistently. When statistics are not produced annually, interpolation and extrapolation have been necessary tools for imputation.

#### 6.3.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 6.3.1.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculation has been done for NFR 5B1 Composting.

#### 6.3.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 6.3.2 Anaerobic digestion at biogas facilities, NFR 5B2

#### 6.3.2.1 SOURCE CATEGORY DESCRIPTION

Sweden is reporting of emissions of $NH_3$ from anaerobic digestion at biogas facilities. Emissions of $NO_X$, CO, NMVOC, TSP, $PM_{10}$, $PM_{2.5}$, BC, HCB, Pb, Cd, Hg, Cr, Zn, HCH, PCBs, PCDD/F, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3,-cd)pyrene are reported as not estimated (NE). Other emissions are reported as not applicable (NA).

A summary of the latest key source assessment is presented in Table 6-9.

**Table 6-9. Summary of key source analysis, NFR 5B2, according to approach 1.**

| NFR | Key Source Assessment 2022 | |
|---|---|---|
| | Level | Trend |
| 5B2 | - | - |

### 6.3.2.2 METHODOLOGICAL ISSUES

Emissions of $NH_3$ occurs from anaerobic co-digesters and farm-based plants, where the emissions from the co-digesters are allocated to NFR 5B2. The emissions from the farm-based plants are allocated to NFR sector 3 Agriculture (NFR 3D2c).

#### *6.3.2.2.1 Emission factor used*

The Tier 1 default value of the content of $NH_3$-N in N from the EMEP/EEA Emission Inventory Guidebook 2019 (see Table 6-10) is used with the factor 17/14 for $NH_3$.

**Table 6-10. Emission factor used for NFR 5B2 Anaerobic digestion at biogas facilities.**

| Pollutant | Value | Unit | 95% confidence interval | | Reference |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| $NH_3$-N | 0.0275 | kg $NH_3$-N per kg N in feedstock | 0.0163 | 0.0501 | Guidebook (2019) |

#### *6.3.2.2.2 Activity data used*

Activity data on N in feedstock is used for the emissions of $NH_3$. The data is compiled from data sources on feedstock quantities by various categories of feedstocks treated by anaerobic digestion, and factors of N content for each category of feedstock. The categories of feedstocks are:
-Municipal organic waste
-Manure
-Food waste (from food processing)
-Slaughterhouse waste
-Energy crops
-Other waste

The result is a national total quantity of N in feedstock to anaerobic digestion (as presented in Table 6-11 below).

**Table 6-11. Activity data used for NFR 5B2 Anaerobic digestion at biogas facilities.**

| Year | N in feedstock (t) (AD used for $NH_3$ from anaerobic digestion at biogas facilities) |
|---|---|
| 1990 | **12**[1] |
| 1991 | 13 |
| 1992 | 266 |
| 1993 | 267 |
| 1994 | 267 |
| 1995 | **312**[2] |
| 1996 | 551 |
| 1997 | 790 |
| 1998 | 1 028 |
| 1999 | 1 267 |
| 2000 | 1 506 |
| 2001 | 1 744 |
| 2002 | 1 983 |
| 2003 | 2 222 |
| 2004 | 2 461 |
| 2005 | **2 699**[3] |
| 2006 | **3 219**[4] |
| 2007 | **4 273**[5] |
| 2008 | **3 684**[6] |
| 2009 | **5 373**[7] |
| 2010 | **6 497**[8] |
| 2011 | **6 269**[9] |
| 2012 | **7 436**[10] |
| 2013 | **8 296**[11] |
| 2014 | **10 602**[12] |
| 2015 | **13 289**[13] |
| 2016 | **13 139**[14] |
| 2017 | **12 934**[15] |
| 2018 | **13 880**[16] |
| 2019 | **15 119**[17] |
| 2020 | **15 017**[18] |
| 2021 | **15 275**[19] |
| 2022 | **14 650**[20] |
| 2023 | **14 475**[21] |

*Data in bold are compiled, other data is extrapolated or interpolated.

1-2) Szudy, Ek, Linné, Olshammar, 2017, 3-21) Swedish Energy Agency, 2007-2024

The data sources for the early years are rather scarce, but from year 2005, a survey on biogas production and utilization by the Swedish Energy has been published annually. The survey presents not only produced and utilized quantities of biogas but also the feedstock used for the biogas production.

The factors of N content in the feedstocks are from both EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019 and from national reports.

### 1.1.1.7 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The used uncertainties are presented below.

**$NH_3$ from anaerobic digestion at biogas facilities**

Emission factor:
0.0163-0.0501 kg $NH_3$-N per kg N in feedstock
(Default).

Activity data “N in feedstock”:
± 20% (1990),
± 10% (2023),
(Expert judgement).

The time series in the waste sector are calculated consistently. When statistics are not produced annually, interpolation and extrapolation have been necessary tools for imputation.

#### 6.3.2.3 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 6.3.2.4 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculation has been done for NFR 5B2 Anaerobic digestion at biogas facilities.

#### 6.3.2.5 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

## 6.4 Waste incineration, NFR 5C

Emissions from incineration of hazardous and industrial waste and since 2003 also MSW, from one large plant are reported in NFR 5C1bii.

In NFR 5C1bv emissions of mercury, dioxin, benzo(a)pyrene and PAH1-4 from cremation are reported, and from submission 2016 onwards also $NO_X$, $SO_2$, NMVOC, CO, HCB, PCB, heavy metals other than mercury, and PAH other than benzo(a)pyrene are included in the reporting. Particulate matter from cow and sheep burning using air curtain incinerator is also reported in NFR 5C1bv starting from submission 2016.

CO, $SO_2$, $NO_x$, NMVOC, particulate matter, heavy metals, dioxins, and PAH1-4 from domestic open waste burning, such as garden fires, are reported in 5C2.

Regarding incineration of medical waste, no national activity and emission data for this source category is available.

### 6.4.1 Incineration of municipal waste, industrial waste, clinical waste and sewage sludge, NFR 5C1a, 5C1bi, 5C1biii and 5C1biv

Emissions from these sources are reported for one plant in Sweden and included in NFR 5C1bii. Since 2003, also MSW incineration occurs at the plant.

A summary of the latest key source assessment is presented in Table 6-12.

**Table 6-12. Summary of key source analysis, NFR5C1 according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 5C1 | *As, DIOX, Hg, PM2.5, Pb* | *DIOX, Hg* |

### 6.4.2 Incineration of hazardous waste, NFR 5C1bii

#### 6.4.2.1 SOURCE CATEGORY DESCRIPTION

Emissions from incineration of hazardous and industrial waste and since 2003 also MSW, from one large plant are reported in NFR 5C1bii. In NFR 5C1bv emissions of mercury, dioxin, benzo(a)pyrene and PAH1-4 from cremation are reported, and from submission 2016 onwards also $NO_X$, $SO_2$, NMVOC, CO, HCB, PCB, heavy metals other than mercury, and PAH other than benzo(a)pyrene are included in the reporting. Particulate matter from cow and sheep burning using air curtain incinerator is also reported in NFR 5C1bv starting from submission 2016. CO, $SO_2$, $NO_x$, NMVOC, particulate matter, heavy metals, dioxins, and PAH1-4 from domestic open waste burning, such as garden fires, are reported in 5C2.

Regarding incineration of medical waste, no national activity and emission data for this source category is available.

#### 6.4.2.2 METHODOLOGICAL ISSUES

Incineration of hazardous waste, other than cremation, occurs at nine plants in Sweden. There is one major plant for handling and destruction of hazardous waste, which is the only one for which emission data is available. For 2004 around 88% of the total amount of incinerated hazardous waste was incinerated at this plant. The emissions from the plant are reported in 5C1bii. Emissions from incineration of hazardous waste not reported in 5C1bii are included in 1A1a and in 1A2c, d, e and f.

The facility included in 5C1bii was operated with an electrostatic precipitator (ESP) from the start in 1983 until 1990, when a textile filter with coal injection replaced the ESP. During 2000, wet flue gas cleaning was installed after the textile filter.

Reported emissions are for the whole time series obtained from the facility's environmental report or directly from the facility on request. Reported emissions are $NO_X$, $SO_2$, NMVOC, CO, $NH_3$, particulate matter, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PAH1-4, B(a)P, B(b)F, B(k)F, I(cd)P, HCB, PCB and dioxin. $SO_2$, $NO_X$, CO, particulate matter and Hg are continuously measured in the flue gases. Dioxins in flue gases have been measured by spot tests but are continuously collected and analysed once a week since June 2001. Emissions of $NH_3$ have been obtained from the facility from 2008 and onwards. For 2003 – 2007 reported $NH_3$ emissions are calculated based on implied emission factor for 2008. The estimates for Se, PAH1-4, B(a)P, B(b)F, B(k)F, I(cd)P, HCB, PCB and Zn are based on the amount of incinerated waste and emission factors from EMEP/EEA Guidebook 2023.

Reported activity data are amounts of incinerated waste (kt). The activity has increased over time. During 1990-2002, the plant combusted about 31 kt waste per year. In 2003 the capacity of the plant was increased substantially by taking a new incinerator into operation. In this new incinerator, the facility incinerates a mixture of MSW, industrial waste and hazardous waste – about 145 kt in total annually. As a consequence of increased capacity, emissions from 2003 onwards have increased compared to earlier years.

#### 6.4.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions continuously measured in the flue gases are expected to be quite low, ± 30%. Uncertainties for emissions calculated with emission factors from EMEP/EEA Guidebook 2023 are based on data in the Guidebook. For other emissions, measured by spot tests, the uncertainties are set to ± 50%.

More information is given in IIR Annex 1.

Time series for incineration of hazardous waste reported in NFR code 5C1bii have been reviewed in later years and considered to be consistent.

#### 6.4.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No SOURCE-SPECIFIC QA/QC has been performed.

#### 6.4.2.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2025, share of hazardous waste was corrected for 2021 and 2022, resulting in the following emissions changes in 2021 and 2022. Emission changes in 2021 are: benzo(a)pyrene (+2.3%), benzo(b)fluoranthene (+1%), benzo(k)fluoranthene (+0.7%), Indeno(1,2,3-cd)pyrene (+0.7%), Se (+0.3%), Zn (0.1%), HCB (-0.4%) and PAH1-4 (-0.04%). Emission changes in 2022 are: benzo(a)pyrene (+12%), benzo(b)fluoranthene (+4.4%), benzo(k)fluoranthene (+3%), Indeno(1,2,3-cd)pyrene (+3.3%), Se (+1.4%), Zn (0.4%), HCB (-1.6%) and PAH1-4 (-0.2%), and PCB (+0.00002%).

#### 6.4.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 6.4.3 Cremation, NFR 5C1bv

#### 6.4.3.1 SOURCE CATEGORY DESCRIPTION

In NFR 5C1bv emissions of mercury, dioxin, benzo(a)pyrene and PAH1-4 from cremation of human bodies are reported, and from submission 2016 onwards also $NO_X$, $SO_2$, NMVOC, CO, HCB, PCB, heavy metals other than mercury, and PAH other than benzo(a)pyrene are included in the reporting.

Particulate matter from cow and sheep burning using air curtain incinerator is reported in NFR 5C1bv from submission 2016 onwards.

#### 6.4.3.2 METHODOLOGICAL ISSUES

Reported activity data is the number of cremations of human bodies.

**Cremation of human bodies**

Estimates of emissions of PAH1-4, benzo(a)pyrene and dioxin from cremation of human bodies have been calculated based on national emission factors and statistics on the number of annual cremations. In submission 2016 emissions of $NO_X$, TSP, $PM_{10}$, $PM_{2.5}$, $SO_2$, NMVOC, CO, As, Cr, Cu, Ni, Pb, Se, Zn, PCB, HCB, B(b)F, B(k)F, and I(cd)P from cremation were reported for the first time. The estimates are made with emission factors from EMEP/EEA Guidebook 2023, which do not specify whether the condensable component of the particles is included or not. Emissions from PAH1-4 have been adjusted with respect to available estimates for B(b)F, B(k)F and I(cd)P. BC emissions have not been estimated due to lack of information is reported NE in accordance with EMEP/EEA Guidebook 2023.

The emissions of mercury are estimated using a methodology presented by Wängberg (2013)[216]. From the late 1990´s, abatement techniques have been considered in the estimations. The method is based on statistics on the annual number of cremations at each of the Swedish crematories in combination with information on installation of emission control, i.e., filter with activated carbon. The implied emission factors for 1990 - 2023 are given in Table 6-13.

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[216] Wängberg, I. 2013. PM Utredning nr 7 Hg från krematorier

**Table 6-13. Implied emission factors for Hg emission estimates 1990 – 2023. All represents kg per cremated body.**

| Year | IEF for Hg emissions |
|---|---|
| 1990 | 0.00300 |
| 1995 | 0.00287 |
| 2000 | 0.00168 |
| 2005 | 0.00087 |
| 2010 | 0.00069 |
| 2015 | 0.00031 |
| 2016 | 0.00031 |
| 2017 | 0.00029 |
| 2018 | 0.00027 |
| 2019 | 0.00028 |
| 2020 | 0.00027 |
| 2021 | 0.00027 |
| 2022 | 0.00027 |
| 2023 | 0.00026 |

Emission factors used to calculate benzo(a)pyrene emissions from cremation of human bodies are from USEPA[217] and for dioxin a suggested emission factor from the European Dioxin Inventory[218] was used. UNEP[219] presents emission factors for dioxins in the range 0.4 – 90 µg TEQ/cremation, while an earlier Swedish Inventory[220] suggested 6-12 µg TEQ/cremation, referred to in the European Dioxin Inventory. An average of 9 µg TEQ/cremation has been used in the present emission estimates. This agrees with a recent experimental study that recommends 6-13 µg TEQ/cremation[221]. The number of annual cremations of human bodies has increased from 58 000 in 1990 to just below 80 000 in 2023, and associated dioxin emissions have thus increased from 0.52 g TEQ to 0.72 g TEQ during the same period.

## Cow and sheep burning

Emissions of particulate matter (TSP, $PM_{10}$ and $PM_{2.5}$) from cow and sheep burning using air curtain incinerator were for the first time reported in submission 2016. The estimates are made with emission factors from EMEP/EEA Guidebook 2023, which do not specify whether the condensable component of the particles is included or not. Cow and sheep burning using air curtain incinerator occurs rather seldom in Sweden; according to the Swedish Farming Services – the company responsible for collection and handling of cadavers – this only happens when there is a significant risk of infection, otherwise alternative utilization methods are used.

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[217] USEPA. 1998. Locating and Estimating Air Emissions from Sources of Polycyclic organic matter. EPA-454/R-98-014. Office of Air Quality Planning and Standards, USA

[218] Quass et al., 2001. http://europa.eu.int/comm/environment/dioxin/pdf/stage1/cremation.pdf

[219] UNEP, 2001. www.chem.unep.ch/pops/pdf/toolkit/toolkit.pdf

[220] deWit. 1993, unpublished

[221] Wang, 2003.

The company estimates that only a few animals are burned with air curtain incinerator annually[222].

The assumption is that ten cows and ten sheep annually are incinerated in air curtain incinerators. The average weight of an animal has been set at 600 kg/cow and 43 kg/sheep. Of the reported particulate emissions in NFR 5C1bv, combustion of cows and sheep accounts for less than 0.2% of reported amounts of TSP, $PM_{10}$ and $PM_{2.5}$.

#### 6.4.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR 5C1bv are displayed in Annex 1.

Time series for emissions from cremations reported in NFR code 5C1bv have been reviewed in later years and considered to be consistent.

#### 6.4.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No SOURCE-SPECIFIC QA/QC has been performed.

#### 6.4.3.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2025, recalculations have been made emissions due to updates regarding purification with activated carbon (corrected installation dates) for years 1990, 1991, 2000, 2017 and 2021. Yearly Hg emissions increased by 0.002 t, 0.003 t, 0.0002 t, 0.0002 t and 0.0003 t, respectively.

#### 6.4.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 6.4.4 Open burning of waste, NFR 5C2

The NFR category 5C2 Open burning of waste, includes emissions from:
- Garden burning and bonfires
- Landfill fires

A summary of the latest key source assessment is presented in Table 6-14.

**Table 6-14. Summary of key source analysis, NFR5C2 according to approach 1.**

| NFR | Key Source Assessment | |
|---|---|---|
| | Level | Trend |
| 5C2 | - | - |

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[222] Mikael Lidholm, Svensk Lantbrukstjänst AB

#### 6.4.4.1 SOURCE CATEGORY DESCRIPTION

##### *6.4.4.1.1 Garden burning and bonfires*

Emissions from CO, $SO_2$, $NO_X$, NMVOC, particulate matter, heavy metals, dioxin and PAH1-4 from garden burning and bonfires, are reported in 5C2.

##### *6.4.4.1.2 Landfill fires*

Emissions from particulate matter, heavy metals, dioxin and PAH1-4 from landfill fires, are reported in 5C2.

#### 6.4.4.2 METHODOLOGICAL ISSUES

##### *6.4.4.2.1 Garden burning and bonfires*

All emission factors are from EMEP/EEA Guidebook 2019 or 2023 (Table 3-1). Emission factors presented in EMEP/EEA Guidebook 2023[223], chapter “Small-scale waste burning” represents emissions from open burning of agricultural waste. A study in 2004[224] reveals that it is very rare that the farmers practice field burning in Sweden. According to the Swedish Board of Agriculture and the Swedish Regulation regarding direct support (SJVFS 2014:41) it is forbidden to burn crop residue in Sweden for any farmer who wants support from EU. However, there is an exception if the farmer needs to make any plant protection measures due to e.g. fungal disease. Then the farmer may apply for permission by the County Administration. The issue was discussed with the Swedish Board of Agriculture (2020-05-25), who made a thorough investigation about this in 2017. The Swedish Board of Agriculture made the conclusion that it is very unusual that crop residues are burnt in Sweden. Based on the results from the investigation by the Swedish Board of Agriculture we consider that the emissions from open burning of farming/plantation waste small-scale waste are under considered insignificant for Sweden.

In submission 2016 emissions of Pb, Cd, As, Cr, Cu, Se, Zn and dioxins from burning of garden waste are reported for the first time for 1996 and onwards. The estimates are calculated with emission factors from EMEP/EEA Guidebook 2023. In submission 2019 activity data were updated which is why emissions could be reported for all years. As there are no national statistics regarding the extent of garden burning and bonfires, instead statistics on number of small houses have been used. In the case of garden burning, the calculations are based on the assumption that 20% of small houses burn 10 kg of garden waste, twice a year. The number of small houses is obtained from Statistics Sweden. When it comes to bonfires, it is assumed that in every municipality in Sweden (289 psc.) bonfires are burned twice a year and that these weigh 4 tons. The assumption of two bonfires per municipality is based on permits applied for from the Swedish Police Authority for the years

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[223] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/5-waste/5-c-2-open-burning/view

[224] Wikström, H. and Adolfsson, R. 2004. Field Burning of Crop Residues.

2015-2018. These estimates indicate that around 9.5 kt is burned annually in garden fires and bonfires. The data should be considered as indicative levels of emissions from these sources.

#### *6.4.4.2.2 Landfill fires*

All emissions from landfill fires are in this submission based on the duration of fires in Sweden[225], number of hours for landfill fires, and emission factors derived from measurements performed during landfill fires[226, 227]. Activity data are only available from 1996 and onwards. In Table 6-15, the emission factors used are presented, and in Table 6-16, the number of hours for landfill fires are presented. In 2020 there was a very big landfill fire that caused very high emissions and the fire influenced the emission data substantially for the year 2020. The entire time series for landfill fires have been updated in submission 2023 due to new activity data and new emissions factors. Also new emissions from particulate matter, benzo(k)fluoranthene (BkF), As, Cd, Cr, Cu, Pb and Zn have been reported for the first time in submission 2023.

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[225] The Swedish Civil Contingencies Agency, personal communication

[226] Pettersson et al., 1996.

[227] Johansson & Silvergren, 2021.

**Table 6-15. Emission factors used for estimation of particulate matter, heavy metals, dioxin and PAH emissions from landfill fires.**

| Pollutant | Value | Unit | Reference |
|---|---|---|---|
| Dioxin | 0.00011 | g/hour | Pettersson et al., 1996. |
| PM10 | 50 | kg/hour | Johansson & Silvergren, 2021. |
| PM2.5 | 44.5 | kg/hour | Johansson & Silvergren, 2021. |
| BC | 1.425 | kg/hour | Johansson & Silvergren, 2021. |
| benzo(a) pyrene (BaP) | 0.49 | g/hour | Pettersson et al., 1996., Johansson & Silvergren, 2021. |
| benzo(b) fluoranthene (BbF) | 0.68 | g/hour | Pettersson et al., 1996., Johansson & Silvergren, 2021. |
| benzo(k) fluoranthene (BkF) | 0.464 | g/hour | Johansson & Silvergren, 2021. |
| Indeno(1,2,3-cd)-pyrene (Ind) | 0.59 | g/hour | Pettersson et al., 1996., Johansson & Silvergren, 2021. |
| As | 3.5 | g/hour | Johansson & Silvergren, 2021. |
| Cd | 2.9 | g/hour | Johansson & Silvergren, 2021. |
| Cr | 3.1 | g/hour | Johansson & Silvergren, 2021. |
| Cu | 163 | g/hour | Johansson & Silvergren, 2021. |
| Hg | 0.67 | g/hour | Pettersson et al., 1996. |
| Pb | 333 | g/hour | Johansson & Silvergren, 2021. |
| Zn | 489 | g/hour | Johansson & Silvergren, 2021. |

**Table 6-16. Number of hours of landfill fires in Sweden 1996 – 2023.**

| Year | Landfill fire, no. of hours |
|---|---|
| 1996 | 797 |
| 2000 | 429 |
| 2005 | 1188 |
| 2010 | 706 |
| 2011 | 985 |
| 2012 | 681 |
| 2013 | 1101 |
| 2014 | 196 |
| 2015 | 359 |
| 2016 | 282 |
| 2017 | 363 |
| 2018 | 584 |
| 2019 | 467 |
| 2020 | 2532 |
| 2021 | 551 |
| 2022 | 217 |
| 2023 | 278 |

### 6.4.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

#### *6.4.4.3.1 Garden burning and bonfires*

Uncertainties for emissions of TSP, $PM_{10}$, $PM_{2.5}$ are calculated according to Guidebook 2023. Assessed uncertainties for are ± 200%, ± 200% and ± 200%, respectively. Uncertainties for emissions for dioxin and metals are calculated according to Guidebook 2023. Uncertainty for DIOX, Pb, Cd, As, Se, Zn, Cr and Cu are ± 200%, ± 200%, ± 200%, 200%, ± 200%, ± 200%, ± 250% and ± 200%, respectively. Uncertainties for emissions for CO, $SO_2$, $NO_x$ and NMVOC are calculated according to Guidebook 2023. The uncertainties are: CO ± 200%, NMVOC ±

201%, $NO_x$ ± 200% and $SO_2$ ± 191%. Uncertainty for emissions for PAH is calculated according to Guidebook Quality Rating E. Uncertainty for PAH is ± 1000%.

More information is given in IIR Annex 1.

Time series for particles and PAH from garden burning and bonfires reported in NFR code 5C2 have been reviewed in later years and considered to be consistent.

##### *6.4.4.3.2 Landfill fires*

Uncertainties for emissions of particulate matter, heavy metals, dioxin and PAH are based on Guidebook Quality Rating D and they are ± 300% each.

More information is given in IIR Annex 1.

Time series for landfill fires reported in NFR code 5C2 have been reviewed in later years and considered to be consistent.

In 2020 there was a very big landfill fire that caused very high emissions and the fire influenced the emission data substantially.

#### 6.4.4.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source specific QA/QC has been performed.

#### 6.4.4.5 SOURCE-SPECIFIC RECALCULATIONS

##### *6.4.4.5.1 Garden burning and bonfires*

No source-specific recalculations have been performed during submission 2025.

##### *6.4.4.5.2 Landfill fires*

No source-specific recalculations have been performed during submission 2025.

#### 6.4.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

# 6.5 Wastewater handling, NFR 5D

## 6.5.1 Domestic wastewater handling, NFR 5D1

### 6.5.1.1 SOURCE CATEGORY DESCRIPTION

Sweden is reporting emissions of NMVOC (from municipal wastewater treatment plants) and $NH_3$ (from latrines).

Emissions of TSP, $PM_{10}$, $PM_{2.5}$, Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn are reported as not estimated (NE). Other emissions are reported as not applicable (NA).

A summary of the latest key source assessment is presented in Table 6-15.

**Table 6-15. Summary of key source analysis, NFR 5D1, according to approach 1.**

| NFR | Key Source Assessment 2022 | |
|---|---|---|
| | Level | Trend |
| 5D1 | - | - |

### 6.5.1.2 METHODOLOGICAL ISSUES

### *6.5.1.2.1 Emission factors used*

Tier 1 default emission factor from the EMEP/EEA Emission Inventory Guidebook 2019 are used for NMVOC (from wastewater handling at municipal wastewater treatment plants). See further in the Table 6-16 below.

**Table 6-16. Emission factor used for NFR 5D1 Domestic wastewater handling (at municipal wastewater treatment plants).**

| Pollutant | Value | Unit | 95% confidence interval | | Reference |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| NMVOC | 15 | mg/m$^3$ waste water | 5 | 50 | Atasoy et al. (2004) |

Tier 2 default emission factor from the EMEP/EEA Emission Inventory Guidebook 2019 are used for $NH_3$ (from latrines). See further in the Table 6-17 below.

**Table 6-17. Emission factor used for NFR 5D1 Domestic wastewater handling (latrines).**

| Pollutant | Value | Unit | 95% confidence interval | | Reference |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| $NH_3$ | 1.6 | kg/person/year | 0.8 | 3.2 | Guidebook (2006) |

### *6.5.1.2.2 Activity data used*

Activity data on discharged volumes of treated wastewater is used for NMVOC emissions, compiled and published by Statistics Sweden for Swedish EPA.

Data on population with latrines has been estimated in a study[228] on availability of data on latrines in Sweden. Good quality data on collected latrine is available from 2012 and onwards from Swedish Waste Management. By assuming an average generation rate of urine and feces of 1.53 kg/person/day[229], an average population equivalent of 2 000 persons has been calculated. The estimate of 2 000 persons is used for the years 1990-2022. See activity data in Table 6-18.

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[228] Ejhed, Hellsten, Olshammar, Szudy, 2018

[229] Rose et al., 2015

**Table 6-18. Activity data used for NFR 5D1 Domestic wastewater handling.**

| Year | Discharged volumes of treated wastewater* (1000 $m^3$)<br>(AD used for NMVOC from wastewater handling at municipal wastewater treatment plants) | Population with latrines* (persons)<br>(AD used for $NH_3$ from latrines) |
|---|---|---|
| 1990 | **1 305 000**[1] | 2 000 |
| 1991 | 1 276 050 | 2 000 |
| 1992 | **1 247 100**[2] | 2 000 |
| 1993 | 1 263 600 | 2 000 |
| 1994 | 1 280 100 | 2 000 |
| 1995 | **1 296 600**[3] | 2 000 |
| 1996 | 1 315 067 | 2 000 |
| 1997 | 1 333 533 | 2 000 |
| 1998 | **1 352 000**[4] | 2 000 |
| 1999 | 1 357 459 | 2 000 |
| 2000 | **1 362 917**[5] | 2 000 |
| 2001 | 1 295 459 | 2 000 |
| 2002 | **1 228 000**[6] | 2 000 |
| 2003 | 1 206 612 | 2 000 |
| 2004 | **1 185 223**[7] | 2 000 |
| 2005 | 1 212 514 | 2 000 |
| 2006 | **1 239 805**[8] | 2 000 |
| 2007 | 1 249 172 | 2 000 |
| 2008 | **1 258 539**[9] | 2 000 |
| 2009 | 1 222 653 | 2 000 |
| 2010 | **1 186 767**[10] | 2 000 |
| 2011 | 1 227 949 | 2 000 |
| 2012 | **1 269 131**[11] | 2 000 |
| 2013 | 1 243 112 | 2 000 |
| 2014 | **1 217 093**[12] | 2 000 |
| 2015 | 1 147 873 | 2 000 |
| 2016 | **1 078 652**[13] | 2 000 |
| 2017 | 1 089 548 | 2 000 |
| 2018 | **1 100 444**[14] | 2 000 |
| 2019 | 1 141 361 | 2 000 |
| 2020 | **1 182 278**[15] | 2 000 |
| 2021 | 1 182 278 | 2 000 |
| 2022 | 1 182 278 | 2 000 |
| 2023 | 1 182 278 | 2 000 |

*Data in bold are compiled, other data is extrapolated or interpolated.

1) Statistics Sweden 1992, 2) Statistics Sweden 1994, 3) Statistics Sweden 1997, 4-11) Statistics Sweden 2014, 12) Statistics Sweden 2016, 13) Statistics Sweden 2018, 14) Statistics Sweden 2020, 15) Statistics Sweden 2022.

Population with latrines is estimated from data on collected latrine 2012-2017, Swedish Waste Management 2013-2018.

### 6.5.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The used uncertainties are presented below.

**NMVOC (from municipal wastewater treatment plants)**
Emission factor:
5-50 mg/$m^3$ wastewater
(Default).

Activity data “Discharged volumes of treated wastewater”:

± 10% (1990),
± 10% (2023),
(Expert judgement).

**$NH_3$ (from latrines)**
Emission factor:
0.8-3.2 kg/person/year
(Default).

Activity data “Population with latrines”:
± 30% (1990),
± 20% (2023),
(Expert judgement).

The time series in the waste sector are calculated consistently. When statistics are not produced annually, interpolation and extrapolation have been necessary tools for imputation.

#### 6.5.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 6.5.1.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculation has been done for NFR 5D1 Domestic wastewater handling.

#### 6.5.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 6.5.2 Industrial wastewater handling, NFR 5D2

#### 6.5.2.1 SOURCE CATEGORY DESCRIPTION

Sweden is reporting of emissions of NMVOC. Emissions of $NH_3$, TSP, $PM_{10}$, $PM_{2.5}$, Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn are reported as not estimated (NE). Other emissions are reported as not applicable (NA).

A summary of the latest key source assessment is presented in Table 6-19.

**Table 6-19. Summary of key source analysis, NFR 5D2, according to approach 1.**

| NFR | Key Source Assessment 2022 | |
|---|---|---|
| | Level | Trend |
| 5D2 | - | - |

#### 6.5.2.2 METHODOLOGICAL ISSUES

##### *6.5.2.2.1 Emission factors used*

Tier 1/Tier 2 default emission factor from the EMEP/EEA Guidebook 2019 is used for NMVOC (from wastewater treatment in industry), see Table 6-20.

**Table 6-20. Emission factor used for NFR 5D2 Industrial wastewater handling.**

| Pollutant | Value | Unit | 95% confidence interval<br>Lower | <br>Upper | Reference |
|---|---|---|---|---|---|
| NMVOC | 15 | mg/m$^3$ waste water | 5 | 50 | Atasoy et al. (2004) |

### *6.5.2.2.2 Activity data used*

Activity data on discharged volumes of treated wastewater is used for emissions of NMVOC. The data has been compiled and published by Statistics Sweden, see Table 6-21.

**Table 6-21. Activity data used for NFR 5D2 Industrial wastewater handling (NMVOC).**

| Year | Discharged volumes of treated wastewater* (1000 m$^3$) | Year | Discharged volumes of treated wastewater* (1000 m$^3$) |
|---|---|---|---|
| 1990 | 933 056 | 2010 | **1 039 591**[4] |
| 1991 | 933 056 | 2011 | 996 482 |
| 1992 | 933 056 | 2012 | 953 373 |
| 1993 | 933 056 | 2013 | 910 265 |
| 1994 | 933 056 | 2014 | 867 156 |
| 1995 | **933 056**[1] | 2015 | **824 047**[5] |
| 1996 | 930 496 | 2016 | 827 459 |
| 1997 | 927 936 | 2017 | 830 870 |
| 1998 | 925 375 | 2018 | 834 282 |
| 1999 | 922 815 | 2019 | 837 693 |
| 2000 | **920 255**[2] | 2020 | **841 105**[6] |
| 2001 | 931 282 | 2021 | 841 105 |
| 2002 | 942 310 | 2022 | 841 105 |
| 2003 | 953 337 | 2023 | 841 105 |
| 2004 | 964 365 | | |
| 2005 | **975 392**[3] | | |
| 2006 | 988 232 | | |
| 2007 | 1 001 072 | | |
| 2008 | 1 013 911 | | |
| 2009 | 1 026 751 | | |

*Data in bold are compiled, other data is extrapolated or interpolated.

1) Statistics Sweden 1996, 2) Statistics Sweden 2001, 3) Statistics Sweden 2007, 4) Statistics Sweden 2011, 5) Statistics Sweden 2017, 6) Statistics Sweden 2021

### 6.5.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The used uncertainties are presented below.

**NMVOC (from industrial wastewater handling)**
Emission factor:
5-50 mg/m$^3$ wastewater
(Default).

Activity data “Discharged volumes of treated wastewater”:
± 50% (1990),
± 50% (2023),
(Expert judgement).

The time series in the waste sector are calculated consistently. When statistics are not produced annually, interpolation and extrapolation have been necessary tools for imputation.

#### 6.5.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 6.5.2.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculation has been done for NFR 5D2 Industrial wastewater handling.

#### 6.5.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

# 6.6 Other waste, NFR 5E

The NFR category 5E Other waste, includes emissions from:
-Sludge spreading (mechanical dewatering of digested sludge)
-House and Car fires
-Pets

A summary of the latest key source assessment is presented in Table 6-22.

**Table 6-22. Summary of key source analysis, NFR5E according to approach 1.**

| NFR | Key Source Assessment 2022 | |
|---|---|---|
| | Level | Trend |
| 5E | *As, Cd, DIOX, Hg, NH3, PM10, PM2.5, TSP* | *As, Cd, DIOX, Hg, NH3, PM10, PM2.5, TSP* |

## 6.6.1 Other waste, sludge spreading, NFR 5E

#### 6.6.1.1 SOURCE CATEGORY DESCRIPTION

Sweden is reporting of emissions of $NH_3$ from sludge spreading (mechanical dewatering of digested sludge at wastewater treatment plants).

#### 6.6.1.2 METHODOLOGICAL ISSUES

##### *6.6.1.2.1 Emission factors used*

Tier 2 default emission factor from the EMEP/EEA Emission Inventory Guidebook 2019 are used for $NH_3$ (from sludge spreading). See further in Table 6-23 below.

**Table 6-23. Emission factor used for NFR 5E Other waste, Sludge spreading.**

| Pollutant | Value | Unit | 95% confidence interval | | Reference |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| $NH_3$ | 50 | g/kg $NH_3$ in the sludge | 10 | 150 | Guidebook (2006) |

### *6.6.1.2.2 Activity data used*

Activity data used are summarized in Table 6-24.

**Table 6-24. Activity data used for NFR 5E Other waste, Sludge spreading.**

| Year | Quantity of N in anaerobically digested sludge* (t) (AD used for $NH_3$ from sludge spreading) | Year | Quantity of N in anaerobically digested sludge* (t) (AD used for $NH_3$ from sludge spreading) |
|---|---|---|---|
| 1990 | 8 073 | 2010 | **8 971**[8] |
| 1991 | 8 073 | 2011 | 8 948 |
| 1992 | 8 073 | 2012 | **8 925**[9] |
| 1993 | 8 073 | 2013 | 8 989 |
| 1994 | 8 073 | 2014 | **9 053**[10] |
| 1995 | **8 073**[1] | 2015 | **8 919**[11] |
| 1996 | 8 296 | 2016 | **9 259**[12] |
| 1997 | 8 518 | 2017 | 9 489 |
| 1998 | **8 741**[2] | 2018 | **9 720**[13] |
| 1999 | 8 656 | 2019 | 10 025 |
| 2000 | **8 571**[3] | 2020 | **10 330**[14] |
| 2001 | 8 878 | 2021 | 10 330 |
| 2002 | **9 185**[4] | 2022 | 10 330 |
| 2003 | 8 802 | 2023 | 10 330 |
| 2004 | **8 419**[5] | | |
| 2005 | 8 565 | | |
| 2006 | **8 710**[6] | | |
| 2007 | 8 908 | | |
| 2008 | **9 105**[7] | | |
| 2009 | 9 038 | | |

*Data in bold are compiled, other data is extrapolated or interpolated.

1) Statistics Sweden 1997, 2) Statistics Sweden 1999, 3-9) Statistics Sweden 2014, 10) Statistics Sweden 2016, 11) Sweden's reporting according to the Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture. 12) Statistics Sweden 2018, 13) Statistics Sweden 2020, 14) Statistics Sweden 2022.

### 6.6.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The used uncertainties are presented below.

**$NH_3$ (from mechanical dewatering of digested sludge)**
Emission factor:
10-150 g/kg N in the sludge
(Default).

Activity data "Quantity of nitrogen in anaerobically digested sludge":
± 10% (1990),
± 2% (2023),
(Expert judgement).

The time series in the waste sector are calculated consistently. When statistics are not produced annually, interpolation and extrapolation have been necessary tools for imputation.

#### 6.6.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

#### 6.6.1.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculation has been done for NFR 5E Other waste, Sludge spreading (mechanical dewatering of digested sludge at wastewater treatment plants).

#### 6.6.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 6.6.2 Other waste, house and car fires, NFR 5E

#### 6.6.2.1 SOURCE CATEGORY DESCRIPTION

Since submission 2016 also emissions of $PM_{2.5}$, $PM_{10}$, TSP, Pb, Cd, Hg, As, Cr, Cu and dioxin from House/car fires are included in 5E (1990 and onwards).

#### 6.6.2.2 METHODOLOGICAL ISSUES

Emissions of $PM_{2.5}$, $PM_{10}$, TSP, Pb, Cd, Hg, As, Cr, Cu and dioxin from house and car fires are reported for the first time in submission 2016. The emissions are based on the number of fires in Sweden[230] and emission factors (Tier 2) from EMEP/EEA Guidebook 2023. Used activity data are: car fires, detached and undetached house fires, apartment building fires and industrial building fires. Statistics for 1990-1997 are missing, and therefore the average amount of fires for 1998-2003 is used instead. In Table 6-27, the emission factors used are presented, in Table 6-28 the number of house and car fires are presented and in Table 6-29, the reported emissions of TSP, PM, metals and dioxin emissions from house and car fires are presented. In submission 2019 new activity data were present and the whole time series was updated.

**Table 6-27. Emission factors used for estimation of TSP, PM, metals and dioxin emissions from house and car fires.**

| | TSP | $PM_{10}$ | $PM_{2.5}$ | Pb | Cd | Hg | As | Cr | Cu | Dioxin |
|---|---|---|---|---|---|---|---|---|---|---|
| **Fire category** | **kg/fire** | **kg/fire** | **kg/fire** | **g/fire** | **g/fire** | **g/fire** | **g/fire** | **g/fire** | **g/fire** | **mg/fire** |
| Cars | 2.3 | 2.3 | 2.3 | NE | NE | NE | NE | NE | NE | 0.048 |
| Detached house | 143.82 | 143.82 | 143.82 | 0.42 | 0.85 | 0.85 | 1.35 | 1.29 | 2.99 | 1.44 |
| Undetached house | 61.62 | 61.62 | 61.62 | 0.18 | 0.36 | 0.36 | 0.58 | 0.55 | 1.28 | 0.62 |
| Apartment building | 43.78 | 43.78 | 43.78 | 0.13 | 0.26 | 0.26 | 0.41 | 0.39 | 0.91 | 0.44 |
| Industrial building | 27.23 | 27.23 | 27.23 | 0.08 | 0.16 | 0.16 | 0.25 | 0.24 | 0.57 | 0.27 |

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[230] www.msb.se

**Table 6-28. Number of house and car fires.**

| Year | Car fires<br>number | Detached house fires<br>number | Undetached house fires<br>number | Apartment building fires<br>number | Industrial building fires<br>number |
|---|---|---|---|---|---|
| 1990 | 4250 | 3695 | 203 | 3012 | 4057 |
| 1995 | 4250 | 3695 | 203 | 3012 | 4057 |
| 2000 | 4333 | 3172 | 208 | 3355 | 4081 |
| 2005 | 4079 | 3698 | 175 | 2669 | 3585 |
| 2010 | 4211 | 4197 | 231 | 2934 | 3873 |
| 2015 | 4496 | 3068 | 247 | 2773 | 3367 |
| 2016 | 5220 | 3446 | 285 | 3125 | 3645 |
| 2017 | 5330 | 3353 | 286 | 3305 | 3702 |
| 2018 | 5155 | 3653 | 345 | 3395 | 3668 |
| 2019 | 4711 | 3640 | 343 | 3394 | 3780 |
| 2020 | 4519 | 3562 | 388 | 3279 | 3607 |
| 2021 | 4081 | 3904 | 366 | 3177 | 3450 |
| 2022 | 4841 | 3578 | 348 | 2661 | 2542 |
| 2023 | 4817 | 3826 | 353 | 2738 | 3444 |

**Table 6-29. Emissions of TSP, PM, metals and dioxin emissions from house and car fires in Sweden 1990 – 2023.**

| Year | TSP<br>kt | $PM_{10}$<br>kt | $PM_{2.5}$<br>kt | Pb<br>t | Cd<br>t | Hg<br>t | As<br>t | Cr<br>t | Cu<br>t | PCDD/F<br>g |
|---|---|---|---|---|---|---|---|---|---|---|
| 1990 | 0.8 | 0.8 | 0.8 | 0.002 | 0.005 | 0.005 | 0.007 | 0.007 | 0.016 | 8.1 |
| 1995 | 0.8 | 0.8 | 0.8 | 0.002 | 0.005 | 0.005 | 0.007 | 0.007 | 0.016 | 8.1 |
| 2000 | 0.74 | 0.74 | 0.74 | 0.002 | 0.004 | 0.004 | 0.007 | 0.006 | 0.015 | 7.5 |
| 2005 | 0.77 | 0.77 | 0.77 | 0.002 | 0.004 | 0.004 | 0.007 | 0.007 | 0.016 | 7.8 |
| 2010 | 0.86 | 0.86 | 0.86 | 0.002 | 0.005 | 0.005 | 0.008 | 0.008 | 0.018 | 8.7 |
| 2015 | 0.68 | 0.68 | 0.68 | 0.002 | 0.004 | 0.004 | 0.006 | 0.006 | 0.014 | 6.9 |
| 2016 | 0.76 | 0.76 | 0.76 | 0.002 | 0.004 | 0.004 | 0.007 | 0.007 | 0.016 | 7.7 |
| 2017 | 0.76 | 0.76 | 0.76 | 0.002 | 0.004 | 0.004 | 0.007 | 0.007 | 0.016 | 7.7 |
| 2018 | 0.81 | 0.81 | 0.81 | 0.002 | 0.005 | 0.005 | 0.007 | 0.007 | 0.017 | 8.2 |
| 2019 | 0.81 | 0.81 | 0.81 | 0.002 | 0.005 | 0.005 | 0.007 | 0.007 | 0.017 | 8.2 |
| 2020 | 0.79 | 0.79 | 0.79 | 0.002 | 0.005 | 0.005 | 0.007 | 0.007 | 0.016 | 8 |
| 2021 | 0.83 | 0.83 | 0.83 | 0.002 | 0.005 | 0.005 | 0.008 | 0.007 | 0.017 | 8.4 |
| 2021 | 0.76 | 0.76 | 0.76 | 0.002 | 0.004 | 0.004 | 0.007 | 0.007 | 0.016 | 7.7 |
| 2022 | 0.76 | 0.76 | 0.76 | 0.0022 | 0.0044 | 0.0044 | 0.0070 | 0.0067 | 0.016 | 7.7 |
| 2023 | 0.80 | 0.80 | 0.80 | 0.0023 | 0.0046 | 0.0046 | 0.0074 | 0.0070 | 0.016 | 8.1 |

### 6.6.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions from house and care fires reported in NFR 5E for TSP, $PM_{10}$ and $PM_{2.5}$ are based on data from the Guidebook 2023, and they are ± 67% each. Uncertainties for emissions of DIOX and metals are calculated according to

Guidebook 2023. Assessed uncertainties for DIOX, Cd, Hg, As, Cr, Cu and Pb are ± 66%, ± 67%, ± 67%, ± 68%, ± 70%, ± 68% and ± 74%, respectively. More information is given in IIR Annex 1.

Time series for house and car fires reported in NFR code 5E have been reviewed in later years and considered to be consistent.

#### 6.6.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC has been performed.

#### 6.6.2.5 SOURCE-SPECIFIC RECALCULATIONS

Minor recalculations were performed in submission 2025 as a result of updated activity data for 2022.

#### 6.6.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

The time series will be recalculated for submission 2026 due to an ongoing project that looks to provide better and more precise activity data.

### 6.6.3 Other waste, pets, NFR 5E

#### 6.6.3.1 SOURCE CATEGORY DESCRIPTION

Emissions are to be allocated in NFR 6A according to EMEP/EEA Guidebook 2023. However, Sweden has chosen to continue to report emissions in NFR 5E due to practical reasons.

#### 6.6.3.2 METHODOLOGICAL ISSUES

The estimates of emissions of ammonia from cats and dogs are based on the calculation method and emission factors from Guidebook 2023. Emissions from all horses, including those raised or used for leisure purposes, are included in the agriculture sector and accounted for there.

Activity data was collected from three sources: Statistics Sweden, Novus and The Swedish Board of Agriculture. Historic population data for cats and dogs was retrieved from three surveys, two by Statistics Sweden[231] in 2006 and 2012, as well as one by Novus[232] in 2017. The activity data was extrapolated to the start of the time series (1990), as well as interpolated between the years of the surveys.

More recent population data was retrieved from the cat- and dog register of The Swedish Board of Agriculture, where the dog register was established in 2018 while the cat register was initiated in 2023. The dog register is considered to be representative for the dog population in Sweden and is used as a data source for the

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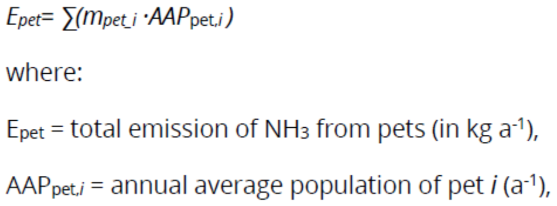
[231] Statistics Sweden, 2012. Ny SCB-statistik om antalet sällskapsdjur i Sverige: Hundarna blir fler och katterna färre. https://mb.cision.com/Main/622/9379154/98411.pdf

[232] Novus, 2017. Hundar och katter allt vanligare i svenska hem. https://novus.se/nyheter/2017/11/hundar-och-katter-allt-vanligare-svenska-hem/

time series 2018 onwards. The cat register, however, is still lacking sufficient data regarding the cat population in Sweden. Therefore, the activity data from the 2017 survey is applied for cats for 2017 onwards. As cats are continuously registered, the data will become more reliable and may be used for input in the future.

The emissions are calculated according to the method described in Guidebook 2023, from which also the emission factors are retrieved:



$$E_{pet} = \sum(m_{pet\_i} \cdot AAP_{pet,i})$$

where:

$E_{pet}$ = total emission of $NH_3$ from pets (in kg $a^{-1}$),

$AAP_{pet,i}$ = annual average population of pet $i$ ($a^{-1}$),

### 6.6.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions of $NH_3$ from cats and dogs are based on Guidebook Quality Rating D. Assessed uncertainties for $NH_3$ are ± 54%. More information is given in IIR Annex 1.

Time series for pets reported in NFR code 5E are considered to be consistent.

### 6.6.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC has been performed.

### 6.6.3.5 SOURCE-SPECIFIC RECALCULATIONS

Due to a change in calculation method during submission 2025, recalculations have been performed over the whole time series 1990-2022. Recalculation led to emission increases ranging from 0.2 to 0.5 kt.

### 6.6.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

# 7 Other (NFR sector 6)

$NH_3$ emissions from cats and dogs are included in NFR 5E, and emissions from horses used for leisure purposes are included in the agriculture sector, due to historical reasons. Since no other sectors are included in the Swedish emission inventory, the sector is reported “IE”.

# 8 Recalculations and Improvements

In this submission, recalculations are explained under each sector and NFR-code.

As requested by the EEA, a copy of table 4 of the latest (September 2024) NECD Review report, which is the 2024 Final Review Report with recommendations from TERT and comments on the status of implementation are included in Table 8-1 for $NO_X$, NMVOC, $SO_2$, $NH_3$, $PM_{2.5}$ and $PM_{10}$.

**Table 8-1. All findings for $NO_X$, NMVOC, $SO_2$, $NH_3$, $PM_{2.5}$ and $PM_{10}$, including those made during the 2024 NECD inventory review and those not implemented from previous reviews.**

| Review year of initial recommendation (number of years it has been recommended) | Observation | Key Category | NFR, Pollutant(s), Year(s) | RE, TC in 2023 | RE, TC, or UPTC in 2024 |
|---|---|---|---|---|---|
| 2023 (2) | SE-1A3bvi-2023-0001 | No | 1A3bvi Road transport: Automobile tyre and brake wear, $PM_{2.5}$, $PM_{10}$, 1990-2022 | No | RE |
| **Assessment of the implementation of the initial recommendation**<br>For categories 1A3bvi Road Transport: Automobile Tyre and Brake Wear and 1A3bvii Road Transport: Automobile Road Abrasion, pollutants $PM_{2.5}$, $PM_{10}$, all years, the TERT had noted that the $PM_{10}/PM_{2.5}$ ratio was significantly higher than all other Member States (apart from one) and the EU27 average (5.0 vs. 1.9). During the 2023 review, there has been a long list of Questions/Answers exchange between the TERT and Sweden and the main outcome was that the reported emissions were probably over-estimated and this issue was under investigation with a new methodology being under development. In any case, the final emission values were expected to be substantially lower (about one third), so there was no concern of emissions being above any emission reduction commitments. In the relevant 2024 IIR sections, Sweden describes the recommendation of the TERT and concludes by mentioning that: “Sweden aims to apply the new method in the 2025 submission, and to include any relevant explanation in accordance with the TERT recommendations”. In response to a question raised during the 2024 review, Sweden provided a revised estimate (and a draft explanation of the methodology) which was accepted by the TERT.<br>**The TERT recommends that Sweden include the revised estimate in the next 2025 submission by updating the calculations for the whole time series and providing all relevant explanations in the IIR.** | | | | | |
| **Status of implementation:** Resolved. The new methodology-based om the NORTRIP model has been implemented in submission 2025 which has had a profound effect on some of the emissions from tyre and brake wear as well as on road abrasion. The new methodology is thoroughly described in chapter 3.2.13 of this IIR. | | | | | |

| Review year of initial recommendation (number of years it has been recommended) | Observation | Key Category | NFR, Pollutant(s), Year(s) | RE, TC in 2023 | RE, TC, or UPTC in 2024 |
|---|---|---|---|---|---|
| 2024 (1) | SE-0A-2024-0001 | No | 0A National total - National total for the entire territory - Based on fuel sold/fuel used, $SO_2$, $PM_{2.5}$, HCB, $PM_{10}$, BC, TSP, 2022 | NA | No |

**Assessment of the implementation of the initial recommendation**

For BC, $PM_{10}$, $PM_{2.5}$, $SO_X$ and TSP, 2022, the TERT noted that there is a lack of transparency resulting from the heavy use of the notation key 'C' (Confidential) by Sweden for both emissions and activity data in the NFR tables leading to an inconsistency between the sector total and the national total in Annex I. This was raised during the 2022 and 2023 NECD inventory review under observation SE-0A-2022-0001. The TERT notes that the issue is below the threshold of significance for a technical correction. The TERT further notes that the IIR explains the use of 'C' within each NFR subchapter affected.

**The TERT reiterates the recommendation that Sweden continue to work towards reducing or even eliminating the use of the notation key 'C' and provide emission estimates instead to aid transparency.**

**Status of implementation:** An internal review performed during 2016 of the use of confidential data in the inventory showed that additional data should be considered confidential compared to previous submissions in order to comply with the Public Access to Information and Secrecy Act of the Swedish law. When the confidentiality analysis showed that a certain category should be classified to protect data of one or more companies, the companies have been asked to give consent to publish the data. If the company declined or a consent could not be acquired, the data are considered confidential and marked using notation key ‘C’. This has affected some sub-sectors in stationary combustion (NFR 1) and industrial processes and product use (NFR 2), which have been classified with the notation key Classified (C). Sweden is working continuously with improving the transparency of our reporting and strives to minimize the extent of confidentiality in inventory data.

| Review year of initial recommendation (number of years it has been recommended) | Observation | Key Category | NFR, Pollutant(s), Year(s) | RE, TC in 2023 | RE, TC, or UPTC in 2024 |
|---|---|---|---|---|---|
| 2022 (3) | SE-1A3bvii-2022-0001 | Yes | 1A3bvii Road transport: Automobile road abrasion, $PM_{2.5}$, $PM_{10}$, TSP, 1990-2022 | No | No |

**Assessment of the implementation of the initial recommendation**

For category 1A3bvii Road Transport: Automobile Road Abrasion, pollutants $PM_{2.5}$, $PM_{10}$, TSP, all years, the TERT found that, in 2023, Sweden has started developing improved model estimates by applying the results from a new research project in order to replace the usage of the outdated 2013 version of the EMEP/EEA Guidebook for emission calculations from road abrasion and tyre and brake wear. Studying the 2024 IIR, it is mentioned that “Sweden aims to apply the new method in the 2025 submission, and to include any relevant explanation in accordance with the TERT recommendations” (section 3.2.13.6, pp. 100-101). The TERT notes that the updated tyre and brake wear emission factors are not expected to affect the total PM emissions from non-exhaust sources due to the current method of separation of PM emissions within these categories.

**Therefore, the TERT reiterates the recommendation that Sweden implement this improvement in the 2025 submission by applying the results from the new research project and document this transparently in the IIR.**

**Status of implementation**: Resolved. The new methodology-based om the NORTRIP model has been implemented in submission 2025 which has had a profound effect on some of the emissions from tyre and brake wear as well as on road abrasion. The new methodology is thoroughly described in chapter 3.2.13 of this IIR.

| Review year of initial recommendation (number of years it has been recommended) | Observation | Key Category | NFR, Pollutant(s), Year(s) | RE, TC in 2023 | RE, TC, or UPTC in 2024 |
|---|---|---|---|---|---|
| 2024 (1) | SE-1A3di(i)-2024-0001 | No | 1A3di(i) International maritime navigation - Memo Item, $NO_X$, 2022 | NA | No |

**Assessment of the implementation of the initial recommendation**

For category 1A3di(i) International maritime navigation - Memo Item, pollutant $NO_X$, year 2022, the TERT noted a low Implied Emission Factor (IEF), i.e., outside of the 95% confidence interval when compared to other Member States (i.e., -5% lower than the lower bound). In response to a question raised during the review, Sweden answered that the lower IEFs in 2021 and 2022 stem mainly from a lower $NO_X$ emission factor, i.e., not from changes to the fuel mix. The Baltic Sea is a NECA zone where ships above 500 GT with a certain engine output and built after the 1st of January 2021 need to comply with IMO Tier III $NO_X$ emission standards. As more Tier III compliant ships navigate Swedish waters, the emission factor for $NO_X$ has reduced in recent years. This is the reason why Sweden's $NO_X$ IEF is lower in an international context.

**The TERT recommends that Sweden include these explanations in the next IIR submission in order to improve transparency.**

**Status of implementation:** Resolved. The reason for Sweden’s unusually low NOx emission factor has been described in the IIR of submission 2025, chapter 3.2.15.

| Review year of initial recommendation (number of years it has been recommended) | Observation | Key Category | NFR, Pollutant(s), Year(s) | RE, TC in 2023 | RE, TC, or UPTC in 2024 |
|---|---|---|---|---|---|

<table>
<tr><td>2023 (2)</td><td>SE-1A4ciii-2023-0001</td><td>No</td><td>1A4ciii Agriculture/Forestry/Fishing: National fishing, $PM_{2.5}$, $PM_{10}$, 1990-2022</td><td>No</td><td>No</td></tr>
<tr><td colspan="6"><b>Assessment of the implementation of the initial recommendation</b><br><br>For category 1A4ciii Agriculture/Forestry/Fishing: National Fishing, all years, the TERT notes that $PM_{2.5}$ is equal to $PM_{10}$, while for this category $PM_{10}$ was expected to be higher. The reason for this equality was clarified during the 2023 review and the TERT recommended that Sweden add the relevant explanations in the IIR in order to improve the transparency and avoid the re-iteration of a similar observation. The TERT did not find an updated description in the 2024 IIR. In response to a question raised during the 2024 review, Sweden answered that the relevant information will be added in the 2025 IIR submission.<br><br><b>The TERT reiterates the recommendation that Sweden provide these explanations in the next IIR submission.</b></td></tr>
<tr><td colspan="6"><b>Status of implementation:</b> Resolved. The reason for this has been described in the IIR of submission 2025, 3.2.19.</td></tr>
<tr><th>Review year of initial recommendation (number of years it has been recommended)</th><th>Observation</th><th>Key Category</th><th>NFR, Pollutant(s), Year(s)</th><th>RE, TC in 2023</th><th>RE, TC, or UPTC in 2024</th></tr>
<tr><td>2022 (3)</td><td>SE-1B1a-2022-0001</td><td>No</td><td>1B1a Fugitive emission from solid fuels: Coal mining and handling, $PM_{2.5}$, $PM_{10}$, 1990-2022</td><td>No</td><td>No</td></tr>
<tr><td colspan="6"><b>Assessment of the implementation of the initial recommendation</b><br><br>For category 1B1a Fugitive Emission from Solid Fuels: Coal Mining and Handling, $PM_{2.5}$ and $PM_{10}$, for all years the TERT notes Sweden states in their IIR that 'Emissions from handling of imported coal are reported in NFR 1B1c. For the 2025 submission, Sweden will consider reporting emissions from handling of imported coal in NFR 1B1a.' This was raised during the 2022 and 2023 NECD inventory review. The TERT notes that the issue is below the threshold of significance for a technical correction. The TERT notes that the IIR states that emissions are reported in category 1B1c Other Fugitive Emissions from Solid Fuels and the issue will be considered in the 2025 submission.<br><br><b>The TERT reiterates the recommendation that Sweden report emissions from storage and handling of imported coal in category 1B1a Fugitive Emission from Solid Fuels: Coal Mining and Handling, aligned with the 2019 and 2023 EMEP/EEA Guidebook, in the next submission.</b></td></tr>
<tr><td colspan="6"><b>Status of implementation:</b> Sweden has reported emissions from storage and handling of imported coal in category 1B1a in submission 2025, described in the IIR of submission 2025, 3.3.1.</td></tr>
<tr><th>Review year of initial recommendation (number of years it has been recommended)</th><th>Observation</th><th>Key Category</th><th>NFR, Pollutant(s), Year(s)</th><th>RE, TC in 2023</th><th>RE, TC, or UPTC in 2024</th></tr>
</table>

<table>
<tr><td>2023 (2)</td><td>SE-1B2c-2023-0001</td><td>No</td><td>1B2c Venting and flaring (oil, gas, combined oil and gas), $SO_2$, 2021, 2022</td><td>No</td><td>No</td></tr>
<tr><td colspan="6"><b>Assessment of the implementation of the initial recommendation</b><br><br>For category 1B2c Venting and flaring (oil, gas, combined oil and gas) for the years 2021 and 2022 and pollutant $SO_2$ the TERT notes that there is a lack of transparency in the IIR (Section 3.3.8) regarding use of the notation key 'IE' (included elsewhere) and where emissions are included. Emission estimates for this category are provided for years before 2021. This was raised during the 2023 NECD inventory review. In response to a question raised during the review, Sweden explained that $SO_2$ emissions from 1B2c Venting and flaring are reported in 1A1b Petroleum Refining for the years 2021 and 2022 in submission 2024 due to confidentiality reasons. Sweden further explained that it is planning to allocate emissions of $SO_2$ from 1B2c Venting and flaring to 1A1b Petroleum Refining for the entire time series in the 2025 submission for a more consistent reporting, while including the detailed emission data in the IIR as far as possible.<br><br><b>The TERT recommends that Sweden provides consistent reporting for the entire time series by either providing emission estimates under 1B2c Petroleum Refining for the full time series or by allocating emissions of $SO_2$ from 1B2c Venting and flaring to 1A1b Petroleum Refining for the full time series (using notation key 'IE') and, within confidentiality constraints, providing full details in the next submission.</b></td></tr>
<tr><td colspan="6"><b>Status of implementation:</b> Sweden has included time series for all refinery-related emissions in the IIR of submission 2025, 3.3.5.</td></tr>
<tr><td>Review year of initial recommendation (number of years it has been recommended)</td><td>Observation</td><td>Key Category</td><td>NFR, Pollutant(s), Year(s)</td><td>RE, TC in 2023</td><td>RE, TC, or UPTC in 2024</td></tr>
<tr><td>2023 (2)</td><td>SE-2D-2023-0001</td><td>No</td><td>2D Non energy products from fuels and solvent uses, NMVOC, 2008, 2017</td><td>No</td><td>No</td></tr>
<tr><td colspan="6"><b>Assessment of the implementation of the initial recommendation</b><br><br>For 2D3h Printing, NMVOC, 2008 and 2017 the TERT notes there is a lack of transparency regarding noticeable jumps or dips in the time series. This does not relate to an over- or under-estimate of emissions. This was raised during the 2023 NECD inventory review. In response to a question raised during the review, Sweden explained that comments will include information about general trends and major deviations in the trends for the NFR codes 2D3a Domestic Solvent Use Including Fungicides, 2D3d Coating Applications, 2C3e Degreasing, 2D3f Dry Cleaning, 2D3g Chemical Products, 2D3h Printing and 2D3i Other solvent use in the next IIR submission.<br><br><b>The TERT recommends that Sweden include an explanation on trends and noticeable jumps/dips in the IIR in the next submission.</b></td></tr>
<tr><td colspan="6"><b>Status of implementation:</b> Sweden has included information on trends and major deviations in 2D3 solvent use in the IIR of submission 2025, 4.5.3.</td></tr>
<tr><td>Review year of initial recommendation (number of years it has been recommended)</td><td>Observation</td><td>Key Category</td><td>NFR, Pollutant(s), Year(s)</td><td>RE, TC in 2023</td><td>RE, TC, or UPTC in 2024</td></tr>
</table>

| | | | | | |
|---|---|---|---|---|---|
| 2023 (2) | SE-3-2023-0001 | No | 3 Agriculture, $NO_X$, $NH_3$, NMVOC, $PM_{2.5}$, 1990-2022 | No | No |

**Assessment of the implementation of the initial recommendation**

For category 3B manure management, PM, all years, the TERT notes that emission factors from the 2013 edition of the EMEP/EEA Guidebook are still used. While the TERT acknowledges that there is no real Tier 2 for PM in most recent versions of the EMEP/EEA Guidebook, the TERT considers that latest versions of the EMEP/EEA Guidebook should now be considered as significant changes are observed, in particular for swine (Tier 1). This was raised during the 2023 NECD inventory review. In response to a question raised during the review, Sweden confirmed that the recommendation could not be implemented in time. By applying Tier 1 emission factors, the TERT finds an impact above the threshold for category 3B3 Manure management - swine, in 2020, 2021 and 2022, but considering that this impact is lower than the threshold when including both cattle and swine, this is not matter for a technical correction.

**The TERT recommends that Sweden implement new estimates for PM from livestock in accordance with the 2023 EMEP/EEA Guidebook in the next submission.**

**Status of implementation**: Sweden has updated the calculation and a Tier 1 method is now used for cattle and swine.

| Review year of initial recommendation (number of years it has been recommended) | Observation | Key Category | NFR, Pollutant(s), Year(s) | RE, TC in 2023 | RE, TC, or UPTC in 2024 |
|---|---|---|---|---|---|
| 2023 (2) | SE-5C1bv-2023-0001 | No | 5C1bv Cremation, $PM_{2.5}$, $PM_{10}$, 1990-2022 | No | No |

**Assessment of the implementation of the initial recommendation**

For 5C1bv Cremation, particulate matter, all years, the TERT notes that there is a lack of transparency regarding what is covered under this category. This does not relate to an over- or under-estimate of emissions. This was raised during the 2023 NECD inventory review. The TERT realises that the burning of cow and sheep carcasses is a very small issue, but also notes that a comprehensive explanation of the extent of reported activity helps to avoid misunderstandings about possible emissions. The TERT notes that some minor changes were made to the text in the 2024 IIR but that the text is still unclear with regards to the activity data and share of the PM emissions from incinerating cow and sheep carcasses. In response to a question raised during the 2024 NECD review, Sweden stated that an explanation of how particle emissions from burning of cow and sheep carcasses are calculated and what proportion this they are of the total particle emission in NFR 5C1bv Cremation will be included in IIR Submission 2025.

**The TERT reiterates the recommendation that Sweden include this information in its next IIR submission.**

**Status of implementation**: Sweden has included this information in the IIR of submission 2025, 6.4.3.

# 9 Projections

The most recent projections were produced in 2025 and are based on historical data according to submission 2025. The projections include emissions of $NO_X$, $SO_2$, NMVOC, $NH_3$, $PM_{2.5}$ and BC covering the years 2025, 2030, 2035, 2040, 2045 and 2050.

The projections are based on year 2022. However, since emissions for 2023 are estimated in submission 2025, it is verified that projections are in line with emissions for 2023. The methodologies used for projections are in general based on the methodologies that are used for the respective sector and category in the historical emission inventory. See respective chapter of the IIR for more information on methodologies.

There are many data sources contributing to the projections, some of the most important being energy projections by the Swedish Energy Agency, road traffic projections by the Swedish Transport Administration and projections by the Swedish Board of Agriculture. Projections in the energy sector are based on projections on economic development produced by the National Institute of Economic Research, using the general equilibrium model EMEC[233].

## 9.1 Stationary combustion

Projections for activity data is based on the long-term energy projections by the Swedish Energy Agency that are modified to fit the NFR format. The energy system model Times-Nordic[234] is used to estimate the projected energy supply for production of electricity and district heating. For the other sectors, results from the Times-Nordic model are combined with expert assessments.
For energy use in industry, an Excel-based model is used that links energy use to economic factors and energy prices. This is harmonized with contacts with energy-intensive companies and industry organisations as well as the results from the Times-Nordic model.

Emission factors for projections are in general based on expert judgments based on expected trends and current legislation. Some emission factors are projected to decrease whereas some are assumed to be constant in the projections.

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[233] https://www.konj.se/english/about-nier/environmental-economics/general-equlibrium-modelling---emec.html

[234] https://www.profu.se/times.htm

Emission factors and projections for small-scale wood combustion are specified for modern and older types of stoves and boilers and projections for the use of different technologies were developed[235, 236].

## 9.2 Mobile combustion

### 9.2.1 Road transport

Projections for road transport are produced by the Swedish Transport Administration. These projections are in turn based on projected vehicle kilometres from the Swedish Energy Agency and emission factors from HBEFA. Energy use for road traffic is based on evaluation on future transport demand and the development of the vehicle fleet. For passenger cars, demography, fuel prices and household income are important factors for transport demand whereas economic development and oversees trade are the basis for the demand for freight transport. The development of the vehicle fleet is based on fuel allocation and annual efficiency which is a result of existing instruments and historical trends.

Projections of PM emissions from road, tyre and brake wear are calculated by the NORTRIP[237] model.

### 9.2.2 Other mobile combustion

Projections for mobile combustion are based on energy projections developed by the Swedish Energy Agency. These projections are adjusted to fit the NFR format as well as to correspond to national fuel deliveries.

Emission factors for projections are based on expert judgements. Most emission factors are the same as in previous projections or updated as necessary, e.g. when emission factors for inventory data are lower than previously estimated projection emission factors.

## 9.3 Fugitive emissions

Activity data is based on energy projections from the Swedish Energy Agency that are adjusted to fit the NFR format. Emission factors or implied emission factors are used to calculate emission projections. In submission 2025, all projected emissions from refineries are reported in NFR 1A1b in order to achieve consistency with the latest statistical years.

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[235] Gustafsson, T., Helbig, T. (2018) Förbättrade nationella beräkningsunderlag för utsläpp av PM2,5, BC, EC/OC, CH4, NMVOC och CO från småskalig biobränsleeldning. SMED Prememoria 2018-02-28. Available in Swedish.

[236] Helbig, T., Gustafsson, T., Kindbom, K., Jonsson, M. (2018) Uppdatering av nationella emissionsfaktorer för övrig sektor (CRF/NFR 1A4). SMED Rapport Nr 13 2018. Available in Swedish.

[237] Denby et al 2012

## 9.4 Industrial processes and product use

The larger emission sources are identified and handled in more detail than smaller sources, which are assumed to have constant emissions in the projections.

Activity data for NFR sources 2A, 2B and 2C is based on trend analysis of historical emissions and information from industry companies and organisations.

Where national or default emission factors are used in the emission inventory, emission projections are calculated based on these. In other cases, where emissions correlate to activity data historically, implied emission factors are calculated on a plant-level basis and used to calculate emission projections. If emissions do not correlate to activity data historically, constant emissions are assumed unless there is other available information.

For the iron and steel sector, major technological developments with the aim of reducing $CO_2$ emissions are expected. The impact of these technological developments on emissions of air pollutants have been investigated and applied in the 2025 submission for projections.

For NFR 2H1 pulp and paper, a new method for estimating projections of NOx, $SO_2$ and particles was developed in 2020. Production volumes are assumed to correlate to the development of black liquor projected by the Swedish Energy Agency. Emission factors for NOx, $SO_2$ and particles are assumed to be equivalent to the higher end of the Associated Emission Levels (AEL) of the BAT Conclusions for the Production of Pulp, Paper and Board, or lower if emissions are below the AEL. Emission factors used to calculate historical emissions are used to calculate other air pollutants.

For solvent use (NFR 2D), emissions from most sub-categories are assumed to stay constant for lack of better information. However, the sub-category 2.D.3.d coating application is projected to decrease in future years.

For NFR sources 2G and 2H2, constant emissions are assumed.

## 9.5 Agriculture

Emission projections are based on projections by the Swedish Board of Agriculture. The Swedish Board of Agriculture applies a Swedish Agricultural Model (SASM) to produce projections for activity data for the years 2030 and 2050. These activity data projection model considers availability, prices on input material, processing of products, demand on food, and transportation costs. The model projects the development of the Swedish agriculture assuming the best economic outcome based on the input parameters. For emission projections from SASAM, activity data for 2025, 2035, 2040 and 2045 are interpolated or extrapolated. Some types of activity data that are not included in the projections by the Swedish Board of Agriculture are estimated in other ways. This includes amounts of harvested products of certain crops and number of some swine categories.

The emission projections are also based on projections according to the national air quality program for the years 2025 and 2030. The activity data is updated to reflect a change in manure management of liquid manure, application of liquid manure and a ban on mink farms from 2025. For emission projections from the national air quality program data for 2035, 2040, 2045 and 2050 have the same value as the year 2030.

The emission factors are assumed to stay constant compared to inventory year 2023 but as the composition of manure management and application techniques of liquid manure is changing the combined emission factors has changed in the scenario in this submission.

## 9.6 Waste

NMVOC emissions from NFR 5A landfilling, $NH_3$ emissions from NFR 5B1 and $NH_3$ emissions from NFR 5B2 are assumed to follow corresponding projections for $CH_4$ emissions.
Emission projections for $PM_{2.5}$ for NFR 5A are assumed to be constant. NFR categories 5D1, 5D2 and 5E are also assumed to be constant.

## 9.7 Consistency with inventory data

During the last few years, the process of producing projections have been more synchronised with the system for emission inventory. For example, calculations for projections have been integrated in the same data models as for the emission inventory when possible, and data is stored on the same aggregation level and in the same database as inventory data. This has helped to ensure that projection data is consistent with inventory data.

# 10 Reporting of gridded emissions and LPS

## 10.1 Gridded emissions

Gridded emission data gives information of the geographical distribution of emissions and is used for control purpose and serves as an important input data for atmospheric dispersion modelling.

### 10.1.1 Scope

Swedish gridded emissions were last reported to UNECE in 2021 and will be reported again spring 2025. The years 1990, 2000, 2005, 2010, 2015, 2019 and 2023 will be included in the submission for the following components: $NO_X$, NMVOC, $SO_X$, $NH_3$, $PM_{2.5}$, $PM_{10}$, BC, CO, Pb, Cd, Hg, PCDD/PCDF (dioxins/furans), PAHs, HCB and PCB.

The gridded emissions were aggregated into GNFR-sectors: A_PublicPower, B_Industry, C_OtherStationaryComb, E_Solvents, F_RoadTransport, G_Shipping, H_Aviation, I_Offroad, J_Waste, K_AgriLivestock and L_AgriOther. Due to data confidentiality, it has not been possible to report the GNFR-sector D_Fugitive as a separate sector; these emissions have been included in the sector B_Industry.

The new EMEP grid resolution of 0.1° × 0.1°, introduced in the 2014 Reporting Guidelines, was implemented in the last reported gridded emissions in 2021 and onwards. The previous gridded emissions reported in 2017 followed the old EMEP grid resolution of 50 km × 50 km.

### 10.1.2 Methodology

Both top-down and bottom-up approaches are used in order to calculate gridded emissions in Sweden. The methodology to allocate emissions into grid cells is schematically described below and emanate from spatial mapping of emission in the EMEP/EEA air pollutant emission inventory guidebook 2019.

- For some emissions sources, the emissions are allocated with a bottom-up approach:

    - Emissions from large point sources are allocated directly into the appropriate grid cells.

    - Emissions from road transport are allocated to grid cells using a national road database (NVDB) containing the Swedish road network, vehicle kilometers and vehicle compositions.

    - Emissions from national shipping are allocated to grid cells with a system that uses AIS-data.

- For other emission sources where the emissions are not known for every grid cell, a top-down approach is used:
    - For many emission sources, activity data (or surrogate data) on an aggregated geographical level (for example municipality level) is used together with geographical data, in order to create a proxy. For example, emissions from civil aviation (LTO) are allocated with a proxy containing the numbers of LTOs per Swedish airport as activity data and the locations of the airports as the geographical data. Another example is emissions from manure management that are allocated with a proxy containing the numbers of animals per municipality as activity data and agriculture areas as the geographical data.
    - For some emission sources, activity data is only available on national level. For such emissions, only geographical data is used as a proxy. One example is emissions of $NH_3$ from pets; these emissions are allocated with population density as a proxy/surrogate data.
- If the emission source has both LPS and other parts that are not known (top-down) LPS emission are first distributed and the remains of the emission is distributed according to the top-down approach.

# Description of methodology for each sector in the gridded emissions

## A_PublicPower

**Public electricity and heat production, 1A1a**
Different methodologies are used for estimation of gridded emissions for 1990-2000 and from 2005, respectively. In 1990 and 2000, the availability of administrative information about various facilities within one company and the connection between the observation id and the identity of the specific combustion identity was low. Therefore, the emissions in these years are estimated at municipality level and distributed over areas according to 2005.

Activity data is the same as the one used for estimating the annual emissions to CLRTAP - Quarterly fuel statistics (KvBr) - which is a total survey regarding the public electricity and heat production. The emissions are aggregated at id-level and all of the administrative variables are kept in order to add the respective coordinates. Register variables are merged with the following geographical data:

- Real estate and addresses from register
- Real estate from real estate maps with assessment
- Information about the real estate maps
- The facilities’ boundary line
- The working places of the Statistical Business Register

- Municipality borders
- Borders of urban areas
- Grid net 1 km × 1 km

Each facility in the activity data has a specific administrative number that is used in order to merge with coordinates. In those cases where the merge cannot be done due to lack of administrative number, information about real estate, urban areas are used to add coordinates to the facility.

In some of the observations, the emissions represent more than one emission source. The observations are in those cases divided and assigned different coordinates which enable the facilities to be located at different municipalities or different grid cells. Real estate coordinates are matched and controlled with information from EU-ETS data base and other sources to estimate the fraction of emissions that represent each source. In submission 2021, there were 10 observations from the Quarterly fuel statistics that were distributed to 75 facilities. In submission 2025 we have identified about 40 additional observations that represent several nearby but still differently located point sources, which will improve the spatial accuracy of emissions in this sector.

The quality of the gridded emissions in the Public electricity and heat production sector is rather good, since the public electricity and heat production sector in the quarterly fuel statistics is a total survey, which includes all the facilities. Information about fuel boilers in each observation might be limited, which increases the uncertainty at grid level. In addition, the uncertainty increases due to that some of the observations include several facilities. In general, the emissions are estimated with emission factors for each fuel combusted and are deemed to be certain at national level. However, for certain municipalities the uncertainty might be of significance since it cannot be expected that the facilities in each municipality have the same combustion technique. Uncertainties of emission factors for some emissions, e.g heavy metals are large. Regarding these emissions, the trend is more reliable. The uncertainties are also larger for the emissions in year 1990 and 2000, since emissions are not estimated at facility level (estimated at municipality level and distributed according to 2005 methodology).

## B_Industry

Since submission 2018, various industry sectors are aggregated into a larger industry sector. The reason for this large aggregation of several sectors is due to confidential activity data which cannot be revealed according to the Swedish regulations for the emission years 2015 and forward. In order to keep a consistent methodology, this aggregation is applied for the whole time series. The aggregated industry sector includes the following sources:

- Petroleum refining (1A1b)

- Fuels combustion within the manufacturing industry for energy purposes (1A2)
- Industrial processes: Mineral, chemistry, metal, paper and pulp, use of fluorinated gases and other sectors (2)
- Fugitive emissions from fuel management (1B)

### Petroleum refining, 1A1b

There are five large and a few smaller refineries in Sweden, which generate pollutant emissions to air. The five large facilities represent 99.9% of the fuel combusted, generating emissions to air.

Emissions from the large refineries are gathered from the EU-ETS database for $CO_2$-emissions. Other emissions are based on the fuel consumption reported in EU-ETS. EU-ETS data is used from 2007 and forward. For previous years 1990, 2000, 2005 and 2006, specific facility level activity data is used. The quality of the EU-ETS data base is considered to be high for all the refineries. Also, the facility level data used before 2005 is considered to be of high quality.

### Manufacture of solid fuels and other energy industries, 1A1c

Activity data on coke production is collected from environmental reports. Emissions of NMVOC and CO are estimated with the Tier 2 methodology with national emission factors. Estimates of emissions of $SO_2$ and $NO_X$ are available from environmental reports on aggregate level, and these emissions are distributed over the different NFR codes (1A1c, 1A2a, 1B1c and 2C1, $SO_2$ also 2B5 and 1B1b) according to the activity data distribution. The gridded emissions are estimated as 1A1a.

### Iron and steel, 1A2a

National emissions from this sector are mainly based on the Quarterly fuel statistics for the years 2005 and forward and for 1990 and 2000 the main source is the Energy use in the manufacturing industry (ISEN). The gridded emissions follow the same method as in 1A1.

The quality of the gridded emissions is considered to vary between municipalities. Data in municipalities with few larger facilities are often of higher quality.

### Non-Ferrous Metals, 1A2b

See 1A2a.

### Chemicals, 1A2c

See 1A2a.

### Pulp, Paper and Print, 1A2d

See 1A2a.

### Food Processing, Beverages and Tobacco, 1A2e

See 1A2a.

### Non-metallic minerals, 1A2f

Divided between counties proportional to the number of construction permits issued. Within each county distributed according to population density (1.A.2.f.i.ii).

### Other Industries, 1A2g

National emissions from this sector are mainly based on the Quarterly fuel statistics for the years 2005 and forward and for 1990 and 2000 the main source is the Energy use in the manufacturing industry (ISEN). The gridded emissions follow the same method as in 1A1, except for the small industries, due to that the AD for this category is aggregated and there is no administrative information at facility level. These emissions are distributed according to a list of all known smaller industry companies. In Submission 2025 this list has been updated for years 2015-2023 to better reflect annual changes within the small industry population.

The quality of the gridded emissions is considered to vary between municipalities. Data in municipalities with few larger facilities are often of higher quality. However, in municipalities with a large proportion of aggregated emissions, the uncertainty is higher.

### Coal mining and handling. 1B1a

Sweden has no emissions from this sector.

### Solid fuel transformation, 1B1b

The code covers coke production from coking coal occurring at two facilities. Emissions are linked to the geographical coordinates of the facilities.

### Other, 1B1c

The code covers two activities:

- Flaring of coke oven gas occurring at two facilities. Emissions are linked to the geographical coordinates of the facilities.
- Milling of peat on peat extractions also are included. Emissions are distributed over areas with marshland and are weighted by county according to statistics on concession area for peat extraction.

### Hydrogen production plants at refineries, 1B2ai

Hydrogen production occurs at three refining facilities. Emissions are linked to the geographical coordinates of the facilities.

### Refining/storage, 1B2aiv

The code covers desulphurization, make-up coke burning, catalyst regeneration, and fugitive emissions (evaporation from tanks) within Swedish refining facilities. Emissions are linked to the geographical coordinates of the facilities.

### Gasoline handling and distribution, 1B2av

Emissions from petrol handling from the more than 3,000 fuel stations in Sweden, are distributed over the number of fuel stations per km (data from the Swedish Agency for Growth Policy Analysis (Tillväxtanalys)).

### Transmission and distribution of natural gas and gasworks gas – fugitive emissions, 1B2b

Fugitive emissions of methane that occur in distribution of natural gas is distributed over 68 measuring stations, line valve stations, inspection stations and branches per km along the Swedish natural gas network. The emissions are distributed in proportion to the capacity of the lines measured in gas pressure.

### Venting and flaring, 1B2c

The code covers three activities:

- Venting of natural gas in the distribution network. A major part of venting (up to 98% of the total vented amounts) occurs at the large storage facility– these emissions are linked to the facility's coordinates. The remaining emissions are distributed over 68 measuring stations, line valve stations, inspection stations and branches per km along the Swedish natural gas network, in proportion to the capacity of the lines measured in gas pressure.
- Flaring of natural gas in the distribution network. The emissions are distributed over 68 measuring stations, line valve stations, inspection stations and branches per km along the Swedish natural gas network, in proportion to the capacity of the lines measured in gas pressure.
- Flaring of refinery gas and other gases (hydrogen, sulphur anhydride) at refineries occurring at four facilities. Emissions are linked to the geographical coordinates of the facilities.

### Cement production, 2A1

Emissions from cement production are linked to the geographical coordinates of the facilities.

### Lime production, 2A2

Major part of the emissions from lime production is linked to the geographical coordinates of the facilities. The remaining emissions are are evenly distributed across industrial areas.

### Glass production, 2A3

Most emissions are linked to the geographical coordinates of the facilities. Emissions from small-scale manual glass production are are evenly distributed across industrial areas.

### Quarrying and mining of minerals other than coal, 2A5a

Emissions from use of explosives are evenly distributed over total mining areas including 165-170 mining sites. Emissions from limestone mining are distributed over limestone mining facilities.

### Construction and demolition, 2A5b

Emissions from construction and demolition activities are evenly distributed across industrial areas.

**Other mineral products, 2A6**

The code covers production of batteries and production of mineral wool. Emissions from both activities are linked to the geographical coordinates of the facilities.

**Nitric acid production, 2B2**

Emissions from nitric acid production are linked to the geographical coordinates of the facilities.

**Carbide production, 2B5**

Emissions from calcium carbide production are linked to the geographical coordinates of the facility.

**Other chemical industry, 2B10a**

Emissions from a variety of chemical plants are linked to the geographical coordinates of the facilities.

**Iron and steel production, 2C1**

Emissions from production of iron and steel (primary and secondary steel production, production of sponge iron) are linked to the geographical coordinates of the facilities.

**Ferroalloy production, 2C2**

Emissions from production of ferroalloys are linked to the geographical coordinates of the facilities.

**Aluminum production, 2C3**

Emissions from aluminum production are linked to the geographical coordinates of the facilities.

**Other metal production, 2C7c**

The code includes emissions from all production of non-ferrous metals. Emissions are linked to the geographical coordinates of the facilities.

**Road paving and asphalt, 2D3b**

Geographical distribution of emissions is made after traffic work from SIMAIR / the Swedish Transport Administration (Trafikverket) for asphalting of roads.

**Asphalt roofing, 2D3c**

Geographical distribution of emissions is done according to industrial areas for the production of roofing with asphalt.

**Pulp and paper industry, 2H1**

Emissions from pulp and paper mills are linked to the geographical coordinates of the facilities.

**Food and beverages industry, 2H2**

Emissions from food and beverage producers are evenly distributed across industrial areas.

**Wood processing, 2I**

Emissions from sawmills are evenly distributed across industrial areas.

**Consumption of POPs and heavy metals, 2K**

Emissions from the use of fluorinated gases are distributed according to population density.

# C_OtherStationaryComb

**NFR Codes: 1A4ai, 1A4bi, 1A4ci**

**Commercial/Institutional Stationary combustion, 1A4ai**

This sector refers to heating of commercial and public premises. Energy statistics for premises have been used for the distribution of fuel consumption and emissions per fuel type and temperature zone. Temperature zone has been selected because the data material is not adapted for reporting on finer geographical level than that. Because the necessary data for geographical distribution is only available for the years 2005, 2006 and 2008, the shares for other years have been calculated as follows: 1990 and 2000 = same distribution as 2005; 2010, 2015 and 2019 = same distribution as 2008. A division has been made between refined and unprocessed fuel and between modern and traditional technology for the whole time series.

**Residential Stationary combustion, 1A4bi**

This sector contains emissions from all small-scale heating systems in detached houses, holiday houses and apartment buildings. The data consists of model estimates from the annual energy balances. The distribution of emissions is made at a municipal level and is based on:

- Statistics from The Swedish Civil Contingencies Agency (MSB) on the number of fireplaces (wood boilers, local fireplaces, pellet boilers and oil boilers) per municipality /emergency services.
- The energy needs of small houses have been calculated with the ENLOSS energy balance model to find the energy requirement for an average meteorological year.
- Assumptions about heating habits and share of fuel, which are made from the outside experience from other studies and surveys as well as knowledge on the number of detached houses connected to district heating networks per municipality.
- Emission factors per type of fireplace and efficiency.

For the distribution keys, separation has been made of wood boilers with ceramic fireplace, where these emissions are calculated with emission factors for environmentally approved boilers. While those without a ceramic fireplace have been calculated with emission factors for non-environmentally approved wood boilers. Within each municipality, the emissions are then distributed by living area per square kilometers for each house type. The living areas are taken from the property register. The district heating supply in each urban area has been calculated from statistics from the Swedish Energy Markets Inspectorate’s (Ei) register of district heating networks. In this way, emissions within each urban area are reduced by a factor that depends on number of detached houses connected to district heating networks according to this register. Thus, emissions increase in urban areas that are less connected to district heating.

**Agriculture/Forestry/Fishing: Stationary combustion, 1A4ci**
This sector includes emissions that arise at stationary combustion in areal industries, such as agricultural and forestry premises. The data consists of model estimates from the annual energy balances, and the distribution of emissions from these fixed installations is evenly distributed over living space for agriculture. A division has been made between refined and unprocessed fuel and between modern and traditional technology for the whole time series.

## D_Fugitives (Are included in B_Industry)

## E_Solvents

**NFR Codes: 2D3a, 2D3d, 2D3e, 2D3f, 2D3g, 2D3h, 2D3i, 2G4**

**Domestic solvent use, 2D3a**
Households' use of solvents consists of about 1/3 of the emissions from the total use of solvents. Emissions are calculated based on national statistics from Swedish Chemicals Agency (KEMI). The emissions are distributed according to population density for each year.

**Coating applications, 2D3d**
Households' use of ink consists of about 1/3 of the emissions from the total use of ink. Emissions are calculated based on national statistics from Swedish Chemicals Agency (KEMI). The issues are distributed according to population density for each year. The use of ink in businesses is evenly distributed over industrial areas.

**Degreasing, 2D3e**
The source refers to emissions of volatile organic compounds from use of degreasing in industry. The emissions are evenly distributed across industrial areas.

**Dry cleaning, 2D3f**

The source refers to emissions of volatile organic substances from dry cleaners. The emissions are distributed according to population density for each year.

**Chemical product use, 2D3g**

The source refers to emissions of volatile organic compounds from use of solvents and chemical products in industry. The emissions are evenly distributed across industrial areas.

**Printing, 2D3h**

The source refers to emissions of volatile organic compounds from printing works. The emissions are evenly distributed across industrial areas.

**Other solvent and product use, 2D3i**

The source refers to emissions of volatile organic compounds from other activities, which are dominated by agriculture and forestry (approx. 25%) and other non-industrial (approx. 38%). The emissions are distributed by population density. Another emission in this source is carbon dioxide from the use of urea in SCR catalysts (SCR = Selective catalytic reduction) Reported carbon dioxide emissions from urea use are based on national statistics from the Swedish Chemicals Agency (KEMI), and on emission factors from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The emissions of carbon dioxide from the use of urea in catalysts are distributed across industrial land for the year 1990 and after traffic work for the year 2000 and onwards.

**Other product use, 2G4**

This sector includes air pollutants from tobacco smoking and fireworks. Emissions are calculated using emission factors and statistics quantities of sold tobacco products (excluding snus) and national statistics on the import of fireworks. The emissions are distributed according to population density. Another emission originates from the use of products as anesthesia, firefighting equipment, aerosol cans and other nitrous oxide use. These emissions are distributed geographically according to population density.

## F_RoadTransport

**NFR Codes: 1A3bi, 1A3bii, 1A3biii, 1A3biv, 1A3bv, 1A3bvi, 1A3bii**

**Road transport: Passenger cars, 1A3bi**

Road traffic emissions are calculated by the SIMAIR air quality system. Emission factors used for exhaust and evaporative emissions are from HBEFA 3.3.
Roads in Sweden is a combined system with a nationwide network maintained by the Swedish transport administration, complemented by local roads maintained by each municipality, and private roads. All roads are classified by its role in the traffic system on a 10-grade scale called FVK, going from 0 for the back-bone highway links connecting the major cities or abroad to 9 that ends e.g. in an agricultural field with almost no traffic demand. The national roads undergo systematic traffic

counts such that each road has a count somewhere in the last few years. To get a total coverage picture of the traffic activity simulations of the national roads are performed to adopt a consistent flow that is as well adopted to all counts.
At municipal level traffic counts are also performed but not on all roads, and not all counts are reported to the Swedish transport administration. Roads with traffic counts are included in the traffic activity simulation for the part of the road it is considered to be a good estimate. Apart from the roads considered in the traffic activity simulation the nation is divided in thousands of areas and within these areas the remaining demand for transport both the first/last piece of a travel going to or from a larger road and transports within the area is estimated by a model. This transport demand is distributed among all roads with no previous estimate from the traffic simulation by the simple assumption that each grade on the FVK is a tenfold in traffic amount for all vehicle types.

**Road transport: Light duty vehicles, 1A3bii**
Same methodology as for passenger cars.

**Road transport: Heavy duty vehicles and buses, 1A3biii**
Heavy duty vehicles have the same methodology as passenger cars.

Emission from bus traffic are distributed according to the energy used by the various counties buses. Collection of regional statistics on energy use per fuel has been taken from FRIDA’s vehicle database which contains the various region’s buses in public transport except of Stockholm which has been collected through contact with Stockholm’s local traffic. FRIDA’s database only contain energy statistics from 2018, so for the older emissions years, statistics from, among other things, The Swedish Transport Agency, trade journal and other trade associations have been used to estimate the regional energy used by fuel. All county figures are compiled and summed up and each county’s share of Sweden’s total is calculated for the various fuel classes. The national emission is then distributed according to each county’s share of Sweden’s total amount of energy. The county statistic are then combined with the existing traffic distribution key (same methodology as for passenger cars) to obtain the complete distribution methodology.

**Road transport: Mopeds & motorcycles, 1A3biV**
Same methodology as for passenger cars.

**Road transport: Gasoline evaporation, 1A3bv**
Same methodology as for passenger cars.

**Road transport: Automobile tyre and brake wear, 1A3bvi**

From submission 2025, the NORTRIP model (Denby et al., 2012) will be used to distribute emission from non-exhaust particles.

The calculations are done by first dividing the country into municipalities. For each municipality, meteorological data, which is one of the input data to NORTRIP, is extracted at the coordinates of its city hall and the same meteorological data is used for all the calculations done within the same municipality. The road network data including information of road work from the Swedish Transport Administration is used in our calculations. All the major types of roads are included in all the representations of the road network used, and the traffic is modelled by the SAMPERS/EMME traffic model. A combination of road parameters is used to generate a list of possible roads within each municipality. These road parameters describe various road characteristics and thus affect wear emissions and emission factors calculated. Key road parameters include:

- Traffic variations
- Speed limit
- Road category
- Congestion profile (tyre changing periods, type of pavement material and driving cycle)
- Proportion of heavy traffic
- Annual average daily traffic (AADT)

For every road link, emission is calculated through multiplying the emission factor (emissions per vehicle), the Average Annual Daily Traffic (AADT), and the road's length, representing the total emissions generated on a specific road segment.

**Road transport: Automobile road abrasion, 1A3bvii**

See NFR code 1A3bvi for methodology.

## G_Shipping

**NFR Codes: 1a3dii**

### National Navigation, 1A3dii

Emissions from national navigation are divided into leisure boats and other domestic navigation. Domestic navigation refers to the traffic between Swedish ports. The calculation system Shipair developed by Swedish Meteorological and Hydrological Institute (SMHI) and the Swedish Maritime Administration (SMA) is used as the basis for the distribution of emissions from other domestic navigation. The system includes a bottom-up model for ship emissions that combines data from Automatic Identification System (AIS) with detailed ship characteristics. If the characteristics of a ship are known, the positions from AIS can be used to calculate energy and fuel consumption between two moments. Depending on the ship's cruise status, different emission factors are used. Cruise status refers to whether the vessel is in normal operation, maneuvering or standing still at a normal quay, electrically powered dock or at anchor. Distribution keys have been produced in Shipair for the years 2010-2022 (for the years before 2010 the distribution key is used for 2010)

The distribution of emissions from leisure boats is done separately for the coast and inland. Most boats are located on the coast and their emissions can be distributed with the help of aerial and satellite photos. For each square kilometer box, the number of wharfs within a distance of 10 km is used as a measure of the traffic. Within the hinterland, there is no wharf inventory and the boats are instead distributed evenly over the watercourses weighting with municipal population. For the distribution of leisure boats over Sweden's inland and coastal areas materials are used from several different sources: Statistics Sweden (SCB), The Swedish Mapping, Cadastral and Land Registration Authority (Lantmäteriet), Norrbotten and Stockholm County Administrative Boards, and Swedish Meteorological and Hydrological Institute (SMHI)

# H_Aviation

**NFR codes: 1A3a i-ii**

**Civil Aviation, 1A3a i-ii**

This sector includes all civil aviation below an altitude of 1000 m (LTO, "Landing and Take-Off") for both domestic and international travel. But since the methodology for domestic aviation over 1000 meters (domestic cruise) are produced in the same way, this is also included here.

The distribution of emissions is based on landing statistics for Swedish airports from the Swedish Transport Agency (STAg) in combination with actual flight movements, and takes place according to the following steps:

1. Calculation of a representative geographically distributed flight pattern between each domestic airport and aviation to/from a domestic airport to all international airports.
2. Calculation of total emissions for each airport pair and aircraft type based on annual landing statistics. The emissions are then distributed over the airport couple's representative flight pattern.
3. Summary of the above issues to a total distribution over Swedish territory.

Landing statistics for Sweden's airports are obtained from STAg for the year 2005 and onwards, for 1990 and 2000, landing statistics are missing, so for these years the same distribution key is used as in 2005.

The geographically distributed flight patterns are based on data collected over four weeks in 2015. Data were collected from Automatic Dependent Surveillance – Broadcast (ADS-B), Multilateration (MLAT), and radar over Swedish territory from aircraft during the LTO phase and cruise. These flight movements were then used to create a representative flight pattern and flight distance between each pair of airports.

For the aircraft's emission factors, the calculation tools available with the EMEP/EEA Guidebook for emissions (European Environment Agency, 2016, 1.A.3.a Aviation) are used. These are used to calculate the emission factors for different long flight distances, as well as separate emissions from the LTO phase divided into taxi out, take off, climb out, landing and taxi in. In this way, emission

factors are produced for 40 of the most common types of aircraft for Cruise, and for 33 of the most common types of aircraft for LTO. All aircraft that do not have specific emission factors are assigned values from an aircraft with similar characteristics.
The total emissions are then calculated for each airport pair and aircraft type according to the STAg:s landing statistics. LTO emissions are distributed according to activity in the flight pattern between 0 and 1000 meters altitude and cruise emissions are distributed according to activity at altitudes above 1000 meters (domestic cruise). The results are then summed up in a total distribution pattern over Swedish territory.

## I_OtherMobile

**NFR codes: 1A2gvii, 1A3c, 1A3e, 1Aeii, 1A4aii, 1A4bii, 1A4cii, 1A5b**

Among the subsectors to 1.A.2.g.vii the emissions are divided according to the amount of fuels consumed derived from a model run.

**Mobile combustion: Construction, 1A2gvii**
Divided between counties proportional to the number of construction permits issued. Within each county distributed according to population density.

**Mobile combustion: Road construction, 1A2gvii**
Distributed along the road network proportional to the traffic work.

**Mobile combustion: Industry, 1A2gvii**
Distributed over areas of land use industrial.
**Mobile combustion: Iron and steel, 1A2gvii**
Distributed among the facilities weighted by the number of employees according to the trade association Jernkontoret.

**Mobile combustion: Forestry, 1A2gvii**
Divided between counties proportional to the amount logged forest according to the Swedish Forest Agency. Within each county distributed over areas of land use industrial.

**Mobile combustion: Mines, 1A2gvii**
Divided between the production facilities proportional to the amount of gangue mined. Evenly distributed over the area of each facility.

**Railway, 1A3c**
Emissions are from diesel powered engines for shunting and long haul and MTUs and rail cars for passenger traffic. Emissions are divided to 70% shunting and 30% on the lines. Shunting emissions are divided into marshalling yards proportional to the number of carriage movements. For each marshalling yard the emissions are distributed on land tagged land use rail in OpenStreetMap within a 10 km radius

from the central coordinates of the yard. Emissions on the lines are distributed according to the traffic counts for diesel powered engines, MTUs and railcars.

**Other transportation: Pipeline, 1A3e**
Distributed along the pipeline system for natural gas according to the number of regulatory stations where distribution nets with lower pressure is attached.

**Other transportation: Railways, 1A3eii**
Divided between the national railway system and the local tram systems that are running regular traffic proportional to their maintenance budgets. In each tram system the emissions are distributed evenly along all rail. In the national railway system the emissions are distributed proportional to the traffic counts of engines for each part of the system.

**Other transportation: Airport, 1A3eii**
Divided between airports proportional to the number of landings according to the Swedish Transport Agency. Evenly distributed over the area of the airport according to OpenStreetMap.

**Other transportation: Harbors, 1A3eii**
Distributed on harbor areas, divided between the harbors proportional to the number of arrivals according to the Swedish Maritime Administration.

**Commercial/Institutional: Mobile, 1A4aii**
Distributed as floor area of apartment buildings.

**Residential Mobile: AWD, 1A4bii**
Divided between municipalities according to the number of registered vehicles. Within each municipality distributed as the floor area of detached houses, semi-detached houses and vacation houses.

**Residential Mobile: Household/Garden, 1A4bii**
Distributed as the floor area of detached houses, semi-detached houses and vacation houses.

**Off-road vehicles and other machinery: Agriculture, 1A4cii**
Divided between municipalities proportional to the total motor power for all tractors registered in the municipality. Within each municipality distributed on farmland.

**Off-road vehicles and other machinery: Forestry, 1A4cii**
Evenly distributed on areas subject to actual logging determined from differences in satellite pictures.

**Off-road vehicles and other machinery: National fishing, 1A4cii**

Emissions calculated by an emission model for ships, Shipair, developed by SMHI. Emissions are calculated from ship movements in AIS data and properties of the ships provided directly from the AIS data as well as two other databases with ship properties. About 350 of the 1300 Swedish fishing ships are using AIS transponders but are considered representative for the whole fleet.

### Other mobile: Military traffic, 1A5b

Included in another sector (IE) and distributed in the same manner as that sector.

### Other mobile: Military navigation, 1A5b

Included in another sector (IE) and distributed in the same manner as that sector.

### Other mobile: Military aviation, 1A5b

Included in another sector (IE) and distributed in the same manner as that sector.

## J_Waste

**NFR codes: 5A, 5B1, 5B2, 5C1bii, 5C1bv, 5C2, 5D1, 5D2, 5E**

### Solid Waste disposal on land, 5A

The data for the distribution consists of municipal landfills from Swedish Waste Management’s reports with landfills quantities of household waste, park waste and municipal sewage sludge. Deposited quantities have been collected from several years: 1994, 2000 and 2001, in order to even out variations between them. For biological industrial waste, the distribution has been made according to information on industry-specific waste in Swedish Waste Management’s reports. The information about recovered methane gas has been obtained from Swedish Waste Managements and the distribution is made separately for each type of waste.

### Composting, 5B1

The sector includes emissions of nitrous oxide and methane from composting plants. To distribute these emissions, information is taken from Swedish Waste Managements for the year 2005 and 2008-2017. Available data have been composting per municipality (tons of waste per year). The remaining post from all other municipality is evenly distributed over the remaining municipalities. Within each municipality the emissions is distributed across industrial land.

### Anaerobic digestion at biogas facilities, 5B2

The sector includes emissions of nitrous oxide and methane from so-called co-digestion plants, i.e. digestion at biogas plants. To distribute these emissions, information is taken from Swedish Waste Managements for the year 2005 and 2008-2017. Available data have been rotting per municipality (tons of waste per year). The remaining post from all other municipality is evenly distributed over the remaining municipalities. Within each municipality the emissions is distributed across industrial land.

### Incineration of hazardous waste, 5C1bii

This sector consists of the combustion carried out at Fortum's facility (SAKAB) in Kumla municipality, i.e. all emissions are facility specific.

### Cremation, 5C1bv

The emissions from incineration at the crematorium are distributed on Swedish crematoria. The emissions have either been reported by the crematorium or calculated using a standard value based on the number of cremated per facility. Statistics have been obtained from Swedish environmental reporting portal (SMP) and the Swedish Cemetery and crematorium associations (SKKF). Cadaver incineration is also included in the national total for this sector.

### Garden burning and bonfires, 5C2

Emissions from garden fires, may fires and equivalent, are distributed proportional to living space detached houses and holiday house.

### Domestic waste-water handling, 5D1

The emissions are partly distributed by emissions of total nitrogen from all major and smaller municipal treatment plants in the country, and partly on individual sewers. Emissions from the individual sewers are distributed according to the population, within the parts of the country that have a population density that is less than 10 inhabitants per square kilometer. To determine the proportion of emissions allocated to individual sewers, the same methodology is used as within the international reporting of Sweden's total emissions.

The emissions of $NH_3$ and NMVOC are separately reported for latrines (temporarily portable toilet). Distribution of these emissions takes place according to statistics from Swedish Waste Managements of weighted amount of waste (tons) per municipality. As there is too much uncertainty in the data from individual years, an average value for the years 2012-2017 is used, thus the same activity data is used throughout the time series. The emissions within municipalities are then distributed according to population density for each year.

### Industrial waste-water handling, 5D2

The emissions from treatment of waste water from industries (not connected to municipal sewage treatment plants) is distributed over industrial land per square kilometer.

### Other waste: Sludge spreading, 5E

The emissions are distributed over municipal sewage treatment plants.

### Other waste: Landfill fires, 5E

The same distribution as NFR 5A - Solid waste disposal on land.

### Other waste: House and car fires, 5E

Emissions from house and car fires include emissions of particles, heavy metals and dioxin for various types of fires; car fires, house fires (isolated and non-insulated houses), apartment fires and industrial building fires. The emissions are distributed according to municipal statistics on fires from Swedish Civil Contingencies Agency (MSB) The fires are divided into categories (cars, detached houses, chain houses, apartment buildings and industrial buildings) on which the emissions is calculated according to associated emission factors. Different distribution keys are then used within the municipalities depending on the type of building in which the fires took place:

- For car fires, emissions within municipalities are distributed over living space apartment buildings per square kilometer, as a significant part of the fires take place in multi-dwelling areas.
- For fires in detached houses and chain houses, the emissions are distributed within municipalities over living space detached houses per square kilometer.
- For fires in apartment buildings, the emissions within municipalities are distributed over living space apartment buildings per square kilometer.
- For fires in industrial buildings, the emissions are distributed within municipalities over the share of industrial land per square kilometer.

**Other waste: Pets, 5E**
Emissions from small-animal feces are weighted according to population density.

## K_AgriLivestock

**NFR codes: 3B1a, 3B1b, 3B2, 3B3, 3B4d, 3B4e, 3B4g, 3B4h**

**Manure management: Dairy cattle, 3B1a + Non-dairy cattle, 3B1b**
The emissions from cattle manure are distributed according to the number of animals per municipality / county and are placed on pasture. For municipalities that have classified information on the number of animals, the difference between the total number of animals at county level, and the sum of the municipalities for which there is information is calculated. This difference is then distributed between the municipalities that have classified information according to the same situation that prevailed between these municipalities a year when the information was not covered by confidentiality. For municipalities that have had secrecy for all years, the rest is evenly distributed instead.
Since the number of animals per municipality is updated only every third year, while county statistics are updated every year, annual statistics on the number of animals at county level are also used. The county totals are distributed in the intermediate years according to the same municipal conditions as the closest year for which there is municipal statistics.

**Manure management: Sheep, 3B2**

The emissions from sheep manure are distributed according to municipal statistics on the number of sheep per municipality, according to the same methodology as for cattle. Within the municipalities the emissions are distributed by number of animal places per holding.

**Manure management: Swine, 3B3**

The geographical distribution is made by weighting the emissions by the number of swine per municipality / county, according to the same methodology as for cattle. The distribution within the municipalities is then based on production location per holding. Data on the number of animals per municipality / county are of higher quality than holding-specific data, so by basing the distribution on holding-specific data, and then weighted with reviewed data, a certain quality assurance is obtained without losing the available holding data. The emissions are then distributed over the living area for agricultural properties.

**Manure management: Goats, 3B4d**

The emissions from goat manure are distributed according to municipal statistics on the number of goats per municipality, according to the same methodology as for cattle. Within the municipalities, the emissions are distributed according to the number of animal places per holding.

**Manure management: Horses, 3B4e**

The emissions from horse manure are distributed according to the number of horses per municipality, according to the same methodology as for cattle. Within the municipalities, the emissions are distributed over pasture land.

**Manure management: Poultry, 3B4g**

Emissions are produced by weighting according to statistics from the Swedish Board of Agriculture (Jordbruksverket) / Statistics Sweden (SCB) on the number of poultry per municipality, according to the same methodology as for cattle. Within the municipalities, the emissions are then distributed according to the number of poultry places per holding.

**Manure management: Other Animals, Reindeer, 3B4h**

Emissions for reindeer manure are evenly distributed over all land in the counties where reindeer occur.

## L_AgriOther

**NFR codes: 3Da1, 3Da2a, 3Da2b, 3Da2c, 3Da3 , 3Da4, 3Da5, 3Da6, 3Db, 3Dc, 3De, 3Df**

**Inorganic N-fertilizers (includes also urea application), 3Da1**

The code includes emissions from fertilizers on arable land. These emissions are distributed on arable land and weighted by the amount of nitrogen per county that comes from artificial fertilizers (the amounts of nitrogen added from commercial fertilizers according to Statistics Sweden's (SCB) statistics). For counties that do not have large amount of agricultural land, the data may for some years be so small that the information is classified. In these cases, data is used from other available years (without confidentiality) to geographical distribution these counties. The use of urea is evenly distributed over arable land.

### Animal manure applied to soils, 3Da2a

For animal manure applied to soils, emissions are generated by weighting the total nitrogen supply per animal species. The activity data is the number of animals per municipality. Manure from grazing animals is distributed over grazing land and weighted by the number of animals per municipality / county.

### Sewage sludge applied to soils, 3Da2b

The emissions from sewage sludge applied to soils are evenly distributed over arable land.

### Other organic fertilizers applied to soils, 3Da2c

The emissions of other organic fertilizers are geographically distributed on arable land and weighted by the amount of nitrogen per county that comes from commercial fertilizers.

### Urine and dung deposited by grazing animals, 3Da3

The emissions for fertilization from grazing animals are produced by weighting based on total nitrogen supply per animal species. Activity data used is the number of animals per municipality. Manure from grazing animals is distributed over grazing land and weighted by the number of animals per municipality / county.

### Crop residues applied to soils, 3Da4

The emissions of nitrous oxide from the use of crop residues as fertilizer, are added to arable land and weighted by the total harvest in the county (tons per year) for all crops from the Swedish Board of Agriculture (Jordbruksverket). For counties that do not have large amount of agricultural land, the data may for some years be so small that the information is classified. In these cases, data is used from other available years (without confidentiality) to geographical distribution these counties.

### Mineralization/immobilization associated with loss/gain of soil organic matter, 3Da5

The emissions of nitrous oxide from the processing of mineral soil are distributed over the agricultural land and weighted by the mineral soil areas at county level.

### Cultivation of organic soils, 3Da6

The emissions of nitrous oxide are distributed on arable land and weighted with the help of organic soil areas on county level. Information on organic soil areas has been obtained from Swedish University of Agriculture (SLU).

### Indirect emissions from managed soils, 3Db

This sector contains indirect emissions of nitrous oxide to the atmosphere, nitrogen leakage and drainage. Emissions to the atmosphere are distributed over agricultural land. The emissions from nitrogen leakage and drainage are distributed over the arable land.

**Farm-level agricultural operations, 3Dc**
The code includes emissions of particles from the storage, handling and transport of agricultural products. These emissions are distributed over the living space for agricultural properties.

**Cultivated crops, 3De**
The emissions of NMVOC from crop cultivation are evenly distributed over arable land.

**Use of pesticides, 3Df**
The emission of Hexachlorobenzene from use of pesticides are evenly distributed over the arable land.

### 10.1.3 Recent improvements

A summary of the major improvements of the gridded emissions reported in 2025, in comparison with gridded emissions reported in 2021, is given below:

- Reported AD in A_PublicPower sometimes represents several point sources. The allocation of emissions from such “multiple facilities” has been improved in 2025 by including more multiple facilities and reviewing both the location and distribution coefficient estimates of point sources.
- Aggregated remaining AD within B_Industry is distributed over all smaller industry companies, for which there are no individual information on activity or emissions. In 2025 the distribution of emissions to small industry facilities has been improved by replacing a static list an annually updated lists of companies in this dynamic population, focussing on the period 2015-2023. The method now also considers size, in terms of nr of employees, in the allocation of emissions to individual companies (the earlier method assumed an equal distribution).
- New and updated distribution keys for road traffic (Cars, Light trucks, Heavy trucks, Buses and Motorcycles/mopeds) have been introduced based on traffic data from the Swedish Transport Administration for 2021 (used for emission years 2018- 2023) For this distribution key, version 4.1 of the exhaust emission model HBEFA has been used .
- The distribution key for the 2015 traffic road network (used for emission year 2018- 2023 now also has updated SAMS surfaces. These areas with low traffic, located between major road links, have been given the same distribution method as the newer road networks. Previously, the traffic work was spread evenly over the entire SAMS surface, which could lead to emissions being placed at sea or other unreasonable areas. With this update, emissions are distributed only along the actual paths within the SAMS surface, improving data quality.

- The distribution methodology for bus traffic has been updated to also take into account what fuel is used in the buses within different counties. This change will have a significant impact on how emissions are distributed within the sector, as fuel use varies significantly between counties.
- The distribution methodology for domestic civil shipping in the years 2010 – 2023 has been developed with Shipair 2. The updated system brings several improvements, including a more detailed division of fuel types (including LNG) and updated emission factors. In addition, the methodology for identifying domestic journeys has been improved, providing a more accurate division between domestic and international traffic.
- A new distribution methodology has been developed in the agricultural sector to improve the quality of geographically distributed emissions from animal husbandry. The updated method replaces outdated grids by using a dual-grid system, ensuring emissions are only allocated to areas with registered production facilities for greater accuracy.
- From the 2025 submission, the NORTRIP model will be used to distribute emissions from non-exhaust particles in road transport. See Chapter 10.1.2, "Road Transport: Automobile Tyre and Brake Wear, 1A3bvi", for a more detailed explanation.

### 10.1.4 Planned improvements

Potential major improvements for the next reported gridded Swedish emissions (in 2029) is given below:

- A new road network (Cars, Light trucks, Heavy trucks, Buses and Motorcycles/mopeds) will be developed in 2025 with updated emission factors from exhaust emission model HBEFA 5.0
- Correction of traffic volumes in the road networks 2013, 2018, 2021 to handle traffic volumes from HBEFA which affect the distribution of road traffic. Correction of Nortrip for recalculation of wear particles and geographical distribution. Application to emissions of wear particles during the years 1990-2023.
- The quality of the geographical distribution may be improved by utilizing new open geodata regarding land use.

## 10.2 LPS

Swedish LPS data were reported to UNECE in 2021 and will be reported again spring 2025. The report includes emissions of $NO_x$, NMVOC, $SO_2$, $NH_3$, $PM_{2.5}$, $PM_{10}$, CO, Pb, Cd, Hg and PCDD/PCDF (dioxins/furans) for 2019. The text in this section has been slightly revised since submission 2021, due to the recommendation that was put forward during the 2021 NECD review.

### 10.2.1 Description

Every four years from 2017 onward, parties are required to provide data on Large Point Sources (LPS). The Guidelines for Reporting Emissions and Projections Data (ECE/EB.AIR/125) states that as far as possible, reported LPS data should be consistent with emissions data available under the European Pollutant Release and

Transfer Register (E-PRTR). However, the E-PRTR Regulation does not cover all information that is requested for LPS. This concerns emissions of $PM_{2.5}$, information on stack height and the facilities GNFR code.

From release year 2018 the requested information according to the E-PRTR Regulation is separated into two different dataflows, i.e. the EU Registry on industrial sites and the Integrated E-PRTR/LCP. The EU Registry on industrial sites includes administrative information (national facility ID, facility name, coordinates) about facilities that are covered by E-PRTR, whereas the E-PRTR/LCP dataflow includes information on emissions.

### 10.2.2 Completeness

The Swedish LPS data is consistent with the national officially reported data according to the E-PRTR Regulation (166/2006/EC) for 2019. When preparing the LPS data according to Annex VI, Sweden uses officially reported data according to the Integrated E-PRTR/LCP data flow and as well as the EU Registry on industrial sites for 2019.

In order to avoid duplicated reporting requirements for operators Sweden has chosen to integrate the reporting according to the E-PRTR Regulation with the national environmental reporting system (see Annex 4). Consequently, same information source is used when compiling parts of the main NFR Annex 1 inventory (see section 3.3, 4 and 6.4 for relevant sectors) and the E-PRTR dataset. Furthermore, the reported information in the operator’s environmental reports is also used in the inventory for quality assurance and allocation of emissions between different sectors (for example energy and industry) and as well for development of emission factors.

None of the reported Swedish facilities that are included in E-PRTR for 2019 reports emissions of PAH, HCB and PCB. Information on stack height is not mandatory for LPS according to the reporting guidelines (ECE/EB.AIR/125) nor to the E-PRTR Regulation. Information on stack hight is not available for the Swedish E-PRTR facilities. Consequently, information on stack height is not included in Annex VI for Sweden.

### 10.2.3 Methodology

Information on $PM_{2.5}$ and GNFR is mandatory for LPS according to the reporting guidelines (ECE/EB.AIR/125). However, this information is not mandatory according to the E-PRTR Regulation and therefor this information is not reported by the operators of the Swedish E-PRTR facilities. Consequently, this information has been prepared by the inventory team and are included in Annex VI for Sweden.

#### 10.2.3.1 GNFR

Each facility has been given a GNFR code based on its reported activity code according to Annex I of the E-PRTR Regulation. The TFEIP's revised reporting codes table (TFEIP, 2019), that is available on the CEIP's webpage, has been used for the mapping between Annex I activity code and GNFR.

#### 10.2.3.2 $PM_{2.5}$

Emissions of $PM_{2.5}$ have been calculated based on the operators reported emissions of $PM_{10}$ as follows:

1. Based on reported emissions of $PM_{10}$ and $PM_{2.5}$ in the NFR tables for GNFR "B_Industry" the average ratio of $PM_{2.5}$ to $PM_{10}$ has been calculated. Some NFR codes (2D3b, 2C3, 2A5a and 2A5b) have not been included in the calculation, since no facilities with the corresponding Annex 1 activity code are reported in the Swedish E-PRTR data for 2019.
2. Based on the facilities' reported $PM_{10}$ emissions according to E-PRTR, the calculated average ratio (83%) has been used to calculate $PM_{2.5}$ emission for LPS:s.

### 10.2.4 Recent improvements

In line with the recommendation that was put forward during the 2021 NECD review, the consistency between the main NFR Annex 1 inventory and the LPS reporting has been clarified in the IIR (see section 10.2.1).

### 10.2.5 Planned improvements

No major improvements are currently planned.

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