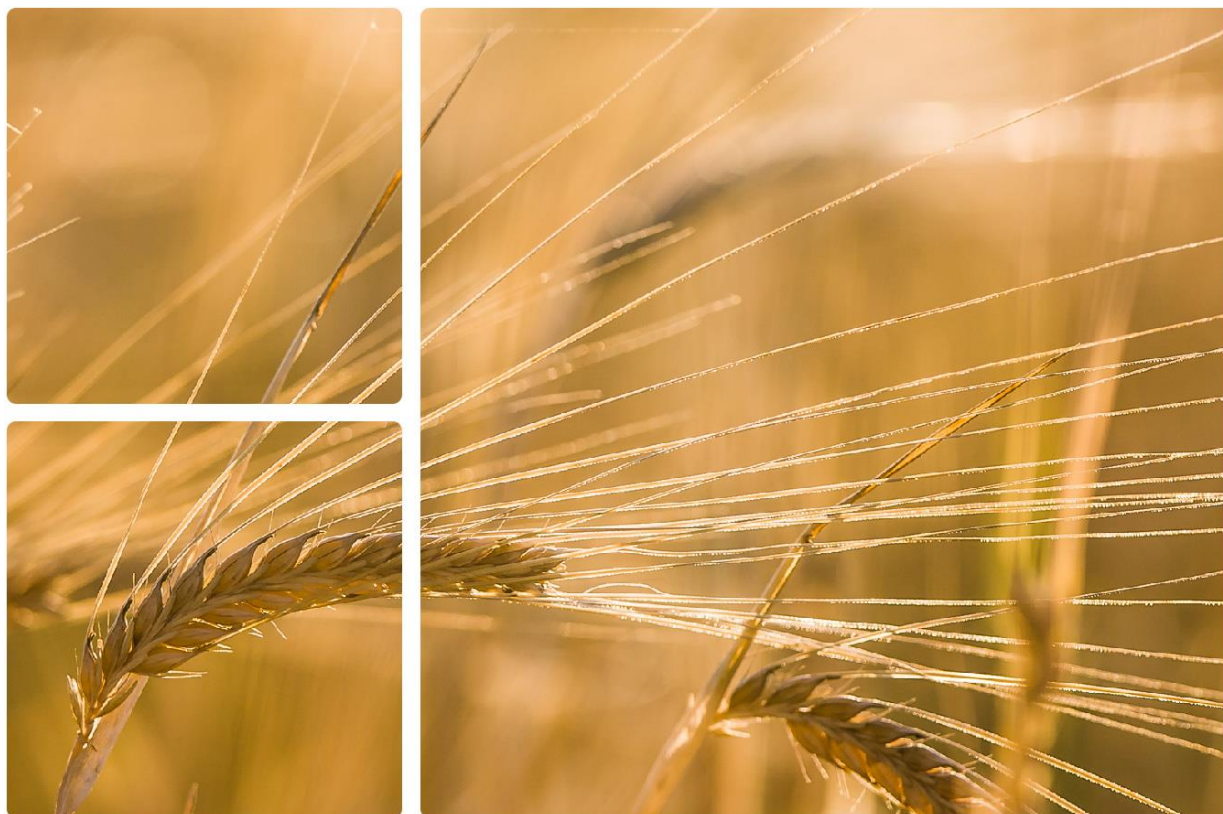


# Informative Inventory Report Sweden 2017

Submitted under  
the Convention on Long-Range Transboundary Air Pollution



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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 reports of air pollutants for the year 2017 is prepared in accordance with the 2016 Reporting Guidelines and according to the CLRTAP's revised Gothenburg Protocol as agreed by the parties to the Convention in Geneva, 2012. The inventory reports are submitted to the UNECE Secretariat and to the EEA annually.

This report constitutes Sweden's IIR 2017 (inventory data 2015) for anthropogenic emissions of air pollutants: NO<sub>x</sub>, CO, NMVOC, SO<sub>2</sub>, NH<sub>3</sub>, TSP, PM<sub>10</sub> and PM<sub>2.5</sub>, BC, heavy metals, dioxins, HCB and PAH. The report contains information on Sweden's inventories of air pollutants for all years from 1980 to 2015, including descriptions of methods, data sources, uncertainties, the quality assurance and quality control (QA/QC) activities carried out and a trend analysis. 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 for estimating and reporting of emission data 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. energy 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 as methodological guidance.

Sweden also uses methodologies in accordance with the IPCC 2006 Guidelines for National Greenhouse Gas Inventories<sup>1</sup> 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)<sup>2</sup>. Some parts of the methodologies are taken directly from the IPCC Guidelines, the Good Practice Guidance and the EMEP/EEA Air Pollutant Emission Inventory Guidebook<sup>3</sup>.

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<sup>1</sup> <http://www.ipcc-nggip.iges.or.jp/public/2006gl/>

<sup>2</sup> The Good Practice Guidance can be found at:  
<http://www.ipcc-nggip.iges.or.jp/public/gp/english/>

<sup>3</sup> <http://www.eea.europa.eu/publications/emep-eea-guidebook-2013>

Due to changes in the routines for handling data it was discovered that a higher degree of confidentiality is required for some activity data. This has affected some sub-sectors in the energy sector (NFR1A and 1B) which have been classified with the notation key Classified (C). Sweden works continuously on limiting 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<sub>2</sub>, NO<sub>x</sub>, NH<sub>3</sub>, NMVOCs, PM<sub>10</sub>, PM<sub>2.5</sub> and BC) have been reduced significantly since 1990. Other air pollutants, such as CO, poly aromatic hydrocarbons (PAH-4), dioxins and priority heavy metals cadmium namely, (Cd), mercury (Hg) and lead (Pb) have all been reduced significantly since 1990.

The decline in emissions of the main air pollutants and heavy metals has been achieved through regulatory controls and application of better technologies in industry, energy, and transport sector. 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 NO<sub>x</sub>-fee. However, emissions of HCB have increased significantly since 1990 mainly due to increased use of biomass as a fuel and increased incineration of hazardous waste.

### *Nitrogen oxides*

The estimated emissions of nitrogen oxides (NO<sub>x</sub>) were about 130 kt in 2015. The total emissions of NO<sub>x</sub> have declined by more than a half (53 %) since 1990 and by 3 % compared to the previous year.

The energy sector (NFR1) accounted for most of the NO<sub>x</sub> emission (79 %) of which transport was responsible for 39 % of the national total. The industrial processes and product use sector (NFR2) and the agriculture sector (NFR3) were responsible for about 11 and 10 %, respectively. NO<sub>x</sub> -emissions from the waste sector (NFR5) are very limited.

Emissions from the transport sector (NFR1A3) have declined by more than two thirds since 1990 and by about 8 % compared to 2014. Emissions from diesel passenger cars continued to increase by 6 % between 2014 and 2015. Emissions of NO<sub>x</sub> from heavy-duty vehicles the emissions declined by about 31 % compared to 2014. The decline in emissions from heavy duty vehicles is mainly due to the tightening of the EU road vehicle emission regulation standards.

Other important reasons for the decline of NO<sub>x</sub> emission is the increased use of district heating and the introduction of NO<sub>x</sub> 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<sub>2</sub>) decreased from 106 kt in 1990 to 19 kt in 2015, a reduction of 82 %. The emissions in 2015 decreased by 7 % compared to 2014. About a half of the total SO<sub>2</sub> comes from the energy sector (1). Remaining emissions (52 %) arise from the industrial processes and product use sector. SO<sub>2</sub>-emission from the waste sector is very limited. The largest source is public electricity and heat production (1A1a), 16 %, followed by metal industry (2C), 24 %, and pulp and paper industry (2H1), 21 %. Transport (1A3) was a major source of SO<sub>2</sub> in early 90s but now is responsible for just 2 % of the total emission. The general reduction in these sectors including the transport sector is mainly due to a transfer from fuels with high sulphur content to low-sulphur fuels.

### ***Ammonia***

The total emissions of ammonia (NH<sub>3</sub>) amounted to 60 kt in 2015. Compared to emission levels in 1990, the emissions were 8 % lower in 2015. The agriculture sector was the dominant source of NH<sub>3</sub> in 2015, accounting for 86 % of total emissions. NH<sub>3</sub> is emitted from farm animals dung and urine and the use of inorganic fertilizers. The rest of the emission comes mainly from pulp and paper industry and transport, mainly from urea in vehicles filters that release HN<sub>3</sub>. The main drivers for the reduced emission are a decline in number of animals, a reduced use of inorganic fertilizers and a more effective production.

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

In 2015, a total of 164 kt of NMVOCs were emitted in Sweden. Less than a half (43 %) of the NMVOC emissions come from the industrial processes and product use sector (NFR2). The energy sector and the agriculture sector contributed with 37 and 19 %, respectively. Remaining emissions (0.4 %) arise from the waste sector.

The total emissions of NMVOCs have declined by 54 % since 1990 but increased marginally compared to 2014. The decline is sharp in the energy sector (mainly transport) and is clearly visible in the industrial processes and product use sector, amounting to about 71 % and 34 %, respectively compared to 1990. The main drivers for the sharp decrease in the energy sector in the last two decades are the increased energy efficiency in cars and the introduction of stricter emission standards in the EU- regulations for road vehicles.

### ***Carbon monoxide***

The aggregated emissions of carbon monoxide (CO) have decreased from 1100 kt in 1990 to less than 500 kt in 2015, a decline of 58 %. In 2015, the energy sector (NFR1) accounted for most of the CO emission (94 %). The rest (6 %) comes from the industrial processes and product use sector. CO-emission from the waste sector is very limited. Emissions of CO from transport sector decreased by 87 % between 1990 and 2015. The introduction of catalytic converters in cars is the main driver for this reduction.

### ***Particles Matter (PM<sub>10</sub> and PM<sub>2.5</sub>)***

In 2015, emissions of PM<sub>10</sub> and PM<sub>2.5</sub> in Sweden were about 38 and 19 kt, respectively. Compared to 1990, the emissions have been reduced by 32 % and 47 %, respectively and by 0 and 2 % since 2014. Road transport is a large source for the emissions of PM. The amount of emissions depends on total traffic work and the use of studded tires. The main reason for the overall reductions in transport sector since 1990 is stricter European emission standards, resulting in lower emissions from heavy duty vehicles and busses. The combined emissions of PM from road abrasion, tires- and brake wear show an increasing trend. This is because the total amount of traffic has increased since 1990.

### ***Black Carbon***

Emissions of black carbon (BC) were 3.3 kt in 2015. The emissions were 30 % lower in 2015 than in 2000 and decreased by 4 % since 2014. The largest source is other sectors (NFR1A4) accounting for 36 % of the total BC emissions. The transport sector (NFR1A3) accounted for about one-fourth of total BC emissions in 2015 of which road traffic is the major contributor of the emissions in the sector. Emissions from road transport have been halved since 2000 as a result of stricter exhaust requirements.

### ***Poly Aromatic Hydrocarbons***

Emissions of poly aromatic hydrocarbons (PAH-4) were 12.3 tonnes in 2015. The emissions have been reduced by 31 % since 1990 and by 1 % since 2014. Wood combustion for residential heating is the dominant emission source for PAH, accounting for about two-third of the total emissions.

The largest reduction of PAH-4 emissions comes from the metal industry, 83 %, compared to 1990, and has been achieved through the application of new technologies.

### ***Hexachlorobenzene***

The total emissions of hexachlorobenzene (HCB) were 2.5 kg in 2015. Emissions have increased by 80 % since 1990 and increased by 1 % compared to 2014. The largest source of HCB emissions in 2015 was the electricity- and heat production, 37 % of the total emissions. In addition, emissions from electricity- and heat production have doubled since 1990, mainly due to increased use of biomass as a fuel. The increased emission of HCB from iron and steel industry since 1990 is due to increased production volume. The largest increase of HCB in relative terms comes from the incineration and open burning in the waste sector, which has increased by 300 % times since 1990, due to increased combustion of hazardous waste.

### ***Priority Heavy Metals***

In 2015, the total emissions of cadmium (Cd) in Sweden were 544 kg, a decrease of 77 % compared to 1990. The largest sources of Cd emissions in 2015 were electricity- and heat production, the industrial processes and product use and stationary combustion in the residential sector, accounting for about one-fourth each of the total emissions. Emissions from the industrial processes and product use have decreased by more than 90 % since 1990 mainly due to better technologies applied in the metal industry.

In 2015, the total emissions of mercury (Hg) in Sweden were about 413 kg, a decrease of about 70 % compared to 1990. The largest source of Hg emissions in 2015 was electricity- and heat production which was responsible for about one-third of the total emissions. Other large sources are metal industry and manufacturing industries and construction. The waste sector is also a significant contributor. Emissions from industrial processes and product use have decreased by more than 80 % since 1990 mainly due to better technologies applied in the metal industry.

Total emissions of lead (Pb) in Sweden were 10 t in 2015 and have decreased by 97 % compared to 1990. The largest sources of Pb emissions in 2015 were the metal industry followed by the transport sector which accounted for about one-third and one-fourth of the total emission, respectively. Emissions of Pb from the transport sector have decreased by more than 95 % since 1990 due to the phasing out the use of leaded gasoline, while the decrease of emissions from the industrial processes and product use (about 95 %) is mainly attributed to better technologies applied in the metal industry.

# 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<sub>2</sub>, NO<sub>x</sub>, NMVOC, CO and NH<sub>3</sub>, particulate matter, black carbon (BC), various heavy metals and POPs using the revised 2014 Guidelines for Estimating and Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution<sup>4</sup>

This report constitutes Sweden's Informative Inventory Report (IIR) due by March 15 2017. The report contains information on Sweden's inventories for all years from 1980 to 2015 including descriptions of methods, data sources, QA/QC activities carried out, and a trend analysis. The inventory accounts for anthropogenic emissions of SO<sub>2</sub>, NO<sub>x</sub>, NH<sub>3</sub>, NMVOC, CO, BC, TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PAH and dioxins.

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

Sweden uses the revised 2014 Guidelines for Estimating and Reporting Emission Data for reporting to the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the 2013 EMEP/EEA Air Pollutant Emission Inventory Guidebook as methodological guidance<sup>5</sup>. 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<sup>6</sup> 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<sup>7</sup>). Some parts of the methodologies are taken directly from the IPCC Guidelines, the Good Practice Guidance and the 2013 EMEP/EEA Air Pollutant Emission Inventory Guidebook.

## 1.1 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.

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<sup>4</sup> [http://www.ceip.at/fileadmin/inhalte/emep/2014\\_Guidelines/ece.eb.air.125\\_ADVANCE\\_VERSION\\_reporting\\_guidelines\\_2013.pdf](http://www.ceip.at/fileadmin/inhalte/emep/2014_Guidelines/ece.eb.air.125_ADVANCE_VERSION_reporting_guidelines_2013.pdf)

<sup>5</sup> <http://www.eea.europa.eu/publications/emep-eea-guidebook-2013>

<sup>6</sup> <http://www.ipcc-nggip.iges.or.jp/public/2006gl/>

<sup>7</sup> <http://www.ipcc-nggip.iges.or.jp/public/gp/english/>

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.

### **1.1.1 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 29<sup>th</sup> 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.

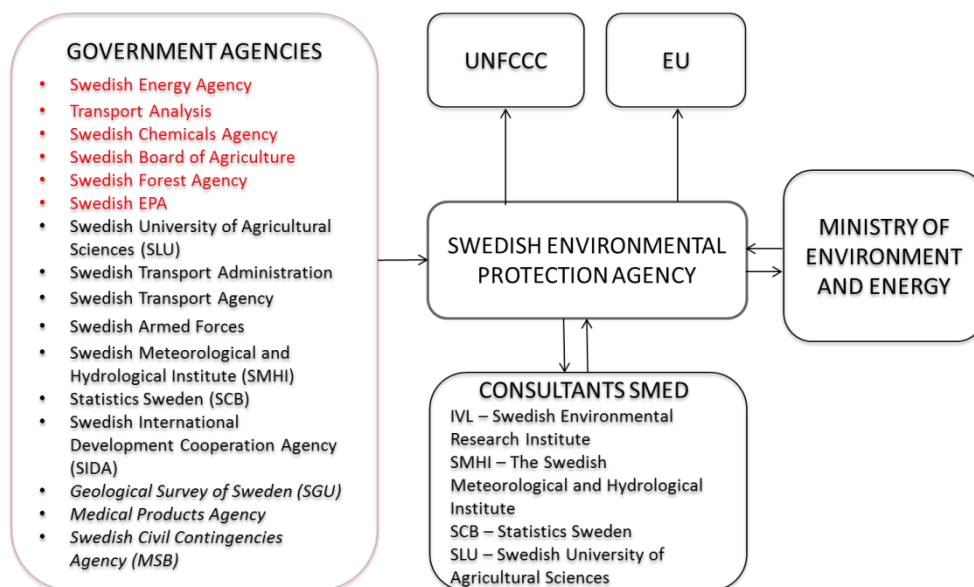
According to Directive 2003/87/EC and national Act (2004:1199) on emission trading, emission data for plants included in the emission trading system should be reported annually. These data are used as a supplementary source within this air pollutant inventory.

### **1.1.2 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 red). 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.**

#### 1.1.2.1 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.

#### 1.1.2.2 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
<b>Energy</b>	Swedish Energy Agency, the Swedish Transport Administration, the Swedish Transport Agency, Transport Analysis, the Swedish Armed Forces.	Swedish Energy Agency (energy sector excluding transports) Transport Analysis (transports)
<b>Industrial Processes and Product Use</b>	Swedish Chemicals Agency, Medical Products Agency.	The Swedish EPA (CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O) Swedish Chemicals Agency
<b>Agriculture</b>	Swedish Board of Agriculture, Statistics Sweden (SCB).	The Swedish Board of Agriculture
<b>Land Use, Land-Use Change And Forestry Sector</b>	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 The Swedish Board of Agriculture (agriculture related parts)
<b>Waste</b>		The Swedish EPA

#### 1.1.2.3 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)<sup>8</sup>, 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). 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 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

<sup>8</sup> <http://www.smed.se/>



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.

## 1.2 Inventory planning, preparation and management

The present Swedish air pollutant inventory was compiled according to the recommendations for inventories set out in the revised 2014 Guidelines for Estimating and Reporting Emission Data for reporting to the Convention on Long-Range Transboundary Air Pollution (CLRTAP<sup>9</sup>) and the 2013 EMEP/EEA Air Pollutant Emission Inventory Guidebook as methodological guidance<sup>10</sup> 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<sup>11</sup>). 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.

### 1.2.1 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<sup>12</sup>. 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 followed up in accordance with specified quality requirements so that the inventory is continuously developed and improved.

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<sup>9</sup> [http://www.ceip.at/fileadmin/inhalte/emep/2014\\_Guidelines/ece.eb.air.125\\_ADVANCE\\_VERSION\\_reporting\\_guidelines\\_2013.pdf](http://www.ceip.at/fileadmin/inhalte/emep/2014_Guidelines/ece.eb.air.125_ADVANCE_VERSION_reporting_guidelines_2013.pdf)

<sup>10</sup> <http://www.eea.europa.eu/publications/emep-eea-guidebook-2013>

<sup>11</sup> <http://www.ipcc-nggip.iges.or.jp/public/gp/english/>

<sup>12</sup> Swedish EPA, National Greenhouse Gas and Air Pollutants Inventory System in Sweden

## Procedural Arrangements



**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 (2005:626) 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.<sup>13</sup> 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.

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.

<sup>13</sup> Manual for SMED:s Quality System in the Swedish Air Emission Inventories, available at [www.smed.se](http://www.smed.se)

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	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec		
Swedish Energy Agency					data for the energy sector available April 15th																					
Swedish Transport Administration, Swedish Transport Agency, National Maritime Administration, Swedish Armed Forces							data for the transport sector available June 18th																			
Annual Environmental Reports				data for industrial processes and waste sector available from March 31st																						
Trade associations and private companies				data for industrial processes available																						
Swedish Chemicals Agency									data for the solvents and other products use sector available August 15th																	
Swedish Board of Agriculture					data for the agriculture sector available August 1st																					
Statistics Sweden				data for the agriculture sector available April 15th																						
Trade associations					data for waste sector available																					
Swedish EPA, Statistics Sweden	data for waste sector (some intermittent) available																									
SMED	development projects																									
Swedish EPA	decision on and approval of results from development projects																									
SMED				data collection, calculations and internal QA/QC																						
SMED				preparation of report for peer review to EPA									October 15th													
Swedish Energy Agency, Transport Analysis, The Swedish EPA, Swedish Chemicals Agency, Swedish Board of Agriculture, National Board of Forestry																										
SMED						national peer review								October 16th - October 31st												
Swedish EPA						finalization of report after peer review																				
Swedish EPA						finalization of report after peer review								publishing mid December												
Swedish EPA														submission to NEC directive EU December 31st												
Swedish EPA																	submission to CLRTAP February 15th									
UNECE	International Review																									

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

### **1.2.2 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.

### **1.2.3 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.

#### 1.2.4 Inventory preparation (DO)

SMED gather 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.

##### 1.2.4.1 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 statistics 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 2013 Guidebook are used to complement the national estimates.

##### 1.2.4.2 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 Road Administration, the National Rail 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 EMEP/EEA 2013 Guidebook are used to complement the national estimates.

##### 1.2.4.3 ENERGY – FUGITIVE EMISSIONS

For handling of solid fuels, activity data from Statistical 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 EMEP/EEA 2013 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. 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.

#### 1.2.4.4 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 EMEP/EEA 2013 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.

#### 1.2.4.5 AGRICULTURE

Data on livestock population, 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 EMEP/EEA 2013 Guidebook are used to complement the national estimates.

#### 1.2.4.6 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 EMEP/EEA 2013 Guidebook.

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

#### 1.2.5.1 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 8.1 in IPCC Good Practice Guidance (2000), 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
- 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).

All QC measures performed are documented by SMED in QC checklists for each CRF code or group of codes. When the reporting tables and the NIR are completed by SMED, a project quality control team (QC-team) performs checks before internal delivery to the SMED quality coordinator. The QC-team consists of one inventory compiler from each SMED organization (IVL, SCB and SLU) and the review

is performed so that each member of the team checks data and documentation from the inventory that it has not been involved in developing. In addition, the QC-team performs data checks in terms of the functionality of the CRF Reporter (i.e. checks of completeness, time-series consistency and recalculation explanations).

Before delivery of the inventory to the Swedish EPA, the SMED quality coordinator performs the final quality control. The QC-team and SMED quality coordinator checks serve as both quality control and quality assurance in accordance with the 2006 IPCC guidelines.

In addition, the project management team performs checks of submission data using the REPDAB tool<sup>14</sup>.

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

CRF		Action
1A, 1B and parts of 2	Energy amounts	Analysis of differences between the CRF 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.

#### 1.2.5.2 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 2016 submission, the Swedish EPA inventory compiler team consisted of seven 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.

<sup>14</sup> <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 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 9). 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 1.2.8.

The in-depth expert peer review includes methodologies, models, activity data and emissions 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 1.2.8.

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 1.2.8.

### **1.2.6 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<sup>15</sup>.

The Swedish EPA submits the inventory to the NEC Directive/European Commission on December 31<sup>st</sup> and to the CLRTAP/UNECE on February 15<sup>th</sup>. Reported data in the submission of year X relates to emissions year X-2, in other words emissions which took place during 2011 are reported in early 2013.

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<sup>15</sup> [www.naturvardsverket.se](http://www.naturvardsverket.se)

### 1.2.7 Data storage

A system for handling emission data, entitled Technical Production System (TPS)<sup>16</sup>, 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<sup>17</sup>. 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 the 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.

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

Each year, all comments received from national and international reviews that are not already addressed and also 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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<sup>16</sup> <https://tps.naturvardsverket.se/>

<sup>17</sup> [www.projectplace.com](http://www.projectplace.com)

## 1.3 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, level and trend assessments are carried out for the following pollutants: As, Cd, CO, Cr, Cu, dioxins/furans, Hg, NH<sub>3</sub>, Ni, NMVOC, NO<sub>x</sub>, PAH 1-4, Pb, PM<sub>2.5</sub>, PM<sub>10</sub>, Se, SO<sub>2</sub>, TSP and Zn. The level and the trend assessment are done with both the approach 1 and the approach 2 methods. The results of the Swedish key source analysis for 2015 are presented in Annex 1 together with the methodology.

## 1.4 General uncertainty evaluation

Since submission 2012, the general uncertainty evaluation is updated every submission. The uncertainties in the Swedish emission inventory reported to the CLRTAP were for the first time evaluated in 2003<sup>18</sup>, covering the emissions in 1990 and 2001. In order 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.

In 2009, SMED performed a study to provide transparent uncertainty estimates of national emissions for the Swedish reporting to the CLRTAP of the submission 2010 in accordance with the Tier 1 methodology described in the EMEP/EEA Guidebook 2009 (Table 6-1).<sup>19</sup>

The complete results of the Swedish uncertainty analysis for 2015 are presented in Annex 1 together with the methodology. The summary table below (Table 1- 3) show the uncertainty for the total emissions together with the uncertainty for the trend for all substances. The tables A.1.1 to A.1.19 in the annex show for all pollutants; estimated emissions 1990 and 2015, the uncertainty for the trend 1990-2015 and the uncertainty in national emissions 2015 together with the estimated uncertainty for the emission factor and for the activity data. For several of the substances the majority of the total variance derives from only a limited number of sources. For example, 72% of the variance in total NO<sub>x</sub> emissions derives from the application of mineral fertilisers. In general, the emission factors are more uncertain than the activity data.

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<sup>18</sup> Kindbom, 2004

<sup>19</sup> Gustafsson, 2009

**Table 1- 3. Summary of uncertainties in total inventory by pollutant in 2015 and trend uncertainties 1990-2015.**

Pollutant	Uncertainty in total inventory 2015 (%)	Uncertainty introduced into the trend 1990-2015 (%)
As	89.7	11.6
Cd	37.3	7.3
CO	22.2	11.8
Cr	27.8	4.7
Cu	61.8	12.9
DIOX	133.3	106.2
Hg	69.6	2.6
NH <sub>3</sub>	25.2	15.8
Ni	23.0	2.9
NMVOC	20.3	6.8
NO <sub>x</sub>	27.7	8.3
PAH 1-4	677.0	112.5
Pb	22.5	0.6
PM <sub>2.5</sub>	18.4	5.1
PM <sub>10</sub>	15.2	5.2
Se	348.6	161.4
SO <sub>2</sub>	9.2	1.5
TSP	11.8	4.8
Zn	161.6	52.1

## 1.5 General assessment of the 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 no pollutants not yet have been estimated, but may occur, include: 1A3ei Pipeline transport; 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; and 5C1biii, Clinical waste incineration.

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

As a consequence of the in-depth review of the 2013 submission of the Swedish inventory under the CLRTAP and EU NEC directive, Sweden has implemented emission estimates for all missing sources and pollutants in the Swedish inventory where there are default emissions factors available and they can be considered to be representative of the national circumstances (first time in Submission 2016). In Table 1-4a and 1-4b those sources are listed that are not estimated in the Swedish emission inventory and where there are default emission factors available in the

EMEP/EEA Guidebook 2013. For each of these sources, 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 <sub>x</sub>	NMVOC	SO <sub>x</sub>	NH <sub>3</sub>	PM <sub>2.5</sub>	PM <sub>10</sub>	TSP	BC	CO
2B10b					NE (2)	NE (2)	NE (2)		
1B1c				NE (5)				NE	
2C1b				NE (5)					
2C1c				NE (5)					NE (5)
2C7a								NE (3)	
2C7d					NE (3)	NE (3)	NE (3)		
3B4h					NE(6)	NE(6)	NE(6)		
5C1a	NE (7)	NE (7)	NE (7)					NE (7)	NE (7)
5C1bi	NE (7)	NE (7)	NE (7)					NE (7)	NE (7)
5C1biii	NE (7)	NE (7)	NE (7)				NE (7)	NE (7)	NE (7)
5C1biv								NE (7)	
11B	NE (8)	NE (8)	NE (8)	NE (8)	NE (8)	NE (8)	NE (8)		NE (8)

**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
1B1b			NE (1)	NE (1)				NE (1)		NE	NE
1B1c										NE	NE
1B2A1	NE (5)	NE (5)	NE (5)	NE (5)	NE (5)	NE (5)	NE (5)	NE (5)	NE (5)		
1B2A4							NE				
1B2C21	NE (5)	NE (5)	NE (5)	NE (5)	NE (5)	NE (5)	NE (5)	NE (5)	NE (5)	NE	NE
2C1b									NE (4)	NE (5)	NE (4)
2C1c									NE (4)		
2C7a											NE (4)
2C7b							NE (3)				
2K			NE (4)								NE (4)
5C1bi									NE (7)	NE (7)	
5C1biii	NE (7)	NE (7)	NE (7)	NE (7)	NE (7)	NE (7)	NE (7)	NE (7)			

(1) Notation key should be IE (included in NFR2C1). Will be corrected in submission 2018

(2) Notation key should be IE (included in NFR2B10a). Will be corrected in submission 2018

(3) Notation key should be IE (included in NFR2C7c). Will be corrected in submission 2018

(4) Default EF results in unreasonable emissions and is not applicable to Swedish conditions

(5) Not possible to estimate with the country-specific methodology currently used.

(6) No default method exists

(7) Notation key should be IE (included in NFR 5C1bii). Will be corrected in submission 2018

(8) Source is not mandatory

For the 1980's no other data than the National total is reported in the NFR-tables for most of the pollutants and NE is inserted for sources where emissions could not be reported but would be expected. Data which are detailed enough to correctly report emissions by source for the 1980's are not available. Particles, PAH and dioxin are however reported for individual sources from 1980. From 1988 this also applies for NMVOC.

### **1.5.1 Energy**

Estimated emissions are considered to be complete for most sources. There might still be some incompleteness as regards 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<sub>2</sub> 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.

### **1.5.2 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 air pollutant emission inventory guidebook – 2013. 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.

### **1.5.3 Agriculture**

Emissions of NO<sub>x</sub> and NH<sub>3</sub> from crop residues are currently not estimated, because neither a country specific method nor a default method in the guidebook exists. Particulate matter from fur-bearing animals planned to be added to the inventory in submission 2018. Also emissions of NH<sub>3</sub> from application of sewage sludge are planned to be implemented in submission 2018. Beyond that all relevant agricultural emissions and sources are considered to be included in the inventory. For example does the majority of the country's horses not belong to a farm, but are despite that included in the agricultural sector of the inventory. All sales of fertilizers are included, also quantities used in other sectors.

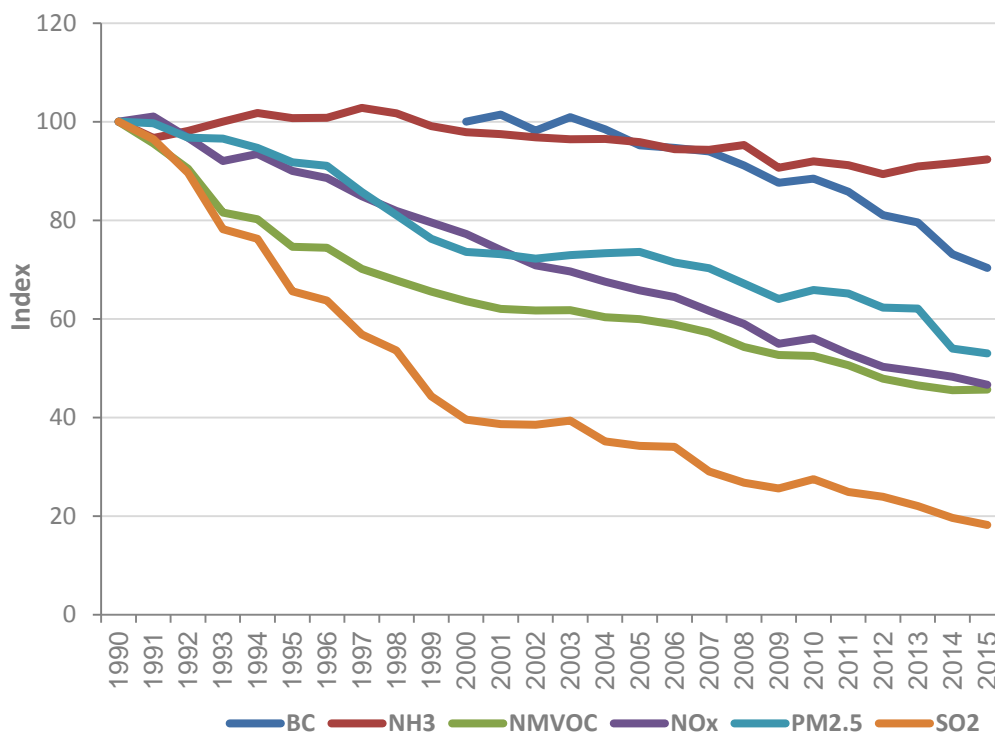
### **1.5.4 Waste**

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 complete. 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 2013.

## 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 ( $\text{SO}_2$ ,  $\text{NO}_x$ ,  $\text{NH}_3$ , NMVOCs,  $\text{PM}_{2.5}$  and BC) have been reduced since 1990.

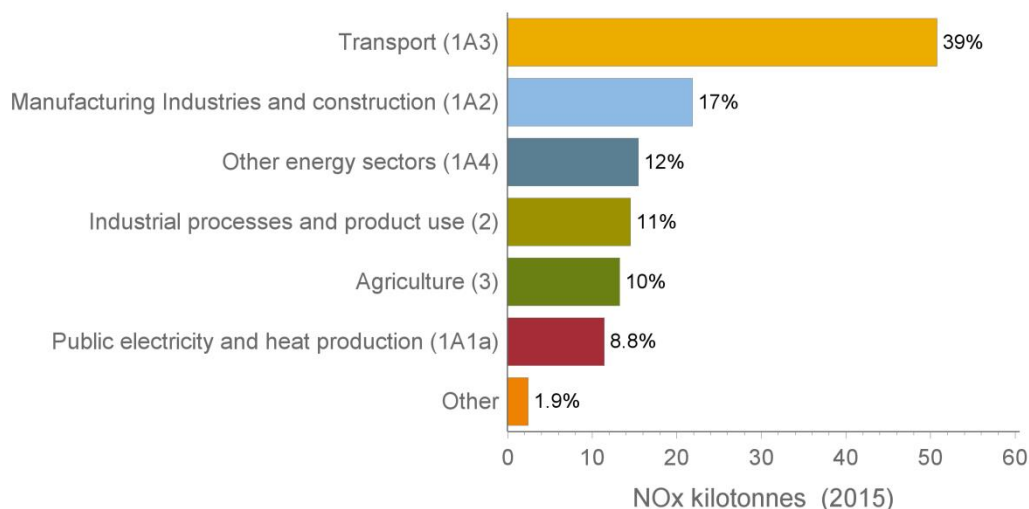


**Figure 2-1. Trends in emissions 1990-2015 for  $\text{NO}_x$ ,  $\text{SO}_2$ ,  $\text{NH}_3$ , NMVOC,  $\text{PM}_{2.5}$  index 1990=100 and BC index 2000=100.**

### 2.1.1 Nitrogen oxides (NO<sub>x</sub>)

Swedish emissions of NO<sub>x</sub> amounted to 130.3 kt in 2015. Total emissions have decreased by 53 % since 1990 and by 3 % since 2014.

The different sectors' share of the NO<sub>x</sub> emissions in Sweden 2015 is shown in Figure 2-2.

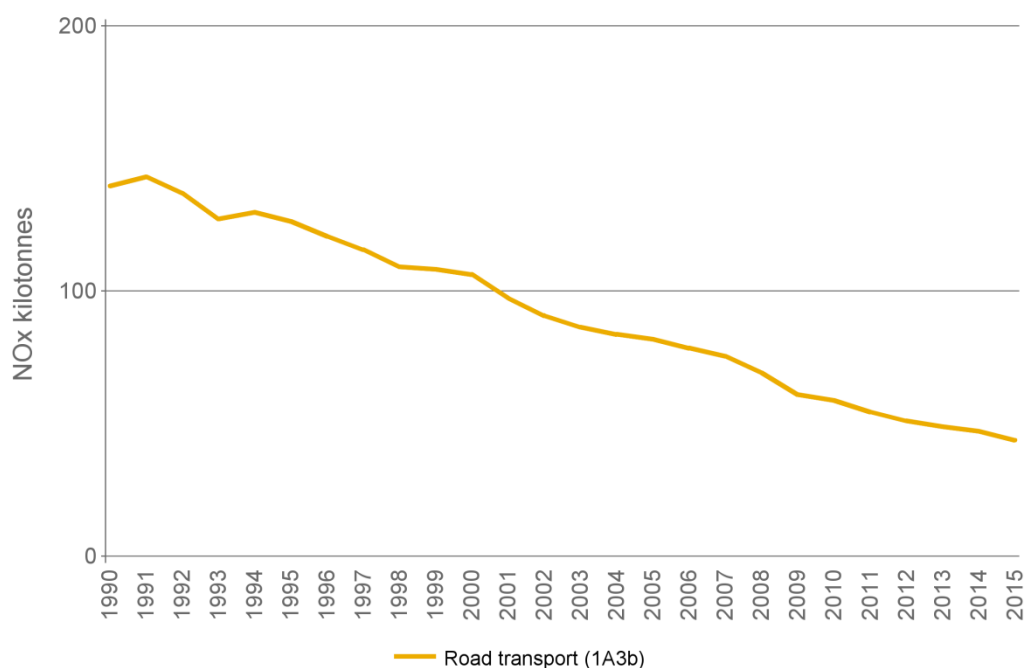


**Figure 2-2. Distribution of NO<sub>x</sub> emissions among major contributing sectors and subsectors in 2015**

The largest source of NO<sub>x</sub> emissions in 2015 was the transport sector (NFR1A3), where emissions amounted to 51.4 kt, corresponding to 39 % of total emissions. Emissions from the transport sector have been reduced by 69 % since 1990 and by 7 % since 2014. The main reason for the reduction since 1990 is stricter emission requirements for new vehicles during the period.

NO<sub>x</sub> emissions from passenger cars (NFR1A3b) were 76 % lower in 2015 compared to 1990 but since 2012 the emissions are increasing. Since 1990 there is more than a six fold increase in NO<sub>x</sub> emissions from diesel passenger cars and between 2014 and 2015 the increase was 6 %. The combination of increased use of diesel due to the political ambition to reduce CO<sub>2</sub>-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<sub>x</sub> from gasoline cars and heavy duty vehicles continue to decrease. Emissions from heavy duty vehicles were reduced by 15 % between 2014 and 2015 and by 67 % since 1990.



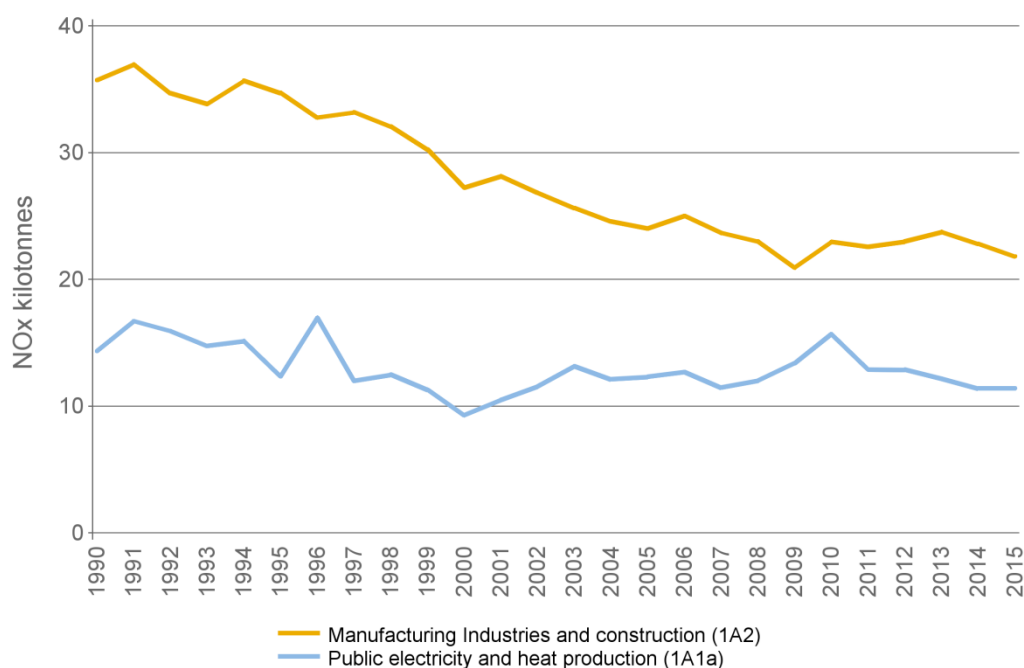


**Figure 2-3. Trend in NO<sub>x</sub> emissions from transport (1A3b) 1990-2015**

The second largest source of NO<sub>x</sub> emissions in 2015 was combustion in manufacturing industries and construction (NFR1A2) in which emissions were 21.8 kt corresponding to 17 % of total emissions. NO<sub>x</sub> emissions in the sector have been reduced by 39 % since 1990 and by 4 % since 2014.

Emissions of NO<sub>x</sub> from electricity and heat generation (NFR1A1a) amounted to 11.4 kt in 2015 corresponding to 9 % of total emissions. Emissions have varied during the period with decreasing emissions during the 90's and increasing emissions between 2000 and 2010. Energy supply for electricity and heat generation more than doubled between 1990 and 2015 while emissions were 20 % lower in 2015 compared to 1990. After 2010 a decreasing trend in emissions can be seen. Emissions to some extent depend on temperature and precipitation resulting in higher emissions during 1996 and 2010 which were cold and dry years.

A NO<sub>x</sub> fee, introduced in 1992, includes combustion plants (NFR1A1a and 1A2) with an output of more than 25 GWh per year. Since the introduction of the fee NO<sub>x</sub> emissions per unit produced energy have been reduced to less than half. This is an important reason why emissions of NO<sub>x</sub> from combustion in manufacturing industries and construction and electricity and heat production have been reduced despite increased energy production.



**Figure 2-4. Trends in emissions from Public electricity and heat production and Manufacturing industries and construction 1990-2015**

Emissions of NO<sub>x</sub> from other sectors (NFR1A4) were 14.4 kt corresponding to 11 % of total emissions in 2015. Emissions have been reduced by 53 % since 1990. The reduction since 1990 is due to expanded district heating and increased use of heat pumps that have replaced oil heaters.

Industrial processes (2) accounted for 11 % or 14.5 kt NO<sub>x</sub> emissions in 2015. Emissions have decreased by 27 % since 1990 and by 1 % since 2014. The main part, 72 %, of the emissions originates from the pulp- and paper industry (NFR2H1).

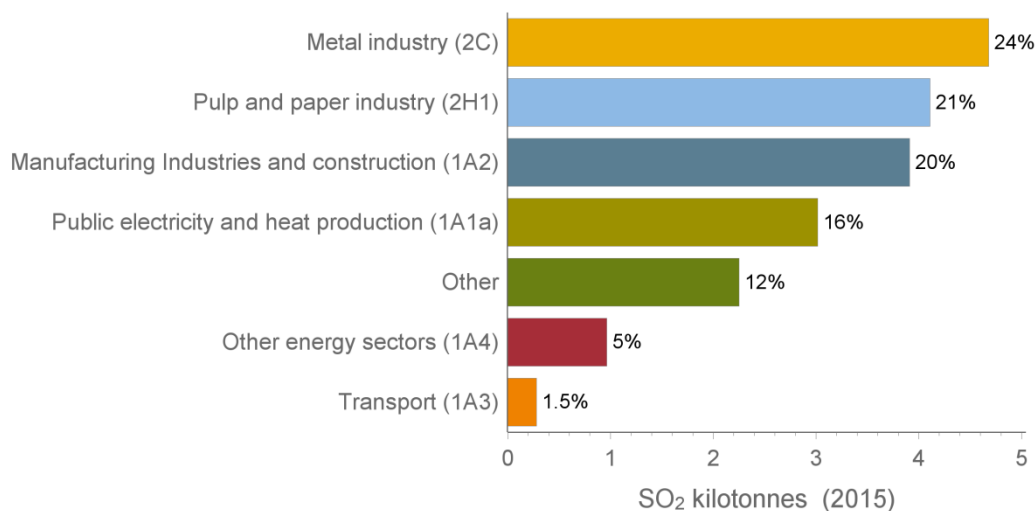
Agriculture contributed with 10 % of total emissions of NO<sub>x</sub> in 2015. The main sources are inorganic fertilizers and animal manure applied to soils. This post is new in the Swedish inventory as from submission 2016 and is considered to have high uncertainty.

### 2.1.2 Sulphur dioxide (SO<sub>2</sub>)

Total emissions of SO<sub>2</sub> have decreased by 82 % since 1990 and by 7 % since 2014 and amounted to 19.3 kt in 2015.

The different sectors share of the SO<sub>2</sub> emissions in Sweden 2015 is shown in Figure 2-5.

z



**Figure 2-5. Distribution of SO<sub>2</sub> emissions among major contributing sectors and sub-sectors in 2015**

Industrial processes (NFR2) was the sector with largest emissions of SO<sub>2</sub> in 2015. Processes within the metal industry (NFR2C) and pulp and paper industry (NFR2H1) generated 4.7 and 4.1 kt of SO<sub>2</sub> respectively in 2015, corresponding to 24 and 21 % respectively. Emissions have been reduced by 52 % and 68 % since 1990 and by 12 % and 4 % since 2014.

Emissions from combustion in manufacturing industries and construction (NFR1A2) amounted to 3.9 kt in 2013, corresponding to 20 % of total emissions. Emissions have been reduced by 81 % since 1990 and by 5 % since 2014. The main reasons for the large reduction since 1990 are a reduced use of oil in the sector and better pollution control.

Emissions from electricity and heat generation (1 NFRA1a) amounted to 3.0 kt in 2015. Emissions from the sector have been reduced by 82 % since 1990 and by 4 % since 2014. The two main reasons for the reduction since 1990 are reduced use of coal and oil and pollution control.

Transport (NFR1A3) and other sectors (NFR1A4) amounted to 1.0 and 0.9 kt respectively in 2014, each corresponding to roughly 4 %. Emissions in these sectors have been reduced by over 90 % since 1990 due to reduced use of oil and reduced sulphur content in the oil used.

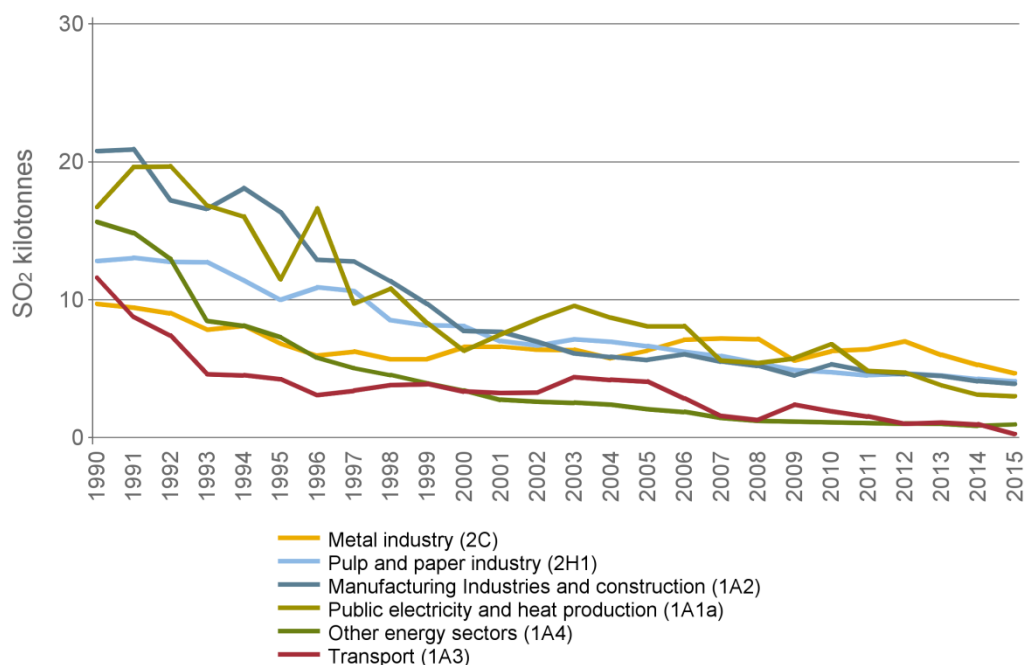


Figure 2-6. Trends in SO<sub>2</sub> emissions from major sectors and subsectors 1990-2015

### 2.1.3 Ammonia (NH<sub>3</sub>)

Total emissions of NH<sub>3</sub> in Sweden were 8 % lower in 2015 than in 1990 and amounted to 60.3 kt. Between 2014 and 2015 emissions increased by 1 %.

The different sectors share of the NH<sub>3</sub> emissions in Sweden 2014 is shown in Figure 2-7.

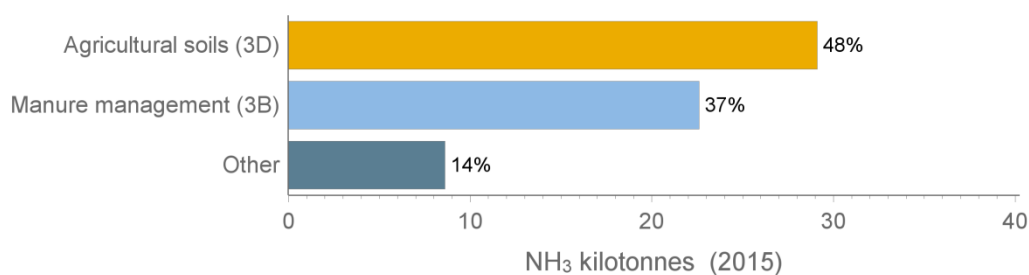
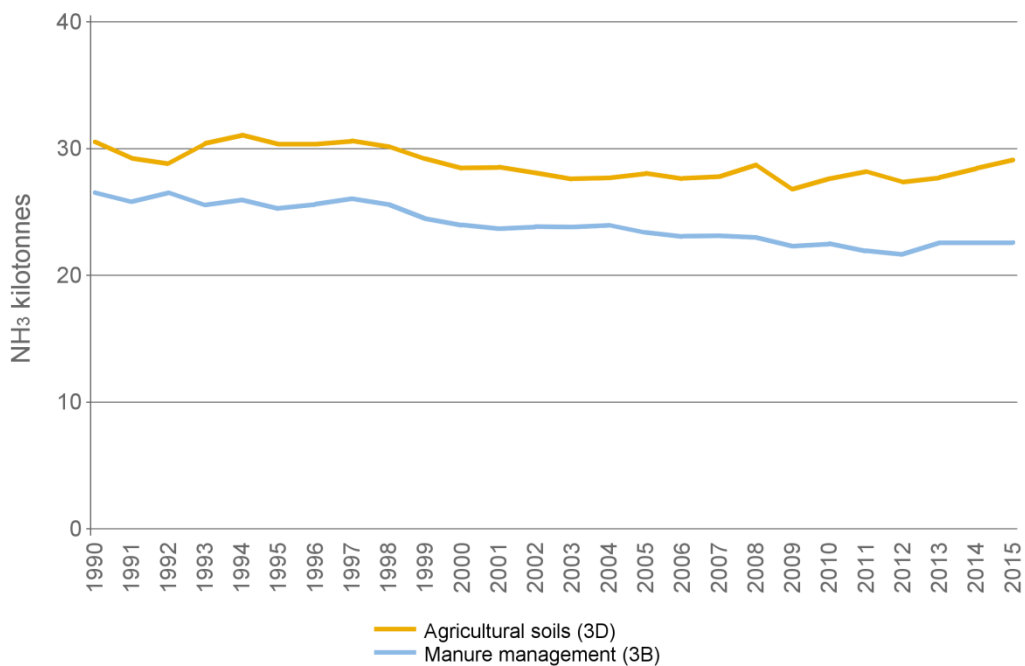


Figure 2-7. Distribution of NH<sub>3</sub> emissions among major contributing sectors and subsectors in 2015

Agriculture (NFR3) was the main source for emissions of  $\text{NH}_3$  in 2015 and emissions were 51.7 kt. Ammonia is emitted from farm animals' dung and urine and during the spreading of animal manure and the use of inorganic fertilizers.

Emissions from agricultural soils 3D were 29.1 kt in 2015 contributing with 48 % to total emissions. The main contributions coming from animal manure and inorganic fertilizers applied to soils. Emissions were slightly lower in 2015 compared to 1990 but since 2012 a slight increase can be discerned.

Emissions from manure management (NFR3B) were 22.6 kt in 2015, contributing with 37 % of total emissions in 2015. The main contribution came from dairy cattle, 3.9 kt, and non-dairy cattle, 9.6 kt. Emissions from manure management were 15 % lower in 2015 compared to 1990. The reasons for the reduction of emissions are a decline in number of animals, a reduced use of inorganic fertilizers and a more effective production. There is a direct relationship between emissions of  $\text{NH}_3$  and the number of animals.

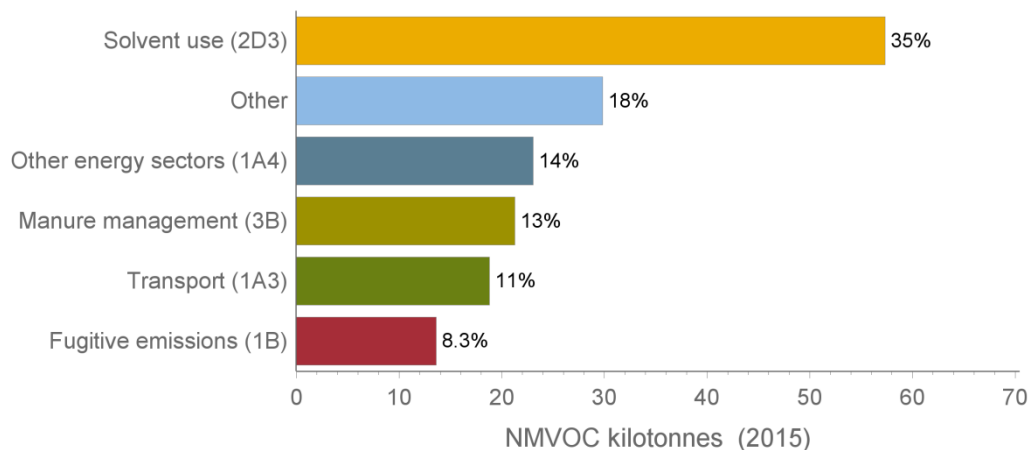


**Figure 2-8. Trend in  $\text{NH}_3$  emissions from manure management (NFR3B) and Agricultural Soils (3D) 1990-2015**

#### 2.1.4 NMVOC

Emissions of NMVOC which amounted to 163.9 kt in 2015 have decreased by 54 % since 1990 and remained stable since 2014.

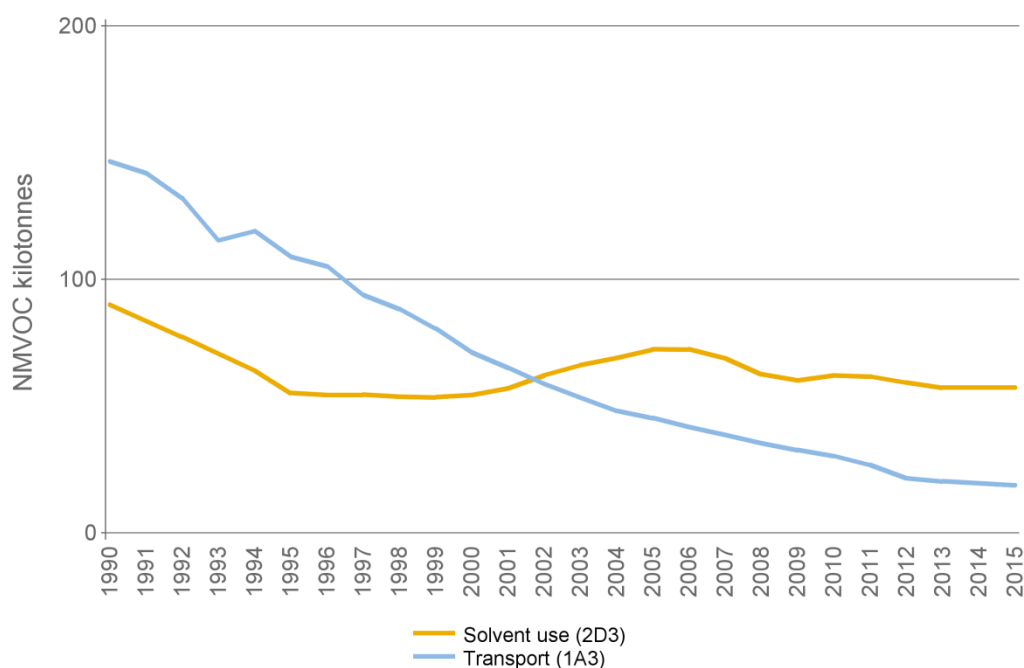
The different sectors' share of the NMVOC emissions in Sweden 2015 is shown in Figure 2-9.



**Figure 2- 9. Distribution of NMVOC emissions among major contributing sectors and subsectors in 2015**

Emissions of NMVOC from solvent use (NFR2D3) were 57.3 kt in 2015 and it was the dominant source contributing with 35 % to total emissions. Emissions from solvent use have decreased by 36 % since 1990. Important reductions occurred from coating applications (NFR2D3d) where emissions decreased by 68 % since 1990. Emissions from other non-specified (NFR2D3i) have more than doubled since 1990.

Emissions from the transport sector (NFR1A3) which accounted for 18.8 kt, corresponding to 11 % of national totals in 2015, have decreased by 87 % since 1990 and by 4 % since 2013. The main part of the reduction since 1990 (58 %) comes from passenger cars (NFR1A3bi) with the main reason being more energy efficient cars and the introduction of new exhaust requirements. Emissions from gasoline evaporation (NFR1A3bv) have been reduced by 98 % since 1990 due to emission control measures.



**Figure 2-10. Trends in NMVOC emissions from solvent use (2D3) and transport (1A3) 1990-2015**

Emissions from other sectors (NFR1A4) amounted to 23.0 kt in 2015, corresponding to 14 %. Since 1990 emissions have increased by 9 %. The main contribution, 15.7 kt or 10 % 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 stationary combustion in other sectors were at the same level in 2015 as in 1990. Emissions from working machinery increased until 2008 and have decreased since then. In 2015 emissions from working machinery were 23 % above 1990 level.

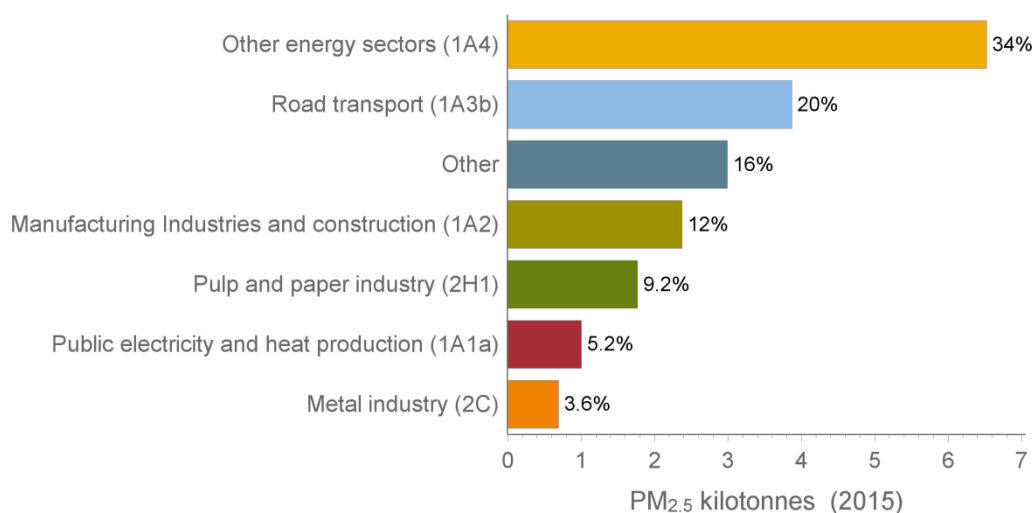
Emissions of NMVOC from manure management (NFR3B) were 21.3 kt in 2015, corresponding to 13 %. Emissions are related to the number of animals and have as a result been reduced by 22 % since 1990.

Fugitive emissions (NFR1B) of NMVOC were 13.6 kt in 2015 (nearly 8 % of total emissions of NMVOC). The emissions have decreased by 57 % since 1990 but increased by 9 % since 2013. The main part (close to 70 %) of fugitive emissions originates from refineries and the main reduction can be seen in the emissions from gasoline distribution.

### 2.1.5 Particulate matter (PM<sub>2.5</sub>)

Emissions of PM<sub>2.5</sub> were 19.2 kt in 2015. Emissions have been reduced by 47 % since 1990 and by 2 % since 2014.

The different sectors' share of the PM<sub>2.5</sub> emissions in Sweden 2015 is shown in Figure 2-11.



**Figure 2-11. Distribution of PM<sub>2.5</sub> emissions among major contributing sectors and subsectors in 2015**

Other sectors (NFR1A4) were the largest source of PM<sub>2.5</sub> in 2014 accounting for 6.5 kt or one third of total emissions in 2015. Emissions were 14 % lower in 2015 compared to 1990. The main part of the emissions in the sector (89 %) came from stationary biomass combustion and biomass combustion in the residential sector (NFR1A4b). Emissions from biomass combustion in the residential sector, which have varied over the period, were 10 % lower in 2015 compared to 1990.

Emissions from road transport (NFR1A3b), the second largest source, amounted to 3.8 kt in 2015. Emissions from road transport have decreased by 34 % since 1990. The main reason for reductions since 1990 is stricter standards resulting in lower emissions from heavy duty vehicles (85 % reduction since 1990) and buses (93 % reduction since 1990). Specific emissions of PM<sub>2.5</sub> from diesel passenger cars have been reduced by over 90 % since 1990 but overall emissions have not decreased to the same extent due to the sharp increase in diesel consumption which resulted in emissions being 53 % lower in 2015 compared to 1990. The emissions from road abrasion, which depend on the total traffic work and the use of studded tires, increased with 25 % between 1990 and 2015.



Emissions from combustion in manufacturing industries and construction (NFR1A2) were 2.4 kt in 2015. Emissions from the sector have been reduced by 48 % since 1990 and by 2 % since 2014. About half of the total emissions in the sector originated from biomass combustion within pulp- and paper (NFR1A2d) and other (NFR1A2g) including combustion in industries for wood and wood products. Emissions from biomass combustion in the sector have been halved since 1990. Another 30 % of emissions in the sector originate from off-road vehicles and other machinery in manufacturing industries and construction (NFR1A2g), mainly from the mining industry.

Emissions from electricity and heat generation (NFR1A1a) amounted to 1.0 kt in 2015. Emissions have decreased by 53 % since while energy supply for electricity and heat generation more than doubled between 1990 and 2015. The reason for this decrease is better pollution control. Emissions in 2015 were at the same level as in 2014.

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 1.9 and 0.7 kt respectively in 2015. In the metal industries there was a large reduction (57 %) in emissions between 2013 and 2014 much of which can be explained by a new electro filter at a large pellet plant. Between 2014 and 2015 emissions were reduced by 20 %. There has been a significant reduction (72 %) in emissions from the pulp- and paper industry between 1990 and 2015.

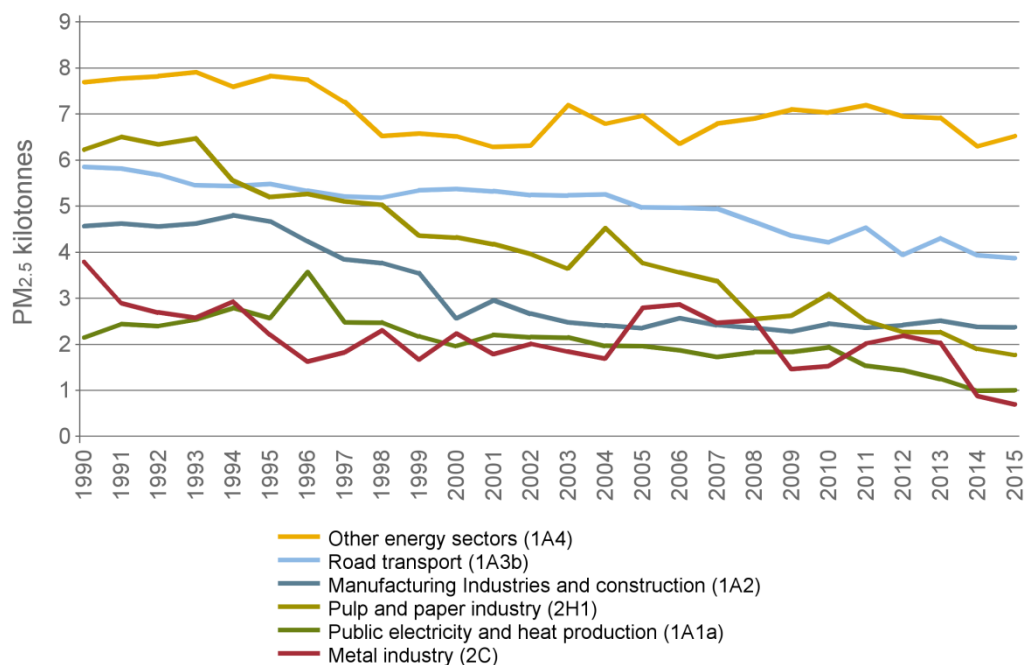
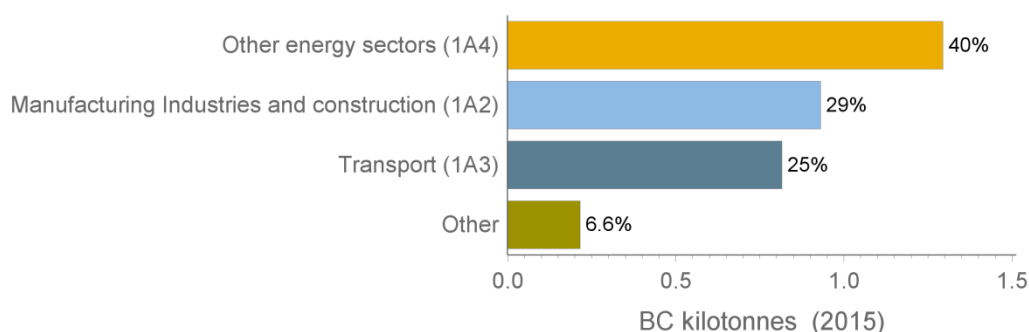


Figure 2-12. Trends in PM<sub>2.5</sub> emissions from major sectors and subsectors 1990-2015

### 2.1.6 Black carbon (BC)

Total emissions of BC in Sweden were 3.3 kt in 2015. Emissions have been reduced by 30 % since 2000 and by 4 % since 2014.

The share of the BC emissions in Sweden 2015 is shown in Figure 2-13.



**Figure 2-13. Distribution of BC emissions among major contributing sectors and sub-sectors in 2015**

The largest source of BC emissions with over one third of emissions in 2015 is other sectors (NFR1A4) where emissions amounted to 1.3 kt. The main part, 1.0 kt, originates from stationary biomass combustion. Emissions of BC from stationary biomass combustion were 27 % higher in 2014 than in 2000. Compared to 2013 emissions were 4 % higher. Off-road vehicles and other machinery in agriculture, forestry and fishing contribute by 23 % of emissions in the sector in 2015.

The second largest source is the transport sector (NFR1A3) in which emissions amounted to 0.8 kt in 2015. The most important source was road transport (NFR1A3b), contributing with 0.7 kt or 80 % of the emissions in the sector. Emissions from road transport have been reduced by 60 % since 2000 and the most important contribution to the reduction comes from heavy duty vehicles (73 %) and passenger cars (63 %) since 2000. The reductions are a result of stricter exhaust requirements.

Emissions from combustion in manufacturing industries and construction (NFR1A2) were 0.9 kt in 2015. Emissions were 10 % lower in 2015 compared to 2000 and 2 % lower compared to 2014. About half of the emissions can be contributed to biomass combustion within pulp- and paper (NFR1A2d) and other (NFR1A2g) including combustion in industries for wood and wood products. Emissions from biomass combustion in the sector have been halved since 1990. Another 30 % originates from off-road vehicles and other machinery in (NFR1A2g), mainly from the mining industry.

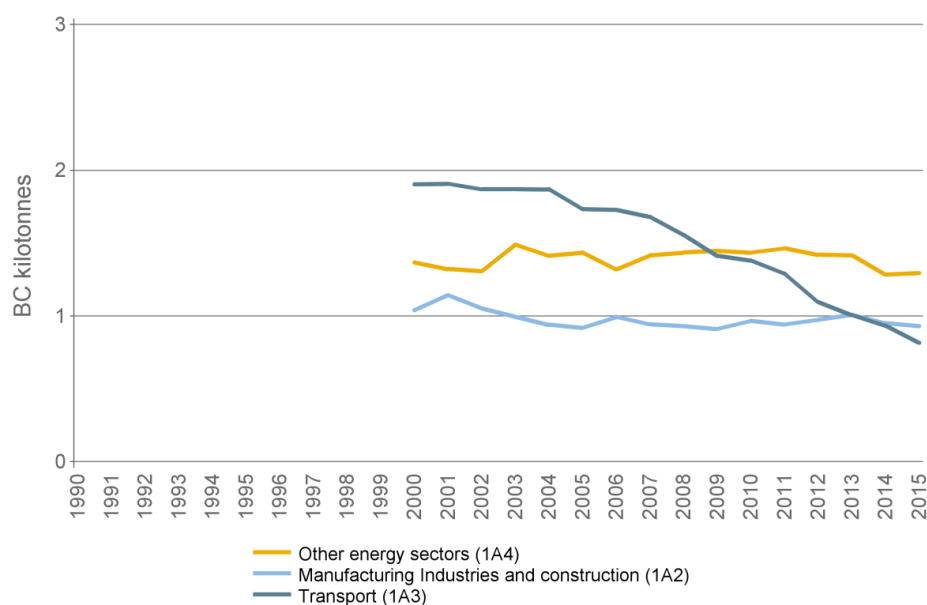


Figure 2-14. Trends in BC emissions from major sectors and subsectors 1990-2015

## 2.2 CO, PM<sub>10</sub>, PAH-4, HCB & Dioxins

Emissions of CO, PM<sub>10</sub> and dioxins show a decreasing trend over the period (1990-2015). Emissions of PAH-4 varied between 1990 and 2008. Between 2008 and 2009 there was a sharp decrease in emissions due to change in technology in the aluminum industry. Emissions of HCB show an increasing trend over the period with the main reason being increased use of biomass in electricity- and heat production and increased production of iron and steel.

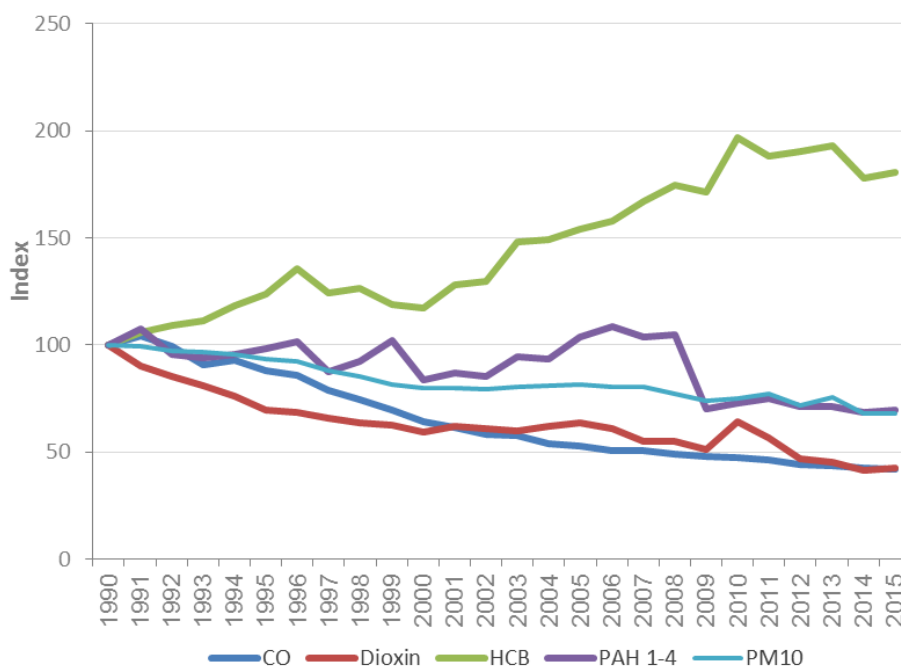
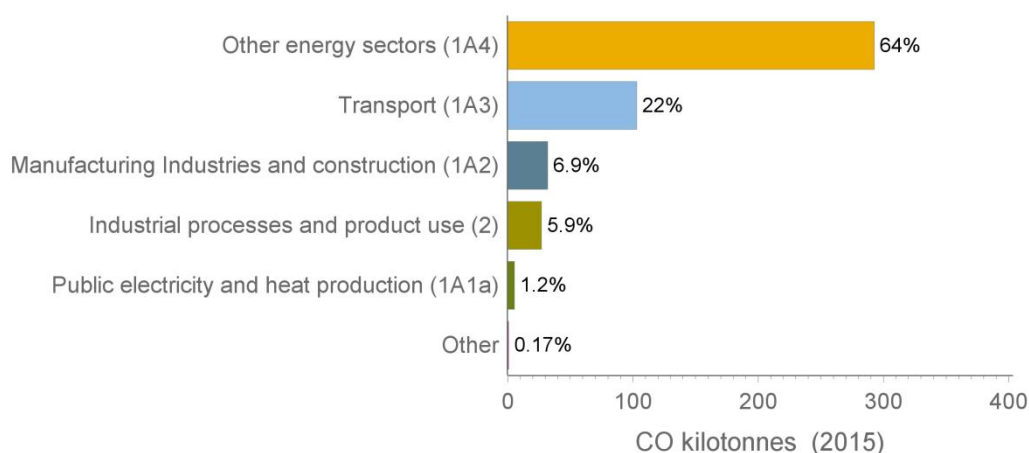


Figure 2-15. Trends in emissions 1990-2015 for CO, PM<sub>10</sub>, PAH-4, HCB and dioxins. Index 1990=100

### 2.2.1 Carbon monoxide (CO)

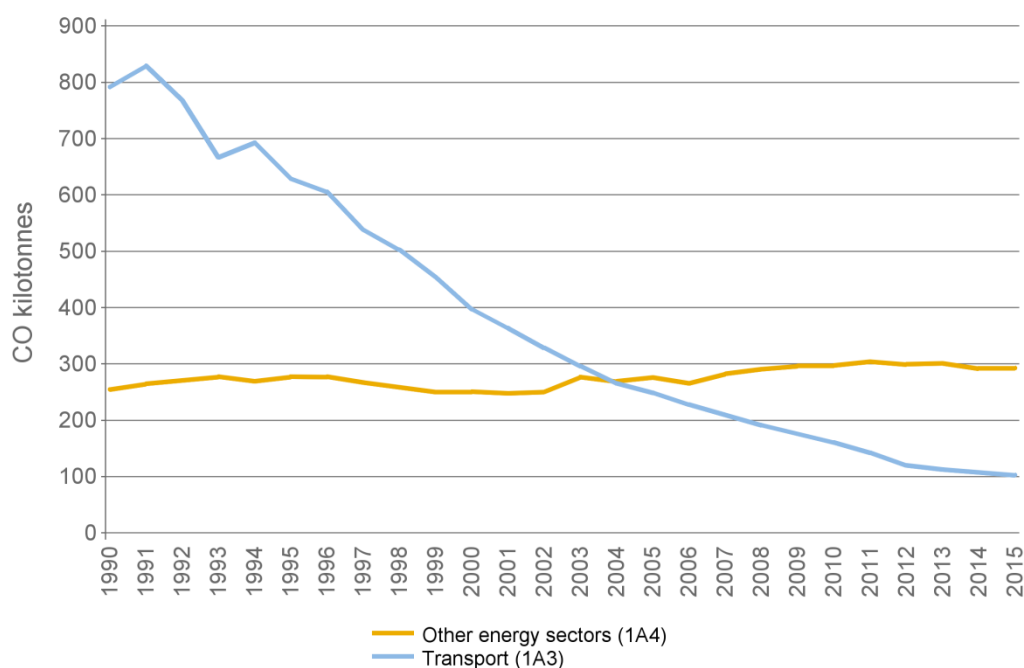
The aggregated emissions of carbon monoxide (CO) amounted to 461 kt in 2015. The emissions show a declining trend over the period and decreased by 58 % between 1990 and 2015. Between 2014 and 2015 emissions decreased by 1 %. The share of the CO emissions in Sweden in 2015 is shown in Figure 2-16.



**Figure 2-16. Distribution of CO emissions among major contributing sectors and subsectors in 2015**

The largest source for CO emissions in 2015 was other sectors (NFR1A4) where emissions amounted to 292 kt, corresponding to about two-third of the total emissions, of which most of the emission is derived from biomass combustion in residential stationary plants, i.e. stoves and boilers (NFR1A4bi). The rest comes from other stationary combustion (NFR1A4ai), off-road vehicles and other stationery (NFR1A4aai) and agriculture, forestry and fishing (NFR1A4c). Carbon monoxide emissions from 1A4 were 17 % higher in 2015 compared to 1990, mainly due to increased emission from off-road vehicles and to a less extent increased emission from stationary combustion (Figure 2-17).

The transport sector (NFR1A3) is the second largest source of CO emissions and amounted to 104 kt in 2015. Emissions of CO from NFR1A3 decreased by 87 % between 1990 and 2015, mostly due to reduced emissions from road transport (NFR1A3b) as catalytic converters on cars were introduced (Figure 2-17).



**Figure 2-17. Trends in CO emissions from other sectors (NFR1A4) and transport (NFR1A3) 1990-2015**

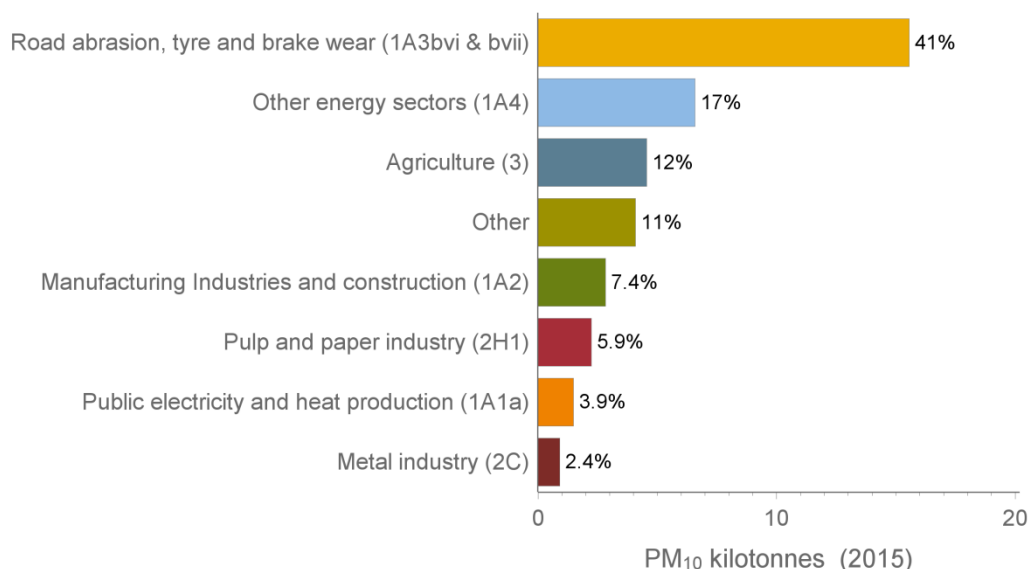
In 2015, emissions from electricity- and heat production (NFR1A1a) and combustion within manufacturing industries and construction (NFR1A2) amounted to 5.4 and 32 kt CO, respectively. Most of the emission in electricity- and heat production is derived from biomass combustion and the emissions have increased by more than 70 % since 1990 due to increased use of biomass as a fuel.

Carbon monoxide emissions from the industrial processes and product use sector (2) were 27 kt in 2015 and derived mainly from aluminum production (NFR2C3), pulp and paper industry (NFR2H1) and iron and steel production (NFR2C1). Emissions from industrial processes and product use have increased by about 24 % compared to 1990. Aluminum production is responsible for most of the increase as CO is emitted as a by-product gas.

## 2.2.2 Particulate matter (PM<sub>10</sub>)

Emissions of PM<sub>10</sub> were about 38 kt in 2015 and have decreased by 32 % since 1990. The emission has decreased slightly compared to 2014.

The share of the PM<sub>10</sub> emissions in Sweden in 2015 is shown in Figure 2-18.



**Figure 2-18. Distribution of PM<sub>10</sub> emissions among major contributing sectors and subsectors in 2015**

The main source of PM<sub>10</sub> emissions in 2015 was road abrasion, tyre and brake wear (NFR1A3bvi & NFR1A3bvii) accounted for 15.6 kt and the major part (94 %) comes from road abrasion. The emissions from road abrasion, tyre and brake wear were 25 % higher in 2015 than in 1990. Emissions of PM<sub>10</sub> depend on total traffic work and the use of studded tires.

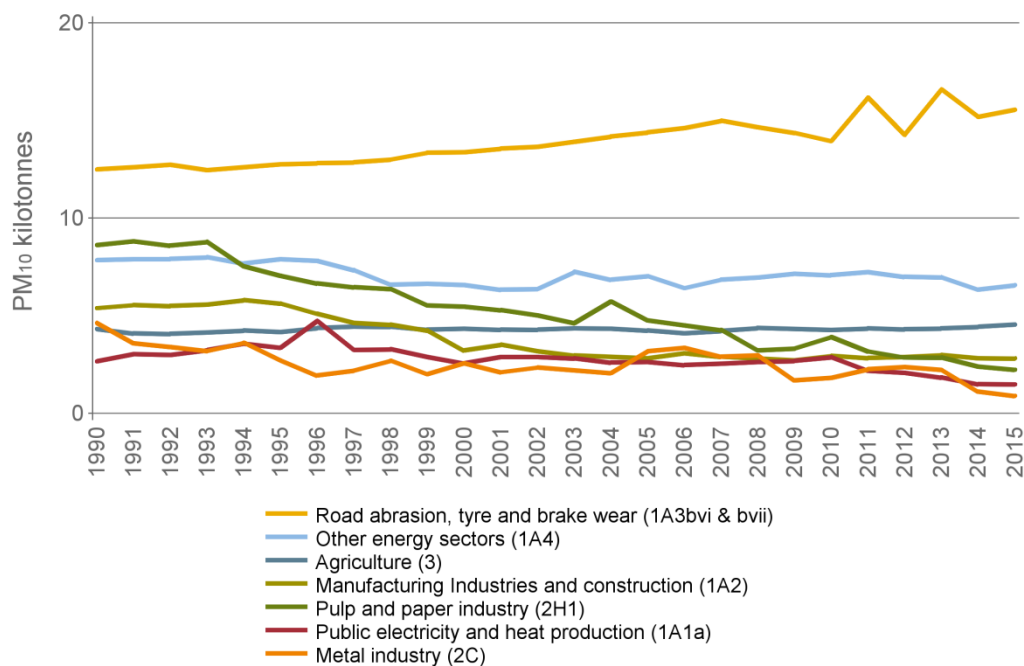
The second largest source of PM<sub>10</sub> emissions was other sectors (NFR1A4) and amounted to 6.6 kt or 17 % of total emissions in 2015. Most of the emission is derived from biomass combustion in residential stationary plants, i.e. stoves and boilers (NFR1A4bi) with a total of 4.9 kt. Emissions from residential stationary plants varied during the period (1990-2015) and were 18 % lower in 2015 than in 1990. The emission in 2015 increased by more than 6 % compared to the previous year (Figure 2-19).

Emissions from agriculture sector (NFR3) were about 4.6 kt in 2015. Manure management (NFR3B) and agricultural soils (NFR3D) contributed with about 2.4 and 2.2 kt respectively. Emissions from manure management (mainly poultry) have increased by 35 % since 1990 due to increased numbers of slaughter chickens, but for agricultural soils (mainly cultivated crops, NFR3De) the emissions have decreased by about 15 % during the same period.

Emissions from electricity- and heat production (NFR1A1a) were less than 2 kt of about 5 % of the total emission in 2015 and most of the emission is derived from biomass combustion. Emissions have increased by about 60 % since 1990 mainly due to improved technology in large combustion plants (Figure 2-19).

PM<sub>10</sub> emissions from the pulp and paper industry (NFR2H1) were 2.2 kt in 2015 and have been reduced by 74 % since 1990 and by 7 % since 2014. Large reductions in emissions have also occurred in metal industry (NFR2C), 81 % since 1990, mainly due to installation of new flue gas treatment in pellets production (2C1e).

Emissions of PM<sub>10</sub> from combustion in manufacturing industries and construction (NFR1A2) amounted to 2.8 kt in 2015 and have been reduced by 48 % since 1990. Biomass combustion in pulp, paper and print (NFR1A2d) contributed with 1.0 kt in 2015. The rest is derived from diesel combustion in off-road vehicles (NFR1A2gvii) and biomass combustion in industry (NFR1A2gviii).

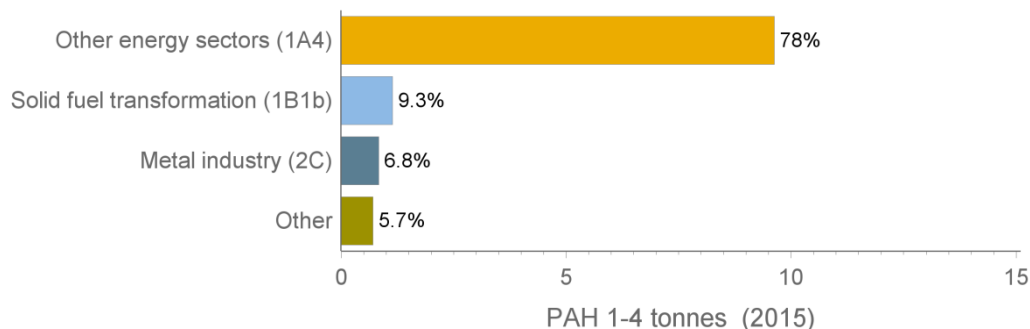


**Figure 2-19. Trends in PM<sub>10</sub> emissions from major sectors and subsectors 1990-2015**

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

Emissions of poly aromatic hydrocarbons (PAH-4) were 12.3 t in 2015. Emissions have been reduced by 31 % since 1990 and increased by 1 % since 2014.

The share of the PAH-4 emissions in Sweden in 2015 is shown in Figure 2-20.



**Figure 2-20. Distribution of PAH-4 emissions among major contributing sectors and subsectors in 2015.**

Other sectors (NFR1A4) was the largest source of PAH-4, with 9.6 t or 78 % of the total emissions in 2015. Most of the emission is derived from biomass combustion in stationary plants (NFR1A4b). Emissions were slightly lower in 2015 compared to 1990 (Figure 2-21). The largest source of PAH-4 emissions within other sectors is combustion of biomass in residential stationary plants, i.e. stoves and boilers (NFR1A4bi), about 8 t which have varied during the period and were about 13 % lower in 2015 compared to 1990. The main part of the rest of the emissions, about 1.0 t, derived from stationary biomass combustion in agriculture, forestry and fishing (NFR1A4ci) and commercial (NFR1A4ai).

PAH-4 emissions from solid fuel transformation (NFR1B1b) amounted to 1.1 t in 2015, equivalent to 9 % of the total emissions.

Metal industry (NFR2C) is also a significant source of PAH-4 emissions which was responsible for 0.8 t in 2015. Between 1990 and 2015 emissions have been reduced by 83 % due to application of new technologies. Aluminium production (NFR2C3) was a key source of PAH-4 emission in Sweden until 2008 and decreased strongly since then as all pot-lines operating the Söderberg technology were shut-down in 2008 resulting in a reduction of emissions by 92 % between 2008 and 2009 (Figure 2-21).



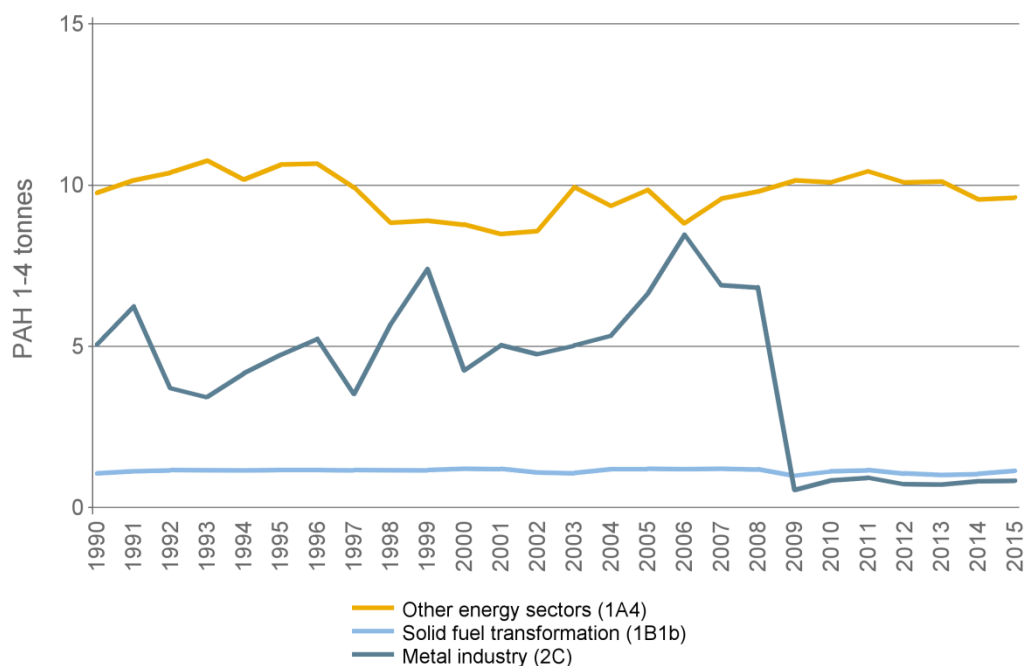


Figure 2-21. Trends in PAH-4 emissions from major sectors and subsectors 1990-2015

#### 2.2.4 Hexachlorobenzene (HCB)

The total emissions of HCB in Sweden were 2.5 kg in 2015. Emissions have increased by 80 % since 1990 and increased by about 1 % compared to 2014.

The share of the HCB emissions in Sweden in 2015 is shown in Figure 2-22.

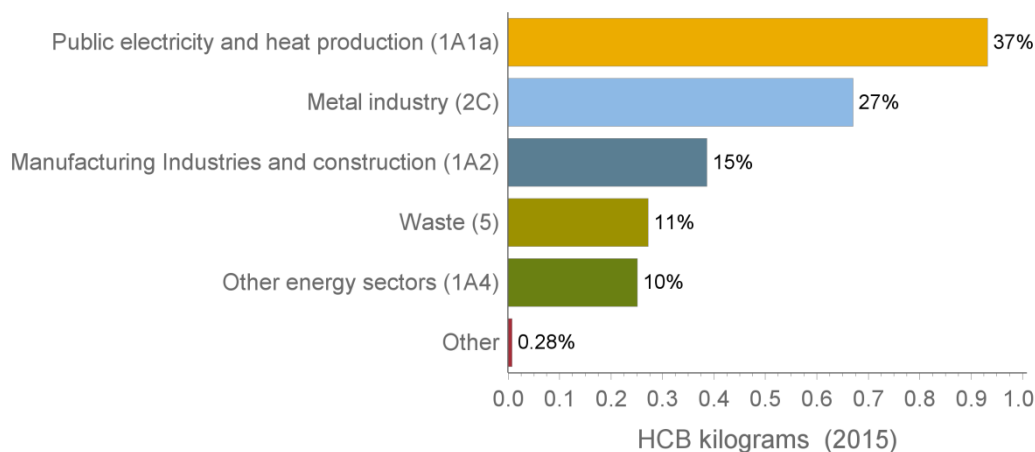
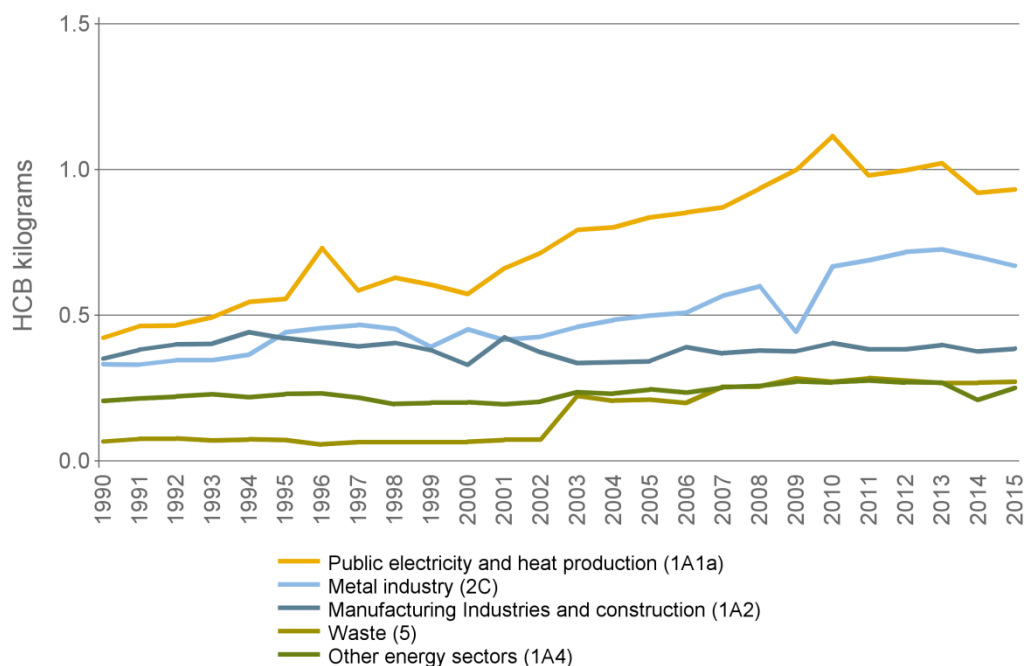


Figure 2-22. Distribution of HCB emissions among major contributing sectors and subsectors in 2015

Emissions of HCB from electricity- and heat production (NFR1A1a) amounted to 0.9 kg in 2015 of which 0.7 kg derived from biomass combustion. Emissions from electricity and heat production have more than doubled (120 %) since 1990 mainly due to increased use of biomass as a fuel. HCB emission from electricity and heat production to some extent depends on temperature and precipitation conditions.

For example, the observed high emissions (jumps) in 1996 and 2010 were particularly cold years (Figure 2-23).



**Figure 2-23. Trends in HCB emissions from major sectors and subsectors 1990-2015**

Emissions of HCB from metal industry (NFR2C) were less than 0.7 kg in 2015. Emissions derived entirely from the iron and steel production (NFR2C1) and have doubled since 1990 as a result of increased production. The economic recession in 2009 is clearly visible as a dip in the emission trend (Figure 2-23).

In 2015, about 0.4 kg of HCB was derived from manufacturing industry and construction (NFR1A2), mainly as a result of biomass combustion in pulp, paper and print (NFR1A2d) and other (NFR1A2g). Emissions have varied since 1990 and were 10 % higher in 2015 compared to 1990.

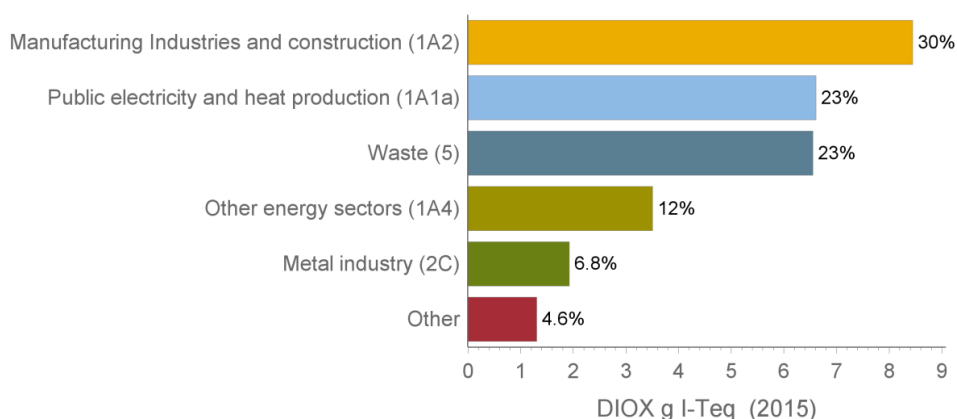
The waste sector (NFR5) is also a significant source of HCB emission and was responsible for 0.27 kg or 11 % of the total emission in 2015. The emissions were mostly derived from incineration and open burning of waste (NFR5C). Emissions have increased by about 300 % since 1990 as a result of increased burning of hazardous waste.

Biomass combustion in residential stationary plants, i.e. stoves and boilers (NFR1A4bi) accounted for 8 % of the national emission of HCB in 2015. Emissions have increased by 8 % since 1990. Emissions resulted from heating of public and other facilities have also increased.

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

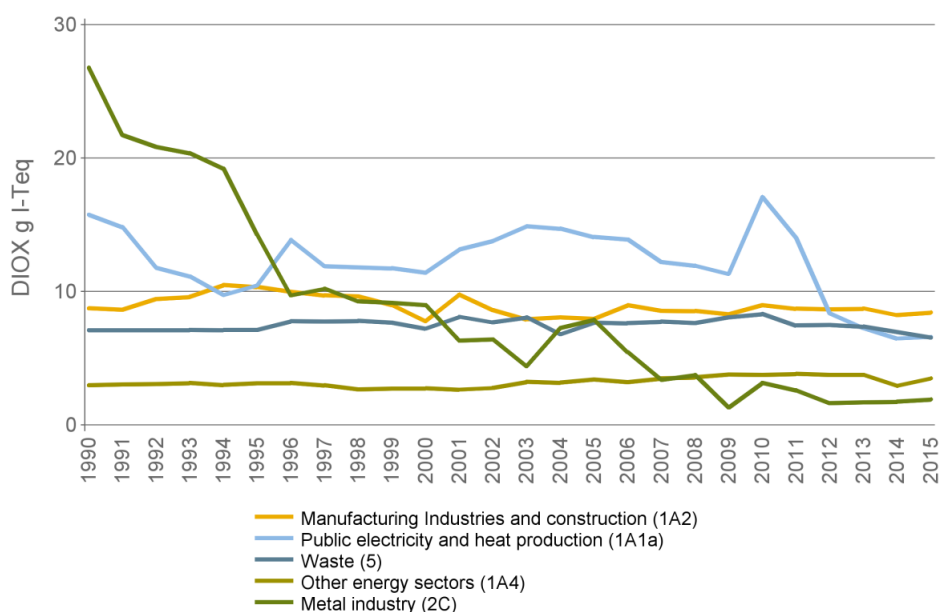
The aggregated emissions of dioxins in Sweden were 28.3 g-Teq in 2015. Emissions have decreased by 57 % since 1990 and increased by about 2 % compared to 2014.

The share of the dioxins emissions in Sweden in 2015 is shown in Figure 2-24.



**Figure 2-24. Distribution of dioxins emissions among major contributing sectors and subsectors in 2015**

Revised emission factors for emission of dioxins from electricity- and heat production (NFR1A1a) have been implemented in this submission. Emissions of dioxins from electricity- and heat production (NFR1A1a) amounted to 6.6 g-Teq in 2015, of which most of the emission is derived from biomass combustion. Emissions from this key source category (23 % of the total emission of dioxins) have decreased by about 60 % since 1990 as a result of improved technology in combustion plants (Figure 2-25).



**Figure 2-25. Trends in dioxins emissions from major sectors and subsectors 1990-2015**

The amount of emissions of dioxins depends to some extent on temperature and precipitation conditions in Sweden. The observed high emissions (jumps) in 1996 and 2010 were particularly cold years.

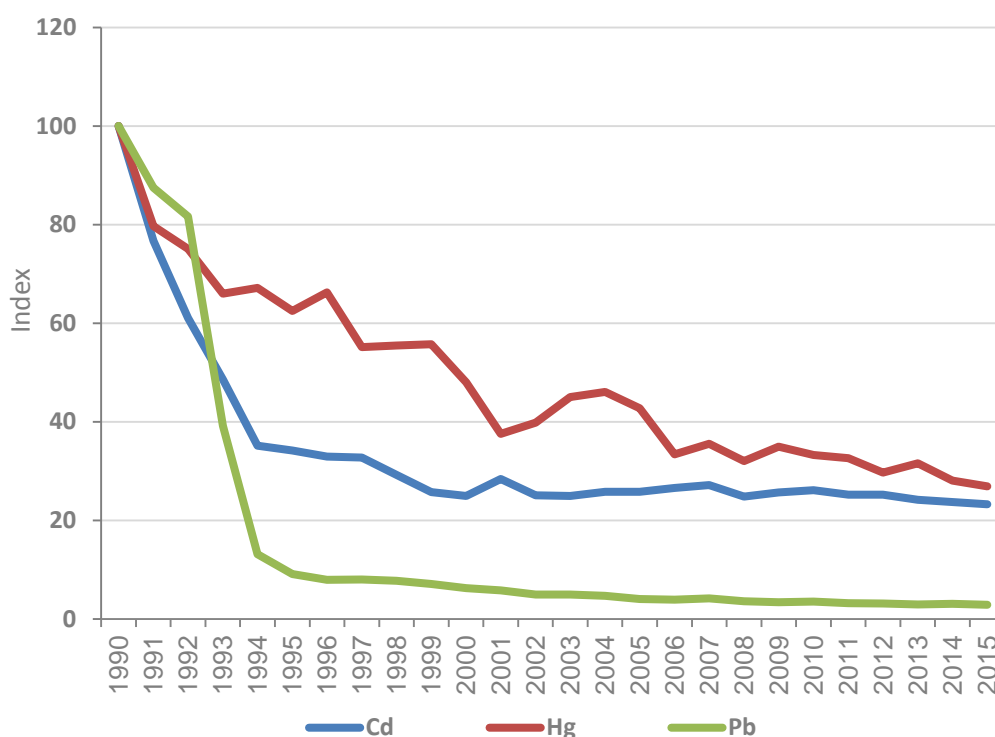
In 2015, about 8.4 g-Teq of dioxins emission to air were derived from manufacturing industry and construction (NFR1A2), mostly as a result of biomass combustion in pulp, paper and print (NFR1A2d) and other (NFR1A2g). Emissions from NFR1A2, which constitutes about 30 % of the total emission, have varied slightly since 1990 and were 3 % lower in 2015 compared to 1990. The observed variation in the time series is most probably due to variations in production volume. The decreased in emission since 1990 is mainly due to improved technologies that have been adopted in various industries.

Stationary combustion plants (NFR1A4), i.e. residential plants accounted for 12 % of the national emission of dioxins in 2015. The emission from residential plants (stoves and boilers) has increased by 8 % since 1990. Emissions resulted from heating of public and other facilities have also increased as a result of increases use of biomass as a fuel.

House- and car fires (reported in the waste sector) also cause emissions of dioxins to air and accounted for 19 % in 2015. Emissions have fallen by about 20 % since 1990. A small amount of dioxin emissions to air come from combustion of hazardous waste and amounted for about 4 % of the total emission. Since 1990 the emissions was doubled due to increased combustion of hazardous waste.

## 2.3 Emissions of priority heavy metals

Emissions of cadmium (Cd), mercury (Hg) and lead (Pb) have all been reduced significantly since 1990. The most drastic decrease in emissions came from Pb being phased out from gasoline blends in the early 1990's. Pb emissions have since 1990 been reduced by 97 %. In the early 1990's Cd emissions were also heavily reduced, mainly due to efficiency improvements in metal production. Hg emissions were reduced by nearly half from 1990 until 1999 and most of the reduction came from improvements in metal processing and the waste sector (mainly cremation).

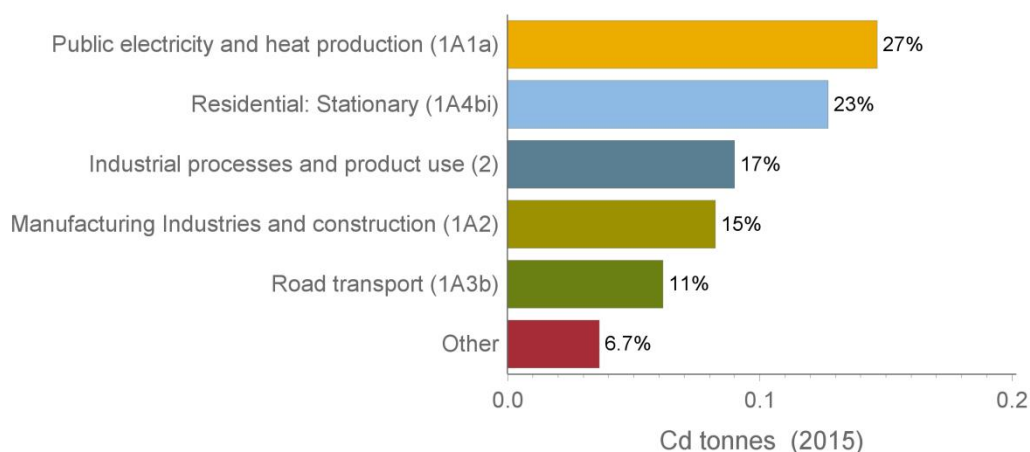


**Figure 2-26 Trends in emissions 1990-2015 for Cd, Hg and Pb. Index 1990=100.**

### 2.3.1 Cd

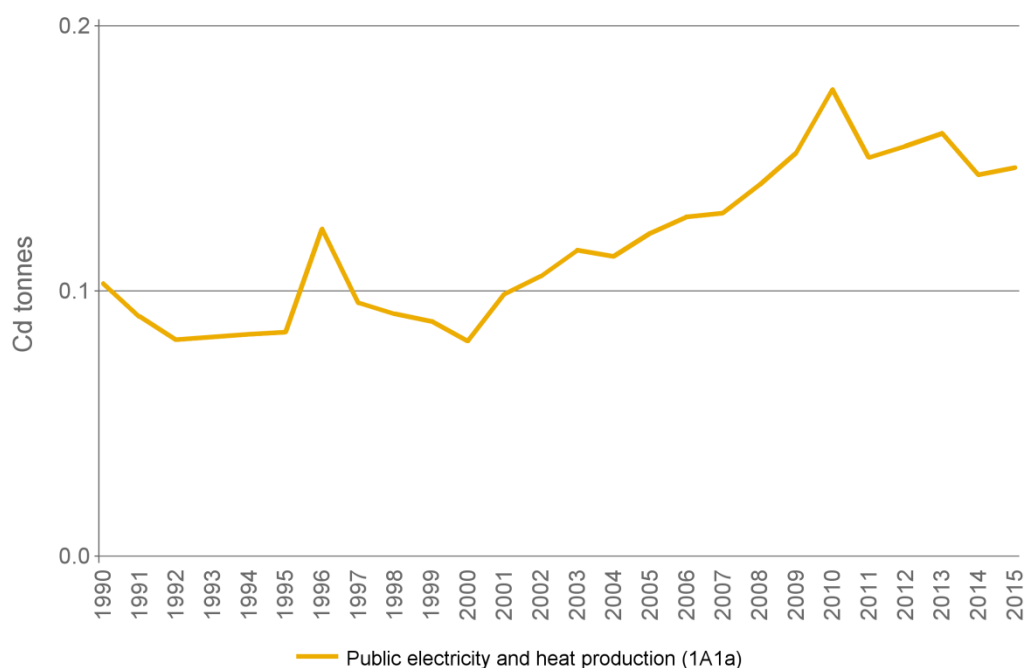
Total emissions of Cd in Sweden were 544 kg in 2015, a total decrease of 77 % compared to emissions in 1990.

Emissions of Cd are dominated by five sectors, as seen in Figure 2-27.



**Figure 2-27. Distribution of Cd emissions among major contributing sectors and sub-sectors in 2015**

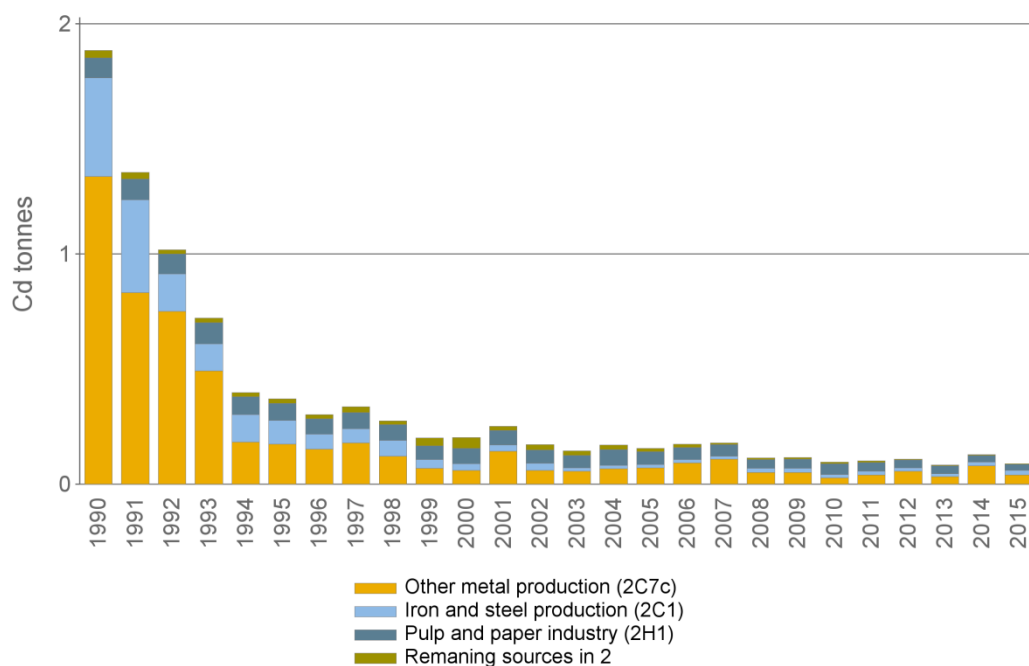
The largest source of Cd emissions in 2015 was electricity and heat generation (NFR1A1a) where emissions amounted to 147 kg, corresponding to 27 % of total emissions. Emissions of Cd from electricity and heat generation have increased by 43 % from 1990, much due to intensified activity over the years. The majority of these emissions occurred at plants for combined heat and power generation where emissions from incineration of biomass have increased by 160 % since 1990. To some extent the emissions depend on temperature and precipitation resulting in the high emissions seen during 1996 and 2010 which were particularly cold years. After 2010, when temperatures have been higher the emissions have been lower in the electricity and heat generation sector.



**Figure 2-28. Trend in emissions from electricity and heat production (1A1a) 1990-2015**

Stationary combustion in the residential sector (NFR1A4bi) was the second largest source of Cd emissions with a total of 127 kg in 2015, corresponding to 23 % of total emissions. These emissions have decreased by 5 % compared to levels in 1990.

Industrial processes and product use (NFR2) amounted to 90 kg in 2015, corresponding to 17 % of total Cd emissions. Most of these emissions occurred in the metal industry (NFR2C) and pulp and paper industry (NFR2H1), with 11 % and 5 %, respectively, of total Cd emissions. Emissions in each industry are seen in Figure 2-29. Emissions from industrial processes and product use have decreased by 95 % from 1990. The emissions were drastically reduced during the early 1990's and levels have been relatively stable since the early 2000's. From 2014 to 2015 the emissions within industrial processes and product use were unchanged.



**Figure 2-29. Emissions of Cd from industrial processes and product use 1990-2015**

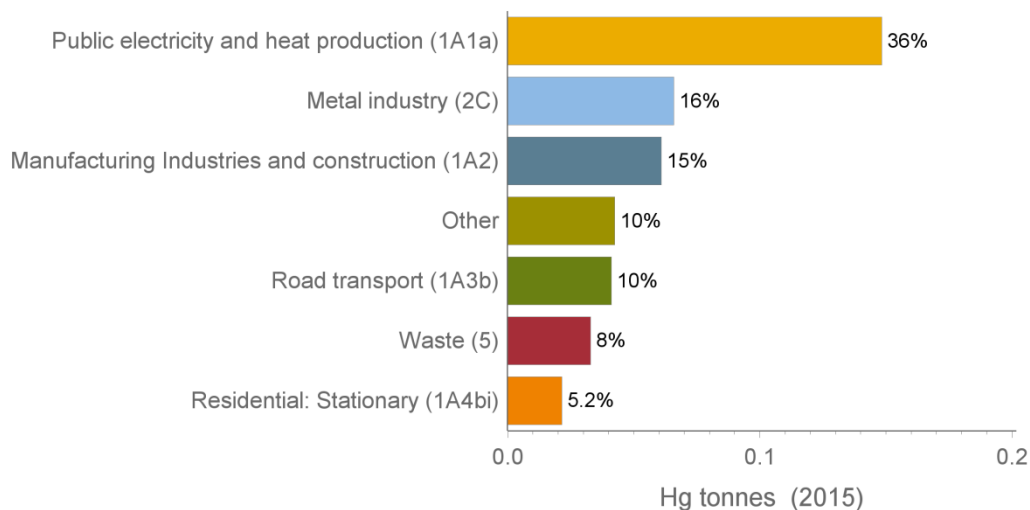
Combustion in manufacturing industries and construction (NFR1A2) represent 15 %, 82 kg, of total Cd emissions in 2015, mostly due to use the of biofuels. Most of these emissions, 8 % of total Cd emissions, occurred in the pulp, paper and print industries (NFR1A2d). Cd emissions in the pulp, paper and print industries have decreased by 35 % since 1990. Emissions from combustion in manufacturing industries and construction have been relatively stable over the past ten year period. From 2014 to 2015 the emissions increased by 1 %.

Emissions from road traffic in the transport sector (NFR1A3b) accounted for 11 %, 62 kg, of the Cd emissions in 2015. The major part of these emissions came from gasoline use in passenger cars, with a total of 23 kg Cd emitted in 2015. This corresponds to a decrease by 43 % since 1990. During the same period emissions from use of diesel fuels have increased, both in passenger cars and heavy goods vehicles. The increase from 1990 to 2015 was over 800 % for passenger cars, nearly 50 % for heavy duty vehicles and nearly 90 % for light duty vehicles. Cd emissions from use of diesel fuel amounted to 29 kg in 2015, with approximately 40 % coming from passenger cars and 60 % from heavy goods vehicles.



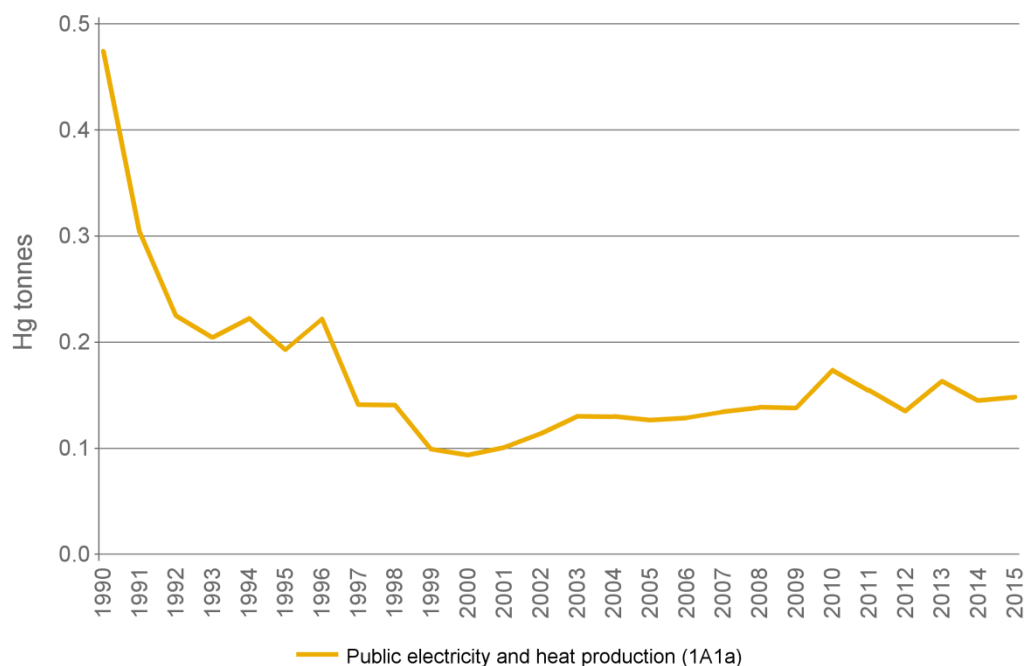
### 2.3.2 Hg

Total emissions of Hg in Sweden were 410 kg in 2015, a total decrease of 73 % compared to emissions in 1990. The total emission level was unchanged from 2014 to 2015.



**Figure 2-30. Distribution of Hg emissions among major contributing sectors and sub-sectors in 2015**

In 2015, roughly one third of Hg emissions were generated through electricity and heat generation (NFR1A1a) where emissions amounted to 148 kg. Most of these emissions, 117 kg, were generated from combined heat and power generation, where Hg emissions have decreased by 63 % since 1990. Much of these emissions were related to the use of biomass as fuel. The emissions mainly decreased between 1990 and 2000, after which emission levels increased for three consecutive years. For the past ten years the emissions from electricity and heat generation have been relatively stable. From 2014 to 2015 these emissions increased by 2 %.



**Figure 2-31. Emissions of Hg in from Public electricity and heat generation (1A1a) 1990-2015**

Processes within the metal industry (NFR2C) accounted for 16 % of total Hg emissions in 2015. Emissions have been reduced by 86 % since 1990 and 20 % since 2014. In 2015 the emissions amounted to 66 kg.

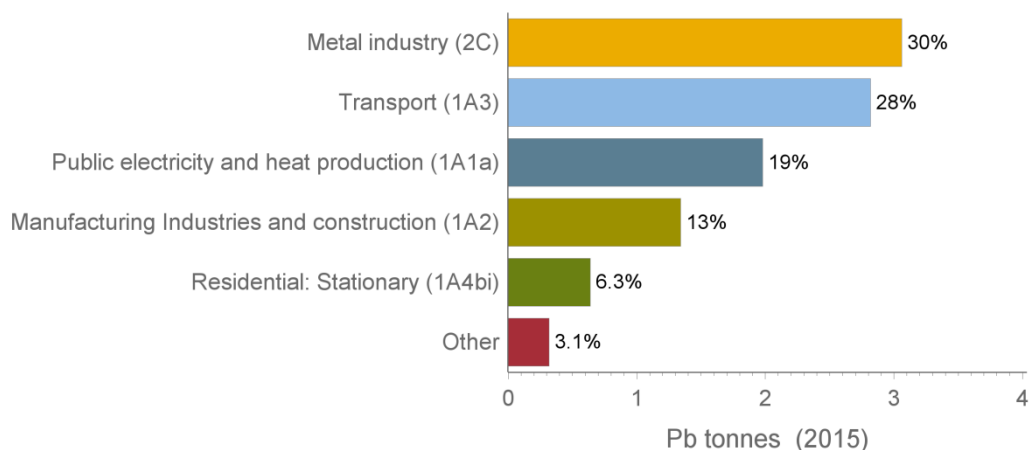
In 2015, 15 % of total emissions occurred due to combustion in manufacturing industries and construction (NFR1A2), which corresponded to 61 kg of total emissions. Emissions have been reduced by 28 % since 1990, much due to less fuel being used in the Cd emission heavy sectors of non-metallic minerals (NFR1A2f), pulp, paper and print (NFR1A2d) and other (NFR1A2g).

Emissions from road traffic in the transport sector (NFR1A3b) accounted for 10 % of the Hg emissions in 2015. Half of these emissions came from gasoline use in passenger cars, with a total emission of nearly 20 kg in 2015, while the other half came from use of diesel and other fuels. Emissions from road transportation have decreased by four percent since 1990 although emission levels remained nearly unchanged from 2014 to 2015. While emissions from combustion of gasoline have decreased the emissions from combustion of the increasingly popular diesel have increased during the period.

Emissions from incineration and open burning of waste in the waste sector (NFR5C) accounted for eight percent of the Hg emissions in 2015. The emissions in 2015 were 81 % lower than in 1990. During this period more waste have been handled by the energy sector where electricity and district heating is produced from waste incineration. This results in less material being accounted for in the waste sector.

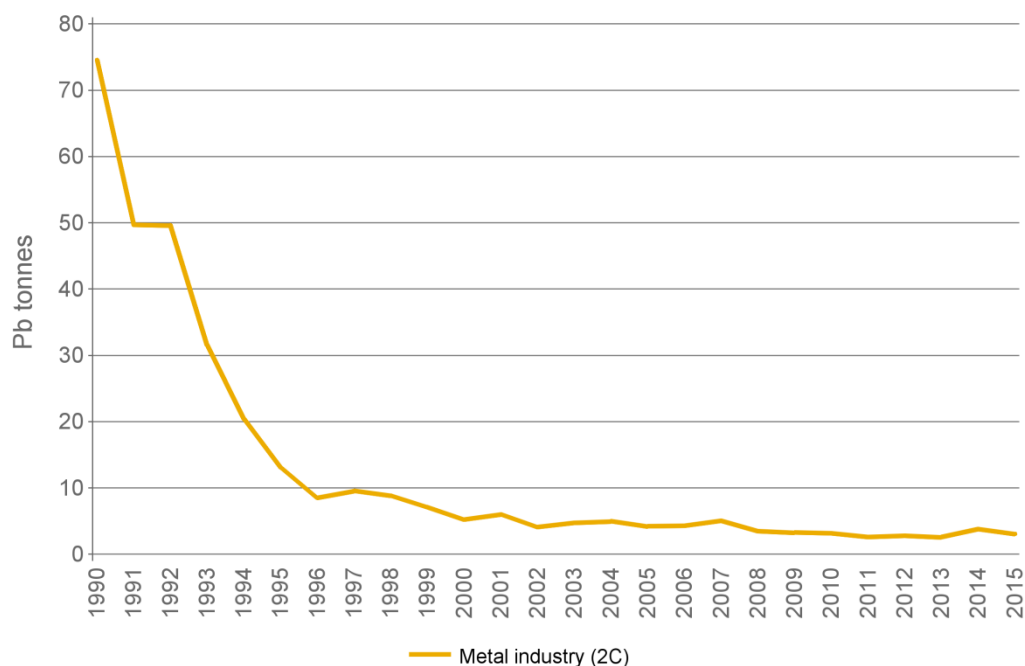
### 2.3.3 Pb

Total emissions of lead (Pb) in Sweden were 10 t in 2015, a total decrease of 97 % compared to emissions in 1990. The most important sector, with nearly one third of emissions, was processes and product use in the metal industry (NFR2C), and roughly one fourth was related to the transport sector (NFR1A3).



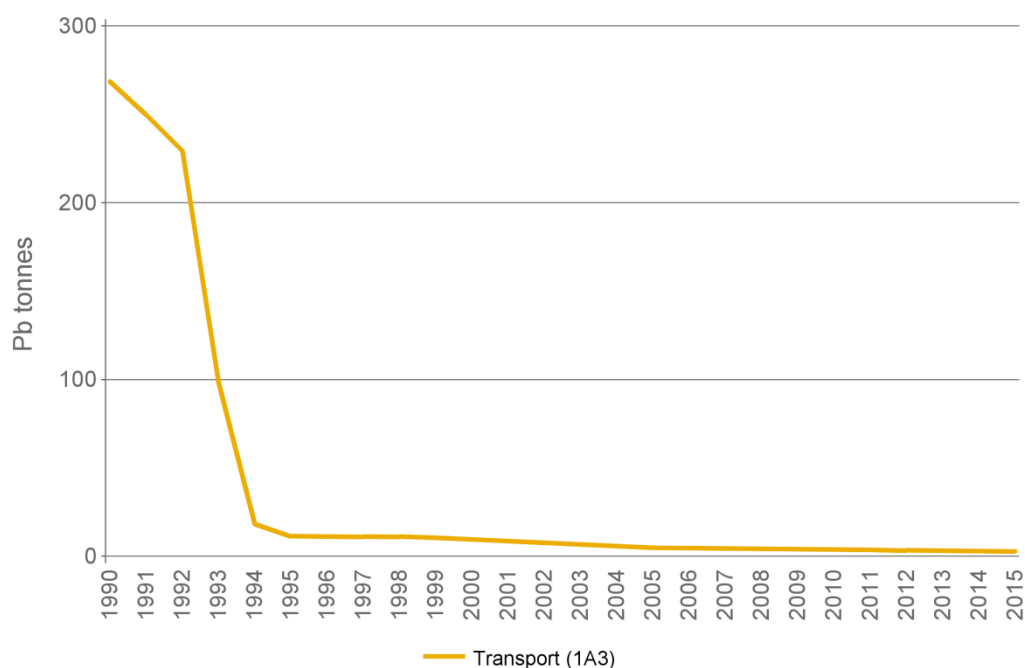
**Figure 2-32. Distribution of Pb emissions among major contributing sectors and sub-sectors in 2015**

The most important source of Pb emissions was industrial processes and product use (NFR2). In 2015 these emissions amounted to 3.2 t, one third of national totals. The metal industry (NFR2C) was responsible for the majority of these emissions and a small fraction came from the pulp and paper industry (NFR2H1). Emissions were reduced drastically between 1990 and 1996 and since 2002 emissions have been leveled out with only slight variation between years. From 2014 to 2015 emission levels in the pulp and paper industry have increased by 1 %.



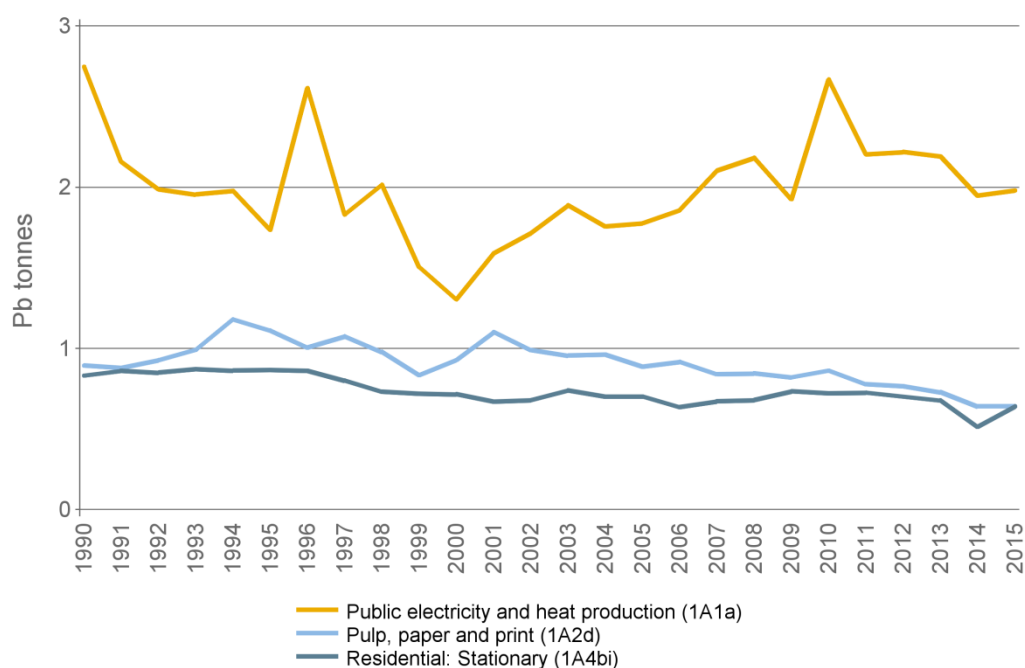
**Figure 2-34. Trend in emissions of Pb from Metal industry (2C) 1990-2015**

The transport sector (NFR1A3) was the second most important source of emissions, mainly due to Pb content in gasoline for road transportation (NFR1A3b), resulting in 28 % of total emissions. In road transportation there were mainly two processes from which Pb emissions were generated, automobile tyre and brake wear and fuel combustion. These processes generated 4 % and 21 %, respectively, of total emissions in 2015. As gasoline is almost only used for passenger cars these generated close to all of the emissions related to fuel combustion in road transportation. As a consequence of lead being phased out from gasoline blends in the early 1990's these emissions have been reduced by 99 % compared to 1990. In 1990 the emissions from passenger cars amounted to 246 t, and in 2015 these emissions were 2 t.



**Figure 2-33. Trend in emissions of Pb from transport (1A3) 1990-2015**

Nearly 3 t, nearly one third of the total emissions, are related to combustion of biofuels. The substantial part of this biofuel was used within electricity and heat generation (NFR1A1a), pulp, paper and print industries (NFR1A2d) and the residential sector (NFR1A4bi). Electricity and heat generation (NFR1A1a) produced 18 % of total emissions in 2015, almost entirely due to Pb content in biofuels. The emissions in this sector have been reduced by nearly one third compared to emission levels in 1990. In 2015 the emissions were 2 t, as they were in 2014 as well.



**Figure 2-34 Trends in emissions from Public electricity (1A1a) and heat production, Pulp, paper and print (1A2d) and residential stationary (1A4bi) 1990-2015**

Combustion within manufacturing industries and construction (NFR1A2) accounted for 13 % (1.3 t) of total emissions in 2015, with pulp, paper and print industry being the major contributor. Emissions from manufacturing industries and construction have been reduced by one third compared to emission levels in 1990. From 2014 to 2015 emission levels remained unchanged.

Five percent of total emissions, 0.6 t, occurred in the residential sector (NFR1A4b) where combustion of biomass was the major source. Compared to levels in 1990 emissions from biomass combustion have increased by 8 %. Compared to levels in 2014 emissions were unchanged.

## 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. The energy sector, including transport, has long accounted for the major part of Swedish greenhouse gas emissions, and emissions of carbon DIOxide dominate overwhelmingly in this sector.

### 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 include domestic military operations.

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**

Since 1980 the Swedish energy system has changed substantially. The dependence on fossil fuels (oil and coal), both for heating purposes and in industry, has decreased. During the period 1980-1990, the production of electricity from nuclear power plants increased from 26 TWh to 68 TWh. Another factor behind the decrease in fossil fuel use is the increased use of district heating. Use of biofuel (wood chips, bark) and incineration of municipal waste is common in district heating plants. The use of heat pumps both in district heating plants and in residential houses has increased since 1985. In the manufacturing industry the combustion of oil products has decreased from 1980 and has to a large extent been replaced by biofuels.

Swedish production of electricity is characterized by large proportions of hydropower and nuclear energy. Only a small share of electricity production is based on fuels used in conventional power plants. Public electricity and heat use vary between years, mainly due to variations in ambient wintertime temperatures. 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. 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. Electricity is an important energy source in the manufacturing industry, which is dominated by the pulp and paper industry and the steel industry.

Production of district heating is currently to a large extent based on biomass and waste. There has been a continuous 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 2015, 75 % of all fuels used for district heating were biomass (including the biogenic fraction of waste), while waste (fossil fraction) accounted



for 11 %<sup>20</sup>. 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 175 PJ (2014)<sup>21</sup> but, due to the more frequent use of biomass, greenhouse gas emissions from district heating were smaller in 2015 than in 1990.

The number and distribution of Swedish power stations in 2014 are presented by the Swedish Energy Agency<sup>22</sup> (Table 3-1). Changes in number of plants and their installed effect have been minor in the production of district heating, 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 2014**

Type of plant <sup>8</sup>	Number of plants	Gross Production GWh	Gross Production TJ
Total power stations	4 069	153 615	553 014
Power generation not based on fuels	3 902	75 105	270 378
Wind power	2 961	11 234	40 442
Hydropower	941	63 871	229 936
Power generation based on fuels	167	78 509	282 632
Nuclear power	3	64 877	233 557
Conv. thermal power	164	13 632	490 75

The trend in fuel consumption in this sector varies depending on the production of hydropower and climate variables. The greatest changes in fuel consumption are for biomass fuels, where the consumption has increased significantly due to, for instance, increased district heating. There was a significant increase in the use of natural gas in 2009 due to an increase in the number of gas fuelled facilities. In 2010, the production and use of district heating was unusually high due to the cold weather with unusually low temperatures in the beginning and the end of the year.

A summary of the latest key category assessment is presented in Table 3-2.

<sup>20</sup> 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 1A1a.ii and 1A1a.iii

<sup>21</sup> Statistics Sweden/Swedish Energy Agency EN11SM 1501 (Electricity supply, district heating and supply of natural and gasworks gas 2014.). Data for 2015 currently not available.

<sup>22</sup> Statistics Sweden /Swedish Energy Agency EN11SM 1501 (Electricity supply, district heating and supply of natural and gasworks gas 2014.). Data for 2015 currently not available.

**Table 3-2. Summary of key source analysis, NFR1A1a, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A1a	Biomass – As, Pb, Cd, Hg, DIOX, Zn, Ni, Se, Cu, Cr, NO <sub>x</sub> , PM <sub>2.5</sub> , NMVOC, PM <sub>10</sub> , SO <sub>2</sub> , TSP, PAH 1-4	Biomass – As, Pb, Cd, Hg, DIOX, Zn, Ni, Se, Cu, Cr, NO <sub>x</sub> , PM <sub>2.5</sub> , NMVOC, PM <sub>10</sub> , SO <sub>2</sub> , TSP, PAH 1-4, NH <sub>3</sub>
	Gaseous –	Gaseous –
	Liquid – Ni, SO <sub>2</sub>	Liquid – Se, Ni, SO <sub>2</sub> , NO <sub>x</sub>
	Solid – , SO <sub>2</sub> , Hg, As, Cr, Cd, NO <sub>x</sub> , Ni	Solid – Se, PM <sub>2.5</sub> , SO <sub>2</sub> , PM <sub>10</sub> , TSP, Hg, As, DIOX, NO <sub>x</sub> , Ni
	Other – Hg, As, Se, Pb, DIOX, SO <sub>2</sub> , Cr, Cd, Ni, PM <sub>2.5</sub> , NO <sub>x</sub> , PM <sub>10</sub>	Other – Hg, As, Se, Pb, DIOX, SO <sub>2</sub> , Cr, Cd, Ni, PM <sub>2.5</sub> , NO <sub>x</sub> , PM <sub>10</sub>
	Peat– PM <sub>10</sub> , SO <sub>2</sub> , As, Hg	Peat– PM <sub>10</sub> , TSP, SO <sub>2</sub> , DIOX, Hg, , Ni, NO <sub>x</sub>

### 3.2.1.2 METHODOLOGICAL ISSUES

A combined Tier 2 and 3 method 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 ISIC 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.

### 3.2.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

For the energy sector, the largest uncertainties come from activity data for the 1980's and from emission factors.

Due to problems with data files on energy consumption in energy industries and manufacturing industries 1980-1989, it has not been possible to recalculate emissions as has been done for different sectors 1990 and later years (described below). Because of this, time series 1980-89 and 1990-later are not directly comparable. The differences are largest for NFR1A1b, 1A1c, 1A2a, 1A2c, 1B1b and 1B1c.

Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3-3 the average uncertainties for activity data and emission factors by fuel group are weighted.

**Tabell 3-3. Uncertainties in activity data and emission factors for all substances for the base year and the year of latest emissions (2015) reported for NFR1A1a.**

Source category	Fuel group	Fuel type	Substance	Base year uncertainty (%)	Year 2015 uncertainty (%)
1A1a	Biomass	Landfill gas	As	100	100
1A1a	Biomass	Tall oil	As	100	100
1A1a	Biomass	Wooden fuels	As	400	400
1A1a	Biomass	Other biomass	As	400	400
1A1a	Gaseous Fuels	Natural gas	As	100	100
1A1a	Liquid Fuels	All fuels	As	100	100
1A1a	Other Fuels	Waste	As	900	900
1A1a	Other Fuels	Other non-specified	As	100	100
1A1a	Solid Fuels	All fuels	As	100	100
1A1a	Biomass	Landfill gas	CO	50	50
1A1a	Biomass	Tall oil	CO	50	50
1A1a	Biomass	Wooden fuels	CO	75	75
1A1a	Biomass	Other biomass	CO	75	75
1A1a	Gaseous Fuels	Natural gas	CO	30	30
1A1a	Gaseous Fuels	Gas works gas	CO		30
1A1a	Liquid Fuels	Diesel oil	CO	50	50
1A1a	Liquid Fuels	Domestic heating oil	CO	40	40
1A1a	Liquid Fuels	Residual fuel oil	CO	40	40
1A1a	Liquid Fuels	Kerosene	CO	50	50
1A1a	Liquid Fuels	LPG	CO	30	30
1A1a	Liquid Fuels	Gas works gas	CO	30	30
1A1a	Liquid Fuels	Other petroluem fuels	CO	50	50
1A1a	Other Fuels	Waste	CO	30	30
1A1a	Other Fuels	Other non-specified	CO	50	50
1A1a	Solid Fuels	Coke oven gas	CO	30	30
1A1a	Solid Fuels	Coal	CO	40	40
1A1a	Solid Fuels	Steel converter gas	CO	30	30
1A1a	Solid Fuels	Blast furnace gas	CO	30	30
1A1a	Solid Fuels	Other solid fuels	CO	50	50
1A1a	Peat	Peat	CO	30	30
1A1a	Liquid Fuels	All fuels	Cd	100	100
1A1a	Other Fuels	Waste	Cd	100	100
1A1a	Solid Fuels	Coal	Cd	100	100
1A1a	Peat	Peat	Cd	100	100
1A1a	Biomass	All fuels	Cd	40	40
1A1a	Biomass	All fuels	Cr	40	40
1A1a	Liquid Fuels	All fuels	Cr	100	100
1A1a	Other Fuels	Waste	Cr	100	100
1A1a	Solid Fuels	Coal	Cr	50	50
1A1a	Peat	Peat	Cr	40	40
1A1a	Biomass	Wooden fuels	Cu	100	100
1A1a	Biomass	Other biomass	Cu	40	40
1A1a	Liquid Fuels	All fuels	Cu	100	100
1A1a	Other Fuels	Waste	Cu	900	900
1A1a	Solid Fuels	Coal	Cu	100	100
1A1a	Biomass	Landfill gas	DIOX	300	300
1A1a	Biomass	Tall oil	DIOX	100	100
1A1a	Biomass	Wooden fuels	DIOX	300	300
1A1a	Biomass	Other biomass	DIOX	300	300
1A1a	Gaseous Fuels	All fuels	DIOX	50	50
1A1a	Liquid Fuels	Diesel oil	DIOX	50	50
1A1a	Liquid Fuels	Domestic heating oil	DIOX	100	100
1A1a	Liquid Fuels	Residual fuel oil	DIOX	50	50
1A1a	Liquid Fuels	LPG	DIOX	50	50
1A1a	Liquid Fuels	Gas works gas	DIOX	50	50
1A1a	Other Fuels	Waste	DIOX	300	300
1A1a	Solid Fuels	Coal	DIOX	50	50
1A1a	Liquid Fuels	All fuels	Hg	100	100

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1A1a	Solid Fuels	Steel converter gas	Hg	50	50
1A1a	Solid Fuels	Blast furnace gas	Hg	40	40
1A1a	Peat	Peat	Hg	40	40
1A1a	Biomass	Landfill gas	N2o	100	100
1A1a	Biomass	Wooden fuels	N2o	40	40
1A1a	Biomass	Other biomass	N2o	100	100
1A1a	Gaseous Fuels	Natural gas	N2o	20	20
1A1a	Gaseous Fuels	Gas works gas	N2o	20	20
1A1a	Liquid Fuels	Domestic heating oil	N2o	200	200
1A1a	Liquid Fuels	Residual fuel oil	N2o	200	200
1A1a	Liquid Fuels	Kerosene	N2o	100	100
1A1a	Liquid Fuels	LPG	N2o	20	20
1A1a	Liquid Fuels	Gas works gas	N2o	20	20
1A1a	Liquid Fuels	Other petroluem fuels	N2o	200	200
1A1a	Other Fuels	Waste	N2o	40	40
1A1a	Other Fuels	Other non-specified	N2o	200	200
1A1a	Solid Fuels	Coke oven gas	N2o	20	20
1A1a	Solid Fuels	Coal	N2o	40	40
1A1a	Solid Fuels	Steel converter gas	N2o	20	20
1A1a	Solid Fuels	Blast furnace gas	N2o	20	20
1A1a	Solid Fuels	Övriga fasta bränslen	N2o	100	100
1A1a	Peat	Peat	N2o	40	40
1A1a	Biomass	Landfill gas	NH3	50	50
1A1a	Biomass	Tall oil	NH3	40	40
1A1a	Biomass	Wooden fuels	NH3	20	20
1A1a	Biomass	Other biomass	NH3	40	40
1A1a	Gaseous Fuels	Natural gas	NH7	40	40
1A1a	Gaseous Fuels	Gas works gas	NH8		20
1A1a	Liquid Fuels	Diesel oil	NH3	50	50
1A1a	Liquid Fuels	Domestic heating oil	NH3	40	40
1A1a	Liquid Fuels	Residual fuel oil	NH3	40	40
1A1a	Liquid Fuels	Kerosene	NH3	40	40
1A1a	Liquid Fuels	LPG	NH3	20	20
1A1a	Liquid Fuels	Gas works gas	NH3	20	20
1A1a	Liquid Fuels	Other petroluem fuels	NH3	50	50
1A1a	Other Fuels	Waste	NH3	40	40
1A1a	Other Fuels	Other non-specified	NH3	50	50
1A1a	Solid Fuels	Coke oven gas	NH3	20	20
1A1a	Solid Fuels	Coal	NH3	20	20
1A1a	Solid Fuels	Steel converter gas	NH3	20	20
1A1a	Solid Fuels	Blast furnace gas	NH3	20	20
1A1a	Solid Fuels	Övriga fasta bränslen	NH3	50	50
1A1a	Peat	Peat	NH3	40	40
1A1a	Biomass	Landfill gas	NMVOC	50	50
1A1a	Biomass	Tall oil	NMVOC	50	50
1A1a	Biomass	Wooden fuels	NMVOC	75	75
1A1a	Biomass	Other biomass	NMVOC	50	50
1A1a	Gaseous Fuels	Natural gas	NMVOC	30	30
1A1a	Gaseous Fuels	Gas works gas	NMVOC		30
1A1a	Liquid Fuels	Diesel oil	NMVOC	30	30
1A1a	Liquid Fuels	Domestic heating oil	NMVOC	30	30
1A1a	Liquid Fuels	Residual fuel oil	NMVOC	30	30
1A1a	Liquid Fuels	Kerosene	NMVOC	30	30
1A1a	Liquid Fuels	LPG	NMVOC	30	30
1A1a	Liquid Fuels	Gas works gas	NMVOC	30	30
1A1a	Liquid Fuels	Other petroluem fuels	NMVOC	50	50
1A1a	Other Fuels	All fuels	NMVOC	50	50
1A1a	Solid Fuels	Coke oven gas	NMVOC	30	30
1A1a	Solid Fuels	Coal	NMVOC	50	50
1A1a	Solid Fuels	Steel converter gas	NMVOC	30	30
1A1a	Solid Fuels	Blast furnace gas	NMVOC	30	30
1A1a	Solid Fuels	Övriga fasta bränslen	NMVOC	50	50
1A1a	Peat	Peat	NMVOC	50	50

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1A1a	Biomass	Landfill gas	NO <sub>x</sub>	50	50
1A1a	Biomass	Tall oil	NO <sub>x</sub>	20	20
1A1a	Biomass	Wooden fuels	NO <sub>x</sub>	50	50
1A1a	Biomass	Other biomass	NO <sub>x</sub>	20	20
1A1a	Gaseous Fuels	All fuels	NO <sub>x</sub>	20	20
1A1a	Liquid Fuels	Diesel oil	NO <sub>x</sub>	50	50
1A1a	Liquid Fuels	Domestic heating oil	NO <sub>x</sub>	20	20
1A1a	Liquid Fuels	Residual fuel oil	NO <sub>x</sub>	20	20
1A1a	Liquid Fuels	Kerosene	NO <sub>x</sub>	50	50
1A1a	Liquid Fuels	LPG	NO <sub>x</sub>	50	50
1A1a	Liquid Fuels	Gas works gas	NO <sub>x</sub>	50	50
1A1a	Liquid Fuels	Other petroluem fuels	NO <sub>x</sub>	50	50
1A1a	Other Fuels	Waste	NO <sub>x</sub>	20	20
1A1a	Other Fuels	Other non-specified	NO <sub>x</sub>	50	50
1A1a	Solid Fuels	All fuels	NO <sub>x</sub>	20	20
1A1a	Solid Fuels	All fuels	NO <sub>x</sub>	50	50
1A1a	Peat	Peat	NO <sub>x</sub>	20	20
1A1a	Biomass	All fuels	Ni	40	40
1A1a	Liquid Fuels	All fuels	Ni	100	100
1A1a	Other Fuels	Waste	Ni	420	420
1A1a	Solid Fuels	Coal	Ni	40	40
1A1a	Peat	Peat	Ni	40	40
1A1a	Biomass	All fuels	PAH	100	100
1A1a	Gaseous Fuels	All fuels	PAH	70	70
1A1a	Liquid Fuels	Diesel oil	PAH	100	100
1A1a	Liquid Fuels	Domestic heating oil	PAH	100	100
1A1a	Liquid Fuels	Residual fuel oil	PAH	100	100
1A1a	Liquid Fuels	Kerosene	PAH	100	100
1A1a	Liquid Fuels	Other petroluem fuels	PAH	100	100
1A1a	Peat	Peat	PAH	100	100
1A1a	Biomass	Landfill gas	PM <sub>10</sub>	100	100
1A1a	Biomass	Tall oil	PM <sub>10</sub>	100	100
1A1a	Biomass	Wooden fuels	PM <sub>10</sub>	40	40
1A1a	Biomass	Other biomass	PM <sub>10</sub>	40	40
1A1a	Gaseous Fuels	All fuels	PM <sub>10</sub>	100	100
1A1a	Liquid Fuels	Diesel oil	PM <sub>10</sub>	100	100
1A1a	Liquid Fuels	Domestic heating oil	PM <sub>10</sub>	40	40
1A1a	Liquid Fuels	Residual fuel oil	PM <sub>10</sub>	40	40
1A1a	Liquid Fuels	Kerosene	PM <sub>10</sub>	100	100
1A1a	Liquid Fuels	LPG	PM <sub>10</sub>	100	100
1A1a	Liquid Fuels	Gas works gas	PM <sub>10</sub>	100	100
1A1a	Liquid Fuels	Other petroluem fuels	PM <sub>10</sub>	100	100
1A1a	Other Fuels	Waste	PM <sub>10</sub>	100	100
1A1a	Other Fuels	Other non-specified	PM <sub>10</sub>	40	40
1A1a	Solid Fuels	Coke oven gas	PM <sub>10</sub>	40	40
1A1a	Solid Fuels	Coal	PM <sub>10</sub>	40	40
1A1a	Solid Fuels	Steel converter gas	PM <sub>10</sub>	40	40
1A1a	Solid Fuels	Blast furnace gas	PM <sub>10</sub>	40	40
1A1a	Solid Fuels	Övriga fasta bränslen	PM <sub>10</sub>	100	100
1A1a	Peat	Peat	PM <sub>10</sub>	40	40
1A1a	Biomass	Landfill gas	PM <sub>2.5</sub>	100	100
1A1a	Biomass	Tall oil	pm2.6	100	100
1A1a	Biomass	Wooden fuels	pm2.7	40	40
1A1a	Biomass	Other biomass	pm2.8	40	40
1A1a	Gaseous Fuels	All fuels	PM <sub>2.5</sub>	100	100
1A1a	Liquid Fuels	Diesel oil	PM <sub>2.5</sub>	100	100
1A1a	Liquid Fuels	Domestic heating oil	PM <sub>2.5</sub>	40	40
1A1a	Liquid Fuels	Residual fuel oil	PM <sub>2.5</sub>	40	40
1A1a	Liquid Fuels	Kerosene	PM <sub>2.5</sub>	100	100
1A1a	Liquid Fuels	LPG	PM <sub>2.5</sub>	100	100
1A1a	Liquid Fuels	Gas works gas	PM <sub>2.5</sub>	100	100
1A1a	Liquid Fuels	Other petroluem fuels	PM <sub>2.5</sub>	100	100
1A1a	Other Fuels	Waste	PM <sub>2.5</sub>	100	100

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1A1a	Other Fuels	Other non-specified	PM <sub>2.5</sub>	40	40
1A1a	Solid Fuels	Coke oven gas	PM <sub>2.5</sub>	40	40
1A1a	Solid Fuels	Coal	PM <sub>2.5</sub>	40	40
1A1a	Solid Fuels	Steel converter gas	PM <sub>2.5</sub>	40	40
1A1a	Solid Fuels	Blast furnace gas	PM <sub>2.5</sub>	40	40
1A1a	Solid Fuels	Övriga fasta bränslen	PM <sub>2.5</sub>	100	100
1A1a	Peat	Peat	PM <sub>2.5</sub>	40	40
1A1a	All fuels	All fuels	Pb	100	100
1A1a	Biomass	Landfill gas	SO <sub>2</sub>	70	70
1A1a	Biomass	Tall oil	SO <sub>2</sub>	20	20
1A1a	Biomass	Wooden fuels	SO <sub>2</sub>	20	20
1A1a	Biomass	Other biomass	SO <sub>2</sub>	70	70
1A1a	Gaseous Fuels	Natural gas	SO <sub>2</sub>	20	20
1A1a	Gaseous Fuels	Gas works gas	SO <sub>2</sub>	70	70
1A1a	Liquid Fuels	Diesel oil	SO <sub>2</sub>	70	70
1A1a	Liquid Fuels	Domestic heating oil	SO <sub>2</sub>	20	20
1A1a	Liquid Fuels	Residual fuel oil	SO <sub>2</sub>	20	20
1A1a	Liquid Fuels	Kerosene	SO <sub>2</sub>	70	70
1A1a	Liquid Fuels	LPG	SO <sub>2</sub>	20	20
1A1a	Liquid Fuels	Gas works gas	SO <sub>2</sub>	20	20
1A1a	Liquid Fuels	Other petroluem fuels	SO <sub>2</sub>	70	70
1A1a	Other Fuels	Waste	SO <sub>2</sub>	20	20
1A1a	Other Fuels	Other non-specified	SO <sub>2</sub>	70	70
1A1a	Solid Fuels	Coke oven gas	SO <sub>2</sub>	20	20
1A1a	Solid Fuels	Blast furnace gas	SO <sub>2</sub>	20	20
1A1a	Gaseous Fuels	All fuels	Se	100	100
1A1a	Liquid Fuels	All fuels	Se	100	100
1A1a	Other Fuels	Waste	Se	430	430
1A1a	Solid Fuels	Coal	Se	100	100
1A1a	Peat	Peat	Se	100	100
1A1a	Biomass	Landfill gas	TSP	100	100
1A1a	Biomass	Tall oil	TSP	100	100
1A1a	Biomass	Wooden fuels	TSP	20	20
1A1a	Biomass	Other biomass	TSP	20	20
1A1a	Gaseous Fuels	All fuels	TSP	100	100
1A1a	Liquid Fuels	Diesel oil	TSP	100	100
1A1a	Liquid Fuels	Domestic heating oil	TSP	20	20
1A1a	Liquid Fuels	Residual fuel oil	TSP	20	20
1A1a	Liquid Fuels	Kerosene	TSP	100	100
1A1a	Liquid Fuels	LPG	TSP	100	100
1A1a	Liquid Fuels	Gas works gas	TSP	100	100
1A1a	Liquid Fuels	Other petroluem fuels	TSP	100	100
1A1a	Other Fuels	Waste	TSP	20	20
1A1a	Other Fuels	Other non-specified	TSP	100	100
1A1a	Solid Fuels	Coke oven gas	TSP	20	20
1A1a	Solid Fuels	Coal	TSP	20	20
1A1a	Solid Fuels	Steel converter gas	TSP	20	20
1A1a	Solid Fuels	Blast furnace gas	TSP	20	20
1A1a	Solid Fuels	Övriga fasta bränslen	TSP	100	100
1A1a	Peat	Peat	TSP	20	20
1A1a	Biomass	All fuels	Zn	100	100
1A1a	Other Fuels	Waste	Zn	800	800
1A1a	Biomass	Tall oil	AD	2	2
1A1a	Biomass	Wooden fuels	AD	2	2
1A1a	Biomass	Other biomass	AD	10	10
1A1a	Gaseous Fuels	All fuels	AD	2	2
1A1a	Liquid Fuels	All Fuels	AD	2	2
1A1a	Liquid Fuels	Domestic heating oil	AD	2	2
1A1a	Liquid Fuels	Residual fuel oil	AD	2	2
1A1a	Liquid Fuels	Kerosene	AD	2	2
1A1a	Liquid Fuels	LPG	AD	2	2
1A1a	Liquid Fuels	Gas works gas	AD	2	2
1A1a	Liquid Fuels	Other petroluem fuels	AD	10	10

1A1a	Other Fuels	Waste	AD	2	2
1A1a	Other Fuels	Other non-specified	AD	10	10
1A1a	Solid Fuels	Coke oven gas	AD	2	2
1A1a	Solid Fuels	Coal	AD	2	2
1A1a	Solid Fuels	Steel converter gas	AD	2	2
1A1a	Solid Fuels	Blast furnace gas	AD	2	2
1A1a	Solid Fuels	Peat	AD	7	2
1A1a	Solid Fuels	Other solid fuel	AD	10	10
1A1a	Biomass	All fuels	HCB	900	900
1A1a	Peat	All fuels	HCB	200	200
1A1a	Solid Fuels	All fuels	HCB	200	200
1A1a	Biomass	All fuels	PCB	900	900
1A1a	Peat	All fuels	PCB	200	200
1A1a	Solid Fuels	All fuels	PCB	200	200
1A1a	Other	All fuels	HCB	462	462
1A1a	Other	All fuels	PCB	171	171

#### 3.2.1.4 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, of course, 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. Remarks in reports from the UNFCCC and CLRTAP/NEC reviews have been carefully read and taken into account.

As part of the inventory procedure for submission 2007, a separate study<sup>23</sup> was performed to verify the quality of all fossil fuel combustion-related activity data from the largest plants (in terms of CO<sub>2</sub>-emissions) in Sweden in 2005. The verifi-

<sup>23</sup> Backman & Gustafsson, 2006

cation consisted of a comparison of plant-specific SMED-data (energy statistics from the quarterly fuel statistics) with data from the EU Emission Trading System (ETS). The results showed that for 21 plants, accounting for about 50 % of the fossil fuel consumption of the 63 plants included in the study, no significant differences between the two data sources were identified. For a number of plants, large differences occurred between the two data sources. In 2007, 19 of these plants were further surveyed in another study<sup>24</sup>. Again, energy statistics (the quarterly fuel statistics) and ETS data by plant were compared and analysed.

The results show that the reported fuel amounts differ slightly between the data sets and since ETS data are verified, they are likely to be more correct. Another deficiency in the quarterly fuel statistics is that unconventional fuels are often grouped and the emission factors of these fuels are associated with very large uncertainties, since they are not specific for the current fuel and plant. Finally, another problem is that some of those unconventional fuels are incorrectly classified. According to data reported to ETS, some of these fuels are often partly biogenic and should hence be classified as "Other biomass".

#### 3.2.1.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2017 a major revision of the emission factors was made. The revision is described in more detail in Annex 2. Briefly, the revision includes several fuel types and recalculations are made for the whole time series for all the revised fuel types except for CO<sub>2</sub> emissions from solid waste, which was only revised for the emission year 2015<sup>25</sup>.

In submission 2017 a major revision of emission factors were made for several fuel types. These are reported in Table 3-3.

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<sup>24</sup> Nyström, 2007

<sup>25</sup> Mawdsley, I., Wisell, T., Stripple, H., Ortiz, C. 2016. Revision of emission factors for electricity generation and district heating (CRF/NFR 1A1a). SMED Report No 194 2016. Agreement No 2250-16-003. Commissioned by the Swedish Environmental Protection Agency



**Table 3-3. Revised emissions factors for submission 2017 by fuel type and their variability in time**

Sub-stance	Fuel Type	Years
SO <sub>2</sub>	Coal, Wooden fuels, Peat, Waste, Tall oil, Landfill gas	All fuels variable in time except Landfill gas
NO <sub>x</sub>	Domestic heating oil, Residual fuel oil, LPG, Gas works gas, Natural gas, Blast furnace gas, Steel converter gas, Coal, Wooden fuels, Peat, Waste, Tall oil, Other biomass	All fuels variable in time except Domestic heating oil and Residual fuel oil
NH <sub>3</sub>	Coal, Wooden fuels	Constant in time
CO	Coal, Wooden fuels, Peat, Waste	Constant in time
NMVOC	No changes	-
BC	Domestic heating oil, Residual fuel oil, Coke oven gas, Blast furnace gas, Steel converter gas, Coal, Wooden fuels, Peat, Waste, Other biomass	Coal, Wooden fuels, Peat, Waste and Other biomass are variable in time
PM <sub>10</sub>	Domestic heating oil, Residual fuel oil, Coke oven gas, Blast furnace gas, Steel converter gas, Coal, Wooden fuels, Peat, Waste, Other biomass	Coal, Wooden fuels, Peat, Waste and Other biomass are variable in time
PM <sub>2.5</sub>	Domestic heating oil, Residual fuel oil, Coke oven gas, Blast furnace gas, Steel converter gas, Coal, Wooden fuels, Peat, Waste, Other biomass	Coal, Wooden fuels, Peat, Waste and Other biomass are variable in time
As	Residual fuel oil, Coal, Peat, Waste	Coal, Peat and Waste variable in time
Cd	Coal, Peat, Waste	Coal and Peat variable in time
Cr	Domestic heating oil, Residual fuel oil, Coal, Wooden fuels, Peat, Waste and Other biomass	Coal, Wooden fuels, Peat and Other biomass are variable in time
Cu	Residual fuel oil, Coal, Wooden fuels, Peat, Waste and Other biomass	Coal, Wooden fuels, Peat and Other biomass are variable in time
Hg	Coke oven gas, Steel converter gas, Coal	Coal variable in time
Ni	Domestic heating oil, Residual fuel oil, Coal, Wooden fuels, Peat, Waste and Other biomass	Coal and Peat variable in time
Pb	Domestic heating oil, Residual fuel oil, Coal, Wooden fuels, Peat, Waste, Other biomass	Coal, Peat and Waste are variable in time
Se	Domestic heating oil, Residual fuel oil, Coal, Wooden fuels, Peat, Waste, Other biomass	Coal, Wooden fuels and Peat are variable in time
Zn	Domestic fuel oil, Residual fuel oil, Wooden fuels, Peat, Waste, Other biomass	Wooden fuels variable in time
Dioxin	Coal, Wooden fuels, Peat, Waste, Tall oil, Diesel oil, Landfill gas, Other biomass	All variable in time
B(a)p	LPG, Gas works gas, Natural gas, Coke oven gas, Blast furnace gas, Steel converter gas, Coal, Peat, Waste, Landfill gas	All constant in time
B(b)f	LPG, Gas works gas, Natural gas, Coke oven gas, Blast furnace gas, Steel converter gas, Coal, Peat, Waste, Landfill gas	All constant in time
B(k)f	LPG, Gas works gas, Natural gas, Coke oven gas, Blast furnace gas, Steel converter gas, Coal, Peat, Waste, Landfill gas	All constant in time
In-denopyrenes	LPG, Gas works gas, Natural gas, Coke oven gas, Blast furnace gas, Steel converter gas, Coal, Peat, Waste, Landfill gas	All constant in time
PAH 1-4	LPG, Gas works gas, Natural gas, Coke oven gas, Steel converter gas, Coal, Peat, Waste, Landfill gas	All constant in time
PCB	No changes	
HCB	No changes	

**Table 3-4. Effects of revised emission factors in NFR1AA1A during submission 2017.**

NFR	Fuel group	Substance	Effect
1A1Ai	Liquid fuels	Cr, Ni, Pb, Se, TSP, Zn, Benzo(a)pyrene	Lower
1A1Ai	Liquid fuels	Cu, PM <sub>10</sub> , PM <sub>2.5</sub>	Lower, mores table in time
1A1Ai	Biomass	BC, CO, Cu, NH <sub>3</sub> , PM <sub>10</sub> , PM <sub>2.5</sub> , Se, TSP, Sn	Lower
1A1Aii	Solid fuels	As, Cr, Dioxine, Ni, So2, Benzo(a)pyrene , Benso(a)flouranthene, Benso(b)flouranthene, Benso(k)flouranthene, NO <sub>x</sub> , Hg	Lower
1A1Aii	Solid fuels	CO, Indenopyrene, NH <sub>3</sub> , PAH 1-4, PM <sub>10</sub> , PM <sub>2.5</sub> , Pb, Se, TSP	Lower, more stable in time
1A1Aii	Solid fuels	BC, Cu	Higher
1A1Aii	Gaseous fuels	NO <sub>x</sub>	Lower
1A1Aii	Biomass	Cu, Dioxins, Indenopyrene, N <sub>2</sub> O, NH <sub>3</sub> , Ni, PAH 1-4, PM <sub>10</sub> , PM <sub>2.5</sub> , SO <sub>2</sub> , Zn, Benso(a)flouranthene, Benso(b)flouranthene, Benso(k)flouranthene	Lower
1A1Aii	Biomass	CO, Se, TSP	Lower, more stable
1A1Aii	Biomass	BC	Lower, faster decrease in time
1A1Aii	Biomass	As, Cr, Pb,	Higher
1A1Aiii	Liquid fuels	As, BC, Cr, Ni, Pb, NO <sub>x</sub>	Lower
1A1Aiii	Liquid fuels	Cu, PM <sub>10</sub> , PM <sub>2.5</sub>	Lower, more stable
1A1Aiii	Liquid fuels	Dioxins	New
1A1Aiii	Biomass	As, Dioxins, NH <sub>3</sub> , PM <sub>10</sub> , PMN2.5, SO <sub>2</sub>	Lower
1A1Aiii	Biomass	CO	Lower, mores stable
1A1Aiii	Biomass	BC, Se, TSP, Zn	Lower, faster decrease in time
1A1Aiii	Other fuels	Cd, Dioxins, Indenopyrene, Ni, PAH 1-4, Pb, SO <sub>2</sub> , Benso(a)flouranthene, Benso(b)flouranthene, Benso(k)flouranthene	Lower
1A1Aiii	Other fuels	As, CO	Lower, more stable
1A1Aiii	Peat	As, Dioxins, PAH 1-4, Benso(a)flouranthene, Benso(b)flouranthene, Benso(k)flouranthene	Lower
1A1Aiii	Peat	BC, Ni, PM <sub>10</sub> , PM <sub>2.5</sub> , SO <sub>2</sub> , Se, TSP	Lower, faster decrease in time
1A1Aiii	Peat	Cd, Cr, Cu,	Lower, variable in time
1A1Aiii	Peat	Indenopyrene	Higher

The effects of the new emission factors for NFR1AA1A are variable in both magnitude and trend and these affect the IEF trend in many cases. In general the revision of emission factors led to lower IEF for most all of the fuel types. In some cases also the time series is affected because the emission factors that were constant where changed to time variable emission factors during the revision. The effects of the IEF by magnitude (lower/higher) and on the time series are aggregated by fuel groups and shown in Table 3-4.

### 3.2.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

### 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.

**Table 3-5. Summary of key source analysis, NFR1A1b, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A1b	<i>Liquid Fuels - PM<sub>2.5</sub>, PM<sub>10</sub>, TSP, Ni, SO<sub>2</sub>, NO<sub>x</sub></i>	<i>Liquid Fuels - PM<sub>2.5</sub>, PM<sub>10</sub>, TSP, Ni, SO<sub>2</sub></i>

#### 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 has been collected directly from each company for 1990-1999, since the industrial energy statistics and quarterly fuel statistics did not account for all fuels produced within refineries for 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, e.g. before the EU Emission Trading System (ETS) was established, energy statistics was used as the data quality was improved compared to the 1990's and is considered to be sufficient for these years.

As a result of a specific SMED study during 2006<sup>26</sup>, data from the EU Emission Trading System (ETS) are used for four refinery plants for 2005 and later years. For the fifth plant data from environmental reports were used. In 2008 and later years, the quality of ETS data is considered to be very high for all the five refineries, and thus this is the primary source of activity data for this sector.

<sup>26</sup> Backman & Gustafsson, 2006

The fuel consumption in this sector is mainly based on liquid fuels and the use has increased compared to the early 1990's due to higher demand of refined products. Since the early 2000's, however, there is no obvious trend in fuel consumption in this sector.

For confidentiality reasons all emissions in 1A1b are reported as C.

### 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.

The assigned uncertainties are based on information directly from the facilities. These are updated regularly but not annually. The emission factor uncertainty and the activity data uncertainty is around 10% for submission 2016. 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 %.

Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3-6 the average uncertainties for activity data and emission factors by fuel group are weighted.

**Tabell 3-6. Uncertainties in activity data and emission factors for all substances for the base year and the year of latest emissions (2015) reported for NFR1A1b.**

Source category	Fuel group	Fuel type	Substance	Base year uncertainty (%)	Year 2015 uncertainty (%)
1A1b	Gaseous Fuels	Natural gas	AD	2	2
1A1b	Liquid Fuels	Refinery oil	AD	2	2
1A1b	Liquid Fuels	Diesel oil	AD	2	2
1A1b	Liquid Fuels	Domestic heating oil	AD	2	2
1A1b	Liquid Fuels	Kerosene	AD	2	2
1A1b	Liquid Fuels	LPG	AD	2	2
1A1b	Liquid Fuels	Raffinaderigaser	AD	10	10
1A1b	Liquid Fuels	Other petroleum fuels	AD	10	10
1A1b	Gaseous Fuels	Natural gas	As	100	100
1A1b	Liquid Fuels	All Fuels	As	100	100
1A1b	Liquid Fuels	Raffinaderigaser	As	100	100
1A1b	Gaseous Fuels	Natural gas	CO	30	30
1A1b	Liquid Fuels	Refinery oil	CO	40	40
1A1b	Liquid Fuels	Diesel oil	CO	50	50
1A1b	Liquid Fuels	Domestic heating oil	CO	40	40
1A1b	Liquid Fuels	Kerosene	CO	50	50
1A1b	Liquid Fuels	LPG	CO	30	30
1A1b	Liquid Fuels	Raffinaderigaser	CO	50	50
1A1b	Liquid Fuels	All fuels	Cd	100	100
1A1b	Liquid Fuels	All fuels	Cr	100	100
1A1b	Liquid Fuels	All fuels	Cu	100	100
1A1b	Liquid Fuels	All fuels	Hg	100	100
1A1b	Gaseous Fuels	Natural gas	N <sub>2</sub> O	20	20
1A1b	Liquid Fuels	Refinery oil	N <sub>2</sub> O	40	40

1A1b	Liquid Fuels	Diesel oil	N <sub>2</sub> O	100	100
1A1b	Liquid Fuels	Domestic heating oil	N <sub>2</sub> O	40	40
1A1b	Liquid Fuels	Kerosene	N <sub>2</sub> O	100	100
1A1b	Liquid Fuels	LPG	N <sub>2</sub> O	20	20
1A1b	Liquid Fuels	Raffinaderigaser	N <sub>2</sub> O	100	100
1A1b	Gaseous Fuels	Natural gas	NH <sub>3</sub>	40	40
1A1b	Liquid Fuels	Refinery oil	NH <sub>3</sub>	40	40
1A1b	Liquid Fuels	Diesel oil	NH <sub>3</sub>	50	50
1A1b	Liquid Fuels	Domestic heating oil	NH <sub>3</sub>	40	40
1A1b	Liquid Fuels	Kerosene	NH <sub>3</sub>	40	40
1A1b	Liquid Fuels	LPG	NH <sub>3</sub>	20	20
1A1b	Liquid Fuels	Raffinaderigaser	NH <sub>3</sub>	50	50
1A1b	Gaseous Fuels	Natural gas	NMVOC	30	30
1A1b	Liquid Fuels	Refinery oil	NMVOC	50	50
1A1b	Liquid Fuels	Diesel oil	NMVOC	30	30
1A1b	Liquid Fuels	Domestic heating oil	NMVOC	30	30
1A1b	Liquid Fuels	Kerosene	NMVOC	30	30
1A1b	Liquid Fuels	LPG	NMVOC	30	30
1A1b	Liquid Fuels	Raffinaderigaser	NMVOC	50	50
1A1b	Gaseous Fuels	Natural gas	NO <sub>x</sub>	50	50
1A1b	Liquid Fuels	All fuels	NO <sub>x</sub>	50	50
1A1b	Liquid Fuels	All fuels	Ni	100	100
1A1b	Gaseous Fuels	Natural gas	PAH	100	100
1A1b	Liquid Fuels	All fuels	PAH	100	100
1A1b	Gaseous Fuels	Natural gas	PM <sub>10</sub>	100	100
1A1b	Liquid Fuels	All fuels	PM <sub>10</sub>	100	100
1A1b	Gaseous Fuels	Natural gas	PM <sub>2.5</sub>	100	100
1A1b	Liquid Fuels	All fuels	PM <sub>2.5</sub>	100	100
1A1b	Liquid Fuels	All fuels	Pb	100	100
1A1b	Gaseous Fuels	Natural gas	SO <sub>2</sub>	70	70
1A1b	Liquid Fuels	All fuels	SO <sub>2</sub>	70	70
1A1b	Liquid Fuels	All fuels	Se	100	100
1A1b	Gaseous Fuels	Natural gas	TSP	100	100
1A1b	Liquid Fuels	All fuels	TSP	100	100
1A1b	Liquid Fuels	All fuels	Zn	100	100

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

In general, the same QA/QC procedures are used for NFR1A1b as for 1A1a described above. For each of the five refineries, ETS data for the latest year are verified against the refineries' legal environmental reports. During the national peer review remarks have been made 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 re-coded as refinery gas. Environmental reports show that natural gas has been used in NFR1A1b 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

No recalculations have been carried out in submission 2017.

### 3.2.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

## 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<sup>27</sup>. 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.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3-7.

**Table 3-7. Summary of source category description, NFR1A1c, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A1c	<i>Solid fuels – TSP, NO<sub>x</sub></i>	<i>Solid fuels – TSP, SO<sub>2</sub>, NO<sub>x</sub></i>

### 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<sub>2</sub> and NO<sub>x</sub> 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<sub>2</sub> also 2B5 and 1B1b) according to the activity data distribution.

For 1980-1989, activity data is taken from the industrial statistics and quarterly statistics. For more details on the surveys see Annex 2. 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.

<sup>27</sup> 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.

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.

For confidentiality reasons all emissions in 1A1b are reported as C.

### 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.

Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3-8 the average uncertainties for activity data and emission factors by fuel group are weighted.

**Tabell 3-8. Uncertainties in activity data and emission factors for all substances for the base year and the year of latest emissions (2015) reported for NFR1A1c**

Source category	Fuel group	Fuel type	Substance	Base year uncertainty (%)	Year 2015 uncertainty (%)
1A1c	All Fuels	All Fuels	AD	5	5
1A1c	All Fuels	All Fuels	As	5	5
1A1c	Biomass	Wooden fuels	CO	75	75
1A1c	Gaseous Fuels	Natural gas	CO		30
1A1c	Liquid Fuels	Domestic heating oil	CO	40	40
1A1c	Liquid Fuels	Residual fuel oil	CO	40	40
1A1c	Liquid Fuels	LPG	CO	30	30
1A1c	Solid Fuels	Coke oven gas	CO	30	30
1A1c	Solid Fuels	Blast furnace gas	CO	30	30
1A1c	Biomass	Wooden fuels	Cd	40	40
1A1c	Liquid Fuels	Domestic heating oil	Cd	100	100
1A1c	Liquid Fuels	Residual fuel oil	Cd	100	100
1A1c	Biomass	Wooden fuels	Cr	40	40
1A1c	All Fuels	All Fuels	Cr	100	100
1A1c	Biomass	Wooden fuels	Cu	40	40
1A1c	Liquid Fuels	Domestic heating oil	Cu	100	100
1A1c	Liquid Fuels	Residual fuel oil	Cu	100	100
1A1c	Liquid Fuels	LPG	Cu	100	100
1A1c	Biomass	Wooden fuels	DIOX	100	100
1A1c	Biomass	Wooden fuels	Hg	40	40
1A1c	Liquid Fuels	Domestic heating oil	Hg	100	100
1A1c	Liquid Fuels	Residual fuel oil	Hg	100	100
1A1c	Liquid Fuels	LPG	Hg	100	100
1A1c	Solid Fuels	Coke oven gas	Hg	40	40
1A1c	Solid Fuels	Blast furnace gas	Hg	40	40
1A1c	Biomass	Wooden fuels	N <sub>2</sub> O	40	40

1A1c	Gaseous Fuels	Natural gas	N <sub>2</sub> O		20
1A1c	Liquid Fuels	Domestic heating oil	N <sub>2</sub> O	40	40
1A1c	Liquid Fuels	Residual fuel oil	N <sub>2</sub> O	40	40
1A1c	Liquid Fuels	LPG	N <sub>2</sub> O	20	20
1A1c	Solid Fuels	Coke oven gas	N <sub>2</sub> O	20	20
1A1c	Solid Fuels	Blast furnace gas	N <sub>2</sub> O	20	20
1A1c	Biomass	Wooden fuels	NH <sub>3</sub>	40	40
1A1c	Gaseous Fuels	Natural gas	NH <sub>3</sub>		40
1A1c	Liquid Fuels	Domestic heating oil	NH <sub>3</sub>	40	40
1A1c	Liquid Fuels	Residual fuel oil	NH <sub>3</sub>	40	40
1A1c	Liquid Fuels	LPG	NH <sub>3</sub>	20	20
1A1c	Solid Fuels	Coke oven gas	NH <sub>3</sub>	20	20
1A1c	Solid Fuels	Blast furnace gas	NH <sub>3</sub>	20	20
1A1c	Biomass	Wooden fuels	NM VOC	75	75
1A1c	Gaseous Fuels	Natural gas	NM VOC		30
1A1c	Liquid Fuels	Domestic heating oil	NM VOC	30	30
1A1c	Liquid Fuels	Residual fuel oil	NM VOC	30	30
1A1c	Liquid Fuels	LPG	NM VOC	30	30
1A1c	Solid Fuels	Coke oven gas	NM VOC	30	30
1A1c	Solid Fuels	Blast furnace gas	NM VOC	30	30
1A1c	All Fuels	All Fuels	NO <sub>x</sub>	50	50
1A1c	Biomass	Wooden fuels	Ni	40	40
1A1c	All Fuels	All Fuels	Ni	100	100
1A1c	All Fuels	All Fuels	PAH	100	100
1A1c	All Fuels	All Fuels	PM <sub>10</sub>	100	100
1A1c	All Fuels	All Fuels	PM <sub>2.5</sub>	100	100
1A1c	Biomass	Wooden fuels	Pb	50	50
1A1c	Liquid Fuels	Domestic heating oil	Pb	100	100
1A1c	Liquid Fuels	Residual fuel oil	Pb	100	100
1A1c	All Fuels	All Fuels	SO <sub>2</sub>	70	70
1A1c	Biomass	Wooden fuels	Se	40	40
1A1c	Liquid Fuels	Domestic heating oil	Se	100	100
1A1c	Liquid Fuels	Residual fuel oil	Se	100	100
1A1c	All Fuels	All Fuels	TSP	100	100
1A1c	Biomass	Wooden fuels	Zn	40	40
1A1c	Liquid Fuels	Residual fuel oil	Zn	100	100

#### 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<sup>28</sup> 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<sup>29</sup>.

#### 3.2.3.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been carried out in submission 2017.

<sup>28</sup> Skärman, T., Danielsson, H., Kindbom, K., Jernström, M., Nyström, A-K. 2008.

<sup>29</sup> Gustafsson, T., Nyström, A-K., Gerner, A., 2010



### 3.2.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

## 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. The Swedish iron and steel works produced in total 4.8 Mt of steel in 2010, which is 73% more than the production in 2009. In 2015, the production was 4.4 Mt<sup>30</sup>. 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 category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3-9.

**Table 3-9. Summary of key source analysis, NFR1A2a, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A2a	Liquid – Ni, SO <sub>2</sub> , NO <sub>x</sub>	Liquid – – Ni, Se,
	Solid –SO <sub>2</sub>	Solid – SO <sub>2c</sub>

### 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 industrial energy statistics for 1990-1996 and 2000-2002, and from quarterly fuel statistics for 1997-1999 and 2003 onwards, further described in Annex 2.

Emissions reported from primary steel works and other iron and steel works are reported in both NFR1A1c, 1A2a, 1B1b, 1B1c and 2C1 since some emissions arise

<sup>30</sup> The Swedish Steel Producers' Association, 2016-11-14.

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.

#### 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 consists of material flows between coke oven, blast furnace and steel-works, and in one plant, rolling mill (see Figure 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.

Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3-10 the average uncertainties for activity data and emission factors by fuel group are weighted.

**Tabell 3-10. Uncertainties in activity data and emission factors for all substances for the base year and the year of latest emissions (2015) reported for NFR1A2a.**

Source category	Fuel group	Fuel type	Sub-stance	Base year uncertainty (%)	Year 2015 uncertainty (%)
1A2a	Biomass	Wooden fuels	AD	5	5
1A2a	Biomass	Other biomass	AD	10	10
1A2a	Gaseous Fuels	Natural gas	AD	5	5
1A2a	Liquid Fuels	All fuels	AD	5	5
1A2a	Other Fuels	Waste	AD	5	5

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1A2a	Other Fuels	Other non-specified	AD	10	10
1A2a	Solid Fuels	Coke	AD	5	5
1A2a	Solid Fuels	Coke oven gas	AD	5	5
1A2a	Solid Fuels	Coal	AD	5	5
1A2a	Solid Fuels	Blast furnace gas	AD	5	5
1A2a	Solid Fuels	Other solid fuels	AD	10	10
1A2a	Biomass	Wooden fuels	As	400	400
1A2a	Biomass	Other biomass	As	400	400
1A2a	Gaseous Fuels	Natural gas	As	100	100
1A2a	Liquid Fuels	All fuels	As	100	100
1A2a	Biomass	All fuels	CO	75	75
1A2a	Gaseous Fuels	Natural gas	CO	30	30
1A2a	Liquid Fuels	Diesel oil	CO	50	50
1A2a	Liquid Fuels	Domestic heating oil	CO	40	40
1A2a	Liquid Fuels	Residual fuel oil	CO	40	40
1A2a	Liquid Fuels	Kerosene	CO	50	50
1A2a	Liquid Fuels	Petroleum coke	CO	40	40
1A2a	Liquid Fuels	LPG	CO	30	30
1A2a	Solid Fuels	Coke	CO	40	40
1A2a	Solid Fuels	Coke oven gas	CO	30	30
1A2a	Solid Fuels	Coal	CO	40	40
1A2a	Solid Fuels	Blast furnace gas	CO	30	30
1A2a	Solid Fuels	Other solid fuels	CO	50	50
1A2a	Biomass	Wooden fuels	Cd	40	40
1A2a	Biomass	Other biomass	Cd	40	40
1A2a	Liquid Fuels	All fuels	Cd	100	100
1A2a	Solid Fuels	All fuels	Cd	40	40
1A2a	Liquid Fuels	All fuels	Cr	100	100
1A2a	Solid Fuels	All fuels	Cr	50	50
1A2a	Biomass	All fuels	Cu	40	40
1A2a	Liquid Fuels	All fuels	Cu	100	100
1A2a	Solid Fuels	All fuels	Cu	40	40
1A2a	All Fuels	All Fuels	Diox	100	100
1A2a	Biomass	All fuels	Hg	40	40
1A2a	Solid Fuels	All fuels	Hg	40	40
1A2a	Biomass	Wooden fuels	N <sub>2</sub> O	40	40
1A2a	Biomass	Other biomass	N <sub>2</sub> O	100	100
1A2a	Liquid Fuels	Diesel oil	N <sub>2</sub> O	100	100
1A2a	Liquid Fuels	Residual fuel oil	N <sub>2</sub> O	40	40
1A2a	Solid Fuels	Coke	N <sub>2</sub> O	40	40
1A2a	Solid Fuels	Coal	N <sub>2</sub> O	40	40
1A2a	Solid Fuels	Blast furnace gas	N <sub>2</sub> O	20	20
1A2a	Solid Fuels	Other solid fuels	N <sub>2</sub> O	100	100
1A2a	Biomass	All fuels	NH <sub>3</sub>	40	40
1A2a	Gaseous Fuels	Natural gas	NH <sub>3</sub>	40	40
1A2a	Liquid Fuels	Diesel oil	NH <sub>3</sub>	50	50
1A2a	Liquid Fuels	Domestic heating oil	NH <sub>3</sub>	40	40
1A2a	Liquid Fuels	Residual fuel oil	NH <sub>3</sub>	40	40
1A2a	Liquid Fuels	Kerosene	NH <sub>3</sub>	40	40
1A2a	Solid Fuels	Coke	NH <sub>3</sub>	40	40
1A2a	Solid Fuels	Coke oven gas	NH <sub>3</sub>	20	20
1A2a	Solid Fuels	Coal	NH <sub>3</sub>	40	40
1A2a	Solid Fuels	Blast furnace gas	NH <sub>3</sub>	20	20
1A2a	Solid Fuels	Other solid fuels	NH <sub>3</sub>	50	50
1A2a	Biomass	Wooden fuels	NMVOC	75	75
1A2a	Biomass	Other biomass	NMVOC	50	50
1A2a	Gaseous Fuels	Natural gas	NMVOC	30	30
1A2a	Liquid Fuels	All fuels	NMVOC	30	30
1A2a	Liquid Fuels	All fuels	NMVOC	50	50
1A2a	Solid Fuels	All fuels	NMVOC	50	50
1A2a	Solid Fuels	All fuels	NMVOC	30	30
1A2a	All Fuels	All Fuels	NO <sub>x</sub>	50	50
1A2a	Biomass	All fuels	Ni	40	40

1A2a	Liquid Fuels	All fuels	Ni	100	100
1A2a	Solid Fuels	All fuels	Ni	40	40
1A2a	All Fuels	All Fuels	PAH	100	100
1A2a	All Fuels	All Fuels	PM <sub>10</sub>	100	100
1A2a	All Fuels	All Fuels	PM <sub>2.5</sub>	100	100
1A2a	Biomass	Wooden fuels	Pb	50	50
1A2a	Biomass	Other biomass	Pb	100	100
1A2a	Liquid Fuels	All fuels	Pb	100	100
1A2a	Solid Fuels	All fuels	Pb	40	40
1A2a	All Fuels	All Fuels	SO <sub>2</sub>	70	70
1A2a	Biomass	All fuels	Se	40	40
1A2a	Liquid Fuels	All fuels	Se	100	100
1A2a	Liquid Fuels	All fuels	Zn	100	100

#### 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

No recalculations have been carried out in submission 2017.

#### 3.2.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 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 1A2b and the aluminium producers account for 32-45 %. The most common fuel is LPG (45-61 % in recent years), followed by natural gas and heating oils.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3-8.

**Table 3-8. Summary of key source analysis, NFR1A2b, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A2b	Liquid –	Liquid –
	Solid –	Solid –

### 3.2.5.2 METHODOLOGICAL ISSUES

The Tier 2 method is used. Activity data is taken from industrial energy statistics 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. Fuel consumption shows a decreasing trend since 1990.

### 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.

Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3-9 the average uncertainties for activity data and emission factors by fuel group are weighted.

**Table 3-9. Uncertainties in activity data and emission factors for all substances for the base year and the year of latest emissions (2015) reported for NFR1A2b**

Source category	Fuel group	Fuel type	Substance	Base year uncertainty (%)	Year 2015 uncertainty (%)
1A2b	Biomass	Wooden fuels	AD	5	5
1A2b	Biomass	Other biomass	AD	10	10
1A2b	Gaseous Fuels	Natural gas	AD	5	5
1A2b	Liquid Fuels	All Fuels	AD	5	5
1A2b	Other Fuels	Waste	AD	5	5
1A2b	Solid Fuels	Coal	AD	5	5
1A2b	Solid Fuels	Other solid fuels	AD	10	10
1A2b	All Fuels	All Fuels	As	100	100
1A2b	Gaseous Fuels	Natural gas	CO	30	30
1A2b	Liquid Fuels	Diesel oil	CO	50	50
1A2b	Liquid Fuels	Domestic heating oil	CO	40	40
1A2b	Liquid Fuels	Residual fuel oil	CO	40	40
1A2b	Liquid Fuels	Kerosene	CO	50	50
1A2b	Liquid Fuels	LPG	CO	30	30
1A2b	Solid Fuels	Coal	CO	40	40
1A2b	Solid Fuels	Other solid fuels	CO	50	50
1A2b	Liquid Fuels	All Fuels	Cd	100	100
1A2b	Solid Fuels	Coal	Cd	40	40
1A2b	Liquid Fuels	All Fuels	Cr	100	100
1A2b	Solid Fuels	Coal	Cr	50	50
1A2b	Liquid Fuels	All Fuels	Cu	100	100
1A2b	Solid Fuels	Coal	Cu	40	40
1A2b	All Fuels	All Fuels	Diox	100	100
1A2b	Liquid Fuels	All Fuels	Hg	100	100

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1A2b	Solid Fuels	Coal	Hg	40	40
1A2b	Gaseous Fuels	Natural gas	N <sub>2</sub> O	20	20
1A2b	Liquid Fuels	Diesel oil	N <sub>2</sub> O	100	100
1A2b	Liquid Fuels	Domestic heating oil	N <sub>2</sub> O	40	40
1A2b	Liquid Fuels	Residual fuel oil	N <sub>2</sub> O	40	40
1A2b	Liquid Fuels	Kerosene	N <sub>2</sub> O	100	100
1A2b	Liquid Fuels	LPG	N <sub>2</sub> O	20	20
1A2b	Solid Fuels	Coal	N <sub>2</sub> O	40	40
1A2b	Solid Fuels	Other solid fuels	N <sub>2</sub> O	100	100
1A2b	Gaseous Fuels	Natural gas	NH <sub>3</sub>	40	40
1A2b	Liquid Fuels	Diesel oil	NH <sub>3</sub>	50	50
1A2b	Liquid Fuels	Domestic heating oil	NH <sub>3</sub>	40	40
1A2b	Liquid Fuels	Residual fuel oil	NH <sub>3</sub>	40	40
1A2b	Liquid Fuels	Kerosene	NH <sub>3</sub>	40	40
1A2b	Liquid Fuels	LPG	NH <sub>3</sub>	20	20
1A2b	Solid Fuels	Coal	NH <sub>3</sub>	40	40
1A2b	Solid Fuels	Other solid fuels	NH <sub>3</sub>	50	50
1A2b	Gaseous Fuels	Natural gas	NM VOC	30	30
1A2b	Liquid Fuels	All Fuels	NM VOC	30	30
1A2b	Solid Fuels	All Fuels	NM VOC	50	50
1A2b	Biomass	All fuels	NO <sub>x</sub>	50	50
1A2b	Gaseous Fuels	Natural gas	NO <sub>x</sub>	50	50
1A2b	Liquid Fuels	All Fuels	NO <sub>x</sub>	50	50
1A2b	Other Fuels	Waste	NO <sub>x</sub>	50	50
1A2b	Solid Fuels	All Fuels	NO <sub>x</sub>	50	50
1A2b	Liquid Fuels	All Fuels	Ni	100	100
1A2b	Solid Fuels	Coal	Ni	40	40
1A2b	Gaseous Fuels	Natural gas	PAH	100	100
1A2b	Liquid Fuels	All Fuels	PAH	100	100
1A2b	Solid Fuels	All Fuels	PAH	100	100
1A2b	Biomass	All fuels	PM <sub>10</sub>	100	100
1A2b	Gaseous Fuels	Natural gas	PM <sub>10</sub>	100	100
1A2b	Liquid Fuels	All Fuels	PM <sub>10</sub>	100	100
1A2b	Other Fuels	Waste	PM <sub>10</sub>	100	100
1A2b	Solid Fuels	All Fuels	PM <sub>10</sub>	100	100
1A2b	Biomass	All fuels	PM <sub>2.5</sub>	100	100
1A2b	Gaseous Fuels	Natural gas	PM <sub>2.5</sub>	100	100
1A2b	Liquid Fuels	All Fuels	PM <sub>2.5</sub>	100	100
1A2b	Other Fuels	Waste	PM <sub>2.5</sub>	100	100
1A2b	Solid Fuels	All Fuels	PM <sub>2.5</sub>	100	100
1A2b	Liquid Fuels	All Fuels	Pb	100	100
1A2b	Solid Fuels	Coal	Pb	40	40
1A2b	Biomass	All fuels	SO <sub>2</sub>	70	70
1A2b	Gaseous Fuels	Natural gas	SO <sub>2</sub>	70	70
1A2b	Liquid Fuels	All Fuels	SO <sub>2</sub>	70	70
1A2b	Other Fuels	Waste	SO <sub>2</sub>	70	70
1A2b	Solid Fuels	All Fuels	SO <sub>2</sub>	70	70
1A2b	Liquid Fuels	All Fuels	Se	100	100
1A2b	Solid Fuels	Coal	Se	40	40
1A2b	Biomass	All fuels	TSP	100	100
1A2b	Gaseous Fuels	Natural gas	TSP	100	100
1A2b	Liquid Fuels	All Fuels	TSP	100	100
1A2b	Other Fuels	Waste	TSP	100	100
1A2b	Solid Fuels	All Fuels	TSP	100	100
1A2b	Liquid Fuels	All Fuels	Zn	100	100
1A2b	Solid Fuels	Coal	Zn	700	700

#### 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<sup>31</sup>. The aim of this study was to investigate suspected errors in several CRF/NFR codes. Data for selected plants were verified with environmental reports per facility on an aggregate level, i.e. NFR1+2 together. This study showed no reasons for revisions in NFR1A2b.

#### 3.2.5.5 SOURCE-SPECIFIC RECALCULATIONS

No revisions were made in this category in submission 2017.

#### 3.2.5.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 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. Throughout the time series, liquid fuels account for about 80 % of the energy and gaseous fuels for 10-15 %.

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

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3-10.

**Table 3-10. Summary of key source analysis, NFR1A2c, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A2c	Biomass –	Biomass –
	Liquid – Ni, NO <sub>x</sub> , SO <sub>2</sub>	Liquid – Ni, NO <sub>x</sub>
	Other Fuels – SO <sub>2</sub>	Other Fuels – SO <sub>2</sub>

#### 3.2.6.2 METHODOLOGICAL ISSUES

The Tier 2 method is used. Activity data is, with exceptions mentioned below, collected from industrial energy statistics for 1990-1996 and 2000-2002 and from

<sup>31</sup> Skårman et.al, 2010.

quarterly fuel statistics for 1997-1999 and 2003 and later. For more details on these surveys see Annex 2.

Generally, plants classified as ISIC Division 24 according to ISIC Rev.3<sup>32</sup> in the energy 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 % methane, the emission factors are considered to be accurate also for methane-rich gas mixtures of liquid origin.

In a development project in 2010<sup>33</sup>, 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 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<sub>3</sub>, were corrected and set to zero for all substances except for NO<sub>x</sub>.

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.

### 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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<sup>32</sup> United Nations Statistics Division, 2010

<sup>33</sup> Gustafsson, Nyström & Gerner, 2010



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

Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3-11 the average uncertainties for activity data and emission factors by fuel group are weighted.

**Table 3-11. Uncertainties in activity data and emission factors for all substances for the base year and the year of latest emissions (2015) reported for NFR1A2c**

Source category	Fuel group	Fuel type	Sub-stance	Base year uncertainty (%)	Year 2015 uncertainty (%)
1A2c	Biomass	Landfill gas	AD	5	5
1A2c	Biomass	Ethanol	AD	10	10
1A2c	Biomass	Tall oil	AD	2	2
1A2c	Biomass	Wooden fuels	AD	5	5
1A2c	Biomass	Other biomass	AD	10	10
1A2c	Gaseous Fuels	Natural gas	AD	5	5
1A2c	Liquid Fuels	Refinery oil	AD	2	2
1A2c	Liquid Fuels	Diesel oil	AD	5	5
1A2c	Liquid Fuels	Domestic heating oil	AD	5	5
1A2c	Liquid Fuels	Residual fuel oil	AD	5	5
1A2c	Liquid Fuels	Kerosene	AD	5	5
1A2c	Liquid Fuels	Methane	AD	10	10
1A2c	Liquid Fuels	Petroleum coke	AD	5	5
1A2c	Liquid Fuels	LPG	AD	5	5
1A2c	Liquid Fuels	Gas works gas	AD	5	5
1A2c	Liquid Fuels	Hydrogen	AD	5	5
1A2c	Liquid Fuels	Other petroleum fuels	AD	10	10
1A2c	Other Fuels	Waste	AD	5	5
1A2c	Other Fuels	Other non-specified	AD	10	10
1A2c	Solid Fuels	Carbide furnace gas	AD	10	10
1A2c	Solid Fuels	Coke	AD	5	5
1A2c	Solid Fuels	Coal	AD	5	5
1A2c	Solid Fuels	Peat	AD	7	2
1A2c	Biomass	Landfill gas	As	100	100
1A2c	Biomass	Ethanol	As	100	100
1A2c	Biomass	Tall oil	As	100	100
1A2c	Biomass	Wooden fuels	As	400	400
1A2c	Biomass	Other biomass	As	400	400
1A2c	Gaseous Fuels	Natural gas	As	100	100
1A2c	Liquid Fuels	All fuels	As	100	100
1A2c	Other Fuels	Waste	As	900	900
1A2c	Other Fuels	Other non-specified	As	100	100
1A2c	Solid Fuels	Carbide furnace gas	As	100	100
1A2c	Solid Fuels	Coke	As	100	100
1A2c	Solid Fuels	Coal	As	100	100
1A2c	Solid Fuels	Peat	As	400	400
1A2c	Biomass	Landfill gas	CO	50	50
1A2c	Biomass	Ethanol	CO	50	50
1A2c	Biomass	Tall oil	CO	50	50
1A2c	Biomass	Wooden fuels	CO	75	75
1A2c	Biomass	Other biomass	CO	75	75
1A2c	Gaseous Fuels	Natural gas	CO	30	30
1A2c	Liquid Fuels	Refinery oil	CO	40	40
1A2c	Liquid Fuels	Diesel oil	CO	50	50
1A2c	Liquid Fuels	Domestic heating oil	CO	40	40
1A2c	Liquid Fuels	Residual fuel oil	CO	40	40
1A2c	Liquid Fuels	Methane	CO	50	50
1A2c	Liquid Fuels	LPG	CO	30	30

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1A2c	Liquid Fuels	Gas works gas	CO	30	30
1A2c	Liquid Fuels	Hydrogen	CO	50	50
1A2c	Liquid Fuels	Other petroluem fuels	CO	50	50
1A2c	Other Fuels	Waste	CO	30	30
1A2c	Other Fuels	Other non-specified	CO	50	50
1A2c	Solid Fuels	Carbide furnace gas	CO	50	50
1A2c	Solid Fuels	Coke	CO	40	40
1A2c	Solid Fuels	Coal	CO	40	40
1A2c	Solid Fuels	Peat	CO	30	30
1A2c	Biomass	Landfill gas	Cd	100	100
1A2c	Biomass	Ethanol	Cd	1	1
1A2c	Biomass	Tall oil	Cd	100	100
1A2c	Biomass	Wooden fuels	Cd	30	30
1A2c	Biomass	Other biomass	Cd	100	100
1A2c	Gaseous Fuels	Natural gas	Cd	5	5
1A2c	Liquid Fuels	Refinery oil	Cd	1	1
1A2c	Liquid Fuels	Diesel oil	Cd	5	5
1A2c	Liquid Fuels	Domestic heating oil	Cd	1	1
1A2c	Liquid Fuels	Residual fuel oil	Cd	1	1
1A2c	Liquid Fuels	Methane	Cd	5	5
1A2c	Liquid Fuels	LPG	Cd	5	5
1A2c	Liquid Fuels	Gas works gas	Cd	5	5
1A2c	Liquid Fuels	Other petroluem fuels	Cd	100	100
1A2c	Other Fuels	Waste	Cd	20	20
1A2c	Other Fuels	Other non-specified	Cd	100	100
1A2c	Solid Fuels	Carbide furnace gas	Cd	5	5
1A2c	Solid Fuels	Coke	Cd	5	5
1A2c	Solid Fuels	Coal	Cd	3	3
1A2c	Solid Fuels	Peat	Cd	20	20
1A2c	Biomass	Ethanol	Cr	100	100
1A2c	Biomass	All fuels	Cr	40	40
1A2c	Liquid Fuels	All fuels	Cr	100	100
1A2c	Other Fuels	Waste	Cr	900	900
1A2c	Solid Fuels	Coke	Cr	50	50
1A2c	Solid Fuels	Coal	Cr	50	50
1A2c	Solid Fuels	Peat	Cr	40	40
1A2c	Biomass	Ethanol	Cu	100	100
1A2c	Biomass	All fuels	Cu	40	40
1A2c	Liquid Fuels	All fuels	Cu	100	100
1A2c	Other Fuels	Waste	Cu	900	900
1A2c	Solid Fuels	Coke	Cu	100	100
1A2c	Solid Fuels	Coal	Cu	40	40
1A2c	Solid Fuels	Peat	Cu	40	40
1A2c	All fuels	All fuels	DIOX	100	100
1A2c	Biomass	Ethanol	Hg	100	100
1A2c	Biomass	All fuels	Hg	40	40
1A2c	Liquid Fuels	All fuels	Hg	100	100
1A2c	Other Fuels	Waste	Hg	900	900
1A2c	Solid Fuels	All fuels	Hg	40	40
1A2c	Biomass	Landfill gas	N <sub>2</sub> O	100	100
1A2c	Biomass	Ethanol	N <sub>2</sub> O	100	100
1A2c	Biomass	Tall oil	N <sub>2</sub> O	100	100
1A2c	Biomass	Wooden fuels	N <sub>2</sub> O	40	40
1A2c	Biomass	Other biomass	N <sub>2</sub> O	100	100
1A2c	Gaseous Fuels	Natural gas	N <sub>2</sub> O	20	20
1A2c	Liquid Fuels	Refinery oil	N <sub>2</sub> O	40	40
1A2c	Liquid Fuels	Diesel oil	N <sub>2</sub> O	100	100
1A2c	Liquid Fuels	Domestic heating oil	N <sub>2</sub> O	40	40
1A2c	Liquid Fuels	Residual fuel oil	N <sub>2</sub> O	40	40
1A2c	Liquid Fuels	Methane	N <sub>2</sub> O	20	20
1A2c	Liquid Fuels	LPG	N <sub>2</sub> O	20	20
1A2c	Liquid Fuels	Gas works gas	N <sub>2</sub> O	20	20
1A2c	Liquid Fuels	Other petroluem fuels	N <sub>2</sub> O	100	100

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1A2c	Other Fuels	Waste	N <sub>2</sub> O	40	40
1A2c	Other Fuels	Other non-specified	N <sub>2</sub> O	100	100
1A2c	Solid Fuels	Carbide furnace gas	N <sub>2</sub> O	100	100
1A2c	Solid Fuels	Coke	N <sub>2</sub> O	40	40
1A2c	Solid Fuels	Coal	N <sub>2</sub> O	40	40
1A2c	Solid Fuels	Peat	N <sub>2</sub> O	40	40
1A2c	Biomass	Landfill gas	NH <sub>3</sub>	50	50
1A2c	Biomass	Ethanol	NH <sub>3</sub>	40	40
1A2c	Biomass	Tall oil	NH <sub>3</sub>	40	40
1A2c	Biomass	Wooden fuels	NH <sub>3</sub>	40	40
1A2c	Biomass	Other biomass	NH <sub>3</sub>	40	40
1A2c	Gaseous Fuels	Natural gas	NH <sub>3</sub>	40	40
1A2c	Liquid Fuels	Refinery oil	NH <sub>3</sub>	40	40
1A2c	Liquid Fuels	Diesel oil	NH <sub>3</sub>	50	50
1A2c	Liquid Fuels	Domestic heating oil	NH <sub>3</sub>	40	40
1A2c	Liquid Fuels	Residual fuel oil	NH <sub>3</sub>	40	40
1A2c	Liquid Fuels	Methane	NH <sub>3</sub>	50	50
1A2c	Liquid Fuels	LPG	NH <sub>3</sub>	20	20
1A2c	Liquid Fuels	Gas works gas	NH <sub>3</sub>	20	20
1A2c	Liquid Fuels	Hydrogen	NH <sub>3</sub>	40	40
1A2c	Liquid Fuels	Other petroluem fuels	NH <sub>3</sub>	50	50
1A2c	Other Fuels	Waste	NH <sub>3</sub>	40	40
1A2c	Other Fuels	Other non-specified	NH <sub>3</sub>	50	50
1A2c	Solid Fuels	All fuels	NH <sub>3</sub>	40	40
1A2c	Biomass	Landfill gas	NMVOC	50	50
1A2c	Biomass	Ethanol	NMVOC	50	50
1A2c	Biomass	Tall oil	NMVOC	50	50
1A2c	Biomass	Wooden fuels	NMVOC	75	75
1A2c	Biomass	Other biomass	NMVOC	50	50
1A2c	Gaseous Fuels	Natural gas	NMVOC	30	30
1A2c	Liquid Fuels	Refinery oil	NMVOC	50	50
1A2c	Liquid Fuels	Diesel oil	NMVOC	30	30
1A2c	Liquid Fuels	Domestic heating oil	NMVOC	30	30
1A2c	Liquid Fuels	Residual fuel oil	NMVOC	30	30
1A2c	Liquid Fuels	Methane	NMVOC	50	50
1A2c	Liquid Fuels	LPG	NMVOC	30	30
1A2c	Liquid Fuels	Gas works gas	NMVOC	30	30
1A2c	Liquid Fuels	Hydrogen	NMVOC	50	50
1A2c	Liquid Fuels	Other petroluem fuels	NMVOC	50	50
1A2c	All fuels	All fuels	NMVOC	50	50
1A2c	All fuels	All fuels	NO <sub>x</sub>	50	50
1A2c	Biomass	Ethanol	Ni	100	100
1A2c	Biomass	Tall oil	Ni	40	40
1A2c	Biomass	Wooden fuels	Ni	40	40
1A2c	Biomass	Other biomass	Ni	40	40
1A2c	Liquid Fuels	All fuels	Ni	100	100
1A2c	Other Fuels	Waste	Ni	900	900
1A2c	Solid Fuels	All fuels	Ni	40	40
1A2c	All fuels	All fuels	PAH	100	100
1A2c	Gaseous Fuels	Natural gas	PAH	100	100
1A2c	Other Fuels	All fuels	PAH	100	100
1A2c	Solid Fuels	All fuels	PAH	100	100
1A2c	All fuels	All fuels	PM <sub>10</sub>	100	100
1A2c	Gaseous Fuels	Natural gas	PM <sub>10</sub>	100	100
1A2c	All fuels	All fuels	PM <sub>2.5</sub>	100	100
1A2c	Gaseous Fuels	Natural gas	PM <sub>2.5</sub>	100	100
1A2c	Biomass	Ethanol	Pb	100	100
1A2c	Biomass	Wooden fuels	Pb	50	50
1A2c	Biomass	Other biomass	Pb	50	50
1A2c	All fuels	All fuels	Pb	100	100
1A2c	Other Fuels	Waste	Pb	500	500
1A2c	Solid Fuels	All fuels	Pb	40	40
1A2c	All fuels	All fuels	SO <sub>2</sub>	70	70

1A2c	Gaseous Fuels	Natural gas	SO <sub>2</sub>	70	70
1A2c	Biomass	Ethanol	Se	100	100
1A2c	Biomass	Wooden fuels	Se	40	40
1A2c	Biomass	Other biomass	Se	40	40
1A2c	Liquid Fuels	All fuels	Se	100	100
1A2c	Solid Fuels	All fuels	Se	40	40
1A2c	Solid Fuels	All fuels	Se	100	100
1A2c	All fuels	All fuels	TSP	100	100
1A2c	Biomass	Ethanol	Zn	100	100
1A2c	Biomass	Tall oil	Zn	100	100
1A2c	Biomass	Wooden fuels	Zn	40	40
1A2c	Biomass	Other biomass	Zn	40	40
1A2c	Liquid Fuels	All fuels	Zn	100	100
1A2c	Other Fuels	Waste	Zn	100	100
1A2c	Solid Fuels	Coke	Zn	700	700
1A2c	Solid Fuels	Coal	Zn	700	700
1A2c	Solid Fuels	Peat	Zn	40	40

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

In general, the same QA/QC procedures are used for NFR1A2c as for 1A2a–b 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 energy statistics.

In the development project in 2010<sup>34</sup> mentioned above, 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 plant level and verified against environmental reports and when necessary, the plants were contacted for explanations or complementary data.

#### 3.2.6.5 SOURCE-SPECIFIC RECALCULATIONS

No revisions were made in this category in submission 2017.

#### 3.2.6.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 3.2.7 Pulp, Paper and Print, NFR1A2d

#### 3.2.7.1 SOURCE CATEGORY DESCRIPTION

In 2015 there were 50 paper mill and pulp industry plants and 120 sawmills (production capacity >10 000 m<sup>3</sup>/year) in Sweden. In total, they were producing 10.2 Mt of paper, 18.1 million m<sup>3</sup> of sawn timber and 11.6 Mt of pulp<sup>35</sup>. 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 in recent years, the share

<sup>34</sup> Gustafsson, Nyström & Gerner, 2010

<sup>35</sup> The Swedish Forest Industries Federation, 2016-11-16  
<http://www.skogsindustrierna.se/siteassets/dokument/statistik/svenska/branschstatistik-sammandrag-2015.pdf>

of energy from biomass fuels has increased, from 68 % of fuel consumption in 2007 to 84 % in 2015. As for NFR1A2 in general, emissions from companies with less than 10 employees are allocated to NFR1A2g.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3-12.

**Table 3-12. Summary of key source analysis, NFR1A2d, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A2d	Biomass – As, Pb, Zn, TSP, Cr, DIOX, Cd, CO, PM <sub>10</sub> , SO <sub>2</sub> , Ni, Hg, PM <sub>2.5</sub> , NO <sub>x</sub> , NMVOC, Se, Cu	Biomass – As, Pb, Zn, TSP, Cr, DIOX, Cd, CO, PM <sub>10</sub> , SO <sub>2</sub> , Ni, Hg, PM <sub>2.5</sub> , NO <sub>x</sub> , NMVOC, PAH 1-4, Se
	Liquid – SO <sub>2</sub> , Pb, Ni, NO <sub>x</sub> , Se, As	Liquid – SO <sub>2</sub> , Ni, NO <sub>x</sub> , PM <sub>10</sub> , TSP, PM <sub>2.5</sub> , Se
	Solid Fuels –	Solid Fuels – SO <sub>2</sub> , Se

### 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 NFR2D1, see section 4.6 Other industrial processes and product use, NFR2H.

Activity data is, if not otherwise stated, collected from industrial energy statistics 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. There is no apparent trend in fuel consumption since 1990.

During 2009, an investigation of emissions of NO<sub>x</sub>, SO<sub>2</sub> 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 factors per fuel. Instead, emissions of NO<sub>x</sub>, SO<sub>2</sub> and particulate matter from fuel combustion in pulp and paper production facilities are enumerated with the same mean factors for all fuels:

$$\begin{aligned} \text{NO}_x: & \quad \text{EM} = 0.736 * \text{EF}(\text{NO}_x) * \text{AD} \\ \text{SO}_2 & \quad \text{EM} = 0.565 * \text{EF}(\text{SO}_2) * \text{AD} \\ \text{TSP/PM}_{10}/\text{PM}_{2.5}: & \quad \text{EM} = 0.686 * \text{EF}(\text{TSP/PM}_{10}/\text{PM}_{2.5}) * \text{AD}; \end{aligned}$$

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.

### 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.

Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3-13 the average uncertainties for activity data and emission factors by fuel group are weighted.

**Tabell 3-13. Uncertainties in activity data and emission factors for all substances for the base year and the year of latest emissions (2015) reported for NFR1A2d**

Source category	Fuel group	Fuel type	Substance	Base year uncertainty (%)	Year 2015 uncertainty (%)
1A2d	Biomass	Landfill gas	AD	5	5
1A2d	Biomass	Tall oil	AD	2	5
1A2d	Biomass	Wooden fuels	AD	2	5
1A2d	Biomass	Other biomass	AD	10	10
1A2d	Gaseous Fuels	Natural gas	AD	2	5
1A2d	Liquid Fuels	All fuels	AD	2	5
1A2d	Other Fuels	Waste	AD	2	5
1A2d	Other Fuels	Other non-specified	AD	10	10
1A2d	Solid Fuels	Coke	AD	5	5
1A2d	Solid Fuels	Coal	AD	2	5
1A2d	Solid Fuels	Peat	AD	7	2
1A2d	Solid Fuels	Other solid fuels	AD	10	10
1A2d	Biomass	Landfill gas	As	100	100
1A2d	Biomass	Tall oil	As	100	100
1A2d	Biomass	Wooden fuels	As	400	400
1A2d	Biomass	Other biomass	As	400	400
1A2d	Gaseous Fuels	Natural gas	As	100	100
1A2d	Liquid Fuels	All fuels	As	100	100
1A2d	Other Fuels	Waste	As	900	900
1A2d	Other Fuels	Other non-specified	As	100	100
1A2d	Solid Fuels	Coal	As	100	100
1A2d	Solid Fuels	Peat	As	400	400
1A2d	Biomass	Landfill gas	CO	50	50
1A2d	Biomass	Tall oil	CO	50	50
1A2d	Biomass	Wooden fuels	CO	75	75
1A2d	Biomass	Other biomass	CO	75	75
1A2d	Gaseous Fuels	Natural gas	CO	30	30
1A2d	Liquid Fuels	Diesel oil	CO	50	50
1A2d	Liquid Fuels	Domestic heating oil	CO	40	40
1A2d	Liquid Fuels	Residual fuel oil	CO	40	40
1A2d	Liquid Fuels	Kerosene	CO	50	50
1A2d	Liquid Fuels	Petroleum coke	CO	40	40
1A2d	Liquid Fuels	LPG	CO	30	30

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1A2d	Liquid Fuels	Gas works gas	CO	30	30
1A2d	Other Fuels	Waste	CO	30	30
1A2d	Other Fuels	Other non-specified	CO	50	50
1A2d	Solid Fuels	Coal	CO	40	40
1A2d	Solid Fuels	Peat	CO	30	30
1A2d	Biomass	Wooden fuels	Cd	40	40
1A2d	Biomass	Other biomass	Cd	40	40
1A2d	Liquid Fuels	All fuels	Cd	100	100
1A2d	Other Fuels	Waste	Cd	40	40
1A2d	Solid Fuels	All fuels	Cd	40	40
1A2d	Biomass	All fuels	Cr	40	40
1A2d	Liquid Fuels	All fuels	Cr	100	100
1A2d	Other Fuels	Waste	Cr	900	900
1A2d	Solid Fuels	All fuels	Cr	50	50
1A2d	Solid Fuels	All fuels	Cr	40	40
1A2d	Biomass	All fuels	Cu	40	40
1A2d	Liquid Fuels	All fuels	Cu	100	100
1A2d	Other Fuels	Waste	Cu	900	900
1A2d	Solid Fuels	All fuels	Cu	40	40
1A2d	Biomass	All fuels	DIOX	100	100
1A2d	Liquid Fuels	Petroleum coke	DIOX	100	100
1A2d	Other Fuels	Waste	DIOX	100	100
1A2d	Solid Fuels	All fuels	DIOX	100	100
1A2d	Biomass	All fuels	Hg	40	40
1A2d	Liquid Fuels	All fuels	Hg	100	100
1A2d	Other Fuels	Waste	Hg	900	900
1A2d	Solid Fuels	All fuels	Hg	40	40
1A2d	Biomass	Landfill gas	N <sub>2</sub> O	100	100
1A2d	Biomass	Tall oil	N <sub>2</sub> O	100	100
1A2d	Biomass	Wooden fuels	N <sub>2</sub> O	40	40
1A2d	Biomass	Other biomass	N <sub>2</sub> O	100	100
1A2d	Gaseous Fuels	Natural gas	N <sub>2</sub> O	20	20
1A2d	Liquid Fuels	Diesel oil	N <sub>2</sub> O	100	100
1A2d	Liquid Fuels	Domestic heating oil	N <sub>2</sub> O	40	40
1A2d	Liquid Fuels	Residual fuel oil	N <sub>2</sub> O	40	40
1A2d	Liquid Fuels	Kerosene	N <sub>2</sub> O	100	100
1A2d	Liquid Fuels	Petroleum coke	N <sub>2</sub> O	40	40
1A2d	Liquid Fuels	LPG	N <sub>2</sub> O	20	20
1A2d	Liquid Fuels	Gas works gas	N <sub>2</sub> O	20	20
1A2d	Other Fuels	Waste	N <sub>2</sub> O	40	40
1A2d	Other Fuels	Other non-specified	N <sub>2</sub> O	100	100
1A2d	Solid Fuels	All fuels	N <sub>2</sub> O	40	40
1A2d	Biomass	Landfill gas	NH <sub>3</sub>	50	50
1A2d	Biomass	Tall oil	NH <sub>3</sub>	40	40
1A2d	Biomass	Wooden fuels	NH <sub>3</sub>	40	40
1A2d	Biomass	Other biomass	NH <sub>3</sub>	40	40
1A2d	Gaseous Fuels	Natural gas	NH <sub>3</sub>	40	40
1A2d	Liquid Fuels	Diesel oil	NH <sub>3</sub>	50	50
1A2d	Liquid Fuels	Domestic heating oil	NH <sub>3</sub>	40	40
1A2d	Liquid Fuels	Residual fuel oil	NH <sub>3</sub>	40	40
1A2d	Liquid Fuels	Kerosene	NH <sub>3</sub>	40	40
1A2d	Liquid Fuels	Petroleum coke	NH <sub>3</sub>	40	40
1A2d	Liquid Fuels	LPG	NH <sub>3</sub>	20	20
1A2d	Liquid Fuels	Gas works gas	NH <sub>3</sub>	20	20
1A2d	Other Fuels	Waste	NH <sub>3</sub>	40	40
1A2d	Other Fuels	Other non-specified	NH <sub>3</sub>	50	50
1A2d	Solid Fuels	All fuels	NH <sub>3</sub>	40	40
1A2d	Biomass	Landfill gas	NMVOC	50	50
1A2d	Biomass	Tall oil	NMVOC	50	50
1A2d	Biomass	Wooden fuels	NMVOC	75	75
1A2d	Biomass	Other biomass	NMVOC	50	50
1A2d	Gaseous Fuels	Natural gas	NMVOC	30	30
1A2d	Liquid Fuels	Diesel oil	NMVOC	30	30

1A2d	Liquid Fuels	Domestic heating oil	NMVOC	30	30
1A2d	Liquid Fuels	Residual fuel oil	NMVOC	30	30
1A2d	Liquid Fuels	Kerosene	NMVOC	30	30
1A2d	Liquid Fuels	Petroleum coke	NMVOC	50	50
1A2d	Liquid Fuels	LPG	NMVOC	30	30
1A2d	Liquid Fuels	Gas works gas	NMVOC	30	30
1A2d	Other Fuels	Waste	NMVOC	50	50
1A2d	Other Fuels	Other non-specified	NMVOC	50	50
1A2d	Solid Fuels	All fuels	NMVOC	50	50
1A2d	All fuels	All fuels	NO <sub>x</sub>	50	50
1A2d	Biomass	Tall oil	Ni	40	40
1A2d	Biomass	Wooden fuels	Ni	40	40
1A2d	Biomass	Other biomass	Ni	40	40
1A2d	Liquid Fuels	All fuels	Ni	100	100
1A2d	Other Fuels	Waste	Ni	900	900
1A2d	Solid Fuels	All fuels	Ni	40	40
1A2d	All fuels	All fuels	PAH	100	100
1A2d	All fuels	All fuels	PM <sub>10</sub>	100	100
1A2d	All fuels	All fuels	PM <sub>2.5</sub>	100	100
1A2d	Biomass	All fuels	Pb	50	50
1A2d	Liquid Fuels	All fuels	Pb	100	100
1A2d	Other Fuels	Waste	Pb	500	500
1A2d	Solid Fuels	All fuels	Pb	40	40
1A2d	All fuels	All fuels	SO <sub>2</sub>	70	70
1A2d	Biomass	All fuels	Se	40	40
1A2d	Liquid Fuels	All fuels	Se	100	100
1A2d	Solid Fuels	Coal	Se	40	40
1A2d	Solid Fuels	Peat	Se	100	100
1A2d	All fuels	All fuels	TSP	100	100
1A2d	Biomass	Tall oil	Zn	100	100
1A2d	Biomass	Wooden fuels	Zn	40	40
1A2d	Biomass	Other biomass	Zn	40	40
1A2d	Liquid Fuels	All fuels	Zn	100	100
1A2d	Other Fuels	Waste	Zn	100	100
1A2d	Solid Fuels	Coal	Zn	700	700
1A2d	Solid Fuels	Peat	Zn	40	40

#### 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.

#### 3.2.7.4 SOURCE-SPECIFIC RECALCULATIONS

No recalculations in NFR1A2d have been carried out in submission 2017.

#### 3.2.7.5 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 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<sup>36</sup>. The largest number of

<sup>36</sup> The Swedish Food Federation 2013-10-02



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 fuel consumption varies between years. A slight decrease can be observed since 1990. In later years, gaseous fuels account for 45-49 % and liquid fuels account for about 38-40 % of the total fuel consumption. As for NFR1A2 in general, emissions from companies with less than 10 employees are allocated to NFR1A2g.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3-14.

**Table 3-14. Summary of key source analysis, NFR1A2e, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A2e	Biomass –	Biomass –
	Liquid – <i>Ni</i>	Liquid – <i>Ni, SO<sub>2</sub>, Se, NO<sub>x</sub></i>
	Other –	Other –

#### 3.2.8.2 METHODOLOGICAL ISSUES

The Tier 2 method is used. Activity data is collected from industrial energy statistics 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 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.

#### 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.

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

Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3-15 the average uncertainties for activity data and emission factors by fuel group are weighted.

**Tabell 3-15. Uncertainties in activity data and emission factors for all substances for the base year and the year of latest emissions (2015) reported for NFR1A2e**

Source category	Fuel group	Fuel type	Substance	Base year uncertainty (%)	Year 2015 uncertainty (%)
1A2e	Biomass	Landfill gas	AD	5	5
1A2e	Biomass	Wooden fuels	AD	5	5
1A2e	Biomass	Other biomass	AD	10	10
1A2e	Gaseous Fuels	Natural gas	AD	5	5
1A2e	Liquid Fuels	All fuels	AD	5	5
1A2e	Liquid Fuels	Other petroleum fuels	AD	10	10
1A2e	Other Fuels	Waste	AD	5	5
1A2e	Other Fuels	Other non-specified	AD	10	10
1A2e	Solid Fuels	Coke	AD	5	5
1A2e	Solid Fuels	Coal	AD	5	5
1A2e	Solid Fuels	Other solid fuels	AD	10	10
1A2e	Biomass	Landfill gas	As	100	100
1A2e	Biomass	Wooden fuels	As	400	400
1A2e	Biomass	Other biomass	As	400	400
1A2e	Gaseous Fuels	Natural gas	As	100	100
1A2e	Liquid Fuels	All fuels	As	100	100
1A2e	Other Fuels	Waste	As	900	900
1A2e	Other Fuels	Other non-specified	As	100	100
1A2e	Solid Fuels	All fuels	As	100	100
1A2e	Biomass	Landfill gas	CO	50	50
1A2e	Biomass	Wooden fuels	CO	75	75
1A2e	Biomass	Other biomass	CO	75	75
1A2e	Gaseous Fuels	Natural gas	CO	30	30
1A2e	Liquid Fuels	Diesel oil	CO	50	50
1A2e	Liquid Fuels	Domestic heating oil	CO	40	40
1A2e	Liquid Fuels	Residual fuel oil	CO	40	40
1A2e	Liquid Fuels	Kerosene	CO	50	50
1A2e	Liquid Fuels	LPG	CO	30	30
1A2e	Liquid Fuels	Gas works gas	CO	30	30
1A2e	Other Fuels	Waste	CO	30	30
1A2e	Other Fuels	Other non-specified	CO	50	50
1A2e	Solid Fuels	Coke	CO	40	40
1A2e	Solid Fuels	Coal	CO	40	40
1A2e	Biomass	All fuels	Cd	40	40
1A2e	Liquid Fuels	All fuels	Cd	100	100
1A2e	Other Fuels	Waste	Cd	40	40
1A2e	Solid Fuels	All fuels	Cd	40	40
1A2e	Biomass	All fuels	Cr	40	40
1A2e	Liquid Fuels	All fuels	Cr	100	100
1A2e	Other Fuels	Waste	Cr	900	900
1A2e	Solid Fuels	All fuels	Cr	50	50
1A2e	Biomass	All fuels	Cu	40	40
1A2e	Liquid Fuels	All fuels	Cu	100	100
1A2e	Other Fuels	Waste	Cu	900	900
1A2e	Solid Fuels	All fuels	Cu	40	40
1A2e	Biomass	All fuels	DIOX	100	100
1A2e	Other Fuels	Waste	DIOX	100	100
1A2e	Solid Fuels	All fuels	DIOX	100	100
1A2e	Biomass	All fuels	Hg	40	40
1A2e	Liquid Fuels	All fuels	Hg	100	100
1A2e	Other Fuels	Waste	Hg	900	900
1A2e	Solid Fuels	All fuels	Hg	40	40
1A2e	Biomass	Landfill gas	N <sub>2</sub> O	100	100
1A2e	Biomass	Wooden fuels	N <sub>2</sub> O	40	40
1A2e	Biomass	Other biomass	N <sub>2</sub> O	100	100
1A2e	Gaseous Fuels	Natural gas	N <sub>2</sub> O	20	20
1A2e	Liquid Fuels	Diesel oil	N <sub>2</sub> O	100	100
1A2e	Liquid Fuels	Domestic heating oil	N <sub>2</sub> O	40	40

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1A2e	Liquid Fuels	Residual fuel oil	N <sub>2</sub> O	40	40
1A2e	Liquid Fuels	Kerosene	N <sub>2</sub> O	100	100
1A2e	Liquid Fuels	LPG	N <sub>2</sub> O	20	20
1A2e	Liquid Fuels	Gas works gas	N <sub>2</sub> O	20	20
1A2e	Other Fuels	Waste	N <sub>2</sub> O	40	40
1A2e	Other Fuels	Other non-specified	N <sub>2</sub> O	100	100
1A2e	Solid Fuels	Coke	N <sub>2</sub> O	40	40
1A2e	Solid Fuels	Coal	N <sub>2</sub> O	40	40
1A2e	Biomass	Landfill gas	NH <sub>3</sub>	50	50
1A2e	Biomass	Wooden fuels	NH <sub>3</sub>	40	40
1A2e	Biomass	Other biomass	NH <sub>3</sub>	40	40
1A2e	Gaseous Fuels	Natural gas	NH <sub>3</sub>	40	40
1A2e	Liquid Fuels	Diesel oil	NH <sub>3</sub>	50	50
1A2e	Liquid Fuels	Domestic heating oil	NH <sub>3</sub>	40	40
1A2e	Liquid Fuels	Residual fuel oil	NH <sub>3</sub>	40	40
1A2e	Liquid Fuels	Kerosene	NH <sub>3</sub>	40	40
1A2e	Liquid Fuels	LPG	NH <sub>3</sub>	20	20
1A2e	Liquid Fuels	Gas works gas	NH <sub>3</sub>	20	20
1A2e	Other Fuels	Waste	NH <sub>3</sub>	40	40
1A2e	Other Fuels	Other non-specified	NH <sub>3</sub>	50	50
1A2e	Solid Fuels	Coke	NH <sub>3</sub>	40	40
1A2e	Solid Fuels	Coal	NH <sub>3</sub>	40	40
1A2e	Biomass	Landfill gas	NMVOC	50	50
1A2e	Biomass	Wooden fuels	NMVOC	75	75
1A2e	Biomass	Other biomass	NMVOC	50	50
1A2e	Gaseous Fuels	Natural gas	NMVOC	30	30
1A2e	Liquid Fuels	Diesel oil	NMVOC	30	30
1A2e	Liquid Fuels	Domestic heating oil	NMVOC	30	30
1A2e	Liquid Fuels	Residual fuel oil	NMVOC	30	30
1A2e	Liquid Fuels	Kerosene	NMVOC	30	30
1A2e	Liquid Fuels	LPG	NMVOC	30	30
1A2e	Liquid Fuels	Gas works gas	NMVOC	30	30
1A2e	Other Fuels	Waste	NMVOC	50	50
1A2e	Other Fuels	Other non-specified	NMVOC	50	50
1A2e	Solid Fuels	Coke	NMVOC	50	50
1A2e	Solid Fuels	Coal	NMVOC	50	50
1A2e	All fuels	All fuels	NO <sub>x</sub>	50	50
1A2e	Biomass	All fuels	Ni	40	40
1A2e	Liquid Fuels	All fuels	Ni	100	100
1A2e	Other Fuels	Waste	Ni	900	900
1A2e	Solid Fuels	Coke	Ni	40	40
1A2e	Solid Fuels	Coal	Ni	40	40
1A2e	All fuels	All fuels	PAH	100	100
1A2e	All fuels	All fuels	PM <sub>10</sub>	100	100
1A2e	All fuels	All fuels	PM <sub>2.5</sub>	100	100
1A2e	Biomass	All fuels	Pb	50	50
1A2e	Liquid Fuels	All fuels	Pb	100	100
1A2e	Other Fuels	Waste	Pb	500	500
1A2e	Solid Fuels	All fuels	Pb	40	40
1A2e	All fuels	All fuels	SO <sub>2</sub>	70	70
1A2e	Biomass	All fuels	Se	40	40
1A2e	Liquid Fuels	All fuels	Se	100	100
1A2e	Solid Fuels	All fuels	Se	40	40
1A2e	All fuels	All fuels	TSP	100	100
1A2e	Biomass	All fuels	Zn	40	40
1A2e	Liquid Fuels	All fuels	Zn	100	100
1A2e	Other Fuels	Waste	Zn	100	100
1A2e	Solid Fuels	All fuels	Zn	700	700

#### 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

No recalculations in NFR1A2e in submission 2017.

#### 3.2.8.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 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 the major part of the emissions. The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3-16.

**Table 3-16. Summary of source category description, NFR1A2f, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A2f	Biomass – Zn, DIOX, Cd	Biomass – Zn, DIOX
	Liquid – Ni, Hg, SO <sub>2</sub> , As, Se, Pb	Liquid – Hg, As
	Solid – Pb, Hg, SO <sub>2</sub> , As, Se, Cr, Ni, DIOX, Cd, NO <sub>x</sub>	Solid – Pb, Hg, TSP, As, Se, Cr, Ni

#### 3.2.9.2 METHODOLOGICAL ISSUES

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 industrial energy statistics for 1990-1996 and 2000-2002, and from quarterly fuel statistics 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.

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

For practical reasons, SO<sub>2</sub> and NO<sub>x</sub> emission data available from environmental reports are reported in NFR2A7. All other energy related emissions for this facility are reported in NFR1A2f.

### 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.

Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3-17 the average uncertainties for activity data and emission factors by fuel group are weighted.

**Table 3-17. Uncertainties in activity data and emission factors for all substances for the base year and the year of latest emissions (2015) reported for NFR1A2f**

Source category	Fuel group	Fuel type	Sub-stance	Base year uncertainty (%)	Year 2015 uncertainty (%)
1A2f	Biomass	Landfill gas	AD	5	5
1A2f	Biomass	Ethanol	AD	10	10
1A2f	Biomass	Tall oil	AD	5	5
1A2f	Biomass	Wooden fuels	AD	10	10
1A2f	Biomass	Other biomass	AD	10	10
1A2f	Gaseous Fuels	Natural gas	AD	10	10
1A2f	Liquid Fuels	Diesel oil	AD	20	20
1A2f	Liquid Fuels	Domestic heating oil	AD	20	20
1A2f	Liquid Fuels	Residual fuel oil	AD	20	20
1A2f	Liquid Fuels	Kerosene	AD	10	10
1A2f	Liquid Fuels	Petroleum coke	AD	10	10
1A2f	Liquid Fuels	LPG	AD	10	10
1A2f	Liquid Fuels	Gas works gas	AD	5	5
1A2f	Liquid Fuels	Hydrogen	AD	10	10
1A2f	Liquid Fuels	Other petroleum fuels	AD	10	10
1A2f	Other Fuels	Waste	AD	5	5
1A2f	Other Fuels	Other non-specified	AD	10	10
1A2f	Solid Fuels	Coke	AD	10	10
1A2f	Solid Fuels	Coke oven gas	AD	5	5
1A2f	Solid Fuels	Coal	AD	10	10
1A2f	Solid Fuels	Peat	AD	7	2
1A2f	Solid Fuels	Other solid fuels	AD	10	10
1A2f	Biomass	Landfill gas	As	100	100
1A2f	Biomass	Wooden fuels	As	400	400
1A2f	Biomass	Other biomass	As	400	400
1A2f	Gaseous Fuels	Natural gas	As	100	100
1A2f	Liquid Fuels	All fuels	As	100	100
1A2f	Other Fuels	Other non-specified	As	100	100
1A2f	Solid Fuels	Coke	As	100	100
1A2f	Solid Fuels	Coal	As	100	100
1A2f	Solid Fuels	Peat	As	400	400
1A2f	Solid Fuels	Other solid fuels	As	100	100
1A2f	Biomass	Landfill gas	CO	50	50
1A2f	Biomass	All fuels	CO	75	75
1A2f	Gaseous Fuels	Natural gas	CO	30	30
1A2f	Liquid Fuels	Diesel oil	CO	50	50
1A2f	Liquid Fuels	Domestic heating oil	CO	40	40
1A2f	Liquid Fuels	Residual fuel oil	CO	40	40

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1A2f	Liquid Fuels	Kerosene	CO	50	50
1A2f	Liquid Fuels	Petroleum coke	CO	40	40
1A2f	Liquid Fuels	LPG	CO	30	30
1A2f	Liquid Fuels	Gas works gas	CO	30	30
1A2f	Liquid Fuels	Other petroluem fuels	CO	50	50
1A2f	Other Fuels	Other non-specified	CO	50	50
1A2f	Solid Fuels	Coke	CO	40	40
1A2f	Solid Fuels	Coal	CO	40	40
1A2f	Solid Fuels	Peat	CO	30	30
1A2f	Solid Fuels	Other solid fuels	CO	50	50
1A2f	Biomass	All fuels	Cd	40	40
1A2f	Liquid Fuels	All fuels	Cd	100	100
1A2f	Solid Fuels	All fuels	Cd	40	40
1A2f	Biomass	All fuels	Cr	40	40
1A2f	Liquid Fuels	All fuels	Cr	100	100
1A2f	Solid Fuels	Coke	Cr	50	50
1A2f	Solid Fuels	Coal	Cr	50	50
1A2f	Solid Fuels	Peat	Cr	40	40
1A2f	Biomass	All fuels	Cu	40	40
1A2f	Liquid Fuels	All fuels	Cu	100	100
1A2f	Solid Fuels	All fuels	Cu	40	40
1A2f	All fuels	All fuels	DIOX	100	100
1A2f	Biomass	All fuels	Hg	40	40
1A2f	Liquid Fuels	All fuels	Hg	100	100
1A2f	Solid Fuels	All fuels	Hg	40	40
1A2f	Biomass	Landfill gas	N <sub>2</sub> O	100	100
1A2f	All fuels	All fuels	N <sub>2</sub> O	100	100
1A2f	Gaseous Fuels	Natural gas	N <sub>2</sub> O	20	20
1A2f	Liquid Fuels	Domestic heating oil	N <sub>2</sub> O	40	40
1A2f	Liquid Fuels	Residual fuel oil	N <sub>2</sub> O	40	40
1A2f	Liquid Fuels	Kerosene	N <sub>2</sub> O	100	100
1A2f	Liquid Fuels	Petroleum coke	N <sub>2</sub> O	40	40
1A2f	Liquid Fuels	LPG	N <sub>2</sub> O	20	20
1A2f	Liquid Fuels	Gas works gas	N <sub>2</sub> O	20	20
1A2f	Liquid Fuels	Other petroluem fuels	N <sub>2</sub> O	100	100
1A2f	Other Fuels	Other non-specified	N <sub>2</sub> O	100	100
1A2f	Solid Fuels	Coke	N <sub>2</sub> O	40	40
1A2f	Solid Fuels	Coal	N <sub>2</sub> O	40	40
1A2f	Solid Fuels	Peat	N <sub>2</sub> O	40	40
1A2f	Solid Fuels	Other solid fuels	N <sub>2</sub> O	100	100
1A2f	Biomass	Landfill gas	NH <sub>3</sub>	50	50
1A2f	Biomass	Wooden fuels	NH <sub>3</sub>	40	40
1A2f	Biomass	Other biomass	NH <sub>3</sub>	40	40
1A2f	Gaseous Fuels	Natural gas	NH <sub>3</sub>	40	40
1A2f	Liquid Fuels	Diesel oil	NH <sub>3</sub>	50	50
1A2f	Liquid Fuels	Domestic heating oil	NH <sub>3</sub>	40	40
1A2f	Liquid Fuels	Residual fuel oil	NH <sub>3</sub>	40	40
1A2f	Liquid Fuels	Kerosene	NH <sub>3</sub>	40	40
1A2f	Liquid Fuels	Petroleum coke	NH <sub>3</sub>	40	40
1A2f	Liquid Fuels	LPG	NH <sub>3</sub>	20	20
1A2f	Liquid Fuels	Gas works gas	NH <sub>3</sub>	20	20
1A2f	Liquid Fuels	Other petroluem fuels	NH <sub>3</sub>	50	50
1A2f	Other Fuels	Other non-specified	NH <sub>3</sub>	50	50
1A2f	Solid Fuels	Coke	NH <sub>3</sub>	40	40
1A2f	Solid Fuels	Coal	NH <sub>3</sub>	40	40
1A2f	Solid Fuels	Peat	NH <sub>3</sub>	40	40
1A2f	Solid Fuels	Other solid fuels	NH <sub>3</sub>	50	50
1A2f	Biomass	Landfill gas	PAH	50	50
1A2f	Biomass	Wooden fuels	PAH	75	75
1A2f	Biomass	Other biomass	PAH	50	50
1A2f	Gaseous Fuels	Natural gas	PAH	30	30
1A2f	Liquid Fuels	Diesel oil	PAH	30	30
1A2f	Liquid Fuels	Domestic heating oil	PAH	30	30

1A2f	Liquid Fuels	Residual fuel oil	PAH	30	30
1A2f	Liquid Fuels	Kerosene	PAH	30	30
1A2f	Liquid Fuels	Petroleum coke	PAH	50	50
1A2f	Liquid Fuels	LPG	PAH	30	30
1A2f	Liquid Fuels	Gas works gas	PAH	30	30
1A2f	Liquid Fuels	Other petroleum fuels	PAH	50	50
1A2f	Other Fuels	Other non-specified	PAH	50	50
1A2f	All fuels	All fuels	PAH	50	50
1A2f	All fuels	All fuels	PM <sub>10</sub>	100	100
1A2f	Gaseous Fuels	Natural gas	PM <sub>10</sub>	100	100
1A2f	All fuels	All fuels	PM <sub>2.5</sub>	100	100
1A2f	Gaseous Fuels	Natural gas	PM <sub>2.5</sub>	100	100
1A2f	Biomass	All fuels	Pb	50	50
1A2f	Liquid Fuels	All fuels	Pb	100	100
1A2f	Solid Fuels	All fuels	Pb	40	40
1A2f	All fuels	All fuels	SO <sub>2</sub>	70	70
1A2f	Gaseous Fuels	Natural gas	SO <sub>2</sub>	70	70
1A2f	Biomass	All fuels	Se	40	40
1A2f	Liquid Fuels	All fuels	Se	100	100
1A2f	Solid Fuels	Coke	Se	40	40
1A2f	Solid Fuels	Coal	Se	40	40
1A2f	Solid Fuels	Peat	Se	100	100
1A2f	All fuels	All fuels	TSP	100	100
1A2f	Gaseous Fuels	Natural gas	TSP	100	100
1A2f	Biomass	All fuels	Zn	40	40
1A2f	Liquid Fuels	All fuels	Zn	100	100
1A2f	Solid Fuels	Coke	Zn	700	700
1A2f	Solid Fuels	Coal	Zn	700	700
1A2f	Solid Fuels	Peat	Zn	40	40

#### 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 recalculations. In previous submissions, emissions in 1A2f were reported included in 1A2g.

#### 3.2.9.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

#### 3.2.9.7 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been carried out in submission 2017.

### 3.2.10 Other industries, NFR1A2g

#### 3.2.10.1 SOURCE CATEGORY DESCRIPTION

This source category is by nature somewhat heterogeneous. 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, and stationary combustion within all companies with less than 10 employees re-

regardless of branch, and stationary combustion within the construction sector. The quarterly fuel statistics 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.

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<sub>2</sub> 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. For mobile combustion, i.e. working machinery, fuel consumption in 2014 was about 50 % higher than in 1990.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3-18.

**Table 3-18. Summary of key source analysis, NFR1A2g, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A2g vii	Biomass – Cu	Biomass – Cu
	Liquid – Cu, NO <sub>x</sub> , PM <sub>2.5</sub> , PM <sub>10</sub> , TSP, Cd, CO, SO <sub>2</sub> , NMVOC	Liquid – Cu, NO <sub>x</sub> , PM <sub>2.5</sub> , PM <sub>10</sub> , TSP, Cd, CO, SO <sub>2</sub> , Ni,
	Other –	Other –
1A2g viii	Biomass – TSP, As, Pb, PM <sub>10</sub> , PM <sub>2.5</sub> , SO <sub>2</sub> , CO, Cd, NO <sub>x</sub> , Se, DIOX, Zn, Cr, Hg, Ni,	Biomass – TSP, As, Pb, PM <sub>10</sub> , PM <sub>2.5</sub> , SO <sub>2</sub> , Cd, PAH 1-4, Se, DIOX, Zn, Cr, Hg, Ni, NMVOC
	Liquid – Ni, SO <sub>2</sub> , NO <sub>x</sub> ,	Liquid – Ni, SO <sub>2</sub> , PM <sub>10</sub> , PM <sub>2.5</sub> , NO <sub>x</sub> , Se, TSP
	Other – SO <sub>2</sub> , NO <sub>x</sub> , Hg, Cr, As, DIOX, Pb, Se	Other – SO <sub>2</sub> , NO <sub>x</sub> , Hg, Cr, As, DIOX, Pb, Se, Ni

### 3.2.10.2 METHODOLOGICAL ISSUES

All consumption of motor gasoline and diesel oil in manufacturing industries and construction is allocated to mobile combustion, and all other fuels (heating oils, natural gas etc.) 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 industrial energy statistics for 1990-1996 and 2000-2002, and from the quarterly fuel statistics 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<sup>37</sup>. 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.

Emissions from stationary combustion in the construction industry are calculated with activity data from Statistics Sweden<sup>38</sup> 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<sub>2</sub> from process emissions. The reason is that the facility has restructured its environmental report, and only reports emissions of SO<sub>2</sub> on an aggregate level. The median value for the share of process-related SO<sub>2</sub> missions of the total SO<sub>2</sub> 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<sub>2</sub> and NO<sub>x</sub>, 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 energy 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<sub>x</sub>, SO<sub>2</sub> 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.

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<sup>37</sup> Statistics Sweden, EN20SM 1990-2008. See also Annex 2.

<sup>38</sup> Statistics Sweden, EN20SM 1990-2008. See also Annex 2.

### 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, 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<sub>2</sub> 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 3-19.

**Table 3-19. Distribution of emissions from off-road vehicles and other machinery**

Category	NFR	Definition IPCC Guidelines
<b>Industry</b>	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.
<b>Other</b>	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.
<b>Commercial/ Institutional</b>	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.
<b>Residential</b>	1A4b ii	All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts
<b>Agriculture, Forestry</b>	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 *Mobile combustion*

Uncertainties for activity data and emissions reported in NFR1A2g ii are displayed in Table 3-20.

**Table 3-20. Uncertainties for working machinery reported in NFR1A2g ii**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1A2g ii	SO <sub>x</sub>	5	20	5	20
1A2g ii	NO <sub>x</sub>	5	20	5	20
1A2g ii	NMVOC	5	20	5	20
1A2g ii	CO	5	20	5	20
1A2g ii	NH <sub>3</sub>	5	30	5	30
1A2g ii	TSP	5	30	5	30
1A2g ii	PM <sub>10</sub>	5	30	5	30
1A2g ii	PM <sub>2.5</sub>	5	30	5	30
1A2g ii	As, Cd, Cr, Cu, Ni, Se, Zn	5	100	5	100

Time series from mobile combustion in other industries reported in NFR1A2g ii have been reviewed in later years and are considered to be consistent.

#### 3.2.10.3.2 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.

Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3-17 the average uncertainties for activity data and emission factors by fuel group are weighted. Uncertainties are the same as in 1A2f and are found in that section.

#### 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

No recalculations have been performed in NFR1A2g in submission 2017.

The modelled estimate of used gasoline and diesel in working machinery has been adjusted with regard to volume of low blended biofuels. The modelled fuel consumption has also been modified due to a redistribution of a residual of diesel and gasoline. The residual is a result of balancing the consumption of diesel and gasoline (in the whole mobile sector) estimated from a bottom-up and a top-down approach, respectively. Both adjustments of the modelled consumptions have been done for all years and they equal each other out, more or less.

### 3.2.10.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

## 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 for the reporting of air pollution according to the Long-Range Transboundary Air Pollution Convention (LRTAP), emissions from national and international aviation during the LTO cycle<sup>39</sup> *both* belong to the national totals. And emissions from both domestic and international aviation during the Cruise cycle<sup>40</sup> is reported separately as memo items and not included in national totals.

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

The energy consumption by the LTO cycle and the Cruise cycle differ a great deal, as can be seen in Figure 3-1. The energy consumption from the LTO cycle has *decreased* by 8 % between 1990 and 2015 and by 9 % since 2014, whereas the energy consumption from the cruise cycle has *increased* by 40 % since 1990 but decreased by 3 % since 2014.

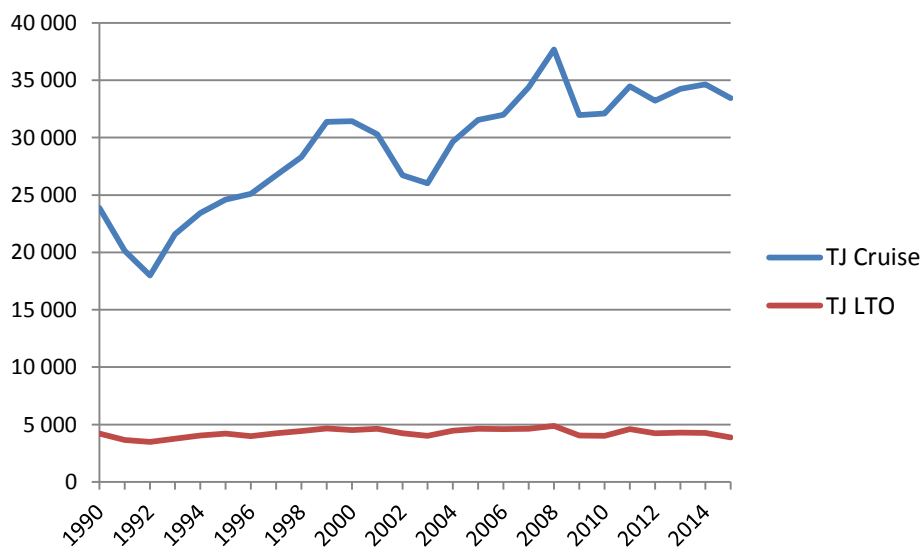


Figure 3-1. Energy use by aviation: LTO & Cruise cycle

<sup>39</sup> Landing and take-off.

<sup>40</sup> Cruise cycle: above 3000 feet.

<sup>41</sup> Transportstyrelsen, 2013.

The emissions of NO<sub>x</sub> from the LTO cycle have fluctuated over the years, but have a decreasing trend, while the emissions of NO<sub>x</sub> from the Cruise cycle increased by 66 % between 1990 and 2007, when they peaked and has since then decreased by 24 %. The emission of NO<sub>x</sub> decreased from both cycles between 2014 and 2015.

The emissions of CO from the LTO cycle decreased by 17 % between 1990 and 2003, while they more than halved for the cruise cycle for the same time period. For both cycles the emissions of CO went up to just about the same level in 2015 as in 1990, although there is a decreasing trend for the last two years.

The emissions of NMVOC from LTO have fluctuated a lot over the years, but have decreased by 26% since 1990 and by 16% since 2014. The emissions of NMVOC from the cruise cycle have had a decreasing trend for the whole time period and decreased by 65 % since 1990. The decrease in the emission of NMVOC in recent years, is a result of a phasing out of a specific type of airplane (MD-80/82), which is a major contributor to these emissions.

**Table 3-21. Summary of key source analysis, NFR1A3a i-ii, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A3a	Aviation Gasoline - Pb	Aviation Gasoline - Pb

### 3.2.11.2 METHODOLOGICAL ISSUES

Sweden uses Tier 1 to estimate emissions of SO<sub>2</sub>, Tier 2 to estimate the emissions of NMVOC and Tier 3a to estimate the emissions of all other gases. Emissions from aviation used by the agricultural and forestry sectors are reported as civil aviation. Emissions from military use of aviation fuels are reported under Other – mobile sources (NFR1A5b) or 1D2 Military operations abroad.

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<sup>42</sup>.

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 aircrafts 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 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<sub>2</sub> in 1995 (4.85 % of CO<sub>2</sub> emissions). Emissions of NO<sub>x</sub> were calculated in a similar way. The mean value of the ratio between NO<sub>x</sub> and CO<sub>2</sub> emissions in 1995-2004 is used for 1990-1994 (4.03 % of CO<sub>2</sub> emissions). Emissions of HC for 1990-1994 are calculated by extrapolation.

From 1995 and onwards, emissions of SO<sub>2</sub>, NO<sub>x</sub>, CO and HC are estimated by FOI as described above. The emissions of NMVOC and CH<sub>4</sub> are estimated based on the model estimated emissions of HC and emission factors from EMEP/EEA air pollutant emission inventory guidebook. N<sub>2</sub>O emissions from LTO are estimated using information from STAg on the number of LTO cycles together with emission factors from EMEP/EEA guidebook. Emissions of N<sub>2</sub>O from cruise are based on emission factors from EMEP/EEA guidebook together with the fuel consumption for cruise activities as well as emissions of particles.

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 lower emissions compared to the International Civil Aviation Organization (ICAO) standards.<sup>43</sup> For international flights, ICAO standard taxi time has been used for the part of the LTO cycle occurring on international airports.<sup>44</sup>

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<sup>42</sup> Calculation of exhaust emissions from air traffic. T. Mårtensson, A. Hasselrot. FOI R 3677 mSE

<sup>43</sup> Gustafsson, 2005.

<sup>44</sup> Näs, 2005.

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 the governmental call to reduce 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.

### 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 (Table 3-22). Regarding time-series consistency, see the Methodology section.

**Table 3-22. Uncertainties for civil aviation reported in NFR1A3a**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1A3a	NM VOC	10	±100	10	±100
1A3a	NO <sub>x</sub>	10	±100	10	±100
1A3a	Pb	10	±100	10	±100
1A3a	SO <sub>x</sub>	10	±50	10	±50
1A3a	CO	10	±100	10	±100
1A3a	TSP	10	±20	10	±20
1A3a	PM <sub>10</sub>	10	±20	10	±20
1A3a	PM <sub>2.5</sub>	10	±20	10	±20
1A3a	BC	10	±20	10	±20

### 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

No source-specific recalculation was made in submission 2017.

### 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<sup>45</sup> and the Swedish citizens travelled more than 65 000 millions of km by car in 2015.

<sup>45</sup> Ministry of the Environment, 2001

This is an increase by approximately 17 % since 1990. For all trucks (LCV & HGV) there has been an increase in number of travelled km by nearly 79 % since 1990, while buses drive nearly the same number of km in 2015 as in 1990 (**Fel! Hittar inte referensskälla.**). The Swedish road network comprises of around 140,700 km of public roads, whereof 2,660 km freeways and motor-traffic roads<sup>46</sup>.

**Table 3-22 Millions of km driven by different kinds of vehicles in 1990, 2000 and 2015.**<sup>47</sup>

Year	Passenger cars	LCV	HGV	Motorcycles	Buses
1990	55 696	3 709	3 653	407	964
2000	58 555	4 574	4 310	670	917
2015	65 246	8 503	4 660	847	975

Road transport includes five vehicle categories: 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 93% respectively 30% since 1990<sup>48</sup> in contrast to the emissions of NO<sub>x</sub> and NMVOC (from the same vehicles), where the emissions of NMVOC have decreased by 90 % by all vehicles while the emissions of NO<sub>x</sub> have decreased 59% by trucks and 76% by passenger cars. This is mainly a result of the introduction of three-way catalytic converters on passenger cars and trucks. 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.

The emissions of CO also show a downward trend for all years (1990-2015) as well as the emissions of SO<sub>2</sub>, as the sulphur content in fuel has been heavily restricted over the years. The emissions of NH<sub>3</sub> showed an increasing trend until 2001 but have decreased steadily since then.

Gasoline has previously been the most common fuel used for road transportation, but as from 2011 the amount of diesel used by road traffic as well as the emissions of GHG from diesel surpassed gasoline. 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 HGV and LCV. The total consumption of diesel by HGV and LCV correspond to 51.6 % of the total consumption of diesel by road traffic in 2015, while passenger cars consume around 42 % of the total diesel for road traffic.

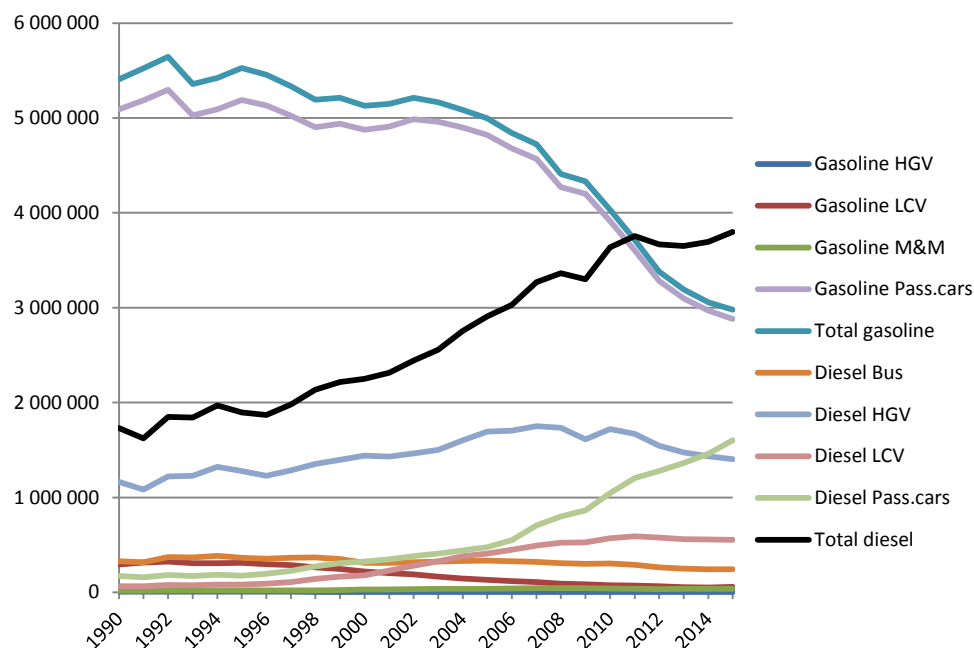
<sup>46</sup> Trafikverket 2014/2015. <http://www.trafikverket.se/Privat/Vagarresa-och-jarnvagartrafik/vag/Sveriges-vagnat/>

<sup>47</sup> Data from the road emission model HBEFA (Trafikverket).

<sup>48</sup> Statistics Sweden, 1990-2014, [http://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START\\_TK\\_TK1001\\_TK1001A/Fordon/table/tableViewLayout1/?rxid=4684d4ed-485d-47fc-a72f-b79caac19adf](http://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START_TK_TK1001_TK1001A/Fordon/table/tableViewLayout1/?rxid=4684d4ed-485d-47fc-a72f-b79caac19adf)



The consumption of diesel by HGV increased by 50 % between 1990 and 2007, from an already high level, and then started to decrease (Figure 3-2). The consumption of diesel by HGV was 21 % higher in 2015 than in 1990. The consumption of diesel by LCV has increased by 762 % since 1990, levelled out in 2011 and is still on a lower level than both passenger cars and HGV. The consumption of diesel by passenger cars, on the other hand, keeps increasing.



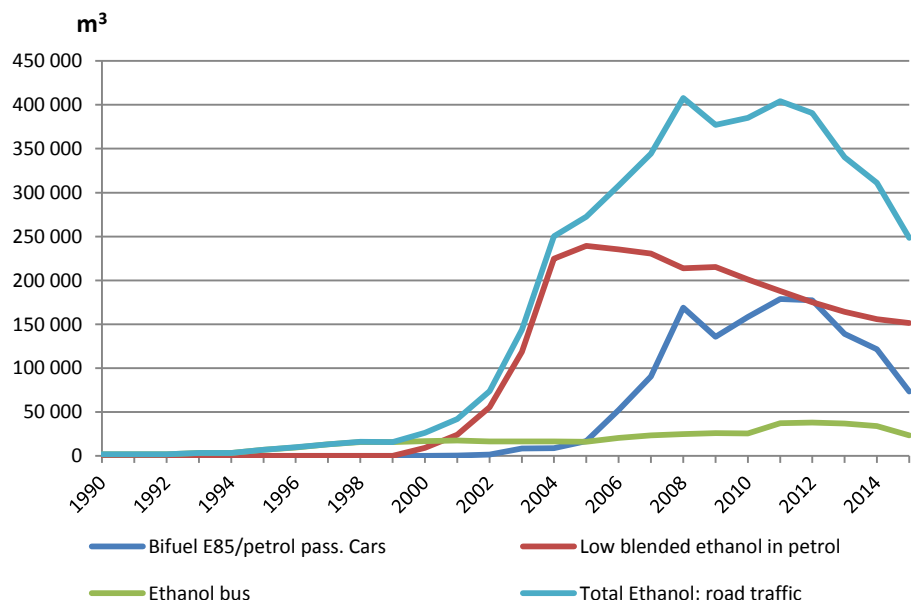
**Figure 3-2. Consumption of diesel and gasoline by vehicle type 1990-2015 (m<sup>3</sup>).**

The total use of liquid biofuels (FAME and ethanol) has increased by more than a factor of seven since 2003, when large-scale blending of ethanol into petrol began. The increasing production and use of biofuels was initiated by advantageous policy regulations and tax reliefs for biofuels<sup>49</sup>. 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.

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. As from 2012, the amount of low-blended ethanol in gasoline started to decline as a result of the shift from gasoline cars to diesel cars. Today, just about all petrol sold in Sweden contains around 5 % ethanol.

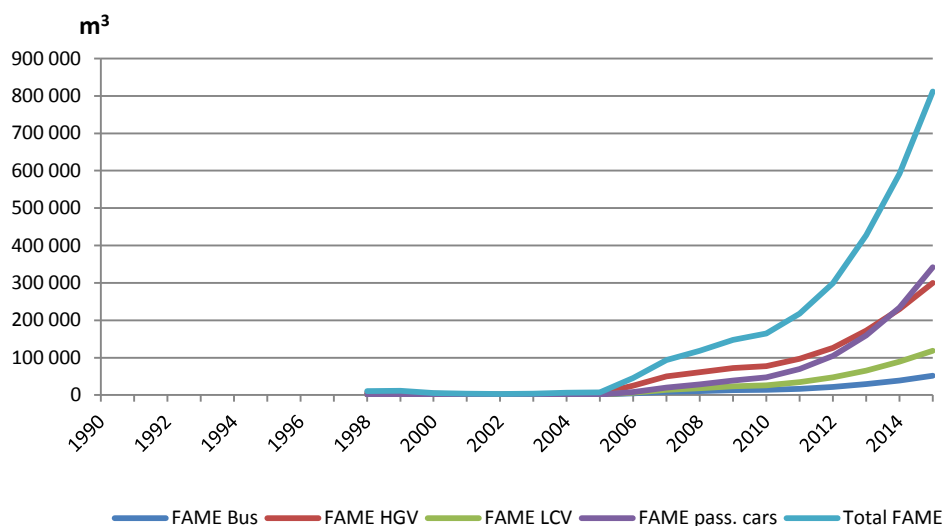
<sup>49</sup> Swedish Energy Agency, 2013.

Ethanol is also used by ethanol buses and by E85 passenger cars (flexifuel cars). The ethanol used by E85 cars and by buses, increased steadily until 2011 respectively 2012, when the trend turned downward again (Figure 3-3).



**Figure 3-3. Consumption of ethanol by road traffic 1990-2015 (m³)**

Large-scale blending of FAME into diesel began in 2007/2008 and has increased steadily ever since (Figure 3-4). The total use of FAME by road traffic has increased by 33-43 % each year starting 2011. This is mainly a result of a growing trend for diesel cars and a rising fraction of FAME blended into diesel.



**Figure 3-4. Consumption of FAME by road traffic 1990-2015 (m³).**

**Table 3-24. Summary of source category description, NFR1A3b i-iv, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A3b i	Biomass – <i>Cd, Zn, Hg</i>	Biomass – <i>Cd, Zn, Hg</i>
	Diesel oil – <i>NO<sub>x</sub>, Hg, Cr, Cd, Zn, PM<sub>2.5</sub>, PM<sub>10</sub></i>	Diesel oil – <i>NO<sub>x</sub>, Hg, Cr, Cd, Zn,</i>
	Gasoline – <i>CO, NO<sub>x</sub>, NMVOC, Pb, NH<sub>3</sub>, Hg, DIOX, Cd, Zn, Cr, PM<sub>2.5</sub></i>	Gasoline – <i>CO, NO<sub>x</sub>, NMVOC, Pb, NH<sub>3</sub>, Hg, DIOX, Cd, Cr, PM<sub>10</sub>, PM<sub>2.5</sub>, TSP, SO<sub>2</sub></i>
	Gasoline evaporation -	Gasoline evaporation – <i>NMVOC</i>
1A3b ii	Biomass –	Biomass –
	Diesel oil – <i>NO<sub>x</sub>, Cd, Zn, PM<sub>2.5</sub>, PM<sub>10</sub></i>	Diesel oil – <i>NO<sub>x</sub>, Hg, Cd, Zn, PM<sub>2.5</sub></i>
	Gasoline –	Gasoline – <i>CO, NO<sub>x</sub>, Pb, NMVOC</i>
1A3b iii	Biomass – <i>Cd</i>	Biomass – <i>Zn</i>
	Diesel oil – <i>NO<sub>x</sub>, Cr, Cd, PM<sub>2.5</sub>, Hg, PM<sub>10</sub>, TSP, CO, Zn</i>	Diesel oil – <i>NO<sub>x</sub>, Cr, Cd, PM<sub>2.5</sub>, Hg, PM<sub>10</sub>, TSP, SO<sub>2</sub>, Zn, NMVOC</i>
	Gaseous Fuels – <i>NO<sub>x</sub></i>	Gaseous Fuels – <i>NO<sub>x</sub></i>
1A3b iv	Gasoline – <i>CO</i>	Gasoline –

### 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 different emissions from road traffic. The fuel consumption is adjusted to be in line with national statistics on supply and delivery of petroleum products<sup>50</sup>. The fuel consumption and emissions are allocated by fuel type and five vehicle categories: 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 National Road and Transport Research Institute (VTI) and the Swedish Transport Administration (STA).

Emissions of SO<sub>2</sub> are based on the fuel consumption per vehicle type and country specific thermal values and emission factors. The emission factors for SO<sub>2</sub> 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<sub>2</sub> are provided by SPBI<sup>51</sup>. Prior to submission 2007, emissions of SO<sub>2</sub> from diesel and gasoline were based on the maximum allowed sulphur content of different environmental classes. Data on maximum allowed sulphur content was provided by SPBI.

<sup>50</sup> Statistic Sweden. Data from Monthly fuel, gas and inventory statistics ([www.scb.se](http://www.scb.se)). See Annex 2. chapter “1.4 Allocation of fuels for mobile combustion” for more information regarding the allocation of fuels for mobile combustion.

<sup>51</sup> Swedish petroleum and biofuel institute

The emissions of CO, NO<sub>x</sub>, NMVOC, NH<sub>3</sub>, Pb and particles from road traffic are estimated by HBEFA. The emissions of Cd, Hg, As, Cr, Cu, Ni, Se and Zn from combustion were estimated for the first time in submission 2016, with default emission factors from EMEP/EEA Guidebook 2013.

Activity data for natural gas is available from 1990, while reliable activity data for biogas exists from 1996 and for ethanol and FAME from 1998. Thermal values for biogas have been collected from the Swedish Biogas Association, for ethanol from SPBI and for FAME from the “Eco fuel” web page<sup>52</sup>.

The bottom-up estimations of the fuel consumption by the HBEFA model differ slightly from those 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 **Fel! Hittar inte referenskälla..**

**Table 3-25. 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 STA	NFR1A3b i-iv	NFR1A3b i-iv* STA to the Swedish border	NFR1A3b i-iv *
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.

Military transport emissions are reported under NFR1A5b. Military road transport is included in the road traffic emissions estimated by HBEFA. To subtract and separate emissions from military transport from emissions from civil road transport, emissions from HBEFA for each vehicle type are reduced by an amount equal to the weight of the fuel consumption reported by the Swedish Armed Forces relative to the fuel consumption from national statistics allocated to civil road transport, according to the equation below:

<sup>52</sup> <http://www.ecobransle.se/>

$$A = B - \sum((C-D)/C * E_i)$$

A = Military transport emissions

B = Total HBEFA emissions

C = Total fuel consumption National Statistics

D = Military fuel consumption Swedish Armed Forces

E<sub>i</sub> = HBEFA emissions per vehicle type

Data on particle emissions are lacking for the years 1981-1984 and 1986 and are therefore interpolated. It should also be noted that emissions of particles reported under NFR1A3b for the 1980s include military activities.

Emissions of dioxin from road transport were before submission 2008 not separated into different sub-sectors and were aggregated under Road Transportation (1A3b). In submission 2008 data from 1990 were updated since detailed background information (m<sup>3</sup> gasoline and diesel) per vehicle category from the HBEFA model, has made it possible to report emitted dioxin separately for Passenger cars (1A3b i), Light duty vehicles (1A3b ii), Heavy duty vehicles (1A3b iii) and Mopeds & Motorcycles (1A3b iv). From submission 2012 data from the HBEFA 3.1 model were used instead of data from the ARTEMIS model. The emission factors used are from Finstad et al (2001)<sup>53</sup>.

Further, as 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 3.1 (from submission 2012) regarding yearly mileages (km x 10<sup>6</sup>) per vehicle and fuel category, as well as emission factors, have been used. Emission factors presented by Westerholm et al. (2001)<sup>54</sup> 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 Light duty vehicle/Heavy duty vehicle in the EMEP-Corinair Guidebook and emission factors for Heavy duty vehicle according to Westerholm et al (2001)**Fel! Bokmärket är inte definierat..** 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 **Fel! Hittar inte referenskälla.26.**

<sup>53</sup> Finstad et al, 2001

<sup>54</sup> 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

**Table 3-26. Emission factors used for estimations of dioxin and PAH emissions from fuel combustion in NFR1 A 3 b i - iv.**

	Gasoline		Diesel					
	Leaded	Unleaded	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	
Dioxin (µg/Mg)	2.00	0.10				0.10		
Benzo(a)pyrene (µg/km)	0.48	0.32	2.85	0.63	0.90	0.95	0.21	0.30
Benzo(b)fluoranthene (µg/km)	0.88	0.36	3.30	0.60	5.45	0.09	0.18	1.60
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 PAH-4 from 1980, but data for 1980 - 1989 are not updated in the NFR-tables.

For the dioxin emission estimates the share of leaded gasoline of the total amount of gasoline must be taken into consideration (**Fel! Hittar inte referensskälla.**). 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 (**Fel! Hittar inte referensskälla.**). All Heavy duty vehicles are assumed to have direct injection. Also the share of of MK1 diesel of the total amount of diesel used has to be known (Table 3-27).

**Table 3-27. Distribution of vehicles with respect to fuel type and injection system.**

Year	Gasoline		Without direct injection		With direct injection		Diesel type	
	Leaded	Un-leaded	Passenger cars	Light duty vehicles	Passenger cars	Light duty vehicles	MK1	Conventional
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 and for FAME from 1999.

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 that goes through MOT in the beginning of 2015 has driven the most part during 2014. 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 be shown as clearly in the development of vehicle mileage as in statistics on fuel consumption.

### 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

The HBEFA model is updated annually regarding vehicle fleet composition, fuel composition, emission factors etc. Beside these yearly updates, the following adjustments to the model has also taken place:

- The allocation of different traffic situations<sup>55</sup> regarding trucks has been updated, taken into account that foreign trucks are split into different segments<sup>56</sup> than Swedish trucks.

<sup>55</sup> A traffic situation takes into account 4 different scenarios: area, road type, speed limit and how free flowing the traffic is (4 different levels).

<sup>56</sup> A type of vehicle, here trucks, is divided into different segments = vehicle groups of similar size and engine technology (~fuel type)

- The fuel consumption by passenger cars has been adjusted, as the progress to decrease the fuel consumption has been slower than declared values.

The update of the model only result in marginal changes in the emissions of hydrocarbons, nitrogen oxides, methane, nitrous oxide and particulate matter from fuel combustion.

The emissions of SO<sub>2</sub>, heavy metals, PAH and dioxins are revised due to updated activity data (vehicle mileage and fuel consumption) in the road emission model HBEFA. This is especially noticeable for the emissions of dioxin from HDV in 1990-2004 and 2016, where the emissions of dioxin have decreased by 5-16 % and for passenger cars in 2009-2015 when the emissions have increased by 5-14 %. This difference in the emissions between submission 2017 and submission 2016 is due to updated fuel consumption in HBEFA.

The emissions of Indeno and PAH by motorbikes have decreased by a factor of 100 in submission 2017 compared to submission 2016. The activity data used to estimate these emissions is the amount km travelled and in submission 2016 the activity data for passenger cars was by mistake also used for motorbikes. In submission 2017 the correct activity data is used.

#### 3.2.12.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

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

#### 3.2.13.1 SOURCE CATEGORY DESCRIPTION

TSP emissions from tyre and brake wear have since 1990 increased by 25 %. Emissions from tyre and brake wear are heavily dependent on the total amount of vehicle driven kilometres which has also increased with 25 %.

**Table 3-28. Summary of source category description, NFR1A3b vi-vii, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A3b vi	Automobile tyre and brake wear– Cu, Zn, Pb, TSP, PM <sub>10</sub> , PM <sub>2.5</sub>	Automobile tyre and brake wear– Cu, Zn, Pb, TSP, PM <sub>10</sub> , PM <sub>2.5</sub>
1A3b vii	Automobile road abrasion – TSP, PM <sub>10</sub> , PM <sub>2.5</sub>	Automobile road abrasion – TSP, PM <sub>10</sub> , PM <sub>2.5</sub>



### 3.2.13.2 METHODOLOGICAL ISSUES

From submission 2017 and onwards, a national model is used to estimate emissions from tyre and brake wear and road abrasion<sup>57</sup>. The national model takes into account several factors that have not been considered in previous estimates, such as meteorology, regional variations and measured PM<sub>10</sub> concentrations in urban street canyons for model verification. The new method has the advantage in that the emissions are calculated separately for eight regions in Sweden. Hence, the variability in both meteorological conditions and in the use of studded tyres is taken into account.

Activity data is obtained from the national model, divided by eight regions, and adjusted to fit activity data from the HBEFA 3.1 model.

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

Emission factors for PM<sub>10</sub> 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 PM<sub>2.5</sub> emissions have been estimated based on the PM<sub>10</sub> emission factor according to the EMEP/EEA Guidebook 2013 and other literature. As the modelled PM<sub>10</sub> 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<sup>-1</sup>, according to literature values.

TSP emissions are separated further into tyre wear and brake wear and passenger cars, light duty vehicles, mopeds and motorcycles, based on the time series from previous years (1990-2014).

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

The separation between particles from tyre wear and brake wear also makes it possible to calculate and report PAH-4 from tyre wear and brake wear in 1A3b 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 **Fel! Hittar inte referenskälla..**

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<sup>57</sup> Mawdsley, I., Jerksjö, M., Andersson, S., Arvelius, J., Omstedt, G. 2015. New method of calculating emissions from tyre and brake wear and road abrasion. SMED report No 177 2015.

**Table 3-23 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 Hjortenkrans et al. (2006)<sup>58</sup> 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 **Fel! Bokmärket är inte definierat.** and emissions calculated for heavy duty vehicles are 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 (**Fel! Hittar inte referensskälla.**).

**Table 3-30. Emission factors used for metal emission calculations from tyre wear in 1A3b vi.**

Vehicle category	Emission factors, TYRE WEAR, (mg/kg)					
	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

Hjortenkrans et al. (2006)<sup>59</sup> also studied the metal content in both branded brake linings and those from independent suppliers. A similar study was made in the late 1990s<sup>60</sup> 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. Also for Cu the metal content in linings from independent suppliers from 2005<sup>61</sup> is much lower

<sup>58</sup> Hjortenkrans et al. 2006. Metallemission från trafiken i Stockholm – Däck. (in Swedish, results from a study on metal emissions from tyre wear)

<sup>59</sup> Hjortenkrans et al. 2006. Metallemission från trafiken i Stockholm – Bromsbelägg. (in Swedish, results from a study on metal emissions from brake linings)

<sup>60</sup> Westerlund, K.-G. 2001. Metal Emissions from Stockholm Traffic's Wear of Brake Linings; Reports from SLB-analys, 2:2001; Environment and Health Protection Administration in Stockholm: Stockholm. 2001.

<sup>61</sup> Hjortenkrans et al. 2006. Metallemission från trafiken i Stockholm – Bromsbelägg. (in Swedish, results from a study on metal emissions from brake linings)

than in 1998<sup>62</sup>. 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 **Fel! Bokmärket är inte definierat.** and Westerlund **Fel! Bokmärket är inte definierat.** 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 **Fel! Bokmärket är inte definierat.** for the years 1980 - 1998, and on results presented by Hjortenkrans **Fel! Bokmärket är inte definierat.** 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 **Fel! Bokmärket är inte definierat.**

The emission factors used for calculating metal emissions from tyre wear and brake wear are presented in **Fel! Hittar inte referenskälla.**

**Table 3- 4. 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

The same method is used throughout the time series, which is considered to be consistent. Uncertainties for NFR1A3bvi and 1A3bvii are displayed in Table 3-32.

**Table 3-32. Uncertainties for NFR1A3bvi and 1A3bvii. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1A3bvi-vii	TSP	0	15	0	15
1A3bvi-vii	PM <sub>10</sub>	0	15	0	15
1A3bvi-vii	PM <sub>2.5</sub>	0	15	0	15
1A3bvi	Cd	0	75	0	75
1A3bvi	Cr	0	75	0	75
1A3bvi	Cu	0	75	0	75
1A3bvi	Ni	0	1000	0	1000

<sup>62</sup> Westerlund, K.-G. 2001. Metal Emissions from Stockholm Traffic's Wear of Brake Linings; Reports from SLB-analys, 2:2001; Environment and Health Protection Administration in Stockholm: Stockholm. 2001.

1A3bvi	Pb	0	75	0	75
1A3bvi	Zn	0	1000	0	1000
1A3bvi	PAH1-4	0	1000	0	1000

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

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

#### 3.2.13.5 SOURCE-SPECIFIC RECALCULATIONS

Due to the implementation of a national model, all emissions are updated throughout the whole time series. The emissions of TSP have increased with about 95 %, PM<sub>10</sub> emissions with about 87 % and PM<sub>2.5</sub> emissions with about 94 %.

#### 3.2.13.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No planned improvements for this category.

### 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.

**Table 3-32. Summary of source category description, NFR1A3c according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A3c	<i>Liquid Fuels – Nox</i>	<i>Liquid Fuels – Nox</i>

#### 3.2.14.2 METHODOLOGICAL ISSUES

Both Tier 1 and Tier 2 methods are used to estimate emissions from diesel. Information on emissions from railways is provided by the Swedish Transport Administration (STA). STA estimates the emissions of SO<sub>2</sub>, NO<sub>x</sub>, NMVOC and CO, based on the amount of diesel consumed by the railways<sup>63</sup> and various emission factors described below.

The estimated diesel consumption is based on fees paid by the rail operators and is considered to be of very high quality. Emissions of SO<sub>2</sub> are based on country-specific thermal values and the actual sulphur content for diesel fuel.

The threshold limits for CO and NO<sub>x</sub> is used as emission factors for all emissions from engines that comply with the EU emission standards Stage IIIA and Stage IIIB.<sup>64</sup> For engines introduced before the implementation of EU emissions stand-

<sup>63</sup> Estimated by the governmental agency "Transport Analysis". [www.trafa.se](http://www.trafa.se)

<sup>64</sup> <http://www.dieselnet.com/standards/eu/nonroad.php#rail>

ards, the emission factors from EMEP/EEA guidebook 2013 are used to estimate emissions of CO and NO<sub>x</sub>.

The conversion of g/kWh to g/litre is based on the fuel consumption factors in Table 3-5 in the EMEP/EEA Guidebook 2013 and a diesel density of 816 g / litre. The same density is used for all years.

The emissions of NMVOC and particles are estimated with emission factors from EMEP/EEA guidebook 2013.

#### 3.2.14.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The emissions for NFR1A3c are associated with low uncertainties. The estimate of diesel consumption is based on fees paid by the rail operators and is considered to be of very high quality.

#### 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.

#### 3.2.14.5 SOURCE-SPECIFIC RECALCULATIONS

The emission factors for TSP, PM<sub>10</sub> and PM<sub>2.5</sub> have been updated with default emissions factors from EMEP/EEA air pollutant emission inventory guidebook 2013. The emission for these pollutants has decreased with 53 %, since 1990 because of the change of emission factors.

#### 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 diesel oil, domestic heating oil and residual fuel oil purchased and used in Sweden by large commercial ships and leisure boats. The energy consumption from all fuels by national navigation has decreased by 37 % since 1990 and most emissions have decreased as well during the period with a few exceptions. The emissions of CO have increased by 20 % since 1990 and the emissions of NH<sub>3</sub> have increased by roughly 160%, but the level of emissions is quite low compared to the other emissions.

**Table 3-33. Summary of source category description, NFR1A3d ii, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A3d ii	Gas/diesel oil – CO, NMVOC, PM <sub>2.5</sub> , NO <sub>x</sub> , Ni, PM <sub>10</sub> , TSP	Gas/diesel oil – SO <sub>2</sub> , CO, NMVOC, PM <sub>2.5</sub> , NO <sub>x</sub> , Ni, PM <sub>10</sub>
	Residual oil – Ni, As, PM <sub>2.5</sub> , NO <sub>x</sub>	Residual oil – Ni, SO <sub>2</sub> , As, PM <sub>2.5</sub> , NO <sub>x</sub> , PM <sub>10</sub>

### 3.2.15.2 METHODOLOGICAL ISSUES

This source category covers domestic navigation and leisure boats. Domestic navigation is defined as emissions from diesel oil, domestic heating oil and residual fuel oil purchased and used in Sweden. Emissions from fuels that are purchased in Sweden but used abroad are reported separately as international bunker emissions. The allocation of emissions from navigation is summarized in **Fel! Hittar inte referensskälla..**

**Table 3- 5. 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

Emissions from national navigation are estimated using Tier 1. The activity data for domestic navigation<sup>65</sup> is based on the amount of fuel purchased and consumed in Sweden by national navigation according to the monthly survey on supply and delivery of petroleum products from Statistics Sweden<sup>66</sup>. The emissions of factors for NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> are provided by the Swedish Maritime Administration (SMA) as for 2005 and later years. Emissions by national navigation in 1990-2002 are calculated using emission factors from a SMED study conducted in 2004<sup>67</sup>. Emissions for 2003 and 2004 have been estimated using the same emissions factors as in 2002.

The Swedish Maritime Administration also report emissions from domestic navigation. These can however not be compared with emissions from the Swedish National Inventory, since the former include emissions from the whole Baltic Sea region.

The fuel consumption by leisure boats were studied in 2014, which resulted in an increased consumption of gasoline by leisure boats in 2005-2013 and an inclusion of the diesel consumption by leisure boats for the whole time series and the related emissions<sup>68</sup>. The gasoline and diesel consumption by leisure boats in Sweden 1990-2004 is based on a survey regarding leisure boat from 2004 and a study carried out by SMED in 2005<sup>69</sup>. The gasoline consumption by leisure boats is esti-

<sup>65</sup> Except for leisure boats.

<sup>66</sup> Statistic Sweden. Monthly fuel, gas and inventory statistics. See annex 2 for more information regarding different surveys.

<sup>67</sup> Cooper and Gustafsson, 2004.

<sup>68</sup> Eklund V. 2014.

<sup>69</sup> Gustafsson, 2005.

mated to 32,500 m<sup>3</sup>/year<sup>70</sup> and the diesel consumption to 12,000 m<sup>3</sup>/year for the years 1990-2004 as a result of these studies.

The gasoline and diesel consumption by leisure boats in 2005-2013 is based on a leisure boat survey from 2010<sup>71</sup> and an analysis of the result in the survey carried out by SMED in 2014<sup>72</sup>. The gasoline consumption is estimated to 37,768 m<sup>3</sup>/year and the diesel consumption to 18,172m<sup>3</sup>/year for 2010 and onwards as a result of these studies. The consumption of both gasoline and diesel has been estimated by interpolation for the years 2005-2009.

Emissions of SO<sub>2</sub> from leisure boats are based on the fuel consumption and the same thermal values and emission factors as for civil road traffic regarding both gasoline and diesel. Emission factors for NO<sub>x</sub>, NMVOC and CO are all based on estimated fuel consumption together with emission factors from EMEP/EEA guidebook 2009. Emissions of NO<sub>x</sub>, NMVOC and CO from leisure boats also depend on the ratio between 2-stroke and 4-stroke engines. The estimated ratios between the two are based on a study by Statistics Sweden from 2005. The study indicates that there is a larger share of 4-stroke engines in 2004 than in 1990. Based on the assumption that the move towards a larger number of 4-stroke engines has been gradual since 1990, the ratio for each year between 1990 and 2004 has been estimated by interpolation. From 2005 and onwards, the ratio between 2- and 4-stroke engines is assumed to be the same as for 2004.

Emissions of particles from leisure boats have been estimated with the assumption that they generate the same amount of emissions per energy unit as for gasoline-run off road vehicles and other machinery for households<sup>73</sup>.

In 2008, a merge between refineries resulted in uncertain data regarding their consumption of residual fuel oil in 2010. A decision was made to interpolate the activity data for 2010 based on the consumption of residual fuel oil by the company concerned in 2009 and 2011. As from 2011, the data on residual fuel oil is considered to be reliable.

In 2009 there is a shift from the use of “Domestic heating oil” to “Residual fuel oil” and in 2012 there is a noticeable decrease in the consumption of diesel by national navigation. The changes in 2012 was a result of a reallocation of diesel to domestic heating oil and a major part of the domestic consumption of fuels was at

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<sup>70</sup> Statistics Sweden, 2005a.

<sup>71</sup> Transportstyrelsen, 2010.

<sup>72</sup> Eklund V. 2014.

<sup>73</sup> Kindbom and Persson. 1999

the same time reallocated to bunker fuels. These changes were due to a new administration system by one company.

#### 3.2.15.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The distribution of marine distillate fuels and residual fuel oils over domestic and international navigation (bunkers) entail additional uncertainties. The current distribution is provided by the respondents of the survey on supply and delivery of petroleum products, but these are suspected to lack full information on the end-use of all the fuels they provide. Hence, the distribution between domestic and international use might vary considerably for some years. As a result fuel consumption by national and international navigation has been looked into in a SMED study<sup>74</sup>. Fuel data in the Monthly fuel, gas and inventory statistics, which is used as activity data for estimating emissions from national navigation and international maritime bunkers, has been analysed. The fuel data is collected from oil companies and other fuel providers who have 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.

Data on domestic and international bunker fuel in the Monthly fuel, gas and inventory statistics has been found to be of good quality. As a consequence of that VAT is applied on national fuel consumption, but not on international bunkers, all respondents to the survey are able to separate these fuel amounts with high accuracy. Fuels used for domestic and international navigation have been separated correctly and in line with IPCC Guidelines.

The fuel consumption in 2010 for national navigation has increased noticeably since 2009. The data has been verified and is correct according to reported amounts of fuel deliveries. Note that the amount of fuel used by national navigation is relatively small compared to the total amount of fuel for navigation, including international navigation (bunkers).

#### 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.

In 2011 an attempt was made to verify the emissions for domestic shipping by comparison with an alternative, independent bottom-up calculation. The bottom-up calculation includes all ship movements in the waters around Sweden. Ship positioning data is gathered using the AIS (Automatic Identification System), which is a complement to radar that provides positions and some static information for almost all ships found in the Baltic and the North Sea. The calculations distinguish

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<sup>74</sup> Eklund et al. 2011. Emissions from navigation and fishing including international bunkers



domestic shipping from international shipping by tracking each ship from its origin to its destination harbour. A route is classified as domestic if origin and destination is within the same country. Where the ship refuels is not possible to distinguish using this method, which causes a slight difference to the reporting guidelines. However, for the purpose of verification this difference is considered to be of little importance.

Emission factors are assigned individually for each ship depending on its technical properties. The power output, fuel consumption and emissions are estimated with 5 minute resolution for all ships carrying an AIS transponder. For the years 2009-2011, about 40 000 unique transponder IDs are registered by AIS.

The results from the bottom-up calculation show higher emissions than reported emissions from domestic navigation. This is probably related to fishing vessels (reported under NFR1A4c) and military ships (1A5b). Further studies should also include fishing and military ships to get the whole picture.

#### 3.2.15.5 SOURCE-SPECIFIC RECALCULATIONS

The amount of diesel for national navigation was slightly modified for all years with regard to the distribution of the residual of diesel to 1A3b (road transportation), 1A3d (domestic navigation), 1A2g vii, 1A3e, 1A4b and 1A4c (off-road vehicles and working machinery) and 1A4c (fishing).

#### 3.2.15.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### **3.2.16 Other transportation, NFR1A3e ii**

#### 3.2.16.1 SOURCE CATEGORY DESCRIPTION

Emissions reported in NFR1A3e ii refer to off-road vehicles and other machinery including ground activities in airports and harbours, and off-road activities not otherwise reported under 1A2g, 1A4a, 1A4b or 1A4c. A list of NFR codes in which emissions from working machinery are reported is found in Table 3-35.

**Table 3-35. 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.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3-36.

**Table 3-36. Summary of source category description, NFR1A3e ii, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A3e ii	<i>Diesel oil - NO<sub>x</sub>, PM<sub>2.5</sub></i>	<i>Diesel oil - NO<sub>x</sub>, PM<sub>10</sub>, TSP, PM<sub>2.5</sub></i>

### 3.2.16.2 METHODOLOGICAL ISSUES

A national model is used to estimate emissions from all working machinery used in Sweden, considered to correspond to Tier 3 for all emissions, except for CO<sub>2</sub> and SO<sub>2</sub> which are estimated according to Tier 2. The model is further explained in Annex 2.

### 3.2.16.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

#### 3.2.16.3.1 *Mobile combustion*

Uncertainties for activity data and emissions reported in NFR1A3e ii are displayed in Table 3-37.

**Table 3-37. Uncertainties for working machinery reported in NFR1A3e ii**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1A2g vii	SO <sub>x</sub>	5	20	5	20
1A2g ivi	NO <sub>x</sub>	5	20	5	20
1A2g vii	NMVOC	5	20	5	20
1A2g vii	CO	5	20	5	20
1A2g vii	NH <sub>3</sub>	5	30	5	30
1A2g vii	TSP	5	30	5	30
1A2g vii	PM <sub>10</sub>	5	30	5	30
1A2g vii	PM <sub>2.5</sub>	5	30	5	30
1A2g vii	As, Cd, Cr, Cu, Ni, Se, Zn	5	100	5	100

Time series from mobile combustion in NFR1A3e ii have been reviewed in later years and are considered to be consistent.

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

The model 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

The modelled estimate of used gasoline and diesel in working machinery has been adjusted with regard to volume of low blended biofuels. The modelled fuel consumption has also been modified due to a redistribution of a residual of diesel and gasoline. The residual is a result of balancing the consumption of diesel and gasoline (in the whole mobile sector) estimated from a bottom-up and a top-down approach, respectively. Both adjustments of the modelled consumptions have been done for all years and they equal each other out, more or less.

#### 3.2.16.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 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. Also emissions from working machinery used in these activities are included.

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, around year 2000 it had decreased to about 20000 TJ, and in 2015 it was around 7900 TJ. Liquid fuels account for most of the decrease. The corresponding share in 1990 was about 55 %.

For premises, the area heated with district heating only has increased from 43 % in 1990 to 80 % in 2014, while the area heated with oil only has decreased from 22 % in 1990 to 1 % in 2014. For multi-dwellings, the area heated with district heating only increased from 67 % in 1990 to 83 % in 2013. The area heated with oil only in multi-dwellings has decreased from 15 % in 1990 to less than 0.5 % in 2014. For one- and two-dwellings the area heated by district heating has been constantly

around 11-12 % since 2010. The area heated with oil only in one- and two-dwellings has decreased from 13 % in 1990 to 1 % in 2014<sup>75</sup>.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3-38.

**Table 3-38. Summary of source category description, NFR1A4a, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A4a	Biomass – PAH 1-4, CO, Cd, PM <sub>2.5</sub> , PM <sub>10</sub> , TSP, Zn	Biomass – PAH 1-4, CO, Cd, PM <sub>2.5</sub> , PM <sub>10</sub> , TSP
	Diesel oil – NO <sub>x</sub> , PM <sub>2.5</sub>	Diesel oil –
	Gasoline - CO, NMVOC, NO <sub>x</sub>	Gasoline - CO
	Liquid fuels - ,	Liquid fuels - Ni, SO <sub>2</sub> , NO <sub>x</sub> , Se, PM <sub>2.5</sub> , TSP, PM <sub>10</sub>

### 3.2.17.2 METHODOLOGICAL ISSUES

#### 3.2.17.2.1 Stationary combustion

For stationary combustion within NFR1A4a, all activity data is on national level by fuel type and estimated emissions are therefore considered to correspond to Tier 1. 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. 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.

#### 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<sub>2</sub> 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 3-39.

<sup>75</sup> Swedish Energy Agency 2015.

**Table 3-39. Distribution of emissions from off-road vehicles and other machinery**

Category	NFR	Definition IPCC Guidelines
<b>Industry</b>	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.
<b>Other</b>	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.
<b>Commercial/ Institutional</b>	1A4a ii	Garden machinery, e.g. lawn mowers and clearing saws, not used by private users. Also tractors not used in industry or forestry or agriculture.
<b>Residential</b>	1A4b ii	All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts
<b>Agriculture, Forestry</b>	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.<sup>76</sup> 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<sup>77</sup>. 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.

<sup>76</sup> Gustafsson, et al. 2005.

<sup>77</sup> Paulrud et al. 2005.

#### 3.2.17.2.4 Activity data for stationary combustion in other sectors

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.

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 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 interannual variations in total fuel consumption can be high.

#### 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 Tier 1 methodology with data from the annual energy balances. Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3-40 the average uncertainties for activity data and emission factors by fuel group are weighted.

**Tabell 3-40. Uncertainties in activity data and emission factors for all substances for the base year and the year of latest emissions (2015) reported for NFR1A4a**

Source category	Fuel group	Fuel type	Substance	Base year uncertainty (%)	Year 2015 uncertainty (%)
1A4a	Biomass	All fuels	HCb	500	500
1A4a	Solid Fuels	All fuels	HCb	94	94
1A4a	Biomass	All fuels	PCb	900	900
1A4a	Solid Fuels	All fuels	PCb	53	53
1A4a	Biomass	Wooden fuels	AD	10	10
1A4a	Gaseous Fuels	All fuels	AD	10	10
1A4a	Liquid Fuels	Domestic heating oil	AD	20	20
1A4a	Liquid Fuels	Residual fuel oil	AD	20	20
1A4a	Liquid Fuels	LPG	AD	10	10
1A4a	Liquid Fuels	Gas works gas	AD	10	10
1A4a	Solid Fuels	Coke	AD	5	5

1A4a	Solid Fuels	Coal	AD	10	10
1A4a	Biomass	Wooden fuels	As	400	400
1A4a	Gaseous Fuels	All fuels	CH <sub>4</sub>	20	20
1A4a	Liquid Fuels	Gas works gas	CH <sub>4</sub>	20	20
1A4a	Biomass	Wooden fuels	CO	75	75
1A4a	Gaseous Fuels	All fuels	CO	30	30
1A4a	Gaseous Fuels	All fuels	CO	30	30
1A4a	Liquid Fuels	Domestic heating oil	CO	40	40
1A4a	Liquid Fuels	Residual fuel oil	CO	40	40
1A4a	Liquid Fuels	LPG	CO	30	30
1A4a	Gaseous Fuels	All fuels	CO <sub>2</sub>	5	5
1A4a	Gaseous Fuels	All fuels	CO <sub>2</sub>	5	5
1A4a	Liquid Fuels	Domestic heating oil	CO <sub>2</sub>	1	1
1A4a	Liquid Fuels	Residual fuel oil	CO <sub>2</sub>	1	1
1A4a	Liquid Fuels	LPG	CO <sub>2</sub>	5	5
1A4a	Liquid Fuels	Gas works gas	CO <sub>2</sub>	5	5
1A4a	Biomass	Wooden fuels	Cd	150	150
1A4a	Liquid Fuels	All fuels	Cr	100	100
1A4a	Biomass	Wooden fuels	Cu	500	500
1A4a	Liquid Fuels	All fuels	Cu	100	100
1A4a	All fuels	All fuels	DIOX	1000	1000
1A4a	Biomass	Wooden fuels	Hg	40	40
1A4a	Liquid Fuels	All fuels	Hg	100	100
1A4a	Biomass	Wooden fuels	N <sub>2</sub> O	100	100
1A4a	Liquid Fuels	Domestic heating oil	N <sub>2</sub> O	40	40
1A4a	Liquid Fuels	Gas works gas	N <sub>2</sub> O	20	20
1A4a	Liquid Fuels	Residual fuel oil	NH <sub>3</sub>	40	40
1A4a	Biomass	Wooden fuels	NMVOG	75	75
1A4a	All fuels	All fuels	NO <sub>x</sub>	50	50
1A4a	Biomass	Wooden fuels	PAH	1000	1000
1A4a	All fuels	All fuels	PM <sub>10</sub>		10
1A4a	Biomass	Wooden fuels	Se	40	40
1A4a	All fuels	All fuels	TSP		10

Uncertainties for activity data and emissions reported for working machinery in NFR1A4a ii are displayed in Table 3-41.

**Table 3-41. Uncertainties for working machinery reported in NFR1A4a ii**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1A2g ii	SO <sub>x</sub>	5	20	5	20
1A2g ii	NO <sub>x</sub>	5	20	5	20
1A2g ii	NMVOG	5	20	5	20
1A2g ii	CO	5	20	5	20
1A2g ii	NH <sub>3</sub>	5	30	5	30
1A2g ii	TSP	5	30	5	30
1A2g ii	PM <sub>10</sub>	5	30	5	30
1A2g ii	PM <sub>2.5</sub>	5	30	5	30
1A2g ii	As, Cd, Cr, Cu, Ni, Se, Zn	5	100	5	100

Time series from mobile combustion in NFR1A4a ii have been reviewed in later years and are considered to be consistent.

#### 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<sup>78</sup>. 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<sup>79</sup>. 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

Activity data for all categories in this sector has been revised for year 2014 due to revision of the annual energy balances.

The modelled estimate of used gasoline and diesel in working machinery has been adjusted with regard to volume of low blended biofuels. The modelled fuel consumption has also been modified due to a redistribution of a residual of diesel and gasoline. The residual is a result of balancing the consumption of diesel and gasoline (in the whole mobile sector) estimated from a bottom-up and a top-down approach, respectively. Both adjustments of the modelled consumptions have been done for all years and they equal each other out, more or less.

#### 3.2.17.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 3.2.18 Residential, NFR1A4b

#### 3.2.18.1 SOURCE CATEGORY DESCRIPTION

In this category both stationary and mobile combustion occur. Stationary combustion of fuels within residential decreased by almost 70 % between 1990 and 2015, mainly due to a continuous increase in district heating use. In recent years, the use of heat pumps has also increased significantly<sup>80</sup>. Most of this change occurred before 2006; however, the use of heating oils is still decreasing while combustion

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<sup>78</sup> Gustafsson, et al. 2005.

<sup>79</sup> Paulrud et al. 2005.

<sup>80</sup> Swedish Energy Agency 2014b



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.

Mobile combustion in NFR1A4b refer to gardening machines used in households e.g. lawn mowers, hedged cutters, clearing saws and more. Also snow mobiles and four wheelers not used for professional purposes are allocated to NFR1A4b.

**Table 3-42. Summary of source category description, NFR1A4b, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A4b	Biomass – <i>PM<sub>2.5</sub>, PAH 1-4, Cd, CO, DIOX, Zn, Cr, Pb, PM<sub>10</sub>, As, TSP, Cu, Hg, NMVOC, SO<sub>2</sub>, NO<sub>x</sub>, Se, Ni</i>	Biomass – <i>PM<sub>2.5</sub>, PAH 1-4, Cd, CO, DIOX, Zn, Cr, Pb, PM<sub>10</sub>, As, TSP, Hg, NMVOC, SO<sub>2</sub>, NO<sub>x</sub>, Se, Ni</i>
	Liquid – <i>SO<sub>2</sub>, CO, NMVOC, PM<sub>10</sub>, PM<sub>2.5</sub>, TSP, NO<sub>x</sub></i>	Liquid – <i>SO<sub>2</sub>, CO, Ni, NMVOC, PM<sub>10</sub>, PM<sub>2.5</sub>, TSP, NO<sub>x</sub>, Se, NH<sub>3</sub></i>

### 3.2.18.2 METHODOLOGICAL ISSUES

#### 3.2.18.2.1 *Stationary combustion*

Emissions from dwellings within stationary combustion is reported in NFR1A4b i. For stationary combustion, all activity data is on national level by fuel type and estimated emissions are therefore considered to correspond to Tier 1.

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 are surveyed on the three most common combustion technologies: boiler, stoves and open fire places. 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.

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.

#### 3.2.18.2.2 *Mobile combustion*

Emissions from mobile machinery used in households are included in NFR1A4b ii. Machines included here are mainly several types of gardening machines e.g. lawn mowers, hedge cutters and chain saws. Also emissions from snow mobiles used in households are reported here. Emissions from gardening machines for professional use are reported in 1A4a ii. Also emissions from tractors that are not used in forest-

ry, agriculture or the industry are reported here as are emissions from generator sets and mobile freezers and chillers. A national model is used to estimate most emissions from all working machinery used in Sweden, considered to correspond to Tier 3 for all emissions, except SO<sub>2</sub> 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 3-43.

**Table 3-43. Distribution of emissions from off-road vehicles and other machinery**

Category	NFR	Definition IPCC Guidelines
<b>Industry</b>	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.
<b>Other</b>	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.
<b>Commercial/ Institutional</b>	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.
<b>Residential</b>	1A4b ii	All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts
<b>Agriculture, Forestry</b>	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.

### 3.2.18.3 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 haven't been any major changes in methodology or input data to the energy balances that affect this category.

Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3.44 the average uncertainties for activity data and emission factors by fuel group are weighted.

**Tabell 3-44. Uncertainties in activity data and emission factors for all substances for the base year and the year of latest emissions (2015) reported for NFR1A4b**

Source category	Fuel group	Fuel type	Substance	Base year uncertainty (%)	Year 2015 uncertainty (%)
1A4b	Biomass	All fuels	HCb	500	500
1A4b	Biomass	All fuels	PCB	900	900
1A4b	Biomass	Wooden fuels	AD	10	10
1A4b	Gaseous Fuels	All fuels	AD	10	10
1A4b	Liquid Fuels	Domestic heating oil	AD	20	20
1A4b	Liquid Fuels	Residual fuel oil	AD	20	20
1A4b	Liquid Fuels	LPG	AD	10	10
1A4b	Liquid Fuels	Gas works gas	AD	10	10
1A4b	Biomass	Wooden fuels	As	400	400
1A4b	Gaseous Fuels	All fuels	CH <sub>4</sub>	20	20
1A4b	Liquid Fuels	Residual fuel oil	CH <sub>4</sub>	40	40
1A4b	Liquid Fuels	LPG	CH <sub>4</sub>	20	20
1A4b	Liquid Fuels	Gas works gas	CH <sub>4</sub>	20	20
1A4b	Biomass	Wooden fuels	CO	75	75
1A4b	Gaseous Fuels	All fuels	CO	30	30
1A4b	Gaseous Fuels	All fuels	CO		30
1A4b	Liquid Fuels	Domestic heating oil	CO	40	40
1A4b	Liquid Fuels	Residual fuel oil	CO	40	40
1A4b	Liquid Fuels	LPG	CO	30	30
1A4b	Liquid Fuels	Gas works gas	CO	30	30
1A4b	Biomass	Wooden fuels	CO <sub>2</sub>	30	30
1A4b	Gaseous Fuels	Natural gas	CO <sub>2</sub>	5	5
1A4b	Gaseous Fuels	Gas works gas	CO <sub>2</sub>		5
1A4b	Liquid Fuels	Domestic heating oil	CO <sub>2</sub>	1	1
1A4b	Liquid Fuels	Residual fuel oil	CO <sub>2</sub>	1	1
1A4b	Liquid Fuels	LPG	CO <sub>2</sub>	5	5
1A4b	Liquid Fuels	Gas works gas	CO <sub>2</sub>	5	5
1A4b	Biomass	Wooden fuels	Cd	150	150
1A4b	Liquid Fuels	All fuels	Cd	100	100
1A4b	Biomass	Wooden fuels	Cr	200	200
1A4b	Liquid Fuels	All fuels	Cr	100	100
1A4b	Biomass	Wooden fuels	Cu	500	500
1A4b	Biomass	Wooden fuels	Hg	40	40
1A4b	Gaseous Fuels	All fuels	N <sub>2</sub> O	20	20
1A4b	Liquid Fuels	Residual fuel oil	N <sub>2</sub> O	40	40
1A4b	Liquid Fuels	LPG	N <sub>2</sub> O	20	20
1A4b	Gaseous Fuels	Natural gas	NH <sub>3</sub>	40	40
1A4b	Gaseous Fuels	Gas works gas	NH <sub>3</sub>		20
1A4b	Gaseous Fuels	All fuels	NMVOC		30
1A4b	Liquid Fuels	All fuels	Ni	100	100
1A4b	Biomass	Wooden fuels	PAH	1000	1000
1A4b	Liquid Fuels	All fuels	PAH	100	100
1A4b	All fuels	All fuels	PM <sub>10</sub>	65	65
1A4b	All fuels	All fuels	PM <sub>10</sub>		65
1A4b	All fuels	All fuels	PM <sub>2.5</sub>	65	65
1A4b	Biomass	Wooden fuels	Pb	50	50
1A4b	Liquid Fuels	All fuels	Pb	100	100
1A4b	Biomass	Wooden fuels	SO <sub>2</sub>	75	75
1A4b	Gaseous Fuels	All fuels	SO <sub>2</sub>	70	70
1A4b	Liquid Fuels	All fuels	SO <sub>2</sub>	70	70
1A4b	Biomass	Wooden fuels	Se	40	40
1A4b	Liquid Fuels	All fuels	Se	100	100
1A4b	All fuels	All fuels	TSP	65	65
1A4b	All fuels	All fuels	TSP		65
1A4b	Biomass	Wooden fuels	Zn	200	200
1A4b	Liquid Fuels	All fuels	Zn	100	100

### 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 are displayed in Table 3-45.

**Table 3-45. Uncertainties for working machinery reported in NFR1A4b ii**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1A2g vii	SO <sub>x</sub>	5	20	5	20
1A2g vii	NO <sub>x</sub>	5	20	5	20
1A2g vii	NM VOC	5	20	5	20
1A2g vii	CO	5	20	5	20
1A2g vii	NH <sub>3</sub>	5	30	5	30
1A2g vii	TSP	5	30	5	30
1A2g vii	PM <sub>10</sub>	5	30	5	30
1A2g vii	PM <sub>2.5</sub>	5	30	5	30
1A2g vii	As, Cd, Cr, Cu, Ni, Se, Zn	5	100	5	100

### 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

Following revisions of the energy balances, the activity data for stationary combustion within 1A4b was revised for all fuels for the year 2014.

The modelled estimate of used gasoline and diesel in working machinery has been adjusted with regard to volume of low blended biofuels. The modelled fuel consumption has also been modified due to a redistribution of a residual of diesel and gasoline. The residual is a result of balancing the consumption of diesel and gasoline (in the whole mobile sector) estimated from a bottom-up and a top-down approach, respectively. Both adjustments of the modelled consumptions have been done for all years and they equal each other out, more or less.

### 3.2.18.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

## 3.2.19 **Agriculture/Forestry/Fisheries, NFR1A4c i**

### 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. Consumption of solid fuels within this sector has decreased substantially since 1990.

**Table 3-46. Summary of source category description, NFR1A4c i, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1A4c i	Biomass – PAH 1-4, CO, Cd, DIOX, PM <sub>2.5</sub> , PM <sub>10</sub> , TSP, NMVOC, Zn, Se, Pb, NO <sub>x</sub> , SO <sub>2</sub>	Biomass – PAH 1-4, CO, Cd, DIOX, PM <sub>2.5</sub> , Cr, PM <sub>10</sub> , TSP, NMVOC, Zn, Cu, Se, Pb, Hg, NO <sub>x</sub> , SO <sub>2</sub>
	Liquid – Ni, SO <sub>2</sub> , NO <sub>x</sub> , PM <sub>2.5</sub> , PM <sub>10</sub> , TSP, Cu, CO, NMVOC, Cd	Liquid – Ni, SO <sub>2</sub> , PM <sub>2.5</sub> , PM <sub>10</sub> , TSP, Cu, CO, NMVOC, Cd
	Solid –	Solid – SO <sub>2</sub> , Se, TSP, Hg, PM <sub>10</sub>

### 3.2.19.2 METHODOLOGICAL ISSUES

In this sector both stationary and mobile combustion occur.

#### 3.2.19.2.1 Stationary combustion

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).

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. As a consequence, emissions from stationary combustion 2002-2006 were revised in submission 2009. Emissions for the most recent year will be revised in next submission when annual statistics are available. Note that as a consequence of this revision, emissions from biomass are inconsistent with a sharp increase to a higher level in 2003. There is no information available to improve data 2002 and earlier years. Emissions 1990 are considered to be of sufficient quality as the 1985 survey then was only five years old.

#### 3.2.19.2.2 Mobile combustion

Mobile combustion in 1A4c 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<sub>2</sub> which is estimated according to Tier 2. The model is further explained in Annex 2.

Emissions from Fisheries, NFR1A4c, 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<sup>81</sup> 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 estimate on fuel consumption provided by Statistics Sweden refer 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.

The emissions factors used to estimate emissions from Fisheries are based on a SMED study from 2005<sup>82</sup>, producing emission factors for SO<sub>2</sub>, NO<sub>x</sub> and NMVOC, for 1990-2004. As from 2005, the estimates are based on the same consumption estimate and emission factors as for 2004. However, from 2007 and onwards the emission factors for SO<sub>2</sub> from fisheries are assumed to be the same as for domestic navigation, which are updated every year.

Emissions from fisheries are derived under the assumption that the fishing fleet operates using medium speed diesel engines running on marine distillate fuel. The emission abatement technologies used by the fleet (e.g. Selective Catalytic Reduction (SCR) for NO<sub>x</sub> reduction) is assumed to be negligible.

Emissions from working machinery are also reported in NFR1A2g vii, 1A3e ii, 1A4a ii and 1A4b ii. See Table 3-47.

**Table 3-47. Distribution of emissions from off-road vehicles and other machinery**

Category	NFR	Definition IPCC Guidelines
<b>Industry</b>	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.
<b>Other</b>	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.
<b>Commercial/ Institutional</b>	1A4a ii	Garden machinery, e.g. lawn mowers and clearing saws, not used by private users. Also tractors not used in industry or forestry or agriculture.
<b>Residential</b>	1A4b ii	All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts
<b>Agriculture, Forestry</b>	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.

<sup>81</sup> Statistics Sweden, 2006 ENFT0601.

<sup>82</sup> Cooper et al., 2005a.

### 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.

Uncertainties for activity data and emission factors are generally set by fuel type. In Table 3-48 the average uncertainties for activity data and emission factors by fuel group are weighted.

**Tabell 3-48. Uncertainties in activity data and emission factors for all substances for the base year and the year of latest emissions (2015) reported for NFR1A4c**

Source category	Fuel group	Fuel type	Substance	Base year uncertainty (%)	Year 2015 uncertainty (%)
1A4c	Biomass	All fuels	HCb	500	500
1A4c	Solid Fuels	All fuels	HCb	94	94
1A4c	Biomass	All fuels	PCB	900	900
1A4c	Solid Fuels	All fuels	PCB	53	53
1A4c	Biomass	Wooden fuels	AD	10	10
1A4c	Gaseous Fuels	Natural gas	AD	10	10
1A4c	Liquid Fuels	Domestic heating oil	AD	20	20
1A4c	Liquid Fuels	Residual fuel oil	AD	20	20
1A4c	Liquid Fuels	LPG	AD	10	10
1A4c	Solid Fuels	All fuels	AD	10	10
1A4c	Biomass	Wooden fuels	As	400	400
1A4c	Solid Fuels	All fuels	As	100	100
1A4c	Gaseous Fuels	Natural gas	CH <sub>4</sub>	20	20
1A4c	Liquid Fuels	Domestic heating oil	CH <sub>4</sub>	40	40
1A4c	Liquid Fuels	Residual fuel oil	CH <sub>4</sub>	40	40
1A4c	Liquid Fuels	LPG	CH <sub>4</sub>	20	20
1A4c	Solid Fuels	All fuels	CH <sub>4</sub>	20	20
1A4c	Biomass	Wooden fuels	CO	75	75
1A4c	Gaseous Fuels	Natural gas	CO	30	30
1A4c	Liquid Fuels	Domestic heating oil	CO	40	40
1A4c	Liquid Fuels	Residual fuel oil	CO	40	40
1A4c	Liquid Fuels	LPG	CO	30	30
1A4c	Solid Fuels	All fuels	CO	40	40
1A4c	Biomass	Wooden fuels	CO <sub>2</sub>	30	30
1A4c	Gaseous Fuels	Natural gas	CO <sub>2</sub>	5	5
1A4c	Liquid Fuels	Domestic heating oil	CO <sub>2</sub>	1	1
1A4c	Liquid Fuels	Residual fuel oil	CO <sub>2</sub>	1	1
1A4c	Liquid Fuels	LPG	CO <sub>2</sub>	5	5
1A4c	Solid Fuels	Coke	CO <sub>2</sub>	5	5
1A4c	Solid Fuels	Coal	CO <sub>2</sub>	3	3
1A4c	Biomass	Wooden fuels	Cd	150	150
1A4c	Liquid Fuels	All fuels	Cd	100	100
1A4c	Solid Fuels	All fuels	Cd	60	60
1A4c	Liquid Fuels	All fuels	Cr	100	100
1A4c	Biomass	Wooden fuels	Cu	500	500
1A4c	Liquid Fuels	All fuels	Cu	100	100
1A4c	Biomass	Wooden fuels	DIOX	1000	1000
1A4c	Solid Fuels	All fuels	DIOX	100	100

1A4c	Biomass	Wooden fuels	Hg	40	40
1A4c	Solid Fuels	All fuels	Hg	40	40
1A4c	Biomass	Wooden fuels	N <sub>2</sub> O	100	100
1A4c	Gaseous Fuels	Natural gas	N <sub>2</sub> O	20	20
1A4c	Biomass	Wooden fuels	NH <sub>3</sub>	40	40
1A4c	Gaseous Fuels	Natural gas	NH <sub>3</sub>	40	40
1A4c	Liquid Fuels	Residual fuel oil	NH <sub>3</sub>	40	40
1A4c	Liquid Fuels	LPG	NH <sub>3</sub>	20	20
1A4c	Solid Fuels	All fuels	NH <sub>3</sub>	40	40
1A4c	Biomass	Wooden fuels	NMVOC	75	75
1A4c	Gaseous Fuels	Natural gas	NMVOC	30	30
1A4c	Liquid Fuels	All fuels	NMVOC	30	30
1A4c	Solid Fuels	All fuels	NMVOC	50	50
1A4c	All fuels	All fuels	NO <sub>x</sub>	50	50
1A4c	Biomass	Wooden fuels	Ni	40	40
1A4c	Liquid Fuels	All fuels	Ni	100	100
1A4c	Solid Fuels	All fuels	Ni	40	40
1A4c	Biomass	Wooden fuels	PAH	1000	1000
1A4c	Liquid Fuels	All fuels	PAH	100	100
1A4c	Solid Fuels	All fuels	PAH	100	100
1A4c	All fuels	All fuels	PM <sub>10</sub>	30	30
1A4c	All fuels	All fuels	PM <sub>2.5</sub>	30	30
1A4c	Biomass	Wooden fuels	Pb	50	50
1A4c	Liquid Fuels	All fuels	Pb	100	100
1A4c	Solid Fuels	All fuels	Pb	40	40
1A4c	Biomass	Wooden fuels	SO <sub>2</sub>	75	75
1A4c	Gaseous Fuels	Natural gas	SO <sub>2</sub>	70	70
1A4c	Solid Fuels	All fuels	SO <sub>2</sub>	70	70
1A4c	Biomass	Wooden fuels	Se	40	40
1A4c	Liquid Fuels	All fuels	Se	100	100
1A4c	All fuels	All fuels	TSP	30	30
1A4c	Liquid Fuels	All fuels	Zn	100	100
1A4c	Solid Fuels	All fuels	Zn	50	50

### 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 NFR1A4c ii are displayed in Table 3-49.

**Table 3-49. Uncertainties for working machinery reported in NFR1A4c ii. Numbers within brackets are for gasoline fueled vehicles.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1A4c ii	SO <sub>x</sub>	5 (3)	20	5 (3)	20
1A4c ii	NO <sub>x</sub>	5 (3)	20	5 (3)	20
1A4c ii	NMVOC	5 (3)	20	5 (3)	20
1A4c ii	CO	5 (3)	20	5 (3)	20
1A4c ii	NH <sub>3</sub>	5 (3)	30	5 (3)	30
1A4c ii	TSP	5 (3)	30	5 (3)	30
1A4c ii	PM <sub>10</sub>	5 (3)	30	5 (3)	30
1A4c ii	PM <sub>2.5</sub>	5 (3)	30	5 (3)	30
1A4c ii	As, Cd, Cr, Cu, Ni, Se, Zn	5 (3)	100	5 (3)	100



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

Following revisions of the energy balances, the activity data for stationary combustion within 1A4c was revised for all fuels 2014. In addition revision of the energy consumption of biomass and natural gas within the agriculture and forestry sector was made for the years 2005-2013.

#### 3.2.19.5 SOURCE-SPECIFIC RECALCULATIONS

The modelled estimate of used gasoline and diesel in working machinery has been adjusted with regard to volume of low blended biofuels. The modelled fuel consumption has also been modified due to a redistribution of a residual of diesel and gasoline. The residual is a result of balancing the consumption of diesel and gasoline (in the whole mobile sector) estimated from a bottom-up and a top-down approach, respectively. Both adjustments of the modelled consumptions have been done for all years and they equal each other out, more or less.

#### 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 Military transport, NFR1A5b

#### 3.2.21.1 SOURCE CATEGORY DESCRIPTION

NFR1A5 includes emissions from military transports. The emissions have decreased over the years since 1990 due to a decrease in activity.

**Table 3-51. Summary of source category description, NFR1A5b according to approach 1.**

NFR	Key Source Assessment 2015 Level	Trend
1A5b	<i>Liquid Fuels - NO<sub>x</sub></i>	<i>Liquid Fuels - NO<sub>x</sub></i>

#### 3.2.21.2 METHODOLOGICAL ISSUES

Emissions from military transport are based on data on fuel consumption including all military activities and are considered to correspond to Tier 1. Fuel consumption from some more administrative military activities, such as the Swedish Defence Material Administration (FMV), the Swedish Fortification Department (FORTV), the Swedish Defence Research Agency (FOI) and the National Defence Radio Institute (FRA), are not included in the calculations.

Emissions from military aviation are based on an average of LTO and cruise emission factors. Emissions from military navigation are estimated using emission factors from civil navigation. Emissions from the use of diesel oil by military stationed abroad is reported under Multilateral operations, NFR1C2.

Military road transport is included in the road traffic emissions estimated by the road emission model HBEFA 3.1. To subtract and separate emissions from military transport from emissions from civil road transport, emissions according to the HBEFA model for each vehicle type are reduced by an amount equal to the weight of the fuel consumption reported by the Swedish Armed Forces relative to the fuel consumption from national statistics allocated to civil road transport, according to the equation below:

$$A = B - \sum((C-D)/C * E_i)$$

A = Military transport emissions

B = Total HBEFA emissions

C = Total fuel consumption National Statistics

D = Military fuel consumption Swedish Armed Forces

E<sub>i</sub> = HBEFA emissions per vehicle type

The consumption of ethanol for road traffic by the military has been added as from 2007 as from submission 2013.

Please note that for 1980-1989, only emissions of particles from jet gasoline in military aviation is reported due to the lack of sufficient information for the other sub-sectors. Also note that emissions from FAME were only calculated for 1999-2002, since the military estimated their use of FAME for those years only.

#### 3.2.21.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty analysis tables are presented in NIR Annex 7 and a general description of the uncertainties is presented in NIR section 1.7.

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

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

#### 3.2.21.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been made.

#### 3.2.21.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 3.2.22 Memo Items International bunkers, 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* do-

mestic and international aviation should be reported separately as a memo items 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. The emissions of NO<sub>x</sub> have increased since 2009, except for the last year, which probably is explained by an increased use of “Dreamliner” airplanes according to Swedish Defence Research Agency who calculate the emission. The emissions of CO from cruise have had a decreasing trend since 2003 and an increasing trend between 2003 and 2013 when the emissions started to decrease again. The emissions of Pb have decreased noticeably for the whole period, as leaded gasoline has been phased out. The emissions of NMVOC fluctuate, but show a decreasing trend.

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. Emissions from international navigation are not included in the national total, but are 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<sup>83</sup>. The emissions from international navigation fluctuate over time in line with the fluctuating fuel consumption.

The distribution of marine distillate fuels and residual fuel oils over domestic and international navigation (bunkers) entail uncertainties. The current distribution is provided by the respondents of the survey on supply and delivery of petroleum products, but these are suspected to lack full information on the end-use of all the fuels provided. Hence, the distribution between domestic and international use might vary considerably for some years. The fuel data in the Monthly fuel, gas and inventory statistics was analysed in 2011 and found to be of relatively good quality<sup>84</sup>. This is a consequence of that VAT is applied on national fuel consumption, but not on international bunkers, which makes all respondents to the survey separate the fuel used for national respectively international navigation with accuracy.

To evaluate Swedish emissions, international bunkers are of course important, especially as international bunkering of fuel is substantially greater than the fuel used for domestic navigation and aviation. Emissions have increased significantly since 1990 due to increased travelling and transportation of goods.

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<sup>83</sup> Statistic Sweden. [http://www.scb.se/sv\\_/Hitta-statistik/Statistik-efter-amne/Energi/Tillforsel-och-anvandning-av-energi/Manatlig-bransle--gas--och-lagerstatistik/](http://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Energi/Tillforsel-och-anvandning-av-energi/Manatlig-bransle--gas--och-lagerstatistik/)

<sup>84</sup> Eklund et al. 2011. Emissions from navigation and fishing including international bunkers

**Table 3-52. Key source assessment International aviation,, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
International Aviation: Jet kerosene	NO <sub>x</sub>	NO <sub>x</sub>

#### 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 items in NFR1A3ai respectively 1A3di.

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
- 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<sup>85</sup>.

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<sup>86</sup>. 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).

<sup>85</sup> Mårtensson, T. & Hasselrot, A., 2013.

<sup>86</sup> Gustafsson, 2005.

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.

#### 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 items in NFR1A3ai and 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.

#### 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 to non-Swedish destinations, but excludes consumption by fishing vessels. 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.

Emission from multilateral operations are not included in the national total but instead reported separately as a memo item in NFR1A3di. These emissions are derived from fuel purchased in Sweden and used abroad by Swedish forces participating in UN related operations. These emissions account for very small amounts.

#### 3.2.22.3 *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 reliable quality, as VAT is applied on national fuel consumption but not on international bunkers which results in that the respondents to the survey are able to separate national from international fuel consumption with high accuracy.

#### 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*

No source-specific recalculations have been made.

#### 3.2.22.6 *SOURCE-SPECIFIC PLANNED IMPROVEMENTS*

No major improvements are planned for the next submission.

### 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 (hence reported as NO).

#### 3.3.2 Solid fuel transformation, NFR1B1b

##### 3.3.2.1 SOURCE CATEGORY DESCRIPTION

NFR1B1b includes emissions of SO<sub>2</sub>, HN<sub>3</sub>, Se and PAH from quenching and extinction at coke ovens. Particle emissions, also occurring during from coke production, are allocated to NFR1A1c (industrial combustion). The summary of the latest key source assessment is presented in Table 3-53.

**Table 3-53. Summary key category assesment, NFR1B1b, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1B1b	PAH 1-4, Se	PAH 1-4

##### 3.3.2.2 METHODOLOGICAL ISSUES

Information on SO<sub>2</sub> emissions are retrieved from the companies' environmental reports and direct communication. PAH-4 emissions from quenching and extinction at coke ovens have been calculated for the time period 1987-2015. Estimated emissions of PAH-4 from coke production are based on activity data in combination with emission factors for extinction and quenching from US EPA (United States Environmental Protection Agency, EPA-454/R-98-014). The same emission factors have been used for the whole time series. For the time period before 1987 no reliable activity data are available.

NH<sub>3</sub> and Se emissions from coke production are reported from submission 2016 onwards. Emission factors are obtained from EMEP/EEA Guidebook 2013 and applied to activity data. Activity data, produced amount of coke, has been acquired from official statistics (1987 - 2000) and from the annual environmental reports for the two facilities producing coke (2001 and onwards).

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.

### 3.3.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR1B1b are displayed in Table 3-54. Uncertainties are mostly expert estimates, except for  $\text{HN}_3$  and Se, for which the emission factor uncertainties are calculated based on the intervals in the EMEP/EEA Guidebook 2013.

**Table 3-54. Uncertainties for NFR1B1b (If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty are reported under the emission factor)**

Source category	Substance	Base year uncertainty(%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1B1b	$\text{SO}_2$	±5	±50	±5	±50
	$\text{NH}_3$	±5	±170	±5	±170
	Se	±5	±900	±5	±900
	PAH	±5	±1000	±5	±1000

### 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<sup>87</sup> 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

Emissions of  $\text{SO}_2$  from one of the facilities have been corrected for 2014, resulting in ~2% increase for this code.

### 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.

## 3.3.3 Other, NFR1B1c

### 3.3.3.1 SOURCE CATEGORY DESCRIPTION

NFR1B1c includes emissions from flaring of coke oven gas at coke ovens handling ( $\text{NO}_x$ , CO, NMVOC,  $\text{SO}_2$ , TSP,  $\text{PM}_{10}$  and  $\text{PM}_{2.5}$ ) and particle emissions from solid fuels handling (TSP,  $\text{PM}_{10}$  and  $\text{PM}_{2.5}$ ). The summary of the latest key source assessment is presented in Table 3-55.

**Table 3-55. Summary key category assesment, NFR1B1c, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1B1c	Solid Fuels – TSP, $\text{PM}_{10}$	

<sup>87</sup> Skårman, T., Danielsson, H., Kindbom, K., Jernström, M., Nyström, A-K. 2008.

### 3.3.3.2 METHODOLOGICAL ISSUES

#### 3.3.3.2.1 *Flaring of coke oven gas*

Table 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 Table 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<sub>2</sub>, 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<sub>2</sub>, 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 amounts of flared COG vary considerably between years, and during some years (2009, 2015) they were unusually high, resulting in increasing emissions. According to environmental reports<sup>88</sup>, COG is flared when the production is temporarily stopped because of urgent needs of reparation of equipment or other maintenance measures.

#### 3.3.3.2.2 *Handling of solid fuels*

Particulate emissions from handling of solid fuels have been calculated for all years since 1980. Emission factors used for handling of exported and imported fuels are those suggested in the CEPMEIP-project<sup>89</sup>. The TSP emission factor is 0.15 kg/tonne where PM<sub>10</sub> constitutes 40 % and PM<sub>2.5</sub> 4 % of the total particulate emissions. The same emission factors have been used for the entire time series.

No production of coal occurs in Sweden but peat production does occur and from submission 2011 particulate emissions from production of milled peat is included in the estimates of particle emissions. Activity data (as m<sup>3</sup> 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.

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<sup>88</sup> SSAB, 2008, 2009, 2015

<sup>89</sup> CEPMEIP, 2001. TNO.  
[http://www.mep.tno.nl/wie\\_we\\_zijn\\_eng/organisatie/kenniscentra/centre\\_expertise\\_emissions\\_assessment.html](http://www.mep.tno.nl/wie_we_zijn_eng/organisatie/kenniscentra/centre_expertise_emissions_assessment.html)



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)<sup>90</sup> and the share of PM<sub>10</sub> and PM<sub>2.5</sub> are from Tissari *et al.* (2006)<sup>91</sup>. 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- .

**Table 3- 56. Particle emission factors for milled peat production.**

Harvesting method	Particle emission factors (g/m <sup>3</sup> ) for peat production		
	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>
HAKU method	0.09	0.042	0.030
Mechanical collector	0.14	0.066	0.046
Pneumatic collector	0.12	0.056	0.039
<b>Average</b>	<b>0.12</b>	<b>0.055</b>	<b>0.039</b>

Due to problems with data files on energy consumption in energy industries and manufacturing industries for 1980-1989, it has not been possible to recalculate emissions as has been done for different sectors for 1990 and onwards. Hence, time series for the eighties are not directly comparable with later years for NFR1B1c.

### 3.3.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR1B1c are displayed in Table 3-57. Uncertainties 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).

**Table 3-57. Uncertainties for NFR1B1c (If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty are reported under the emission factor)**

Source category	Substance	Base year uncertainty(%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1B1c COG flaring	NO <sub>x</sub> , TSP and PM <sub>10</sub>	±70	±20	±50	±20
	CO, NMVOC	±70	±30	±50	±30
	SO <sub>2</sub>	±70	±50	±50	±50
1B1c Handling of solid fuels	Particles	± 6	±20	± 6	±20

<sup>90</sup> Nuutinen, J., Yli-Pirilä, P., Hytönen, K., Kärtevä, J., 2007, Turvetuotannon poly- ja melupäästöt sekä vaikutukset lähialueen ilmanlaatuun, Symo

<sup>91</sup> 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

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

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

#### 3.3.3.5 SOURCE-SPECIFIC RECALCULATIONS

Emissions of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> from solid fuel handling have been corrected for 2014 in submission 2017, resulting in ~0.001-0.002% decrease for this code.

#### 3.3.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

### 3.3.4 Hydrogen production plants at refineries, NFR1B2a i

#### 3.3.4.1 SOURCE CATEGORY DESCRIPTION

NFR1B2a i includes emissions from hydrogen production at refinery facilities – NO<sub>x</sub>, CO, NMVOC, SO<sub>2</sub>, NH<sub>3</sub>, TSP, PM<sub>10</sub> and PM<sub>2.5</sub> and BC. The summary of the latest key source assessment for aggregated emissions from NFR1B2a is presented in Table 3-58.

**Table 3-58. Summary of key category assessment, NFR1B2a, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1B2a i,iv,v	Oil – NMVOC, SO <sub>2</sub> , DIOX, NO <sub>x</sub>	Oil - NMVOC

#### 3.3.4.2 METHODOLOGICAL ISSUES

The first hydrogen production facility in Sweden was taken into operation in 2005, and in this facility, butane was used as a main raw material until 2011. Since 2011, several fuels are used as stock for hydrogen production, including liquefied natural gas (LNG) from 2015. The second hydrogen production facility is operative since 2006. At this facility, naphtha was used as raw material until 2011 and LNG – from 2011 and onwards. Emissions from these facilities are reported in NFR1B2a i in accordance with 2006 IPCC Guidelines.

The Tier 2 method is used. Activity data as consumed amounts of refinery rest products (mainly butane) and liquefied natural gas are taken from the EU ETS system. The emissions are calculated using plant specific activity data and net calorific values. For butane and natural gas, national emission factors are used, whereas national emission factors for “other petroleum fuels” were used for naphtha due to lack of specific emission factors for this fuel.

The emissions of SO<sub>2</sub> from hydrogen production ended in 2011 when naphtha was no longer used as a raw material in the production.

### 3.3.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR1B2a i are displayed in Table 3-59. Uncertainties are mostly expert estimates. According to data reported to the EU ETS, both hydrogen production plants use the level 2 method to measure activity data, which means that the activity data uncertainty is  $\pm 2.5$  % or less.

**Table 3-59. Uncertainties for NFR1B2a i (If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty are reported under the emission factor)**

Source category	Substance	Base year uncertainty(%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1B2ai	SO <sub>2</sub> , particles	$\pm 2.5$	$\pm 20$	$\pm 2.5$	$\pm 20$
	NO <sub>x</sub>	$\pm 2.5$	$\pm 50$	$\pm 2.5$	$\pm 50$
	NH <sub>3</sub> , NMVOC	$\pm 2.5$	$\pm 75$	$\pm 2.5$	$\pm 75$
	CO	$\pm 2.5$	$\pm 100$	$\pm 2.5$	$\pm 100$

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

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

### 3.3.4.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been made in submission 2017.

### 3.3.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Emissions from these facilities are currently reported in NFR1B2a i. However, since the emissions originate from a chemical process and not from oil exploration, their re-allocation to the Industrial Processes and Product Use sector is under consideration.

## 3.3.5 Refineries, NFR1B2a iv

### 3.3.5.1 SOURCE CATEGORY DESCRIPTION

There five refinery facilities in Sweden. Emissions from refineries reported in NFR1B2 i iv include:

- Fugitive emissions of CH<sub>4</sub> and NMVOC from the total refinery area;
- SO<sub>2</sub> emissions from desulphurisation (occur at four facilities);
- Emissions from cracker coke combustion (occur at three facilities) – NMVOC, NH<sub>3</sub>, PAH and dioxin;
- Emissions from fluidized catalytic cracker (occur at one facility) – SO<sub>2</sub>, NO<sub>x</sub>, CO, TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and BC.

The summary of the latest key source assessment for aggregated emissions from NFR1B2a is presented in Table 3-60.

**Table 3-60. Summary of source category description, NFR1B2a according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1B2a i,iv,v	Oil – NMVOC, SO <sub>2</sub> , DIOX, NO <sub>x</sub>	Oil - NMVOC

### 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 catalytic cracking (CO, SO<sub>2</sub>, and NO<sub>x</sub>), desulphurisation (SO<sub>2</sub>), and from the storage and handling of oil (NMVOC, CH<sub>4</sub>). Catalytic cracking occurs at one plant in Sweden.

CO emissions from catalytic cracking are calculated as:

$$\text{CO} = \left( \frac{\text{Batched amount of raw material in the cracker}}{\text{Total batched amount of raw material in the plant}} \right) \times \text{Total CO emission for the plant}$$

Due to some problems at the plant the total emissions of CO were high for 1997 and 1998 compared to the other years. In 2014 and 2015 the emissions of CO were higher compared to previous years due to larger production.

Emissions of SO<sub>2</sub> from desulphurisation decreased dramatically during the early 1990's and have for most years after 1995 been between 0.4 and 1 Gg with the exception for 2006, when the emissions increased due to operational disturbances at one facility.

Particle emissions from catalytic cracking have only been estimated since 1990 due to lack of data for earlier years. The emissions from cracking have been compiled from information from the company. The particle size distributions have been estimated with expert judgement. The assumed size distribution is 95 % for PM<sub>10</sub> and 85 % for PM<sub>2.5</sub> of estimated TSP for the whole time-series.

Fugitive emissions of NMVOC from refineries include emissions from the process area as well as emissions from the refinery harbours 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<sup>92, 93, 94, 95</sup> and Statistics Sweden<sup>96</sup>. The activity data, as throughput of crude oil, is known for almost all years. Implied emission factors have been developed, based on reported emissions and known activity data. Reported data for years for which either activity data or emission data is missing have been calculated using the implied emission factors thus developed. In

Table 3-, the reported emissions as well as activity data can be seen. Due to secrecy reasons, data for 2015 cannot be displayed.

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<sup>92</sup> Swedish EPA, 1990.

<sup>93</sup> Swedish EPA, 1994a.

<sup>94</sup> Swedish EPA, 1994b.

<sup>95</sup> Swedish EPA. 1995.

<sup>96</sup> Statistics Sweden. 1996 Emissions to air in Sweden of volatile organic compounds (VOC) 1988 and 1994.

**Table 3- 61. Throughput of crude oil at oil refineries and estimated fugitive emissions of NMVOC (Mg) NFR1B2a iv.**

Year	Throughput of crude oil, Mg	Total emissions of NMVOC, Mg
1988	15 600 000	16 318
1989	16 440 000	16 850
1990	17 330 000	14 408
1991	16 810 000	12 900
1992	17 870 000	10 961
1993	18 723 684	10 311
1994	18 192 000	8 933
1995	19 430 000	7 643
1996	20 305 000	9 661
1997	20 130 000	9 749
1998	20 254 000	9 507
1999	19 483 034	10 350
2000	20 253 120	11 568
2001	19 592 852	9 795
2002	19 681 182	10 195
2003	19 661 646	11 602
2004	20 611 941	8 957
2005	19 919 968	7 691
2006	20 050 576	8 269
2007	17 706 518	8 877
2008	20 420 061	8 575
2009	19 669 472	8 779
2010	20 278 888	8 924
2011	19 034 115	8 938
2012	21 021 566	8 576
2013	17 021 700	8 103
2014	19 320 478	7 962

Since submission 2009, emissions from combustion of cracker 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<sup>97</sup>. The cracking reactions produce some carbonaceous 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. Activity data as amount of cracker are taken from the company's report to the EU ETS system. NO<sub>x</sub>, PAH, dioxins and NMVOC are calculated with these plant specific activity data and national emission factors.

<sup>97</sup> 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

### 3.3.5.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

In order to ensure consistency in the calculations (either standard values or values from EU ETS for both calorific values and CO<sub>2</sub> emission factors), corrections have been made for the years 2010-2012. That affected all emissions from cracker coke combustion, as described below.

Uncertainties for NFR1B2a iv are displayed in Table 3-62. Uncertainties are mostly expert estimates. Activity data uncertainties concern only cracker coke combustion (for other activities, emissions from environmental reports are used).

**Table 3-62. Uncertainties for NFR1B2a iv (If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty are reported under the emission factor)**

Source category	Substance	Base year uncertainty(%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1B2aiv	Particles	±20	±20	±7.5	±20
	NH <sub>3</sub>	±20	±40	±7.5	±40
	NO <sub>x</sub> , SO <sub>2</sub>	±20	±50	±7.5	±50
	NM VOC	±20	±75	±7.5	±75
	CO	±20	±100	±7.5	±100
	Dioxin, PAH	±20	±1000	±7.5	±1000

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

Emissions have been revised and verified based on the additional facility-specific data for reporting to EU ETS, as described below.

### 3.3.5.5 SOURCE-SPECIFIC RECALCULATIONS

Corrections of fuel calorific values been made for the years 2010-2012, which resulted in decrease of emissions from cracker coke combustion by between 0.02% (NM VOC) and 7-14% (dioxin, PAH) for NFR1B2a iv, compared to submission 2016.

For one of the largest facilities, amount of combusted cracker coke has been updated for 2014, resulting in small (by ≤1%) increase of emissions in NFR1B2a iv.

### 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 Gasoline handling and distribution, NFR1B2a v

### 3.3.6.1 SOURCE CATEGORY DESCRIPTION

NFR1B2a v includes fugitive emissions of NM VOC from the storage of oil products (oil depots) and from gasoline handling at gasoline stations. The summary of the latest key source assessment for aggregated emissions from NFR1B2a is presented in Table 3-63.

**Table 3-63. Summary of source category description, NFR1B2a, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1B2a i,iv,v	Oil – NMVOC, SO <sub>2</sub> , DIOX, NO <sub>x</sub>	Oil - NMVOC

### 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, 1988-2015, is based on methods given by Concawe<sup>98</sup>, including annual national gasoline consumption and assumptions on the share of gasoline evaporated at different stages of the handling procedure, as well as effects of applied abatement technology at gasoline stations<sup>99</sup>. The basic assumptions are presented in Table 3- 64; ethanol both for use in blends with gasoline and for use unblended is included in the reported gasoline volumes.

**Table 3-6.4 Assumptions for calculating fugitive emissions from the handling and distribution of gasoline.**

Parameter	Assumption	
Density of gasoline	730 kg/m <sup>3</sup> 1988 - 1996 750 kg/m <sup>3</sup> 1997 -	
Distribution of gasoline to gas stations	0.16 %	of distributed volume
Spill	0.01 %	of distributed volume
Filling of car tanks	0.18 %	of filled volume
Measures at distribution to gas station	90 %	Efficiency of measures
Measures at filling cars	70 %	Efficiency of measures

The measures at distribution and filling were introduced over a period of time from 1991-1994, to the extent presented in Table 3- . The amount of gasoline sold at large and small gas stations, respectively, was assumed to be 50/50 for the years 1988-1994. Data on the distributed amounts of gasoline is taken from national statistics from Statistics Sweden for submission 2016 and onwards, Table 3- 6. For earlier submissions data on the distributed amounts of gasoline was taken from the HBEFA model.

**Table 3- 65. Fraction of gasoline stations with technical measures installed**

Year	Large gas stations >2000 m <sup>3</sup>	Small gas stations
1988 – 1990	0%	0%
1991	50%	0%
1992	75%	25%
1993	100%	75%
1994 -	100%	100%

<sup>98</sup> Concawe, 1986, Hydrocarbon emissions from gasoline storage and distribution systems, Report No 85/54.

<sup>99</sup> Andersson, 2000.

### 3.3.6.2.2 Oil depots

Calculated fugitive emissions of NMVOC from the storage of oil products have been obtained from SPI<sup>100</sup> 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<sup>101</sup> for the years 1990-2006 and on Concawe 03/07<sup>102</sup> 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. Handled amount of gasoline and fugitive emissions of NMVOC from depots and gasoline stations are presented in Table 3-6. Due to secrecy reasons, data for 2015 cannot be displayed.

**Table 3- 6. Handled and distributed amount of gasoline and estimated fugitive emissions of NMVOC (Gg) from storage at depots and at gasoline stations. Due to secrecy reasons, data for 2015 cannot be displayed.**

Year	Volume of gasoline and ethanol m <sup>3</sup>	Fugitive emissions of NMVOC at depots Gg	Fugitive emissions of NMVOC at gasoline stations, Gg
1990	5 629 582	2.48	14.38
1995	5 762 693	1.93	3.37
2000	5 372 801	2.07	3.22
2005	5 508 187	2.31	3.30
2006	5 363 256	2.47	3.22
2007	5 253 617	2.35	3.15
2008	4 928 238	2.53	2.96
2009	4 861 776	2.41	2.92
2010	4 550 207	2.21	2.73
2011	4 222 863	2.47	2.53
2012	3 880 860	2.45	2.33
2013	3 685 278	2.20	2.21
2014	3 545 193	1.93	2.13

<sup>100</sup> Per Brännström, 2009-, personal communication; Leif Ljung -2009, personal communications

<sup>101</sup> Concawe, 1986, Hydrocarbon emissions from gasoline storage and distribution systems, Report No 85/54.

<sup>102</sup> Concawe Report No. 3/07, Air pollutant emission estimation methods for E-PRTR reporting by refineries



### 3.3.6.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR1B2a v are displayed in Table 3-67. Uncertainties are mostly expert estimates and are associated with emissions.

**Table 3-67. Uncertainties for NFR1B2a v (If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty are reported under the emission factor)**

Source category	Substance	Base year		Year 2015	
		uncertainty(%)		uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1B2av	NMVOC	IE	±75	IE	±75

### 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

Minor corrections of NMVOC emissions from gasoline depots were made for 2012 and 2014, resulting in emission increase by 0.02% for this code.

### 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). The summary of the latest key source assessment is presented in Table 3-68.

**Table 3-68. Summary key source assessment, NFR1B2b, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1B2b	-	-

### 3.3.7.2 METHODOLOGICAL ISSUES

In 2013, a national method for estimating fugitive emissions of natural gas and gasworks gas has been developed for the period 1990 to 2012<sup>103</sup>. Emission of NMVOC from this subsector is for the first time reported in submission 2014.

<sup>103</sup> Jerksjö M., Gerner A., Wängberg I. 2013

### 3.3.7.2.1 *Transmission and storage of natural gas 1B2b 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<sup>104</sup>, 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.

In 2016, the method for estimating the emissions from the gas transmission network was revised since new measurements of methane emissions became available<sup>105</sup>. Methane leakage rates per hour have been measured at all major types of facilities. Estimated emission factors (see Table 3-69 below) have been applied to the number of facilities of each type.

**Table 3-69. Method for estimation of gas leakage from the national gas transmission network**

Facility type	CH <sub>4</sub> EF g/hour	Number of facilities in 2015	Comment
M/R station	91	42	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
Compressor station	100	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 2015)
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 3-70. Information on gas composition was obtained from Swedegas and constitutes average values from the period 2006 to 2012.

**Table 3-70. 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 <sup>3</sup>	0.817
Density of methane	kg/Nm <sup>3</sup>	0.716

<sup>104</sup> Bjur & Lindsjö, 2016

<sup>105</sup> Jerksjö, M., Salberg, H. 2016. Mätningar av metanläckage längs svenska naturgasnätets stamledning, IVL report C202 (in cooperation with Fluxsense)

Emissions earlier reported as gas leakage have been re-allocated to the sector *NFR1B2c Venting and flaring* since these emissions are controlled and associated with regular network maintenance work rather than with uncontrolled gas leakage.

#### 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
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<sup>106</sup>. 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 modernised 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 and since the beginning of 2011, only pure natural gas is distributed in Gothenburg. 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<sup>107</sup>.

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<sup>106</sup> 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.

<sup>107</sup> 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.

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<sup>108</sup>) was chosen. The emission factor is the result of an evaluation of data from measurements of gas leaks at several places in the Netherlands and is equal to 120 Nm<sup>3</sup> 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 3-71.

**Table 3-71. 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 <sup>3</sup> gas leakage
Emission factor for NMVOC	No emission factors are used. Emissions are calculated based on estimated methane emissions and the content of CO <sub>2</sub> 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.

<sup>108</sup> Wikkerlink. 2006.

In 1993, the city of Gothenburg shifted to a mixture of natural gas and air and since the beginning of 2011, only pure natural gas is distributed in Gothenburg.

The fugitive emissions from distribution of gasworks gas in Stockholm and Gothenburg has been estimated based on statistics on production of gasworks gas and natural gas air mixtures and leakage rate obtained from Stockholm Gas. The content of NMVOC in gasworks gas and natural gas air mixture is shown in table 3-72.

**Table 3- 72. NMVOC content in gasworks gas**

Property	Unit	Value
NMVOC in gasworks gas	kg/Nm <sup>3</sup>	0.04
NMVOC in natural gas air mixture	kg/Nm <sup>3</sup>	0.08

### 3.3.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR1B2b are displayed in Table 3-73.

*Gas transmission:* Emissions have been revised in submission 2017 due to new measurement results available. The associated emission uncertainty is  $\pm 50$  % according to expert estimates.

*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  $\pm 50$  %. 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  $\pm 50$  %.

**Table 3-73. Uncertainties for NFR1B2b (If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty are reported under the emission factor)**

Source category	Substance	Base year uncertainty(%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
1B2b4 Gas transmission	NMVOC	IE	$\pm 50$	IE	$\pm 50$
1B2b5 Gas distribution	NMVOC	IE	$\pm 50$	IE	$\pm 50$

### 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

The method for calculation of diffuse emissions from natural gas transmission and storage has been revised. Part of the emissions, reported by the operator and earlier

considered as diffuse emissions, has been re-allocated to the sector *NFR1B2c Venting and flaring*. Diffuse emissions of NMVOC in submission 2017 have been calculated via CH<sub>4</sub> emission factors based on the measurement results, resulting in relatively large (by up to 18 t) emission increase, compared to submission 2016.

#### 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, three iron and steel plants, one pulp industrial plant, as well as during the national gas network maintenance (NO<sub>x</sub>, CO, NMVOC, SO<sub>x</sub>, NH<sub>3</sub>, TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, and BC). The summary of the latest key source assessment is presented in Table 3-74.

**Table 3-74. Summary of key source assessment, NFR1B2c, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
1B2c	-	-

#### 3.3.8.2 METHODOLOGICAL ISSUES

For flaring of oil products and refineries and other industrial sites, activity data has been collected directly from the plant operators. For 2007 and onwards, activity data is mainly taken from the EU ETS system. Plant specific net calorific values are used when available. The same emission factors are used as for stationary combustion.

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 pigging – 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 vented. For the years 2014 and 2015, 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 pigging are ~0.13-0.42 t.

Beside pigging operations, there is certain amount of gas annually vented to the atmosphere (earlier reported as diffuse emissions) from M/R stations – about 13 Nm<sup>3</sup> gas per station, or about 1 tonne NMVOC in total per year. Much higher and much more varying venting emissions come from the storage facility (put into operation in 2006) – from 6 to 170 t NMVOC per year, depending on how well the

compressor worked. In 2013 the compressor failure<sup>109</sup> resulted in particularly high emissions.

### 3.3.8.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR1B2c are displayed in Table 3-75. Estimates of emissions from natural gas venting are provided by the operator. The associated uncertainty is  $\pm 50$  % 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  $\pm 17.5$  %. 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.

**Table 3-75. Uncertainties for NFR1B2c (If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty are reported under the emission factor)**

Source category	Substance	Base year uncertainty(%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
Gas venting	NM VOC	$\pm 50$	$\pm 50$	$\pm 50$	$\pm 50$
Gas flaring in the transmission network	SO <sub>2</sub>	$\pm 50$	$\pm 20$	$\pm 50$	-
	NO <sub>x</sub> , HN <sub>3</sub>	$\pm 50$	$\pm 20$	$\pm 50$	$\pm 20$
	NM VOC	$\pm 50$	$\pm 30$	$\pm 50$	$\pm 30$
	CO	$\pm 50$	$\pm 40$	$\pm 50$	$\pm 40$
	Particles	$\pm 50$	$\pm 100$	$\pm 50$	$\pm 100$
Flaring at refineries	NO <sub>x</sub> , CO, NH <sub>3</sub> and NM VOC	$\pm 20$	$\pm 50$	$\pm 17.5$	$\pm 50$
	SO <sub>2</sub>	$\pm 20$	$\pm 70$	$\pm 17.5$	$\pm 70$
	Particles	$\pm 20$	$\pm 100$	$\pm 17.5$	$\pm 100$

### 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. For a few plants that flare small amounts of gas, activity data as amount of flared gas is shown neither in the environmental reports, nor in the ETS data. Flaring at these plants was investigated in 2005, and the same values are used for later years. These facilities are regularly asked to verify that the default value is still valid.

### 3.3.8.5 SOURCE-SPECIFIC RECALCULATIONS

The method for calculation of diffuse emissions and venting from natural gas transmission and storage has been revised. Part of the emissions, reported by the operator and earlier considered as diffuse emissions, has been re-allocated to the sector *NFR1B2c Venting and flaring*. NM VOC emissions from gas venting (earlier reported for each eighth year only) are now 0.1-17 t higher than estimates in submission 2016.

<sup>109</sup> Hellström 2013-2015

Amounts of flared gas during pigging have been recalculated since the number of M/R stations for different years (used for estimation of gas flaring numbers) has been corrected based on personal communication with the operator. This resulted in small (~2%) increase of NMVOC emissions for 1990, 1998 and 2006.

Flaring at refineries has been revised based on the additional data for reporting to EU ETS. Several re-allocations between combustion in the energy sector and flaring have been made. For one large facility, flared gas reported as “refinery gas” was further split into methane-rich gas and hydrogen (based on data from EU ETS and environmental reports), which resulted in decrease in activity data in TJ and all emissions except for NO<sub>x</sub> for the years 2007-2014. NO<sub>x</sub> emissions have instead increased due to higher emission factor for methane-rich gas.

#### 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.



## 4 Industrial processes and product use (NFR sector 2)

### 4.1 Overview

For Sweden, the most important industries within the industrial sector has 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 aluminium production and some 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.
- National production statistics or similar information at national level.
- Plant specific data collected by direct contacts with facilities

Under Swedish environmental laws, operators performing environmentally hazardous activities that require a permit by law are obliged to compile and submit an annual environmental report to their supervisory authority. The environmental report consists of three parts:

- Basic identification information about the facility.
- Text section (for example, a description of the facility and the processes, the use of energy, chemicals and raw materials, emissions and conditions in the permit).
- Emission declaration (for example, production data, fuel consumption data, emission data and, in some cases, information on how emission data has been determined).

Data in the environmental reports often originate from measurements or mass balances. The use of default emission factors is limited. Only operators that exceed the thresholds for the substances, listed in the Swedish environmental law concerning environmental reports<sup>110</sup>, are obliged to compile the emission declaration.

The County Administrative Boards audit the data presented in the operators' environmental reports. Since the beginning of year 2007 environmental reports can be submitted electronically via the Swedish Portal for Environmental Reporting

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<sup>110</sup> Swedish EPA, NFS 2000:13, Naturvårdsverkets föreskrifter om miljörapport för tillståndspliktiga miljöfarliga verksamheter.

(SMP)<sup>111</sup>. This database includes not only emissions, but also basic information about the facilities, such as their activity code (national code system, adjustment of NACE four digits), IPPC code and permit, location coordinates, etc. The procedure for updating the database is not regulated by legislation, which results in some incompleteness and inconsistencies in the database.

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<sub>10</sub> and PM<sub>2.5</sub> 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.

Emissions of metals have not been reported for the period 1980 - 1989 due to lack of reliable data for some important sources.

Sweden's emission inventory is in accordance with EMEP/ EEA Air Pollutant Emission Inventory Guidebook<sup>112</sup>, 2006 IPCC Guidelines<sup>113</sup>, and the Guidelines for Estimating and Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution<sup>114</sup>.

## 4.2 Mineral products, NFR2A

### 4.2.1 Cement production, NFR2A1

#### 4.2.1.1 SOURCE CATEGORY DESCRIPTION

Cement production occurs at three facilities in Sweden, with one being dominant. Emission data is taken from environmental reports and by direct contacts with the facilities. Calculation methods have been discussed with the industry.

**Table 4-1. Summary of key source assessment, NFR2A1, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2A1	SO <sub>2</sub> , PM <sub>2.5</sub> , NO <sub>x</sub>	SO <sub>2</sub> , PM <sub>10</sub> , TSP, PM <sub>2.5</sub>

<sup>111</sup> Swedish Portal for Environmental Reporting , Svenska Miljörapporteringsportalen.  
<https://smp.lansstyrelsen.se/>

<sup>112</sup> The EMEP/EEA Guidebook: <http://www.eea.europa.eu/themes/air/emep-eea-air-pollutant-emission-inventory-guidebook/emep>

<sup>113</sup> 2006 IPCC Guidelines for National Greenhouse Gas Inventories <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>

<sup>114</sup> UNECE 2003, Guidelines for Estimating and Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution. Air Pollution Studies No. 15.

#### 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. Emissions of NO<sub>x</sub> are allocated from the energy sector (NFR1A2f) to industrial processes and product use. The reason for this is that there is a lack of correct emission factors due to the fact that the companies use such a large variety of waste as fuel. The use of different waste as fuel varies within and between years.

Also SO<sub>2</sub> emissions are allocated to industrial processes. Reported SO<sub>2</sub> emissions for 2015 have slightly decreased compared to 2014, however emissions since 1990 have decreased substantially. Emissions of TSP, PM<sub>10</sub> and PM<sub>2.5</sub>, also allocated to industrial processes and product use, have been estimated for the time period 1980 – 2015.

Reported emissions of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> for 2010 to 2015 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. BC emissions are reported for 2000 onwards and are calculated as a fraction of PM<sub>2.5</sub> according to EMEP/EEA Guidebook 2013.

NH<sub>3</sub> emissions arise partly due to the selective non-catalytic reduction (SNCR) of NO<sub>x</sub> where NH<sub>3</sub> 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<sub>3</sub> emissions reported by the company. There is a substantial variation in NH<sub>3</sub> 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, PAH-4 and dioxins from the fuels used are calculated based on energy statistics and reported in the energy sector (NFR1).

Table 4- 2 gives an overview of the allocation of pollutants from cement production.

**Table 4- 2. Allocation of pollutants from cement production.**

Pollutant	NFR
NO <sub>x</sub>	2A1
NMVOC	1A2f
SO <sub>2</sub>	2A1
NH <sub>3</sub>	2A1 and 1A2f
PM <sub>2.5</sub>	2A1
PM <sub>10</sub>	2A1
TSP	2A1
BC	NE
CO	1A2f
Metals	1A2f
PAH-4	1A2

#### 4.2.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR2A1 are displayed in Table 4-3.

**Table 4-3. Uncertainties for NFR2A1. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
2A1	NH <sub>3</sub>			±2	±400
2A1	NO <sub>x</sub>	±2	±50	±2	±50
2A1	SO <sub>x</sub>	±2	±20	±2	±20
2A1	TSP	±2	±30	±2	±30
2A1	PM <sub>10</sub>	±2	±30	±2	±30
2A1	PM <sub>2.5</sub>	±2	±30	±2	±30

Time series from cement production reported in NFR2A1 have 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

No recalculations have been performed in NFR2A1 in submission 2017.

#### 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

Emissions of SO<sub>2</sub>, particulate matter and BC from lime production are reported in NFR2A2. 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 2015, there was a slight increase in production compared to 2014 with quantities of around 565 kt, marking however a considerably lower production compared to years 2010-2013.

**Table 4-4. Summary of key category assessment, NFR2A2, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2A2	PM <sub>2.5</sub> , SO <sub>2</sub>	PM <sub>10</sub> , PM <sub>2.5</sub> , SO <sub>2</sub> , TSP

### 4.2.2.2 METHODOLOGICAL ISSUES

Emissions of SO<sub>2</sub> 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<sup>115</sup>. 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<sub>2</sub> emissions for 2008 compared to earlier years. However in 2009 the reported SO<sub>2</sub> emissions were again on the same level as before 2008 due to less use of lime. For 2009-2015 the emission factor for 2008 has been used for the estimation of emissions of SO<sub>2</sub> due to lack of more recent information in the environmental reports.

Emissions of SO<sub>2</sub> 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<sub>2</sub> emissions from quick lime production within carbide production are from submission 2015 onwards included in NFR2A2.

Emissions of particles from lime production have also been estimated. Estimates were made for the period from 1980 onwards and emissions were calculated using emission factors presented in environmental reports by one of the producers and size fractions based on expert judgement.

<sup>115</sup> Nordkalk, <http://www.nordkalk.com>

For corresponding emissions from the production of other lime products, emission factors published by the CEPMEIP project<sup>116</sup> were used. 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<sub>2.5</sub> according to EMEP/EEA Guidebook 2013.

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<sub>2</sub> 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 in recent years not been produced in time, resulting in the need of an alternative data source. In a study carried out in 2015<sup>117</sup>, 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 NFR2A are displayed in Table 4-5.

**Table 4-5. Uncertainties for NFR2A2**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
2A2	SO <sub>x</sub>	±15	±20	±5	±20
2A2	TSP	±15	±50	±5	±50
2A2	PM <sub>10</sub>	±15	±50	±5	±50
2A2	PM <sub>2.5</sub>	±15	±50	±5	±50

Time series from lime production reported in NFR code 2A2 have been reviewed in later years and are consistent.

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

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

#### 4.2.2.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been performed in NFR2A2 in submission 2017.

<sup>116</sup> CEPMEIP, 2001. TNO.  
[http://www.mep.tno.nl/wie\\_wie\\_zijn\\_eng/organisatie/kenniscentra/centre\\_expertise\\_emissions\\_assessment.html](http://www.mep.tno.nl/wie_wie_zijn_eng/organisatie/kenniscentra/centre_expertise_emissions_assessment.html)

<sup>117</sup> Mawdsley, I. 2015. Change of activity data for lime production

#### 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. In addition, emissions from one glass wool producer are included. From glass wool production, emissions of NH<sub>3</sub>, NMVOC, particles and BC are reported.

From the float glass production, the total emissions of SO<sub>2</sub> and NO<sub>x</sub> from the glass furnace are allocated to 2A3 since a separation in energy-related and process-related emissions is not possible. From the container glass production, SO<sub>2</sub> emissions originating from the raw material and small amounts of NMVOC are reported. Emissions of Cu, Se and Ni from the float glass production and emissions of Se and Ni from the container glass production are reported from Submission 2016 onwards.

The only producer of float glass shut down in 2013. The shut-down of the float glass production facility resulted in very low emissions for 2013 as this is the only source of NO<sub>x</sub> emissions in NFR2A3. Also total emissions of SO<sub>2</sub> and particles in 2A3 decreased to a small extent in 2013-2014 due to the ceased production of float glass. In 2014, NO<sub>x</sub> 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 1980–2012 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 1990-2015.

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 2013.

All other emissions from the glass production facilities originate from combustion for energy purposes, and are allocated to the Energy sector (NFR1).

**Table 4-6. Summary of key source assessment, NFR2A3, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2A3	Se, Ni, SO <sub>2</sub>	Se, NH <sub>3</sub> , PM <sub>10</sub> , TSP, PM <sub>2.5</sub> , As, SO <sub>2</sub> , NO <sub>x</sub>

#### 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<sup>118</sup>. Data for missing years and parameters have been estimated or interpolated.

Emission factors for Ni, Se and Cu are obtained from EMEP/EEA Guidebook 2013 and applied to activity data. Activity data, produced amount of float and container glass, has been acquired from the annual environmental reports for the two major producing facilities.

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 NFR2A3 are displayed in Table 4-7.

**Table 4-7. Uncertainties for NFR2A3. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
2A3	As	IE	±100	IE	±100
2A3	Cd	IE	±100	IE	±100
2A3	Cr	IE	±100	IE	±100
2A3	Cu	IE	±86		
2A3	Hg	IE	±1000	IE	±1000
2A3	NH <sub>3</sub>	IE	±400	IE	±400
2A3	Ni	IE	±40	IE	±317
2A3	NMVOC	IE	±400	IE	±400
2A3	NO <sub>x</sub>	IE	±50	IE	±50
2A3	Pb	IE	±50	IE	±50
2A3	Se	IE	±373	IE	±493
2A3	SO <sub>x</sub>	IE	±30	IE	±30
2A3	TSP	IE	±100	IE	±100
2A3	PM <sub>10</sub>	IE	±100	IE	±100
2A3	PM <sub>2.5</sub>	IE	±100	IE	±100
2A3	Zn	IE	±50	IE	±50

Time series from glass production reported in NFR code 2A3 have been reviewed in later years and are consistent.

<sup>118</sup> Bjärborg, 1998.



#### 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

No recalculations have been performed in NFR2A3 in submission 2017.

#### 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.

The use of mining explosives causes emissions of mainly nitrogen oxides, NO<sub>x</sub><sup>119</sup>. The dominating source for emissions of particulate matter are limestone quarrying, crushing and grinding, re-allocated from NFR2A2 in Submission 2016. Ore dressing plants are the dominating source of heavy metals. Data on emissions of NO<sub>x</sub>, particulate matter and heavy metals are mainly collected from the companies' environmental reports to the authorities.

**Table 4-8. Summary key source assessment, NFR2A5a, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2A5a	-	-

#### 4.2.4.2 METHODOLOGICAL ISSUES

NO<sub>x</sub> emissions originating from the use of mining explosives are only reported for the years 2002 - 2015 due to lack of data for earlier years. Emissions of particles are reported for the time period from 1980 and for metals from 1990. Emissions of particles from limestone quarrying, crushing and grinding are re-allocated from NFR2A2 in Submission 2016.

#### 4.2.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR2A5a are displayed in Table 4-9.

<sup>119</sup> Wieland, 2004.

**Table 4-9. Uncertainties for NFR2A5a. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
2A5a	TSP	IE	±49	IE	±49
2A5a	Zn	IE	±50	IE	±50
2A5a	As	IE	±100		
2A5a	Cd	IE	±100		
2A5a	Cu	IE	±50	IE	±50
2A5a	Hg	IE	±1000		
2A5a	Ni	IE	±50	IE	±50
2A5a	NO <sub>x</sub>			IE	±100
2A5a	Pb	IE	±50	IE	±50
2A5a	PM <sub>2.5</sub>	IE	±50	IE	±50
2A5a	PM <sub>10</sub>	IE	±49	IE	±49

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 sourcespecific QA/QC or verification is performed.

#### 4.2.4.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been performed in NFR2A5a in submission 2017.

#### 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. The basis for the calculations is national data on construction activity. Emission factors from the CEPMEIP study are used<sup>120</sup>.

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 Guidebook 2013.

<sup>120</sup> CEPMEIP, 2001. TNO.  
[http://www.mep.tno.nl/wie\\_wie\\_zijn\\_eng/organisatie/kenniscentra/centre\\_expertise\\_emissions\\_assessment.html](http://www.mep.tno.nl/wie_wie_zijn_eng/organisatie/kenniscentra/centre_expertise_emissions_assessment.html)

**Table 4-10. Summary of key source assessment, NFR2A5b, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2A5b	-	-

#### 4.2.5.2 METHODOLOGICAL ISSUES

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<sup>2</sup>)<sup>121</sup>, 1996 - 2015, and economic statistics on annual investments in construction-related activities<sup>122</sup>, 1980 - 2002. As only information on economic investments used for construction work are available for the years 1980 - 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, the economic information was normalised to the 1995 level, and the costs per square meter was assumed to be constant through-out the time series. The investments in construction work in 2002 expressed in SEK and normalised to the 1995 level was used as the base year for the transformation of investment information into constructed square meters 1980 - 1995. The data is divided into four sub-groups; dwellings, industries, other buildings and construction. The latter three are considered to be utilities and are treated as a sum. Emission factors used for calculations of particulate matter from construction activities are all found in the CEPMEIP database<sup>123</sup>.

#### 4.2.5.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR2A5b are displayed in Table 4-11.

**Table 4-11. Uncertainties for NFR2A5b. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
2A5b	PM <sub>10</sub>	IE	±100	IE	±100
2A5b	PM <sub>2.5</sub>	IE	±100	IE	±100
2A5b	TSP	IE	±100	IE	±100

Time series from construction work reported in NFR code 2A5b have been reviewed in later years and are consistent.

<sup>121</sup> Statistics Sweden. <http://www.scb.se>. Housing and construction, Statistics on building permits for housing and non-residential buildings

<sup>122</sup> The Swedish Construction Federation. <http://www.bygg.org>. Personal communication

<sup>123</sup> CEPMEIP, 2001. TNO.  
[http://www.mep.tno.nl/wie\\_wie\\_zijn\\_eng/organisatie/kenniscentra/centre\\_expertise\\_emissions\\_assessment.html](http://www.mep.tno.nl/wie_wie_zijn_eng/organisatie/kenniscentra/centre_expertise_emissions_assessment.html)

#### 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

Particle emissions for 1999 and 2004-2014 for NFR2A5b Construction and demolition have been corrected due to updated data in national statistics, resulting in small changes, between -0.9 to 2.8 % change from the previous submission.

#### 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.

##### 4.2.7.1.1 *Mineral wool production*

Mineral wool has been produced at approximately 2-5 different facilities during the time period 1980-2013. 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 NiCd-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.

**Table 4-12. Key source assessment, NFR2A6, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2A6	-	-

#### 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 - 2015 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<sub>10</sub> and PM<sub>2.5</sub> were calculated from emission factors for production of glass fibres provided in the CEPMEIP study<sup>123</sup>.

##### 4.2.7.2.2 *Batteries manufacturing*

The time series from 1990 - 2015 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 battery manufacturer of NiCd-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.

#### 4.2.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR2A6 are displayed in Table 4-13.

**Table 4-13. Uncertainties for NFR2A6 (Mineral wool production) and 2A6 (Batteries Manufacturing). If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncert. (%)	
		Activity data	Emission factor	Activity data	Emission factor
2A6 (Mineral wool production)	As	IE	±100	IE	±100
2A6 (Mineral wool production)	Cd	IE	±100	IE	±100
2A6 (Mineral wool production)	Cr	IE	±100	IE	±100
2A6 (Mineral wool production)	Cu	IE	±50	IE	±50
2A6 (Mineral wool production)	Hg	IE	±1000		
2A6 (Mineral wool production)	NH <sub>3</sub>	IE	±400	IE	±400
2A6 (Mineral wool production)	Ni	IE	±50	IE	±50
2A6 (Mineral wool production)	NMVOC	IE	±400	IE	±400
2A6 (Mineral wool production)	Pb	IE	±50	IE	±50
2A6 (Mineral wool production)	PM <sub>10</sub>	IE	±100	IE	±100
2A6 (Mineral wool production)	PM <sub>2.5</sub>	IE	±100	IE	±100
2A6 (Mineral wool production)	TSP	IE	±100	IE	±100
2A6 (Mineral wool production)	Zn	IE	±50	IE	±50
2A6 (Batteries Manufacturing)	Cd	IE	±100	IE	±100
2A6 (Batteries Manufacturing)	Ni	IE	±50	IE	±50
2A6 (Batteries Manufacturing)	NMVOC	IE	±400	IE	±400
2A6 (Batteries Manufacturing)	Pb	IE	±50	IE	±50

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

NMVOC and particle emissions for 2013 and 2014 for NFR2A6 other mineral products have been corrected due to new information in the companies' environmental reports to the authorities, resulting in changes, between -10.8 to -3.3 % change from the previous submission.

#### 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<sup>124</sup>. This ammonia 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<sup>125</sup>. Emissions from this industry are included in NFR code 2B5. Ammonia production, 2B1, is thus reported as NO in the NFR-tables.

#### 4.3.1.2 METHODOLOGICAL ISSUES

Emission data on NO<sub>x</sub> and NH<sub>3</sub> 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<sub>x</sub> 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<sub>x</sub> emissions in year 2004 is a result of a long lasting leakage of NO<sub>x</sub> 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<sub>x</sub> and NH<sub>3</sub> were reduced compared to previous years. According to the company the increased NH<sub>3</sub> emissions in 2010-2014 is a result of prioritizing low NO<sub>x</sub> emissions. NH<sub>3</sub> is used as a reducing agent in the de-NO<sub>x</sub> catalyst and hence lower NO<sub>x</sub> implies more injected NH<sub>3</sub>. NH<sub>3</sub> that do not react in the catalyst is emitted to the air. From 2007 emissions are continuously measured

<sup>124</sup> UN. Commodity Production Statistical Database. Department of Economic and Social Affairs, Statistics Division, as referred in FCCC Synthesis and Assessment report 2002 Part I.

<sup>125</sup> Kindbom, 2004.

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) have been implemented during the work with this sub-mission.

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 check-lists.

The time series for all revised data have been studied carefully in search for outliers and to make sure that levels are reasonable. Data have, 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 taken into account.

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 in the end of 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.

**Table 4-14. Summary of key source assessment, NFR2B2, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2B2	-	NO <sub>x</sub>

#### 4.3.2.2 METHODOLOGICAL ISSUES

Emission data on NO<sub>x</sub> and NH<sub>3</sub> 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<sub>x</sub> 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<sub>x</sub> emissions in year 2004 is a result of a long lasting leakage of NO<sub>x</sub> 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<sub>x</sub> and NH<sub>3</sub> were reduced compared to previous years. According to the company the increased NH<sub>3</sub> emissions in 2010-2014 is a result of prioritizing low NO<sub>x</sub> emissions. NH<sub>3</sub> is used as a reducing agent in the de-NO<sub>x</sub> catalyst and hence lower NO<sub>x</sub> implies more injected NH<sub>3</sub>. NH<sub>3</sub> 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.



#### 4.3.2.3 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 NFR2B2 are displayed in Table 4-15.

**Table 4-15. Uncertainties for Nitric acid production, NFR2B2**

Source category	Substance	Base year uncertainty(±%)		Year 2015 uncertainty (±%)	
		Activity data	Emission factor	Activity data	Emission factor
2B2	N <sub>2</sub> O	±2	±5	±2	±5
	NH <sub>3</sub>	±2	±400	±2	±5
	NO <sub>x</sub>	±2	±100	±2	±5

#### 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 2017

#### 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<sub>10</sub>, PM<sub>2.5</sub> and BC are reported from carbide production and estimates are based on information from the company. The distribution of particulates between TSP, PM<sub>10</sub> and PM<sub>2.5</sub> has been determined by expert judgement.

Silicium carbide production does not occur in Sweden.

**Table 4-16. Summary of source category description, NFR2B5, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2B5	PM <sub>2.5</sub>	PM <sub>2.5</sub>

#### 4.3.5.2 METHODOLOGICAL ISSUES

The time series of particle emissions from carbide production are considered complete and consistent in methodology. TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and BC emissions from carbide production are included and the dominating part of reported emissions arises from flaring of carbide oven gas. The partitioning of particles between TSP, PM<sub>10</sub> and PM<sub>2.5</sub> has been done by expert judgement after discussions with the carbide producing company and the emitted mass of PM<sub>10</sub> and PM<sub>2.5</sub> 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.

#### 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 Table 4-17.

**Table 4-17. Uncertainties for Carbide production NFR2B5**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
2B5	TSP	±10	±50	±10	±50

#### 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 2017.

#### 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<sup>126</sup> a study was carried out to collect data on soda ash use and calculate CO<sub>2</sub> emissions. From this study it became clear that no production of soda ash occur in Sweden, and is hence reported as NO in NFR2B7.

<sup>126</sup> Nyström, A-K. 2004. CO<sub>2</sub> 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<sub>x</sub>, CO, NMVOC, SO<sub>2</sub>, NH<sub>3</sub> and TSP are reported. From submission 2016 onwards, emissions of PM<sub>2.5</sub>, PM<sub>10</sub> and BC from three inorganic chemical processes are included: production of carbon black, production of phosphate fertilizers and NPK, and production of PVC. 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 2013 (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.

**Table 4-18. Summary of source category description, NFR2B10a, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2B10	Hg, SO <sub>2</sub> , NMVOC	Hg, SO <sub>2</sub> , NH <sub>3</sub>

##### 4.3.8.2 METHODOLOGICAL ISSUES

The primary information on emissions of NO<sub>x</sub>, CO, NMVOC, SO<sub>2</sub>, NH<sub>3</sub> 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 are considered to be consistent.

From submission 2016 onwards, emissions of PM<sub>2.5</sub>, PM<sub>10</sub> and BC from three inorganic chemical processes are included. Emission factors are based on particulate fractions as in EMEP/EEA Guidebook 2013, and applied to TSP emissions reported by facilities. Activity data on production of PVC and carbon black has been acquired from the facilities' environmental reports. Activity data on production of

phosphate fertilizers was obtained from FAOSTAT<sup>127</sup> for 1990-1995 and from Statistics Sweden database for 1996 onwards.

Mercury emissions reported in NFR2B5 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<sup>128</sup>.

Hardly any information on dioxin emissions from the chemical industry has been available, and it has not been possible to compile any time series of dioxin emissions from these sources. There is only information on dioxin emissions available from a few facilities from 2001.

The SO<sub>2</sub> emissions reported in 2B5 decreased dramatically in 2004 in comparison to earlier years. This is due to that in December 2003 one facility for production of viscose staple fibre was shut down. The yearly SO<sub>2</sub> emissions from this facility represented between 8 and 20 % of the totally reported SO<sub>2</sub> emission in NFR2 – Industrial Processes, 1990 - 2003. In 2007 the CO-emissions were very low from one facility producing PVC. NH<sub>3</sub>-emissions decreased since 2007 due to that one facility are working on replacing NH<sub>3</sub> 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 the quality and reducing the uncertainties of the emissions of the most important substances from chemicals industries in Sweden<sup>129</sup>. 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<sup>130</sup>.

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.

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<sup>127</sup> FAOSTAT <http://faostat3.fao.org>

<sup>128</sup> Levander, 1989.

<sup>129</sup> Swedish EPA. 2010.

<sup>130</sup> Most recommendations on further investigations refer to the energy sector

#### 4.3.8.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR2B10a are displayed in Table 4-19.

**Table 4-19. Uncertainties for NFR2B10a. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
2B10a	CO	IE	±75	IE	±75
2B10a	Dioxin	IE	±1000	IE	±1000
2B10a	Hg	IE	±50	IE	±50
2B10a	NH <sub>3</sub>	IE	±50	IE	±50
2B10a	NMVOC	IE	±75	IE	±75
2B10a	NO <sub>x</sub>	IE	±50	IE	±50
2B10a	SO <sub>2</sub>	IE	±50	IE	±50
2B10a	TSP	IE	±50	IE	±50
2B10a	PM <sub>10</sub>	IE	±314	IE	±170
2B10a	PM <sub>2.5</sub>	IE	±322	IE	±111

Time series for various chemical industries reported in NFR code 2B10a have been reviewed in later years and are considered to be consistent.

#### 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

NMVOC emissions for 2014 from one facility have been corrected due to updated data in the environmental report for 2015. Total NMVOC emissions reported in NFR2B10a decrease therefore by about 0.9 % compared to Submission 2016.

For the years 1992 and 1993 minor corrections have been made regarding the emissions of NO<sub>x</sub> and SO<sub>2</sub>. Emissions for one plant were interpolated for those years but as the plant was not running NE is reported for those years in Submission 2017 instead. This leads to a decrease of less than 0.1 % of both total NO<sub>x</sub> and SO<sub>2</sub> emissions reported in NFR2B10a for both years compared to Submission 2016.

Other minor corrections have been implemented for the years 2012 and 2013 with regard to NO<sub>x</sub> and SO<sub>2</sub> emissions from one plant. Total emissions of SO<sub>2</sub> reported in NFR2B10 increase by less than 0.01 % for both years compared to Submission 2016. Total emissions of NO<sub>x</sub> reported in NFR2B10a decrease by less than 0.01 % for 2012 compared to Submission 2016.

Statistics regarding phosphate fertilizer production for 2014 has been updated as this is data is obtained with a delay of one year. Total PM<sub>10</sub> emission reported in NFR2B10a therefore increase by less than 0.1 % compared to Submission 2016. Total PM<sub>2.5</sub> and BC emissions reported in NFR2B10a increase by about 0.1 % and 0.02 %, respectively.

#### 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.

### 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. The summary of the latest key source assessment is presented in Table 4-20.

In Sweden, there are three primary iron and steel facilities equipped with blast furnaces, producing iron and steel products from virgin materials, and 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. 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. From submission 2009 and onwards, emissions from two major iron ore mines and 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.

**Table 4-20. Summary of key source assessment, NFR2C1, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2C1	Se, Cr, Ni, DIOX, Zn, SO <sub>2</sub> , PM <sub>2.5</sub> , TSP, Cd, PM <sub>10</sub> , Hg, Pb, Cu, NO <sub>x</sub> , PAH 1-4, As	Se, Cr, Ni, DIOX, Zn, SO <sub>2</sub> , PM <sub>2.5</sub> , TSP, Cd, PM <sub>10</sub> , Hg, Pb, Cu, NO <sub>x</sub>

##### 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.

#### *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 Iron ore mining, dressing, sintering and iron ore pellets production*

In Sweden, there are three primary iron and steel facilities equipped with blast furnaces, producing iron and steel products from virgin materials. Emissions from three major iron ore mines and three facilities producing pellets in Sweden are reported in 2C1.

Emissions from a sinter producing facility are also included until 1995, when the production closed down.

#### **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 (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 three 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- 1 gives an overview of the input and output materials, the carbon flows between the different processes (plant stations), and the CO<sub>2</sub>-emitting sources. Note that for non-CO<sub>2</sub> emissions, the different emission sources may vary consid-

erably. 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.



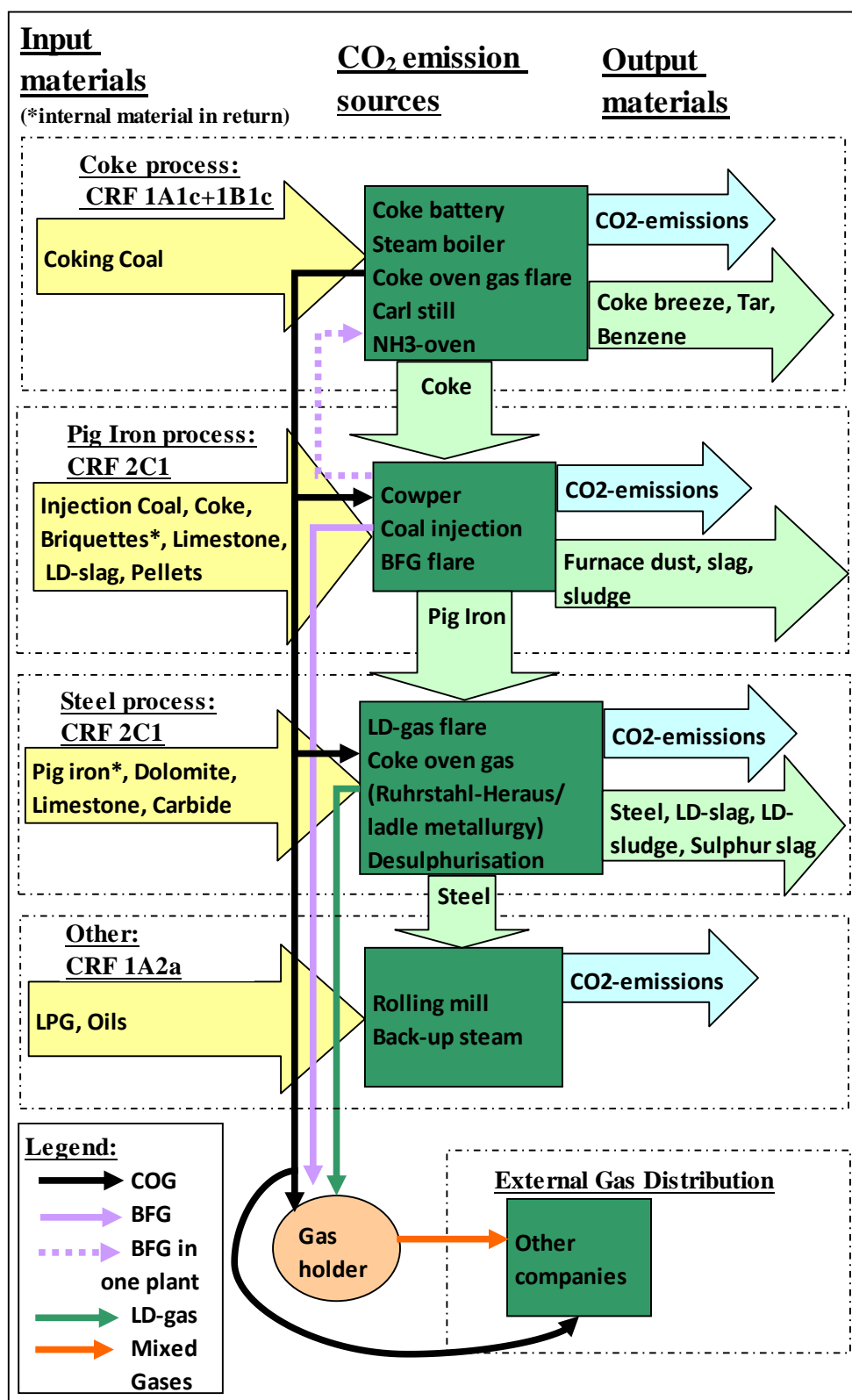


Figure 4- 1. Carbon flow chart of integrated primary iron and steel plants in Sweden.  
CRF = NFR.

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<sup>131</sup> 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 consists 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<sub>x</sub>, SO<sub>2</sub>, 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<sub>x</sub>, SO<sub>2</sub>, 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<sub>x</sub>, SO<sub>2</sub> and TSP are derived from the environmental reports and direct contact with the plants for the entire time series. The allocation of both plants total emissions of NO<sub>x</sub>, SO<sub>2</sub> and TSP on plant stations and consequently NFR category is presented in Table 4- 21 for the year 2014. Due to secrecy reasons, data for 2015 cannot be displayed.

**Table 4- 21. Allocation of NO<sub>x</sub>, SO<sub>2</sub> and TSP emissions for 2014 in integrated primary iron and steel production**

NFR	Plant station	NO <sub>x</sub> emissions 2014 (kt)	SO <sub>2</sub> emissions 2014 (kt)	TSP emissions 2014 (kt)
1A1c	Coke Oven	0.40	0.14	188
1A2a	Combustion in Rolling Mills + Power and Heat Production	0.35	0.35	26
1B1b	SO <sub>2</sub> from quenching and extinction at coke ovens		0.01	
1B1c	Flare in Coke Oven (COG)	<0.01	0.01	<1
2B5	Sulphuric acid production		0.01	
2C1	Blast Furnace + Steelworks (including Flaring of BFG and LD-gas)	0.18	0.60	282
<b>Total</b>		<b>0.93</b>	<b>1.13</b>	<b>596</b>

<sup>131</sup> 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<sub>2</sub> emissions as the surrogate parameter.

Inventory emissions of heavy metals, TSP and dioxin are mostly obtained from the environmental reports, except for selenium, which is included for the first time in submission 2016, calculated using default emission factor from EMEP/EEA Guidebook 2013. In some cases, especially for the early 1990's and for one of the plants, information on heavy metal emissions are lacking and thus estimated by extrapolation using IEF and TSP as a surrogate parameter. Emissions of heavy metals are all reported under NFR2C1. The PM size fractioning has been made according to reported emissions of PM<sub>10</sub> and PM<sub>2.5</sub> from one of the plants. Starting submission 2015, BC emissions are also reported from year 2000 onwards, calculated as a fraction of PM<sub>2.5</sub>, according to the EMEP/EEA Guidebook 2013.

#### 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<sub>x</sub>, NMVOC and SO<sub>2</sub> emissions emitted from electric arc furnaces are reported in 2C1. NO<sub>x</sub> 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 trade association<sup>132</sup> for almost all years 1980-1999 but for 2000 and onwards the information was derived from the companies' environmental reports. TSP data for missing years have been interpolated. The PM size fractioning has been made according to expert judgement, and are based on knowledge about changes in production methods and abatement technology. From submission 2015 onwards, BC emissions are reported from secondary iron and steel production from 2000 onwards. Emissions are calculated as a fraction of PM<sub>2.5</sub> according to EMEP/EEA Guidebook 2013.

The estimated metal emissions from secondary iron and steel processes are based on produced amount of steel, published by the trade association<sup>132</sup>, 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, 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 inter-

<sup>132</sup> The Swedish Steel Producers Association. <http://www.jernkontoret.se>.

polated. 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 US-EPA<sup>133</sup>, dioxin emissions from steel production are strongly dependent on a number of 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 1980 - 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<sup>134</sup>. From 2001 the information concerning the dioxin emissions were derived from the companies' environmental reports.

In submission 2016 emissions of PAH1-4 and PCB from secondary iron and steel processes are reported for the first time. The estimates are based on national figures on produced amount of steel and emission factors from EMEP/EEA Guidebook 2013.

#### 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<sub>10</sub> and PM<sub>2.5</sub> emissions, the same fractions of TSP as in the CEPMEIP project<sup>135</sup> are used.

Starting from submission 2016, emissions of Se, HCB and PCB are reported, calculated with default emission factors from the EMEP/EEA Guidebook 2013.

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<sup>133</sup> U.S. Environmental Protection Agency, 1997.

<sup>134</sup> The Swedish Steel Producers Association. <http://www.jernkontoret.se>.

<sup>135</sup> CEPMEIP, 2001. TNO.  
[http://www.mep.tno.nl/wie\\_we\\_zijn\\_eng/organisatie/kenniscentra/centre\\_expertise\\_emissions\\_assessment.html](http://www.mep.tno.nl/wie_we_zijn_eng/organisatie/kenniscentra/centre_expertise_emissions_assessment.html)

#### 4.4.1.2.4 *Iron ore mining, dressing, sintering and iron ore pellets production*

There are currently two major iron ore mines and three facilities producing pellets in Sweden. Until 1995, emissions from a now closed sinter producing facility are also included. Emissions considered are SO<sub>2</sub> from the sulphur content in the ore and NO<sub>x</sub> 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<sup>136</sup>. Metals are reported for the time period from 1990, whereas emissions of dioxins and particles are reported for the period 1980 onwards.

The figures are 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<sub>10</sub> and PM<sub>2.5</sub> the same ratio has been used as the one used in the CEPMEIP study<sup>137</sup>. Content of heavy metals in particulate matter has been calculated using an analysis provided by the leading company. The analysed samples were from the pellets production, but in the emission estimates the factors have been used on the sum of produced sinter and pellets. BC emissions are reported from submission 2015 and are calculated as a fraction of PM<sub>2.5</sub> according to EMEP/EEA Guidebook 2013.

In submission 2016 emissions of PAH1-4, PCB, HCB from sintering and iron ore pellets production are reported for the first time. For iron ore pellets production also emissions of selenium are reported for the first time. The estimates are based on produced amount and emission factors from EMEP/EEA Guidebook 2013.

The reported emissions of dioxins are based on an emission factor developed using measurements in 2001 and known production data for the same year. Since the production methodology and other circumstances have not changed significantly during the time period, this developed emission factor has been used to calculate the time series of dioxin emissions for the period 1980 - 2001. For 2002 onwards, data on dioxin emissions provided by the companies are reported.

#### 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. The emission of dioxin was 2.3 times higher during submission 2017 in comparison to the year before. However, the

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<sup>136</sup> Wieland, 2004

<sup>137</sup> CEPMEIP, 2001. TNO.  
[http://www.mep.tno.nl/wie\\_we\\_zijn\\_eng/organisatie/kenniscentra/centre\\_expertise\\_emissions\\_assessment.html](http://www.mep.tno.nl/wie_we_zijn_eng/organisatie/kenniscentra/centre_expertise_emissions_assessment.html)

difference only amounted 0.4 g and was an effect of that two smelters reported higher emissions than earlier.

Uncertainties for NFR2C1 are displayed in Table 4-22.

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 2013.

**Table 4-22. Uncertainties for NFR2C1 (If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty are reported under the emission factor)**

Source category	Substance	Base year uncertainty(±%)		Year 2015 uncertainty (±%)	
		Activity data	Emission factor	Activity data	Emission factor
Primary iron and steel (including direct reduced iron)	Cd, Hg	±5	±20	±5	±20
	TSP	±5	±40	±5	±40
	As, Cr, Cu, Pb and Zn	±5	±50	±5	±50
	Ni, NO <sub>x</sub>	±5	±75	±5	±75
	CO, SO <sub>2</sub> , PCB	±5	±100	±5	±100
	NMVOC	±5	±200	±5	±200
	Se, HCB	±5	±900	±5	±900
	dioxin	±5	±1000	±5	±1000
	Cd, Hg	IE	±20	IE	±20
	TSP	IE	±40	IE	±40
Secondary iron and steel production	As, Cr, Cu, Pb	IE	±50	IE	±50
	Zn	IE	±20	IE	±20
	Ni, NO <sub>x</sub>	IE	±100	IE	±100
	Ni, NO <sub>x</sub>	IE	±75	IE	±75
	CO, SO <sub>2</sub> , PCB	IE	±100	IE	±100
	NMVOC	IE	±200	IE	±200
	PAH_1_4	IE	±102	IE	±102
	dioxin	IE	±1000	IE	±1000
Iron sintering	Cd, Hg	±5	±20		
	TSP	±5	±40		
	As, Cr, Cu, Pb and Zn	±5	±50		
	Ni	±5	±75		
	SO <sub>2</sub> , PCB	±5	±100		
	Se, HCB	±5	±900		
	PAH_1_4	±5	±100		
	dioxin	±5	±1000		
Iron ore pellets production	Cd, Hg	±5	±20	±5	±20
	Particles	±5	±40	±5	±40
	As, Cr, Cu, Pb and Zn	±5	±50	±5	±50
	Ni, NO <sub>x</sub>	±5	±75	±5	±75
	SO <sub>2</sub> , PCB	±5	±100	±5	±100
	Se, HCB	±5	±900	±5	±900
	PAH_1_4	±5	±25	±5	±25
	dioxin	±5	±1000	±5	±1000

#### 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:*

No recalculations have been made in submission 2017.

##### 4.4.1.5.2 *Secondary iron production:*

No recalculations have been made in submission 2017

##### 4.4.1.5.3 *Iron ore mining, dressing, sintering and iron ore pellets production:*

No recalculations have been made in submission 2017

#### 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.

**Table 4-23. Summary key source assessment, NFR2C2, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2C2	Cr	Cr

#### 4.4.2.2 METHODOLOGICAL ISSUES

Emission data for SO<sub>2</sub> and NO<sub>x</sub> has been obtained directly from the company for all years. Production of ferrosilicon leads to larger emissions of SO<sub>2</sub> compared to production of ferrochromium. From 2005 the production of ferrosilicon has been much reduced and during 2008 – 2011 and 2014 no ferrosilicon was produced. This led to a distinct decrease in SO<sub>2</sub> emissions during these years. In 2012 the production of ferrosilicon was relatively large compared to adjacent years, which resulted in high emissions of SO<sub>2</sub>. Also emissions of NO<sub>x</sub> 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<sub>2</sub> and NO<sub>x</sub> compared to 2012.

TSP emissions for 1980-1999 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. An expert has performed measurements at the facility since the beginning of the 1980's, and has estimated the size distribution of particulates between PM<sub>10</sub> and PM<sub>2.5</sub><sup>138</sup>. The same particle size distribution was assumed for the time series 1980 - 2001. From 2002 and onwards the reported PM<sub>10</sub> emissions are as presented by the company in their environmental reports. For the years after 2001 the reported PM<sub>2.5</sub> emissions are estimated as for earlier years due to lack of specific information on PM<sub>2.5</sub> emissions from the company.

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 1980 – 2002.

#### 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 Table 4-24.

**Table 4-24. Uncertainties for Ferroalloy production NFR2C2**

Source category	Substance	Base year uncertainty(±%)		Year 2015 uncertainty (±%)	
		Activity data	Emission factor	Activity data	Emission factor
Ferroalloy production 2C2	Particles	±5	±40	±5	±40
	Cr, Pb, Zn	±5	±50	±5	±50
	Ni			±5	±75
	NO <sub>x</sub>	±5	±75	±5	±75
	SO <sub>2</sub>	±5	±30	±5	±30

<sup>138</sup> Peterson, 2002.



#### 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 recalculations have been performed in submission 2017

#### 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

Processes that are included in this category is aluminium production (2C3).

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 are emitted during the anode production. Emissions of PAHs during the electrolysis process are negligible for pre-bake plants but emissions of PAHs did occur until 2008 when the Söderberg plants were used. PAHs emissions occur in Söderberg plants due to the self-baking anode.

**Table 4-25. Summary of key source assessment, NFR2C3, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2C3	CO, SO <sub>2</sub>	CO, PAH 1-4, PM <sub>10</sub>

#### 4.4.3.2 METHODOLOGICAL ISSUES

Primary aluminium production takes place in one facility, where historically both the Prebaked and the Söderberg processes 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<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>, particles and PAH. Reported production statistics and emissions data are based on information in the environmental reports or received directly from the company.

In submission 2016 emissions of dioxin from aluminium production are reported for the first time. The estimates are based on produced amount of aluminium and emission factors from EMEP/EEA Guidebook 2013.

Emissions of NO<sub>x</sub> have been calculated from production statistics using emission factors defined by Swedish EPA<sup>139</sup>. NMVOC emissions have been calculated from reported emissions of tar, assuming that 70 % of the tar is emitted as NMVOC<sup>139</sup>. Closing down the Söderberg ovens also ended the need for anode production in late 2008. Since there was no anode production there was no tar emissions and therefore NMVOC for 2009 and onwards are reported NE. CO emissions were reported for the first time in submission 2008 and are for 2002 - 2015 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<sub>2</sub> emissions, 1990 - 2005. For 2006 - 2015 SO<sub>2</sub> is as reported by the company in their environmental reports.

The elevated SO<sub>2</sub> emission in 2012 is primarily due to high sulphur content of delivered anodes. The desulfurization of flue gases flue gas treatment facilities have not been able to clean sufficiently. Also the CO emissions are higher for 2012 compared to previous years. The reason for this is, according to the company, that a new calculation method has been used for 2012. In 2014 the SO<sub>2</sub> emission was lower than previous year due to improved abatement technology. The improved abatement technology is also shown in the lower SO<sub>2</sub> emissions in 2015.

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 particles from the foundry located at the site of the primary production plant. The particle size fractions of PM<sub>10</sub> and PM<sub>2.5</sub> have been assumed for the whole time period, as given in the CEPMEIP project<sup>140</sup> for primary aluminium production. For particles from the

<sup>139</sup> Ahmadzai, H. Swedish EPA. Personal communication. 2000.

<sup>140</sup> CEPMEIP, 2001. TNO.

[http://www.mep.tno.nl/wie\\_we\\_zijn\\_eng/organisatie/kenniscentra/centre\\_expertise\\_emissions\\_assessment.html](http://www.mep.tno.nl/wie_we_zijn_eng/organisatie/kenniscentra/centre_expertise_emissions_assessment.html)

foundry the same particle size fractions of PM<sub>10</sub> and PM<sub>2.5</sub> have been used. The assumption is thus that PM<sub>10</sub> constitutes 95 % and PM<sub>2.5</sub> 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. Since 2008 no Söderberg ovens has been in operation and no anodes have been produced in the electrode pulp factory. Hence, PAH-4 for the emission years 2009-2015 are reported NA.

According to UNEP<sup>141</sup> 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.

#### 4.4.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR2C3 are displayed in Table 4-26.

**Table 4-26. Uncertainties for NFR2C3. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
2C3	SO <sub>2</sub>	±2	±30	±2	±30
	PM <sub>2.5</sub>	±2	±40	±2	±40
	PM <sub>10</sub>	±2	±40	±2	±40
	TSP	±2	±40	±2	±40
	NO <sub>x</sub>	±2	±50	±2	±50
	NMVOC	±2	±75		
	CO	±2	±100	±2	±100
	PAH_1_4	±2	±1000		
	DIOX	±2	±2900	±2	±2900

Time series from aluminium production 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.

<sup>141</sup> UNEP, 2001. Standardized Toolkit for Identification and Quantifications of Dioxin and Furan Releases. <http://www.chem.unep.ch/pops/pdf/toolkit/toolkit.pdf>

#### 4.4.3.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been performed.

#### 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 of particles 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.

**Table 4-27. Summary of key source assessment, NFR2C7c, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2C7c	<i>Cu, Cd, Pb, As, SO<sub>2</sub>, Cr, Zn, Hg, DIOX, Ni,</i>	<i>Cu, Cd, Pb, As, SO<sub>2</sub>, Cr, Zn, Hg, DIOX, Ni, PM<sub>10</sub>, TSP, PM<sub>2.5</sub></i>

#### 4.4.6.2 METHODOLOGICAL ISSUES

The reported emissions of SO<sub>2</sub> 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<sub>x</sub> in 2C7c represents the same facilities. The SO<sub>2</sub> and NO<sub>x</sub> 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 particles. Emission factors for PM<sub>10</sub> and PM<sub>2.5</sub>, 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<sub>10</sub> from 1980 until 2003 and from 30 to 80 % for PM<sub>2.5</sub> during the same period of time. The suggested emission factors according to CEPMEIP<sup>142</sup>, valid for 1995, correspond to a value of 90 % for PM<sub>10</sub> and 80 % for PM<sub>2.5</sub>. For the years after 2003 the emission factors for PM<sub>10</sub> and PM<sub>2.5</sub> are the same as for 2003.

Emissions of particles and metals from nine secondary non-ferrous metal smelters have been compiled. Emissions are for TSP and the metals as reported by the companies in environmental reports, and further into an emission database. The data in the database are 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. Estimates of the emissions of PM<sub>10</sub> and PM<sub>2.5</sub> were made using the same assumptions concerning particle size fractions as was applied for the large smelter.

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 – 2014.

Chrome and nickel emissions from copper production are reported from submission 2016 onwards. For two smaller smelters, almost all emission data are obtained from the environmental reports and interpolated/extrapolated to cover the period 1990-2010. For the other two facilities, emission factors are obtained from EMEP/EEA Guidebook 2013 with assumptions on applied abatement (see Table 4-29). Activity data is acquired from the facilities' environmental reports.

**Table 4- 28. 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	Facility production data and default EF from Guidebook 2013	0.57 (abatement with 97% efficiency assumed)	Facility production data and default EF from Guidebook 2013	2.1 (abatement with 90% efficiency assumed)
2	Secondary	Facility production data and default EF from Guidebook 2013	0.0039 (abatement with 97% efficiency assumed)	Not estimated	No default Tier II EF in the Guidebook 2013
3	Secondary	Emissions from environmental reports available for 2014+extrapolation		Emissions from environmental reports available for 2008-2014+extrapolation	
4	Secondary	Facility production data and default EF from Guidebook 2013	0.0039 (abatement with 97% efficiency assumed)	Emissions from environmental reports available for 2006 and 2008 + interpolation/extrapolation	

<sup>142</sup> CEPMEIP, 2001. TNO.  
[http://www.mep.tno.nl/wie\\_we\\_zijn\\_eng/organisatie/kenniscentra/centre\\_expertise\\_emissions\\_assessment.html](http://www.mep.tno.nl/wie_we_zijn_eng/organisatie/kenniscentra/centre_expertise_emissions_assessment.html)

#### 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 Table 4-29.

**Table 4-29. Uncertainties for other metal production, NFR2C7c**

Source category	Substance	Base year uncertainty(±%)		Year 2015 uncertainty (±%)	
		Activity data	Emission factor	Activity data	Emission factor
2C7c Other metal production	TSP	±6	±40	±4	±40
	As, Cu, Pb, Zn, NO <sub>x</sub>	±6	±50	±4	±50
	Ni	±6	±54	±4	±54
	Hg, Cd, SO <sub>2</sub>	±6	±20	±4	±20
	Cr	±6	±45	±4	±45
	CO	±6	±100	±4	±100
	Dioxin	±6	±1000	±4	±1000

#### 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 recalculations have been performed in submission 2017.

#### 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 2C7.

## 4.5 Other solvent and product use, NFR2D3

### 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.

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 2013.

**Table 4-30. Summary of key source assessment, NFR2D3, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2D3b	NMVOC	NMVOC

#### 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 onwards 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 (Table 4- 32). For the years 2014 and 2015, data on amount of road paving mixtures delivered in Sweden was unavailable, and estimates are made based on the asphalt statistics<sup>143</sup> and an implied emission factor for the latest year when this data is available (2013). Since production data regarding the total amount of road paving mixtures delivered in Sweden is only available with a lag of one year, activity data and emissions for 2014 are updated in Submission 2017. As for 2015, input data has been set equal to 2014 and will be updated in Submission 2018.

Table 4- 31 shows that the emissions of NMVOC in 2005 were much higher than adjacent years. This is due to that the production of solvent-based bitumen in 2005

<sup>143</sup> Asphalt in figures <http://www.eapa.org/asphalt.php> available 2016-10-15

was extremely high, since it was used to repair roads that had been damaged by a severe storm (“Gudrun”) that hit large areas of southern Sweden in early 2005.

Particle emissions from road paving with asphalt are reported from submission 2016 onwards. Activity data is obtained from asphalt statistics<sup>144</sup>. Emissions factors are obtained from EMEP/EEA Guidebook 2013. 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<sup>145</sup>, it is also assumed that all the facilities use fabric filters to catch major part of the particles.

**Table 4-31. Emissions of NMVOC and particles 1988–2015 from road paving with asphalt**

Year	NMVOC from road paving with asphalt Mg	Emission of particles from road paving with asphalt 1988 – 2015, NFR2D3b, Mg			
		TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	BC
1988	6 600	NE	NE	NE	NE
1989	6 400	NE	NE	NE	NE
1990	6 200	106.4	19.000	3.040	NE
1995	3 800	102.2	18.250	2.920	NE
2000	1 170	100.8	18.000	2.880	0.164
2001	1 080	93.8	16.750	2.680	0.153
2002	845	93.8	16.750	2.680	0.153
2003	603	92.4	16.500	2.640	0.150
2004	920	95.2	17.000	2.720	0.155
2005	1 230	100.8	18.000	2.880	0.164
2006	750	102.2	18.250	2.920	0.166
2007	935	107.8	19.250	3.080	0.176
2008	855	121.8	21.750	3.480	0.198
2009	341	113.4	20.250	3.240	0.185
2010	256	110.6	19.750	3.160	0.180
2011	216	113.4	20.250	3.240	0.185
2012	322	107.8	19.250	3.080	0.176
2013	213	106.4	19.000	3.040	0.173
2014	238	119.0	21.000	3.400	0.194
2015	238	119.0	21.000	3.400	0.194

<sup>144</sup> Asphalt in figures <http://www.eapa.org/asphalt.php> available 2016-10-15

<sup>145</sup> Jan Wikström and Lorentz Lundqvist, NCC Roads AB



#### 4.5.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR2D3b are displayed in Table 4-33.

**Table 4-32. Uncertainties for NFR2D3b. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
2D3b	NM VOC	IE	200	IE	200
	TSP	IE	547	IE	546
	PM <sub>10</sub>	IE	214	IE	214
	PM <sub>2.5</sub>	IE	201	IE	200

Time series from road paving with asphalt reported in NFR code 2D3b have been reviewed in later years and are considered to be 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

Since production data regarding the total amount of road paving mixtures delivered in Sweden is only available with a lag of one year, production data and emissions for 2014 are updated. This leads to an increase of calculated emissions by 12% for NM VOC and particles compared to the provided data in Submission 2016.

#### 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.

Emissions to air linked to the asphalt roofing industry consist mainly of particles, CO and non-methane volatile organic compounds (NM VOC), 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 NM VOC and particle emissions. CO emissions are estimated with the default emission factors from EMEP/EEA Guidebook 2013. 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 2013.

#### 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<sup>146</sup>. The NMVOC emissions from the production of asphalt-saturated felt originates from the felt saturation and coating processes and from leakage from the asphalt storage tanks, of which the latter is the dominating source. For the calculation of the NMVOC emissions separate emission factors, 0.068 kg/Mg and 1.56 kg/Mg, respectively, were used. The emission factors are based on measurements/estimations from 2003 and 1997. The factor used for estimating the TSP emission 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 2013. CO emissions from Swedish production of asphalt-saturated felt are reported from submission 2016 onwards. NMVOC, CO and particle emissions in the sector are presented in Table 4- 35.

The notation key for activity data is C (classified).

**Table 4- 33. Estimated emissions of NMVOC, CO and particles from manufacturing of asphalt-saturated felt (NFR2D3c) in Sweden 1988 – 2015.**

Year	Emission of NMVOC from asphalt roofing 1988 – 2015, NFR2D3c Mg	Emission of CO from asphalt roofing 1988 – 2015, NFR2D3c Mg	Emission of particles from asphalt roofing 1988 – 2015, NFR2D3c		
			Mg TSP	PM <sub>10</sub>	PM <sub>2.5</sub>
1988	81.5*	0.475*	0.285*	0.257*	0.242*
1989	81.5*	0.475*	0.285*	0.257*	0.242*
1990	77.7	0.453	0.279	0.251	0.237
1995	98.6	0.575	0.311	0.280	0.265
2000	111.1	0.647	0.341	0.307	0.289
2001	112.9	0.658	0.351	0.316	0.299
2002	109.2	0.636	0.347	0.313	0.295
2003	101.1	0.589	0.337	0.304	0.287
2004	113.7	0.662	0.356	0.321	0.303
2005	139.7	0.814	0.371	0.334	0.315
2006	132.7	0.773	0.350	0.315	0.297
2007	142.4	0.830	0.357	0.321	0.303
2008	138.6	0.808	0.350	0.315	0.298
2009	103.1	0.601	0.296	0.266	0.252
2010	105.4	0.614	0.298	0.268	0.253
2011	109.6	0.639	0.296	0.267	0.252
2012	110.4	0.643	0.299	0.269	0.254
2013	103.3	0.602	0.298	0.268	0.253
2014	120.1	0.700	0.315	0.283	0.268
2015	119.0	0.693	0.317	0.285	0.269

\* Emissions based on estimated production

<sup>146</sup> Danielsson, 2004.

#### 4.5.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR2D3c are displayed in Table 4-34.

**Table 4-34. Uncertainties for NFR2D3c. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
2D3c	CO	10	216	10	216
	NM VOC	10	200	10	200
	TSP	10	100	10	100
	PM <sub>10</sub>	10	100	10	100
	PM <sub>2.5</sub>	10	100	10	100

Time series from asphalt roofing reported in NFR code 2D3c 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 source-specific recalculations were performed.

#### 4.5.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are currently planned.

### 4.5.3 Solvent use, NFR2D3a, NFR2D3d, NFR2D3e, NFR2D3f, NFR2D3g, NFR2D3h and NFR2D3i

#### 4.5.3.1 SOURCE CATEGORY DESCRIPTION

Use of solvents and products containing solvents results 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<sup>147</sup>.

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).

<sup>147</sup> Skårman et al., 2016. Swedish method for estimating emissions from Solvent Use. Further development of the calculation model. SMED report 192.

Emissions of NMVOC from solvents and products containing solvents have decreased by 32 % from 84 kt NMVOC in 1990 to 57 kt NMVOC in 2015. 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 almost 70% from 35 kt NMVOC in 1990 to 11 kt NMVOC in 2015. 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 2015 (31 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, and ignition fluids. However, a decrease in emissions from the use of ignition fluids 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.

#### 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 both 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.

#### 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 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.

#### 4.5.3.1.7 *NFR2D3i “Other solvent and product use”*

Other solvent and product use is a major source of NMVOC and has increased over time. 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. These products account for about 70% of the increase.

#### 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 domes-

tic 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 for 1990 and the known data for 1995.

Emission factors given in the literature, for example the EMEP/EEA guidebook (EEA, 2013), 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 make it possible 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 very low, since most of the solvents will end up in the product and will not be emitted during production.

A new emission factor for products used diluted in water has been introduced in the new model. The new emission factor is set to 0.275 and it has been calculated based on available information given in the EMEP/EEA guidebook (Domestic solvent use). 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.

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 last year (2015) where data for previous year (2014) has been reported. This practice has been questioned by the ERT several times. The reason for Sweden to report activity data and emissions from solvent use 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.

Uncertainties for NFR2D3a, NFR2D3d, NFR2D3e, NFR2D3f, NFR2D3e, NFR2D3f, NFR2D3h and NFR2D3i are summarised Table 4-35, below.

**Table 4-35. Uncertainties for NFR2D3a, 2D3d, 2D3e, 2D3f, 2D3g, 2D3h and 2D3i. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data*	Emission factor	Activity data	Emission factor
NFR2D3a	NMVOC	± 15	± 25	± 15	± 15
NFR2D3d	NMVOC	± 15	± 25	± 15	± 15
NFR2D3e	NMVOC	± 15	± 25	± 15	± 15
NFR2D3f	NMVOC	± 15	± 25	± 15	± 15
NFR2D3g	NMVOC	± 15	± 25	± 15	± 15
NFR2D3h	NMVOC	± 15	± 25	± 15	± 15
NFR2D3i	NMVOC	± 15	± 25	± 15	± 15

\*=AD for 1995

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

In Table 4-36 it can be seen that the estimates according to the new model results in a significant reduction in the emissions of NMVOC from solvent use in comparison with the old estimates (-18% for 1990, -10% for 2005 and -28% for 2010). The decrease is mainly due to following changes within the model:

- Reallocation between sub-categories. Mainly from NFR2D3i “Other solvent and product use” to NFR2D3a “Domestic solvent use” but also to other sub-categories. In previous estimates an emission factor of 0.95 was used for all activities reported in NFR2D3i “Other solvent and product use”. In the new estimates the emission factor depends on which source group the activity is allocated to.
- Introduction of the new emission factor for products that are used diluted in water reported in “Domestic solvent use” and in “Other solvent use”. In previous estimates these products were not treated separately and consequently the emission factor of 0.95 was used. In the new model an emission factor of 0.275 is used.

**Table 4-36. Recalculations of NMVOC.**

Year	NMVOC, old model	NMVOC, new model
1990	102	84
1991	97	78
1992	92	72
1993	88	66
1994	83	60
1995	78	51
1996	75	51
1997	78	52
1998	76	52
1999	72	52
2000	69	53
2001	68	56
2002	68	61
2003	72	66
2004	76	68
2005	79	71
2006	80	72
2007	80	68
2008	77	62
2009	82	60
2010	86	62
2011	87	61
2012	83	59
2013	80	57
2014	80	57

The differences between the old and the new model are described in detail in Skårman et al., (2016)<sup>148</sup>

#### 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.

<sup>148</sup> Skårman et al., 2016. Swedish method for estimating emissions from Solvent Use. Further development of the calculation model. SMED report 192.



## 4.6 Other product use, NFR2G4

### 4.6.1.1 SOURCE CATEGORY DESCRIPTION

NFR2G4 includes emissions from tobacco smoking and use of fireworks.

#### 4.6.1.1.1 Tobacco smoking

Emissions of NH<sub>3</sub>, Ni, Zn and individual PAHs from tobacco smoking are reported for the first time in submission 2016, using emission factors from EMEP/EEA Guidebook 2013. The emission factors for NO<sub>x</sub>, CO, NMVOC, particles, BC and dioxin have been updated to EMEP/EEA 2013 and emission factors for As, Cd, Cr, Cu, Hg and Pb have been updated to those presented in the Norwegian IIR submission 2015.

#### 4.6.1.1.2 Fireworks

Emissions of NO<sub>x</sub>, SO<sub>2</sub>, CO, As, Cd, Cr, Cu, Hg, Ni and Zn are reported for the first time in submission 2016, using emission factors from EMEP/EEA 2013. Emission factors for particles have been updated to EMEP/EEA 2013. In addition, activity data has been updated for the entire time series, to consider export as well as import of fireworks. As a result, all emissions have been updated.

These changes result in large increases of some substances relative to previously reported emissions from the source, however these two emission sources are overall very small compared to the national total emissions.

**Table 4-37. Summary of key source assessment, NFR2G, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2G	Cu, Ni, PM <sub>2.5</sub> , PM <sub>10</sub> , TSP	Cu, Cr, Ni,

### 4.6.1.2 METHODOLOGICAL ISSUES

Emissions of NO<sub>x</sub>, SO<sub>x</sub>, NMVOC, NH<sub>3</sub>, CO, particles, BC, most heavy metals, dioxins and PAH from tobacco smoking and use of fireworks are included in NFR2G. Emissions from tobacco smoking are based on activity data from official statistics on sold amounts of tobacco for the whole time series from 1980. 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 on imported and exported amounts of fireworks. No significant production of fireworks occurs in Sweden. The activity data for 1980-1987 has been assumed based on available data after 1987, which shows an increasing trend in the use of fireworks. An increasing trend has been applied also to the years where activity data is lacking. Emission factors from EMEP/EEA 2013<sup>149</sup> are used for estimates of emissions from fireworks, and

<sup>149</sup> <http://www.eea.europa.eu/publications/emep-eea-guidebook-2013>

for tobacco smoking, the emission factors are taken from the Norwegian IIR sub-mission 2015, and EMEP/EEA 2013. Emission factors for the two sources are listed in Table 4-38 and in Table 4- 39, corresponding activity data is shown.

**Table 4- 38. Emission factors for tobacco smoking and use of fireworks.**

Pollutant	Tobacco smoking		Fireworks	
	Emission factor	Reference	Emission factor	Reference
NO <sub>x</sub>	1.8 kg/ton	EMEP/EEA 2013	0.26 kg/ton	EMEP/EEA 2013
SO <sub>x</sub>	NE	-	3.02 kg/ton	EMEP/EEA 2013
CO	55.1 kg/ton	EMEP/EEA 2013	7.15 kg/ton	EMEP/EEA 2013
NM VOC	4.84 kg/ton	EMEP/EEA 2013	NE	-
NH <sub>3</sub>	4.15 kg/ton	EMEP/EEA 2013	NA	-
TSP	27 kg/ton	EMEP/EEA 2013	109.83 kg/ton	EMEP/EEA 2013
PM <sub>10</sub>	27 kg/ton	EMEP/EEA 2013	99.92 kg/ton	EMEP/EEA 2013
PM <sub>2.5</sub>	27 kg/ton	EMEP/EEA 2013	51.94 kg/ton	EMEP/EEA 2013
BC	0.45 % of PM <sub>2.5</sub>	EMEP/EEA 2013	NA	-
Pb	0.05 g/ton	Norwegian IIR, 2015	NE	-
Cd	0.1 g/ton	Norwegian IIR, 2015	1.48 g/ton	EMEP/EEA 2013
Hg	0.1 g/ton	Norwegian IIR, 2015	0.057 g/ton	EMEP/EEA 2013
As	0.159 g/ton	Norwegian IIR, 2015	1.33 g/ton	EMEP/EEA 2013
Cr	0.354 g/ton	Norwegian IIR, 2015	15.6 g/ton	EMEP/EEA 2013
Cu	0.152 g/ton	Norwegian IIR, 2015	444 g/ton	EMEP/EEA 2013
Ni	2.7 g/ton	EMEP/EEA 2013	30 g/ton	EMEP/EEA 2013
Zn	2.7 g/ton	EMEP/EEA 2013	260 g/ton	EMEP/EEA 2013
Dioxin	0.1 ug/ton	EMEP/EEA 2013	NA	-
B(a)P	0.111 g/ton	EMEP/EEA 2013	NA	-
B(b)F	0.045 g/ton	EMEP/EEA 2013	NA	-
B(k)F	0.045 g/ton	EMEP/EEA 2013	NA	-
I(1,2,3-cd)P	0.045 g/ton	EMEP/EEA 2013	NA	-

**Table 4- 39. 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	1696
2000	5 599	2556
2005	5 719	2346
2006	5 397	2425
2007	4 882	3115
2008	4 162	1920
2009	4 326	1600
2010	4 324	1749
2011	4 417	1627
2012	4 154	1381
2013	3 993	1537
2014	4 068	1543
2015	3 863	1307

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 – 2015 have decreased compared to 2007 since fewer fireworks were imported.

#### 4.6.1.3 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. Uncertainties for NFR2G4 are displayed in Table 4-40.

**Table 4-40. Uncertainties for other product use, NFR2G4**

Source category	Substance	Base year uncertainty(±%)		Year 2015 uncertainty (±%)	
		Activity data	Emission factor	Activity data	Emission factor
2G4	As	±15	±900	±15	±900
	Cd, Cr	±15	±850	±15	±850
	Cu	±15	±350	±15	±350
	Hg	±15	±800	±15	±800
	Ni	±15	±400	±15	±400
	Zn	±15	±700	±15	±700
	NO <sub>x</sub>	±15	±100	±15	±100
	CO	±15	±80	±15	±80
	TSP, SO <sub>2</sub>	±15	±50	±15	±50

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

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

#### 4.6.1.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been performed in submission 2017

#### 4.6.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are currently planned.

## 4.7 Pulp and paper industry, NFR2H1

#### 4.7.1.1 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 approximately 45 individual pulp and paper facilities were reported before 2002. After 2002 some plants were closed down and for 2015 emissions from 37 individual pulp and paper facilities are included in reported emissions. The Kraft process (sulphate) dominates in Sweden but there are also emissions from four sulphite facilities and 10 facilities that are mainly CTMP (Chemo Thermo Mechanical Pulp) or TMP (Thermo Mechanical Pulp) facilities reported in NFR2H1.

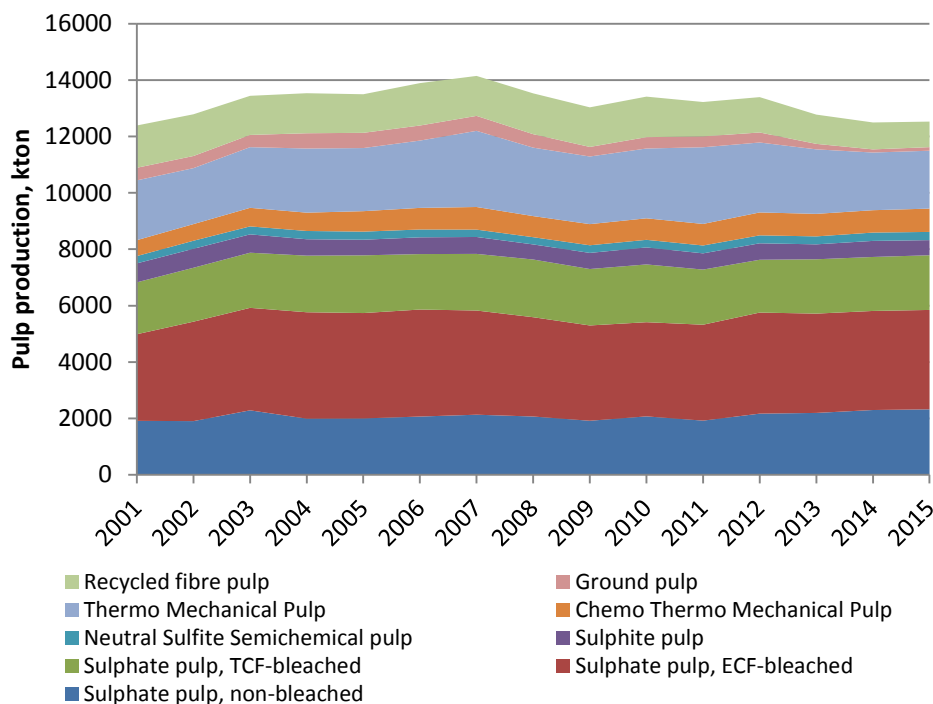
Reported emissions from the pulp and paper industry are for SO<sub>2</sub>, NO<sub>x</sub> and TSP based on information in the companies' environmental reports, while other air pollutants are calculated using nationally derived emission factors.

**Table 4-41. Summary of Key source assessment, NFR2H, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
2H1	<i>TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, NMVOC, SO<sub>2</sub>, As, CO, NH<sub>3</sub>, NO<sub>x</sub>, Pb, Hg, Cd, DIOX, Ni, Cr</i>	<i>TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, NMVOC, SO<sub>2</sub>, As, CO, NH<sub>3</sub>, NO<sub>x</sub>, Pb, Hg, DIOX, Cu, Zn, Ni,</i>

#### 4.7.1.2 METHODOLOGICAL ISSUES

Reported SO<sub>2</sub>, NO<sub>x</sub> and TSP emissions from the pulp and paper industry are primarily based on information on production (Figure 4-2) 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 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.



**Figure 4-2. Production of pulp in Sweden 2001-2015 in kton.**

#### 4.7.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR2H1 are displayed in Table 4-42.

**Table 4-42. Uncertainties for NFR2H1. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
2H1	As	±5	±50	±5	±50
	Cd	±5	±50	±5	±50
	CO	±5	±50	±5	±50
	Cr	±5	±50	±5	±50
	Cu	±5	±50	±5	±50
	DIOX	±5	±1000	±5	±1000
	Hg	±5	±50	±5	±50
	NH <sub>3</sub>	±5	±50	±5	±50
	Ni	±5	±50	±5	±50
	NMVOC	±5	±100	±5	±100
	NO <sub>x</sub>	±5	±10	±5	±10
	PAH_1_4	±5	±1000	±5	±1000
	Pb	±5	±50	±5	±50
	PM <sub>10</sub>	±5	±20	±5	±20
	PM <sub>2.5</sub>	±5	±20	±5	±20
	SO <sub>2</sub>	±5	±20	±5	±20
	TSP	±5	±20	±5	±20
	Zn	±5	±50	±5	±50

Time series from industrial processes for pulp and paper industries reported in NFR codes 2H1 have been reviewed in later years and are consistent.

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

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

#### 4.7.1.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been performed in NFR2H1 in submission 2017.

#### 4.7.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

## 4.8 Food and beverages industry, NFR2H2

#### 4.8.1.1 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.

#### 4.8.1.2 METHODOLOGICAL ISSUES

Estimations of NMVOC emissions are based on activity data from different official statistics. For wine the estimation of NMVOC emissions are based on data on sold amount<sup>150</sup> together with figures on import and export<sup>151</sup>. NMVOC emissions from beer production are based on the Swedish annual total production of beer<sup>152</sup>.

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 available at Statistics Sweden's website<sup>151</sup>. For the NMVOC emission estimations emission factors presented in Table 4- 47, were used.

**Table 4- 43. NMVOC emission factors for the reported production activities in NFR2H2 - Food and drink.**

Production activity	Emission factor	Unit	Reference (footnote)
Wine	0.8	kg/1000 litres	150
Beer	0.35	kg/1000 litres	152
Liquors	0.6	kg/1000 litres	EF based on emission and activity data from one producer, 2001
Bread (sponge dough)	8	kg/Mg	151
Bread (white)	4.5	kg/Mg	151
Bread (wholemeal and light rye)	3	kg/Mg	151
Bread (dark rye)	0	kg/Mg	151
Cakes	0.1	kg/Mg	151
Biscuits	0.1	kg/Mg	151
Breakfast cereals	0.1	kg/Mg	151
Sugar	10	kg/Mg	151
Yeast	18	kg/Mg	151
Margarine and solid cooking fats	10	kg/Mg	151
Coffee roasting	0.55	kg/Mg	151
Animal feed	0.1	kg/Mg	151

#### 4.8.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR2H2 are displayed in Table 4-48.

**Table 4-44. Uncertainties for NFR2H2. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
2H2	NMVOC	±20	±200	±20	±200

<sup>150</sup> Systembolaget. Försäljningsstatistik. <http://www.systembolaget.se>

<sup>151</sup> Statistics Sweden. <http://www.scb.se>. Data from the Industrial production database.

<sup>152</sup> Bryggeriföreningen. <http://sverigesbryggerier.se>

Time series from industrial processes for food and beverages industries reported in NFR codes 2H2 have been reviewed in later years and are consistent.

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

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

#### 4.8.1.5 SOURCE-SPECIFIC RECALCULATIONS

Activity data, thus affecting reported NMVOC emissions, have been updated for:

- Bread (sponge dough): Produced amount 2014
- Bread (white): Produced amount 2014
- Bread (dark rye): Produced amount 2014
- Cakes: Produced amounts 2014
- Biscuits: Produced amounts 2014
- Breakfast cereals: Produced amounts 2014
- Sugar: Produced amounts 2014
- Margarine and solid cooking fats: Produced amounts 2014
- Animal feed: Produced amounts for 2012, 2013, 2014
- Coffee roasting: Produced amounts 2014
- Yeast: Produced amounts 2014
- Wine spirits, beer and cider: 2014

The recalculations resulted in decreased NMVOC emissions of about 0.038 kt 2014.

#### 4.8.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

## 4.9 Wood processing, NFR2I

#### 4.9.1.1 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 fibre 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 in 2015, producing around 350 kt.

**Table 4-45. Summary of key source assessment, NFR2I, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
21	TSP	TSP

#### 4.9.1.2 METHODOLOGICAL ISSUES

Activity data is retrieved from Trä- och Möbelföretagen<sup>153</sup>, 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.

TSP emissions are calculated using activity data and the emission factor from EMEP/EEA air pollutant emission inventory guidebook 2013.

#### 4.9.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The time series reported in the NFR code 2I has been reviewed and is consistent. Uncertainties for NFR2B2 are displayed in Table 4-50.

**Table 4-46. Uncertainties for wood processing NFR2I.**

Source category	Substance	Base year uncertainty(±%)		Year 2015 uncertainty (±%)	
		Activity data	Emission factor	Activity data	Emission factor
2I	TSP	±20	±20	±15	±20

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

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

#### 4.9.1.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been performed in submission 2017.

#### 4.9.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are currently planned.

<sup>153</sup> [http://www.tmf.se/english\\_1/about\\_tmf\\_1](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 2013, however resulting emissions were judged to be unreasonably high for Swedish conditions<sup>154</sup>.

## 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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<sup>154</sup> 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 this sector emissions of ammonia, NMVOC, NO<sub>x</sub> and particulate matter (TSP, PM<sub>10</sub> and PM<sub>2.5</sub>) 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 in agriculture land and decreasing livestock populations. Over the past 50 years the agriculture in Sweden 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 agricultural land area has continued since Sweden joined the European Union in 1995 and 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.

### 5.2 Manure management, NFR3B

#### 5.2.1.1 SOURCE CATEGORY DESCRIPTION

Manure management and housing of livestock give rise to emissions of ammonia, NMVOC, NO<sub>x</sub> and particulate matters. Emissions of ammonia mainly derive from manure management. That is 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 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. Simultaneously emissions of nitrous oxide (N<sub>2</sub>O) occur, but are instead accounted for in the reporting to UNFCCC, being a greenhouse gas. 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.

**Table 5-1. Summary of key source assessment, NFR3B, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
3B1 Dairy cattle	NH <sub>3</sub> , NMVOC, PM <sub>2.5</sub> , TSP, PM <sub>10</sub>	NH <sub>3</sub> , NMVOC, PM <sub>2.5</sub>
3B1 Non-dairy cattle	NH <sub>3</sub> , NMVOC, TSP, PM <sub>2.5</sub> , PM <sub>10</sub>	NH <sub>3</sub> , NMVOC, TSP, PM <sub>2.5</sub>
3B3 Swine	NH <sub>3</sub> , TSP, PM <sub>10</sub> , PM <sub>2.5</sub>	NH <sub>3</sub> , TSP
3B4 Fur-bearing a.		NH <sub>3</sub>
3B4 Horses	NMVOC, NH <sub>3</sub>	NMVOC, NH <sub>3</sub>
3B4 Poultry	PM <sub>10</sub> , TSP, PM <sub>2.5</sub> , NMVOC, NH <sub>3</sub>	PM <sub>10</sub> , TSP, PM <sub>2.5</sub> , NMVOC, NH <sub>3</sub>
3B4 Sheep		NH <sub>3</sub>

#### 5.2.1.2 METHODOLOGICAL ISSUES

##### 5.2.1.2.1 *Activity data*

One of the main sources of activity data to calculate the emission from the agricultural sector is the survey “Use of fertilisers and animal manure in agriculture”<sup>155</sup>. The survey is performed by Statistics Sweden and was carried out every second year until 2013, but after that it is schemed for every third year instead. The latest was for 2012/2013<sup>156</sup>. The field investigation collects data from about 3 500 agricultural holdings. Detailed information about the design and implementation of the field investigation can be found in the report MI 30 SM 1402. From this survey data on, distribution of different manure management systems (solid manure, liquid manure and deep litter), design of manure containers (e.g. with or without a roof), time and method of manure application, timespan before mulching manure and data on stable periods is obtained. Since dairy cows often are stabled at night and also spend time in the stables during milking, the data on stable periods is combined with the assumption that 38% of the dairy cows manure is produced in the stable during the grazing period.

Another important source of activity data is the farm register that the Swedish Board of Agriculture is responsible for. From this register data on livestock population is obtained for most animal categories (table 5-2 and 5-3). Although, some other sources are used for slaughter chicken, horses and furred animals. Concerning horses the Farm Register underestimates the number of horses because only horses on farms are included (i.e. not horses for leisure activities). Two separate surveys<sup>157</sup> estimated total number of horses in Sweden in 2004 and 2010. These estimates are used in the calculations 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 yearly 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.

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Figures about milk yield for dairy cows, which affects the amount of nitrogen and manure excreted, are obtained from the Swedish Dairy Association. For the calculation of particle emissions from laying hens, information on the proportion of hens

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<sup>155</sup> Statistics Sweden, report series MI 30 SM. <http://www.scb.se/mi1001>

<sup>156</sup> The survey planned for 2014/2015 was postponed a year due to limited funds.

<sup>157</sup> Swedish Board of Agriculture, 2011

held in cages and in percherries is needed since different emission factors are used for these two production systems. This information is obtained from The Swedish Board of Agriculture<sup>158</sup>.

**Table 5-2. Population size for cattle and swine (1000s heads).**

Year	Dairy cows	Suckler cows	Heifers	Bulls and steers	Calves	Sows (*)	Pig for meat production	Piglets	Boars
1990	576	75	337	206	524	221	1 276	758	8.6
1995	482	157	370	226	542	237	1 300	768	7.6
2000	428	167	365	224	500	202	1 146	566	4.2
2005	393	177	327	200	508	185	1 085	538	2.7
2010	348	197	322	191	479	154	937	427	2.3
2013	344	189	315	181	467	148	847	402	2.1
2014	344	186	312	179	472	143	857	376	1.7
2015	338	184	309	178	466	140	830	384	1.5

(\*) Between 1995 and 1996 there was an increase in number of sows by 13 %. The reason for this sudden increase is that as from this year also uncovered gilts are included in this group.

**Table 5-3. Population size for the other animal groups (1000s heads).**

Year	Sheep	Lamb	Horses (*)	Goats (***)	Kids (***)	Rein-deer	Fur-bearing animals	Laying hens	Turkeys	Chick-ens	Slaughter Chick-ens (**)
1990	162	244	316	2.9	1.4	271	297	6 400	122	2 200	4 476
1995	195	266	316	3.5	1.8	253	254	6 100	122	1 800	7 055
2000	198	234	316	3.5	1.8	221	276	5 700	122	1 700	7 896
2005	222	249	323	3.7	1.8	251	290	5 100	122	1 700	8 453
2010	273	292	363	3.7	1.8	250	180	6 061	130	1 647	9 159
2013	286	291	363	3.7	1.8	248	210	6 874	80	1 708	9 581
2014	287	301	363	3.7	1.8	254	210	6 549	80	1 713	10 319
2015	289	306	363	3.7	1.8	250	210	7 571	80	1 842	11 044

Data are from the farm register, except: (\*) estimated number of horses 2004 and 2010, by Statistics Sweden and the Swedish Board of Agriculture. (\*\*) Slaughter statistics, Swedish board of agriculture. (\*\*\*) Data on goats were available until 1992, this data have been extrapolated.

<sup>158</sup> Sveriges genomförande av förbudet mot icke inredda burar för värphöns. Report 2007:6 (in Swedish).

**Table 5-4. Livestock stable periods (months).**

Year	Dairy cows	Suckler cows	Heifers	Bulls and steers	Calves	Sheep, horses, goats	Rein-deer	Poultry, Swine and Fur-bearing animals
1990	7.2	6.2	6.5	7.6	7.8	6	0	12
1995	7.2	6.2	6.5	7.6	7.8	6	0	12
2000	7.2	5.8	6.1	7.6	7.6	6	0	12
2005	6.9	4.9	5.6	8.4	7.6	6	0	12
2010	7.2	5.5	5.8	8.8	8.2	6	0	12
2013	7.3	5.8	6.0	9.8	8.2	6	0	12
2014	7.3	5.8	6.0	9.8	8.2	6	0	12
2015	7.3	5.8	6.0	9.8	8.2	6	0	12

(\*) Data from Statistics Sweden's survey "Use of fertilisers and animal manure in agriculture".

**Table 5-5. Liquid waste management systems (fractions)**

Year	Dairy cattle (*)	Suckler cows (*)	Heifers (*)	Bulls and steers (*)	Calves (*)	Pigs for meat production (*)	Other swine (*)	Sheep, goats, horses, reindeer and Fur-bearing animals	Laying Hens, Chickens	Slaughter Chickens, Turkeys
1990	0.23	0.16	0.16	0.19	0.20	0.44	0.44	0	0.25	0.00
1995	0.31	0.21	0.22	0.26	0.26	0.63	0.63	0	0.25	0.00
2000	0.39	0.13	0.13	0.16	0.16	0.81	0.26	0	0.25	0.00
2005	0.51	0.06	0.20	0.23	0.19	0.93	0.32	0	0.21	0.00
2010	0.58	0.11	0.23	0.29	0.17	0.94	0.62	0	0.12	0.00
2013	0.64	0.11	0.26	0.33	0.17	0.95	0.58	0	0.09	0.00
2014	0.64	0.11	0.26	0.33	0.17	0.95	0.58	0	0.09	0.00
2015	0.64	0.11	0.26	0.33	0.17	0.95	0.58	0	0.09	0.00

(\*) Data from Statistics Sweden's survey "Use of fertilisers and animal manure in agriculture".

**Table 5-6. Solid waste management systems (fractions)**

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	0.52	0.29	0.30	0.35	0.36	0.54	0.45	0.5	0	1	0.48	0.55	0.00
1995	0.44	0.23	0.25	0.29	0.29	0.35	0.26	0.5	0	1	0.48	0.55	0.00
2000	0.35	0.28	0.29	0.37	0.37	0.18	0.67	0.5	0	1	0.48	0.55	0.00
2005	0.22	0.19	0.17	0.27	0.23	0.06	0.46	0.5	0	1	0.48	0.73	0.00
2010	0.16	0.20	0.15	0.26	0.22	0.05	0.30	0.5	0	1	0.48	0.88	0.00
2013	0.11	0.20	0.12	0.25	0.16	0.03	0.36	0.5	0	1	0.48	0.78	0.00
2014	0.11	0.20	0.12	0.25	0.16	0.03	0.36	0.5	0	1	0.48	0.78	0.00
2015	0.11	0.20	0.12	0.25	0.16	0.03	0.36	0.5	0	1	0.48	0.78	0.00

(\*) Data from Statistics Sweden's survey "Use of fertilisers and animal manure in agriculture".

**Table 5-7. Deep litter waste management systems (fractions).**

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	0.01	0.07	0.08	0.09	0.09	0.02	0.11	0	0.02	0.20	1.00
1995	0.01	0.07	0.08	0.09	0.09	0.02	0.11	0	0.02	0.20	1.00
2000	0.01	0.08	0.08	0.10	0.10	0.01	0.07	0	0.02	0.20	1.00
2005	0.00	0.16	0.10	0.20	0.22	0.01	0.22	0	0.02	0.07	1.00
2010	0.01	0.15	0.11	0.19	0.30	0.01	0.07	0	0.02	0.00	1.00
2013	0.01	0.17	0.12	0.23	0.35	0.02	0.06	0	0.02	0.13	1.00
2014	0.01	0.17	0.12	0.23	0.35	0.02	0.06	0	0.02	0.13	1.00
2015	0.01	0.17	0.12	0.23	0.35	0.02	0.06	0	0.02	0.13	1.00

(\*) Data from Statistics Sweden's survey "Use of fertilisers and animal manure in agriculture".

#### 5.2.1.2.2 Emissions of ammonia (Tier 2) and emissions of nitric oxide

To estimate the emission of ammonia until 2004 and the emission of NO<sub>x</sub> for the complete time series, Sweden use a slightly modified version of the default Tier 2 model described in the EMEP/EEA guidebook 2013. The ammonia emissions from 2005 and onwards are instead estimated with a country specific model (described in detail below together with an explanations way we use this approach). The main modification of the Tier 2 model is that we use total N instead of TAN to estimate the emissions from stable ventilation and manure storage because the country specific emissions factors we use are developed in that way. The emission factors we use are the same as in the country specific model but here aggregated to fit the calculation level used in the default model (e.g. for different animal categories instead as different spreading 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<sup>159</sup>.

The default Tier 2 methodology for both ammonia and NO<sub>x</sub> follows the same stepwise procedure in the guidebook. We have followed this methodology for all the livestock categories in table 5-2 and 5-3. To ensure consistency with the greenhouse gas inventory the same parameters have been used in both inventories for nitrogen excretion rates and distribution of different manure management systems for all livestock categories.

<sup>159</sup> JTI 2002

### Step 1

By using the annual nitrogen excretion rates (table 5-10) combined with the distribution of different manure management systems (table 5-5 to 5-7) 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.  $m_{\text{build\_Solid\_N}}$ ,  $m_{\text{build\_Liquid\_N}}$ ,  $m_{\text{build\_Deep\_N}}$ ,  $m_{\text{graz\_N}}$ .

### Step 2

Here we calculate the  $\text{NH}_3\text{-N}$  losses from the livestock buildings by multiplying the amount of excreted nitrogen with the emission factor for solid manure, liquid manure and deep litter, respectively (table 5-8).

$$\begin{aligned} E_{\text{build\_Solid\_NH}_3\text{N}} &= m_{\text{build\_Solid\_N}} \times EF_{\text{build\_Solid}} \\ E_{\text{build\_Liquid\_NH}_3\text{N}} &= m_{\text{build\_Liquid\_N}} \times EF_{\text{build\_Liquid}} \\ E_{\text{build\_Deep\_NH}_3\text{N}} &= m_{\text{build\_Deep\_N}} \times EF_{\text{build\_Deep}} \end{aligned}$$

### Step 3

In this step we estimate the amount of total-N in the manure that remains after the ventilation losses. This is the amount that is stored in the different manure management systems.

$$\begin{aligned} m_{\text{storage\_Solid\_N}} &= m_{\text{build\_Solid\_N}} - E_{\text{build\_Solid\_NH}_3\text{N}} \\ m_{\text{storage\_Liquid\_N}} &= m_{\text{build\_Liquid\_N}} - E_{\text{build\_Liquid\_NH}_3\text{N}} \\ m_{\text{storage\_Deep\_N}} &= m_{\text{build\_Deep\_N}} - E_{\text{build\_Deep\_NH}_3\text{N}} \end{aligned}$$

### Step 4

Here we estimate the nitrogen losses that occur from emissions of  $\text{NH}_3$  as well as  $\text{NO}_x$  during storage. In Sweden no manure is spread directly without being stored before applied so this simplifies the calculations compared to the guidelines. The emission factors used can be seen in table 5-9. To estimate the emissions of  $\text{NO}_x$  we have used the default emission factors from the guidebook together with the country specific values of the proportion of total N that is ammoniacal nitrogen (table 5-10).

$$\begin{aligned} E_{\text{storage\_Solid\_NH}_3\text{N}} &= m_{\text{storage\_Solid\_N}} \times EF_{\text{Solid\_Storage}} \\ E_{\text{storage\_Liquid\_NH}_3\text{N}} &= m_{\text{storage\_Liquid\_N}} \times EF_{\text{Liquid\_Storage}} \\ E_{\text{storage\_Deep\_NH}_3\text{N}} &= m_{\text{storage\_Deep\_N}} \times EF_{\text{Deep\_Storage}} \end{aligned}$$

$$\begin{aligned} E_{\text{storage\_Solid\_NO}_x} &= (m_{\text{storage\_Solid\_N}} \times \text{TAN}_{\text{Solid}} + m_{\text{storage\_Deep\_N}} \times \text{TAN}_{\text{Deep}}) \times 0.01 \\ E_{\text{storage\_Liquid\_NO}_x} &= m_{\text{storage\_Liquid\_N}} \times \text{TAN}_{\text{Liquid}} \times 0.0001 \end{aligned}$$

### Step 5

In this step we calculate the amount of N that is available for application to agricultural soil. That is, subtracting the amount of nitrogen lost during storage.

$$\begin{aligned} m_{\text{applic\_Solid\_N}} &= m_{\text{storage\_Solid\_N}} - E_{\text{storage\_Solid\_NH}_3\text{N}} \\ m_{\text{applic\_Liquid\_N}} &= m_{\text{storage\_Liquid\_N}} - E_{\text{storage\_Liquid\_NH}_3\text{N}} \\ m_{\text{applic\_Deep\_N}} &= m_{\text{storage\_Deep\_N}} - E_{\text{storage\_Deep\_NH}_3\text{N}} \end{aligned}$$

### Step 6

Here we estimate the emissions of ammonia from application of manure. 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 5-10).

$$\begin{aligned} E_{\text{applic\_Solid\_NH}_3\text{N}} &= m_{\text{applic\_Solid\_N}} \times \text{TAN}_{\text{Solid}} \times \text{EF}_{\text{Solid\_Appl}} \\ E_{\text{applic\_Liquid\_NH}_3\text{N}} &= m_{\text{applic\_Liquid\_N}} \times \text{TAN}_{\text{Liquid}} \times \text{EF}_{\text{Liquid\_Appl}} \\ E_{\text{applic\_Deep\_NH}_3\text{N}} &= m_{\text{applic\_Deep\_N}} \times \text{TAN}_{\text{Deep}} \times \text{EF}_{\text{Deep\_Appl}} \end{aligned}$$

### Step 7

The emissions of NO<sub>x</sub> are estimated based on total amount of TAN applied to agricultural soils. The emission factor used is the default one from the guidebook.

$$m_{\text{applic\_Tot\_TAN}} = ((m_{\text{applic\_Solid\_N}} \times \text{TAN}_{\text{Solid}}) + (m_{\text{applic\_Slurry\_N}} \times \text{TAN}_{\text{Slurry}}) + (m_{\text{applic\_Deep\_N}} \times \text{TAN}_{\text{Deep}})) \times 0.026$$

### Step 8

Here we calculate the emissions of ammonia from grazing (although reported under NFR3D). Emission factors in table 5-13.

$$E_{\text{graz\_NH}_3\text{N}} = m_{\text{graz\_N}} \times \text{EF}_{\text{grazing}}$$

### 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. The reason we use 46/14 for NO<sub>x</sub> instead of the value stated in the guidebook (30/14) is that the value for nitric oxide should be reported as NO<sub>2</sub> (i.e. not NO) in the NFR-tables.

*Reported per animal (m) in 3B, manure management*

$$\begin{aligned} EM_{3.B.m\_NH_3} &= (E_{\text{build\_Solid\_NH}_3\text{N}} + E_{\text{build\_Liquid\_NH}_3\text{N}} + E_{\text{build\_Deep\_NH}_3\text{N}} + \\ &\quad E_{\text{storage\_Solid\_NH}_3\text{N}} + E_{\text{storage\_Liquid\_NH}_3\text{N}} + E_{\text{storage\_Deep\_NH}_3\text{N}}) \times 17/14 \\ EM_{3.B.m\_NO_2} &= (E_{\text{storage\_Solid\_NO}_N} + E_{\text{storage\_Liquid\_NO}_N}) \times 46/14 \end{aligned}$$

*Reported as a sum for all animals in 3Da2a, animal manure applied to soils*

$$EM_{3.D.a.2.a\_NH_3} = (E_{\text{applic\_Solid\_NH}_3\text{N}} + E_{\text{applic\_Liquid\_NH}_3\text{N}} + E_{\text{applic\_Deep\_NH}_3\text{N}}) \times 17/14$$

*Reported as a sum for all animals in 3Da3, urine and dung deposited by grazing animals*



$$EM_{3,D,a,3\_NH_3} = E_{\text{graz\_}NH_{3N}} \times 17/14$$

#### 5.2.1.2.3 Emissions of ammonia (country specific model)

Sweden has also developed a country specific methodology to estimate emissions of ammonia from agriculture. The methodology<sup>160,161</sup> is developed in collaboration between the Swedish EPA, Statistics Sweden, the Swedish Board of Agriculture 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 also designed to provide the model with correct and accurate activity data. This model is only possible to use from 2005 and forward. The reason is that prior to 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, to use the default Tier 2 model for the complete time series, would result in a less accurate monitoring of these commitments.

The Swedish method estimates the emissions separately from all four stages of the manure handling; stable ventilation, storage, manure application and grazing. The emission factors that describe the share of ammonia lost during the different stages of the manure handling are developed by the Swedish University of Agricultural Sciences and the Swedish Institute of Agricultural and Environmental Engineering (JTI)<sup>162</sup>. The main difference between the country specific model and the Tier 2 model is that the former takes more variables into account when estimating the emissions from storage and application of manure. For example, if the manure is stored with or without a roof, and also type of roof, or application method as well as timespan between spreading and mulching.

The calculations are carried out as:

$$NH_3N_{\text{Ventilation}} = D \times N \times P \times EF_1$$

$$NH_3N_{\text{Storage}} = D \times N \times P \times (1 - EF_1) \times EF_2$$

$$NH_3N_{\text{Application}} = D \times N \times P \times (1 - EF_1) \times (1 - EF_2) \times EF_3$$

$$NH_3N_{\text{Grazing}} = D \times N \times (1 - P) \times EF_4$$

Where, D = number of animal, N = yearly production of nitrogen per type of animal, P = stable period,  $EF_1$  = nitrogen losses through ventilation (fraction of total nitrogen content),  $EF_2$  = nitrogen losses during storage (fraction of total nitrogen content),  $EF_3$  = nitrogen losses during application of animal manure (fraction of

<sup>160</sup> Swedish Environmental Protection Agency 1997

<sup>161</sup> JTI 2002

<sup>162</sup> Swedish Institute of Agricultural and Environmental Engineering (JTI) 2002

ammonium nitrogen content) and  $EF_4$  = nitrogen losses during grazing (fraction of total nitrogen content). In table 5-8 and 5-11 to 5-13 the emission factors used in the calculations are presented.

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 calculated in this model but instead reported under 3D, crop production and agricultural soils. Concerning grazing, the length of the grazing periods for cattle are from the field investigation among farmers, while for horses, sheep and goats the grazing period is fixed to 6 months and to 12 months for reindeers.

**Table 5-8. Emission factors (EF1) used to calculate emissions of ammonia from stable ventilation (% of total N) in both the Tier 2 and the country specific model.**

Animal category	EF solid manure	EF liquid manure	EF deep litter
Cattle	4%	4%	20%
Swine	10%	14%	25%
Sheep	4%	-	15%
Goats	4%	-	15%
Horses	4%	-	15%
Laying hens	10%	10%	35%
Chickens	10%	10%	20%
Slaughter Chickens	-	-	10%
Turkeys	10%	10%	35%
Fur-bearing animals	10%	-	-

**Table 5-9. 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
Dairy Cows	18%	3%	30%
Suckler cows	17%	3%	30%
Heifers	18%	3%	30%
Bulls and steers	17%	3%	30%
Calves	18%	3%	30%
Sows	18%	4%	30%
Boars	18%	4%	30%
Pigs for meat production	18%	4%	30%
Piglets	18%	4%	30%
Sheep	25%	-	-
Goats	25%	-	-
Horses	25%	-	33%
Laying hens	12%	4%	20%
Turkeys	20%	-	20%
Chickens	12%	4%	20%
Slaughter Chickens	5%	-	5%
Fur-bearing animals	30%	-	-
Reindeer*	-	-	-

**Table 5-10. 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	TAN in solid manure	TAN in deep litter	EF for applica- tion of liquid manure	EF for applica- tion of solid manure	EF for applica- tion of deep litter
Dairy Cows* (Milk production 6,000 kg/yr)	97						
Dairy Cows* (Milk production 8,000 kg/yr)	117	60%	51%	10%	33%	38%	41%
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	18.5	70%	51%	10%	30%	35%	48%
Boars	13	70%	51%	10%	29%	34%	46%
Pigs for meat production	9.5	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*	10						

\*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 were used.

**Table 5-11. Emission factors (EF<sub>2</sub>) used to calculate emissions of ammonia from storage (% of total N) in the country specific model.**

Type of manure, handling	Cattle	Swine	Sheep/g oats/hor- ses	Laying hens/ chicken	Slaugh- ter chicken	Tur- keys	Fur- bearing ani- mals
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%	

**Table 5-12. Emission factors (EF<sub>3</sub>) used to calculate emissions of ammonia from spreading (% of TAN) in the country specific model.**

Tillage timing	Spreading strategy	Season	EF solid manure or deep litter	EF urine	EF liquid manure or slurry
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%

**Table 5-13. Emission factors (EF<sub>4</sub>) 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%

#### 5.2.1.2.4 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. 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 methods differ slightly between cattle and other animals. For cattle the methodology is based on feed intake, but on excreted volatile substance for the other animals. That is, the factor MJ<sub>i</sub> is replaced with kg VS<sub>i</sub> (kg volatile solids excreted).

The emissions from cattle for the different subcategories are calculated as:

Feeding of silage:

$$E_{\text{NMVOC,silage\_feeding}_i} = \text{AAP}_i \times \text{MJ}_i \times x_{\text{house}_i} \times \text{EF}_{\text{NMVOC,silage\_feeding}_i} \times \text{Frac}_{\text{silage}_i}$$

Silage stores:

$$E_{\text{NMVOC,silage\_store}_i} = E_{\text{NMVOC,silage\_feeding}_i} \times \text{Frac}_{\text{silage\_store}}$$

Housing (feeding beside silage):

$$E_{\text{NMVOC,house}_i} = \text{AAP}_i \times \text{MJ}_i \times x_{\text{house}_i} \times \text{EF}_{\text{NMVOC,house}_i}$$

Outdoor manure stores:

$$E_{\text{NMVOC,manure\_store}_i} = E_{\text{NMVOC,house}_i} \times (\text{ENH}_{3,\text{storage}_i} / \text{ENH}_{3,\text{house}_i})$$

And the total emission of NMVOC reported in 3B, manure management is:

$$\sum_i \left[ E_{\text{NMVOC,silage\_feeding}_i} + E_{\text{NMVOC,silage\_store}_i} + E_{\text{NMVOC,house}_i} + E_{\text{NMOC,manure\_store}_i} \right]$$

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.  $X_{house_i}$  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.  $Frac_{silage\_store}$  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 2013.  $ENH_{3,storage_i}$ ,  $ENH_{3,house_i}$  and  $ENH_{3,appl_i}$  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 2013 are used. See table 5-14 for a list of the factors used in the calculations of NMVOC from manure management.

**Table 5-14. Parameters and emission factors used for estimating emissions of NMVOC from manure management.**

Source	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	0.59	0.0002002	0.0000353
Bulls and steers	0.63	0.0002002	0.0000353
Heifers	0.81	0.0002002	0.0000353
Calves	-	0.0002002	0.0000353
Sows and boars	-	-	0.007042
Source	Fraction silage feeding	Silage feeding (kg NMVOC/kg VS excreted)	Housing (kg NMVOC/kg VS excreted)
Pigs for meat production and piglets	-	-	0.001703
Sheep	0.68	0.01076	0.001614
Horses	1	0.01076	0.001614
Goats	0.67	0.01076	0.001614
Laying hens and chickens	-	-	0.005684
Slaughter chickens	-	-	0.009147
Turkeys	-	-	0.005684
Reindeers	-	-	0.001614
Fur-bearing animals	-	-	0.005684

#### 5.2.1.2.5 *Particulate matter*

In those cases a Tier 2 methodology is described in the Guidebook it is used to estimate the emissions from animals as well as from crops. The only cases where Tier 1 methodologies are used are for the animal categories where no Tier 2 methodology exists. That is, emissions from sheep, horses, goats, chickens, turkeys and fur-bearing animals. The emission factors used are the default ones from the EMEP/EEA guidebook 2013 (see table 5-15 to 5-17).

**Table 5-15. Tier 2 emission factors used to estimate the emissions from cattle and swine (kg/AAP/year).**

Sub- stance	Manure	Dairy cows	Beef cows	Steers and bulls	Heifers	Calves	Pigs for meat production	Piglets	Sows and boars
TSP	Slurry	1.81	0.69	0.69	0.69	0.34	0.70	0.36	1.36
	Solid	0.94	0.52	0.52	0.52	0.35	0.83	0.00	1.77
PM <sub>10</sub>	Slurry	0.83	0.32	0.32	0.32	0.15	0.31	0.16	0.61
	Solid	0.43	0.24	0.24	0.24	0.16	0.37	0.00	0.80
PM <sub>2.5</sub>	Slurry	0.54	0.21	0.21	0.21	0.10	0.06	0.03	0.11
	Solid	0.28	0.16	0.16	0.16	0.10	0.07	0.00	0.14

**Table 5-16. Tier 2 emission factors used to estimate emissions from laying hens (kg/AAP/year).**

Substance	Housing	Laying hens
TSP	Cages	0.025
	Percheries	0.119
PM <sub>10</sub>	Cages	0.025
	Percheries	0.119
PM <sub>2.5</sub>	Cages	0.003
	Percheries	0.023

**Table 5-17. Tier 1 emission factors used to estimate emissions from other animals (kg/AAP/year).**

Substance	Sheep	Horses	Goats	Chickens	Turkeys	Fur-bearing animals
TSP	0.139	0.48	0.139	0.069	0.52	0.018
PM <sub>10</sub>	0.056	0.22	0.056	0.069	0.52	0.0081
PM <sub>2.5</sub>	0.017	0.14	0.017	0.009	0.07	0.0042

#### 5.2.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As described above it was not possible to apply the Swedish country specific ammonia model for the years prior to 2005. To minimize the time series break between the default Tier 2 model (1990-2004) and the country specific model (2005 and onwards) we have used country specific emission factors in the Tier 2 model. These emission factors are developed according to the country specific model by weighing various detailed variables to the aggregates that are used by the Tier 2 model. For example the Swedish model use much more disaggregated emissions



factors for application of animal manure (i.e. table 5-11). From these we have calculated weighted country specific factors that fit the default Tier 2 model (i.e. table 5-9).

Between 1995 and 1996 there is an increase in the number of sows by 13%. The reason for this sudden increase is that as from this year also uncovered gilts are included in this 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 information from farmers given in Statistics Sweden's field investigation and these results are afflicted with standard errors. Hence all results must be considered with caution regarding the uncertainty in the input data. The emission factors are of course also encumbered with significant uncertainties. The emission factor uncertainties are likely more substantial than the activity data uncertainties. We estimate the uncertainty interval for the activity data for a specific emission category in 3B is some 20%. The uncertainty intervals for the different emission factor are estimated to: NH<sub>3</sub> 50%, NMVOC 200%, NO<sub>x</sub> 80%. PM 150%-200%.

#### 5.2.1.4 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 are in agreement. We conduct regular meetings with the different authorities that provide activity data to the inventory to ensure that the quality of the data are of satisfactory quality and that they in turn use appropriate QC methods.

#### 5.2.1.5 SOURCE-SPECIFIC RECALCULATIONS

During the first half of 2016 we carried out a project to improve the calculation model for the reporting of ammonia. For example we are now able to report a consistent time series since 1990. In previous inventories we had a time series break between 1994 and 1995. This project also had some minor impacts on the emissions of other substances besides ammonia, especially though the production of more detailed activity data from the surveys "Use of fertilisers and animal manure in agriculture from 2005 to 2013 (i.e. the most recent one)". For example we now use updated data on distribution of different manure management systems. Now we have distinct data for all the different non-dairy categories used in the inventory. I.e. suckler cows, heifers, bulls and steers and calves. Earlier we only had data for the two categories, dairy cattle and non-dairy cattle.

In another project the nitrogen excretion rates for all animal categories have been reviewed. This has been done in collaboration with the agriculture statistics unit at Statistics Sweden. The reason was to ensure consistency in excretion rates with the

Swedish nutrient balances reported to Eurostat. The animal categories affected in this inventory were piglets, sheep, horses, laying hens and chickens.

#### 5.2.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

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

## 5.3 Crop production and agricultural soils, NFR3D

### 5.3.1.1 SOURCE CATEGORY DESCRIPTION

From the subsector, crop production and agricultural soils, Sweden report emissions of ammonia, NMVOC, NO<sub>x</sub> 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 operation of tractors and other machinery and are thought to consist of a mixture of organic fragments from the crop and soil mineral and organic matter.

**Table 5-18. Summary of key source assessment, NFR3D, according to approach 1.**

NFR	Key Source Assessment 2015 Level	Trend
3Da1 Inorganic N fertilizers	NO <sub>x</sub> NH <sub>3</sub>	NO <sub>x</sub> NH <sub>3</sub>
3Da2a Animal manure applied to soils	NO <sub>x</sub> NMVOC NH <sub>3</sub>	NO <sub>x</sub> NMVOC NH <sub>3</sub>
3Da2b Sewage sludge applied to soils		NH <sub>3</sub>
3Da2c Other organic fertilizers applied to soils	NH <sub>3</sub>	NH <sub>3</sub>
3Da3 Urine and dung deposited by grazing animals	NO <sub>x</sub> NH <sub>3</sub>	NO <sub>x</sub> NH <sub>3</sub>
3Dc Farm-level agricultural operations	PM <sub>10</sub> PM <sub>2.5</sub>	PM <sub>10</sub> PM <sub>2.5</sub>
3De Cultivated crops	NMVOC	NMVOC

### 5.3.1.2 METHODOLOGICAL ISSUES

#### 5.3.1.2.1 *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 is used in both inventories. The data on total nitrogen content in different types of mineral fertilisers is from the Swedish Board of Agriculture's sales statistics in Sweden (table 5-19). Application of sludge and nitrogen content in sludge is 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". Nitrogen content in animal manure is estimated as the amount remaining after ventilation and storage losses calculated above in category 3B.

The formula used to calculate N content in animal manure applied to soils ( $F_{AM}$ ) is:

$$F_{AM} = \sum_T N_T \times Nex_T \times (1 - Frac_{LossMS}) \times (1 - Frac_{PRP})$$

Where  $N_T$  is the number of heads of livestock in category  $T$  in the country,  $Nex_T$  is the annual average excretion of N per head of category  $T$  in the country,  $Frac_{LossMS}$  is the amount of N lost before application.  $Frac_{PRP}$  is the fraction of the nitrogen in pasture, range and paddock manure. 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 is produced by the Swedish Board of Agriculture<sup>163</sup>.

#### 5.3.1.2.2 *Emissions of Ammonia*

For a methodological description of the emissions from application of manure and grazing animals, see paragraph 5.2.1.2.2 and 5.2.1.2.3. To estimate the ammonia emissions from mineral fertilisers we have used the default Tier 2 methodology from the EMEP/EEA guidebook 2013, and the emission factors that are found in table 3-2 in the guidebook (low soil pH). 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.

<sup>163</sup> Swedish Board of Agriculture, JO 10-series

### 5.3.1.2.3 Emissions of Non-methane volatile organic compounds (NMVOCs)

The estimated value for the emissions of NMVOC from housing is used as the basis for estimating the emissions from manure application. See above in paragraph 5.2.1.2.4, for a description of how  $E_{\text{NMVOC,house}}$  is calculated.

Emissions from animal manure applied to soils (3Da2a):

$$E_{\text{NMVOC,appl}_i} = E_{\text{NMVOC,house}_i} \times (\text{ENH}_{3,\text{appl}_i} / \text{ENH}_{3,\text{house}_i})$$

For 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 assumed the same volatile solid content as swine.

Emissions from sewage sludge applied to soils (3Da2b):

$$E_{\text{NMVOC,Sludge}} = N_{\text{sludge}} \times \text{Frac}_{\text{vs\_swine}} \times \text{EF}_{\text{NMVOC,graz}}$$

Emissions from urine and dung deposited by grazing animals (3Da3):

$$E_{\text{NMVOC,graz}_i} = \text{AAP}_i \times \text{MJ}_i \text{ (or kg VS}_i) \times (1 - x_{\text{house}_i}) \times \text{EF}_{\text{NMVOC,graz}_i}$$

To estimate the emissions from crop production we have used the Tier 1 method, because no Tier 2 method is currently described in the guidebook.

The emissions are calculated as:

$$E_{\text{NMVOC,crops}} = \text{AR}_{\text{area}} \times \text{EF}_{\text{NMVOC,crop}}$$

where;

$\text{AR}_{\text{area}}$  is the area covered with crops, and the emissions factor is amount of NMVOC per hectare (0.86 kg/ha/year).

**Table 5-19. Parameters and emission factors used to estimate emissions of NMVOC from manure management.**

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	-

Source	Grazing (kg NMVOC/kg VS excreted)
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	-

#### 5.3.1.2.4 Nitrogen oxides

The estimate of NO<sub>x</sub> emissions from crop production 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 5-20). This value is multiplied with the default Tier 1 emission factor of 0.026 kg of NO per kg of fertiliser-N applied. Finally the amount of NO is translated to amount of NO<sub>2</sub> to be reported in the NFR-tables.

**Table 5-20. Amount of nitrogen applied from different sources (t/year).**

Year	N in inorganic fertilisers (t)	N in applied organic fertilisers (t)	N in sewage sludge (t)	N in other organic fertilisers (t)	N deposited by grazing animals
1990	224 500	82 332	1 180	1 700	44 245
1995	198 300	84 655	2 304	1 700	46 663
2000	189 400	80 016	1 758	1 800	46 724
2005	161 500	77 658	1 053	1 900	47 474
2010	168 000	75 927	2 224	2 712	45 243
2013	161 100	76 028	2 080	4 282	43 295
2014	181 090	76 352	2 374	4 282	43 383
2015	190 200	76 411	2 802	4 282	43 117

### 5.3.1.3 PARTICULATE MATTER

Emissions from agricultural crop operations are estimated based on cultivated area for the different crops. Statistics on crop areas and data on agricultural crop operations for the different crops are used in the calculations according to the default Tier 2 model. 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 data from the Swedish survey on nitrogen and phosphorus balances for agricultural land.

**Table 5-21. 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 <sub>10</sub>	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 <sub>2.5</sub>	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

### 5.3.1.4 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

There is a decrease in the amount of sold fertilisers in 2009. This is due to an over-consumption in 2008 due to a dropped tax on fertilisers. Statistics on the use of sewage sludge have 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 for the latest years of adequate quality.

We estimate the uncertainty interval for the activity data for a specific emission category in 3D is 20%-35%. The uncertainty intervals for the different emission factor are estimated to: NH<sub>3</sub> 50%, NMVOC 200%, NO<sub>x</sub> 80%-400%. PM 150%-200%.

### 5.3.1.5 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 are in agreement. 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 au-

thorities that provide activity data to the inventory to ensure that the quality of the data are of satisfactory quality and that they in turn use appropriate QC methods.

#### 5.3.1.6 SOURCE-SPECIFIC RECALCULATIONS

The Swedish board of agriculture have updated the time series for sales of different mineral fertilisers. This affects the ammonia emissions. When some sources of NO<sub>x</sub> as well as NMVOC are estimated based on the ammonia emissions, these two substances have also been affected by the updated ammonia model.

#### 5.3.1.7 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 includes 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<sub>10</sub> and PM<sub>2.5</sub>. Emissions of NH<sub>3</sub>, Hg and CO are reported as not estimated (NE). Other emissions are reported as not applicable (NA).

#### 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 2013/2016 are used for NMVOC, TSP, PM<sub>10</sub> and PM<sub>2.5</sub>. See further in the table below.

**Table 6-1. Emission factors used for NFR 5A Solid waste disposal on land**

Pollutant	Value	Unit	95 % confidence interval		Reference
			Lower	Upper	
NMVOC	1.56	kg/Mg	0.5	3.0	UK inventory (2004)
TSP	0.463	g/Mg	0.006	2.21	US EPA (2006)
PM <sub>10</sub>	0.219	g/Mg	0.003	1.05	US EPA (2006)
PM <sub>2.5</sub>	0.033	g/Mg	0.0004	1.16	US EPA (2006)

##### 6.2.1.2.2 *Activity data*

Activity data on emissions of landfill gas is used for emissions of NMVOC. The data is calculated from emission data on methane from solid waste disposal on land, reported to UNFCCC.

For TSP, PM<sub>10</sub> and PM<sub>2.5</sub>, activity data on landfilled waste at landfills for municipal solid waste is used. The data has been compiled and published by the association Swedish Waste Management (RVF/Avfall Sverige).



**Table 6-2 Activity data used for NFR 5A Solid waste disposal on land**

Year	Emission of landfill gas* (m <sup>3</sup> ) (AD used for NMVOC)	Landfilled waste at landfills for municipal solid waste* (t, wet weight) (AD used for TSP, PM <sub>10</sub> and PM <sub>2.5</sub> )
1990	<b>381 513 038</b>	<b>7 000 000</b>
1991	<b>387 325 314</b>	6 770 000
1992	<b>387 440 535</b>	6 540 000
1993	<b>374 396 920</b>	6 310 000
1994	<b>358 913 227</b>	<b>6 080 000</b>
1995	<b>357 976 710</b>	<b>5 340 000</b>
1996	<b>354 903 980</b>	<b>5 050 000</b>
1997	<b>351 430 403</b>	<b>4 750 000</b>
1998	<b>345 702 109</b>	<b>4 800 000</b>
1999	<b>330 900 990</b>	<b>4 900 000</b>
2000	<b>320 485 283</b>	<b>4 450 000</b>
2001	<b>314 665 020</b>	<b>4 240 000</b>
2002	<b>293 879 439</b>	<b>3 770 000</b>
2003	<b>277 121 981</b>	<b>2 940 000</b>
2004	<b>274 360 927</b>	<b>2 480 000</b>
2005	<b>255 200 701</b>	<b>1 940 000</b>
2006	<b>245 123 805</b>	<b>1 830 000</b>
2007	<b>223 208 499</b>	<b>1 994 000</b>
2008	<b>195 802 272</b>	<b>1 670 000</b>
2009	<b>182 124 095</b>	1 618 500
2010	<b>170 184 609</b>	1 567 000
2011	<b>158 301 192</b>	<b>1 515 500</b>
2012	<b>145 315 292</b>	<b>1 555 300</b>
2013	<b>132 663 618</b>	<b>1 391 900</b>
2014	<b>120 019 124</b>	<b>1 432 200</b>
2015	<b>109 619 895</b>	<b>1 662 200</b>

\*Data in bold are compiled data, other data is extrapolated or interpolated.

#### 6.2.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The used uncertainties are presented below.

**Table 6-3. Uncertainties for other product use, 5A Solid waste disposal on land**

Source category	Substance	Year 2015 uncertainty (±%) Activity data	Emission factor
5A1 Managed waste disposal sites	NMVOC	±55	92
5A Solid waste disposal	TSP	±10	377
5A Solid waste disposal	PM <sub>10</sub>	±10	379
5A Solid waste disposal	PM <sub>2.5</sub>	±10	385

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 made in submission 2017 for all of the reported substances, because of adjustments of activity data. For TSP, PM<sub>10</sub> and PM<sub>2.5</sub>, the emissions has changed by between -1% and + 3% for the years 2009 to 2014. For NMVOC, the emissions has changed by -0.3% for 2013 and by -1.6% for 2014.

#### 6.2.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

## 6.3 Biological treatment of waste, NFR 5B

This category includes Composting (NFR 5B1) and Anaerobic digestion at biogas facilities (NFR 5B2).

Emissions from compost production from waste are calculated.

Because of lack of methods in the EMEP/EEA Guidebook 2013, no emissions from anaerobic digestion at biogas facilities are calculated. Therefore emissions from anaerobic digestion are reported as NA (Not applicable). The provided methods and EFs for NH<sub>3</sub> in the EMEP/EEA Guidebook 2016 has not been implemented in the inventory for submission 2017 yet.

### 6.3.1 Composting, NFR 5B1

#### 6.3.1.1 SOURCE CATEGORY DESCRIPTION

Sweden is reporting of emissions of NH<sub>3</sub> and CO (from windrow composting). Emissions of NO<sub>x</sub>, NMVOC, TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and BC are reported as not estimated (NE). Other emissions are reported as not applicable (NA).

#### 6.3.1.2 METHODOLOGICAL ISSUES

##### 6.3.1.2.1 *Emission and abatement factors used*

Tier 2 default emission factors from the EMEP/EEA Emission Inventory Guidebook 2013/2016 are used for NH<sub>3</sub> from compost production (covered composting). When composting food waste and household waste in Sweden, the composting process is normally covered.

The abatement factor 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 the tables below.

**Table 6-4. Emission factor used for NFR 5B1 Composting (covered composting)**

Pollutant	Value	Unit	95 % confidence interval		Reference
			Lower	Upper	
NH <sub>3</sub>	0.24	kg/Mg organic waste	0.1	0.7	Guidebook (2006)

**Table 6-5. Abatement factor used for NFR 5B1 Composting (covered composting)**

Abatement technology	Pollutant	Efficiency Default value	95 % confidence interval		Reference
			Lower	Upper	
Biofilter	NH <sub>3</sub>	90 %	70 %	97 %	Guidebook (2006)

Tier 2 default emission factors from the EMEP/EEA Emission Inventory Guidebook 2013/2016 are used for NH<sub>3</sub> and CO (from windrow composting of garden and park waste). See further in the table below.

**Table 6-6. 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 <sub>3</sub>	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<sub>3</sub>. The data has been compiled and published by the association Swedish Waste Management (RVF/Avfall Sverige).

**Table 6-7. Activity data used for NFR5B1, Composting**

Year	Composted waste* (t, wet weight) (AD used for NH <sub>3</sub> from covered composting)	Composted waste* (t, wet weight) (AD used for CO and NH <sub>3</sub> from windrow composting of garden and park waste)
1990	50 000	20 000
1991	44 940	60 460
1992	39 880	100 920
1993	34 820	141 380
1994	29 760	181 840
1995	<b>24 700</b>	<b>222 300</b>
1996	43 350	197 650
1997	<b>62 000</b>	<b>173 000</b>
1998	72 333	185 167
1999	82 667	197 333
2000	<b>93 000</b>	<b>197 000</b>
2001	102 492	193 271
2002	<b>111 984</b>	<b>189 546</b>
2003	<b>108 745</b>	<b>273 215</b>
2004	<b>99 950</b>	<b>289 430</b>
2005	<b>234 640</b>	<b>225 190</b>
2006	<b>248 230</b>	<b>204 160</b>
2007	<b>261 450</b>	<b>253 840</b>
2008	<b>278 000</b>	<b>290 700</b>
2009	<b>284 940</b>	<b>345 560</b>
2010	<b>297 180</b>	<b>269 030</b>
2011	<b>257 110</b>	<b>432 990</b>
2012	<b>246 680</b>	<b>312 150</b>
2013	<b>211 260</b>	<b>317 210</b>
2014	<b>197 140</b>	<b>270 780</b>
2015	<b>208 430</b>	<b>209 910</b>

\*Data in bold are compiled, other data is extrapolated or interpolated.

#### 6.3.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The used uncertainties are presented below.

**Table 6-8. Uncertainties for other product use, 5B1 Composting**

Source category	Substance	Activity data (%)		
		Emission factor	Base year	Year 2015
5B1 covered composting	NH <sub>3</sub>	± 75	± 15	± 10
5B1 windrow composting	NH <sub>3</sub>	± 90	± 20	± 15
	CO	± 90	± 20	± 15

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

Recalculations has been made in submission 2017 for CO and NH<sub>3</sub>, because of new (revised) AD on composted waste. For CO, the emissions has changed by -11.3% for the year 2014. For NH<sub>3</sub>, the emissions has changed by -11.1% for the year 2014.

#### 6.3.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

## 6.4 Waste incineration, NFR 5C

### 6.4.1 Emissions from incineration of municipal waste, industrial waste, clinical waste and sewage sludge, NFR 5C1a, 5C1bi, 5C1biii and 5C1biv

Emissions from these sources reported for one plant in Sweden, and included in NFR 5C1bii. Since 2003, also MSW incineration occurs at the plant.

**Table 6-9. Summary of key source assessment, NFR5C1 according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
5C1	DIOX, Hg	DIOX, Hg

### 6.4.2 Emissions from 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 emis-

sions of mercury, dioxin, benzo(a)pyrene and PAH-4 from cremation are reported, and from submission 2016 onwards also NO<sub>x</sub>, SO<sub>2</sub>, 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 burn using air curtain incinerator is also reported in NFR 5C1bv starting from submission 2016. Particulate matter and PAH-4 from domestic open waste burning, such as garden fires, are reported in 5C2. Other possible emissions from garden fires and bonfires are currently not reported due to lack of suitable emission factors.

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<sub>x</sub>, SO<sub>2</sub>, NMVOC, CO, particulate matter, Pb, Cd, Hg, As, Cr, Cu, Ni and dioxin. SO<sub>2</sub>, NO<sub>x</sub>, 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.

The time series for Pb, Cd, As, Cr, Cu and Ni are not consistently reported due to lack of data in the environmental reports for later years. For most of the years with reported notation key NE, the reason is that the amounts of metals emitted in the flue gas are below the detection limit.

In submission 2016, emissions of NH<sub>3</sub>, Se, PAH1-4, B(a)P, B(b)F, B(k)F, I(cd)P, HCB, PCB and Zn from incineration of hazardous waste are reported for the first time. The estimates are based on the amount of incinerated hazardous waste and emission factors from EMEP/EEA Guidebook 2013.

The activity has increased over time. In 1995 the plant combusted about 22 000 t and in 2002 the corresponding value was about 33 000 t. 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. As a consequence of increased capacity, emissions from 2003 are increased compared to earlier years.

#### 6.4.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR 5C1b ii are displayed in Table 6-01.

**Table 6-10. Uncertainties for NFR 5C1b ii. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
5C1bii	As	IE	50	IE	50
5C1bii	Cd	IE	50	IE	50
5C1bii	CO	IE	30	IE	30
5C1bii	Cr	IE	50	IE	50
5C1bii	Cu	IE	50	IE	50
5C1bii	Dioxin	IE	50	IE	50
5C1bii	HCB	10	900	10	900
5C1bii	Hg	IE	50	IE	50
5C1bii	NH <sub>3</sub>	IE	510	IE	510
5C1bii	Ni	IE	50	IE	50
5C1bii	NMVOC	IE	50	IE	50
5C1bii	NO <sub>x</sub>	IE	30	IE	30
5C1bii	PAH	10	200	10	200
5C1bii	Pb	IE	50	IE	50
5C1bii	PCB	10	900	10	900
5C1bii	Se	10	900	10	775
5C1bii	SO <sub>x</sub>	IE	30	IE	30
5C1bii	TSP	IE	50	IE	50
5C1bii	PM <sub>10</sub>	IE	50	IE	50
5C1bii	PM <sub>2.5</sub>	IE	50	IE	50
5C1bii	Zn	10	900	10	900

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

No source-specific recalculations are performed.

#### 6.4.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 6.4.3 Emissions from cremation, NFR 5C1bv

#### 6.4.3.1 SOURCE CATEGORY DESCRIPTION

In NFR 5C1bv emissions of mercury, dioxin, benzo(a)pyrene and PAH-4 from cremation are reported, and from submission 2016 onwards also NO<sub>x</sub>, SO<sub>2</sub>, 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 burn using air curtain incinerator is reported in NFR 5C1bv from submission 2016 onwards.

#### 6.4.3.2 METHODOLOGICAL ISSUES

Estimated emissions of PAH-4, benzo(a)pyrene and dioxin from cremation have been calculated based on national emission factors and statistics on the number of annual cremations. In submission 2016 emissions of NO<sub>x</sub>, TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NMVOC, CO, As, Cr, Cu, Ni, Pb, Se, Zn, PCB, HCB, B(b)F, B(k)F, and I(cd)P from cremation are reported for the first time. The estimates are made with emission factors from EMEP/EEA Guidebook 2013. Emissions from PAH-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 and reported NE in accordance with EMEP/EEA Guidebook 2013.

The emissions of mercury are estimated using a methodology presented by Wängberg (2013)<sup>164</sup>. From the late 1990's, abatement techniques have been considered in the estimations. The method is based on statistics on the annual amount 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 1980 - 2015 are given in Table 6- 11.

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<sup>164</sup> Wängberg, I. 2013. PM Utredning nr 7 Hg från krematorier

**Table 6- 11. Implied emission factors for Hg emission estimates 1980 – 2015. All represents kg per cremated body.**

Year	IEF Submission 2017
1980	0.00300
1985	0.00300
1990	0.00296
1995	0.00287
2000	0.00167
2001	0.00103
2002	0.00100
2003	0.00099
2004	0.00093
2005	0.00087
2006	0.00077
2007	0.00073
2008	0.00071
2009	0.00072
2010	0.00071
2011	0.00064
2012	0.00059
2013	0.00051
2014	0.00038
2015	0.00034

Emission factors used to calculate PAH-4 emissions from cremation are from USEPA<sup>165</sup> and for dioxin a suggested emission factor from the European Dioxin Inventory<sup>166</sup> was used. UNEP<sup>167</sup> presents emission factors for dioxins in the range 0.4 – 90 µg TEQ/cremation, while an earlier Swedish Inventory<sup>168</sup> 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<sup>169</sup>. The number of annual cremations has increased from 47000 in 1980 to more than 71000 in 2014, and associated dioxin emissions have thus increased from 0.42 g TEQ to approximately 0.64 g TEQ during the same period.

Emissions of particulate matter (TSP, PM<sub>10</sub> and PM<sub>2.5</sub>) from cow and sheep burn using air curtain incinerator are for the first time reported in submission 2016. The estimates are made with emission factors from EMEP/EEA Guidebook 2013. Cow and sheep burn 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

<sup>165</sup> 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

<sup>166</sup> Quass et al., 2001. <http://europa.eu.int/comm/environment/dioxin/pdf/stage1/cremation.pdf>

<sup>167</sup> UNEP, 2001. [www.chem.unep.ch/pops/pdf/toolkit/toolkit.pdf](http://www.chem.unep.ch/pops/pdf/toolkit/toolkit.pdf)

<sup>168</sup> deWit. 1993, unpublished

<sup>169</sup> Wang, 2003.



infection, otherwise alternative utilization methods are used. The company estimates that only a few animals are burned with air curtain incinerator annually<sup>170</sup>.

#### 6.4.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR 5C1b v are displayed in Table 6-12.

**Table 6-12. Uncertainties for emissions from cremation reported in NFR 5C1b v.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
5C1b v	As	5	900	5	900
5C1b v	Cd	5	900	5	900
5C1b v	CO	5	900	5	900
5C1b v	Cr	5	900	5	900
5C1b v	Cu	5	900	5	900
5C1b v	Dioxin	5	1000	5	1000
5C1b v	HCB	5	900	5	900
5C1b v	Hg	5	30	5	30
5C1b v	Ni	5	900	5	900
5C1b v	NMVOC	5	900	5	900
5C1b v	NO <sub>x</sub>	5	900	5	900
5C1b v	PAH	5	896	5	896
5C1b v	Pb	5	900	5	900
5C1b v	PCB	5	900	5	900
5C1b v	Se	5	900	5	900
5C1b v	SO <sub>x</sub>	5	900	5	900
5C1b v	TSP	5	900	5	900
5C1b v	PM <sub>10</sub>	5	900	5	900
5C1b v	PM <sub>2.5</sub>	5	900	5	900
5C1b v	Zn	5	900	5	900

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

No source-specific recalculations are performed.

#### 6.4.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

<sup>170</sup> Mikael Lidholm, Svensk Lantbrukstjänst AB

#### 6.4.4 Particles and PAH from garden burning and bonfires, NFR 5C2

##### 6.4.4.1 SOURCE CATEGORY DESCRIPTION

Particulate matter and PAH-4 from domestic open waste burning, such as garden fires, are reported in 5C2. Other possible emissions from garden fires and bonfires are currently not reported due to lack of suitable emission factors.

**Table 6-13. Summary of key source assessment, NFR5C2 according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
5C2	<i>PM<sub>2.5</sub>, As, TSP, Cd, PM<sub>10</sub>, DIOX, Zn</i>	<i>PM<sub>2.5</sub>, As, TSP, Cd, PM<sub>10</sub>, DIOX, Zn</i>

##### 6.4.4.2 METHODOLOGICAL ISSUES

In order to estimate emission of PAH from burning of garden waste, emission factors from USEPA were used, while emission factors for open burning of waste suggested by CEPMEIP<sup>171</sup> were used to estimate emissions of TSP, PM<sub>10</sub> and PM<sub>2.5</sub>. Emission factors presented in EMEP/EEA Guidebook 2009<sup>172</sup>, chapter “Small-scale waste burning” represents emissions from open burning of agricultural waste. A study in 2004<sup>173</sup> reveals that it is very rare that the farmers practice field burning in Sweden. Thus, only PAH and particle emissions are reported in NFR 5C2.

In submission 2016 emissions of Pb, Cd, As, Cr, Cu, Se, Zn and dioxines 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 2013.

As there are no national statistics regarding the extent of garden burning and bonfires, instead statistics on number of small houses have been used. The data should be considered as indicative levels of emissions from these sources.

##### 6.4.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for NFR 5C2 are displayed in Table 6-14. As all emissions are reported from 1996 onwards, no uncertainties for 1990 are displayed.

<sup>171</sup> CEPMEIP, 2001. TNO.

<sup>172</sup> <http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009>

<sup>173</sup> Wikström, H. and Adolfsson, R. 2004. Field Burning of Crop Residues.

**Table 6-14. Uncertainties for emissions from cow and sheep burning reported in NFR 5C2. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
5C2	As			75	200
5C2	Cd			75	200
5C2	Cr			75	250
5C2	Cu			75	195
5C2	Dioxin			75	200
5C2	PAH			75	1000
5C2	Pb			75	200
5C2	Se			75	200
5C2	TSP			IE	100
5C2	PM <sub>10</sub>			IE	100
5C2	PM <sub>2.5</sub>			IE	100
5C2	Zn			75	200

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.

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

No SOURCE-SPECIFIC QA/QC has been performed.

#### 6.4.4.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations are performed.

#### 6.4.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

## 6.5 Waste-water 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<sub>3</sub> (from latrines).

Emissions of TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn are reported as not estimated (NE). Other emissions are reported as not applicable (NA).

**Table 6-15. Summary of key source assessment, NFR5D1, according to approach 1.**

NFR	Key Source Assessment 2015	
	Level	Trend
5D1	NH <sub>3</sub>	NH <sub>3</sub>

#### 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 2013/2016 are used for NMVOC (from wastewater handling at municipal wastewater treatment plants). See further in the table 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 <sup>3</sup> waste water	5	50	Atasoy et al. (2004)

Tier 2 default emission factor from the EMEP/EEA Emission Inventory Guidebook 2013 are used for NH<sub>3</sub> (from latrines). See further in the table below.

**Table 6-17. Emission factor used for NFR 5D1 Domestic wastewater handling (latrines)**

Pollutant	Value	Unit	95 % confidence interval		Reference
			Lower	Upper	
NH <sub>3</sub>	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 emissions of NMVOC. The data has been compiled and published by Statistics Sweden for Swedish EPA.

For NH<sub>3</sub>, activity data on population with latrines is used. The data has been compiled by Statistics Sweden for Swedish EPA.

**Table 6-18. Activity data used for NFR 5D1 Domestic wastewater handling**

Year	Discharged volumes of treated wastewater* (1000 m <sup>3</sup> )	Population with latrines* (persons)
	(AD used for NMVOC from wastewater handling at municipal wastewater treatment plants)	(AD used for NH <sub>3</sub> from latrines)
1990	<b>1 305 000</b>	1 300 000
1991	1 276 050	1 300 000
1992	<b>1 247 100</b>	1 300 000
1993	1 263 600	1 300 000
1994	1 280 100	1 300 000
1995	<b>1 296 600</b>	1 300 000
1996	1 315 067	1 300 000
1997	1 333 533	1 300 000
1998	<b>1 352 000</b>	1 300 000
1999	1 357 459	1 300 000
2000	<b>1 362 917</b>	1 300 000
2001	1 295 459	1 300 000
2002	<b>1 228 000</b>	1 300 000
2003	1 206 612	1 300 000
2004	<b>1 185 223</b>	1 300 000
2005	1 212 514	1 300 000
2006	<b>1 239 805</b>	1 300 000
2007	1 249 172	1 300 000
2008	<b>1 258 539</b>	1 300 000
2009	1 222 653	1 300 000
2010	<b>1 186 767</b>	1 300 000
2011	1 227 949	1 300 000
2012	<b>1 269 131</b>	1 300 000
2013	1 243 112	1 300 000
2014	<b>1 217 093</b>	1 300 000
2015	1 217 093	1 300 000

\*Data in bold are compiled, other data is extrapolated or interpolated. The population with latrines is an estimate based on data for 1995, 2000 and 2005 (1 300 000 persons).

#### 6.5.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The used uncertainties are presented below.

**Table 6-19. Uncertainties for emissions from waste water handling NFR 5D1. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
5D1	NMVOC	10	233	10	233
	NH <sub>3</sub>	10	100	5	100

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

Recalculations has been made in submission 2017 for NMVOC, because of the availability of new AD on discharged wastewater. The emissions has changed by - 2.1% for the year 2013 and -4.1% 2014.

#### 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<sub>3</sub>, TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn are reported as not estimated (NE). Other emissions are reported as not applicable (NA).

#### 6.5.2.2 METHODOLOGICAL ISSUES

##### 6.5.2.2.1 *Emission factors used*

Tier 2 default emission factor from the EMEP/EEA Emission Inventory Guidebook 2013 are used for NMVOC (from wastewater treatment in industry). See further in the table below.

**Table 6-20. Emission factor used for NFR 5D2 Industrial wastewater handling**

Pollutant	Value	Unit	95 % confidence interval		Reference
			Lower	Upper	
NMVOC	15	mg/m <sup>3</sup> 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.

**Table 6-21. Activity data used for NFR 5D2 Industrial wastewater handling (NMVOC)**

Year	Discharged volumes of treated wastewater* (1000 m <sup>3</sup> )
1990	933 056
1991	933 056
1992	933 056
1993	933 056
1994	933 056
1995	<b>933 056</b>
1996	930 496
1997	927 936
1998	925 375
1999	922 815
2000	<b>920 255</b>
2001	931 282
2002	942 310
2003	953 337
2004	964 365
2005	<b>975 392</b>
2006	988 232
2007	1 001 072
2008	1 013 911
2009	1 026 751
2010	<b>1 039 591</b>
2011	1 010 917
2012	982 242
2013	953 568
2014	924 893
2015	<b>896 219</b>

\*Data in bold are compiled, other data is extrapolated or interpolated.

#### 6.5.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The used uncertainties are presented below.

**Table 6-22. Uncertainties for emissions from NFR 5D2 Industrial wastewater handling. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
5D2	NMVOC	50	233	50	233

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

Recalculations has been made in submission 2017 for NMVOC, because of the availability of new AD on processed wastewater. The emissions has changed by between -5.5% and -11.0% for the years 2012 to 2014.

#### 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)
- Landfill fires
- House and Car fires
- Pets

**Table 6-22. Summary of key source assessment, NFR5E according to approach 1**

NFR	Key Source Assessment 2015	
	Level	Trend
5E	<i>DIOX, PM<sub>2.5</sub>, NH<sub>3</sub>, PM<sub>10</sub>, TSP, As, Cd</i>	<i>DIOX, PM<sub>2.5</sub>, NH<sub>3</sub>, PM<sub>10</sub>, Hg,</i>

### 6.6.1 Other waste, sludge spreading, NFR 5E

#### 6.6.1.1 SOURCE CATEGORY DESCRIPTION

Since submission 2017, Sweden is reporting of emissions of NH<sub>3</sub> from sludge spreading (mechanical dewatering of digested sludge). In the previous submission, this parameter was construed as sludge spreading in agriculture (land application).

#### 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 2013/2016 are used for NH<sub>3</sub> (from sludge spreading). See further in the table below.

**Table 6-23. Emission factor used for NFR 5E Other waste, Sludge spreading**

Pollutant	Value	Unit	95 % confidence interval		Reference
			Lower	Upper	
NH <sub>3</sub>	50	g/kg NH <sub>3</sub> in the sludge	10	150	Guidebook (2006)



**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 <sub>3</sub> from sludge spreading)
1990	8 073
1991	8 073
1992	8 073
1993	8 073
1994	8 073
1995	<b>8 073</b>
1996	8 296
1997	8 518
1998	<b>8 741</b>
1999	8 656
2000	<b>8 571</b>
2001	8 878
2002	<b>9 185</b>
2003	8 802
2004	<b>8 419</b>
2005	8 565
2006	<b>8 710</b>
2007	8 908
2008	<b>9 105</b>
2009	9 038
2010	<b>8 971</b>
2011	8 948
2012	<b>8 925</b>
2013	8 989
2014	<b>9 053</b>
2015	8 919

\*Data in bold are compiled, other data is extrapolated or interpolated.

SOURCE: MI 22 SM, Swedish EPA and SMED

#### 6.6.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The used uncertainties are presented below.

**Table 6-25. Uncertainties for emissions from NFR 5E Other waste, Sludge spreading. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
5D2	NH <sub>3</sub>	10	140	2	140

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

Recalculations has been made in submission 2017 for NH<sub>3</sub>, because of the new interpretation of the parameter (changed from "sludge spreading in agriculture" to "mechanical dewatering of digested sludge"). The emissions has changed by between 250.4% and 1 447.9% for the years 1990 to 2014.

#### 6.6.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

## 6.6.2 Other waste, landfill fires, NFR 5E

### 6.6.2.1 SOURCE CATEGORY DESCRIPTION

In the sector 5E Other waste, emissions of dioxin, PAH-4 and Hg from landfill fires (1996 and onwards) are included.

### 6.6.2.2 METHODOLOGICAL ISSUES

All emissions from landfill fires are in this submission based on the frequency and duration of fires in Sweden<sup>174</sup> and emission factors derived from measurements performed during landfill fires<sup>175</sup>. The fires were classified as “underground fires” (> 48 hours) or “surface fires” (< 48 hours) depending on the duration of the fire. In Table 6- 25, the emission factors used are presented, and in Table 6- 26, the reported emissions of Hg, dioxin and PAH-4 from landfill fires are presented.

**Table 6-26 Emission factors used for estimation of Hg, dioxin and PAH emissions from landfill fires.**

Fire category	Hg g/hour	Dioxin g/hour	PAH			
			benzo(a) pyrene g/hour	benzo(b) fluoranthene g/hour	benzo(k) fluoranthene g/hour	Indeno(1,2,3- cd)-pyrene g/hour
Surface	1.30	$200 \times 10^{-6}$	0.15	0.24	NE	0.09
Underground	0.031	$12.6 \times 10^{-6}$	-----	-----	-----	-----

**Table 6- 27 Number of hours of landfill fires and estimated Hg, dioxin and PAH emissions in Sweden 1996 – 2015.**

Year	Surface fire, no. of hours	Underground fire, no. of hours	Hg emissions, kg	Dioxin emissions, g	Total PAH emis- sions, kg
1996	1284	966	1.7	0.27	0.62
1997	1108	1772	1.5	0.24	0.53
1998	654	1174	0.9	0.15	0.31
1999	733	2563	1.0	0.18	0.35
2000	969	717	1.3	0.20	0.46
2005	1799	1506	2.4	0.38	0.86
2006	1983	2783	2.7	0.43	0.95
2007	1683	2695	2.3	0.37	0.81
2008	1680	3110	2.3	0.38	0.81
2009	1540	1143	2.0	0.32	0.74
2010	1032	1604	1.4	0.23	0.50
2011	1574	922	2.1	0.33	0.76
2012	1043	1218	1.4	0.22	0.50
2013	1542	2782	2.1	0.34	0.74
2014	494	414	0.7	0.10	0.24
2015	460	541	0.6	0.10	0.22

<sup>174</sup> The Swedish Civil Contingencies Agency, personal communication

<sup>175</sup> Pettersson et al., 1996.

#### 6.6.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions from landfill fires reported in NFR 5E are displayed in Table 6-28.

**Table 6-28. Uncertainties for emissions from landfill fires reported NFR 5E.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
5E	PAH	50	1000	50	1000

Time series for landfill 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

A minor correction regarding amount of surface fires in 2014 has been made and emissions have been updated accordingly. The decrease in hours and emissions can however be considered as insignificant.

#### 6.6.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 6.6.3 Other waste, house and car fires, NFR 5E

#### 6.6.3.1 SOURCE CATEGORY DESCRIPTION

Since submission 2016 also emissions of PM<sub>2.5</sub>, PM<sub>10</sub>, TSP, Pb, Cd, Hg, As, Cr, Cu and dioxin from House/car fires are included in 5E (1990 and onwards).

#### 6.6.3.2 METHODOLOGICAL ISSUES

Emissions of PM<sub>2.5</sub>, PM<sub>10</sub>, 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 frequency and duration of fires in Sweden<sup>176</sup> and emission factors (Tier 2) from EMEP/EEA Guidebook 2013. Used activity data are: car fires, fires in 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- 29, the emission factors used are presented and in Table 6- 18, the reported emissions of TSP, PM, metals and dioxin emissions from house and car fires are presented.

<sup>176</sup> [www.msb.se](http://www.msb.se) 19 januari 2016

**Table 6-29. Emission factors used for estimation of TSP, PM, metals and dioxin emissions from house and car fires.**

	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	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

**Table 6-30. Emissions of TSP, PM, metals and dioxin emissions from house and car fires in Sweden 1990 – 2014.**

Year	TSP kt	PM <sub>10</sub> kt	PM <sub>2.5</sub> kt	Pb t	Cd t	Hg t	As t	Cr t	Cu t	PCDD/F g
1990	0.65	0.65	0.65	0.002	0.004	0.004	0.006	0.006	0.013	6.6
1995	0.65	0.65	0.65	0.002	0.004	0.004	0.006	0.006	0.013	6.6
2000	0.59	0.59	0.59	0.002	0.003	0.003	0.005	0.005	0.012	6.0
2005	0.62	0.62	0.62	0.002	0.004	0.004	0.006	0.005	0.013	6.3
2006	0.61	0.61	0.61	0.002	0.004	0.004	0.006	0.005	0.013	6.2
2007	0.63	0.63	0.63	0.002	0.004	0.004	0.006	0.006	0.013	6.4
2008	0.62	0.62	0.62	0.002	0.004	0.004	0.006	0.005	0.013	6.3
2009	0.67	0.67	0.67	0.002	0.004	0.004	0.006	0.006	0.014	6.8
2010	0.70	0.70	0.70	0.002	0.004	0.004	0.006	0.006	0.014	7.1
2011	0.60	0.60	0.60	0.002	0.004	0.004	0.006	0.005	0.012	6.1
2012	0.62	0.62	0.62	0.002	0.004	0.004	0.006	0.005	0.013	6.3
2013	0.59	0.59	0.59	0.002	0.003	0.003	0.005	0.005	0.012	6.0
2014	0.57	0.57	0.57	0.002	0.003	0.003	0.005	0.005	0.012	5.8
2015	0.52	0.52	0.52	0.002	0.003	0.003	0.005	0.005	0.011	5.4

### 6.6.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions from house and care fires reported in NFR 5E are displayed in Table 6-31.

**Table 6-31. Uncertainties for emissions from house and car fires reported NFR 5E.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
5E	As	100	100	50	100
5E	Cd	100	100	50	100
5E	Cr	100	100	50	100
5E	Cu	100	100	50	100
5E	Dioxin	100	100	50	100
5E	Hg	100	100	50	100
5E	Pb	100	110	50	110
5E	TSP	100	100	50	100
5E	PM <sub>10</sub>	100	100	50	100
5E	PM <sub>2.5</sub>	100	100	50	100

Time series for house and car fires reported in NFR code 5E have been reviewed in later years and considered to be consistent.

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

No source-specific QA/QC has been performed.

#### 6.6.3.5 SOURCE-SPECIFIC RECALCULATIONS

The amount of house and car fires in 2013 and 2014 has been updated according to the latest statistics from the Swedish Civil Contingencies Agency. Reported emissions are adjusted accordingly, the difference to emissions reported in submission 2016 is however considered as insignificant.

#### 6.6.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

### 6.6.4 Other waste, pets, NFR 5E

#### 6.6.4.1 SOURCE CATEGORY DESCRIPTION

Emissions of NH<sub>3</sub> from cats and dogs are also included in NFR 5E Other waste (1990 and onwards).

#### 6.6.4.2 METHODOLOGICAL ISSUES

The estimates of emissions of ammonia from cats and dogs are based on a calculation made in the beginning of the nineties and the same value (0.5 kt NH<sub>3</sub>) has been used for the whole time period from 1990<sup>177</sup>. The calculation is based on data on the number of cats and dogs and an estimated value on the amount of emissions from cats and dog relative to emissions from humans.

#### 6.6.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties for emissions from pets in NFR5E are displayed in Table 6-32.

**Table 6-32. Uncertainties for emissions from pets reported in NFR 5E. If the uncertainty cannot be estimated separately for activity data and emission factor, the uncertainty is reported under the emission factor.**

Source category	Substance	Base year uncertainty (%)		Year 2015 uncertainty (%)	
		Activity data	Emission factor	Activity data	Emission factor
5E	NH <sub>3</sub>	IE	200	IE	200

Time series for pets reported in NFR code 5E have been reviewed in later years and considered to be consistent.

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

No source-specific QA/QC has been performed.

#### 6.6.4.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations are performed.

#### 6.6.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No major improvements are planned for the next submission.

<sup>177</sup> Statistics Sweden, MI 37 SM 0901. Emissions of ammonia to air in Sweden in 2007.

## 7 Other (NFR sector 6)

No other sectors are included in the Swedish emission inventory and for the years 1990-2014, the sector is reported “Not occurring”.

However, for the inventory year 2015, emissions that cannot be reported in respective NFR category due to secrecy reasons are reported in NFR 6A, in order to obtain correct national total emissions.

Emissions that are included in NFR 6A are re-allocated from other source categories as shown in Table 7-1.

**Table 7-1. Emissions sources reallocated to NFR6A.**

Pollutant reported in NFR 6A	Re-allocated from NFR source category
NO <sub>x</sub> , PM <sub>2.5</sub> , PM <sub>10</sub> , TSP	1A1b, 1A1c, 1A2b, part of 1A2d, part of 1A2e, 1B2a1, and 1B2a4
NMVOC	1A1b, 1A1c, 1A2b, part of 1A2d, part of 1A2e, 1B2a1, and 1B2a5
SO <sub>2</sub>	1A1b, 1A1c, 1A2b, part of 1A2d and part of 1A2e
NH <sub>3</sub>	1A1b, 1A2b, part of 1A2d, part of 1A2e, 1B2a1, 1B2a4 and 1B2C
BC,	1A1b, 1A2b, part of 1A2d, part of 1A2e, 1B2a1, and 1B2a4
CO	1A1b, 1A1c, 1A2b, part of 1A2d, part of 1A2e, 1B2a1, 1B2a4 and 1B2C
Hg, Cd, Pb, As, Cr, Cu, Ni, Se, Zn	1A1b, 1A2b, part of 1A2d and part of 1A2e
Dioxin, HCB and PCB	part of 1A2d and part of 1A2e
PAH	1A1b, 1A2b, part of 1A2d and part of 1A2e, 1B2a4

## 8 Recalculations and Improvements

In this submission, recalculations are explained under each sector and NFR-code.

## 9 Projections

No projections are reported in this Submission.



## 10 Reporting of gridded emissions and LPS

Gridded emissions and LPS are not reported in this Submission.

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