ANNUAL ICELANDIC INFORMATIVE INVENTORY REPORT TO UNECE

Emissions of POP‘s and Other Air Pollutants in Iceland 1990-2015

2017

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Reykjavík, 15. March 2017

Preface

The Convention on Long-Range Transboundary Air Pollution (CLRTAP) was adopted in 1979 and entered into force in 1983. The Convention has been extended by eight Protocols, of which Iceland has ratified the Protocol on Persistent Organic Pollutants. Furthermore, in 2009 the national emission ceilings directive (NECD) 2001/81/EC was added to the EEA agreement, with national emission targets set for Iceland for SO_2, NO_x, NMVOC and NH_3.

According to Article 8 of the Convention, Parties shall exchange information on emissions of pollutants. To comply with this requirement and with the NECD, Iceland has prepared an Informative Inventory Report (IIR) for the year 2015. The IIR together with the associated Nomenclature for Reporting tables (NFR tables) is Iceland's contribution to this round of reporting under the Convention, and covers emissions in the period 1990-2015. This report emphasizes on emissions of Persistent Organic Pollutants as Iceland has only ratified the Protocol on Persistent Organic Pollutants (POPs). Emissions of the indirect greenhouse gases (NO_x, CO and NMVOC), NH_3 and SO_2 are provided in the NFR tables as they are calculated to comply with the reporting requirements of the NECD and the United Nations Framework Convention on Climate Change (UNFCCC). Emission estimates for particulate matter (PM), black carbon (BC) and heavy metals(HM) are provided for several emission sources. A description of the trends and the calculation method for the pollutants are given in this report. Further estimates for SO_2, $PM_{2.5}$ and PM_{10} for the volcano Eyjafjallajökull that erupted in 2010, the volcano Grímsvötn that erupted in 2011 and Holuhraun eruption in 2014 and 2015 are provided.

The IIR is written by the Environment Agency of Iceland (EAI).

Environment Agency of Iceland, Reykjavík, 15. March 2017.

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Executive Summary

Background

The Convention on Long-Range Transboundary Air Pollution (CLRTAP) entered into force in 1983. The Convention has been extended by eight Protocols, of which Iceland has ratified the Protocol on Persistent Organic Pollutants (POPs). The Protocol on Persistent Organic Pollutants entered into force in 2003. According to Article 8 of the Convention, Parties shall exchange information on emissions of pollutants. In 2009, the national emission ceilings directive (NECD) 2001/81/EC was added to the EEA agreement, with national emission targets set for Iceland for SO_2, NO_x, NMVOC and NH_3. At the time of writing, work is underway at the EAI and the Icelandic government to evaluate and work at the incorporation of the new National Emissions Ceiling directive (2016/2284) into the EEA agreement.

To comply with the requirements of the Convention and of the national emission ceilings directive, Iceland has prepared an Informative Inventory Report (IIR) for the year 2017. The IIR together with the associated Nomenclature for Reporting tables (NFR tables) is Iceland's contribution to this round of reporting under the Convention, and covers emissions in the period 1990 – 2015. This report emphasizes on anthropogenic emissions of Persistent Organic Pollutants (Dioxin, PAH4, HCB and PCB), as Iceland has only ratified the Protocol on Persistent Organic Pollutants. Anthropogenic emissions of the indirect greenhouse gases (NO_x, CO and NMVOC) and SO_2 are provided in the NFR tables as they are calculated to comply with the reporting requirements of the UNFCCC and of the NECD. For this submission emission estimates for ammonia (NH_3), particulate matter (PM), black carbon (BC) and heavy metals (HM) are provided for a few emission sources. PCB and HM emissions are reported for the first time in this report.

A short description of the trends and the calculation method for those pollutants are given in this report. Further estimates for SO_2, $PM_{2.5}$ and PM_{10} for the volcano Eyjafjallajökull that erupted in 2010, the volcano Grímsvötn that erupted in 2011 and Holuhraun eruption in 2014 and 2015 are provided.

This report and the NFR tables are available on the EIONET Central Data Repository: http://cdr.eionet.europa.eu/is/un/clrtap/

Responsible institute

The Environment Agency of Iceland (EAI), an agency under the direction of the Ministry for the Environment and Natural Resources is responsible for the annual preparation and submission of the Icelandic informative inventory report (IIR) and Nomenclature for Reporting tables (NFR tables) to the Convention on Long-Range Transboundary Air Pollution. The EAI participates in meetings under the United Nations Economic Commission for Europe (UNECE) Task Force on Emission Inventories and Projections (TFEIP) and the related expert panels, where parties to the convention prepare the guidelines and methodologies on inventories.

Trends in POPs emissions

All sources of POPs emissions are included in the energy, the industry and the waste sector; activities belonging to the agriculture sector are either not occurring in Iceland, or do not generate POPs emissions.

From 1990 to 2015 dioxin emissions decreased by 89% (Figure ES. 1). In 2015 the largest contributors of dioxin emissions in Iceland were waste incineration and commercial fishing (Energy sector).

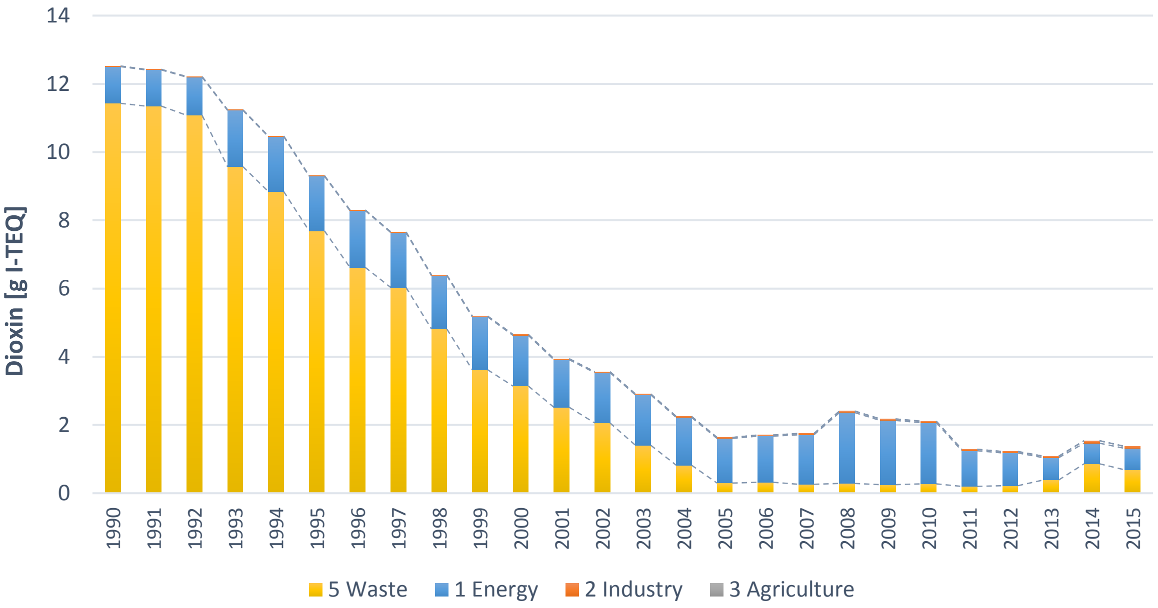

Figure ES. 1 Trends in dioxin emissions by source, 1990-2015.

PAH4 emissions from 1990 to 2015 decreased by 83% (Figure ES. 2). In 2015 the largest contributor of PAH4 emissions in Iceland were the metal industry (industry sector) followed by road transport

(Energy sector) and waste incineration (Waste sector) .

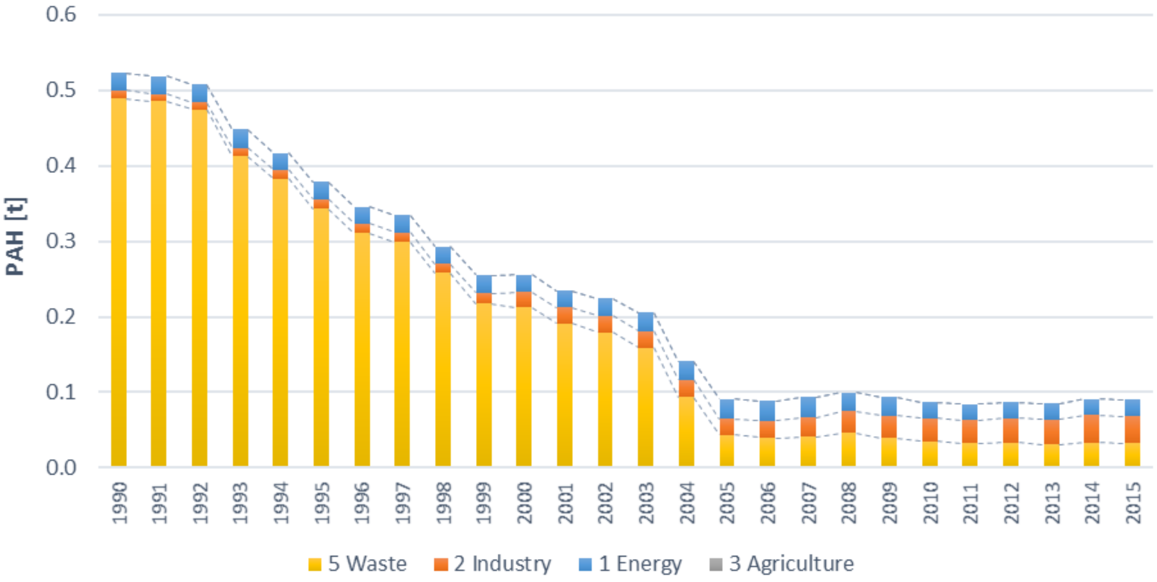

Figure ES. 2 Trends in PAH4 emissions by sector, 1990-2015.

The estimated hexachlorobenzen (HCB) emissions from 1990 to 2015 increased by 246% (Figure ES. 3). The largest contributor of HCB emissions in Iceland is waste incineration with and without energy recovery, followed by emissions originating from navigation and fishing. Emissions from waste incineration with energy recovery are reported under the Energy sector. There was no waste incineration with energy recovery in Iceland in 2015. HCB emissions from the industry sector increased in 2004, following the opening of a secondary aluminium plant. The sudden increase in HCB emission estimates in the waste sector for the year 2004 is partly explained by a lack of an emission factor in the EMAP/EEA 2013 guidebook for open burning of waste (NFR 5C2). Open burning of waste was a large means of waste management practice in Iceland pre-2004. However, an increase in the amount of waste incinerated in incineration plants without recovery occurred in 2004 while a reduction of the amount of waste burned in the open occurred in that same year.

Interpretations of the HCB trend analysis should be done with care as emissions have only been estimated for a few sources.

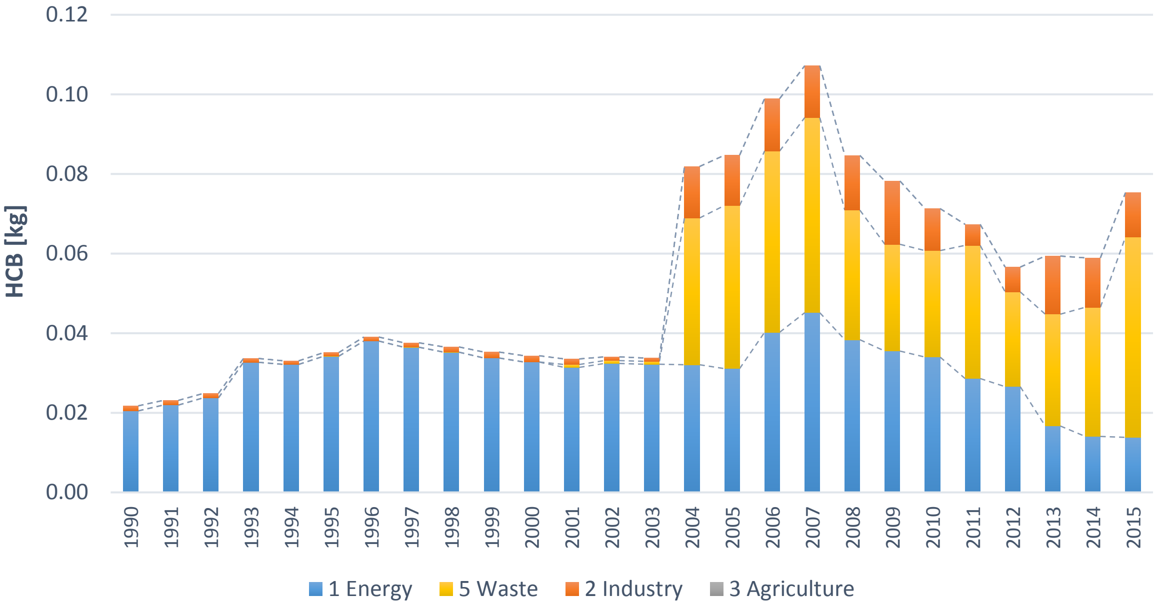

Figure ES. 3 Trends in HCB emissions by sector, 1990-2015.

Polychlorinated biphenyl (PCB) emission estimates are reported for the first time in this report. The PCB emissions from 1990 to 2015 increased by 61% (Figure ES. 4). The largest contributor of PCB emissions in Iceland is waste incineration, with and without energy recovery. Emissions from waste incineration with energy recovery are reported under the Energy sector. There was no waste incineration with energy recovery in 2015. The only source pf PCB estimated from industrial processes is secondary steel production (2C1). The only secondary steel plant in Iceland started its activities in 2014; In 2015, production was much less than in the year before, leading to a decrease in PCB emissions. The sudden increase in PCB emission estimates in the waste sector can partly be explained by the lack of an emission factor in the EMEP/EEA 2013 guidebook for open burning of waste (NFR 5C2). The guidebook provides suggests PCB emissions from open burning of waste to be “not applicable” while an emission factor is given for waste incineration in incineration plants (NFR 5C1a). However, an increase in the amount of waste incinerated in incineration plants without recovery occurred in 2004 while a reduction of the amount of waste burned in the open occurred in that same year.

Interpretations of the total PCB trend analysis should be done with care as emissions have only been estimated for a few sources.

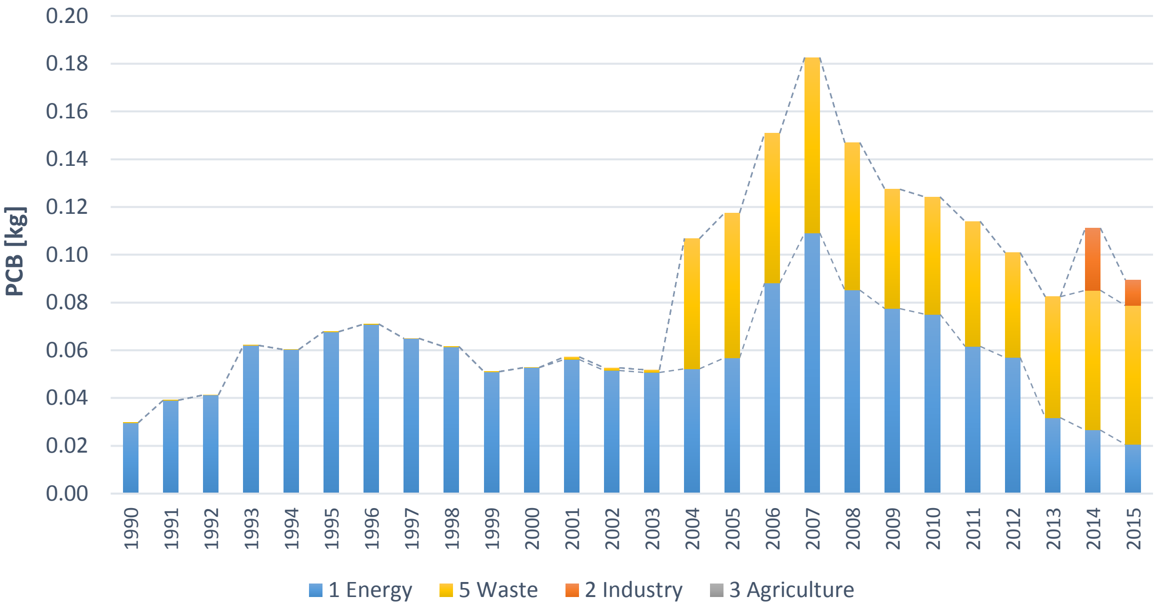

Figure ES. 4 Trends in PCB emissions by sector, 1990- 2015.

1 Introduction

1.1 Background Information

The 1979 Convention on Long-Range Transboundary Air Pollution (CLRTAP) was signed by Iceland on 13th of November 1979 and ratified in May 1983. The Convention entered into force in August 1983. One of the requirements under the Convention is that Parties are to report their national emissions by sources.

The Convention has been extended by eight Protocols, of which the Protocol on Persistent Organic Pollutants (POP-Protocol) has been signed and ratified by Iceland. The POP-Protocol was ratified by Iceland in May 2003 and entered into force in October 2003.

In 2009, the National Emission Ceilings Directive (NECD) 2001/81/EC was incorporated to the EEA agreement, with national emission targets set for Iceland for SO_2, NO_x, NMVOC and NH_3. The targets set were 90 kt, 27 kt, 31 kt and 8 kt, respectively, to be reached by 2010. In December 2016, a new directive, the National Emissions Ceiling Directive (2016/2284), entered into force in all EU Member States. The new NECD includes the same pollutants as the one it replaces, with the addition of CO, Cd, Hg, Pb, POPs (PAH, dioxins/furans, PCBs, HCB), $PM_{2.5}$, PM_{10} and BC if available as obligatory reporting and TSP, As, Cr, Cu, Ni, Se and Zn as voluntary reporting. At the time of writing, work is underway at the EAI and the Icelandic government to evaluate and work at incorporation of the new National Emissions Ceiling Directive (2016/2284) into the EEA agreement; Iceland-specific targets are yet to be determined.

The present report together with the associated NFR (Nomenclature for Reporting) tables is Iceland's contribution to the 2017 reporting under the Convention. As Iceland has only ratified the POP-Protocol, the report emphasizes anthropogenic emissions of POPs and covers anthropogenic emissions of dioxin, PAH4, HCB and PCB in the period 1990-2015, as well as gridded data for dioxin, PAH4 and HCB for the years 1990, 1995, 2000, 2005 and 2010. A description of the trends and calculation methods is given. Anthropogenic emissions of the indirect greenhouse gases (NO_x, CO, NMVOC), NH_3 and SO_2 are provided in the NFR tables for information purposes, as they are calculated to comply with the reporting requirements of the UNFCCC and of the NECD. Emission estimates for ammonia (NH_3) particulate matter (PM), black carbon (BC) and heavy metals (HM) are provided for a few emission sources. A short description of the trends and the calculation methods for those pollutants are given in this report. Further estimates for SO_2, $PM_{2.5}$ and PM_{10} for the volcano Eyjafjallajökull that erupted in 2010, the volcano Grímsvötn that erupted in 2011 and Holuhraun eruption in 2014 and 2015 are provided. Emissions of heavy metals in Iceland were estimated for the first time for this submission.

1.2 Institutional Arrangements for Inventory Preparation

The Environment Agency of Iceland (EAI), an agency under the auspices of the Ministry for the Environment and Natural Resources, has overall responsibility for the annual preparation and submission of the national inventory to the UNECE-LRTAP Convention. EAI compiles and maintains the emission inventory and reports to the Convention. Figure 1.1 illustrates the flow of information and allocation of responsibilities. The methodologies and data sources used for different sectors are described in Chapter 1.3.

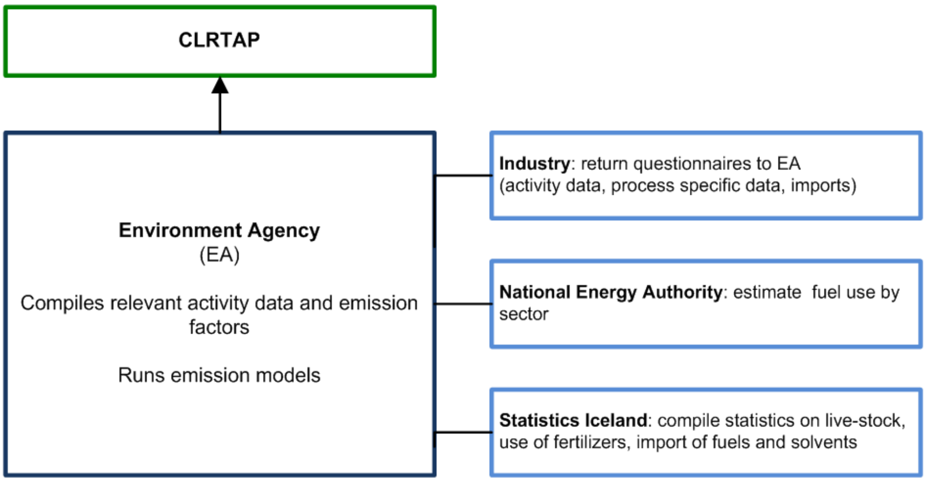

Figure 1.1 Information flow and distribution of responsibilities in the Icelandic emissions inventory system for reporting to the CLRTAP.

1.3 Methodologies & Data Sources

The general emission model is based on the equation:

Emission (E) = Activity level (A) · Emission Factor (EF)

The standard equation for estimating PAH emission factor (example for B[b]F) is:

Emission factor (B[b]F) = Emission Factor (B[a]P) · Profile ratio B[b]F/ B[a]P

The EAI collects the bulk of data necessary to run the general emission model, i.e. activity data and emission factors. Activity data is collected from various institutions and companies, as well as by EAI directly. The National Energy Authority (NEA) collects annual information on fuel sales from the oil companies. This information was until 2008 provided on a voluntary basis. From 2008 and onwards, Act no. 48/2007 amending Act no. 87/2003 about the National Energy Authority, enables the NEA to obtain sales statistics from the oil companies. Statistics Iceland, which is the center for official statistics in Iceland, provides information on population, GDP, production of various products, imports of solvents and other products, import of fertilizers and import and export of fuels. The EAI collects various additional data through the annual emission reports reported under the European Emissions Trading System (EU ETS), European Pollutant Release and Transfer Register (E-PRTR), Green Accounting reports from industry submitted under Regulation no. 851/2002 and directly from operators. EAI also estimates activity data with regard to waste.

Data for using the transport model COPERT originates from EMISIA SA[1] is used for emission estimates from road transport (NFR 1A3b) for selected pollutants between 2000 and 2014 (see more details in the energy sector). The following text is supplied by EMISIA SA regarding the data:

> *The vehicle fleet and activity data provided by EMISIA SA for the compilation of national emission inventories with use of the COPERT model reflect our best knowledge of national situation in each country until 2014. The time series 2000-2010 has been created using the road transport dataset and methodology of the TRACCS and FLEETS research projects. More*

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[1] http://emisia.com/products/copert-data

> *specifically, TRACCS dataset of the period 2005-2010 has been combined with the FLEETS dataset of the period 2000-2005 and, together with the latest 2011-2014 update, an aligned and up to date time series for the period 2000-2014 has been produced. The quality, completeness, and consistency of TRACCS and FLEETS datasets, which have been extensively reviewed and cross-checked, together with the expertise of EMISIA on transport data, ensure that the compiled COPERT data are also of good quality.*
>
> *Important note: The fuel consumption produced by COPERT when using these data has been cross-checked in terms of consistency with national submissions in UNFCCC.*

Aviation emissions for 2005-2015 are reported for the first time using the Eurocontrol dataset.

Other emission factors are mainly taken from the *Emission Inventory Guidebook* (EEA, 2016), the *Emission Inventory Guidebook* (EEA, 2013), the *Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases* (UNEP, 2005), *Annual Danish Informative Inventory Report to UNECE* (NERI, 2016), *Emissions of Black carbon and Organic carbon in Norway 1990-2011* (Aasestad, 2013) as well as the Norwegian reports *Utslipp til luft av dioksiner i Norge – Dokumentasjon av metode og resultater*[2] (Statistics Norway, 2002) and *Utslipp til luft av noen miljögifter i Norge - Dokumentajon av metode og resultater*[3] (Statistics Norway, 2001). Dioxin was measured at several locations in Iceland in 2011, including waste incineration plants, aluminium plants and the ferrosilicon plant. PAH4 was also measured at 1 aluminium plant and the ferrosilicon plant. The results from dioxin measurements from the waste incineration plant have been used for waste incineration emission estimates since the 2012 submission. Results from the measurements at industrial sites have been used since the 2013 submission.

1.4 Key Categories

No Key Category Analysis (KCA) was included in Iceland's previous submission. KCA has now been undertaken based on Approach 1 outlined in the 2016 EMEP Guidelines. The KCA has been performed using the current CLRTAP inventory data. Data for 1990 and 2015 has been extracted for each pollutant and NFR code. KCA has been performed for each pollutant, calculating both the level assessment and trend assessment. Memo items and notation keys have been excluded. The sectors that contribute to more than 80 % of the inventory are identified for each pollutant in ascending order. Formatting has been used to ensure that these sectors are easily identifiable for each pollutant.

But given that this is first KCA performed, it is important to be able to take some time to review the outputs and the process. It will then be possible to consider resource implications and data format requirements of further improvements.

Future improvements might be concerned with the following points:

- The EMEP Guidelines explain that as part of the KCA analysis, subcategories which cumulatively contribute more that 60 % should be treated with significance. Only the 80 % threshold is considered

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[2] Utslipp til luft av dioksiner i Norge: Air emissions of dioxins in Norway – Documentation of methods and results

[3] Utslipp til luft av noen miljögifter i Norge – Dokumentasjon av metode og resultater: Air emissions of several pollutants in Norway - Documentation of methods and results

in the current KCA, and the inclusion of the "top" 60 % subcategories may be considered for future submissions.

- The EMEP 2016 guidance recommends that when using Approach 1, where possible categories should be disaggregated into their major fuel types. This data is not currently readily accessible. The efforts required for improving this in future submissions will be assessed.
- The current KCA does not consider the cross-correlations between categories.

The results presented in this submission represent a significant improvement on previous submissions. Iceland is committed to delivering further progress where it does not entail disproportionate effort.

Table 1.1 presents the results of the key category analysis for the 2015 level for reported POPs. The key category analyses for all other pollutants included in the inventory are presented in Annex III.

Table 1.1 Key category analysis for reported POPs in 2015.

Component	**Key categories (Sorted from high to low from left to right)**					**Total (%)**
DIOX	*National Fishing NFR 1A4ciii* (41.97%)	*Municipal waste incineration NFR 5C1a* (36.5%)	*Open burning of waste NFR 5C2* (7.45 %)			85.95
PAH4	*Open burning of waste NFR 5C2* (23.81 %)	*Ferroalloy production NFR 2C2* (18.83%)	*Aluminium production NFR 2C3* (17.99%)	*Accidental fires NFR 5E* (12.41%)	*Road transport: Passenger cars NFR 1A3bi* (8.08%)	81.1
HCB	*Clinical waste incineration NFR 5C1a* (38.09%)	*Municipal waste incineration NFR 5C1a* (25.67%)	*Fishing NFR 1A4ciii* (17.45%)			81.21
PCB	*Municipal waste incineration NFR 5C1a* (57.24%)	*Fishing NFR 1A4ciii* (22.35%)	*Iron and steel production NFR 2C1* *(12.03%)*			91.62

1.5 Quality Assurance & Quality Control

The objective of QA/QC activities in national emissions inventories is to improve transparency, consistency, comparability, completeness, accuracy, confidence and timeliness. A QA/QC plan for the annual inventory of Iceland has been prepared. The document describes the quality assurance and quality control program. It includes the quality objectives and an inventory quality assurance and a quality control plan. It also describes the responsibilities and the time schedule for the performance of QA/QC procedures. The QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardized procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. Source category specific QC measures have been developed for several key source categories. A quality manual for the Icelandic air emission inventory has been prepared. It is available the EAI's website (ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/Iceland_QAQC_plan.pdf).

A range of QAQC checks have been performed on the Icelandic inventory:

- **Recalculation check** - comparing the values reported in the current (2017) and previous (2016) versions of the inventory.
- **Trends check** - to identify outliers and changes in the trend in the most recent three years of the inventory.
- **Negative and zero values checks** - to highlight the occurrence of negative values (LULUCF is not included) and zero values in the inventory.
- **Notation keys check** - to summarise the occurrence of each notation key to ensure consistency and accuracy in the inventory.
- **PAHs sum check** - to ensure that the sum of the four reported PAHs equals the reported “total” PAH emissions.
- **Particulate Matter check** - to ensure that reported TSP emissions are greater than or equal to PM_{10}, and similarly that reported PM_{10} emissions are greater than or equal to $PM_{2.5}$.

In all cases, the findings of the checks are reviewed, not only to identify where corrections may be required, but also to consider whether there are any steps of the inventory compilation process that need improvement. In addition, reviewing the results also provides information on whether the individual checks are well designed and comprehensive. This ensures that all results from the QAQC process feed back into the continuous improvement programme. Further details are available under Annex II.

1.6 Uncertainty Evaluation

In February 2017, new templates were created for uncertainty estimates based on the 2016 EMEP Guidelines. The new templates were not used for this submission, but implementation is in progress and they will be used for the next submission.

There are two main challenges in calculating uncertainty estimates - estimating the uncertainty of activity data and implementing country-specific emission factors. The utilisation of the new uncertainty templates in future submissions will be accompanied by a review of uncertainties, and will therefore improve the uncertainty estimates as well as providing more transparent documentation.

1.7 General Assessment of Completeness

The aim is to make, in the highest possible level of disaggregation, estimates of all known emissions to air in the informative inventory report. This year is the first year that the Icelandic inventory covers all air pollutants under the CLRTAP. Emissions for heavy metals and PCB were added for the first time for this submission. The inventory is generally complete, however there are some pollutants and/or categories that have not been estimated at all or only for part of the time series. The activities/pollutants not included in the present submission were not estimated due to lack of emission factors (pollutant(s) listed as “not estimated” in the emission factor tables provided in the EMEP/EEA guidebook), lack of data, and/or that additional work was impossible due to time constraints in the preparation of the emission inventory.

Emissions not estimated in the 2017 submission include:

1.7.1 Energy (NFR 1)

- Public Electricity and Heat Production: NH_3, PCB and HCB emissions for all years (lack of emission factors in the EMEP/EEA 2013 Guidebook)
- Road Transport:
    - Pre-2000 emission estimates for NH_3, HCB, PCB and BC
    - Non-exhaust emissions
- Distribution of oil products

1.7.2 Industrial processes (NFR 2)

- Emissions from Quarrying and mining of minerals, and construction and demolition - activity data not currently available
- PM from food and beverages industry - lack of emission factors.
- Emissions from some other product uses have not been estimated, e.g. use of Shoes, inks and glue.

1.7.3 Agriculture (NFR 3)

- NO_x, NMVOC and NH_3 emissions for all categories within 3D (other than inorganic N fertilizers and Urine and dung deposited by grazing animals)

1.7.4 Waste (NFR 5)

- Some pollutants originating from composting
- PAH and PCB emissions from hazardous and clinical waste incineration.
- HCB and IPy from open burning of waste (including bonfires).
- Waste water handling
- HCB and PCB emissions from accidental fires.

1.7.5 Categories reported as Included Elsewhere (IE)

The table below indicates the categories where the notation key IE has been used in the reporting for some or all pollutants.

Table 1.2 Categories included elsewhere (2015 emission estimates)

NFR category		Pollutants	Reported under (NFR)	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	Dioxin	**2C1**	Iron and steel production
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	Dioxin	**2C3**	Aluminium production
1A4bii	Residential: Household and gardening (mobile)	NOx, NMVOC, SOx,NH3, PM,CO, Dioxin, PAH, HCB	**1A4ai**	Stationary combustion: Commercial/institutional
1A4ci	Agriculture/Forestry/Fishing: Stationary	NOx, $PM_{2.5}$, BC, CO, Dioxin, PAH, HCB	**1A4ai**	Stationary combustion: Commercial/institutional
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	NOx, NMVOC, SOx,PM, BC, CO, Dioxin, PAH, HCB	**1A2gviii**	Stationary combustion: Commercial/institutional
5C1bi	Industrial waste incineration	Dioxin	**5C1a**	Mobile combustion in manufacturing industries and construction
5C1bii	Hazardous waste incineration	Dioxin	**5C1a**	Municipal waste incineration
5C1biii	Clinical waste incineration	Dioxin	**5C1a**	Municipal waste incineration
5C1biv	Sewage sludge incineration	Dioxin	**5C1a**	Municipal waste incineration

1.8 Structure of the report

The report is divided into 8 chapters. Chapter 1 provides general information on the institutional arrangements for inventory preparation, inventory preparation process, methodologies and data sources used, key source categories and quality assurance and quality control. Chapter 2 provides information on trends in emissions and Chapters 3 to 7 provide information on emission trends by sector, activity data and methodologies used for emission calculations by sector. Chapter 8 contains information on spatially distributed emissions within the EMEP-grid.

1.9 Recalculations and improvements

The 2017 submission includes for the first time estimates of PCB and heavy metals wherever activity data allowed such calculations.

In the energy sector, until last year available activity data necessary for estimating emissions from civil aviation could not been divided into landing and take-off (LTO) and cruise, and all emissions were included into the aviation memo items. Thus, LTO emissions were missing from the national totals. For this year's submission, the Eurocontrol emission dataset was used for the first time, which allowed a proper estimation of LTO vs. Cruise emissions, and the inclusion of LTO in national totals. HCB, PCB, Particulate matter and heavy metal emissions from national navigation, national fishing and international navigation were estimated for the first time in this submission.

Also for the first time in this year's submission, data was acquired and used in the road transport model COPERT to estimate emissions of heavy metals and PM from 2000. See more details on the recalculations in Section 3.6.2.

Main changes in the Industry sector include the addition of PCB from secondary steel production, PM and NH_3 from mineral wool production, heavy metals from ferroalloy production, Cu and heavy metals from Tobacco. Furthermore, for the first time emissions from fireworks are included, with estimates of SO_2, CO, NO_x, PM and heavy metals.

Significant changes were made in the organization and set up of the calculation files in the agriculture sector, along with minor changes in methodology.

In the waste sector, significant changes were made from the 2016 submission. These changes include, amongst other, splitting up of municipal solid waste incineration into appropriate subcategories, reporting of open pit burning and bonfires under the appropriate category with revised emission factors, and reporting of POPs and heavy metals from sources previously not estimated.

Subsector-specific recalculations and changes are discussed under the relevant sectors.

1.10 Planned improvements

Improvements in the energy sector include a revision of emission factors used in navigation/fishing industry to update to the newest available emission factors. For road transportation, planned improvements include the estimation of non-estimated sources and acquiring comprehensive data for the vehicle fleet to further facilitate the use of the transport model COPERT.

Improvements in the industry sector include a revision of all emission factors currently taken from the revised 1996 IPCC Guidelines, to update them to the most current emission factors. This will potentially impact the NOx, NMVOC and CO of ferroalloy production. Other planned improvement is to add emission estimates for 2A5a Quarrying and mining of minerals other than coal and 2A5b Construction and Demolition.

There are plans to review digestible energy content for both cattle and sheep in order to reflect changes that have occurred in animal nutrition since 1990. Gross energy intake and average animal weight for cattle and sheep will also be reviewed and updated if necessary. This might have changed since data was last updated in view of changes in feed and breeding.

For the waste sector, several improvements are suggested for each subsector and this includes a review of the activity data used in the calculations and PCB and HCB estimations for open burning of waste (NFR 5C2). Further improvements are given under each subsector in Chapter 6.

Another planned improvement consists of adding a comprehensive uncertainty analysis, as described above (Paragraph 1.6).

2 Trends in Emissions

2.1 Emission Profile in Iceland

The emissions profile for Iceland is unusual in some respects. Firstly, emissions from generation of electricity and space heating are very low owing to the use of renewable energy sources. Almost all electricity in Iceland is produced with hydropower (approx. 70% in 2015) and geothermal power (approx. 30% in 2015), with wind power and fossil fuel-derived power accounting for less than 0.1% (0.05 and 0.01%, respectively, according from data from the NEA. Furthermore, geothermal energy sources are used for space heating (in over 90% of all homes). It should be noted, though, that significant amounts of sulphur as hydrogen sulfide (H_2S) are emitted from geothermal power plants. Secondly, 89% of the fuel used in the energy sector is used by mobile sources (transport, mobile machinery and fishing vessels). Thirdly, emissions from industrial processes, especially from non-ferrous metal production, have a higher share in Iceland than in most other countries. This can be seen in the fact that around 75% of the electricity produced in Iceland in 2015 was used in the metal production industry. The production capacity has increased considerably since 1990. In 1990, 87.8 kt of aluminium were produced in one primary aluminium plant and 62.8 kt of ferrosilicon in one ferrosilicon plant. In 1998 a second primary aluminium plant was established and a third in 2007. In 1999 a third furnace was added to the ferrosilicon plant. In 2004, a secondary aluminium smelter opened, followed by a second one in 2012. In 2015, 857.3 kt of aluminium were produced at three primary aluminium plants, 2.2 kt of aluminium at two secondary aluminium plants, and 117.9 kt of ferrosilicon at the ferrosilicon plant.

The emissions profile in Iceland is further influenced by the fact that Iceland was severely hit by an economic crisis late year 2008, when its three largest banks collapsed. The blow was particularly hard owing to the large size of the banking sector in relation to the overall economy as it had grown to be ten times the annual GDP. The crisis resulted in a serious contraction of the economy, a depreciation of the Icelandic króna (ISK), and a drastic increase in external debt. This has led to contraction in private consumption, higher fuel prices and contraction of the construction sector.

2.2 Emission Trends for Persistent Organic Pollutants (POPs)

The Protocol on Persistent Organic Pollutants (POPs) was adopted on 24 June 1998. It entered into force on 23 October 2003. It focuses on a list of 16 substances that have been singled out according to an agreed risk criteria. The substances comprise eleven pesticides, two industrial chemicals and three by-products/contaminants. The ultimate objective is to eliminate any discharges, emissions and losses of POPs. The Protocol bans the production and use of some products outright (aldrin, chlordane, chlordecone, dieldrin, endrin, hexabromobiphenyl, mirex and toxaphene). Others are scheduled for elimination at a later stage (DDT, heptachlor, HCB, PCB). Finally, the Protocol severely restricts the use of DDT, HCH (including lindane) and PCBs. The Protocol includes provisions for dealing with the wastes of products that will be banned. It also obliges Parties to reduce their emissions of dioxins, furans, PAHs and HCB below their levels in 1990 (or an alternative year between 1985 and 1995). For the incineration of municipal, hazardous and medical waste, it lays down specific limit values. Aldrin, chlordane, chlordecone, dieldrin, endrin, hexabromobiphenyl, mirex and toxaphene have never been produced in Iceland. Of these chemicals only aldrin has been used in Iceland, though not since 1975. DDT and heptachlor have not been used in Iceland since 1975 and were banned with a regulation in 1996. Lindane (HCH) was used in Iceland until the early nineties.

Sales statistics exist for 1990 to 1992, and the use of lindane was banned in 1999. PCB was banned in Iceland in 1988.

The total amount of dioxins PAH4, HCB and PCB emitted in Iceland in 1990 and 2015 is presented in Table 2.1 Emissions of POPs in Iceland 1990 and 2015. Dioxin emissions have decreased by 89% and PAH4 emissions by 82% from 1990 to 2015. HCB and PCB emissions have increased significantly, by 246% for HCB and 201% for PCB, during the same period.

Table 2.1 Emissions of POPs in Iceland 1990 and 2015.

Year	Dioxin [g I-TEQ]	PAH4 [t]	HCB [kg]	PCB [kg]
1990	12.52	0.52	0.02	0.03
2015	1.37	0.09	0.08	0.09
Trend 1990-2015	**-89%**	**-82%**	**246%**	**201%**

The trends in total POPs emissions relative to 1990 emissions is shown in Figure 2.1. A decreasing trend is observed for dioxin and PAH4 emission estimates while an increase is observed for HCB and PCB. Important to not here is that HCB and PCB emissions are not estimated from open burning of waste due to the lack of emission factors in the EMEP/EEA guidebook. This is expected to affect these trends significantly. Furthermore, HCB and PCB emission estimates is done for a few sources only and these trends should therefore be interpreted with care. It is expected for these trends to change as more sources are estimated.

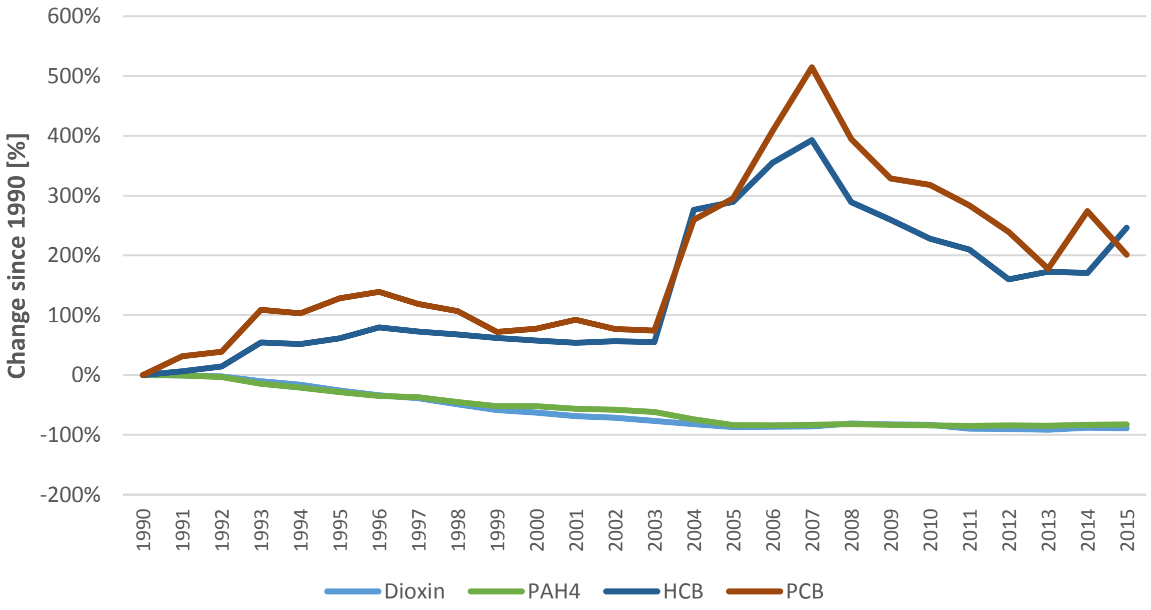

Figure 2.1 Trends in total POPs emissions 1990-2015 (% of 1990 emissions).

2.2.1 Trends in dioxin emissions

Dioxins form a family of toxic chlorinated organic compounds that share certain chemical structures and biological characteristics. Dioxins are members of two closely related families: the polychlorinated dibenzo(p)dioxins (PCDDs; 75 congeners) and polychlorinated dibenzofurans (PCDFs; 135 congeners). Dioxins bio-accumulate in humans and wildlife due to their fat solubility and 17 of these compounds are especially toxic. Dioxins are formed during combustion processes such as commercial or municipal waste incineration and from burning fuels like wood, coal or oil. Dioxins can also be formed in natural processes such as forest fires. Dioxins also enter the environment through the production and use of organochlorine compounds, chlorine bleaching of pulp and paper, certain types of chemical manufacturing and processing and other industrial processes that create small quantities of dioxins. Cigarette smoke also contains small amounts of dioxins.

Emissions of dioxins are presented in g I-TEQ (International Toxic Equivalents). 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is the most toxic of the dioxin congeners. Other congeners (or mixtures thereof) are given a toxicity rating from 0 to 1, where TCDD is 1. The total dioxin toxic equivalence (TEQ) value expresses the toxicity as if the mixture were pure TCDD.

In 1990, the total emissions of dioxins in Iceland were 12.52 g I-TEQ. In 2015 total emissions were 1.37 g I-TEQ. This implies a decrease of 89% over that time period. Figure 2.2 shows the dioxin emissions by source from 1990 to 2015.

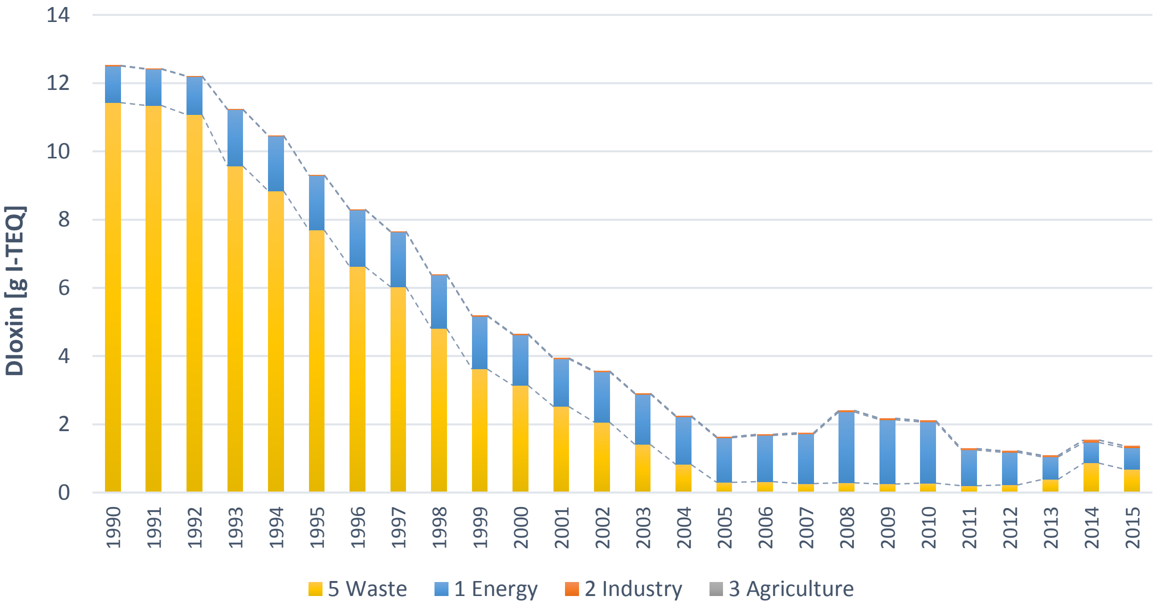

Figure 2.2 Dioxin emissions 1990-2015 by sector.

Figure 2.3 shows the main sources of dioxin emissions in 1990 and 2015. The main reason for the significant reduction of dioxin emissions are reduced emissions from waste incineration. In 2015 the waste sector was the source of 50% of the dioxin emissions. Most of the dioxin emissions in the waste sector come from waste incineration. Other important sources under the waste sector are bonfires and accidental fires. The energy sector (46%) is the second largest dioxin contributor, commercial fishing being the largest source within that sector. It is worth mentioning that transport (energy sector) and industrial processes (industry) are only responsible for 4% each of the total dioxin emissions.

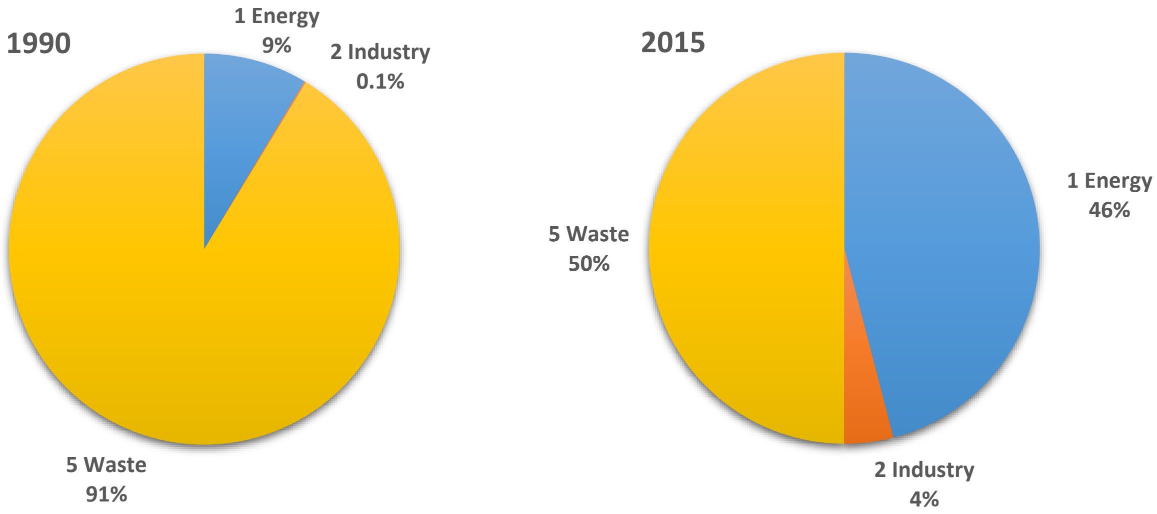

Figure 2.3 Dioxin emission shares by sector, 1990 and 2015.

Practices of waste disposal treatment have undergone a radical change in Iceland since 1990. This is the main reason for the decline in dioxin emissions by 89% from 1990 to 2015. Open pit burning that used to be the most common means of waste disposal outside the capital area, has gradually decreased since 1990. At the same time the total amount of waste being incinerated has decreased while increasing levels were incinerated with energy recovery (reported under 1A1a and 1A4). In the last years those incineration plants have been closed down one by one. At the end of 2015 only one incineration plant was operating in Iceland. The incineration plant is called Kalka and it does not recover energy. Open pit burning is practically non-existent today, the last site was closed by the end of 2010. Emissions from bonfires around New Year celebrations are included in the waste incineration sector. Emissions from bonfires have decreased since 1990, due to the fact that bonfires are fewer and better controlled. Guidelines for bonfires, published in 2000, include restrictions on size, burnout time and the material allowed.

Dioxin emissions from electricity generation and space heating are very low because they are generated from renewable energy sources. Emissions in this sector are dominated by emissions from waste incineration with energy recovery, which are reported under 1A1a and 1A4.

Dioxin emissions from road transport decreased by 90% between 1990 to 2015 despite an increase in the number of vehicles and 56% increase in fuel consumption. This is due to the phase-out of leaded fuel.

Emissions have decreased since 1990 from the fishing sector as well as from the other transport sector due to less fuel consumption in these sectors. For commercial fishing this decline amounted to 39%. Emissions from commercial fishing are high compared to the fuel consumption. The emission factors for burning fuel at sea are much higher than when burning fuel on land, due to the presence of salt (and therefore chlorine) in the air going to the engines. In 1990, emissions from commercial fishing were 7% of the national total. In 2015, emissions from commercial fishing amounted to 42% as emissions from most other sources have decreased drastically since 1990.

Dioxin emissions from industrial processes sector have increased by 251% during the period due to increased activity in the metals production sector. Aluminum production has increased from 87,839 tonnes in 1990 to 857,319 tonnes in 2015, and ferrosilicon has increased from 62,792 tonnes to

117,949 tonnes in the same period. A secondary steel making facility opened in 2014, contributing to a large percentage of the dioxin emissions from the industry sector.

A peak in emissions from accidental fires can be seen in 2004 when a major fire broke out at a recycling company (Hringrás). In the fire 300 tonnes of tires, among other separated waste materials, burned. A fire broke out in the same company in 2011 and was estimated to be 10% the size of that in 2004. In 2014, a major fire broke out in an industrial laundry service when, among other materials, around 60-80 tons of asphalt roll roofing burned.

2.2.2 Trends in polycyclic aromatic hydrocarbons (PAHs) emissions

The polycyclic aromatic hydrocarbons (PAH) are molecules built up of benzene rings which resemble fragments of single layers of graphite. PAHs are a group of approximately 100 compounds. Most PAHs in the environment arise from incomplete burning of carbon-containing materials like oil, coal, wood or waste. Fires can produce fine PAH particles; they bind to ash particles and sometimes move long distances through the air. Thus, PAHs have been ubiquitously distributed in the natural environment for thousands of years. The four compounds benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene are used as PAH indicators for the purposes of emission inventories, as specified in the POP - Protocol.

In 1990, the total emissions of PAH4 in Iceland were 515.1 kg. In 2015 total emissions were 90.3 kg. This implies a decrease of 83% over the time period. Figure 2.4 shows the emissions by source from 1990 to 2015.

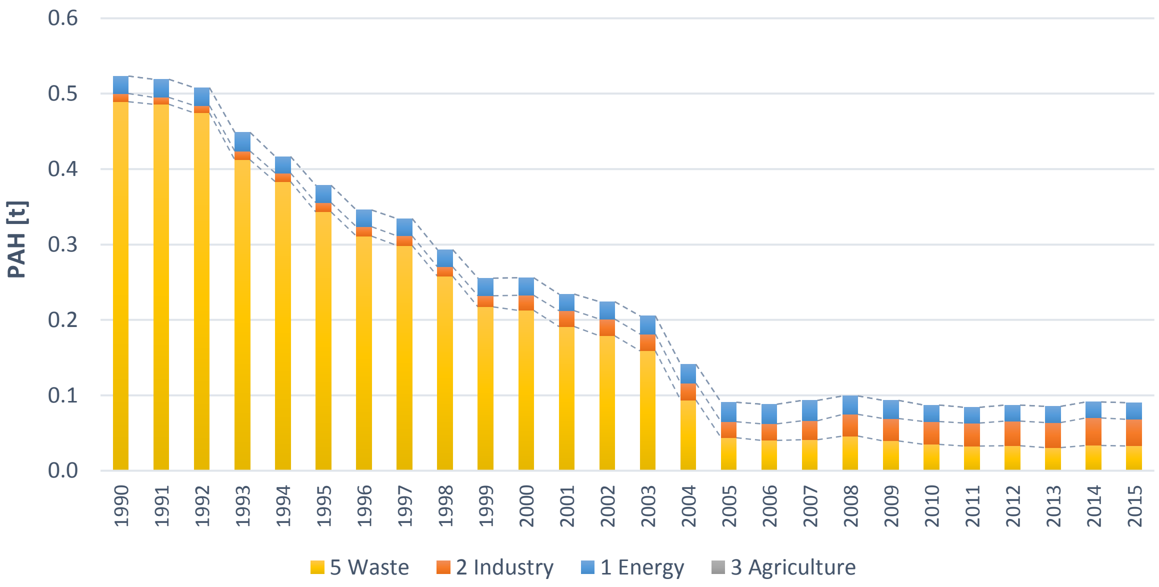

Figure 2.4 PAH4 emissions 1990-2015 by sector.

The main reasons for the reduction in PAH4 emissions since 1990 is decreased emissions from waste incineration. Since 2005 PAH4 emissions from industrial processes (Industry) have increased due to increased production capacity in the non-ferrous metals production sector.

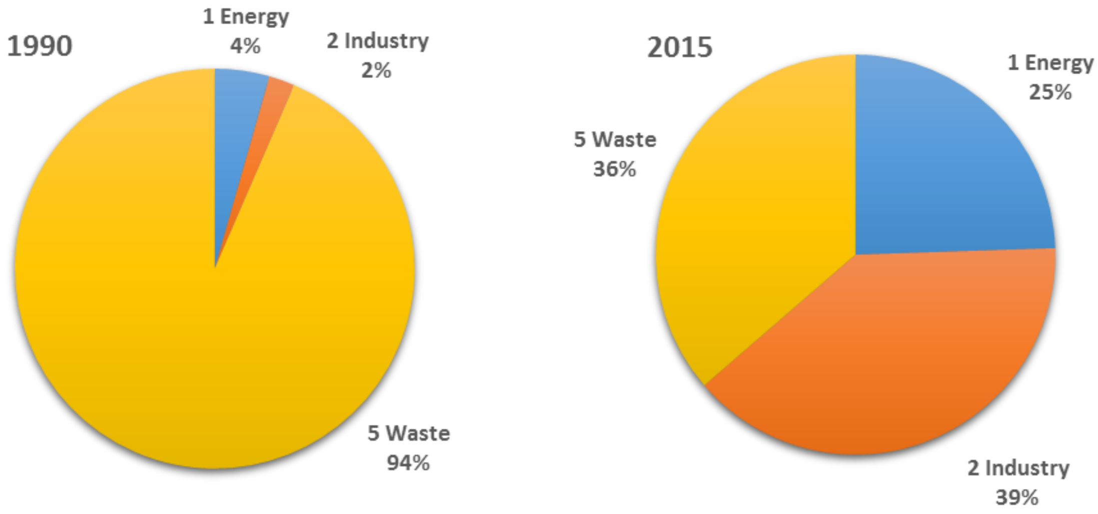

Figure 2.5 PAH4 emission shares by sector, 1990 and 2015.

As mentioned above, the production capacity in the metal production sector has increased substantially in recent years. The main increase in emissions happened in the years 1998-2000 as well as in 2006-2008. Between 1998 and 2000 the increase in emissions was due to increased production capacity both in the aluminium and the ferrosilicon industry. In the years 2006-2008 the cause was increased production capacity in the aluminium industry.

By the mid 1990’s economic growth gained momentum in Iceland. Iceland experienced until 2007 one of the highest growth rates of GDP among OECD countries. Late year 2008, Iceland was severely hit by an economic crisis and three of Iceland’s largest banks collapsed. The crisis resulted in serious contraction of the economy, followed by increased unemployment and a depreciation of the Icelandic króna. The increase in GDP from 1990 to 2007 resulted in higher emissions from most sources, in particular from road transport and the construction sector. The crisis led to collapse of the construction sector in the autumn 2008. PAH4 Emissions from the manufacturing industries & construction sector were 53% lower in 2015 than in 2007.

Road transport is also an important source of PAH4 emissions in Iceland. PAH4 emissions are estimated to have increased by around 100% since 1990. Accidental fires are an important source of PAH4 emissions in Iceland. Emissions from accidental fires were 35% higher in 2015 than in 1990. A peak in emissions from accidental fires can be seen in 2008 when unusually many vehicle fires were registered.

PAH4 Emissions from commercial fishing rose from 1990 to 1996 because a substantial portion of the fishing fleet was operating in distant fishing grounds, consuming more fuel. From 1996 the emissions decreased again reaching 1990 levels in 2004, and have been generally following the same decreasing trend since then. In 2015, the emissions were around 30% below 1990 levels.

PAH4 Emissions from the waste incineration have decreased by around 95% from 1990 to 2015, partly because primitive incineration plants and open pit burning were closed down.

2.2.3 Trends in hexachlorobenzene (HCB) emissions

Hexachlorobenzene (HCB) or perchlorobenzene is a chlorocarbon with the molecular formula C_6Cl_6. HCB is a fungicide that was first introduced in 1945 for seed treatment, especially for control of bunt of wheat. HCB is currently emitted as a by-product in the manufacture of several chlorinated solvents. On the whole, processes resulting in dioxin formation also result in HCB emissions. HCB is considered to be probable human cancerogen. HCB is a very persistent environmental chemical due to its chemical stability and resistance to biodegradation. Analysis of trends in HCB emissions in Iceland must be interpreted with care as only few sources have been estimated and emissions from open pit burning are not estimated between 1990 and 2003, due to lack of emission factors thus HCB emissions estimates from the waste sector are almost non-existing during 1990-2003. In 1990, the total estimated emissions of HCB in Iceland were 21.7 g. In 2015 total emissions were 75.3 g. This implies an increase of 246%% over the time period, which is not likely to reflect the real trend since 1990, as emissions from open burning are missing. If HCB emissions from 2004 and 2015 are compared, it implies a decrease of 8%. Figure 2.6 represents the trend in estimated HCB emissions by source from 1990 to 2015.

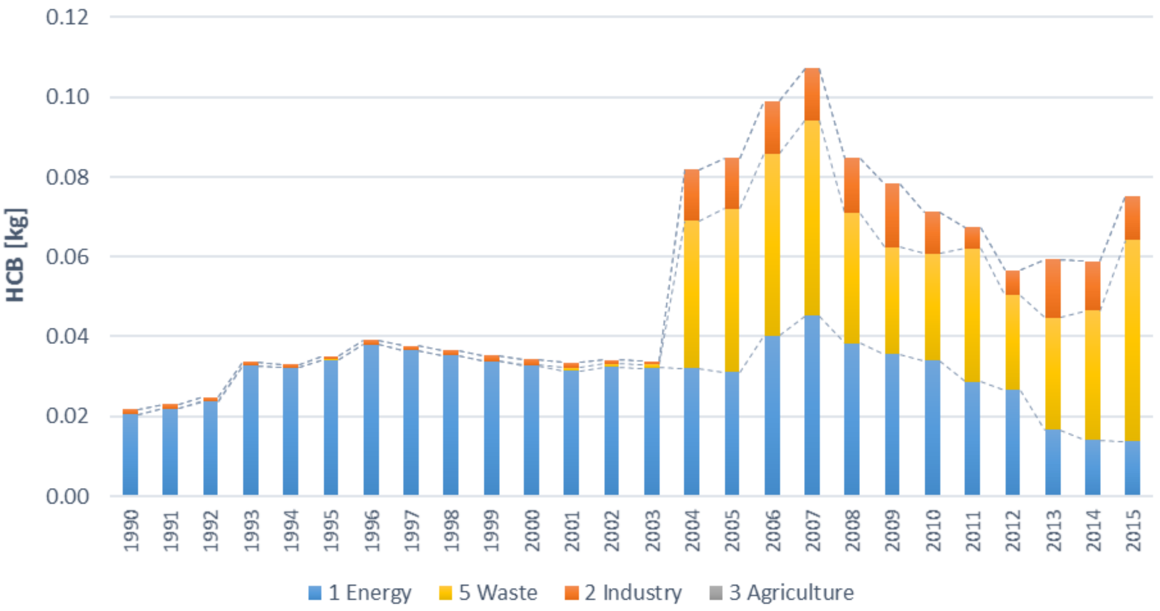

Figure 2.6 HCB emissions 1990-2015 by sector (estimates for waste missing 1990-2003).

The main sources of estimated HCB emissions are waste incineration with and without energy recovery and industrial processes (secondary aluminum production and cement production). A sudden increase in HCB emissions from industrial processes is seen in 2004 when a secondary aluminum production plant was established. From 2009, production started decreasing, until 2013 where another secondary production plant opened, reversing the decreasing trend. As shown in Figure 2.6, waste was responsible for 67% of the estimated HCB emissions in Iceland in 2015. The reduction of HCB emissions in the energy sector is explained by a shut-down of four waste incineration plants with energy recovery on the period 2012-2015.

2.2.4 Trends in polychlorinated biphenyl (PCB) emissions

PCB emissions in Iceland 1990-2015 where estimated for the first time for this submission. Emission estimates for the waste sector during the years 1990-2003 have not been included, as they are represented as NA for open bit burning in the guidelines (EEA, 2016). The only source of PCB estimated from industrial processes is secondary steel production (2C1). The only secondary steel plant in Iceland started its activities in 2014; In 2015, production was much less than in the year before, leading to a decrease in PCB emissions.

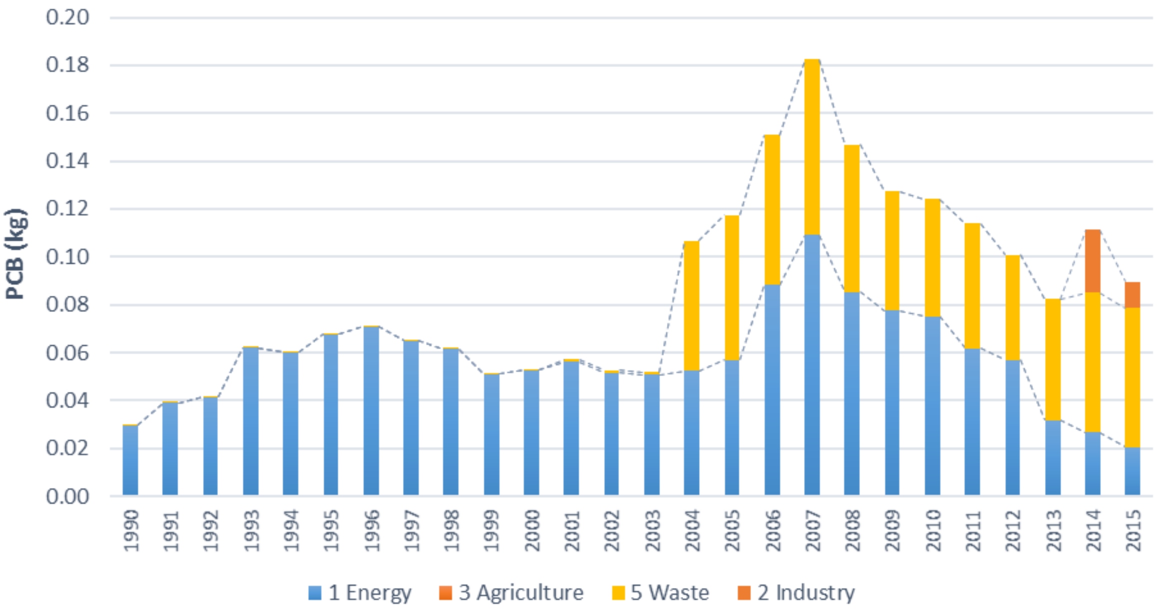

Figure 2.7 PCB emissions 1990- 2015 by sector (estimates for waste missing 1990-2003).

2.2.5 Trends in persistent organic pollutants (POPs) by main source sectors

POPs emissions trends in the energy sector are shown in Figure 2.8 as a percentage of the 1990 levels. Figure 2.9 shows the trends in the contribution of POPs emissions from the sector from 1990 - 2015. In 2015 the energy sector contributed to 46% and 24% of total dioxin and PAH4 emissions, respectively. The contribution of the energy sector to the total PAH4 emissions has decreased since 1990 even though the emissions have increased over the same period of time.

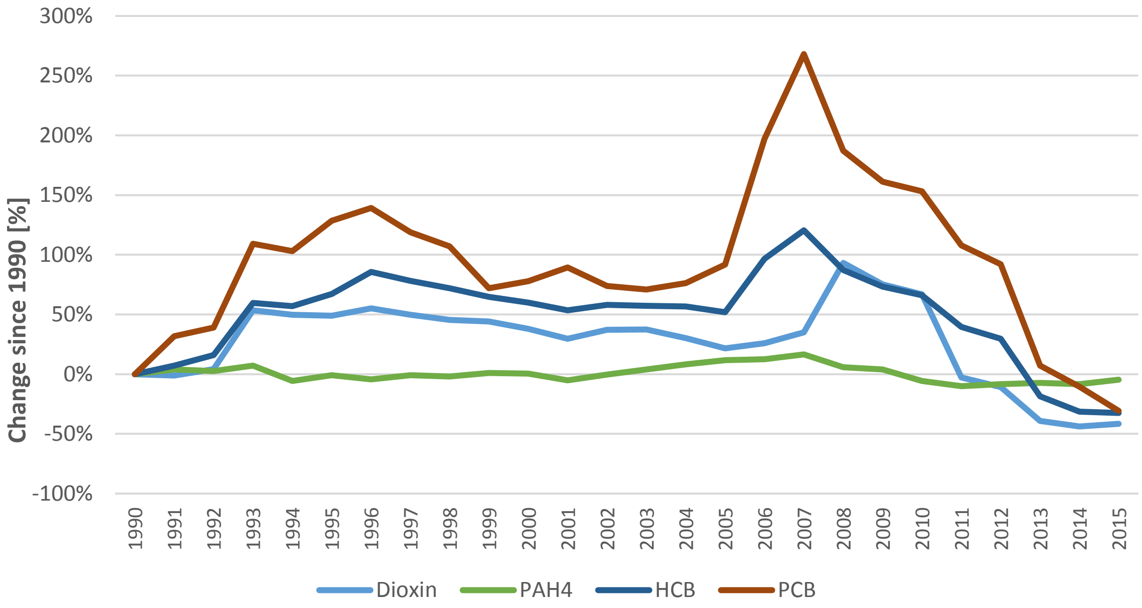

Figure 2.8 Trends in POPs emissions from the energy sector 1990-2015 (% of 1990 levels).

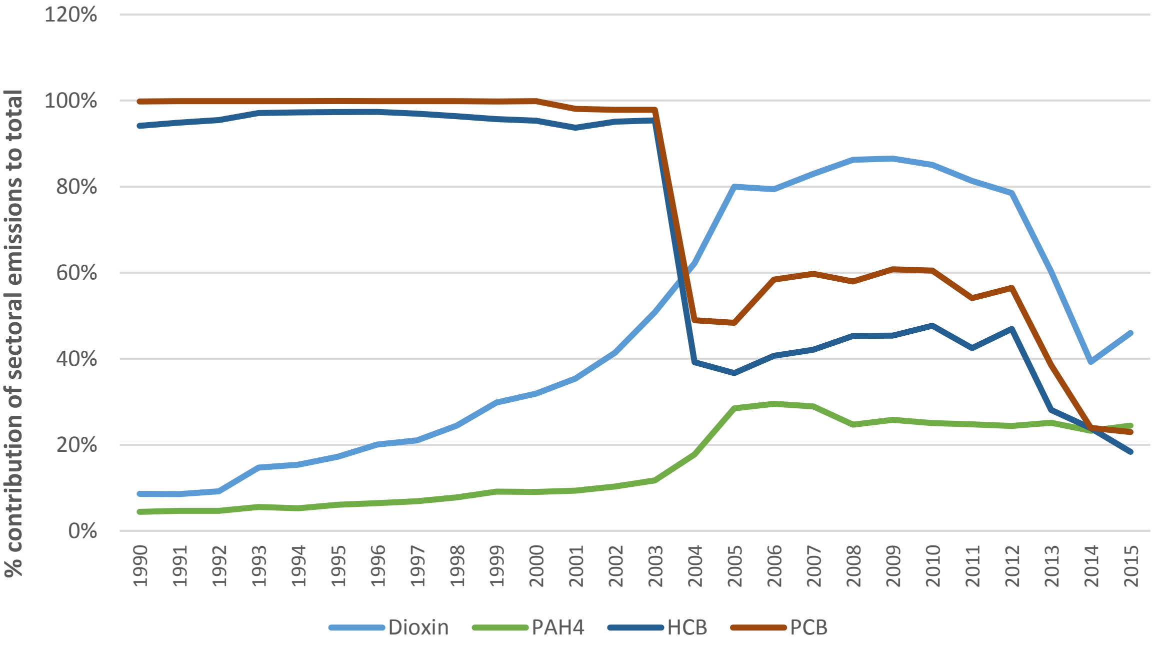

Figure 2.9 Trends in the contribution of POPs emissions from the energy sector (% of total pollutant emissions).

POPs emissions trends in the industrial sector are shown in Figure 2.10 as a percentage of the 1990 levels. Figure 2.11 shows the trends in the contribution of POPs emissions from the industrial sector from 1990-2015. In 2015 the industrial sector contributed 39% of total PAH4 emissions, 15% of total HCB emissions, 4% of total dioxin emissions and 12% of total PCB emissions. The industrial sector has not reduced its emissions of any POPs pollutant since 1990. The contribution of the sector in the total PAH4 emissions has been steadily increasing from 30% in 1990 to around 50% in 2015. The large increase in HCB emissions from 2004-2009 leads to a contribution of the industrial sector of around 20% over that period.

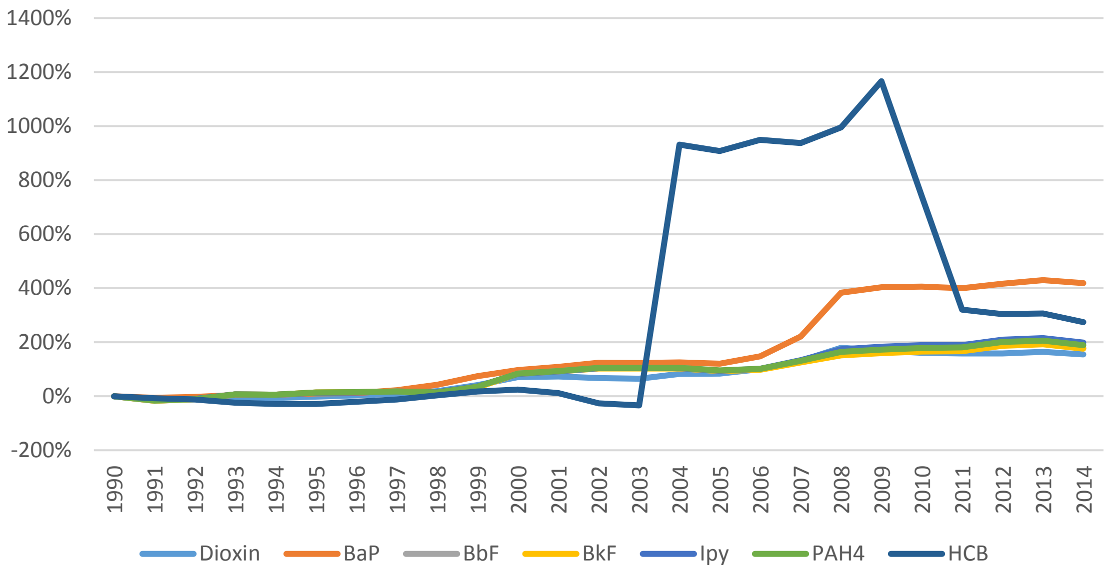

Figure 2.10 Trends in POPs emissions from the industrial sector 1990-2015 (% of 1990 levels).

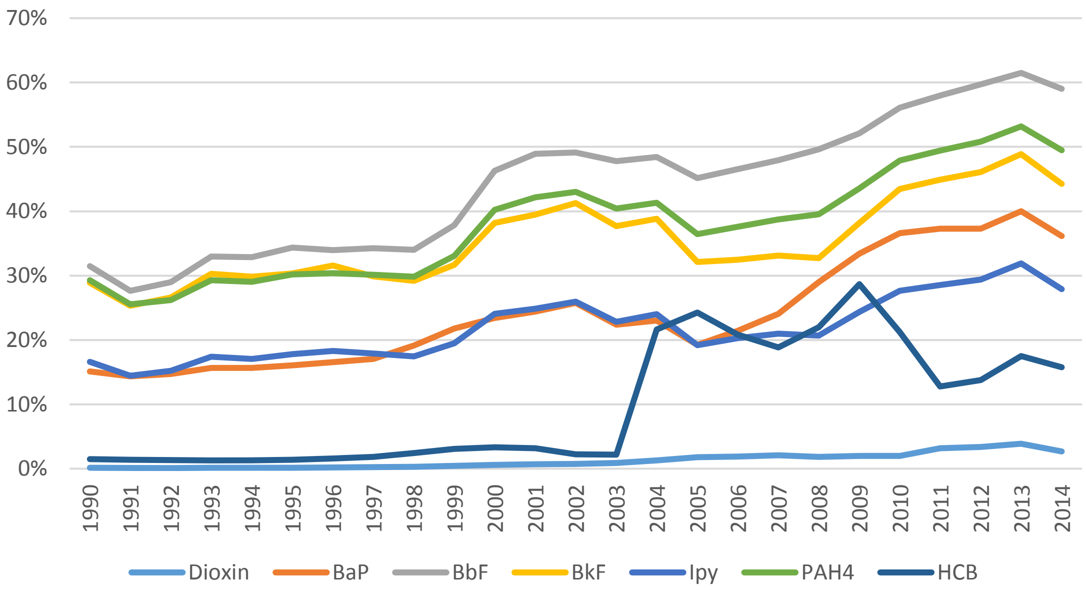

Figure 2.11 Trends in the contribution of POPs emissions from the industrial sector (% of total pollutant emissions).

POPs emissions trends in the waste sector are shown in Figure 2.12 as a percentage of the 1990 levels. Figure 2.13 shows the trends in the contribution of POPs emissions from the sector from 1990-2015. In 2015 the waste sector contributed to 67% of total HCB emissions, 50% of total dioxin emission, 36% of total PAH4 emissions and 65% of total PCB emissions. HCB and PCB emission estimates from the waste sector are, as mentioned previously, due partly to the lack of emission factors for open burning of waste. Furthermore, PCB and HCB emissions are estimated for a few number of sources only and are therefore not presented in the figure.

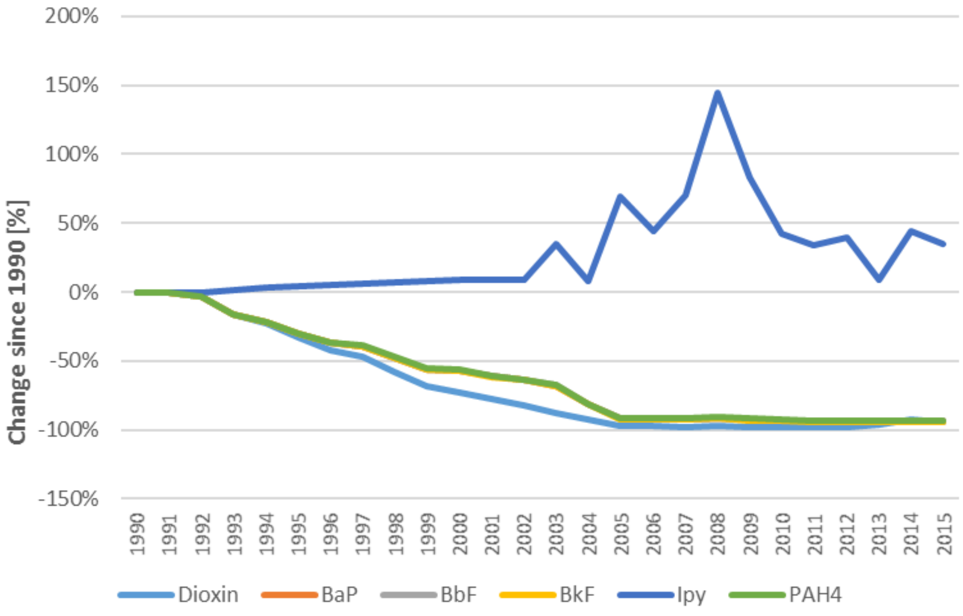

Figure 2.12 Trends in POPs emissions from the waste sector 1990-2015 (% of 1990 levels).

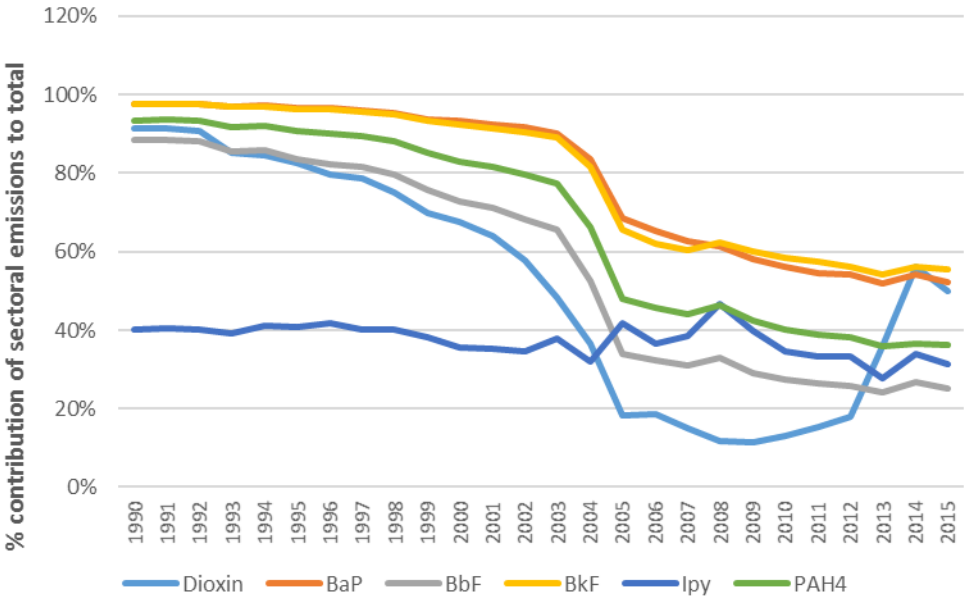

Figure 2.13 Trends in the contribution of POPs emissions from the waste sector (% of total pollutant emissions).

No POPs emissions are occurring in Iceland from categories belonging to the agricultural sector.

2.3 Emission Trends for NO_X, NMVOC, SO_X, NH_3, Particulate Matter, BC and CO

Nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), ammonia (NH_3) and particulate matter (TSP, PM_{10}, $PM_{2.5}$) have an adverse effect on human health and the environment. Iceland implemented the National Emission Ceiling Directive 2001/81/EC into its legislation in 2009, with emission target reductions for NOx, SO_2, NMVOC and NH_3, to be reached by 2010. These pollutants are reported here. Furthermore, emissions of NO_x, CO, NMVOC and SO_2 are also calculated to comply with the reporting requirements of the UNFCCC. For this submission emission estimates for ammonia and particulate matter are provided for a few emission sources. A short description of the trends of those pollutants is given in the following section.

The total amount of SO_2, NO_X, NH_3, NMVOC, CO, PM_{10}, $PM_{2.5}$ and TSP emissions in Iceland in 1990 and 2015 is presented in Table 2.2. The most increase in emissions from 1990 to 2015 are emissions of SO_2 which have increased by 169% during that time period.

Table 2.2 Emissions of SO_2, NO_x, NH_3, NMVOC, CO and PM in 1990 and 2015.

	NO_X [kt] NO_2	**NMVOC [kt]**	**SO_X [kt] SO_2**	**NH_3 [kt]**	**$PM_{2.5}$ [kt]**	**PM_{10} [kt]**	**TSP [kt]**	**BC [kt]**	**CO [kt]**
1990	28.12	14.28	20.93	5.77	0.89	1.12	1.20	0.12	57.6462
2015	21.06	6.98	56.31	5.58	1.23	1.60	1.66	0.19	119.2971
Trend 1990-2015	**-25%**	**-51%**	**169%**	**-3%**	**39%**	**43%**	**38%**	**58%**	**107%**

The emission trends of the total NO_x, NMVOC, SO_2, NH_3, CO, $PM_{2.5}$, PM_{10} and TSP emissions relative to 1990 levels is shown in Figure 2.14. The emissions of SO_2 (H_2S emissions as SO_2 for emissions from geothermal plants) has increased significantly since 1990 levels or by around 169%. CO emissions have increased by around 100% since 1990. The most significant decrease in emissions are NMVOC emissions which have decreased by 51% since 1990 levels.

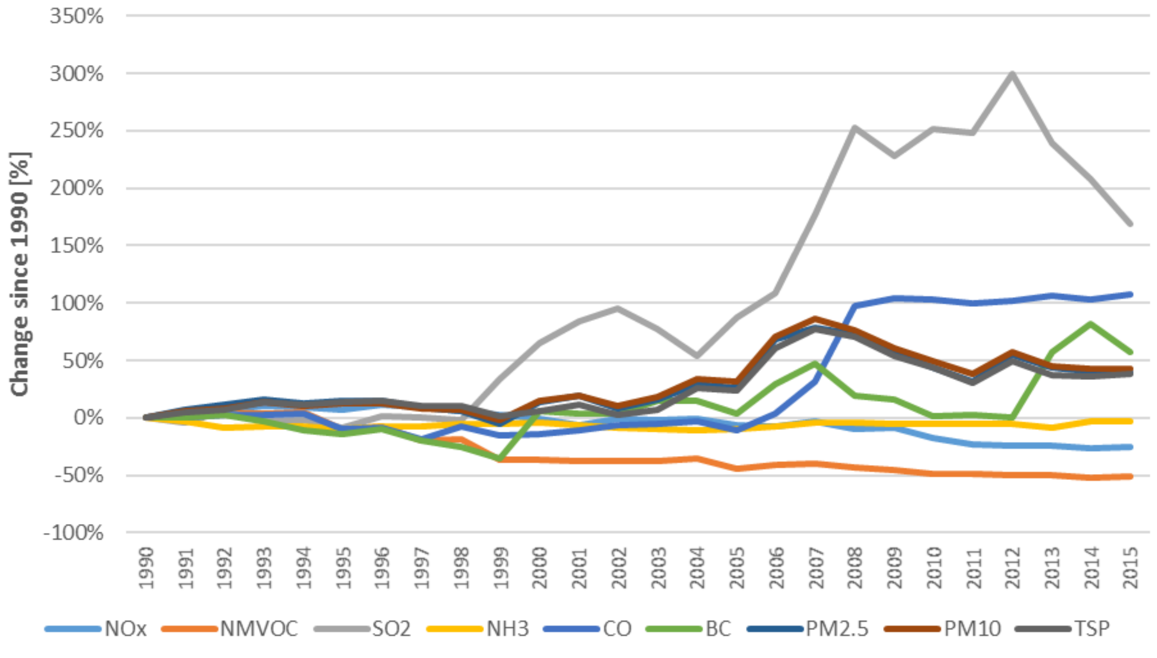

Figure 2.14 Trends in NO_x, NMVOC, SO_2, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC and CO emissions 1990-2015 (% of 1990 emissions).

In 2015 the emissions of all pollutants included in the NECD 2001/81/EC were below the emission maxima set by the NECD: For SO_2, the target was 90 kt and was never exceeded during the reporting period; For NOx, the maximum allowed was 27 kt, and the emissions have been below that value since 2008; For NMVOC, the maximum allowed was 31 kt, and the emissions have been decreasing steadily since 1994, where the maximum NMVOC emissions occurred (15 kt in that year); The NH_3 emissions have been stable between 5 and 6 kt since 1990, below the maximum allowed of 8 kt. As of March 2017, the implementation of the new NECD into the EEA agreement (Directive 2016/2284 - entered into force in 2016 for member states) is being discussed by the Icelandic government, but no new emission targets have been set.

2.3.1 Trends in sulphur oxides (SO_x) emissions

SOx emissions include all forms of sulfur, including reduced species such as H_2S. Geothermal energy exploitation is by far the largest source of Sulphur emissions in Iceland. Sulphur is emitted from geothermal power plants in the form of H_2S and the emissions have increased by 204% since 1990 due to increased activity in this field, as electricity production at geothermal power plants has increased 15-fold since 1990. The expansion of the metal production sector has been accommodated with parallel investments in increased power capacity, especially after 2005. However, in recent years the H_2S emissions from geothermal power plants have decreased because of reinjection of geothermal gases back into the geothermal system. In 2014 ON-Power commissioned a capturing station next to Hellisheiði geothermal power plant, SW Iceland. A part of the exhaust geothermal gas, primarily CO_2, H_2S, H_2, is cleaned by diverting the gas into a scrubbing unit where CO_2 and H_2S are dissolved in water. The gas-charged water is then reinjected back into the geothermal system. In 2015, 3900 tons CO_2 and 2200 tons H_2S were reinjected. The gases, once reinjected, react with the basaltic host rock in the geothermal system to form calcite and metal sulfides (pyrite, pyrrhotite).

Other significant sources of SO_2 in Iceland are industrial processes and manufacturing industry and construction (see Figure 2.15). Emissions from industrial processes are dominated by metal production. Until 1996 industrial process SO_2 emissions were relatively stable. Since then, the metal industry has expanded which has led to increased emissions of SO_2 (331% increase of SO_2 emissions from ferroalloys and aluminium production compared to 1990 levels). The fishmeal industry is the main contributor to SO_2 emissions from fuel combustion in the category Manufacturing Industries and Construction. Emissions from the fishmeal industry increased from 1990 to 1997 but have declined since as fuel was replaced with electricity and production has decreased; the emissions were 78% below the 1990 level in 2015.

Sulphur emissions from the commercial fishing fleet depend upon the use of residual fuel oil. When fuel prices go up, the use of residual fuel oil rises and the use of gas oil drops. This leads to higher Sulphur emissions as the Sulphur content of residual fuel oil is significantly higher than in gas oil. The rising fuel prices since 2008 have led to higher Sulphur emissions from the fishing fleet in recent years. Emissions from the fishing fleet in 2015 were 22% below the 1990 emissions and fuel consumption was 31% less.

In 2015 total Sulphur emissions in Iceland, calculated as SO_2, were 169% above the 1990 level, but 108% above the 1990 level when excluding emissions from geothermal power plants.

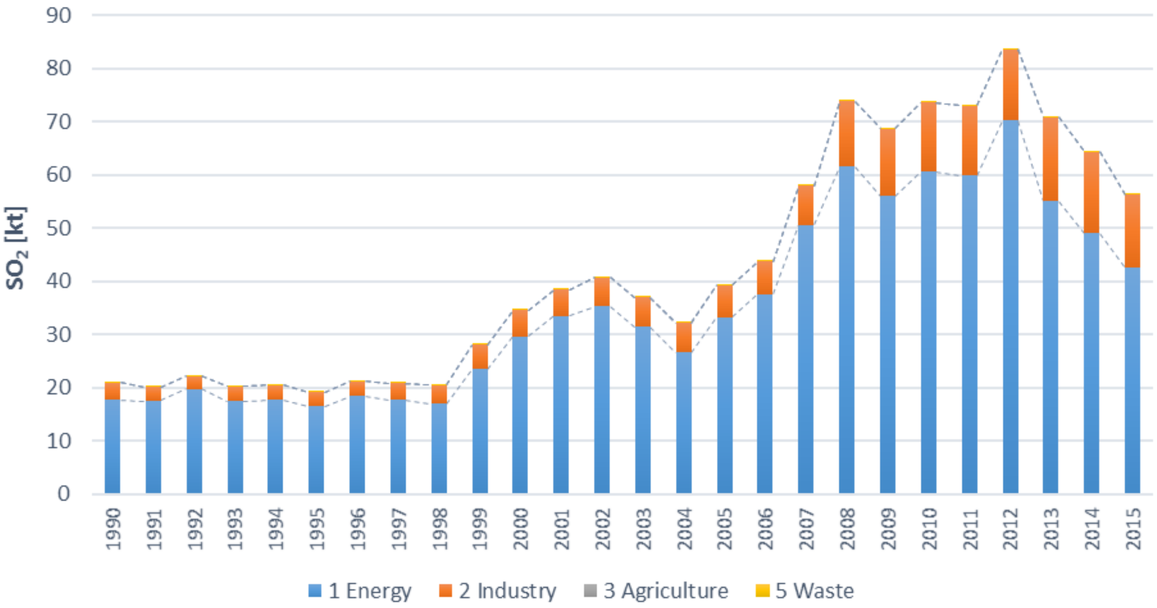

Figure 2.15 SO_2 emissions 1990-2015 by sector.

In 2010 the volcano Eyjafjallajökull started erupting. The eruption lasted from 14th of April until 23rd of May. During that time 127 kt. of SO_2 were emitted or 71% more than total man made emissions in Iceland in 2010.

In 2011 the volcano Grímsvötn started erupting. The eruption lasted from 21st until 28th of May. During that time 1000 kt. of SO_2 were emitted or 12 times more than total man made emissions in 2011.

A large eruption started in Holuhraun on August 29th 2014 and ended on February 27th 2015. It was the biggest eruption in Iceland since the Laki eruption 1783. Total SO_2 emission from this eruption was estimated 12,006 kt. Divided on calendar years 10,880 kt of SO_2 was emitted in the year 2014 and 1,126 kt of SO_2 in the year 2015. To put these numbers in in perspective it can be said that the total SO_2 emission from all the European Union countries for the year 2012 was 4,576 kt. So the emission from the eruption in the year 2014 i.e. from August 29th 2014 to December 31st 2014 was more than twice the total SO_2 emission from all the European Union countries for the whole year. For September alone, during the most intensive period of the eruption, the SO_2 emission from the eruption was similar to the annual emission of the European Union. As these emissions from volcanos are natural they are not included in national totals.

2.3.2 Trends in nitrogen oxides (NO_X) emissions

The main sources of nitrogen oxides (NO_x) in Iceland are commercial fishing, transport, and the manufacturing industry and construction (see Figure 2.16). The NO_x emissions from commercial fishing rose in the years 1990 to 1996 when a substantial portion of the fishing fleet was operating in distant fishing grounds. From 1996 emissions decreased, reaching the 1990 levels in 2001. Emissions rose again in 2002 but have declined since with exception of 2009 due to less fuel consumption. Emissions in 2015 were 31% below the 1990 level. Annual changes are inherent to the nature of fisheries. Emissions from transport are dominated by road transport. These emissions have decreased rapidly (by 20%) after the use of catalytic converters in all new vehicles became obligatory in 1995, despite the fact that fuel consumption has increased by 56%. The rise in emissions from the manufacturing industries and construction until 2007 are dominated by increased activity in the construction sector during the period. In 2015 emissions from manufacturing industry and construction (1A2) were 37% lower than in 1990. This is due to the collapse of the construction sector (including less emission from the cement plant) and to less fuel consumption at fishmeal plants as fuel has been replaced with electricity and production has decreased. Total NO_x emissions, like the emissions from fishing, increased until 1996 and decreased thereafter until 2001. Emission rose again between 2001 and 2004 and then decreased again.

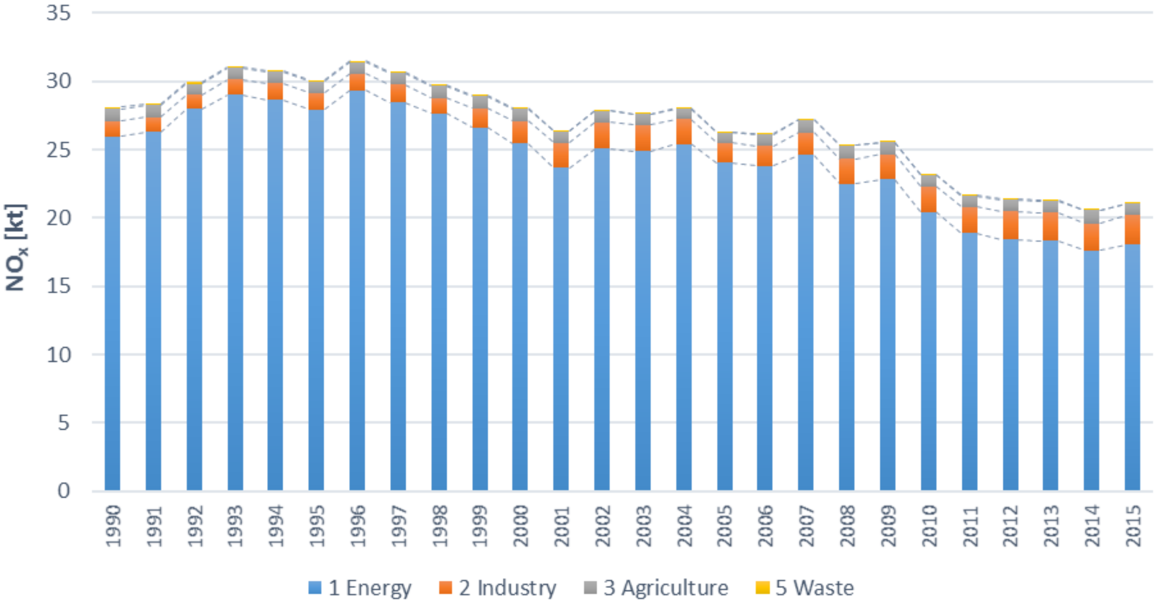

Figure 2.16 NO_X emissions 1990-2015 by sector.

2.3.3 Trends in ammonia (NH_3) emissions

Ammonia emissions (NH_3) are mostly from the agriculture sector (NFR 3). Manure management, manure deposition of grazing animals on pastures, and fertilizer application are the main sources. NH_3 emissions from the other sectors are minimal. Emissions have been fluctuating between 5 and 6 kt. NH_3 since 1990. Emissions decreased by 13% between 1990 and 2004 but have been increasing again since then. The overall trend between 1990 and 2015 was a 5% decrease. The main driver behind the general trend and its oscillations is the trend in livestock population. Sheep and cattle are the main ammonia emissions causing categories constituting more than 65% of total NH_3 emissions. NH_3 emissions from fertilizer application plays only a minor role.

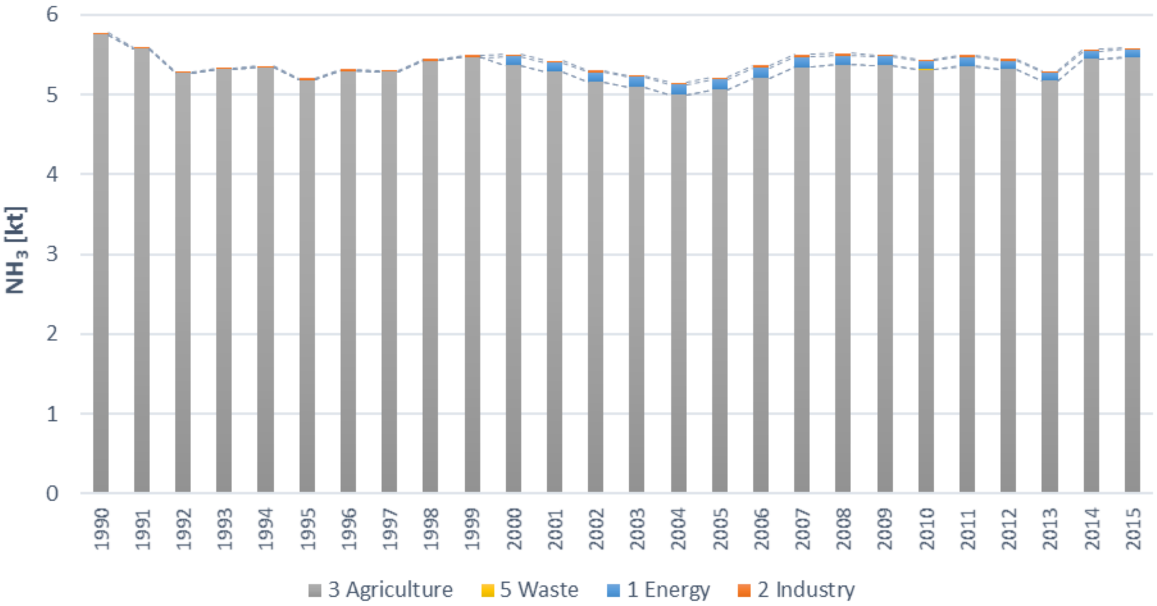

Figure 2.17 NH_3 emissions 1990-2015 by sector.

2.3.4 Trends in non-methane volatile organic compounds (NMVOC) emissions

The main sources of non-methane volatile organic compounds (NMVOC) are transport (energy sector) and solvent use (industry sector), as can be seen in Figure 2.18. Emissions from transport are dominated by road transport. These emissions decreased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995. Emissions from solvent use have been around 1 kt. and show a downward trend in recent years. Other emissions include emissions from industrial processes (industry), where food and drink production is the most prominent contributor. The total emissions showed a downward trend from 1994 to 2015. The emissions in 2015 were 51% below the 1990 level.

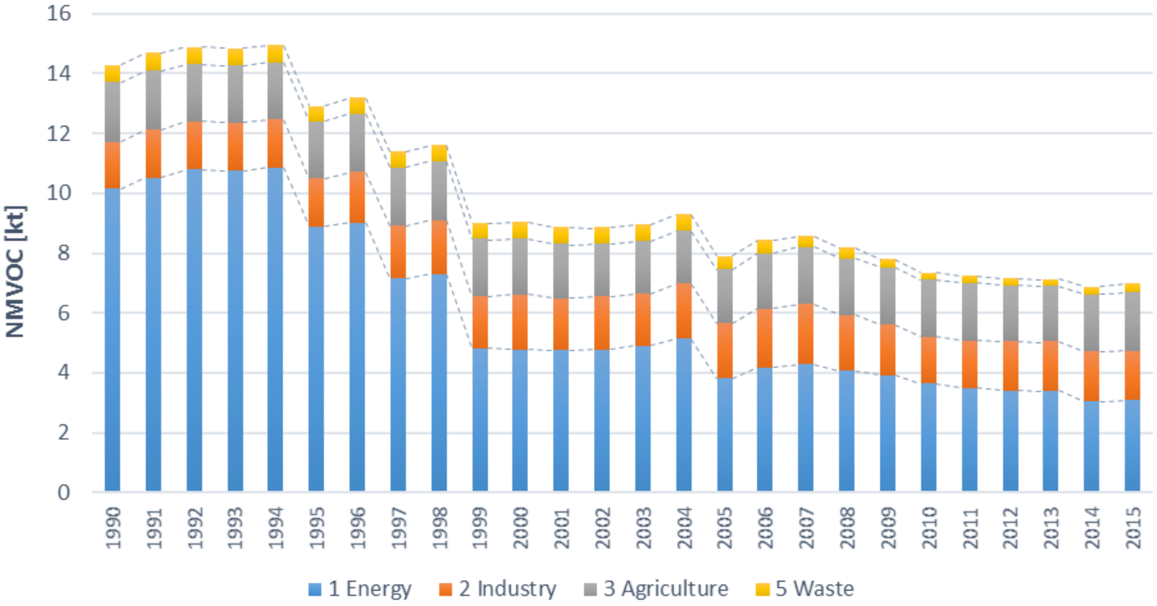

Figure 2.18 NMVOC emissions 1990-2015 by sector.

2.3.5 Trends in carbon monoxide (CO) emissions

Industrial Processes (industry) is the most prominent contributor to CO emissions in Iceland, as can be seen in Figure 2.19, being responsible for 86% of total CO emissions. It is worth mentioning that emissions from road transport have decreased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995. The emissions in 2015 were 107% above the 1990 level.

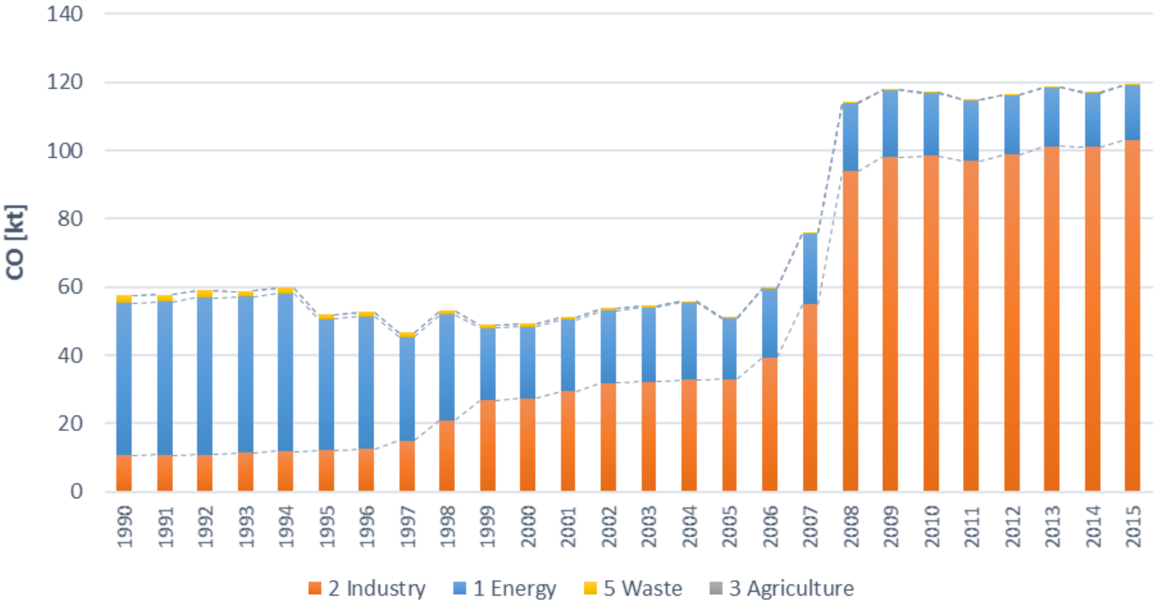

Figure 2.19 CO emissions 1990-2015 by sector.

2.3.6 Trends in particulate matter (PM) and BC emissions

The trend in emissions of TSP, PM_{10} and $PM_{2.5}$ can be seen in Figures Figure 2.20Figure 2.21Figure 2.22. Emissions from the energy and industry sectors dominate the estimated emissions of particulates in Iceland. Important here is that PM emissions from road transport have not been estimated before 2000 (due to the lack of data) suggesting a significant underestimation of these emissions before 2000. As stated above, the production capacity in the metal production sector has increased substantially, leading to an increase in PM emissions. PM emissions from the energy sector originate for the most part from commercial fishing. Agricultural emissions mostly stem from livestock manure management. TSP emissions were 38% above the 1990 level in 2015.

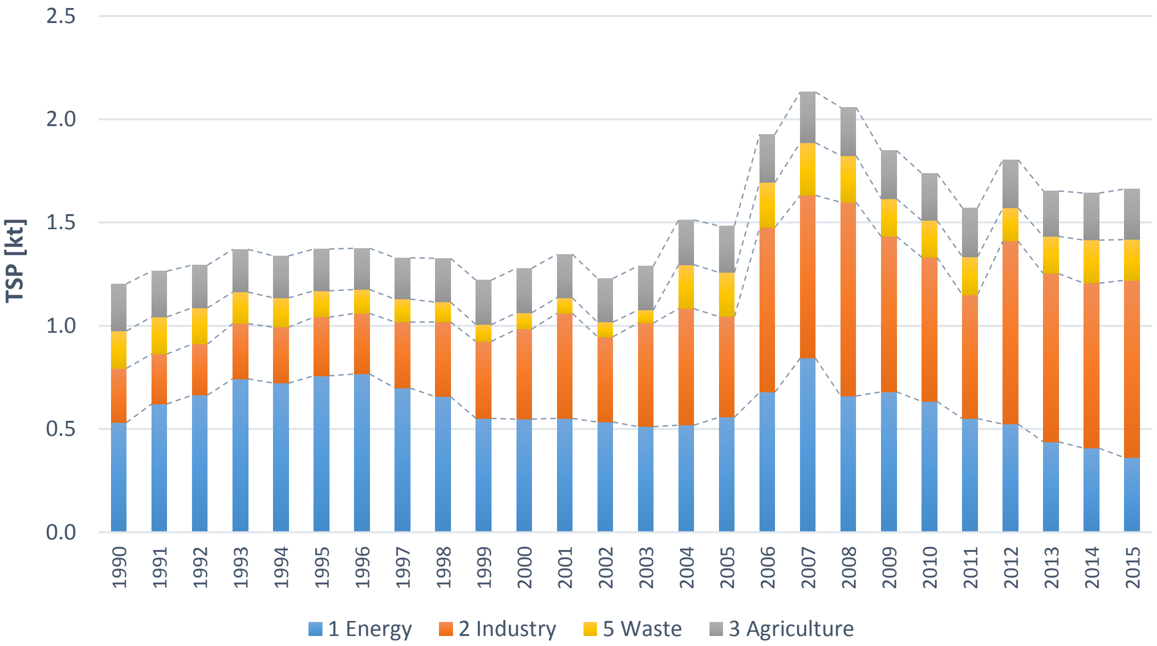

Figure 2.20 TSP emissions 1990-2015 by sector

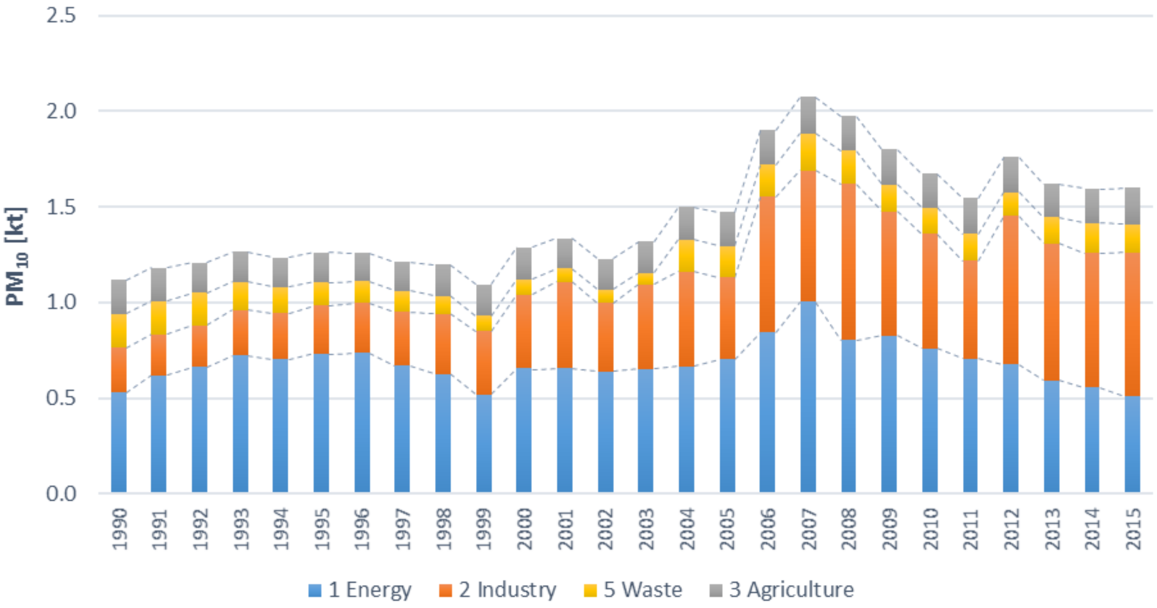

Figure 2.21 PM_{10} emissions 1990-2015 by sector.

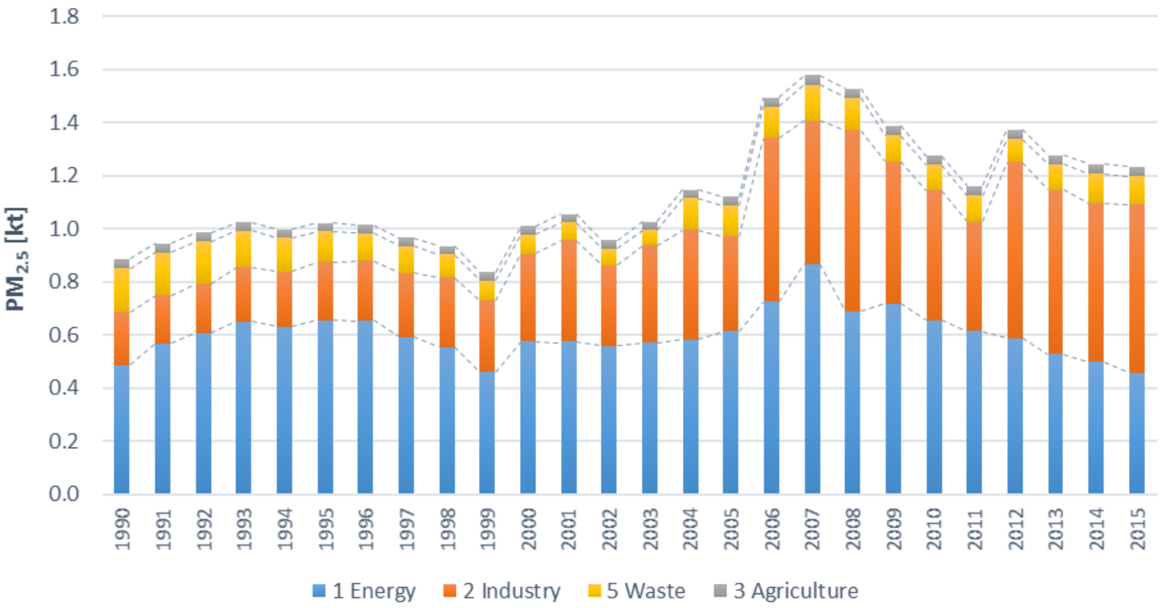

Figure 2.22 PM$_{2.5}$ emissions 1990-2015 by sector.

Black carbon emissions since 1990 were estimated for several subsectors for the first time in this submission, in particular within the Energy sector (public electricity and heat production, aviation, fishing/navigation, road transport) and within the Waste sector (Waste incineration). BC emissions from the Energy sector mostly originate from road transport and from fishing. submission. 2015 BC emissions for Road Transport were consequently assumed the same in 2014 and 2015. This effect is not seen in the figure due to the dominant emission estimates from fishing. BC emissions from waste have been decreasing since 1990, with 2015 emissions 91% below the 1990 and the reason is decrease in open burning of waste.

The total estimated black carbon emissions in 2015 were approximately 194 tonnes , with activities within the Energy sector contributing to almost 80% of the total BC estimates (Figure 2.23). Road transport and national fishing are the main sources of black carbon in the energy sector.

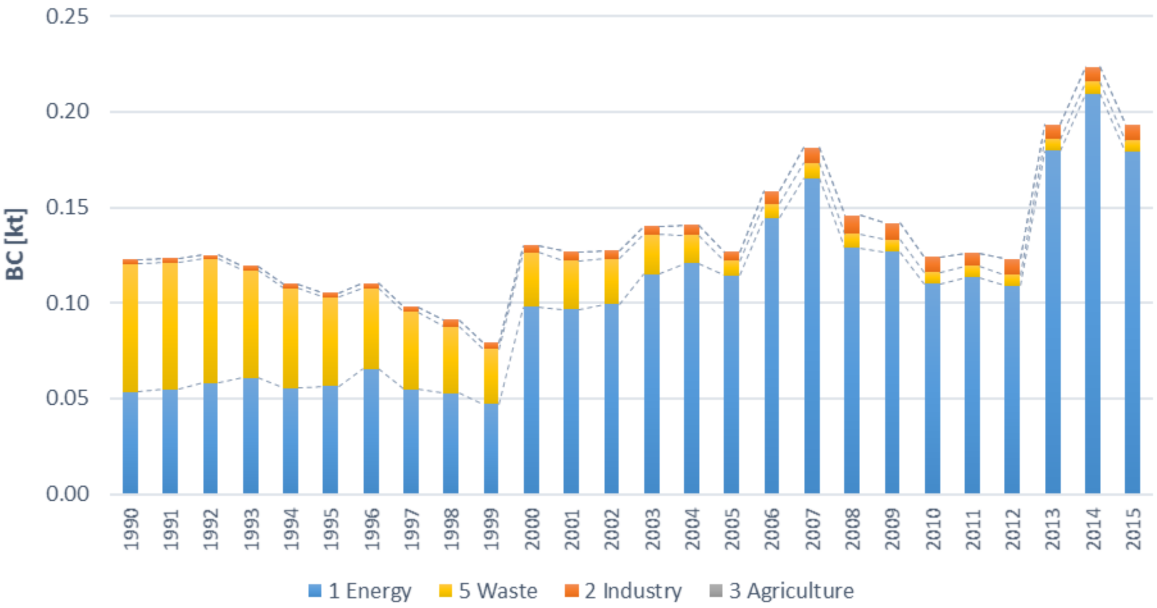

Figure 2.23 Black Carbon (BC) emission 1990-2015 by sector.

In 2010 the volcano Eyjafjallajökull erupted. The eruption lasted from 14th of April until 23rd of May. During that time around 6,000 kt. of PM_{10} were emitted or around 10,000 times more than total estimated man made emissions in 2010.

In 2011 the volcano Grímsvötn erupted. The eruption lasted from 21st until 28th of May. The eruption at Grímsvötn was much larger than at Eyjafjallajökull, and it has been estimated that during the first day more Sulphur and particulates were emitted than during all the Eyjafjallajökull eruption. An estimate of the total particulates emitted has not been estimated but the EAI has scaled the emissions of particulates using the ratio of Sulphur emissions from the two eruptions (1000/127). This gives an approximate estimate of around 47,000 kt. PM_{10} and 13,000 kt. of $PM_{2.5}$. As these emissions from volcanos are natural they are not included in national totals.

A large eruption started in Holuhraun on August 29th 2014 and ended on February 27th 2015. Unlike the eruptions in Eyjafjallajökull and Grímsvötn, which were magmatophreatic eruptions, the eruption in Holuhraun was effusive eruption i.e. the lava steadily flows out of the volcano without explosive activity. Ash production was negligible and emission of PM_{10} and $PM_{2.5}$ was not estimated.

2.3.7 Trends in SO_2, NO_x, NH_3, NMVOC, CO, PM and BC by Main Source Sectors

Figure 2.24 shows trends in the emissions of non-POPs pollutants in the energy sector as a percentage of the 1990 levels. Figure 2.25 shows the trends in the contribution of non-POPs emissions from the sector from 1990-2015. The energy sector contribution to the total non-POPs pollutants emissions in 2015 is 86% for NO_x, 44% for NMVOC, 76% for SO_2, 2% for NH_3, 13% for CO, 32% for PM10, 37% for $PM_{2,5}$ and 92% for BC. Emissions of SO_2 are 140% higher in 2015 than in 1990. The contribution of the energy sector in the total SO_2 emissions has, however, remained relatively stable at around 80% until 2012 due to a similar increase in the emissions in the industrial sector over the same period of time (see Figure 2.26). Since 2012, the SO_2 emissions from geothermal energy have decreased due to reinjection of geothermal sulfur into the subsurface. Emissions of BC in the energy sector is shown to have increased since 1990. However, BC emissions from road transportation has not been estimated before 2000 due to the lack of data, suggesting a significant underestimation of BC emissions before that year; the same applies to other PM emissions. Emissions of NO_X, NMVOC and CO have been steadily decreasing in the energy sector since 1990 as well contribution of this sector to the total emissions of these pollutants.

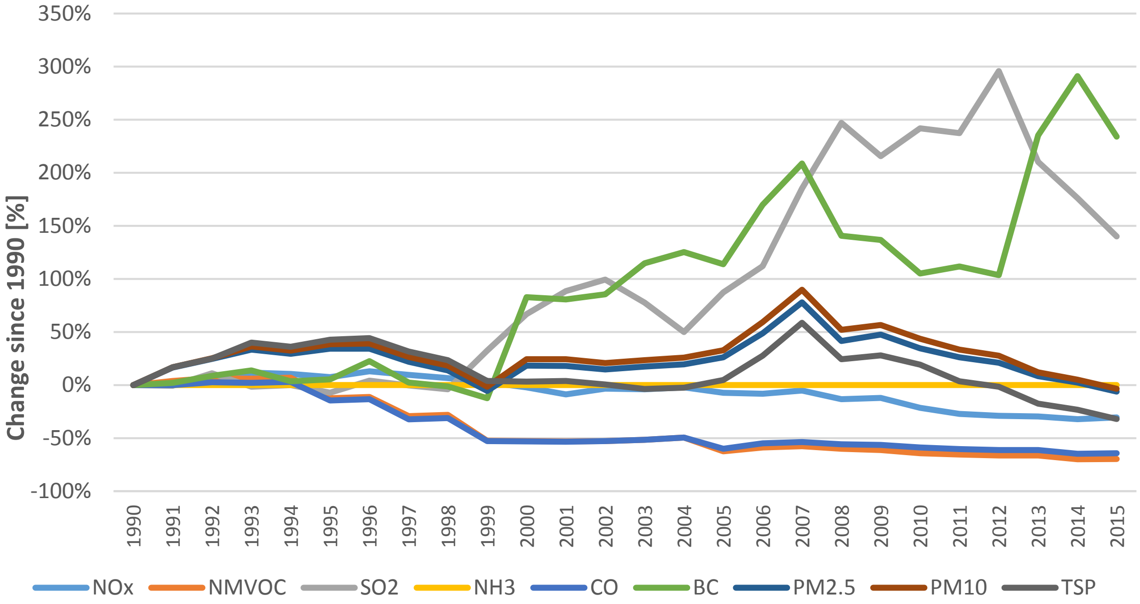

Figure 2.24 Trends in NO_X, NMVOC, SO_2 and CO emissions from the energy sector 1990-2015 (% of 1990 levels).

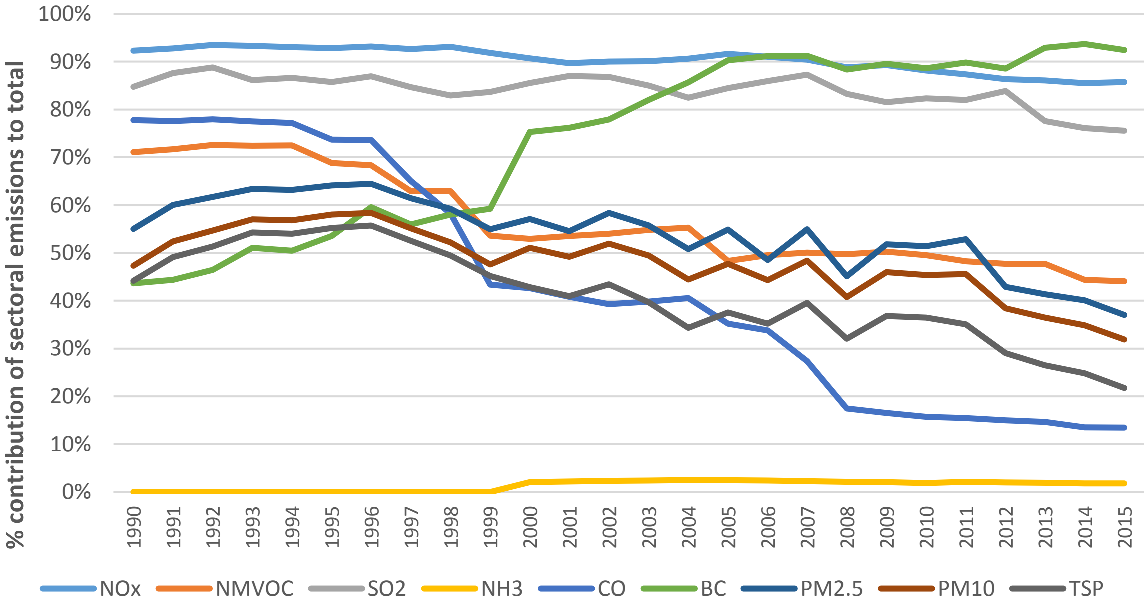

Figure 2.25 Trends in the contribution of NO_X, NMVOC, SO_2 and CO emissions from the energy sector (% of total pollutant emissions).

Figure 2.26 shows trends in the emissions of non-POPs pollutants in the industrial sector as a percentage of the 1990 levels. Figure 2.27 shows the trends in the contribution of non-POPs emissions from the sector from 1990-2015. The industrial sector contributions to the total non-POPs pollutants emissions in 2015 are 10% for NO_x, 24% for NMVOC, 24% for SO_2, 86% for CO, 52% for $PM_{2.5}$, 47% for PM_{10} , 52% for TSP and 4% for BC. The contribution of NH_3 emissions to the total emissions is zero (not applicable or not estimated). The large increase in CO emissions from the industrial sector has made this sector the dominant contributor of CO emissions in Iceland. Emissions of all the reported non-POPS emissions has increased in the industrial sector since 1990. Contributions of the industrial sector to the total emissions has also increased over that same period.

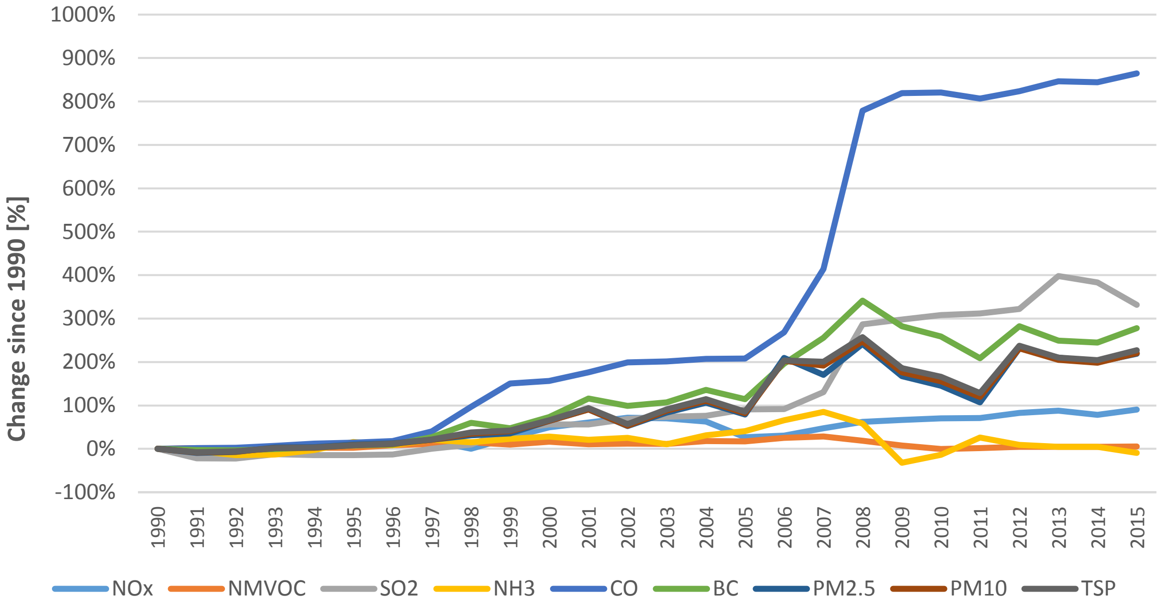

Figure 2.26 Trends in NO_x, NMVOC, SO_2, NH_3, CO, $PM_{2.5}$, PM_{10} and TSP emissions from the industrial sector 1990-2015 (% of 1990 levels).

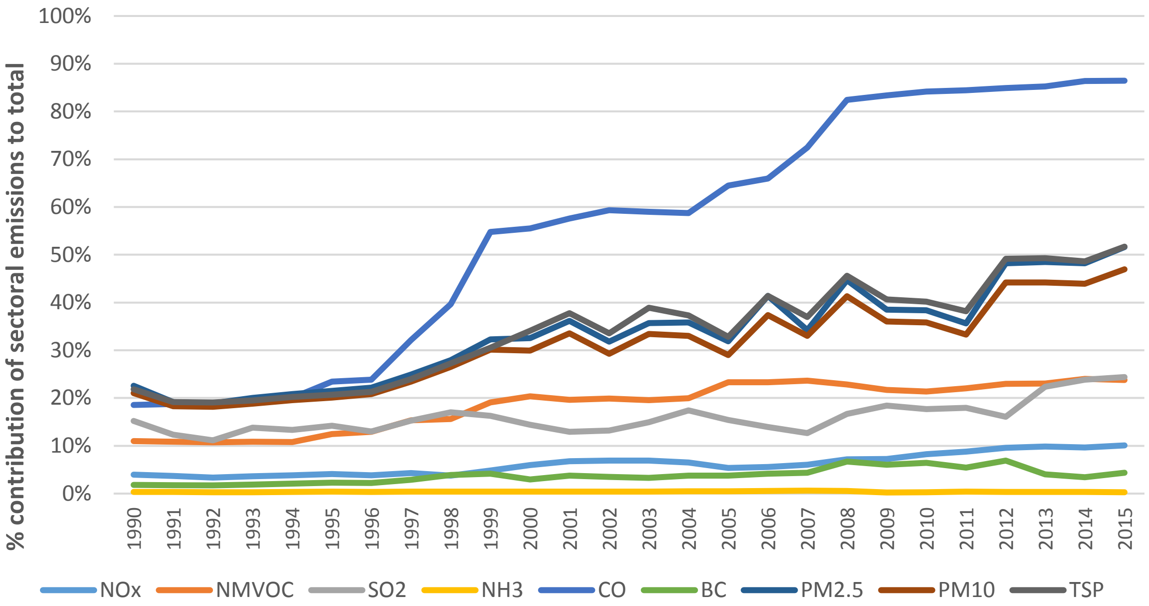

Figure 2.27 Trends in the contribution of NO_X, NMVOC, SO_2, CO and PM emissions from the industrial sector (% of total pollutant emissions).

Figure 2.28 shows trends in the emissions of non-POPs emissions in the agricultural sector as a percentage of the 1990 levels. Figure 2.29 shows the trends in the contribution of non-POPs emissions from the sector from 1990-2015. The agricultural sector contribution to the total emissions in 2015 is 4% for NOX, 28% for NMVOC, 98% for NH_3, 3% for $PM_{2.5}$, 12% for PM_{10} and 15% for TSP. The contribution of other non-POPs emissions to the total emissions is zero (not applicable or not estimated). No significant decrease in emissions have been in this sector since 1990. NO_X emissions have been fluctuating around the 1990 levels with a relatively high amplitude but still remains a negligible contributor to the total NO_X emissions throughout the period.

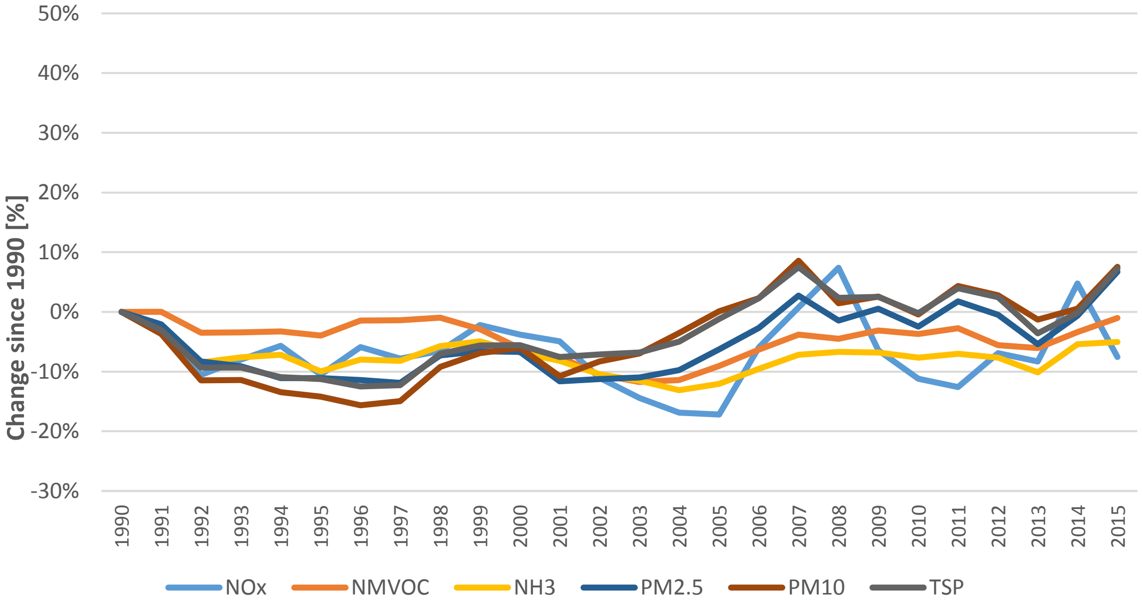

Figure 2.28 Trends in NO_X, NMVOC, NH_3, $PM_{2.5}$, PM_{10} and TSP emissions from the agricultural sector 1990-2015 (% of 1990 levels).

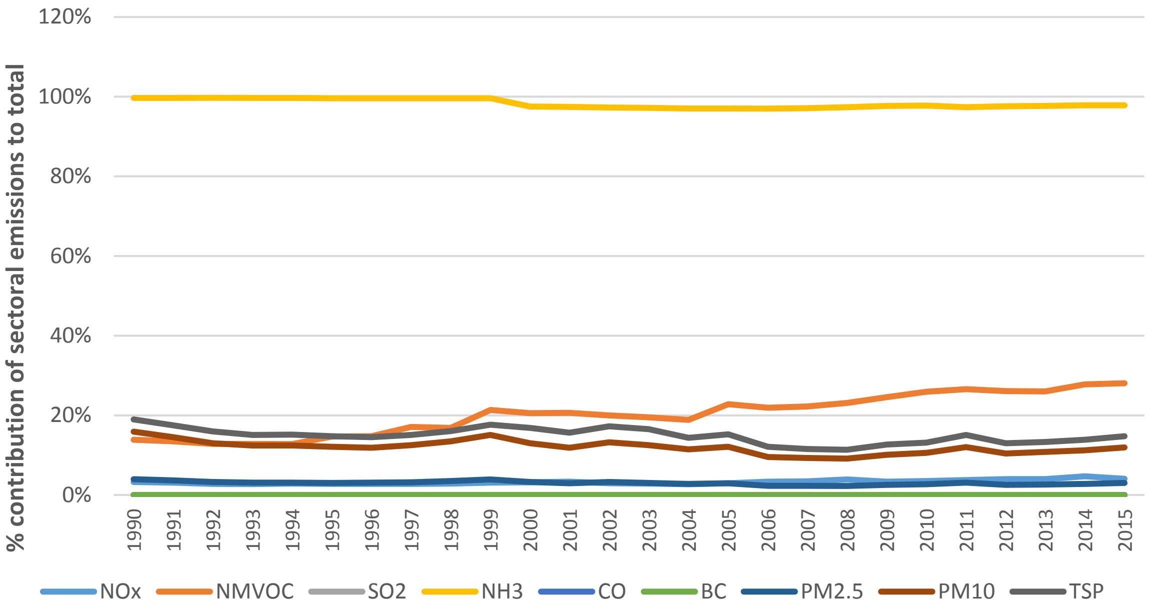

Figure 2.29 Trends in the contribution of NO_X, NMVOC, NH_3 and PM emissions from the agricultural sector (% of total pollutant emissions).

Figure 2.30 shows trends in the emissions in the waste sector as a percentage of the 1990 levels. Figure 2.31 shows the trends in the contribution of emissions from the sector from 1990-2015. Important here is that abatement technologies are not included in these emissions, suggesting there might be a large overestimation of the PM emissions from waste incineration from 2004. EA is planning to acquire technological specifications regarding abatement technologies for the next submission. This also applies to SO_2 emission estimates. The waste sector contribution to the total emissions in 2015 is 4.1% for NMVOC; NO_X, SO_2,NH_3 and CO emissions from the waste sector contribute to less than 1% of the total emissions for each pollutant.

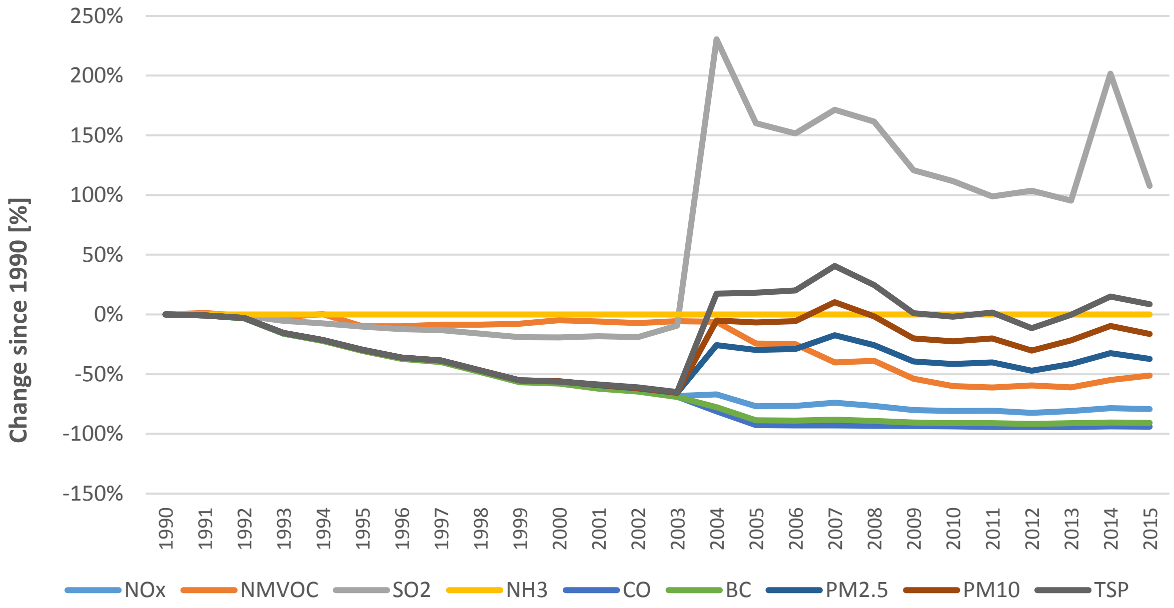

Figure 2.30 Trends in in NO$_x$, NMVOC, SO$_2$, NH$_3$, CO, , BC, PM$_{2.5}$, PM$_{10}$ and TSP emissions from the waste sector 1990-2015 (% of 1990 levels).

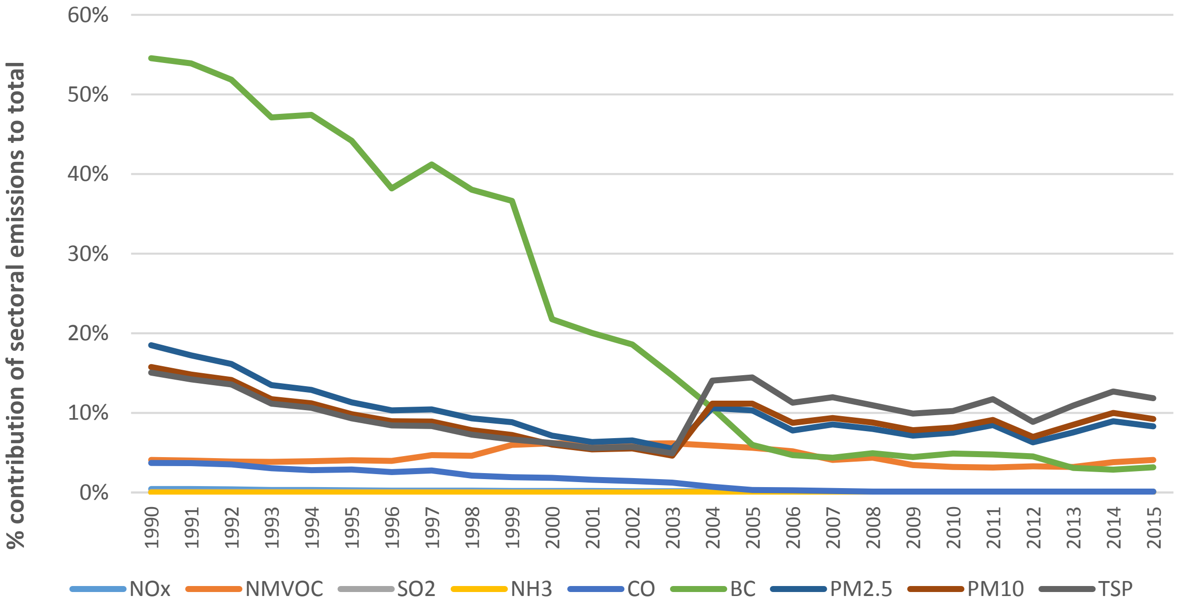

Figure 2.31 Trends in the contribution of NO$_X$, NMVOC, SO$_2$, NH$_3$, CO BC, PM$_{2.5}$, PM$_{10}$ and TSP emissions from the waste sector (% of total pollutant emissions).

2.4 Emission trends for Heavy Metals

Heavy metal emissions were estimated for the first time in this submission, with estimates for 1990 and 2015 shown in Table 2.3. Not all possible categories were estimated, and future improvements include making the heavy metal estimates more complete where possible. Categories not estimated include, amongst others, stationary combustion, automobile road abrasion and tyre and brake wear, aluminium production, solvent and product use, pesticides and fertilizer use and wastewater handling. Furthermore, heavy metal estimates from road transport are not available prior to 2000. Because of the incomplete documentation of heavy metal emissions in Iceland, all trends and contributions from various sectors should be viewed with caution.

Table 2.3 Estimated emissions of heavy metals, 1990 and 2015.

	Pb [t]	**Cd [t]**	**Hg [t]**	**As [t]**	**Cr [t]**	**Cu [t]**	**Ni [t]**	**Se [t]**	**Zn [t]**
1990	0.22	0.0071	0.0082	0.0521	0.0421	0.29	1.49	0.0303	1.22
2015	1.69	0.0421	0.0505	0.0501	0.0794	1.39	1.06	0.0218	1.20

2.4.1 Trends in priority Heavy Metals (Pb, Cd, Hg)

Figure 2.32, Figure 2.33Figure 2.34 show emission trends for Pb, Cd and Hg per sector. Overall the emission profiles are roughly similar for these three heavy metals, as their emission are linked to the same sources. The main contributors to the estimated emissions are energy (since 1993), and waste (since 2004). In 1993, waste incineration with recovery of energy (included in the Energy sector under NFR 1A1a Public electricity and heat production) started in Iceland, leading to an increase in Pb, Cd and Hg. The amount of waste burned with recovery of energy peaked in 2007, and after that decreased until 2013 after which year this activity stopped. Municipal waste incineration without energy recovery started in 2001 and increased by a factor of 50 in 2004, and has been approximately constant since then. By far the biggest source of Pb and Cd in the industry sector is the use of fireworks. In 2007, at the height of the Icelandic economic upswing, record sales of fireworks caused the emission of close to one ton Pb.

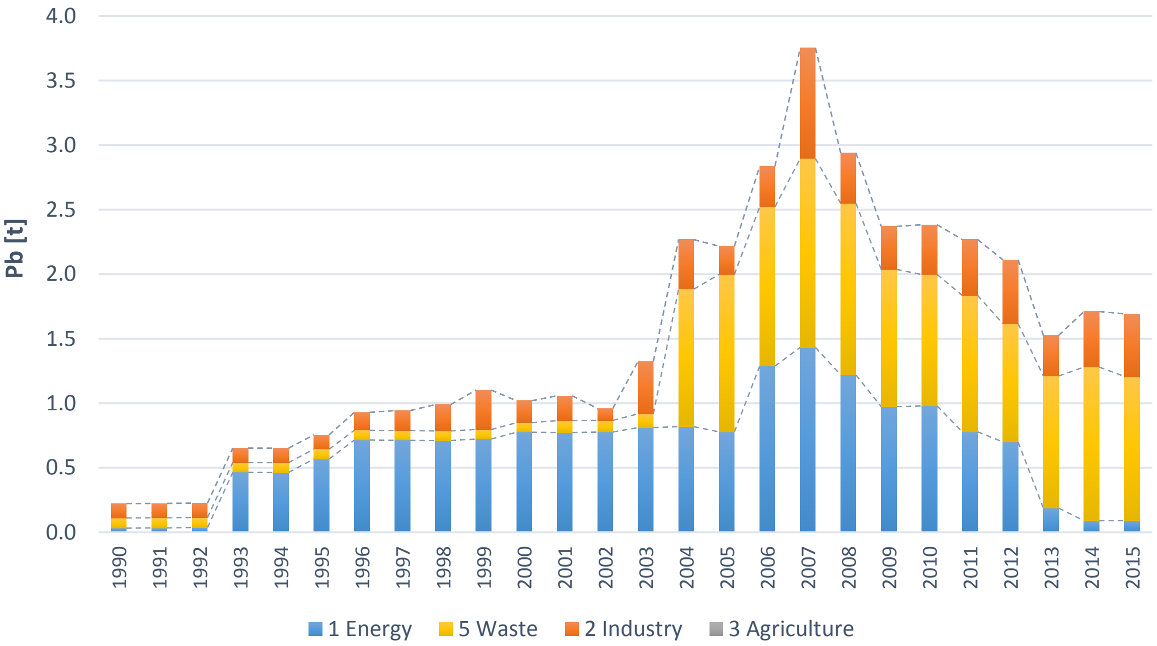

Figure 2.32 Pb emissions 1990-2015 by sector.

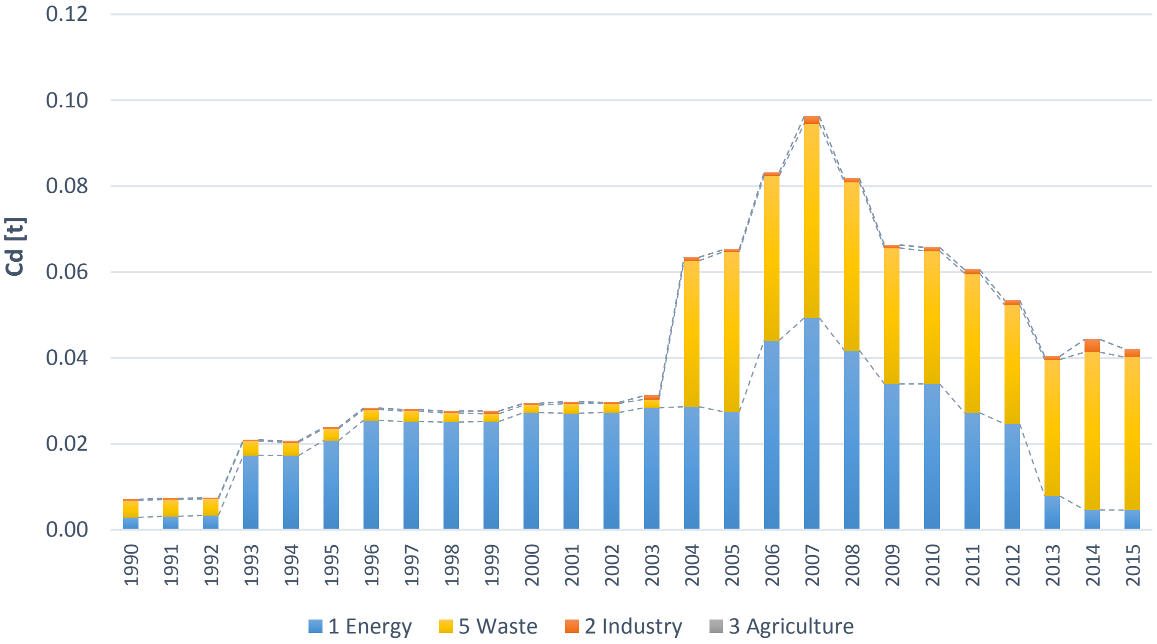

Figure 2.33 Cd emissions 1990-2015 by sector

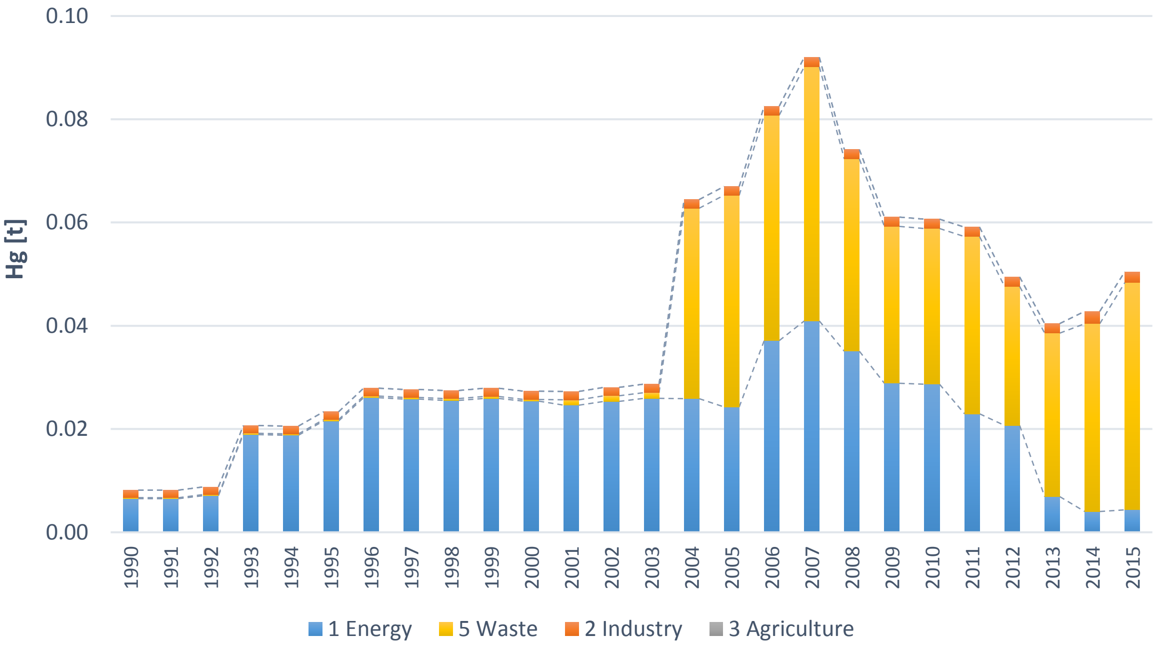

Figure 2.34 Hg emissions 1990-2015 by sector

2.4.2 Trends in additional Heavy Metals (As, Cr, Cu, Ni, Se, Zn)

Figure 2.35 to Figure 2.40 show emission trends for As, Cr, Cu, Ni, Se and Zn per sector. With the exception of Zn, the trends are overall dominated by emissions from the energy sector. Trends in As, Cr, Ni and to a lesser extent Se all show similar patterns, with the main sources being fuel usage in commercial fishing and road transport (with the exception of As, for which emissions from road transport were not estimated). The sharp increases in 2000 in Cu, Cr and Zn are due to the fact that emissions from road transport were not estimated for these elements prior to 2000. In the industrial sector, the main source of arsenic emissions is metal production. All other non-priority heavy metals are largely produced by fireworks, with sharp peaks in emission in 2007 where fireworks sales reached an all-time maximum. In the waste sector, heavy metal emissions come mostly from waste incineration, followed by other waste (building fires, vehicle fires and large-scale fires). The emission pattern for Zn is different (Figure 2.40), with the main contribution being road transport (not estimated before 2000) and waste incineration.

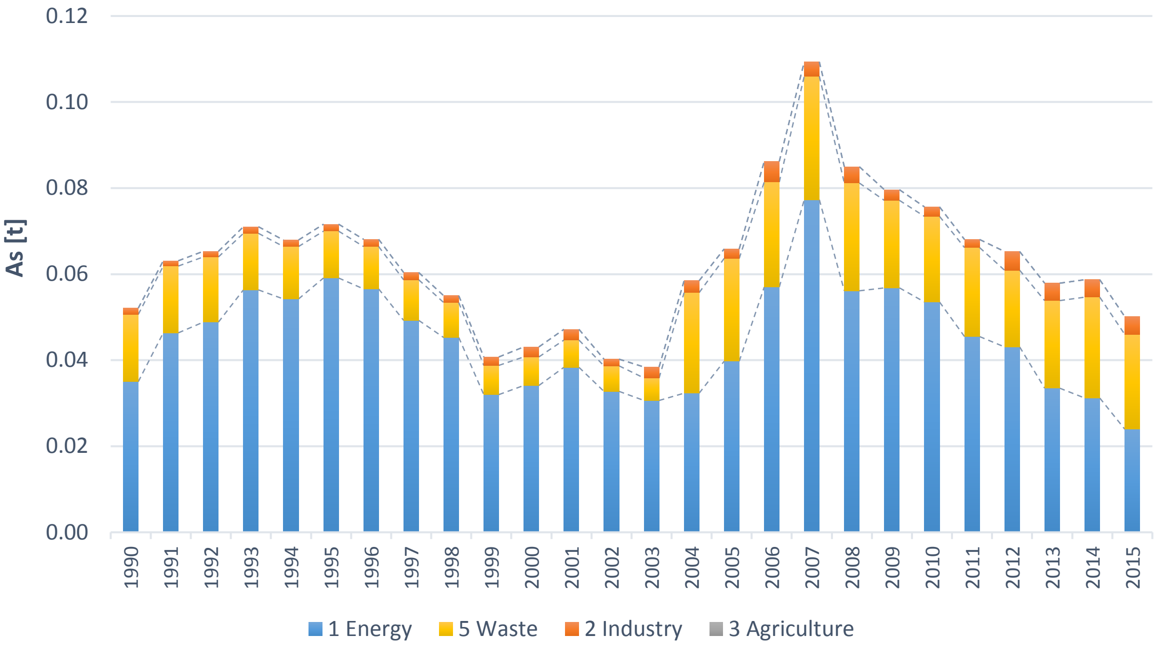

Figure 2.35 As emissions 1990-2015 by sector.

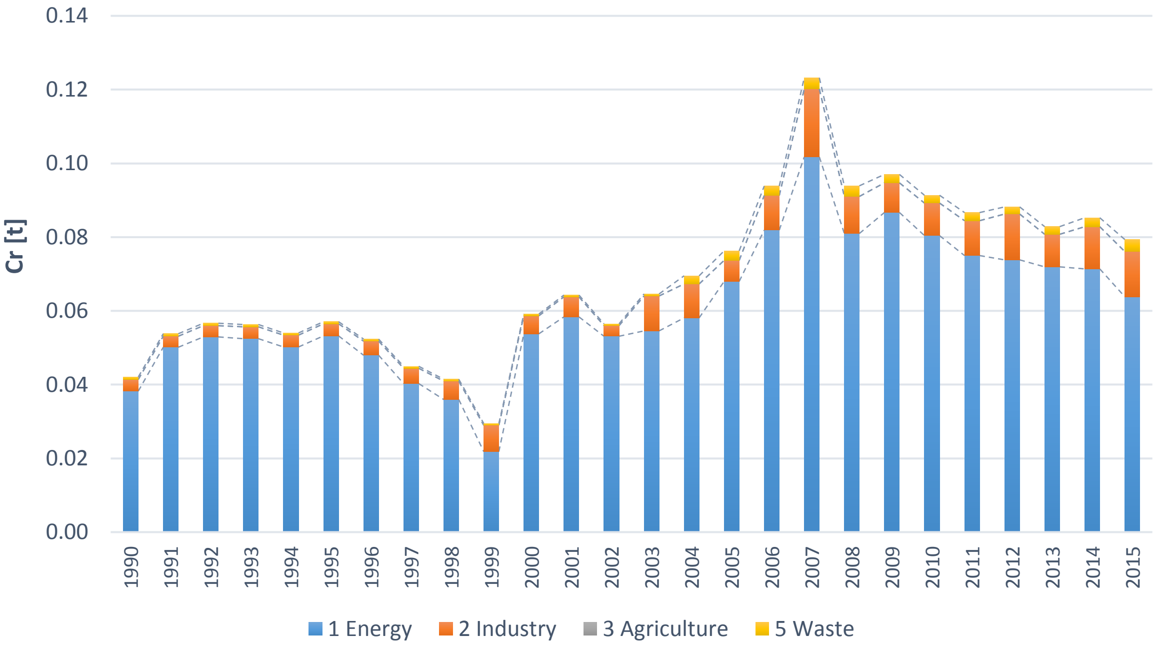

Figure 2.36 Cr emissions 1990-2015 by sector.

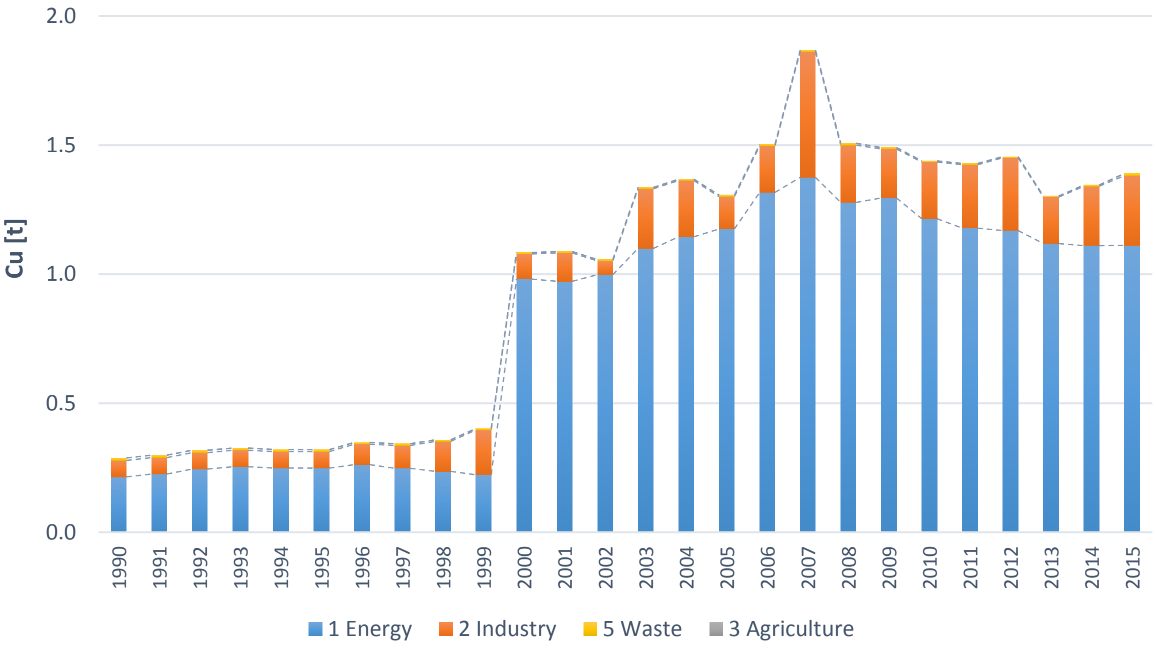

Figure 2.37 Cu emissions 1990-2015 by sector.

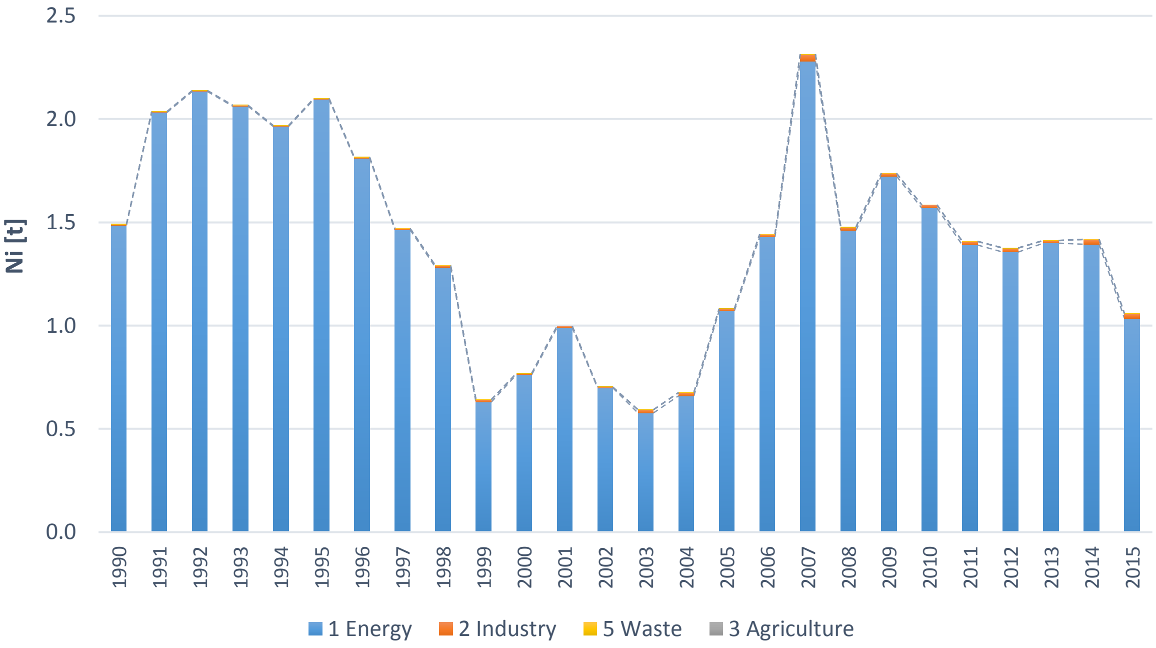

Figure 2.38 Ni emissions 1990-2015 by sector.

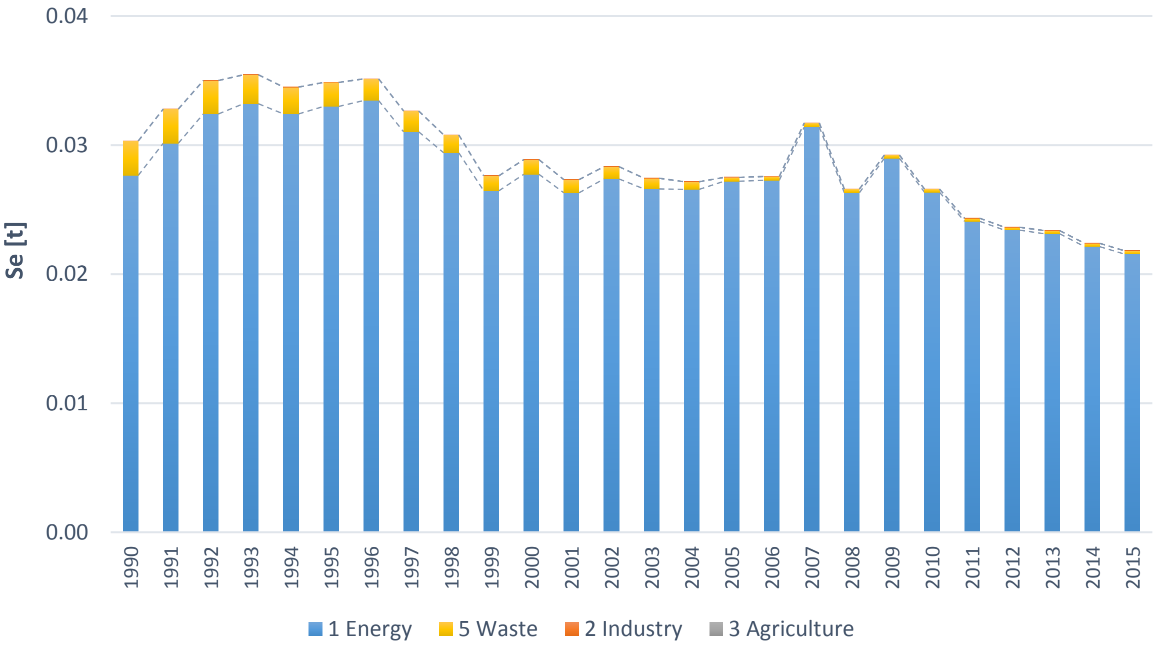

Figure 2.39 Se emissions 1990-2015 by sector.

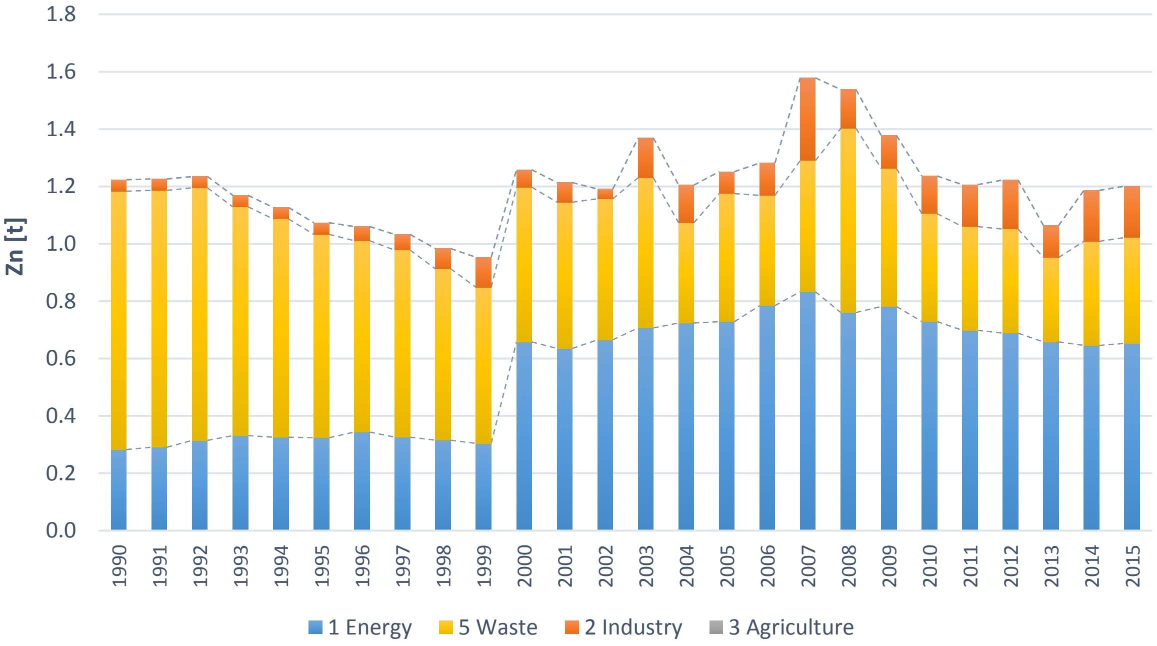

Figure 2.40 Zn emissions 1990-2015 by sector.

3 Energy (NFR sector 1)

3.1 Overview

The energy sector is divided into the following subsectors:

- Energy industries (NFR 1A1)
- Manufacturing Industries and Construction (NFR 1A2)
- Transport (NFR 1A3)
- Other sectors (NFR 1A4)
- Fugitive emissions (NFR 1B2)

For the 2017 submission, the following main changes were made to the emission estimates:

- COPERT data was acquired and used to estimate emissions of previously not-estimated sources within road transportation (NFR 1A3b). This includes the estimation of heavy metals from road transportation. Data was however only retrieved for the years 2000-2014 and 2015 estimates were assumed to be the same as the 2014 estimates for the newly included pollutants.
- EUROCONTROL data was further used for estimating emissions from international aviation (NFR 1A3ai(i)) and domestic aviation (NFR 1A3aii(i)) where before it was based on fuel sales and reported under memo items International aviation cruise (civil) (NFR 1A3ai(ii)) and memo item domestic aviation cruise (civil) (NFR 1A3aii(ii)), respectively.
- New estimates for NFR 1A1a, now includes emission estimates both for waste burning and oil burning. Before, only emissions from waste burning was included in this sector.

3.1.1 Sectoral trends – POP's

Summary tables for the POP's emissions from the energy sector is shown in Table 3.1.

Table 3.1 Overview of emission estimates of POPs from the energy sector in 2015 (NA – Not applicable, NE – Not estimated; NO - Not occurring).

		Dioxin [g I-TEQ]	B(a)P [t]	B(b)F [t]	B(k)F [t]	IPy [t]	PAH4 [t]	HCB [kg]	PCB [kg]
1A1	Energy industries	4.E-05	8.E-05	6.E-04	7.E-05	3.E-07	8.E-04	NE/NO	NE/NO
1A2	Manufacturing industries and construction	5.E-03	1.E-04	6.E-04	9.E-04	2.E-04	2.E-03	NA/NO	NA/NO
1A3	Transport	5.E-02	2.E-03	4.E-03	3.E-03	3.E-03	1.E-02	7.E-04	6.E-04
1A4	Other sectors	6.E-01	6.E-05	6.E-03	5.E-05	5.E-05	6.E-03	1.E-02	2.E-02
1B2	Fugitive emissions from distribution of oil production and energy production	NA/NE/NO	NA/NE/NO	NA/NE/NO	NA/NE/NO	NA/NE/NO	NA/NE/NO	NA/NE/NO	NA/NE/NO
Energy, Total		**0.63**	**0.0027**	**0.012**	**0.0041**	**0.0033**	**0.022**	**0.014**	**0.021**

Trends in POP's emission estimates are shown in Figure 3.1 through Figure 3.4 by subsector.

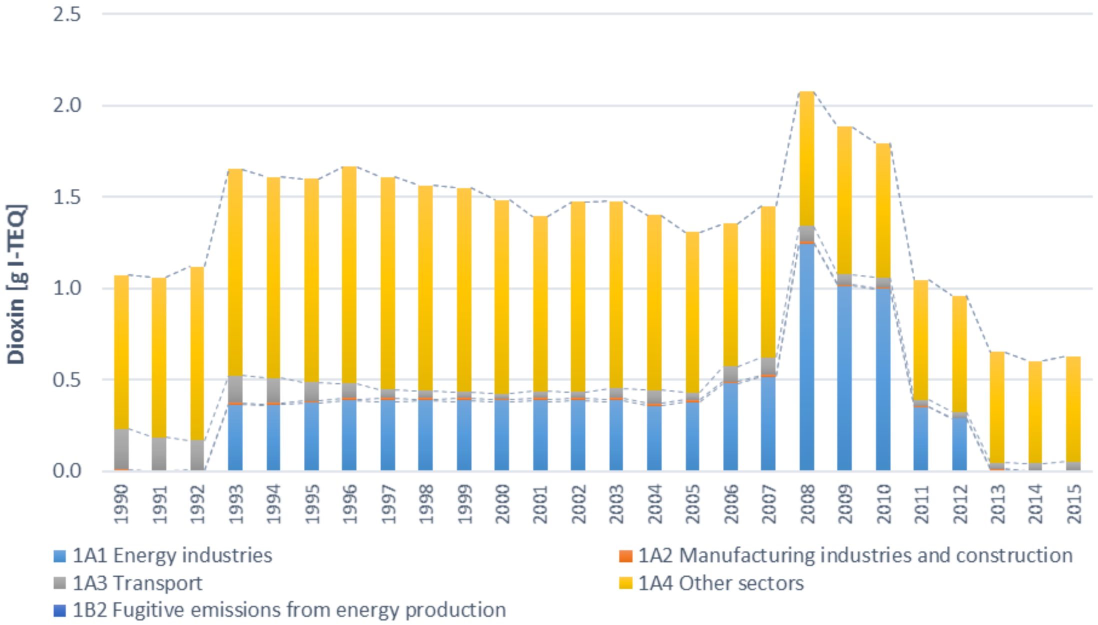

Figure 3.1 Dioxin emission estimates in the energy sector, 1990-2015.

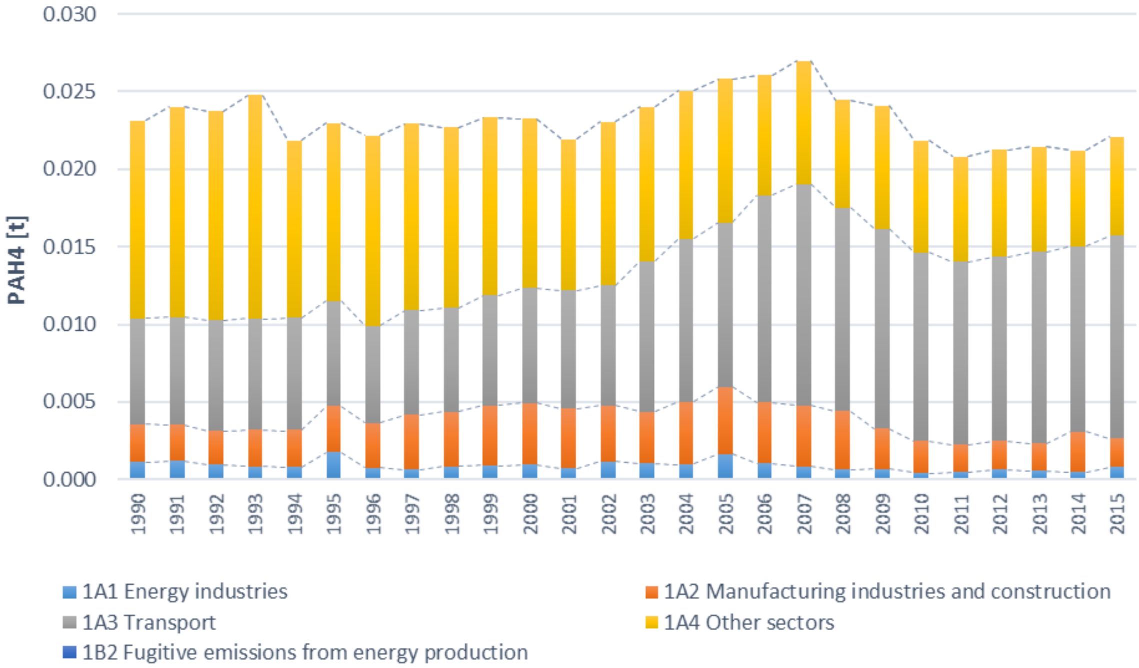

Figure 3.2 PAH4 emission estimates in the energy sector, 1990-2015.

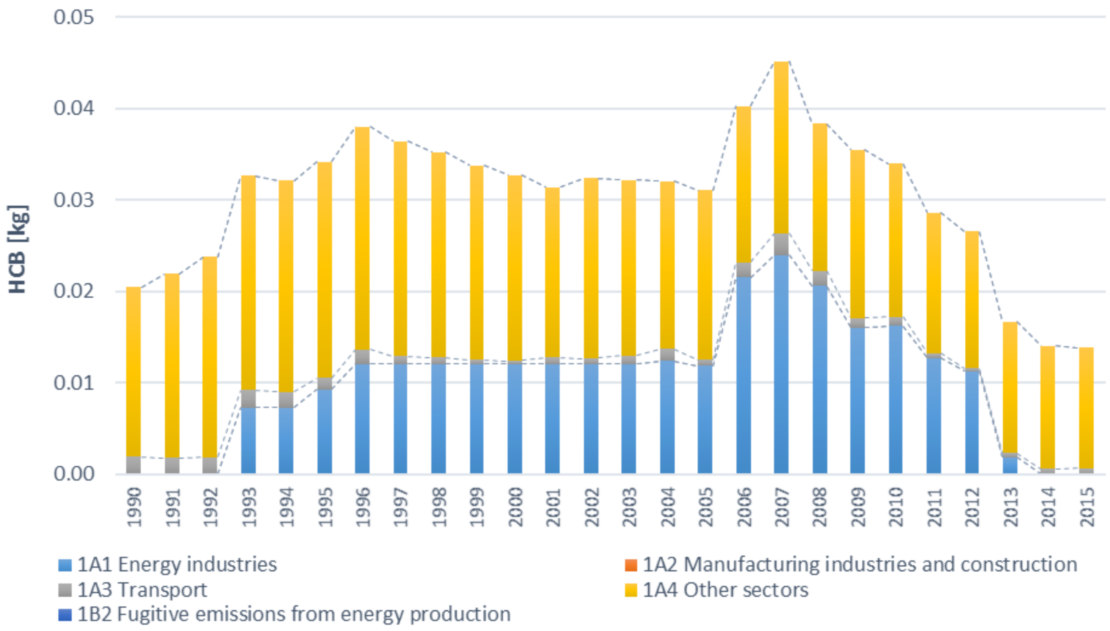

Figure 3.3 HCB emission estimates in the energy sector, 1990-2015.

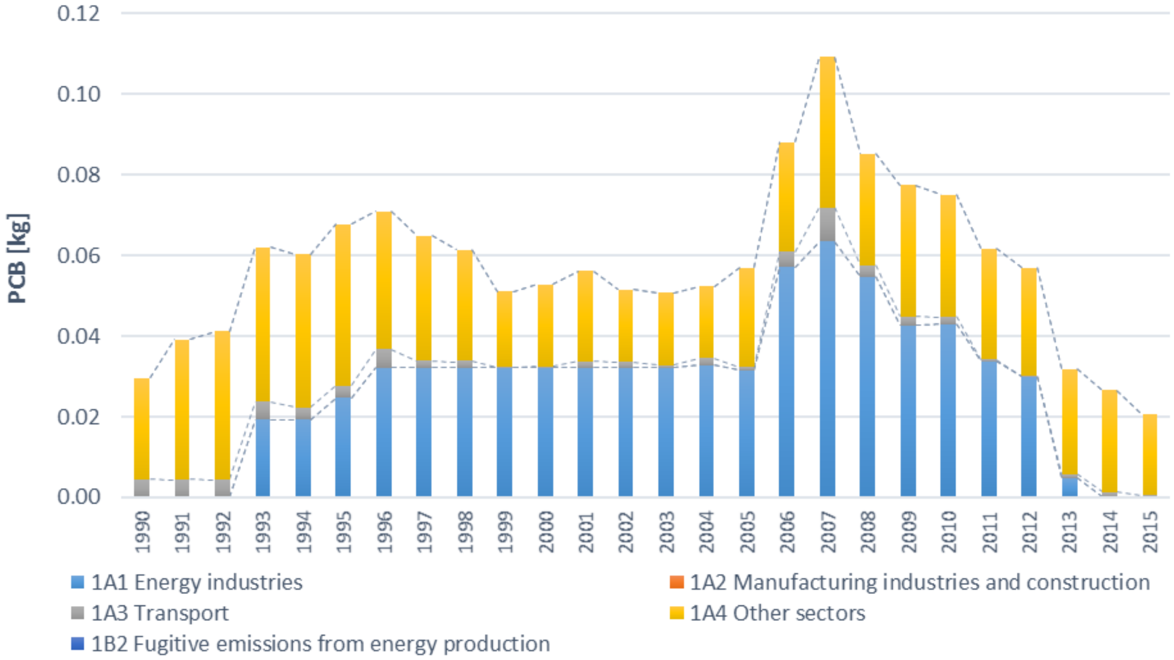

Figure 3.4 PCB emission estimates in the energy sector, 1990-2015.

3.1.2 Sectoral trends – Other pollutants

Summary tables for the non-POP's emissions from the energy sector is shown in *Table 3.2*.

Trends in POP's emission estimates are shown in Figure 6.1 through Figure 6.4 by subsector. The emission estimates are based on the availability of emission factors and data.

Table 3.2 Overview of emission estimates of pollutants other than POP's in 2015 (NA – Not applicable, NE – Not estimated, NO - Not occurring, NR - Not relevant[4]).

		NO_X [kt] NO_2	NMVOC [kt]	SO_X [kt] SO_2	NH_3 [kt]	$PM_{2.5}$ [kt]	PM_{10} [kt]	TSP [kt]	BC [kt]	CO [kt]
1A1	Energy industries	0.0036	5.E-05	0.0090	NE/NO	2.E-04	3.E-04	5.E-04	2.E-05	8.E-04
1A2	Manufacturing industries and construction	1.64	0.23	0.50	NE/NO	NR/NO	NR/NO	NR/NO	0.08	0.49
1A3	Transport	5.41	2.52	0.09	0.10	0.14	0.17	0.02	0.07	14.45
1A4	Other sectors	11.00	0.32	1.47	NE/NO	0.32	0.34	0.34	0.03	1.10
1B2	Fugitive emissions from distribution of oil production and energy production	NO/NE/NA	0.01	40.49	NO/NE/NA	NO/NR/NA	NO/NR/NA	NO/NR/NA	NO/NR/NA	NO/NE/NA
Energy, Total		**18.1**	**3.08**	**42.5**	**0.098**	**0.457**	**0.511**	**0.361**	**0.179**	**16.0**

	(Table continued)	Pb [t]	Cd [t]	Hg [t]	As [t]	Cr [t]	Cu [t]	Ni [t]	Se [t]	Zn [t]
1A1	Energy industries	2.E-04	7.E-05	6.E-05	1.E-04	7.E-05	1.E-04	2.E-03	3.E-04	6.E-04
1A2	Manufacturing industries and construction	NR/NO	NR/NO	NR/NO	NR/NO	NR/NO	NR/NO	NR/NO	NR/NO	NR/NO
1A3	Transport	0.070	3.E-03	2.E-04	6.E-04	0.038	0.97	0.043	4.E-03	0.48
1A4	Other sectors	0.020	2.E-03	4.E-03	0.023	0.025	0.14	1.E+00	0.017	0.17
1B2	Fugitive emissions from distribution of oil production and energy production	NA/NR/NO	NA/NR/NO	NA/NR/NO	NA/NR/NO	NA/NR/NO	NA/NR/NO	NA/NR/NO	NA/NR/NO	NA/NR/NO
Energy, Total		**0.090**	**0.0046**	**0.0043**	**0.024**	**0.064**	**1.11**	**1.04**	**0.022**	**0.65**

Emission data for these pollutants is provided in the NFR tables[5].

3.2 Introduction

The energy sector in Iceland is unique in many ways. Iceland ranks 1st among Organisation for Economic Co-operation and Development (OECD) countries in the per capita consumption of primary energy. The per capita primary energy consumption in 2014 was around 796 GJ. However, the proportion of domestic renewable energy in the total energy budget is about 85%, which is a much higher share than in most other countries. The cold climate and sparse population calls for high energy use for space heating and transport. Also, key export industries such as fisheries and metal

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[4] Iceland uses the notation key NR for not estimated sources that are not POP's pollutants and pollutants that are reported to the UNFCCC under the Kyoto Protocol.

[5] http://cdr.eionet.europa.eu/is/un/clrtap/ (Envelope A)

production are energy-intensive. The metal production industry used approximately 75% of the total electricity produced in Iceland in 2015. Iceland relies heavily on its geothermal energy sources for space heating (over 90% of all homes) and electricity production (30% of the electricity) and on hydropower for electricity production (70% of the electricity). Thus, emissions in the energy sector originate predominantly from mobile sources: road transport, fishing and equipment in the construction sector, as well as waste incineration with energy recovery.

3.3 General Methodology

Emissions from fuel combustion activities are estimated at the sector level based on methodologies suggested by the 2006 IPCC Guidelines. They are calculated by multiplying energy use by source and sector with pollutant specific emission factors. Activity data is provided by the National Energy Authority (NEA), which collects data from the oil companies on fuel sales by sector. The division of fuel sales by sector does not reflect the 2006 IPCC sectors perfectly so EA has made adjustments to the data where needed to better reflect the IPCC categories. This applies for the sectors 1A1 Energy industries, 1A2 Manufacturing industry (stationary combustion) and 1A4 Residential. Tables explaining this adjustment are in Annex I. The first table in Annex I is named “Fuel sales (gas oil and residual fuel oil) by sectors 1A1a, 1A2 (stationary) and 1A4 (stationary) – as provided by the National Energy Authority”. This table contains the original values. The adjustment is done in the following way for gasoil: First fuel consumption needed for the known electricity production with fuels is calculated (1A1a – electricity production), assuming 34% efficiency of the diesel engines. The values calculated are compared with the fuel sales for the category 10X60 Energy industries (nomenclature from the NEA).

- In years where there is less fuel sale to energy industries, according to the sales statistics (1,185 tonnes in 2015), as would be needed for the electricity production (1006 tonnes in 2015), the fuel needed to compensate is taken from the category 10X90 Other; and if that is not sufficient from the category 10X40 House heating and swimming pools.
- In years where there is surplus, the extra fuel is added to the category 10X40 House heating and swimming pools. In 2015 there was a surplus in the energy industries category, so 179 tonnes were added to the category 10X40 House heating and swimming pools. So now the category 10X40 has 1473 tonnes in 2015 (1294+179).
- NEA has estimated the fuel use by swimming pools (1A4a), but it should be noted that the majority of swimming pools in Iceland have geothermal water. The estimated fuel use values are given in the lower table of Annex I. It is 300 tonnes in 2015. These values are subtracted from the adjusted 10X40 category, leaving 1173 tonnes in the category in 2015 (1473-300). This rest is then 1A4c – Residential.
- For years where there is still fuel in the category 10X90 Other (4767 tonnes were left in that category in 2015), this is added to the 10X5X Industry (originally with 5394 tonnes in 2015). This is the fuel use in 1A2 – Industry (5394+4767=10161 tonnes in 2015).

Explanation for the adjustment for residual fuel oil is given in Annex I.

Fuel combustion activities are divided into two main categories; stationary and mobile combustion. Stationary combustion includes Energy Industries, Manufacturing Industries and a part of the Other sectors (Residential and Commercial /Institutional sector). Mobile combustion includes Civil Aviation, Road Transport, Navigation, Fishing (part of the Other sectors), Mobile Combustion in Construction (part of Manufacturing Industries and Construction sector) and International Bunkers.

3.4 Energy Industries (NFR 1A1)

Energy Industries include emissions from electricity and heat production. Iceland has extensively utilized renewable energy sources for electricity and heat production, thus emissions from this sector are low. For dioxin, PAH4, SO_2 and NMVOC waste incineration with energy recovery is the main source of emissions for this category. Activity data on fuel use for the energy industries are based on data provided by the NEA and adjusted by EAI, see Annex I. Activity data on waste is collected by EAI directly from the plants.

3.4.1 Electricity & heat (1A1a)

Electricity was produced from hydropower, geothermal energy and fuel combustion in 2014 (*Table 3.3*), with hydropower as the main source of electricity (NEA, 2014). Electricity was produced with fuel combustion at two locations that are located far from the distribution system (two sparsely populated islands, Grimsey and Flatey). Some public electricity facilities have emergency backup fuel combustion power plants which they can use when problems occur in the distribution system. Those plants are, however, very seldom used, apart from testing and during maintenance.

Table 3.3 Electricity production in Iceland (GWh).

	1990	**1995**	**2000**	**2005**	**2010**	**2014**	**2015**
Hydropower	4,159	4,678	6,352	7,015	12,592	12,873	13,780
Geothermal	283	288	1,323	1,658	4,465	5,238	5003
Windpower	-	-	-	-	-	8	11
Fuel combustion	6	8	5	8	2	2.4	4
Total (GWh)	**4,448**	**4,974**	**7,680**	**8,681**	**17,059**	**18,122**	**18,798**

Activity data (the amount of gasoil used) for electricity production with fuel combustion is calculated from the information on electricity production (GWh), based on the energy content of the gasoil (43 TJ/kt) assuming 34% efficiency.

Geothermal energy is the main source of heat production in Iceland. Some district heating facilities, that lack access to geothermal energy sources, use electric boilers to produce heat from electricity. They depend on curtailable energy. These heat plants have backup fuel combustion in case of electricity shortages or problems in the distribution system. Three district heating facilities burn waste to produce heat and are connected to the local distribution system. Emissions from these waste incineration plants are reported under Energy Industries. A description of the method to estimate emissions from waste incineration plants is given in Chapter 6.6.

3.4.1.1 *Activity data*

Activity data for electricity and heat production with fuel combustion and waste incineration are given in Table 3.4. No fuel consumption for heat production was reported by the NEA for 2010 and 2011. The use of residual fuel oil in 2007 was much higher than in surrounding years. In 2007 a new aluminium plant was established in Iceland. Because the Kárahnjúkar hydropower project (hydropower plant built for this aluminium plant) was delayed, the aluminium plant was supplied with electricity for a while from the distribution system. This led to electricity shortages for the district heating system and industry depending on curtailable energy leading to increased fuel combustion. The different fuel composition from year to year (waste, fuel) effects the IEF (Implied Emission Factor). For example, the IEF for dioxin in this sector is higher in years when fuel combustion is low and the sector is dominated by waste incineration. The following years have been unusual: 1995 (issues in the electricity distribution system caused by snow avalanches in northwest Iceland (the Westfjords) and icing in the northern part of the country), 1997/1998 (unfavorable weather conditions for hydropower plants during the winter) and 2007 (explained above).

Table 3.4 Fuel combustion and waste incineration (kt) for electricity and heat production.

	1990	1995	2000	2005	2010	2014	2015
Gas/Diesel oil (electricity)	1.40	2.12	1.12	1.97	0.43	0.60	0.60
Residual fuel oil (heat)	2.99	3.08	0.07	0.20	NO	0.19	0.19
Solid waste (heat)	NO	4.65	6.05	5.95	8.11	NO	NO

3.4.1.2 *Emission factors*

Emission factors are taken from the EMEP/EEA 2013 guidebook where emission factors are provided for gas/diesel oil and Residual fuel oil in this sector. Emission factors for the burning of waste with energy recovery are taken from table 3-2 of chapter 5C1a of the EMEP/EEA 2013 guidebook. Due to the lack of emission factors given in the guidebook the following pollutants are not estimated:

- Gas oil: NH_3, PCB, HCB.
- Residual fuel oil: NH_3, PCB, BaP, HCB.
- Waste: Emission estimates for all pollutants reported.

Emission factors for BaP, BbF, BkF are taken from table 3-4 of chapter 1A2 of the EMEP/EEA 2013 guidebook. In the guidebook, emission factor is only given for IpY and not the other PAH4 pollutants for NFR sector 1A1a.

Emissions of SO_2 are calculated from the S-content of the fuels.

3.4.1.3 *Recalculations*

For the 2017 submission, new emission estimates for several pollutants were calculated based on available emission factors in the the EMEP/EEA 2013 guidebook. NO_x and CO emission factor were furthermore updated in accordance with the EMEP/EEA 2013 guidebook. The emission factor changed from 1300 kg/TJ to 65 kg/TJ for NO_x and from 350 kg/TJ to 16.2 kg/TJ for CO, consequently leading to a decrease in emissions of these two pollutants. Activity data for this sector remained unchanged from the 2016 submission.

3.4.1.4 *Planned improvements*

Acquire emission factors for not-estimated POP's pollutants and report those emission estimates.

3.5 Manufacturing Industries & Construction (NFR 1A2)

3.5.1 Manufacturing industries, stationary combustion (1A2a-g)

3.5.1.1 *Activity Data*

Information on the total amount of fuel used by the manufacturing industries was obtained from the NEA and adjusted by EAI (see Annex I). The total fuel consumption per fuel type can be seen in Table 3.5. The sales statistics for the manufacturing industry (as adjusted by EAI) are given for the sector as a total. There is thus a given total, which the usage in the different subcategories must sum up to. The sales statistics do not specify the fuel consumption by the different industrial sources. This division is made by the EAI on basis of the reported fuel use by all major industrial plants that fall under law no. 70/2012 on Climate Change (metal production, cement) and from green accounts submitted by the industry in accordance with regulation no. 851/2002 for industry not falling under law no. 70/2012. Fuel consumption in the fishmeal industry from 1990 to 2002 was estimated from production statistics, but the numbers for 2003 to 2014 are based on data provided by the industry (application for free allowances under the EU Emissions Trading System (EU ETS) for the years 2005 to 2010, information from the Icelandic Association of Fishmeal Manufacturers for 2003, 2004 and 2011 and 2012). The difference between the given total for the sector and the sum of the fuel use of the reporting industrial facilities are categorized as 1A2f other non-specified industry. Emissions are calculated by multiplying energy use with a pollutant specific emission factor. Emissions from fuel use in the ferroalloys production is reported under 1A2a. Emissions from the cement industry (the single operating cement plant was closed down in 2011) and the mineral wool production are reported under 1A2fi. For PAH4, emissions from the mineral wool production are not estimated, and for dioxin, emissions from the cement industry are reported under industrial processes (2A1).

Table 3.5 Fuel use (kt), stationary combustion in the manufacturing industry.

	1990	1995	2000	2005	2010	2014	2015
Gas/Diesel oil	5.07	1.13	10.25	22.19	9.39	4.57	3.59
Residual fuel oil	55.93	56.22	46.21	25.01	16.55	1.61	4.99
LPG	0.48	0.39	0.86	0.93	1.05	1.19	1.19
Electrodes (residue)	0.80	0.29	1.50	0.00	0.40	0.00	0.00
Steam coal	18.60	8.65	13.26	9.91	3.65	0.00	0.00
Petroleum coke	0.00	0.00	0.00	8.13	0.00	0.00	0.00
Waste oil	0.00	4.99	6.04	1.82	1.36	0.85	0.85

3.5.1.2 *Emission factors*

Emission factors for dioxin for liquid fuel used in stationary combustion in manufacturing industry are taken from the “Utslipp til luft av dioksiner i Norge” (Statistics Norway, 2002). PAH4 emission factors for coal used in stationary combustion (used in the cement industry) as well as the profile ratio are taken from the chapter “An approach to estimation of PAH emission in the Emission Inventory Guidebook” (EEA 2007). The BaP emission factor for industrial coal combustion for large plants is taken from Appendix 3 of the chapter and the profile ratio is found in section 7. PAH emission factors for liquid fuels are taken from table 3-4 (Tier 1 EF for 1A2 combustion in industry using liquid fuels) from chapter 1.A.2 of the Emission Inventory Guidebook (EEA 2013). The emission factors for dioxin and PAH4 are presented in Table 3.6.

Table 3.6 Emission factors for dioxin and PAH4 from stationary combustion in manuf. industry.

	Dioxin [µg I-TEQ/t fuel]	B(a)P [mg/GJ]	B(b)F [mg/GJ]	B(k)F [mg/GJ]	IPy [mg/GJ]
Gas/Diesel Oil	0.1	1.9	15	1.7	1.5
Residual fuel oil	0.1	1.9	15	1.7	1.5
LPG	0.06	0.72	2.9	1.1	1.08
Electrodes residues	IE[1]	0.14	PR: 0.05	PR: 0.01	PR:0.8
Steam coal	IE[1]	0.14	PR: 0.05	PR: 0.01	PR:0.8
Petroleum coke	IE[1]	1.9	15	1.7	1.5
Waste oil	4	1.9	15	1.7	1.5

[1] Coal, electrodrodes residues and petroleum coke are only used in the cement plant; all dioxin emissions from the cement plant are reported under 2A1. PR: profile ratio.

SO_2 emissions are calculated from the S-content of the fuels. Source specific emission factors for NO_x and CO are taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). Emission factors for NMVOC are taken from EMEP guidebook 2013 (EEA, 2013). Sulphur emissions from use of petroleum coke occur in the cement industry. Further waste oil has mainly been used in the cement industry. Emission estimates for SO_2 for the cement industry are based on measurements.

3.5.2 Manufacturing industries, mobile combustion (1A2gvii)

3.5.2.1 *Activity data*

Activity data for mobile combustion in the construction sector is provided by the NEA. Oil, which is reported to fall under vehicle usage, is in some instances actually used for machinery and vice versa as it happens that machinery refuels at a tank station, (thereby reported as road transport), as well as fuel that is sold to contractors, to be used on machinery, is used for road transport (but reported under construction). This is, however, very minimal and the deviation is believed to level out. Emissions are calculated by multiplying energy use with a pollutant specific emission factor. Activity data for fuel combustion are given in Table 3.7.

Table 3.7 Fuel use (kt), mobile combustion in the construction industry.

	1990	1995	2000	2005	2010	2014	2015
Gas/Diesel oil	37.98	46.74	61.89	67.78	32.23	40.46	30.03

3.5.2.2 *Emission factors*

Emission factors for dioxin from mobile sources are taken from “Utslipp til luft av dioxiner i Norge” (Statistics Norway, 2002). They are 0.1 µg/t fuel. PAH emissions are not estimated from this source. SO_2 emissions are calculated from the S-content of the fuels. Emission factors for NO_x, CO and NMVOC are taken the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual (IPCC, 1996) and the EMEP guidebook 2013 (EEA, 2013). Emission factors for BC are taken from Emissions of Black Carbon and Organic Carbon in Norway 1990-2011 (Aasestad, 2013).

3.6 Transport (NFR 1A3)

3.6.1 Civil aviation (1A3a)

Emissions from aviation are divided into four groups: International Landing and Take-Off (LTO) (1A3ai(i)), Domestic LTO (1A3aii(i), International cruise (1A3ai(ii) and Domestic cruise (1A3aii(ii)). As defined by Eurocontrol "LTO" includes taxi out, take off, climb out (up to a height of 3000 ft.), final approach (from a height of 3000 ft.), landing and taxi in. "Cruise" includes climb from a height of 3000 ft. up to the cruise level, cruise, and descent down to a height of 3000 ft. Emissions occurring during LTO of both domestic and international flights are included in national totals, whereas emissions occurring during the cruise part of the flights are reported as "memo" item and are thus not counted in the national totals.

Emissions for the years 2005-2015 are taken directly from the Eurocontrol dataset for Iceland, which differentiates between Domestic, International, LTO and Cruise emissions. The pollutants reported from the Eurocontrol dataset include: NOx, SO_x, CO, NMVOC, TSP, PM_{10} and $PM_{2.5}$. For the years 1990-2004, emissions were estimated based on fuel type (jet kerosene vs. aviation gasoline), and emissions attributed to either LTO or Cruise using a ratio calculated from the Eurocontrol dataset (see below), with sales data allowing the distinction between international and domestic use.

3.6.1.1 *Activity data*

Activity data is provided by the NEA, which collects data on fuel sales by sector. This data distinguishes between national and international usage. In Iceland, there is one main airport for international flights, Keflavík Airport. Under normal circumstances almost all international flights depart and arrive from Keflavík Airport, except for flights to Greenland, the Faroe Islands, and some flights with private airplanes which depart/arrive from Reykjavík airport. Domestic flights sometimes depart from Keflavík airport in case of special weather conditions. Oil products sold to Keflavík airport are reported as international usage. The deviations between national and international usage are believed to level out. Activity data stems from different datasources depending on the year:

- 1990-2004: Use of jet kerosene and aviation gasoline is based on the NEA's annual sales statistics for fossil fuels.
- 2005-2015: Fuel activity data is included in the Eurocontrol dataset. However, the dataset only includes total amount of fuel burnt (in kt), without differentiating between jet kerosene and aviation gasoline. Since these two types of fuel have slightly different NCV´s (44.3 TJ/kt for aviation gasoline, 44.1 TJ/kt for jet kerosene), in order to obtain total fuel activity data in TJ, the NEA´s annual sales statistics were used as an approximation of the ratio of aviation gasoline to jet kerosene to calculate a weighted-average NCV, which was used to convert the total burnt fuel reported by Eurocontrol into TJ.

Activity data for fuel sales for domestic and international aviation are given in Table 3.8 and Table 3.9.

Table 3.8 Fuel sales (kt.), domestic aviation.

	1990	1995	2000	2005	2010	2014	2015
Jet Kerosene	8.409	8.253	7.728	7.39	6.066	12.3	5.99
Aviation gasoline	1.681	1.131	1.102	0.872	0.648	0.5	0.5

Table 3.9 Fuel sales (kt), international aviation

	1990	1995	2000	2005	2010	2014	2015
Jet Kerosene	69.4	74.64	129.15	133.2	119.52	177.47	213.74
Aviation gasoline	0.2	0.18	0.03	0.40	0.01	0.002	0.01

A complete time series for fuel sales used in the emission estimates are provided in the NFR tables[6] under “liquid fuels” for the relevant NFR sector (expressed as the sum the two fuels used in the sectors).

3.6.1.2 *Emission factors*

1990-2004: Total emissions (LTO + Cruise) were calculated using following emissions factors: Emission factors for dioxin were taken from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2005) and from “Utslipp til luft av dioxiner i Norge” (Statistics Norway, 2002). PAH4 emissions were not estimated as no emission factors are included in the EMEP/EEA 2016 Guidebook, nor are those emissions estimated by Eurocontrol. SO_2 emissions were calculated from the S-content of the fuels provided by the National Energy Authority. Emission factors for NOx, CO and NMVOC were taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual (IPCC, 1996). As per the Eurocontrol dataset there is no particle emission from turboprop airplanes, only from jets; However, data on plane types for the time period 1990-2004 is not available. Thus particle matter emissions are not estimated for domestic aviation for that time. For international aviation, it was assumed that TSP = PM_{10} = $PM_{2.5}$, as is the case in the Eurocontrol dataset. An emission factor was calculated from the Eurocontrol dataset using the average IEF for 2005 til 2015 for international LTO and cruise, respectively, and applied to the period 1990-2004.

In order to allocate emissions to LTO and Cruise, respectively, a distribution factor was calculated using the 2005 Eurocontrol data for each pollutant, and this factor was applied to the 1990-2004 dataset.

2005-2015: Emissions were taken from the Eurocontrol dataset without further calculations, with the exception of dioxin for which estimates were not provided in that dataset. Dioxin was therefore calculated in the same way as for the period 1990-2004.

The emission factors for the period 1990-2004 are presented in Table 3.10, and for particle matter in international aviation in Table 3.11.

Table 3.10 Emission factors for dioxin, NOx, CO and NMVOC by fuel type - 1990-2004 (Except dioxin, where the EF apply for 1990-2015)

	Dioxin [µg I-TEQ/t fuel]	NOx [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]
Jet Kerosene	0.06	250	100	50
Aviation gasoline	2.2	250	100	50

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[6] http://cdr.eionet.europa.eu/is/un/clrtap/ (Envelope A)

Table 3.11 Emission factors for TSP and BC, international aviation - 1990-2004

	TSP [kg/TJ]	PM_{10} [kg/TJ]	$PM_{2.5}$ [kg/TJ]	BC % of TSP
International LTO	2.86	2.86	2.86	18%
International Cruise	4.41	4.41	4.41	18%

3.6.1.3 *Recalculations and planned improvements*

The emission calculation methodology was changed since last year's submission, where the distinction between LTO and Cruise had not been implemented. Therefore, the LTO emissions were marked as "Included Elsewhere" in last year's submission, and were reported under memo items 1A3ai(ii) (International cruise) and 1A3aii(ii) (Domestic cruise). Planned improvements include a reassessment of the emission factors used in the emission estimates for the period 1990-2004.

3.6.2 Road vehicles (1A3b)

This sector covers the emission estimates from exhaust emissions from various types of road transportation vehicles based on fuel sales statistics supplied annually by the National Energy Agency (AEA).

3.6.2.1 *Methodology*

Emissions from road vehicles are estimated by multiplying the fuel use, by type of fuel and vehicle, with fuel and vehicle pollutant specific emission factors. This methodology applies to POP's, NOx, NMVOC and CO. SO_2 emissions are estimated based on the S-Content of the different types of fuels used in road vehicles and by assuming that all Sulphur is converted to SO_2 in the combustion process.

The transport model COPERT v4 is furthermore used to make emission estimates for emission estimates of pollutants other than POP's, NO_x, NMVOC, CO and SO_2. The following text is taken from the COPERT website regarding the applied methodology[7]:

> *"The COPERT methodology is part of the EMEP/EEA air pollutant emission inventory guidebook for the calculation of air pollutant emissions."*

Data that was acquired in the 2017 submission for the use of COPERT is limited to the years 2000-2014 and the assumption is consequently made that the emission estimates for the pollutants estimated with COPERT are the same for 2015 as for 2014. Pre-2000 emission estimates for the pollutants estimated with COPERT are not reported and have not been estimated.

3.6.2.2 *Activity data*

Total use of diesel oil and gasoline are based on the NEA's annual sales statistics for fossil fuels (Table 3.12).

Table 3.12 Fuel use (kt), road transport.

	1990	1995	2000	2005	2010	2014	2015
Gasoline	127.8	135.6	142.6	156.7	148.2	132.0	133.5
Diesel oil	36.6	36.9	47.5	83.5	106.4	112.7	126.4

NEA made estimations on how the fuel consumption is divided between different vehicles groups, i.e. passenger cars, light duty vehicles, and heavy duty vehicles are used for the period 1990 to 2005.

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[7] http://emisia.com/products/copert

From 2006 to 2015 EAI estimated how the fuel consumption is divided between the different vehicles groups, using information on the number of vehicles in each group and the driven mileage in each group from the Icelandic Transport Authority (ICETRA), using average fuel consumption based on the 1996 IPCC Guidelines Regarding Average Fuel Consumption Per Group. The data for 2006 to 2015 contains information on motorcycles. Therefore, the time series is not fully consistent as two different methodologies are used. For the years 1990 to 2005 emissions from motorcycles are included in emissions from other vehicles.

The EAI has estimated the amount of passenger cars by emission control technology. The proportion of passenger cars with three-way catalysts has steadily increased since 1995 when they became mandatory in all new cars. The assumptions are shown in Figure 3.5. Although three-way catalysts have been mandatory for a long time now, it is assumed that the proportion of cars with three-way catalyst stagnates at 86%, as the catalysts usually lose their function after about 10 years.

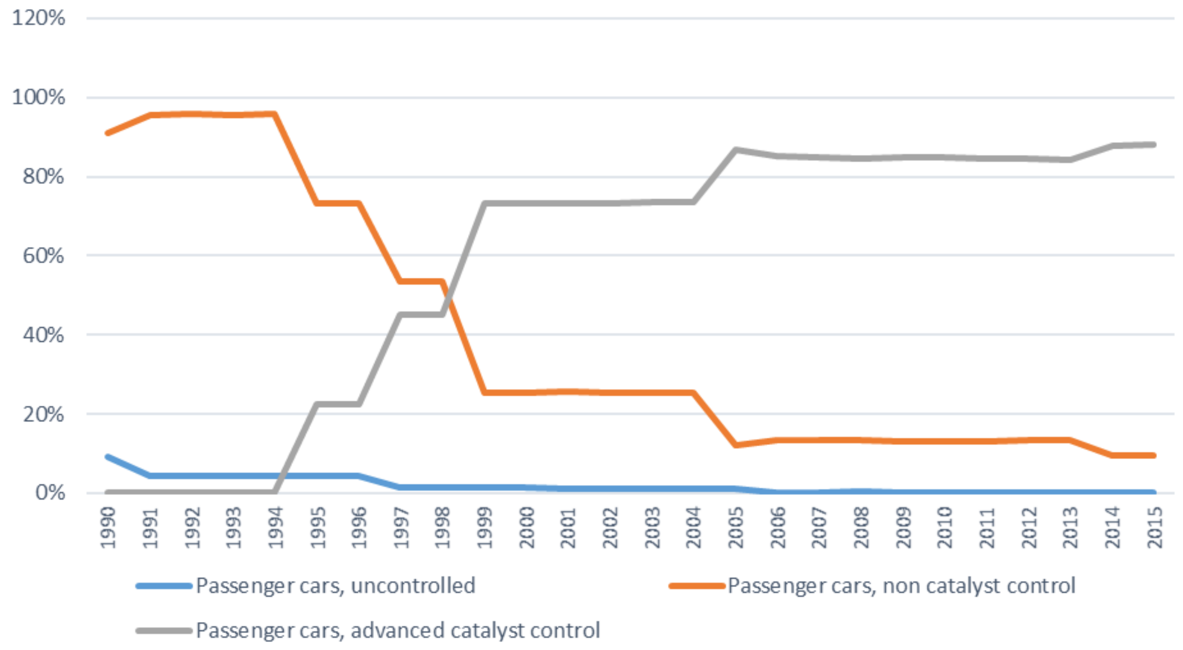

Figure 3.5 Assumptions on emission control technology in passenger cars used in the emission estimates.

For the 2017 submission, a dataset for COPERT was acquired from 2000-2014. This data is detailed for Iceland and includes, among other data, a division of the fleet population into 276 groups depending on vehicle type and technology based on European emission control standards. 2015 data was for COPERT not received before the 2017 submission and therefore the same fleet composition was used in 2014 and 2015.

3.6.2.3 *Emission factors*

Emission factors for dioxin are taken from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2005). They are presented in *Table 3.13*. Emission factors for PAH are taken from the chapter "An approach to estimation of PAH emission" in the Emission Inventory Guidebook (EEA, 2007). Emission factors for PAH4 are presented in *Table 3.14*.

Table 3.13 Emission factors for dioxin, road vehicles.

	Dioxin [µg I-TEQ/t fuel]
Gasoline, leaded	2.2
Gasoline, unleaded, no catalyst	0.1
Gasoline, unleaded, with catalyst	0
Gas/ Diesel oil	0.1

Table 3.14 Emission factors for PAH4, road vehicles.

	B(a)P	Fuel cons.	B(a)P	Ratio to B(a)P		
	[mg/GJ]	[l/100 km]	µg/kg fuel	B(b)F	B(k)F	IPy
Passenger cars - gasoline, conventional	1.1	8.5	17.14	1.2	0.9	1
Passenger cars - gasoline, catalyst	0.4	8.5	6.23	0.9	1.2	1.4
Light duty vehicles - gasoline	1.1	13.6	10.71	1.2	0.9	1
Pass.cars diesel - direct ing.	0.7	7	11.79	0.9	1	1.1
Pass.cars diesel - indirect inj.	2.8	7	47.14	0.9	0.8	0.9
Light duty vehicles - direct inj.	0.7	10.9	7.57	0.9	1	1.1
Light duty vehicles - indirect inj.	2.8	10.9	30.29	0.9	0.8	0.9
HDV (diesel)	1	29.9	3.94	5.6	8.2	1.4
Other use, gas/diesel oil, (*HDV)	1	29.9	3.94	5.6	8.2	1.4

SO_2 emissions are calculated from the S-content of the fuels.

Emission factors for the pollutants NOx, NMVOC and CO are taken from the revised 1996 IPCC Guidelines (IPCC, 1996) and depend on vehicle type and emission control.

Emission factors for other pollutants depend upon vehicle type and emission control. They are taken from the revised 1996 IPCC Guidelines (IPCC, 1996) and are presented in *Table 3.15*5.

Table 3.15 Emission factors for NOx, CO, NMVOC and BC for European vehicles (NE - Not estimated).

	NOx [g/kg fuel]	CO [g/kg fuel]	NMVOC [g/kg fuel]	BC [g/kg fuel]
Passenger cars - gasoline, uncontrolled	27	550	63	NE
Passenger cars - gasoline, non-catalyst control	37	300	72	NE
Passenger cars - gasoline - three way catalyst	8.2	45.9	7.1	NE
Light duty vehicles - gasoline	29	360	59	NE
Heavy duty vehicles - gasoline	40	346	32	NE
Motorcycles - gasoline	2.7	730	530	NE
Passenger cars - diesel	11	12	3	0.325
Light duty vehicle - diesel	16	18	4.6	0.644
Heavy duty vehicles - diesel	42	36	8	0.202

Emission factors for other reported pollutants is based on COPERT emission factors (EMEP/EEA guidebook).

3.6.2.4 *Recalculations*

For the 2017 submission, COPERT data was used in the calculations with the following main changes from the 2016 submission when comparing emission estimates for reporting year 2014:

- Correction in the reporting of NOx and NMVOC and dioxin from passenger cars (NFR 1A3bi) and mopeds and motorcycles (NFR 1A3biv) .
- New emission estimates for the following pollutants from 2000-2014:
    - Main Pollutants: NH_3.
    - Particulate matter: $PM_{2.5}$, PM_{10} and BC[8].
    - Priority heavy metals: Pb, Cd.
    - Additional heavy metals: Cr, Cu, Ni, Se and Zn.

For the 2017 submission, new emission estimates for BC was included for 2013 and 2014 based on COPERT. Emissions for BC increased between the 2016 and 2017 submission due to this.

3.6.2.5 *Planned improvements*

Planned improvements with the highest priority are the following:

- Acquire emission factors not-estimated POP’s and estimate the emissions.
- Acquire comprehensive data for vehicle fleet pre-2000 to facilitate further use of the COPERT transport model in the emission estimates.
- Comparison of emission estimates between COPERT and current estimates for NO_x, NMVOC, CO and SO_2.

3.6.3 National navigation (1A3dii)

Emissions are calculated by multiplying energy use with a pollutant specific emission factor.

3.6.3.1 *Activity data*

Total use of residual fuel oil and gas/diesel oil for national navigation is based on the NEA's annual sales statistics for fossil fuels. Activity data for fuel combustion are given in Table 3.16.

Table 3.16 Fuel use (kt), national navigation.

	1990	**1995**	**2000**	**2005**	**2010**	**2014**	**2015**
Gas/Diesel oil	11.75	7.04	3.43	6.20	8.46	4.29	7.89
Residual fuel oil	7.17	4.76	0.54	0.88	2.61	2.14	0.44

3.6.3.2 *Emission factors*

Emission factors for dioxin and PAH (only B(b)F) are taken from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). SO_2 emissions are calculated from the S-content of the fuels. Emission factors for NOx, CO and NMVOC are taken from Table 1.48 in the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships. Emission factors for PCB, HCB, PM, BC and heavy metals were taken from the EMEP/EEA 2006 Guidelines for navigation. All emission factors are presented in

Table *3.17*.

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[8] Elemental carbon assumed to be comprised of Black carbon only, as suggested by the EMEP/EEA 2013 guidebook.

Table 3.17 Emission factors form national navigation emissions.

	NOx [kg/TJ]	NMVOC [kg/TJ]	CO [kg/TJ]	TSP [kg/t fuel]	PM_{10} [kg/t fuel]	$PM_{2.5}$ [kg/t fuel]
Marine diesel oil	1800	52	180	1.5	1.5	1.4
Bunker fuel oil	1800	52	180	6.2	6.2	5.6
	BC % of TSP	**Dioxin [µg I-TEQ/t fuel]**	**B(b)F [g/t fuel]**	**Pb [g/t fuel]**	**Cd [g/t fuel]**	**Hg [g/t fuel]**
Marine diesel oil	12%	4	0.04	0.13	0.01	0.03
Bunker fuel oil	31%	4	0.04	0.18	0.02	0.02
	As [g/t fuel]	**Cr [g/t fuel]**	**Cu [g/t fuel]**	**Ni [g/t fuel]**	**Se [g/t fuel]**	**Zn [g/t fuel]**
Marine diesel oil	0.04	0.05	0.88	1	0.1	1.2
Bunker fuel oil	0.68	0.72	1.25	32	0.21	1.2

3.6.3.3 *Recalculations and planned improvements*

No recalculations were made for this sector. Planned improvements include an update of emission factors currently taken from the revised 1996 Guidelines.

3.6.4 1A3di(i) International navigation (memo item)

The retail supplier divides fuel use between international navigation (including foreign fishing vessels) and national navigation based on identification numbers which differ between Icelandic and foreign companies. The methodology and emission factors for marine bunkers are the same as described for national navigation, and the emission factors can be found in

Table *3.17*. The resulting emissions are reported as a memo item and are not included in national totals.

3.7 Other Sectors (NFR 1A4)

3.7.1 Commercial, institutional & residential fuel combustion (1A4a, 1A4b)

Since Iceland relies largely on its renewable energy sources, fuel use for residential, commercial, and institutional heating is low. Residential heating with electricity is subsidized and occurs in areas far from public heat plants. Two waste incineration plants used waste to produce heat. One of them used the heat for heating a swimming pool and a school building (Skaftárhreppur, closed down in December 2012), and the other one used the heat for heating a swimming pool (Svínafell, closed down in 2010). Commercial/Institutional fuel combustion also includes the heating of swimming pools with gas oil, but only a few swimming pools in the country are heated with oil.

3.7.1.1 *Activity data*

Activity data for fuel use is provided by the NEA, which collects data on fuel sales by sector. EAI adjusts the data provided by the NEA as further explained in Annex I. Activity data for waste incineration are collected by the EAI directly. Activity data for fuel combustion and waste incineration in the Commercial/Institutional sector are given in *Table 3.18*.

Table 3.18 Fuel use (kt.), commercial/institutional sector.

	1990	1995	2000	2005	2010	2014	2015
Gas/Diesel oil	1.8	1.6	1.6	1.0	0.3	0.3	0.30
Waste oil	3.3	-	-	-	-	-	-
LPG	0.3	0.3	0.5	0.5	0.2	0.3	0.34
Solid waste	NO	0.5	0.6	0.6	0.3	NO	NO

Activity data for fuel combustion in the Residential sector is given in Table 3.19. The table displays that the use of kerosene increased substantially from 2005 to 2010. Kerosene is used in summerhouses but also, to some extent, in the Commercial sector for heating of commercial buildings. The usage has been very low over the years and therefore the kerosene utilisation has all been allocated to the Residential sector. The increase in usage in the years 2008 to 2011 is believed to be attributed to rapidly rising fuel prices in the transport sector. This has motivated some diesel car owners to use kerosene on their cars as the kerosene does not have CO_2 tax, despite the fact that it is not good for the engine. Since 2012 the CO_2 tax covers also kerosene and the use decreased rapidly again.

Table 3.19 Fuel use (kt), residential sector.

	1990	1995	2000	2005	2010	2014	2015
Gas/Diesel oil	8.73	6.36	6.03	3.24	1.92	3.63	3.63
LPG	0.42	0.45	0.72	0.93	1.42	0.77	0.77
Kerosene	0.51	0.15	0.15	0.17	1.22	0.76	0.76

3.7.1.2 *Emission factors*

Emission factors (EFs) for dioxin from stationary combustion are taken from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). They are 0.1 µg/t fuel for gas oil and kerosene, 0.06 µg/t fuel for LPG (Liquified Petroleum Gas) and 4 µg/t for waste oil. Emissions of SO_2 are calculated from the S-content of the fuels. Emission factors for other pollutants are taken from the revised 1996 IPCC Guidelines (IPCC, 1996) and the EMEP/EEA air pollutant emission inventory guidebook (EEA, 2013). Default EFs from Tables 1.7 to 1.11 in the Reference Manual were used in cases where EFs were not available. Emissions from waste incineration with recovery, where the energy is used for swimming pools/school buildings are reported here. The IEF for dioxin in the sector shows fluctuations over the time series. From 1994 to 2012 (as stated above one plant was closed down in 2010 and the other one in 2012) waste was incinerated to produce heat at two locations (swimming pools, school building). The IEF for dioxin for waste is considerably higher than for liquid fuel. Further waste oil was used in the sector from 1990 to 1993. This combined explains the rise in IEF for the whole sector.

3.7.2 Agriculture, forestry & fishing (1A4c)

Emissions from fuel use in agriculture and forestry are included elsewhere, mainly within the construction (1A2fii) and Residential sectors (1A4bi); thus, emissions reported here only stem from the fishing fleet. Emissions from commercial fishing are calculated by multiplying energy use with a pollutant specific emission factor.

3.7.2.1 *Activity data*

Total use of residual fuel oil and gas/diesel oil for the commercial fishing is based on the NEA's annual sales statistics for fossil fuels. Activity data for fuel combustion in the Fishing sector are given in Table 3.20.

Table 3.20 Fuel use (kt), fishing sector.

	1990	1995	2000	2005	2010	2014	2015
Marine diesel oil	174.90	191.13	211.11	171.68	128.16	102.24	116.33
Bunker fuel oil	32.42	53.44	16.01	26.30	41.41	37.38	27.33

3.7.2.2 *Emission factors*

Emission factors for dioxin and PAH (only B(b)F) are taken from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). SO_2 emissions are calculated from the S-content of the fuels. Emission factors for NOx, CO and NMVOC are taken from Table 1.48 in the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships. Emission factors for PCB, HCB, PM, BC and heavy metals were taken from the EMEP/EEA 2006 Guidelines for navigation. All emission factors used for calculating emissions from this sector are the same as those used in the national navigation sector (1A3dii) and are presented in

Table *3.17*.

3.8 Fugitive Emissions (NFR 1B2)

3.8.1 Distribution of oil products (1B2av)

NMVOC emissions from distribution of oil products are estimated by multiplying the total imported fuel with an emission factor. The emission factor is taken from the EMEP/EEA air pollutant emission inventory guidebook – 2009 (EEA, 2009) and is 9 kg/Mg. Data on total import of fuels are taken from Statistics Iceland.

3.8.2 Geothermal energy (1B2d)

Iceland relies heavily on geothermal energy for space heating (90%) and to a significant extent for electricity production (30% of the total electricity production in 2014). Geothermal energy is generally considered to have relatively low environmental impact. Emissions of CO_2 are commonly considered to be among the negative environmental effects of geothermal power production, even though they have been shown to be considerably less extensive than from fossil fuel power plants, or 19 times less (Baldvinsson, 2011). Very small amounts of methane, but considerable quantities of Sulphur in the form of hydrogen supplied (H_2S) are emitted from geothermal power plants.

3.8.2.1 *Activity data*

The H_2S concentration in the geothermal steam is site and time-specific, and can vary greatly between areas and the wells within an area as well as by the time of extraction. The total emissions estimate of H_2S is based on direct measurements. The enthalpy and flow of each well are measured and the H_2S concentration of the steam fraction determined at the wellhead pressure. The steam fraction of the fluid and its H_2S concentration at the wellhead pressure and the geothermal plant inlet pressure are calculated for each well. Information about the period each well discharged in each year is then used to calculate the annual H_2S discharge from each well and finally the total H_2S is determined by adding up the H_2S discharge from individual wells.

Table 3.21 shows the electricity production with geothermal energy and the total Sulphur emissions (calculated as SO_2).

Table 3.21 Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2010	2014	2015
Electricity production (GWh)	282.91	288.18	1322.95	1658.00	4465.00	5238.41	5238.41
Sulphur emissions (as SO_2, kt.)	13.33	11.01	26.02	30.31	57.70	46.71	46.71

3.9 Uncertainties and timeseries consistency

No uncertainty analysis has been done for the waste sector and work has been done to facilitate such calculations for future submissions. For road transport (NFR 1A3b), emission estimates are missing for pollutants calculated with COPERT due to the lack of activity data pre-2000 used in the model.

3.10 QA/QC and verification procedures

The QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission calculations, estimating uncertainties, archiving information and reporting, as further elaborated in the QA/QC manual. No source specific QA/QC procedures have been developed yet for the Energy sector.

4 Industrial Processes (NFR sector 2)

4.1 Overview

Most the expansion of the industrial sector, the contribution of this sector to the total emissions has been increasing since 1990. By far the major category within the industry is metal production, and the emission trends of the various pollutants closely match the opening and closing of various facilities.

While most of the pollution originating from the industrial processes sector can be traced back to the metal production industry, exceptions include NMVOC and Hg, which mostly originate from solvents and product use, NH_3 which comes from the mineral wool industry, and most heavy metals other than Hg that are emitted during the use of fireworks and tobacco (2G Other solvent and product use).

4.1.1 Sectoral trends - POPs

The emissions from the industrial processes sector in 2015 are shown below in Table 4.1. The complete emission dataset can be found in the NFR Tables[9]. Figure 4.1 to Figure 4.4 show the trends for Dioxin, PAH4, HCB and PCB since 1990, subdivided into the 6 subsectors belonging the industrial sector.

Table 4.1 Dioxin, PAH, HCB and PCB emissions from industrial processes, 2015 (NA – Not applicable, NE – Not estimated, NO - Not occurring)

		Dioxin [g I-TEQ]	B(a)P [t]	B(b)f [t]	B(k)f [t]	IPY [t]	PAH4 [t]	HCB [kg]	PCB [kg]
2A	Mineral industry	4.E-05	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO
2B	Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO
2C	Metal production	0.056	2.E-03	0.022	6.E-03	2.E-03	0.035	0.011	0.011
2D	Solvent and product use	1.E-06	NA/NE/NO	NA/NE/NO	NA/NE/NO	NA/NE/NO	NA/NE/NO	NA/NE/NO	NA/NE/NO
2G	Other solvent and product use	3.E-05	3.E-05	1.E-05	1.E-05	1.E-05	7.E-05	NA/NE/NO	NA/NE/NO
2H	Other industry production	NA	NA	NA	NA	NA	NA	NA	NA
Industrial Processes, Total		**0.056**	**0.0025**	**0.022**	**0.0064**	**0.0024**	**0.035**	**0.011**	**0.011**

The main source of POPs is the metal production industry (2C). In 2015, three primary aluminium smelters, one secondary aluminium production facility, one ferrosilicon plant as well as one secondary steel plant were operating in Iceland. Solvents and other solvent and product use (2D, 2G) also emit POPs, but to a very small percentage compared to the metal production industry.

Figure 4.1 shows the dioxin emissions from the industrial sector. The increases in 1998-1999 and in 2007-2008 correspond to the opening of two new primary aluminium smelters, and the increase in 2014 corresponds to the opening of a secondary steel production facility, whose production was much less in 2015 than in 2014 leading to the sharp decrease in 2015. The dioxin emissions from 2A mineral industry mostly originated from a cement factory that ceased production in 2011 .

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[9] http://cdr.eionet.europa.eu/is/un/clrtap/ (Envelope A)

PAH4 emissions, shown in Figure 4.2, also originate almost exclusively from the metal production industry. As for dioxin, the step-wise increase in emissions corresponds to the expansion of the industry.

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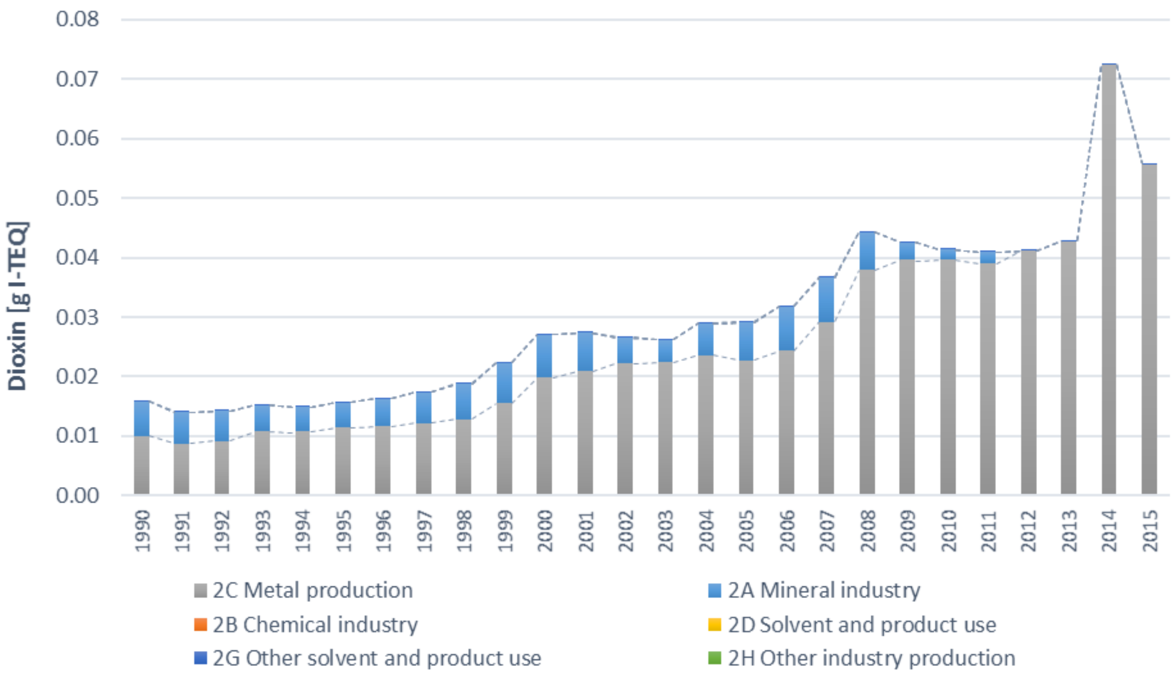

Figure 4.1 Dioxin emissions in the industrial sector, 1990-2015

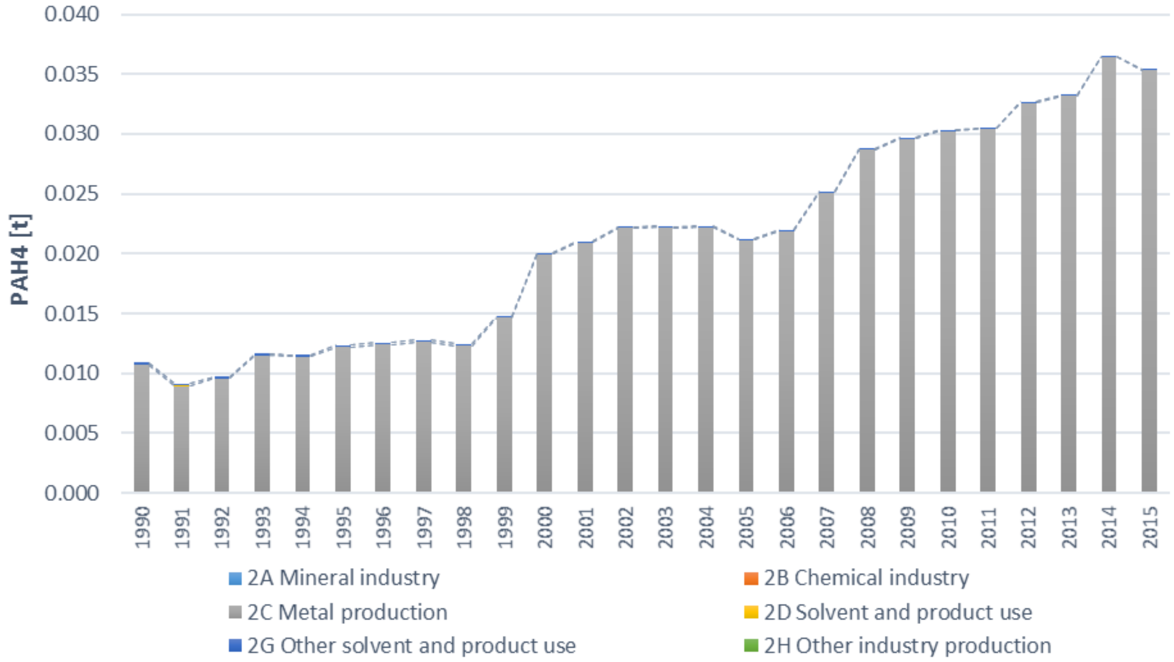

Figure 4.2 PAH4 emissions in the industrial sector, 1990-2015

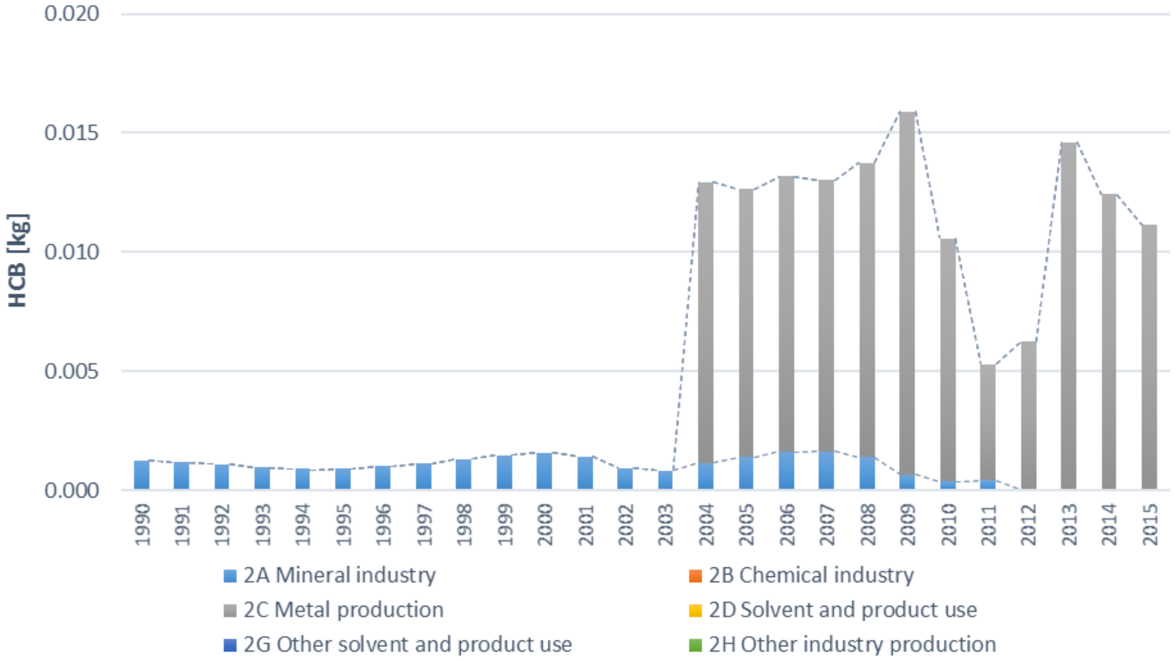

Figure 4.3 HCB emissions in the industrial sector, 1990-2015

Figure 4.3 shows HCB emission trends. The main HCB source was the cement industry, until 2004 where a secondary aluminium production facility, Alur, opened leading to an increase in HCB emissions. In 2010, Alur started stepping down the production, with a corresponding decrease in HCB emissions. In 2013, another secondary aluminium plant, Kratus, opened, leading to a new increase in production.

Figure 4.4 shows the PCB emissions. Only one PCB source is estimated for this sector, which is the secondary steel production industry. Operations at the plant started in 2014, with a much lower production in 2015 than in 2014.

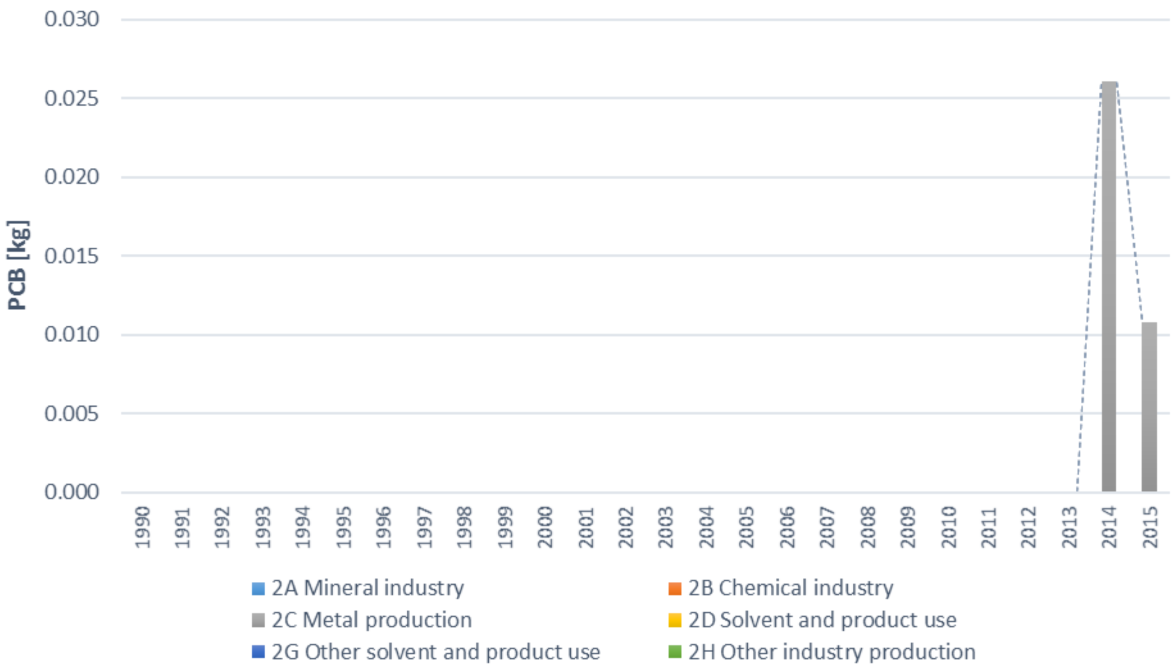

Figure 4.4 PCB emissions in the industrial sector, 1990-2015

Overall, the POPs emissions have been increasing since 1990, with a clear correlation between the emissions and the opening and closing of various facilities.

4.1.2 Sectoral trends - other pollutants

Table 4.2 and Table 4.3 show the 2015 emissions for NOx, NMVOC, SOx, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC and CO, as well as heavy metals. Figures showing the evolution of the emissions since 1990 for each pollutant, by subsector, are shown in Annex IV.

Table 4.2 NOx, NMVOC, SOx, NH_3, PM and CO emissions from industrial processes, 2015 (NA – Not applicable, NE – Not estimated, NO - Not occurring)

		NO_X [kt] NO_2	**NMVOC [kt]**	**SO_X [kt] SO_2**	**NH_3 [kt]**	**$PM_{2.5}$ [kt]**	**PM_{10} [kt]**	**TSP [kt]**	**BC [kt]**	**CO [kt]**
2A	Mineral industry	NO/NE/NA	NO/NE/NA	9.E-04	0.016	0.013	0.015	0.017	3.E-04	0.029
2B	Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C	Metal production	2.12	0.10	13.7	NO/NE	0.59	0.67	0.77	0.0081	103.1
2D	Solvent and product use	NO/NE/NA	1.21	NO/NE/NA	NA/NO	1.E-04	8.E-04	0.0039	6.E-06	NO/NE/NA
2G	Other solvent and product use	7.E-04	0.0013	0.0018	0.0011	0.039	0.068	0.074	3.E-05	0.020
2H	Other industry production	NA	0.35	NA	NA	NR	NR	NR	NR	NA
Industrial Processes, Total		**2.12**	**1.66**	**13.7**	**0.017**	**0.64**	**0.75**	**0.86**	**0.008**	**103.1**

Table 4.3 Heavy metal emissions from industrial processes, 2015 (NA – Not applicable, NO - Not occurring, NR - Not relevant[10])

		Pb [t]	**Cd [t]**	**Hg [t]**	**As [t]**	**Cr [t]**	**Cu [t]**	**Ni [t]**	**Se [t]**	**Zn [t]**
2A	Mineral industry	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO
2B	Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C	Metal production	0.014	1E-03	2E-04	3E-03	3E-03	3E-03	3E-03	NR/NO	0.022
2D	Solvent and product use	NA/NR/NO	NA/NR/NO	2.E-03	NA/NR/NO	NA/NR/NO	NA/NR/NO	NA/NR/NO	NA/NR/NO	NA/NR/NO
2G	Other solvent and product use	0.47	9.E-04	4.E-05	8.E-04	9.E-03	0.27	0.018	3.E-06	0.16
2H	Other industry production	NA	NA	NA	NA	NA	NA	NA	NA	NA
Industrial Processes, Total		**0.49**	**0.0019**	**0.002**	**0.0041**	**0.012**	**0.27**	**0.021**	**3.E-06**	**0.18**

The metal production subsector accounts for most of the NOx, SOx, PM, BC and CO pollution, whereas solvent and product use as well as other industry production (2H2 Food and beverage production) are the biggest source of NMVOC and heavy metals. Heavy metal emissions in Iceland mostly come from fireworks use.

In general, emissions of most pollutants have increased since 1990, mirroring the expansion of the industry, the population growth (30% between 1990 and 2015), with dips of varying magnitude after 2007 following a major financial crisis that drastically affected the Icelandic economy.

4.2 General methodology

Methodology is based on the newest EMEP/EEA air pollutant emission inventory guidebook (EMEP, 2016). In general, emissions are calculated by multiplying the quantity of production or product use with pollutant-specific emissions factors. Emissions factors are taken from EMEP/EEA air pollutant emission inventory guidebook (EMEP, 2016), the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2005), Utslipp til luft av dioxiner I Norge (Statistics Norway, 2002), The 2006 IPCC Guidelines for Greenhouse Gas Inventories (IPCC, 2006) as well as plant-specific emission factors derived from direct measurements at the plants. Activity data is collected from data reported under the EU ETS, Statistics Iceland, Green Accounting or directly from the operators. Detailed, activity-specific methodology for emission estimates is described for each subsector.

This chapter on Industrial Processes (NFR sector 2) is divided into the following chapters:

- Mineral Industry (NFR 2A)
- Chemical Industry (NFR 2B)
- Metal Production (NFR 2C)
- Solvent and Product use (NFR 2D)
- Other solvent and product use (NFR 2G)
- Food and Beverages Industry (NFR 2H2)

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[10] Iceland uses the notation key NR for not estimated sources that are not POP‘s pollutants and pollutants that are reported to the UNFCCC under the Kyoto Protocol.

4.3 Mineral Industry (NFR 2A)

4.3.1 Cement production (2A1)

The single cement plant in Iceland produced cement from shell sand and rhyolite in a rotary kiln using a wet process. The raw material calcium carbonate, which came from shell sand, was calcinated in the production process. The resulting calcium oxide was heated to form clinker and then crushed to form cement.

The production at the cement plant in Iceland slowly decreased after 2000. The construction of the Kárahnjúkar hydropower plant (building time from 2002 to 2007) along with increased activity in the construction sector (from 2003 to 2007) increased demand for cement, and the production at the cement plant increased again between 2004 and 2007, although most of the cement used in the country was imported. In 2011, clinker production at the plant was 69% less than in 2007, due to the collapse of the construction sector. Late 2011 the plant ceased operation.

4.3.1.1 *Activity data*

Process specific data on cement production, clinker production and amounts of coal were collected by the EAI directly from the cement production plant.

4.3.1.2 *Emission factors*

Emission factor for dioxin is taken from the Toolkit for Identification and Quantification of Dioxin and Furan Releases (2013). The factor applies for wet kilns, with ESP/FF temperature < 200°C and is 0.05 µg I-TEQ/t cement. The HCB emission factor is based on the chapter Sources of HCB emissions from the Emission Inventory Guidebook (EEA, 2007). Emission factors for TSP, PM_{10} and $PM_{2.5}$ are based on measurements and the BC emission factor (3% of $PM_{2.5}$) is based on the 2013 Emission Inventory Guidebook (EEA, 2013). Emission estimates for SO_2 are based on measurements from the plant, but include both process-related and combustion-related emissions, and the total SO_2 emissions are reported in the Energy sector under 1A2gviii (Other stationary combustion in manufacturing industries and construction), and marked "IE" in 2A1 Cement production. Emissions of PAH, NOx, CO and NMVOC originate mainly from combustion and are also reported under 1A2gviii. All emission factors are summarized in the table below.

Table 4.4 Emission factors for cement production

	Dioxin [µg/t I-TEQ]	**HCB [µg/t]**	**TSP [kg/kt]**	**PM_{10} [kg/kt]**	**$PM_{2.5}$ [kg/kt]**	**BC % of PM2.5**
Cement production	0.05	11	220	200	100	3

4.3.1.3 *Recalculations and planned improvements*

No recalculations were performed between the previous and the current submission. No major improvements of this subsector are planned at the moment.

4.3.2 Mineral wool production (2A6)

There is one Mineral Wool Production Plant in operation in Iceland.

4.3.2.1 *Activity data*

Activity data for the mineral wool plant is based on data submitted to the EAI under the EU ETS and in Green Accounting.

4.3.2.2 *Emission factors*

Emissions of dioxins are calculated from the amount of electrodes used in the production process. The emission factor is taken from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002) and is 1.6 µg I-TEQ/t electrodes. PAH emissions are not estimated. Emissions of SO_2 are calculated using the S content of the electrodes used. Emission factors of CO, NH_3 and TSP were calculated based on measurements at the factory. IN the case of NH_3 and TSP, measurments were available for 2009, 2011, 2013 and 2015. For those years the actual measurments were used to derive a year-specific emission factor. For the years inbetween, the average of the emission factor of the previous year and of the following year was used. For all years prior to 2009, the average of 2009, 2011, 2013 and 2015 was used. PM_{10} and $PM_{2.5}$ were calculated from TSP using the TSP vs. PM_{10} vs. $PM_{2.5}$ ratios given in the EMEP/EEA 2016 Guidelines. BC was calculated using the ratio to $PM_{2.5}$ given in the 2016 Guidelines. NOx and NMVOC emissions originate from combustion and are reported under sector 1A2gviii.

Table 4.5 shows the emission factors used for mineral wool production.

Table 4.5 Emission factors for mineral wool production (NH_3, TSP: Values are EFs for 1990-2008)

	NH_3 [t/kt]	CO [t/kt]	TSP [t/kt]	PM_{10} % of TSP	$PM_{2.5}$ % of TSP	BC % of PM2.5	Dioxin [µg/t]
Mineral wool production	2.64	2.66	2.56	0.88	0.78	0.02	1.6

4.3.2.3 *Recalculations and planned improvements*

No recalculations were performed between the previous and the current submission. No major improvements of this subsector are planned at the moment.

4.4 Chemical Industry (NFR 2B)

4.4.1 Other (2B10a)

The only chemical industry that existed in Iceland was the production of fertilizer and silicium. The fertilizer production plant was closed down in 2001 and the silicium production plant was closed down in 2004. This industry is not considered to be a source of POPs nor heavy metals.

4.4.1.1 *Activity data*

When the fertilizer production plant was operational it reported its emissions of NO_x and N_2O to the EAI. At the silicium production plant, silicium containing sludge was burned to remove organic material. Emissions of CO_2 and NO_x were estimated on the basis of the C-content and N-content of the sludge provided by the operator.

Activity data for both industries are presented in Table 4.6.

Table 4.6 Production data for 1990, 1995 and 2000 for fertilizer and silicium production (in kt.)

	1990	1995	2000	
Fertilizer production [kt]	63.73	58.52	41.54	Facility closed in 2001
Silicium production, [kt]	26.11	28.14	27.61	Facility closed in 2004

4.4.1.2 *Emission factors*

For Silicium production, emissions of CO_2 and NO_x were estimated based on the C-content and N-content of the sludge provided by the operator. Average NOx IEF for the period 1990-2004 was 15.6 t NOx/kt Si production. Other emissions from soda ash use were not estimated and are considered to be small.

For the fertilizer production, the average IEF for NOx for the period 1990-2001 was 0.296 t NOx/kt fertilizer production. As there is no data readily available about the types of fertilizers produced at the time, no other pollutants were estimated for this industry.

4.4.1.3 *Recalculations and planned improvements*

No recalculations were performed for this submission. For next submission, other emissions from soda ash use will be included.

4.5 Metal Production (NFR 2C)

4.5.1 Secondary steel production (2C1)

Since 2014 a secondary steelmaking facility (GMR) has been operating in Grundartangi next to the ferrosilicon plant and the aluminium smelter Norðurál. GMR produces steel from scrap iron and steel from the aluminium smelters. Carbonates and slags are added to the smelting process, wich occurs in an electric arc furnace.

4.5.1.1 *Activity data*

Activita data used to estimate emissions from secondary steel production are total steel production, which is obtained from yearly Green Accounting reports submitted by the facility to the EAI.

4.5.1.2 *Emission factors*

All emissions are calculated using Tiers 2 emission factors for electric arc furnaces (Table 3.15, EMEP/EEA Guidebook 2016), with the exception of HCB for which there is no Tiers 2 estimate. In this case we used the Tier 1 emission factor, which is unrelated to technology.

Table 4.7 shows all emission factors used.

Table 4.7 Emission factors for secondary steel production.

	NO_x [kg/t]	**NMVOC [kg/t]**	**SO_2 [kg/t]**	**TSP [kg/t]**	**PM_{10} [kg/t]**	**$PM_{2.5}$ [kg/t]**	**BC % of PM2.5**	**CO [kg/t]**
Secondary steel	0.13	0.046	0.06	0.03	0.024	0.021	0.36	1.7
	Dioxin [µg I-TEQ/t]	**HCB [mg/t]**	**PCB [mg/t]**					
Secondary steel	3	0.03	2.5					
	As [g/t]	**Cd [g/t]**	**Cr [g/t]**	**Cu [g/t]**	**Hg [g/t]**	**Ni [g/t]**	**Pb [g/t]**	**Zn [g/t]**
Secondary steel	0.015	0.2	0.1	0.02	0.05	0.7	2.6	3.6

4.5.1.3 *Recalculations and planned improvements*

No recalculations were performed between the previous and the current submission. No major improvements of this subsector are planned at the time of writing.

4.5.2 Ferroalloy production (2C2)

Ferrosilicon (FeSi, 75% Si) is produced at one plant in Iceland. The raw material is quartz (SiO_2). The quartz is reduced to Si and CO using reducing agents. The waste gas CO and some SiO burns to form CO_2 and silica dust. In the production raw ore, carbon material and slag forming materials are mixed and heated to high temperatures for reduction and smelting. Ready-to-use iron pellets for the production are imported so no additional emissions occur from the iron part of the FeSi production. The carbon materials used are coal, coke and wood. Electric (submerged) arc furnaces with Soederberg electrodes are used. The furnaces are semi-covered. Emissions originate from the use of coal and coke as reducing agent, as well as from consumption of electrodes. Waste gases are cleaned via dry absorption units (bag-house filters). When the temperature inside the units gets too high, emergency bypass of the bag-house filters is induced. The operating permit for the ferrosilicon plant contains provisions on the maximal duration of such incidences (in percent over the year).

4.5.2.1 *Activity data*

The consumption of reducing agents and electrodes are collected by the EAI directly from the single operating ferroalloys production plant. Further information on total production is given. Activity data for raw materials and products and the resulting emissions are given in Table 4.8.

Table 4.8 Raw materials (kt) and production (kt) at the ferrosilicon plant.

	1990	1995	2000	2005	2010	2012	2013	2014
Electrodes	3.8	3.9	5.7	6.0	4.8	4.3	4.9	3.8
Coal	45.1	52.4	73.2	86.9	96.1	103.0	115.1	45.1
Coke oven coke	24.9	30.1	46.6	42.6	30.3	29.5	30.9	24.9
Charcoal	-	-	-	2.1	-	-	-	-
Waste wood	16.7	7.7	16.2	15.6	11.3	25.7	27.2	16.7
Limestone	-	-	0.5	1.6	0.5	2.4	2.2	-
Production (FeSi)	62.8	71.4	108.7	111.0	102.2	107.8	117.9	62.8
Coarse Microsilica	0.9	1.0	1.4	1.6	1.1	1.4	1.4	0.9
Fine Microsilica	13.2	15.0	21.4	24.3	17.0	21.0	20.8	13.2

4.5.2.2 *Emission factors*

In 2011 emissions of dioxin and PAH4 (BaP, BaF, BkF, IPy) were measured at the ferrosilicon plant. These measurements were used to obtain plant specific emission factors per tonne of production that were used for the whole time series. Emission factor for CO is 1.62 kg/t FeSi is taken from table 2.16 and emission factors for NOx and NMVOC are taken from table 1.9 and 1.11 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference manual (IPCC, 1996). Emission factors are presented in Table 4.9. Sulphur emissions were calculated from S-content of the reducing agents for the time period 1990-2002, and were taken directly from Green Accounting reports submitted yearly by the factory since 2003.

Emissions of particulates for the period 1990-2011 are calculated by adding up the emissions from filtered exhaust and the amount of particulates that are released during emergency bypass of the exhaust. Emission factor for filtered exhaust is taken from Table 9.9 in “Reference document on Best Available Techniques in the Non Ferrous Metals Industries” (European Commission, 2001). It is 5 mg/Nm^3. This factor is then multiplied with the plant specific yearly amount of exhaust (in Nm^3). To calculate the bypass emissions, first the total Microsilica, fine (collected and sold e.g. to cement producers) and coarse (cyclone dust) are added up and divided by the hours per year (8760 hrs.) to get Microsilica production rate per hour. This is known for all years since 2005. The production rate is then multiplied with the bypass time per furnace and the ratio of the FeSi production per furnace of the total FeSi production each year. The bypass rate is known since 2002 and taken from Green Accounts, submitted in accordance with Regulation no. 851/2002. The bypass rate for previous years was calculated as the average of the years 2002 to 2006. Microsilica (fine and coarse) production rate and production per furnace were extrapolated for the years 1990 to 2001 based on total produced FeSi at the plant each year. Since 2012, TSP are obtained from the yearly Green Accounting report submitted to EAI. The emission factor for BC is taken from the Norwegian IIR (2016).

All emission factors are presented in the table below.

Table 4.9 Emission factors from ferroalloys production.

	NOx [kg/TJ]	NMVOC [kg/TJ]	CO [kg/t FeSi]	PM_{10} % of TSP	$PM_{2.5}$ % of TSP	BC % of PM2.5
FeSi	-	-	1.62	95	95	0.23
Coal	300	20	-	-	-	-
Coke	300	20	-	-	-	-
Charcoal	300	20	-	-	-	-
Waste wood	100	50	-	-	-	-
Electrodes	300	20	-	-	-	-
	Dioxin [µg/t FeSi]	**B(a)P [mg/t FeSi]**	**B(b)F [mg/t FeSi]**	**B(k)F [mg/t FeSi]**	**IPy [mg/t FeSi]**	
FeSi	0.114	2.79	102.22	29.68	9.39	
Coal	-	-	-	-	-	
Coke	-	-	-	-	-	
Charcoal	-	-	-	-	-	
Waste wood	-	-	-	-	-	
Electrodes	-	-	-	-	-	

Several heavy metals (As, Cd, Cr, Cu, Hg, Pb and Zn) were measured in silicon dust in 2014. These measurements were used in combination with the emitted TSP to calculate heavy metals emissions since 1990. Hg was found to be below detection (i.e. < 9 mg/kg silicon dust) in all samples. The heavty metal contents in silica dust are shown in Table 4.10.

Table 4.10 Heavy metal contents in silica dust (mg metal / kg dust)

	As [mg/kg]	Cd [mg/kg]	Cr [mg/kg]	Cu [mg/kg]	Hg [mg/kg]	Pb [mg/kg]	Zn [mg/kg]
Content in silicon dust	11.8	0.46	8.8	10.8	< 9	8.7	25.2

4.5.2.3 *Recalculations and planned improvements*

Small modifications were made to the NCVs for coal, coke, wood and charcoal to reflect the updated values in the 2006 IPCC guidelines. SO_2 values, previously calculated based on estimates of S-contents in raw materials, have been replaced by estimates provided directly by the factory for the period 2003-2015. Planned improvements include revising NOx, NMVOC and CO methodology calculations to update the emission factors (currently taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference manual (IPCC, 1996)).

4.5.3 Primary aluminium production (2C3)

In 2015 aluminium was produced at three primary aluminium plants in Iceland. Best Available Technology (BAT) is used at all plants, i.e. closed prebake systems with point feeding of alumina, efficient process control, hoods covering the entire pot and efficient collection of air pollutants.

Primary aluminium production results in emissions of dioxins, PAH4, NOx, CO, particulate matter and SO_2. Emissions originate from the consumption of electrodes during the electrolysis process.

4.5.3.1 *Activity data*

The EAI collects annual process specific data from the three operators through EU ETS and Green Accounting reports. The total production of the three aluminium plants is given in Table 4.11.

Table 4.11 Aluminium production (kt).

	1990	1995	2000	2005	2010	2014	2015
Primary Al production	87.8	100.2	226.4	272.5	818.9	839.5	857.3

4.5.3.2 *Emission factors*

In 2011 emissions of dioxin were measured at one of the aluminium plants (Norðurál). The same plant also measured PAH4 in 2002 and in 2011, and the average emission factors from these two measurements were calculated. The measurements were used to obtain plant specific emission factors per tonne of production that were used for the whole time series. Of the total pot gases 98.5 % are collected and cleaned via dry adsorption unit. Thus, 1.5% of the pot gases leak unfiltered to the atmosphere. Both dioxin and PAH4 are below detection limit in the cleaned gas. Emission factors are derived from the concentration of dioxin and PAH4 in the raw gas. They are presented in Table 4.12.

NOx and CO were taken from Table 3.2 in the Emission Inventory Guidebook (2016). Particulate matter was calculated from information on particulates per tonne of produced aluminium that the aluminium plants report in their Green Accounting reports submitted to the EAI. Ratios of TSP:PM_{10}:$PM_{2.5}$ as well as the BC emission factor were also taken from the 2016 Guidebook. All emission factors are presented in Table 4.12. Emissions of SO_2 are estimated from S-content of alumina and electrodes.

Table 4.12 Emission factors, primary aluminium production.

	Dioxin [µg/t Al]	PAH4 [mg/t Al]	B(a)P % of PAH4	B(b)F % of PAH4	B(k)F % of PAH4	IPy % of PAH4
Emission factors	0.0329	0.0189	13%	61%	18%	8%
	CO [kg/t Al]	**NOx [kg/t Al]**	**PM10 % of TSP**	**PM2.5 % of TSP**	**BC % of PM2.5**	
Emission factors	120	1	78%	67%	2.3%	

4.5.3.3 *Recalculations and planned improvements*

Recalculations were performed for particle matter, adjusting the ratios between TSP, PM_{10} and $PM_{2.5}$ to match ratios suggested by the EMEP/EEA 2016 Guidebook. No major improvements of this subsector are planned at the time of writing.

4.5.4 Secondary aluminium production (2C3)

Secondary aluminium production started in 2004 at Alur in Helguvík. In 2012, another facility, Kratus, opened next to the Norðurál smelter at Grundartangi. At the end of 2014, Alur was acquired by Kratus and all secondary aluminium production moved to Grundartangi. The plant recycles scrap aluminium from the two primary aluminium plants in southwest of Iceland, by melting scrap metal in batches in a rotary kiln.

4.5.4.1 *Activity data*

All activity data, consisting of produced secondary aluminium, is obtained in Green Accounting reports submitted yearly to the EAI.

Table 4.13 Secondary aluminium production (kt.).

	2005	2010	2014	2015
Secondary Al production	2.25	2.04	2.42	2.20

4.5.4.2 *Emission factors*

Emissions of dioxin, HCB and PM are estimated. The dioxin emission factor comes from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2005). The lowest value (0.5 µg/t aluminium) for secondary aluminium production was chosen as the plant only recycles scrap metal from primary aluminium plants and no coated aluminium, so organic compounds in the input material is minimum. Also no chlorine is added in the process and further oxy-fuel burners are used. The HCB, TSP, PM_{10}, $PM_{2.5}$ and BC emission factors are taken from the Emission Inventory Guidebook (EEA, 2016). Measurements of dioxin at the plant in 2012, showed that the EF of 0.5 µg/t represents the plant well.

	Dioxin [µg/t Al]	HCB [g/t Al]	TSP [kg/t]	PM_{10} [kg/t]	$PM_{2.5}$ [kg/t]	BC % of $PM_{2.5}$
Emission factors	0.5	5	2	1.4	0.55	2.3

4.5.4.3 *Recalculations and planned improvements*

No recalculations were performed between the previous and the current submission. No major improvements of this subsector are planned at the time of writing.

4.6 Solvent and Product Use (NFR 2D)

Activities related to 2D Solvent and product use mostly generate NMVOC (1.21 kt NMVOC in 2015). When volatile chemicals are exposed to air, emissions are produced through evaporation of the chemicals. The use of solvents and other organic compounds in industrial processes and households is an important source of NMVOC evaporation. Emissions of other pollutants than NMVOC were only estimated from road paving with asphalt (2D3b - Dioxin, PM and BC), Domestic solvent use (2D3a - Hg) and other solvent use (Creosotes - 2D3i - PAH). In most cases where the emissions are reported as NE / Not estimated in the NFR tables, emission factors are marked as “Not estimated” in the 2016 EMEP/EEA guidelines. The categories Paint Application, Degreasing, and Other NMVOC emissions from printing and other product use have in common that their activity data consists of data about imported goods. This data was received from Statistics Iceland.

Emission factors for all subcategories of 2D3 are presented in Table 4.14 below. References and more details about individual emission factors are included in the respective under chapters.

Table 4.14 Emission factors for sector 2D3.

	unit	NMVOC [g/unit]	TSP [kg/unit]	PM$_{10}$ [kg/unit]	PM$_{2.5}$ [kg/unit]	BC [% of PM$_{2.5}$]
2D3a Domestic solvent use	head	1800	-	-	-	-
2D3b Road paving with asphalt	t asphalt	16	14	3	0.4	5.7%
2D3d Coating applications	kg paint	230	-	-	-	-
2D3e Degreasing	kg cleaning product	460	-	-	-	-
2D3f Dry cleaning	kg textile treated	177	-	-	-	-
2D3g Chemical products - paint manufacturing	kg product	11	-	-	-	-
2D3h Printing	kg ink	500	-	-	-	-
2D3i Creosotes	kg creosote	105	-	-	-	-
2D3i Organic solvent-borne preservatives	kg preservative	945	-	-	-	-

	unit	Dioxin [µg I-TEQ/unit]	BaP [mg/unit]	BbF [mg/unit]	BkF [mg/unit]	Ipy [mg/unit]
2D3a Domestic solvent use	head	-	-	-	-	-
2D3b Road paving with asphalt	t asphalt	0.007	-	-	-	-
2D3d Coating applications	kg paint	-	-	-	-	-
2D3e Degreasing	kg cleaning product	-	-	-	-	-
2D3f Dry cleaning	kg textile treated	-	-	-	-	-
2D3g Chemical products - paint manufacturing	kg product	-	-	-	-	-
2D3h Printing	kg ink	-	-	-	-	-
2D3i Creosotes	kg creosote	-	1.05	0.53	0.53	0.53
2D3i Organic solvent-borne preservatives	kg preservative	-	-	-	-	-

Table 4.14 (cont´d)

	unit	**Hg [mg/unit]**
2D3a Domestic solvent use	head	5.6
2D3b Road paving with asphalt	t asphalt	-
2D3d Coating applications	kg paint	-
2D3e Degreasing	kg cleaning product	-
2D3f Dry cleaning	kg textile treated	-
2D3g Chemical products - paint manufacturing	kg product	-
2D3h Printing	kg ink	-
2D3i Creosotes	kg creosote	-
2D3i Organic solvent-borne preservatives	kg preservative	-

4.6.1 Domestic solvent use including fungicides (2D3a)

Domestic solvent use is calculated using a default per capita value, as per Tier 1 in the 2016 EMEP/EEA Guidebook (Table 3.1 Chapter 2.D.3.a)

4.6.1.1 *Activity data*

Activity data consists of the Icelandic population, and is given by Statistics Iceland.

4.6.1.2 *Emission factors*

The emission factor for NMVOC for western Europe was used, or 1.8 kg NMVOC/capita. Hg was also estimated, using the default value of 5.6 mg/capita. Both emission factors come from Table 3.1, Chapter 2.D.3.a of the 2016 Guidebook.

4.6.1.3 *Recalculations and planned improvements*

In the 2016 submission an emission factor of 2.7 kg NMVOC/capita was used, as was given in the 2013 Guidebook. With the updated value of 1.8 kg/NMVOC, the recalculated emissions decreased accordingly. No major improvements are planned at this stage.

4.6.2 Road paving with asphalt (2D3b)

Asphalt road surfaces are composed of compacted aggregate and asphalt binder. Gases are emitted from the asphalt plant itself, the road surfacing operations, and subsequently from the road surface.

4.6.2.1 *Activity data*

Information on the amount of asphalt produced comes from Statistics Iceland until 2011, and directly from the companies producing asphalt since 2012.

4.6.2.2 *Emission factors*

The emission factors for NMVOC and BC are taken from Table 3.1 in Chapter 2.D.3.b in the EMEP/EEA emission inventory guidebook 2016 (Tier 1). Emissions factors for TSP are based on measurements from the second-largest asphalt production plant. PM2.5 and PM10 emission factors are then calculated by using the same ratio to TSP as given in Table 3.1, chapter 2.D.3.b in the Guidebook 2016. Emissions of SO_2, NO_x, and CO are expected to originate mainly from combustion and are therefore not estimated here but accounted for under sector 1A2g.

4.6.2.3 *Recalculations and planned improvements*

No recalculations were performed between the previous and the current submission. No major improvements of this subsector are planned at the moment.

4.6.3 Coating applications (2D3d)

The emissions in this category stem from paint applications. Only NMVOC emissions are estimated; Emissions from other pollutants are either considered minimal or non-existent.

4.6.3.1 *Activity data*

The EMEP guidebook (2016) provides emission factors based on amounts of paint applied. Data exists on imported paint since 1990 (Statistics Iceland) and on domestic production of paint since 1998 (Icelandic recycling fund). It is assumed that all paint imported and produced domestically is applied domestically during the same year. Therefore the total amount of solvent based paint is multiplied with the emission factor. For the time before 1998 no data exists about the amount of solvent based paint produced domestically. Therefore the domestically produced paint amount of 1998, which happens to be the highest of the time period for which data exists, is used for the period from 1990-1997. For 2015 no domestic data production was available, therefore an average of the last 5 years was used.

4.6.3.2 *Emission factors*

The Tier 1 emission factor refers to all paints applied, e.g. waterborne, powder, high solid and solvent based paints. The existing data on produced and imported paints however, makes it possible to narrow activity data down to conventional solvent based paints. Therefore Tier 2 emission factors for conventional solvent based paints could be applied. The activity data does not allow for a distinction between decorative coating application for construction of buildings and domestic use of paints. Their NMVOC emission factors, however, are identical: 230 g/kg paint applied.

4.6.3.3 *Recalculations and planned improvements*

Small recalculations were done because of improved activity data obtained from the Icelandic Recycling Fund for 2013 and 2014. The recalculations amount to - 0.02 kt NMVOC in 2014, or 5.7% difference between old and new calculations. Planned improvements include access to better disaggregated activity data from Statistics Iceland and from the Icelandic Recycling Fund.

4.6.4 Degreasing & dry cleaning (2D3e & f)

Degreasing and dry cleaning only generate NMVOC emissions. Emissions related to degreasing were estimated by Tier 1, based on amounts of cleaning products used, and those related to dry cleaning by Tier 2, based on the default amount of textile cleaned per capita. Since there is an overlap in chemicals used for these two activities, they are discussed in the same chapter.

4.6.4.1 *Activity data*

There is data on the amount of cleaning products imported provided by Statistics Iceland. Of the chemicals listed by the EMEP guidebook, activity data is available for: methylene chloride (MC), tetrachloroethylene (PER), trichloroethylene (TRI) and xylenes (XYL). In Iceland, though, PER is mainly used for dry cleaning (expert judgement). In order to estimate emissions from degreasing more correctly without underestimating them, only half of the imported PER was allocated to degreasing. Emissions from dry cleaning are estimated without using data on solvents used (see below). The use of PER in dry cleaning, though, is implicitly contained in the method. In Iceland, xylenes are mainly used in paint production (expert judgement). Furthermore, only half of the imported xylenes were allocated to degreasing. Emissions from paint production are estimated without using data on solvents used but xylene use is implicitly contained in the method. In addition to the solvents mentioned above, 1,1,1,- trichloroethylene (TCA), now banned by the Montreal Protocol, is added for the time period during which it was imported and used. Another category included is paint and varnish removers.

Emissions from dry cleaning were calculated using the Tier 2 emission factor for open-circuit machines provided by the EMEP guidebook. Activity data for calculation of NMVOC emissions is the amount of textile treated annually, which is assumed to be 0.3 kg/head (EMEP guidebook default) and calculated using demographic data.

4.6.4.2 *Emission factors*

The amount of imported solvents for degreasing was multiplied with the NMVOC Tier 1 emission factor for degreasing: 460 g/kg cleaning product.

The NMVOC emission factor for open-circuit machines is 177g/kg textile treated. Since all dry cleaning machines used in Iceland are conventional closed-circuit PER machines, the emission factor was reduced using the respective EMEP guidebook reduction default value of 0.89.

4.6.4.3 *Recalculations and planned improvements*

No recalculations were performed between the previous and the current submission. No major improvements of this subsector are planned at the time of writing.

4.6.5 Chemical products (2D3g)

The only activity identified for the subcategory chemical products, manufacture and processing is manufacture of paints. NMVOC emissions from the manufacture of paints were calculated using the 2016 EMEP guidebook Tier 2.

4.6.5.1 *Activity data*

The activity data consists of the amount of paint produced domestically as discussed above in chapter 4.7.2 Coating Applications

4.6.5.2 *Emission factor*

NMVOC emissions from the manufacture of paints were calculated using the 2016 EMEP guidebook Tier 2emission factor of 11 g/kg product.

4.6.5.3 *Recalculations and planned improvements*

Small recalculations were done because of improved activity data obtained from the Icelandic Recycling Fund for 2013 and 2014. The recalculations amount to - 0.008 kt. NMVOC in 2014. Planned improvements include access to better disaggregated activity data from the Icelandic Recycling Fund.

4.6.6 Printing (2D3h)

4.6.6.1 *Activity data*

Import data on ink was received from Statistics Iceland.

4.6.6.2 *Emission factors*

NMVOC emissions for printing were calculated using the EMEP guidebook Tier 1 emission factor of 500g/kg ink used.

4.6.6.3 *Recalculations and planned improvements*

No recalculations were performed between the previous and the current submission. No major improvements of this subsector are planned at the time of writing.

4.6.7 Other product use (2D3i)

Wood is preserved to protect it against fungal and insect attack and also against weathering. There are three main types of preservative: creosote, organic solvent-based (often referred to as ‘light organic solvent-based preservatives’ (LOSP)) and water borne. Creosote is oil prepared from coal tar distillation. Creosote contains a high proportion of aromatic compounds such as polycyclic aromatic hydrocarbons (PAHs). In Iceland, creosotes were used from 1990 to 2010, and have been banned since 2011. Other wood preservation substances used in Iceland are organic solvent-borne preservatives.

4.6.7.1 *Activity data*

Activity data consists of annual import of creosotes and organic solvent-borne preservatives, and the assumption that all these products are applied during the year of import. Import data on both wood preservatives was received from Statistics Iceland.

4.6.7.2 *Emission factors*

Emission factors for PAH are taken from chapter 2.D.3.i, 2.G of the Emission Inventory Guidebook (EEA, 2016). They are 1.05 mg BaP per kilogramme of creosote, 0.53 mg per kilogramme creosote of the other 3 PAH: BbF, BkF and IPy. NMVOC emissions from wood preservation were calculated using the EMEP guidebook Tier 2 emission factors for creosote preservative type (105 g/kg creosote) and organic solvent borne preservative (945 g/kg preservative).

4.6.7.3 *Recalculations and planned improvements*

No recalculations were performed between the previous and the current submission. No major improvements of this subsector are planned at the moment.

4.6.8 Other solvent and product use (2G)

The two emission sources estimated in this category are use of tobacco and fireworks. Firework - related emissions are reported for the first time in this submission.

Tobacco smoking is a minor source of dioxins, PAH and other pollutants including heavy metals, whereas fireworks are the most significant source of heavy metals in the industrial processes sector.

4.6.8.1 *Activity data*

Activity data consist of all smoking tobacco and all fireworks imported, and are provided by Statistics Iceland. Fireworks import data could only be obtained for the period 1995-2015, and for the period 1990-1994 emissions were calculated assuming the same activity data as in 1995.

4.6.8.2 *Emission factors*

For tobacco use, emission factors for NO_x, CO, NH_3, TSP, PM, BC, NMVOC, dioxin and PAH4 were taken from Table 3-14 in Chapter 2.D.3.i, 2.G in the Emission Inventory Guidebook (EEA, 2016). Emission factors for heavy metals are taken from the Danish IIR (2016), which uses emission factors derived from burning of wood.

For firework use, emission factors for SO_2, CO, NO_x, TSP, PM and heavy metals were taken from Table 3-13 in Chapter 2.D.3.i, 2.G of the Emission Inventory Guidebook (EEA, 2016).

All emission factors are presented in Table 4.15.

Table 4.15 Emission factors for use of tobacco and of fireworks, per mass unit of imported goods

	NO$_x$ [kg/t]	**NMVOC [kg/t]**	**SO$_2$ [kg/t]**	**NH$_3$ [kg/t]**	**TSP [kg/t]**	**PM$_{10}$ [kg/t]**	**PM$_{2.5}$ [kg/t]**	**BC % of PM2.5**	**CO [kg/t]**
Tobacco	1.8	4.84	NE	4.15	27	27	27	0.45	55.1
Fireworks	0.26	NA	3.02	NE	109.83	99.92	51.94	-	7.150

	Dioxin [ng I-TEQ/t]	**B(a)P [g/t]**	**B(b)F [g/t]**	**B(k)F [g/t]**	**IPy [g/t]**
Tobacco	100	0.111	0.045	0.045	0.045
Fireworks	NE	NE	NE	NE	NE

	As [g/t]	**Cd [g/t]**	**Cr [g/t]**	**Cu [g/t]**	**Hg [g/t]**	**Ni [g/t]**	**Pb [g/t]**	**Se [g/t]**	**Zn [g/t]**
Tobacco	0.159	0.02	0.152	0.35	0.01	0.03	0.64	0.01	1.61
Fireworks	1.33	1.48	15.6	444	0.057	30	764	NE	260

4.6.8.3 *Recalculations and planned improvements*

No recalculations took place since last submission. However in last submission some solvents from subcategory 2D were counted in 2G, that are now counted in 2D. Furthermore, firework emissions are reported for the first time in this submission, thus there is a difference between last year’s and this year’s total for category 2G. Planned improvements include to attempt to obtain activity data for fireworks imports for the period 1990-1994.

4.7 Food & Beverages Industry (NFR 2H2)

The only other industry production occurring in Iceland is the food and beverages industry. The only pollutant emitted in this industry is NMVOC.

4.7.1.1 *Activity data*

Production statistics were obtained by Statistics Iceland for beer, fish, meat and poultry for the whole time series. Statistics for coffee roasting and animal feed were available for the years 2005 to 2015. Production statistics were extrapolated for the years 1990 to 2004. Further production of bread, cakes and biscuits was estimated from consumption figures.

4.7.1.2 *Emission factors*

Emission factor for NMVOC were taken from the 2016 EMEP/EEA Guidebook, and are presented in Table 4.16.

Table 4.16 NMVOC emission factors for the production of various food and beverage products

	NMVOC Kg/t produced
Meat, fish and poultry	0.3
Cakes, biscuits and breakfast cereals	1
Beer and malt	0.035
Bread (European)	4.5
Coffee roasting	0.55
Animal feed	1

4.7.1.3 *Recalculations and planned improvements*

Small recalculations were performed due to incorrect calculations in the 2016 submission, and due to a revised emission factor for bread production (previously the EF for North America was used (8 kg/t), now corrected to the European EF (4.5 kg/t)). The difference amounts to 0.05 kt NMVOC for 2014, or 16% of the NMVOC emissions for that year.

5 Agriculture (NFR sector 3)

Iceland is self-sufficient in all major livestock products, such as meat, milk, and eggs. Traditional livestock production is grassland based and most farm animals are native breeds, i.e. dairy cattle, sheep, horses, and goats, which are all of an ancient Nordic origin, one breed for each species. These animals are generally smaller than the breeds common elsewhere in Europe. Beef production, however, is partly through imported breeds, as is most poultry and all pork production. There is not much arable crop production in Iceland, due to a cold climate and short growing season. Cropland in Iceland consists mainly of cultivated hayfields, but barley and rapeseed are grown on limited acreage.

Ammonia, nitric oxide, NMVOC and particulate matter emissions are estimated for animal husbandry and manure management (3.B) as well as crop production and agricultural soils (3.D).

5.1 Overview

The main pollutant emitted from the agriculture sector is ammonia (NH_3) and the largest source is manure management. Dioxin, PAH, HCB, PCB and Heavy Metals emissions are not applicable, not occurring or not estimated. Summary tables for the emissions from the agriculture sector are shown below in Table 5.1 and Table 5.2. All emissions are reported in the NFR Tables[11].

5.1.1 Sectoral trends – POPs

Emissions of POPs from the agriculture sector are either not occurring or not applicable as seen in table 5.1 below.

Table 5.1 Dioxin, PAH4, HCB and PCB emissions from the agriculture sector, 2015 (NA – Not applicable, NO - Not occuring).

		Dioxin [g I-TEQ]	B(a)P [t]	B(b)F [t]	B(k)F [t]	IPy [t]	PAH4 [t]	HCB [kg]	PCB [kg]
3B	Manure management	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO
3D	Crop production and agricultural soils	NA	NA	NA	NA	NA	NA	NA	NA
3F, 3I	Field burning of agricultural wastes and Agriculture other sectors	NO	NO	NO	NO	NO	NO	NO	NO
Agriculture, Total		NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO	NA/NO

5.1.2 Sectoral trends – other pollutants

Ammonia, nitric oxide (expressed as NOx), NMVOC and particulate matter emissions are estimated for animal husbandry and manure management (3.B) as well as crop production and agricultural soils (3.D). The estimated emissions are presented below in table 5.2.

Table 5.2 NO_x, NMVOC, SO_x, NH_3, PM, BC and CO emission estimates from the agriculture sector, 2015 (NA – Not applicable, NE – Not estimated, NO - Not occurring).

		NO_X [kt] NO_2	NMVOC [kt]	SO_X [kt] SO_2	NH_3 [kt]	$PM_{2.5}$ [kt]	PM_{10} [kt]	TSP [kt]	BC [kt]	CO [kt]
3B	Manure management	0.05	1.9572	NA/NO	4.30	0.03	0.12	0.17	NA/NO	NA/NO
3D	Crop production and agricultural soils	0.81	6.93E-08	NA/NE	1.16	0.004	0.07	0.07	NR/NO	NA/NE
3F, 3I	Field burning of agricultural wastes and Agriculture other sectors	NO	NO	NO	NO	NO	NO	NO	NO	NO
Agriculture, Total		**0.85**	**1.96**	**NA/NE/NO**	**5.46**	**0.04**	**0.19**	**0.245**	**NA/NR/NO**	**NA/NE/NO**

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[11] http://cdr.eionet.europa.eu/is/un/clrtap/ (Envelope A)

Emission trends of estimated pollutants from 1990 - 2015 can be seen in figures 5.1 -5.4.

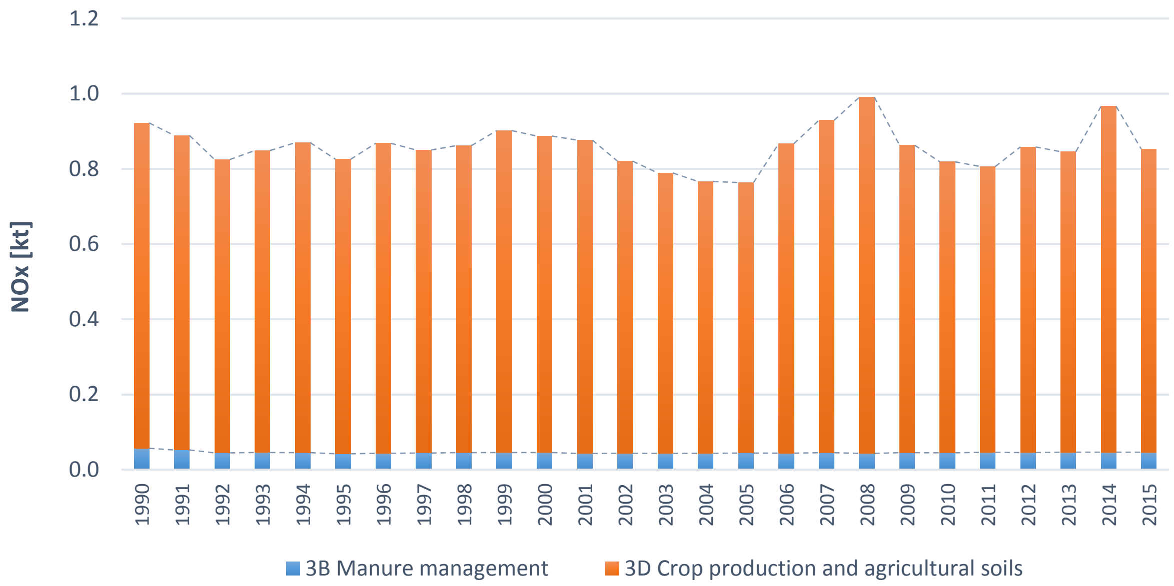

Figure 5.1 NOx emissions in the agriculture sector, 1990-2015.

Trends in NOx emissions from agriculture can be seen in figure 5.1. Emissions are mostly coming from 3.D crop production and agricultural soils with peaks in emissions in 2008 and 2014.

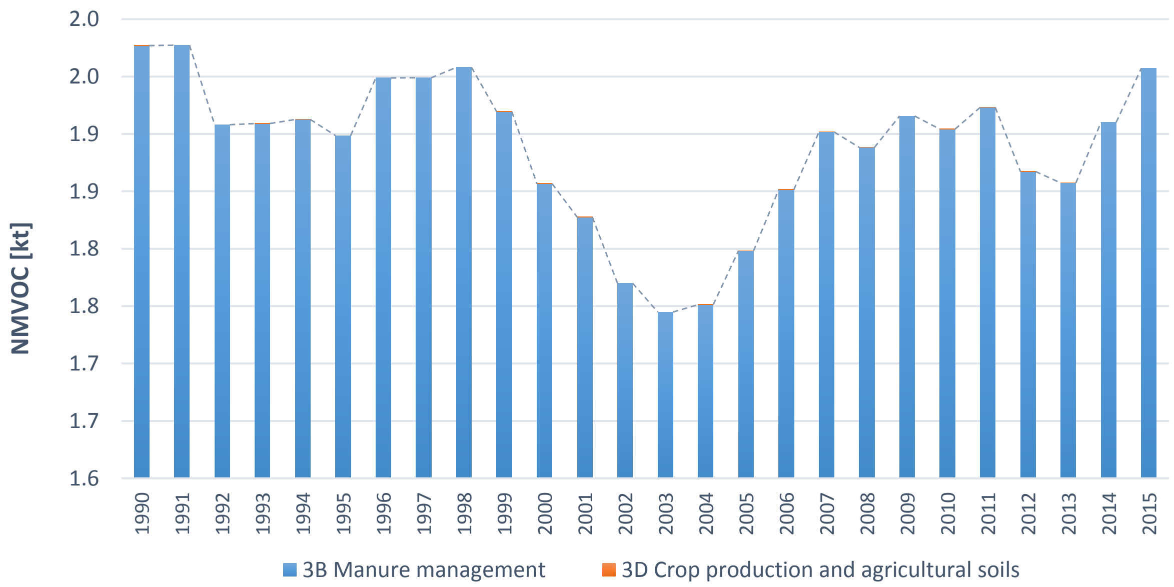

Figure 5.2 NMVOC emissions in the agriculture sector, 1990-2015.

NMVOC emissions from agriculture are mostly coming from manure management, a significant drop was seen in 2001-2003, mostly due to a drop in the population of dairy cows.

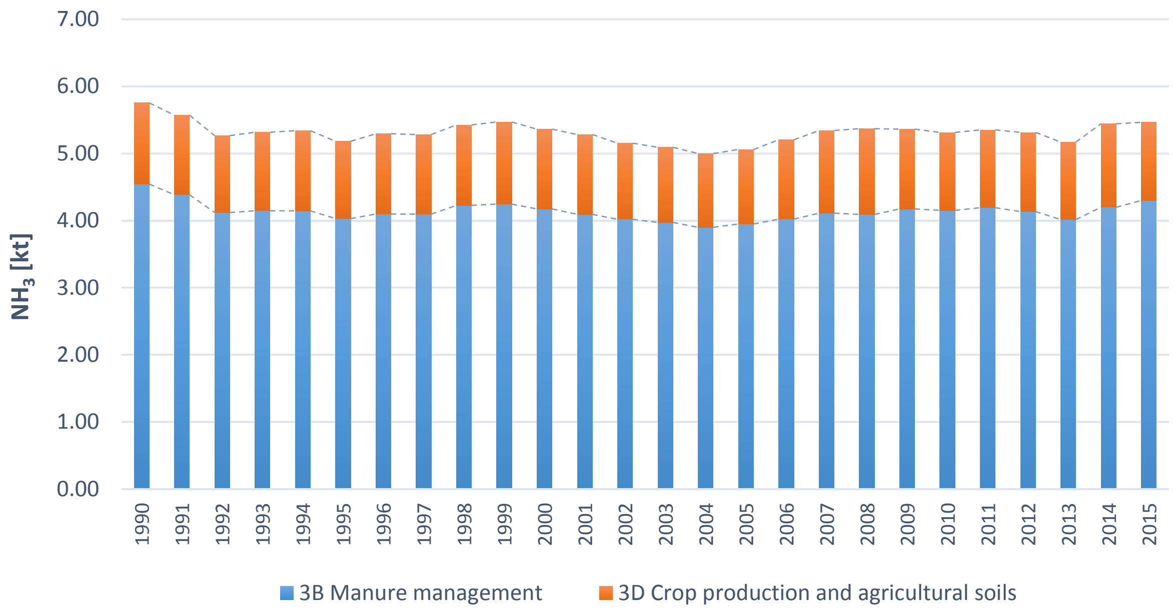

Figure 5.3 NH_3 emissions in the agriculture sector, 1990-2015.

The trend in NH_3 emissions is relatively steady which is driven by relatively constant sheep livestock numbers.

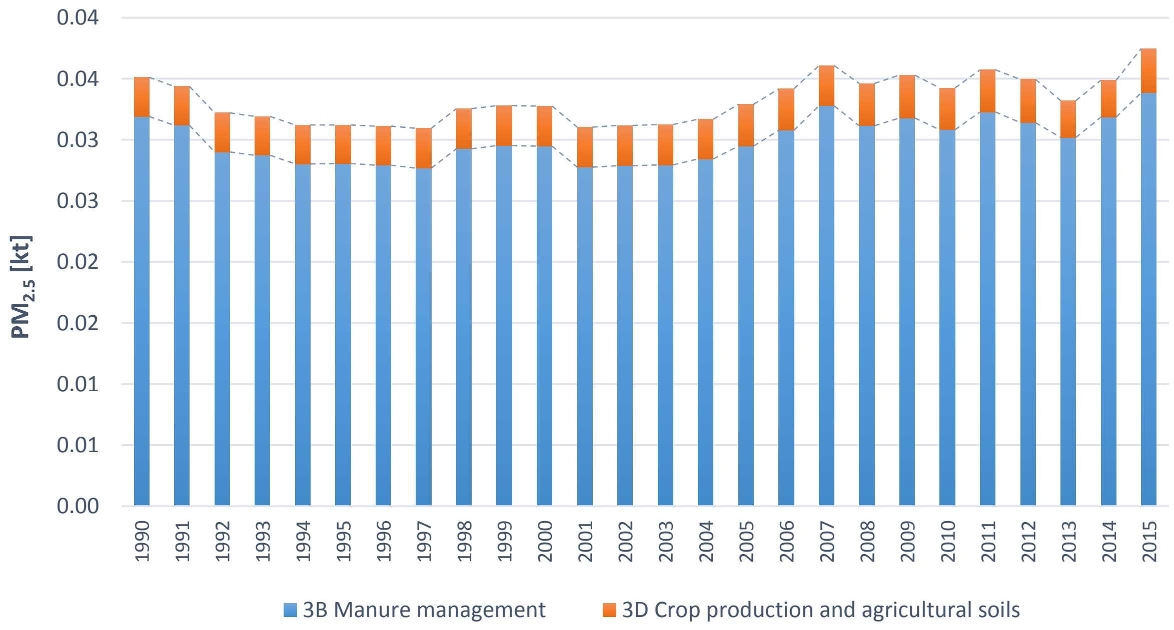

Figure 5.4 $PM_{2.5}$ emissions in the agriculture sector, 1990-2015.

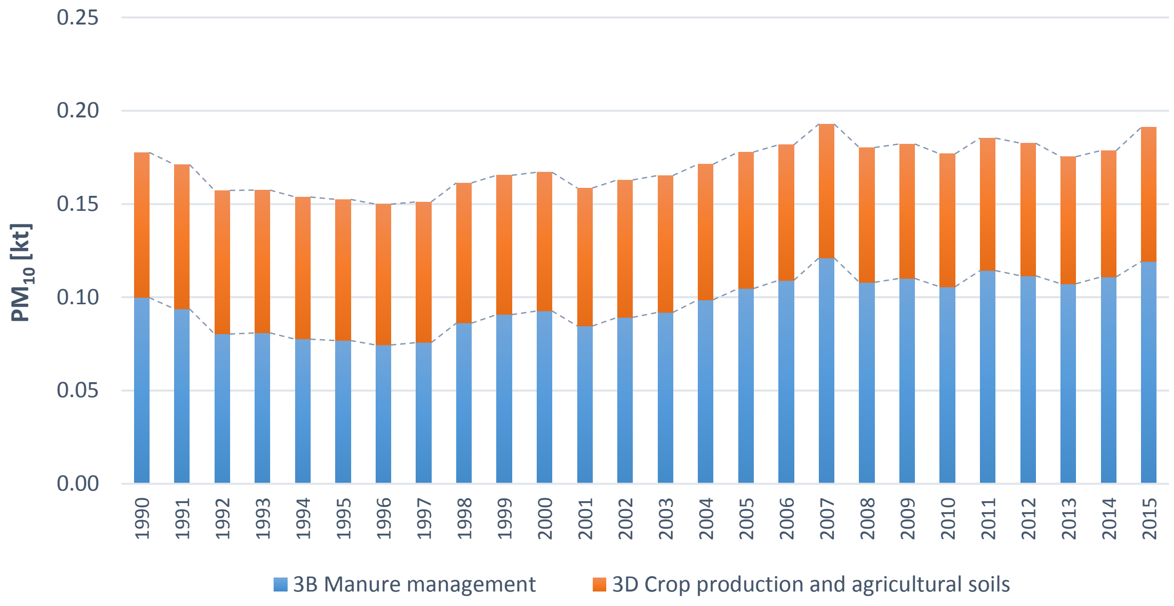

Figure 5.5 PM_{10} emissions in the agriculture sector, 1990-2015.

Figure 5.4 and 5.5 show a steady increase in particulate matter ($PM_{2.5}$ and PM_{10}). The trend is driven by increased emissions from manure management mostly from increasing poultry livestock.

Acccording to the 2016 EMEP/EEA Guidebook , heavy metal emissions in the agriculture sector only arise from the burning of crop residues. Since this activity does not occur in Iceland, there are no heavy metal emissions in the agriculture sector.

5.2 General Methodology

This chapter on Agriculture (NFR sector 3) is divided into the following chapters:

- Manure management (NFR 3B)
- Crop production and agricultural soils (NFR 3D)
- Agriculture other, including use of pesticides (NFR 3D and 3I)

Methodology is based on chapters 3.B and 3.D of the EMEP/EEA air pollutant emission inventory guidebook (EEA, 2016) and all equations as well as the majority of emission factors and other parameters stem from the guidebook chapters. For brevity the guidebook is referred to as the EMEP GB. Equations and parameters are not listed here, reference is made to the information in the EMEP GB instead.

Ammonia, nitric oxide, TSP, PM_{10} and $PM_{2.5}$ emissions are estimated with Tier 2 methods. In absence of higher tiers for 3.D, NO and NMVOC emissions are estimated with Tier 1 e.g. horses in solid storage.

For estimating emissions of NH_3 and NOx in 3.B manure management, the flow approach is used as outlined in the EMEP GB. This considers the flow of total ammoniacal N (TAN) through the manure management system. In the EMEP GB this flow is modelled by a series of equations that considers the amount of TAN and losses at all different stages of the manure management process. The set of equations provided by the EMEP GB was applied to more disaggregated livestock categories than the

NFR methodology demands (e.g. mature ewes, rams, animals for replacement, and lambs instead of just sheep). The resulting emissions were then aggregated to the respective NFR categories.

NH_3 and NOx emissions from grazing animals are part of this N flow approach and are therefore calculated in this context, but reported under agricultural soils (3.D). Similarly, the manure that is available as organic fertilizer for application to land is determined from the N flow approach and is used as an input term in estimating the NH_3 and NOx Activity data, emission factors and other parameters used in these calculations will be discussed in the following chapters.

The Tier 2 methodology for PM emissions consists of the multiplication of livestock populations with default emission factors for slurry and solid manure applied to the time animals spent in housing.

5.3 Manure Management (NFR 3B)

5.3.1 Activity data

All emission estimates in 3.B depend on annual average populations (AAP) of livestock categories. Data on livestock population comes from a census conducted by the Icelandic Food and Veterinary Authority (IFVA). Since this data represents livestock populations at a certain point in time (during winter) it does not reflect their seasonal changes, e.g. animals with a life spanning only one summer. Also, for some livestock categories, it does not include data on young animals, e.g. fattening pigs. Therefore, the number of animals not included in the census is estimated using information on fertility rates, number of offspring, number of animals slaughtered, etc. When calculating the AAP of livestock categories the amount of livestock with a lifespan of less than one year is weighted with its respective lifespan, e.g. a 6 month lifespan equals a factor of 0.5. The inclusion of young animals leads to livestock populations being considerable higher for some categories than the ones published by the IFVA (http://mast.is/default.aspx?pageid=647aa097-b558-452c-99de-8994d03bf7c7) or the complete methodology of calculating the AAP please refer to Iceland´s National Inventory Report on Greenhouse Gas Emissions (EAI, 2015).

Table 5.3 shows the AAP of Icelandic livestock categories for selected years since 1990. The most prominent trends in the development of livestock populations since 1990 are a decrease in dairy cattle and sheep population and an increase in swine and poultry population.

Table 5.3 Annual average population of livestock according to NFR categorization in Iceland for 1990, 1995, 2000, 2005, 2010, 2012, 2013, 2014 and 2015.

	1990	1995	2000	2005	2010	2012	2013	2014	2015
3B1a Dairy cattle	32,249	30,428	27,066	24,538	25,711	24,761	24,210	26,159	27,441
3B1b Non-dairy cattle	42,654	42,771	45,069	41,441	48,070	46,752	44,556	48,285	51,335
3B2 Sheep	861,815	719,530	729,290	711,327	748,002	744,065	735,859	759,470	737,992
3B3 Swine	29,645	31,130	32,267	38,438	40,515	43,978	30,581	36,210	42,542
3B4a Buffalo	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B4d Goats	504	511	608	641	1,065	1,252	1,301	1,441	1,472
3B4e Horses	73,867	80,246	75,630	76,629	78,849	75,948	56,896	66,483	65,915
3B4f Mules and asses	NO	NO	NO	NO	NO	NO	NO	NO	NO
3B4gi Laying hens	214,975	164,402	193,097	166,119	174,519	200,169	202,116	219,163	119,811
3B4gii Broilers	454,305	188,812	338,756	595,171	537,933	572,090	576,864	596,358	127,184
3B4giii Turkeys	0	3,044	10,908	8,120	10,496	11,037	11,662	12,038	0
3B4giv Other poultry	5,277	5,270	2,498	1,716	1,346	991	1,490	1,432	153
3B4h Other (fur animals)	49,592	37,893	41,431	36,948	37,627	40,439	64,764	51,788	48,038

5.3.2 Emission factors & associated parameters

NH_3 and NO Tier 2 emissions depend on the total amounts of N and TAN in manure. Total N is calculated by multiplying livestock AAP with the nitrogen excretion rate per animal. TAN is calculated by multiplying total N with livestock specific TAN fractions provided in the EMEP GB. The nitrogen excretion (NEX) rate per livestock category is calculated using default values from p. 10.58 of vol. 4-2 of the 2006 IPCC guidelines (IPCC, 2006) that take animal weight and therefore the smaller size of Icelandic breeds into account. The NEX for dairy cattle is country specific (Ketilsdóttir and Sveinsson, 2010). Total N and TAN have to be allocated to either slurry or solid manure management. Fractions for slurry and solid manure management are country specific and identical to the ones used in Iceland´s National Inventory Report (EA, 2013). The same is valid for the fractions of the year spent inside. Two more parameters used in the calculation of TAN mass flow are the amount of hay used in animal housing and the amount of N contained in it (only for solid manure management). These amounts (for sheep, goats, and horses) are based on EMEP GB default data of hay used per day adjusted for the time periods animals stay inside. The above mentioned parameters are summarized in Table 5.4. All manure is assumed to be stored before spreading. Emission factors for animal manure either managed as slurry or solid manure during housing, storage, spreading, and grazing are given as shares of TAN by livestock category in the EMEP GB. In the absence of default values for sheep slurry, EMEP GB default values for cattle were used instead.

Table 5.4. Parameters used in calculation of NH_3 and NO emissions of manure management.

Livestock sector (NFR)	Mean NEX [kg head-1 yr-1]	Prop. TAN(of N)	Fraction slurry	Fraction solid	Housing period [days]	Straw [kg/yr]	NMVOC [kg head-1 yr-1]
3B1a Dairy cattle	94,8(72-95)[1]	0.6	1	0	265		
3B1b Non-dairy cattle	39.9 (15-60)[2]	0.6	1	0	30		
3B2 Sheep	14.3 (6-29)[3]	0.5	0.3	0.7	200	133	0.53
3B3 Swine -fattening pigs	7.6	0.7	1	0	365		
3B3 Swine -Sows	23	0.7	1	0	365		
3B4d Goats	20.3	0.5	0	0	201	134	0.54
3B4e Horses	29 (5.7-35.6)[4]	0.6	0	0	51	140	0.58
3B4gi Laying hens	1.4	0.7	0	1	365		
3B4gii Broilers	0.8	0.7	0	1	365		
3B4giii Turkeys	1.4	0.7	0	1	365		
3B4giv Other poultry	1.2	0.7	0	1	365		
3B4h Other (fur animals)	5(5-12)[5]	0.6	0	1	365		

[1] Range for time period due to increase in milk production; [2] Range given for subcategories (cows and steers used for producing meat, heifers, and young cattle); [3] Range given for subcategories (ewes, rams, animals for replacement, and lambs); [4] Range given for subcategories (mature horses, young horses, and foals); [5] Range given for subcategories (foxes, minks, and rabbits).

Tier 2 calculations of particulate matter emissions are based on information on the amount of time livestock spends in housing and the fractions of manure either managed as slurry or as solid manure (see Table 5.4 above). The majority of laying hens in Iceland is kept in cages.

5.3.3 Emissions

NH_3 emissions reported under 3.B manure management exclude emissions from manure deposited on fields by grazing animals, which are reported under 3.D agricultural soils. Total ammonia (NH_3) emissions have been decreasing gradually during the last two decades, from 4.54 kt. in 1990 to 4.3 kt. in 2015. This decrease is mainly due to a decrease of the sheep population. Sheep account for almost 44% of total NH_3 emissions and cattle for approximately 40%. Around 1/3 of emissions occur during livestock housing, 1/4 during manure storage and 2/5 after spreading of manure. The described trends and fractions can be seen in Figure 5.6.

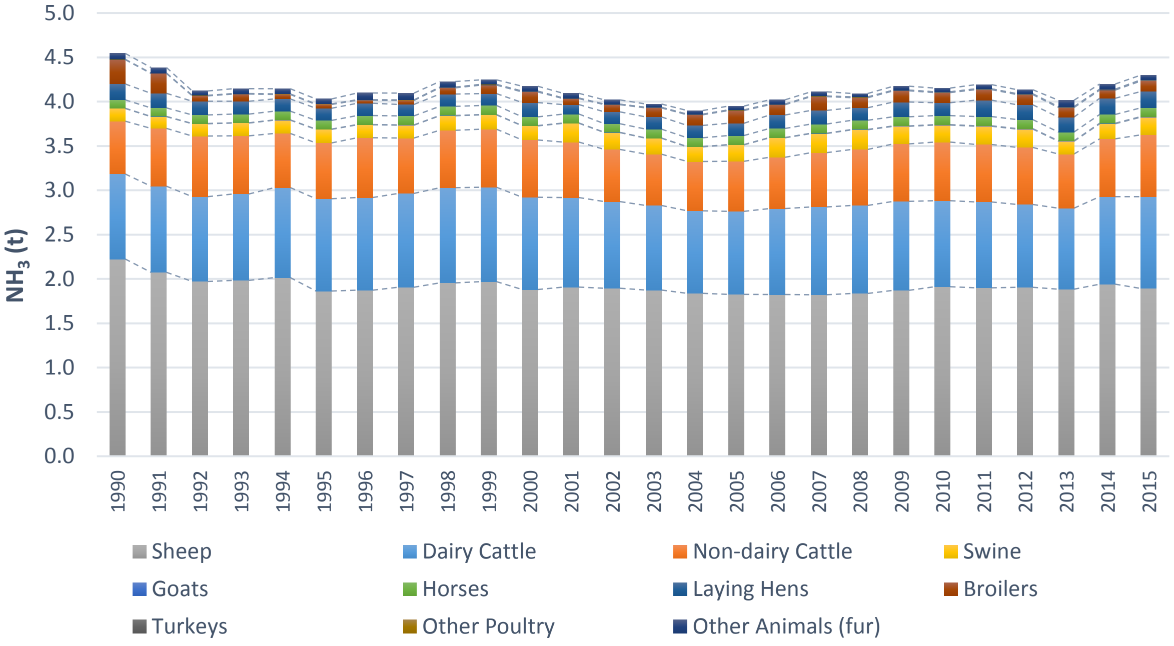

Figure 5.6 Ammonia (NH_3) emissions from animal husbandry and manure management in tonnes.

Nitric oxide emissions, in contrast to ammonia emissions, occur only during storage. They have been decreasing from 57 tonnes in 1990 to 46 tonnes in 2015, or by roughly 20%. This decrease is mainly due to the decrease in sheep population already mentioned above. NO emissions from sheep constitute roughly 2/3 of total NO emissions from livestock. NO emissions from poultry amount to 24% of total NO emissions. Other livestock categories with considerable shares are fur animals and horses. Cattle and swine emissions constitute negligible amounts due to the fact that their manure is stored as slurry, which gives rise to considerably lower emissions than solid manure management systems.

NMVOC emissions in 1990 were 1.98 kt. for manure management and have decreased slightly since then and are now 1.96 kt. The largest source of NMVOC emissions is from cattle 49%, horses 29% and sheep 10%.

PM_{10} emissions increased from 100 tonnes in 1990 to 111 tonnes in 2015 (10%). Emissions were highest in 2007 at 121 tonnes. Both the general increasing trend since 1990 and the decrease since 2007 are almost exclusively due to variations in the broiler population, which quintupled between 1996 and 2007. Other livestock categories that emit substantial shares of total PM_{10} emissions from animal husbandry (besides broilers, which emitted on average around 30% of total PM_{10} emissions between 1990 and 2011) are laying hens, dairy cattle, cattle, and sheep (each around 10 -20%).

Total $PM_{2.5}$ emissions varied between 28 and 34 tonnes (highest in 2015) from 1990 to 2015 and showed no clear trend. Emissions from cattle constituted more than 70% of total emissions, emissions from swine and broilers each amount to 10% of total emissions.

TSP emissions have been slightly increasing from 151 t. in 1990 to 173 t. in 2015, the increase is mostly due to poultry and swine.

5.4 Crop Production & Agricultural Soils (NFR 3D)

5.4.1 Activity data

Activity data for NH_3, NO and NMVOC emissions consists of the amount of fertilizer nitrogen applied to agricultural soils. For NH_3 this amount is divided into type of fertilizer N. The total amount of N in fertilizer is provided in the annual reports of the IFVA (http://mast.is/matvaelastofnun/utgafa/skyrslur/#arsskyrslur). NO data exists that provides information on the types of N fertilizer. However, it is known that

- N in fertilizer applied in Iceland is mainly contained in calcium ammonium nitrate
- the two other fertilizer types of importance are ammonium nitrate and other NK
- less than one per cent of nitrogen is contained in urea (Bjarnason, written communication)

Calcium ammonium nitrate, ammonium nitrate and other NK have identical EF. Therefore their share of total fertilizer was set to 99%. Urea has a considerably higher EF. Its share was set to one per cent.

Activity data for particulate matter emissions consists of the areas of crops cultivated. The total amount of cropland is recorded in the Icelandic geographic land use database (IGLUD), which is maintained by the Agricultural University of Iceland. Data regarding the area of barley fields comes from the Farmers Association of Iceland (http://bondi.lbhi.is/lisalib/getfile.aspx?itemid=2211 and Bragason, written communication). The area of grass fields is calculated by subtracting the area of barley fields from the total cropland area. Barley fields are cultivated and harvested once a year and the produce is cleaned and dried. Grass fields are cultivated about once every 10 years and hay is cut twice per year on average (Brynjólfsson, written communication).

5.4.2 Emission factors

NH_3 emission factors were taken from Table 3-2 in the EMEP GB 2013 (p.14). These emission factors depend on the mean spring air temperature, i.e. the mean temperature of the three month period following the day when accumulated day degrees since January 1st have reached 400 °C. According to this definition the mean spring temperature in Iceland is about 9 °C.

NO and NMVOC emission factors were taken from Table 3-1 of the EMEP GB 2013 (p.11) and were 0.026 and 5.96E-09 kg/kg (EEA, 2009) fertilizer applied, respectively.

PM_{10} and $PM_{2.5}$ emission factors for barley and grass were taken from Tables 3-3 and 3-5 of the EMEP GB, respectively (p. 14-15).

Emissions

Total NH_3 emissions for crop production and agricultural soils varied between 1.1 and 1.3 kilotonnes between 1990 and 2015. In 2015 72% of emissions originate from manure deposited by livestock during grazing and 27% originate from N fertilizer applied to agricultural soils. Total emissions do not show any discernible trend: primarily because the size of (and thus emissions from) the sheep population decreases with time, but the horse population increases. N fertilizer application was highest in 2008 but a weakening of the Icelandic currency has made the import of fertilizer more expensive and thusly lead to diminishing application.

The emission development of NO and NMVOC are linearly dependent from the application of fertilizer and therefore show the same development with a peak in 2008 at 0.61 kilotonnes and a decline since then. In 2015 NO emissions amounted to 0.46 kilotonnes and is increasing again after 2008. NMVOC emissions from crop production and agricultural soils were 69 grams.

PM_{10} emissions decreased due to the decrease in total cropland from 78 tonnes in 1990 to 72 tonnes in 2015. It is estimated that $PM_{2.5}$ emissions have dropped from 3.2 tonnes in 1990 to 3.6 tonnes in 2015. The drop in $PM_{2.5}$ is a little less due to strong increase in the barley cultivation.

5.5 Agriculture Other Including Use of Pesticides (NFR 3Df and 3I)

The POP-protocol focuses on a list of 16 substances, 11 of which are pesticides. A number of pesticides, however, had already been banned in Iceland in 1996 in order to conform to EU legislation (Iceland is part of the European Economic Area). The only pesticide of the ones listed in chapter 3.D.f of the EMEP GB not banned until 2009 is lindane. The last recorded sale of lindane took place in 1992 when 1 kg was sold. In 1990 and 1991, 2 and 16.2 kg were sold, respectively. It is assumed that the lindane sold was applied during the same year. An EF of 0.5 as listed in Table 3-1 of the chapter 3.D of the EMEP GB (p. 5) was applied to these values resulting in HCH emissions of 1, 8,1, and 0.5 kg for the years 1990-1992. **Error! Not a valid bookmark self-reference.** gives an overview of the use of pesticides in Iceland.

Table 5.5 Pesticide use and regulation in Iceland.

Pesticide	Last recorded use	Year of ban
Aldrin	1975	1996
Chlordane	No recorded use	1996
DDT	1975	1996
Dieldrin	No recorded use	1996
Endrin	No recorded use	1996
Heptachlor	1975	1996
Hexachlorobenzene (HCB)	No recorded use	1996
Mirex	No recorded use	1998
Toxaphene	No recorded use	1998
Pentachlorophenol (PCP)	No recorded use	1998
Lindane	1992	2009

6 Waste (NFR sector 5)

6.1 Overview

Last update for this section was for the 2017 submission.

Emission estimates from the waste sector include emission estimates from the following sources:

- Solid waste disposal on land (NFR 5A)
- Biological treatment of solid waste (NFR 5B)
- Waste incineration without energy recovery (NFR 5C)
- Wastewater treatment and discharge (NFR 5D)
- Other waste (NFR 5E)

Each of these sources are described in more details in sections 6.4 to 6.8. Emissions estimates for waste incineration without energy recovery is included in this section, while emission estimates for waste incineration with energy recovery are reported under sector 1A.

For the 2017 submission, revision of the entire waste sector has been laid forward, with implications on activity data, methodology and resulting emission estimates. The following main changes have been made for the current submission.

- Municipal Solid waste incineration has been split up into respective subcategories of Industrial solid waste incineration, hazardous waste incineration, clinical waste incineration and sewage sludge incineration. Relevant emission factors for each subcategory has been applied by using the EMEP/EEA 2013 Guidebook.
- Completeness has been greatly improved with an addition of emission estimates for several pollutants across all waste sources currently reported in the inventory. This includes e.g. emission estimates of heavy metal previously not being estimated.
- Emissions of open pit burning is now reported under NFR 5C2 (Open burning of waste) rather than NFR 5C1 (Waste incineration). Emission factors have been changed accordingly as to reflect the emission variation resulting from the different combustion conditions. Default Emission factors from the EMEP/EEA 2013 Guidebook have been used.
- Emission estimates for bonfires has been revised for all other pollutants than dioxin, since country specific emission factors were previously applied for dioxin emission estimates from bonfires. Bonfires are now reported under NFR 5C2 instead of NFR 5C1.
- Number of “not-estimated” sources of POPs and other pollutants has been reduced. Limitation of estimated sources is now mostly due to the lack of availability of emission factors in the EMEP/EEA 2013 guidebook.

6.1.1 Sectoral trends – POP's

A summary of emission estimates for the waste sector is provided in Table 6.1 for POPs pollutants.

Table 6.1 Overview of emission estimates of POPs in 2015 (NA – Not applicable, NE – Not estimated).

		Dioxin [g I-TEQ]	B(a)P [t]	B(b)F [t]	B(k)F [t]	IPy [t]	PAH4 [t]	HCB [kg]	PCB [kg]
5A	**Solid waste disposal on land**	NA	NA	NA	NA	NA	NA	NA	NA
5B1	**Composting**	NA	NA	NA	NA	NA	NA	NA	NA
5C	**Waste incineration**	0.602	0.004	0.008	0.010	1.E-07	0.022	0.050	0.058
5D	**Wastewater handling**	NE	NE	NE	NE	NE	NE	NE	NE
5E	**Other waste**	0.082	0.002	0.004	0.003	0.003	0.011	NE	NE
Waste, Total		**0.684**	**0.006**	**0.011**	**0.013**	**0.003**	**0.033**	**0.050**	**0.058**

Not estimated POP's emissions (NE) are due to missing emission factors in the EMEP/EEA 2013 guidebook.

Trends in POP's emission estimates are shown in Figure 6.1 through Figure 6.4 by subsector.

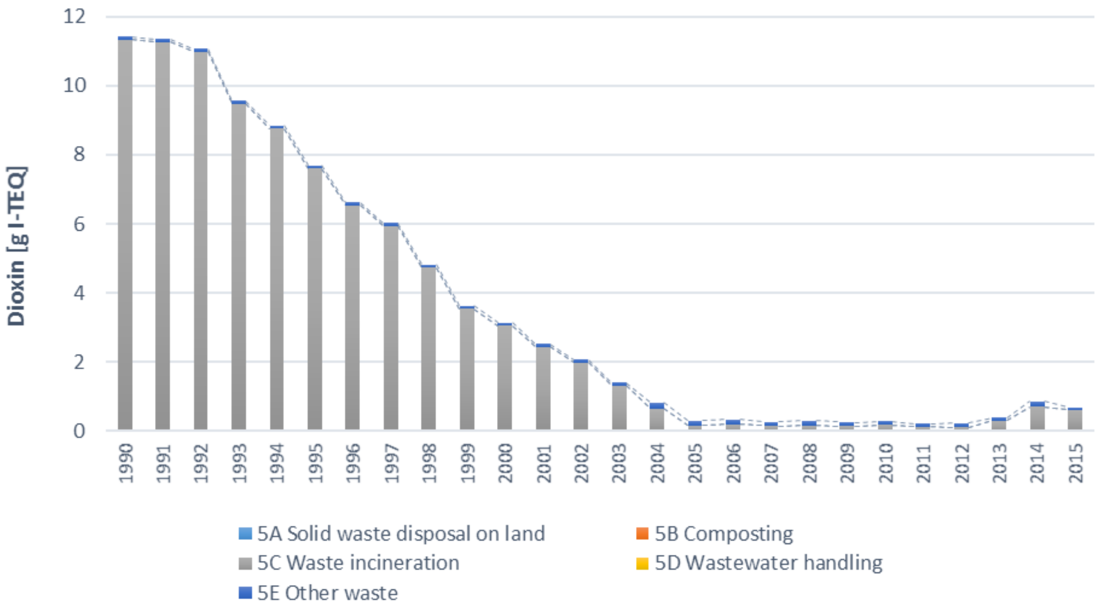

Figure 6.1 Dioxin emission estimates in the waste sector, 1990-2015.

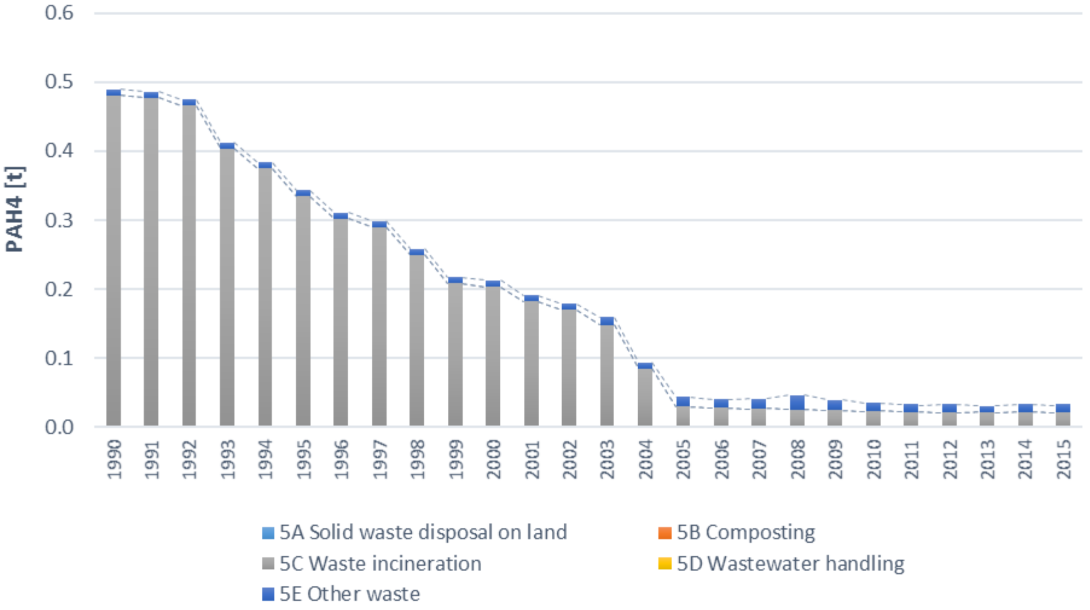

Figure 6.2 PAH4 emission estimates in the waste sector, 1990-2015.

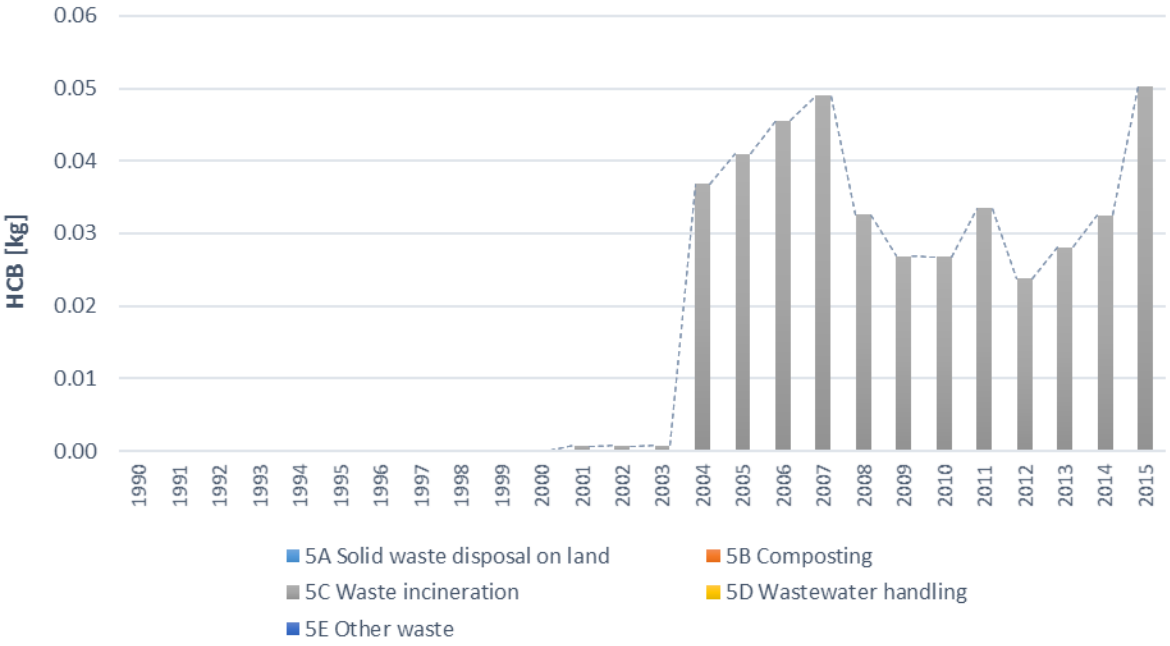

Figure 6.3 HCB emission estimates in the waste sector, 1990-2015.

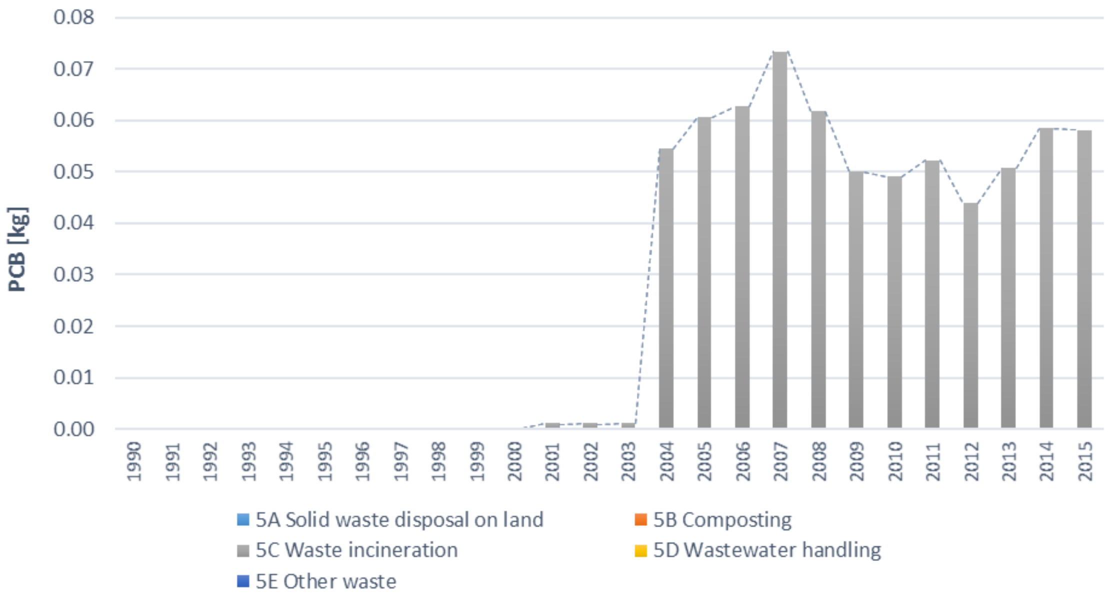

Figure 6.4 PCB emission estimates in the waste sector, 1990-2015.

The sudden increase in HCB and PCB is misleading since HCB and PCB emissions have not been estimated for open burning of waste. The main reason for this is that EMEP/EEA guidebook 2013 does not provide emission factors for the estimation of HCB and PCB emissions for open burning.

6.1.2 Sectoral trends – Other emissions

A summary of emission estimates for other pollutants than POP's is provided in Table 6.2 and

Table 6.3 for the year 2015. Overview of the trends from 1990 to 2015 can be seen in Annex IV and the NFR tables[12].

Table 6.2 Overview of emission estimates of NO$_x$, NMVOC, SO$_x$, NH$_3$, PM and CO in 2015.

		NO$_X$ [kt] NO$_2$	NMVOC [kt]	SO$_X$ [kt] SO$_2$	NH$_3$ [kt]	PM$_{2.5}$ [kt]	PM$_{10}$ [kt]	TSP [kt]	BC [kt]	CO [kt]
5A	**Solid waste disposal on land**	NA	0.27	NA	NE	5.8E-06	3.8E-05	8.1E-05	NA	NA
5B1	**Composting**	NE	NE	NE	0.01	NR	NR	NR	NR	1.2E-02
5C	**Waste incineration**	0.025	0.007	0.018	3.E-05	0.097	0.142	0.191	0.006	0.103
5D	**Wastewater handling**	NA	NE	NA	NE	NR	NR	NR	NR	NE
5E	**Other waste**	6.5E-04	0.003	0.007	NA	0.005	0.005	0.005	NR	0.013
Waste, Total		**0.025**	**0.284**	**0.026**	**0.005**	**0.103**	**0.148**	**0.197**	**0.006**	**0.128**

Table 6.3 Overview of heavy metals emissions estimates in 2015.

		Pb [t]	Cd [t]	Hg [t]	As [t]	Cr [t]	Cu [t]	Ni [t]	Se [t]	Zn [t]
5A	**Solid waste disposal on land**	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B1	**Composting**	NR	NR	NR	NR	NR	NR	NR	NR	NR
5C	**Waste incineration**	1.03	0.035	0.044	0.022	0.0029	0.0056	0.0019	3.E-04	0.043
5D	**Wastewater handling**	NR	NR	NR	NR	NR	NR	NR	NR	NR
5E	**Other waste**	0.084	2.E-04	1.E-05	4.E-05	4.E-04	3.E-03	3.E-04	NR	0.33
Waste, Total		**1.12**	**0.036**	**0.044**	**0.022**	**0.0033**	**0.008**	**0.0022**	**3.E-04**	**0.37**

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[12] http://cdr.eionet.europa.eu/is/un/clrtap/ (Envelope A)

6.2 Historical Background

For most of the 20th century solid waste disposal sites (SWDS) in Iceland were numerous, small and located close to the locations of waste generation so that the waste did not have to be transported far for disposal. In 1967 the waste disposal site in Gufunes was set into operation and most of the waste of the capital´s population landfilled there. Prior to that year, the waste of the capital area was landfilled in smaller SWDS.

Until the 1970s the most common form of waste management outside the capital area was open burning of waste. In some communities, waste burning was complemented with landfills for bulky waste and ash. The existing landfill sites did not have to meet specific requirements regarding location, management and aftercare before 1990 and were often just holes in the ground. Some communities also disposed of their waste by dumping it into the sea. Akureyri and Selfoss, two of the biggest communities outside the capital area opened municipal SWDS in the 1970s and 1980s.

Before 1990 three waste incinerators were opened in Keflavík, Húsavík and Ísafjörður. In total they burned around 15,000 tonnes of waste annually. They operated at low or varying temperatures and the energy produced was not recovered. Waste incineration in Iceland as such started in 1993 with the opening of the incineration plant in Vestmannaeyjar, an archipelago to the south of Iceland. In 2004 the incineration plant Kalka located at the southwest part of Iceland opened and this facility is currently the only waste incineration plant in Iceland. Open burning of waste was banned in 1999. The last place to burn waste openly was the island of Grímsey which stopped doing so by end of 2010.

Recycling and biological treatment of waste started on a larger scale in the beginning of the 1990s. Their share of total waste management increased rapidly since then.

Reliable data about waste composition does not exist until recent years. In 1991 the waste management company Sorpa ltd. started serving the capital area and has gathered data about waste composition of landfilled waste since 1999. For the last few years the waste sector has had to report data about amounts and kinds of waste landfilled, incinerated, and recycled.

The special treatment of hazardous waste did not start until the 1990s, i.e. hazardous waste was landfilled or burned like non-hazardous waste. Special treatment started with the reusing of waste as energy source. In 1996 the Hazardous waste committee (Spilliefnanefnd) was founded and started a collection scheme for hazardous waste. The collection scheme included fees on hazardous substances that were refunded if the substances were delivered to hazardous waste collection points. Hazardous substances collected included oil products, organic solvents, halogenated compounds, isocyanates, oil-based paints, printer ink, batteries, car batteries, preservatives, refrigerants, and more. After collection, these substances were destroyed, recycled or exported for further treatment. The Hazardous waste committee was succeeded by the Icelandic recycling fund in late 2002.

Clinical waste has been incinerated in incinerators either at hospitals or at waste incineration plants.

The trend in waste management practices has been toward managed SWDS as municipalities have increasingly cooperated with each other on running waste collection schemes and operating joint landfill sites. This can be seen in Figure 6.1 which shows the different waste management practices in 1990 and 2010. This development has resulted in larger SWDS and enabled the shutdown of a number of small sites. Currently a large majority of landfilled waste is being disposed of in managed

SWDS. Recycling of waste has increased due to efforts made by the government, local municipalities, recovery companies, and others. Composting started in the mid-1990s and has increased since then.

The shares of the different management practices found in the National Inventory Report on greenhouse gases, delivered annually to the UNFCCC.

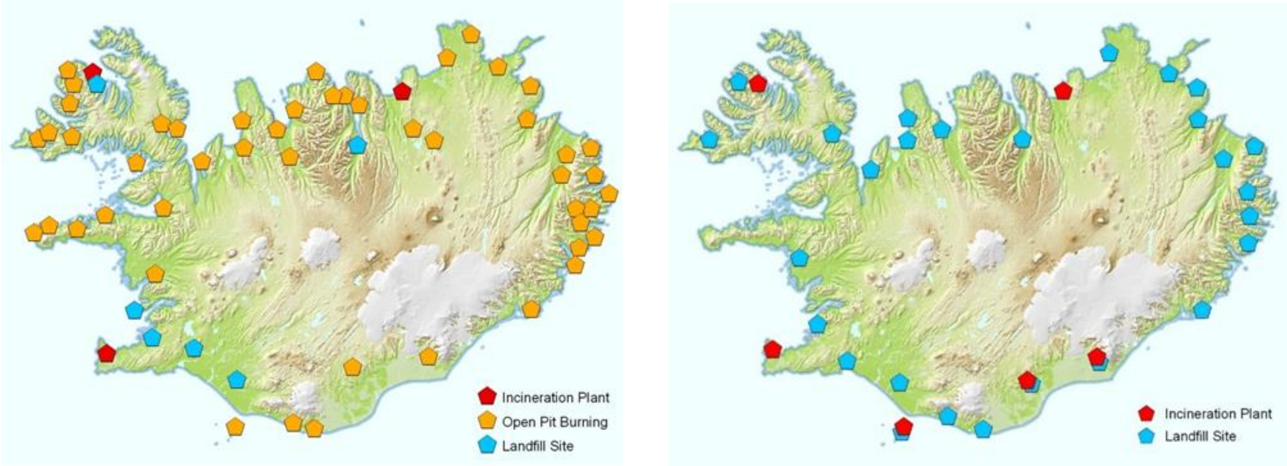

Figure 6.5 Waste management practices in 1990 (left) and in 2010 (right).

6.3 General Methodology

The methodology is mainly based on EMEP air pollutant emission inventory guidebook (EMEP, 2013). Emissions estimates are calculated by multiplying relevant activity data by source with pollutant specific emissions factors. Emissions factors are taken from Emissions Inventory Guidebook (EEA, 2013), the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2005), Annual Danish Informative Inventory Report to the UNECE (National Environmental Research Institute, 2011) and measurements at incineration plants.

The activity data used in for the emission estimates is mainly based on treated waste in Iceland which is reported annually to the EA. This follows an exclusion of waste being treated outside of Iceland and its associated emissions. In addition to data on treated waste in Iceland, activity data for accidental fires, cremation and bonfires is used for estimating emissions from these sources.

6.4 Solid waste disposal (NFR 5A)

This section discusses the emission estimates from solid waste disposal on land and covers the emissions of the following pollutants:

- NMVOCs
- TSP
- PM_{10}
- $PM_{2.5}$

The EMEP/EEA 2013 guidebook mentions the possibility of small quantities of NO_x, NH_3 and CO being emitted from this activity. However, no emission factors for are provided in the guidebook and these emissions have not been estimated in Iceland. Emissions of Hg are considered to be not estimated in accordance with table 3-1 in chapter 5A of the guidebook. Other pollutants are considered not applicable in accordance with that same table.

6.4.1 Methodology

Tier 1 approach of the EMEP/EEA 2013 guidelines is used for the emission estimates for all estimated pollutants. Thus, the total mass of waste disposed of in all landfill sites in Iceland is multiplied with its pollutant specific emission factor.

6.4.2 Activity data

Total mass of waste landfilled in Iceland is used for the emission estimates. Further information on the annual mass of waste landfilled and the source of data can be found in Iceland's National Inventory Report on Greenhouse Gas Emissions. Activity data is presented in the NFR tables[13].

6.4.3 Emission factors

Emission factors from the tier 1 approach of the EMEP/EEA 2013 guidebook is used for estimating emissions from solid waste disposal and are presented Table 6.4. Emission factors are assumed constant for all the years in the calculations.

Table 6.4 Emission factors used in solid waste disposal (NFR 5A)

		NMVOC [kg/t waste]	**TSP** [g/t waste]	**PM10** [g/t waste]	**$PM_{2.5}$** [g/t waste]
5A	**Solid waste disposal**	1.56	0.463	0.219	0.033

6.4.4 Recalculations

TSP, PM_{10} and $PM_{2.5}$ emissions were estimated for the first time in the 2017 submission. Recalculation of NMVOC emissions for all years is a result of a change in methodology from using the emission factor of 5.65 (g NMVOC)/(m^3 landfill gas) to using the emission factor of 1.56 kg/(t waste). Both emission factors are provided in the EMEP/EEA 2013 guidebook. The changes result in an increased estimate of NMVOC emissions of approximately 0.09 kt or around 1% increase in total NMVOC emissions in 2014 compared to the submission in 2016.

A minor correction of notation keys for some pollutants has been laid out in accordance with the EMEP/EEA 2013 guidebook.

6.4.5 Planned improvements

There are currently no planned improvements for this source.

6.5 Biological treatment of solid waste (NFR 5B)

This section discusses the emission estimates from biological treatment of solid waste which consists of the following subsources:

- Composting (NFR 5B1)
- Anaerobic digestion at biogas facilities (NFR 5B2)
- Anaerobic digestion at biogas facilities is currently a non-occurring activity in Iceland. For composting, Iceland reports the emissions of CO and NH_3. Emission factors for other pollutants is not provided in the EMEP/EEA 2013 guidebook.

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[13] http://cdr.eionet.europa.eu/is/un/clrtap/ (Envelope A)

6.5.1 Composting (NFR 5B1)

6.5.1.1 *Methodology*

Emissions estimates are calculated by multiplying waste amounts with relevant pollutant specific emission factors.

6.5.1.2 *Activity data*

Compost production as a means of waste treatment started in Iceland in 1995 and the EA receives annually the amount of waste going to compost production facilities. Activity data is provided in the NFR Tables[14].

6.5.1.3 *Emission factors*

For composting, tier 1 emission factor from the EMEP/EEA 2013 Guidebook is used for estimating NH_3 emissions, while the tier 2 emission factor of the guidebook is used for estimating CO emissions. The emission factors are presented Table 6.4. and are assumed constant for all the years in the calculations.

Table 6.5 Emission factors used in composting (NFR 5B1)

		NH_3 [kg/t waste]	CO [kg/t waste]
5B1	**Composting**	0.24	0.56

6.5.1.4 *Recalculations*

CO emissions were calculated for the first time in the 2017 submission. A minor correction of notation keys for some pollutants has been laid out in accordance with the EMEP/EEA 2013 guidebook.

6.5.1.5 *Planned improvements*

There are currently no planned improvements for this source.

6.5.2 Anaerobic digestion at biogas facilities (NFR 5B2)

This activity is non-occurring in Iceland.

6.6 Waste incineration and open burning (NFR 5C)

This section discusses the emission estimates from burning of waste and consists of the following subsources:

- Waste incineration (NFR 5C1)
- Open burning of waste (NFR 5C2)

Waste incineration covers the emission estimates from waste incineration plants without energy recovery[15] and not from waste incineration with energy recovery. Emission estimates for waste incineration with energy recovery are reported in the relevant subsector under NFR sector 1A1 (Chapter 3.4.1). Waste incineration is separated further into Municipal Waste Incineration (NFR 5C1a), Industrial Waste Incineration (NFR 5C1bi), Hazardous Waste Incineration (NFR 5C1bii), Clinical

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[14] http://cdr.eionet.europa.eu/is/un/clrtap/ (Envelope A)

[15] A quantitative definition of waste incineration with energy recovery is found in Annex IV of regulation 1040/2016 (IS).

Waste incineration (NFR 5C1biii), Sewage Sludge incineration (NFR 5C1biv), Cremation (NFR 5C1bv) and Other Waste Incineration (NFR 5C1bvi).

Open burning of waste covers the emission estimates from open-pit burning facilities and bonfires.

The scope of this section does not include the emissions of waste incinerated outside of Iceland as this would lead to double counting of the emission estimates in a common international emission estimate inventory. Activity data on waste incinerated outside Iceland is provided to the EA annually by the waste burning facilities. Data on waste generation and waste management practices is published by Statistics Iceland.

6.6.1 Waste incineration (NFR 5C1)

6.6.1.1 *Municipal Waste Incineration (NFR 5C1a)*

Incineration of waste in incineration plants without energy recovery started in 2001 in Iceland.

Methodology

The total amount of waste incinerated in all waste incineration plants without energy recovery in Iceland is multiplied with its pollutant specific emission factor as given in the EMEP/EEA 2013 guidebook. This applies to most reported pollutants except for dioxin, where the emission estimates are based on technology specific emission factors from the Standardized toolkit for the identification of Dioxin and Furan releases (UNEP,2005).

Activity data

Activity data on incinerated waste from major incineration plants have been collected by the EA since the year 2000. Waste incineration in incineration plants started in 1993 and currently there is a single operating waste incineration plant in Iceland. Activity data is provided in the NFR Tables[16]. Historic data which was not reported to the EA was estimated using the assumption of 500 kg of waste per inhabitant in communities where waste is known to have been incinerated.

Emission factors

Tier 2 emission factors from table 3-2 in the EMEP/EEA 2013 guidebook is used for all pollutants except for NH_3, Se and Indeno(1,2,3-cd)pyrene and PCDD/F. For NH_3, Se and Indeno(1,2,3-cd)pyrene, tier 1 emission factors from table 3-1 of the EMEP/EEA 2013 guidebook are used. The reason for this is the lack of emission factors given for these pollutants in table 3-2 of the guidebook.

Emission factors for dioxin from waste incineration are based on measurements at the plants, except for Kalka which reports its emissions based on measurements. Average emission from these measurements at similar incineration plants (Hoval technique) at Ísafjörður, Skaftárhreppur and Vestmannaeyjar was close to 50 µg/t. As all these incineration plants are operated as batch, an emission factor for those plants was chosen to be 100 µg/t. The incineration plant at Ísafjörður was closed down in 2010, after a period of malfunctioning. No dioxin measurements took place at the plant for the last three years of operation. Other pollutants were measured at the plant, indicating that there were significantly more emissions from all pollutants for the last three years of operation. For those years, the emission factor of 300 µg/t for uncontrolled domestic waste burning, was taken from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2005). This factor is also used for the incineration plant at Svínafell (also Hoval technique),

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[16] http://cdr.eionet.europa.eu/is/un/clrtap/ (Envelope A)

based on measurements at the plant. For the incineration plant at Húsavík an emission factor of 10 µg/t was chosen, based on measurements.

Recalculations

For the 2017 submission, Municipal Waste Incineration waste amounts were split into relevant subsectors of Industrial Waste Incineration NFR (NFR 5C1bi), Hazardous Waste Incineration (NFR 5C1bii), Clinical Waste incineration (NFR 5C1biii) and Sewage Sludge incineration (NFR 5C1biv). This generally results in a lower emission estimates of pollutants previously estimated for this sector while emissions are introduced in the other sectors where waste was allocated to. Emission estimates from bonfires were furthermore moved into Open Burning of Waste (NFR 5C2) which results in further reduction in emission estimates from the current sector and consequently an increase in emission estimates from open burning of waste.

For the current submission, the following pollutants were estimated for the first time:

- Priority heavy metals: Pb, Cd, Hg
- Additional heavy metals: As, Cr, Cu, Ni, Se, Zn
- POPs: PCB

For Dioxin emission estimates, bonfires are now reported under open burning of waste (NFR 5C2) and hence a reduction in reported emission estimates in the current sector.

Planned improvements

For future submissions, there is need to acquire technology stratification to account for abatement technologies in the Tier 2 methodology of the EMEP/EEA 2013 guidebook. An uncertainty analysis is furthermore in the pipeline.

6.6.1.2 *Industrial Waste Incineration (NFR 5C1bi)*

Methodology

Slaughterhouse waste is the only type of waste that is assumed to be constituting industrial waste incineration for the year 2015. Total reported slaughterhouse waste is multiplied by pollutant specific emission factor to estimate these emissions. Emission estimates are preliminary and further improvements are required for this sector.

Activity data

Activity data for this category has only been included for the year 2015 while for the all other years it is included in 5C1a. Activity data is provided in the NFR Tables[17].

Emission factors

Emission factors are assumed the same as for Municipal Waste Incineration (NFR 5C1a).

Recalculations

For the 2017 submissions, preliminary emission estimates were included for the first time for all pollutants for the year 2015 only. However, since the same emission factors are used as for Municipal Waste Incineration (NFR 5C1a), no changes in total emissions occur due to this.

Planned improvements

Acquire data for the years 1990-2014 and review emission factors currently used.

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[17] http://cdr.eionet.europa.eu/is/un/clrtap/ (Envelope A)

6.6.1.3 *Hazardous Waste Incineration (NFR 5C1bii)*

Methodology

Total amount of hazardous waste is multiplied by a pollutant specific emission factor from the Tier 1 approach of the EMEP/EEA guidebook.

Activity data

Activity data for incinerated hazardous waste exists from 2006 and is currently being reported to the EA. Activity data is presented in the NFR Tables[18].

Emission factors

Emission factor are taken from table 3-1 of chapter 5C1b of the EMEP/EEA 2013 guidebook.

Recalculations

Emission estimates for hazardous waste was done for the first time in the 2017 submission, previously these emissions were reported under NFR sector 5C1a.

Planned improvements

No planned improvements.

6.6.1.4 *Clinical Waste incineration (NFR 5C1biii)*

Methodology

Total amount of clinical waste is multiplied by a pollutant specific emission factor from the Tier 1 approach of the EMEP/EEA guidebook.

Activity data

Activity data for incinerated clinical waste under this sector is from 2001. Activity data is presented in the NFR Tables.

Emission factors

Emission factors are taken from tables 3-1 and 3-2 of chapter 5Cbiii of the EMEP/EEA 2013 guidebook.

Recalculations

Emission estimates for hazardous waste was done for the first time in the 2017 submission, previously these emissions were reported under NFR sector 5C1a.

Planned improvements

No planned improvements.

6.6.1.5 *Sewage Sludge incineration (NFR 5C1biv)*

Methodology

Total amount of sewage sludge is multiplied by a pollutant specific emission factor from the Tier 1 approach of the EMEP/EEA guidebook.

Activity data

Activity data for 2015 is used in the 2017 submission. Review of activity data is necessary. Activity data is presented in the NFR Tables [19]. Activity data for sewage sludge is included in NFR sector 5C1a until 2014.

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[18] http://cdr.eionet.europa.eu/is/un/clrtap/ (Envelope A)

[19] http://cdr.eionet.europa.eu/is/un/clrtap/ (Envelope A)

Emission factors

Emission factors are taken from table 3-2 of chapter 5C1b of the EMEP/EEA 2013 guidebook.

Recalculations

Sewage sludge emission estimates included for the first time in the 2017 submission.

Planned improvements

Review of data for this sector is necessary. Some historic data exists for sewage sludge which need to be introduced until 2014.

6.6.1.6 *Cremation (NFR 5C1bv)*

Methodology

Total number of bodies incinerated is multiplied by a pollutant specific emission factor from the tier 1 approach of the EMEP/EEA 2013 guidebook.

Activity data

Cremation is performed at a single facility located in Reykjavik where human bodies are incinerated along with the coffin. Activity data used is the total number of bodies incinerated and this data is taken from the facility available online.

Emission factors

Emission factors are taken from table 3-1 of chapter 5C1bv of the EMEP/EEA 2013 guidebook.

Recalculations

For the 2017 submission, all pollutants that were not estimated before and where emission factor is given in the guidebook have now been estimated. Previous submission included dioxin and POPs only.

Planned improvements

No planned improvements.

6.6.1.7 *Other Waste Incineration (NFR 5C1bvi)*

Data for other waste incineration is not available for the time being. Improvements are needed regarding this.

6.6.2 Open burning of waste (NFR 5C2)

Open burning of waste includes combustion in nature and open dumps as well as combustion in incineration devices that do not control the combustion air to maintain adequate temperature and do not provide sufficient residence time for complete combustion. Incineration devices on the other hand are characterized by creating conditions for complete combustion. Therefore, the burning of waste in historic incineration devices that did not ensure conditions for complete combustion is allocated to open burning of waste. Open pit burning was a common procedure in the early nineties. In general, open pit burning results in poor combustion conditions due to inhomogeneous and poorly mixed fuel material, chlorinated precursors, humidity or catalytically active metals, but all these factors influence the dioxin formation. It can therefore be hard to come up with a reasonable emission factors. In addition to that the activity data is quite uncertain as well, as no official statistics are available.

It is a tradition to light up bonfires at New Year’s Eve in Iceland. These are quite common throughout the country. In the early nineties, there were no restrictions and no supervision with these bonfires. In the early nineties, some surveillance officers from the Environmental and Public Health Offices

(Local Competent Authority) started to control these fires, by informing the bonfire personnel. In 2000 the EA, Iceland Fire Authority and National Commissioner of Iceland Police published guidelines for bonfires. They include restrictions on size, burnout time and the material allowed. Since that time only wood and paper are allowed on bonfires. Also, the Environmental and Public Health Offices supervise all bonfires. Now they are fewer and better organized.

6.6.2.1 *Methodology*

The total amount of waste incinerated in all waste open pit burning facilities in Iceland is multiplied with its pollutant specific emission factor as given in the EMEP/EEA 2013 guidebook. This applies to most reported pollutants except for dioxin, where the emission estimates are based on technology specific emission factors from the Standardized toolkit for the identification of Dioxin and Furan releases (UNEP,2005). Same methodology is used for emission estimates from bonfires with dioxin being calculated differently. See more detailed description in the following sections.

6.6.2.2 *Activity data*

Historic data on open pit burning was estimated with the assumptions that 500 kg of wastes have been incinerated per inhabitant in the communities where waste is known to have been incinerated in 1990, 1995 and 2000 and interpolated in the years between. These communities were mapped by EAI in the respective years. The date is known at the EA, at which sites, where open pit burning has been performed have been closed and other means of waste disposal have been found. Open pit burning is likely to occur still at various rural sites, but this has not been estimated. The amount of waste burned in open pits has decreased rapidly since the early 1990s, when more than 30 thousand tonnes of waste were burned. Between 2005 and 2010 there was only one site left burning waste openly, on the island of Grímsey. This site was closed by the end of 2010. It was assumed that around 50 tonnes of waste were burned there annually.

For bonfires, activity data is not easily obtained. In 2011 the EAI along with the municipality of Reykjavík decided to weigh all the material of a single bonfire. Then the piled material was photographed and height, width and length measured. The weight was then correlated to the more readily measureable parameters pile height and diameter. The Environmental and Public Health Offices were asked to measure height and diameter of the bonfires in their area, take pictures and send to EA. From this information the total weight of bonfires was estimated for the whole country. The amount was further extrapolated back to 1990, in cooperation with an expert from one Environmental and Public Health Office that has been involved with this field of work for a long time.

6.6.2.3 *Emission factors*

For open pit burning, dioxin emission factor is taken from table 54 in the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2005), it is 300 µg per tonne waste (given for uncontrolled domestic waste burning). Emission factors for other pollutants are taken from table 3.1 in chapter 5C2 of the EMEP/EEA 2013 guidebook

For bonfires, dioxin emission factor have been estimated historically based on assumptions. From 2003 onwards an emission factor of 60 µg/t is used. This factor is taken from table 54 of the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2005) and is given for open burning of wood. For 1990 to 1995 an emission factor of 600 µg per tonne burnt material was used. This relates to the fact that the burning material was very miscellaneous at that time. It was common practice to burn tires, kitchen interior and even boats at the bonfires. Furthermore, some businesses used the opportunity to get rid of all kind of wastes. Therefore, it was considered suitable to double the emission factor used for open pit burning. The emission factor was then interpolated from 600 µg to 60 µg per tonne burned material from 1996 to 2003. The emission factors for other pollutants than dioxin are taken from table 3-1 in chapter 5C2 of the EMEP/EEA 2013 guidebook.

6.6.2.4 *Recalculations*

For the 2017 submission, emissions from open burning of waste were included under NFR sector 5C2 for the first time. In previous submissions, emission estimates were included under sector 5C1a. Recalculations cover all pollutants under NFR 5C2 as new emission factors, provided by the EMEP/EEA 2013 Guidebook, are applied to reflect better open burning conditions. This means modification to emission factors previously applied to open burning of waste and reported in last years submission.

The following pollutant highlights are provided for the recalculations while other emission estimates are provided in the NFR Tables:

- Completeness of emission estimates for the activity of open pit burning and for bonfires is now reached based on the availability of emission factors in the EMEP/EEA 2013 guidebook. Before the emission estimates were largely incomplete.
- New emission estimates for heavy metals except Hg, Ni are now provided for the first time. Emission factors for Hg and Ni are not provided for in the EMEP/EEA guidebook.

6.6.2.5 *Planned improvements*

Emission factors needed to estimate HCB and PCB emissions. Not provided in the EMEP/EEA 2013 guidebook in chapter 5C2.

6.7 Wastewater handling (NFR 5D)

According to the EMEP guidebook (EEA, 2013) wastewater will be an insignificant source for air pollutants. However, in urban areas, NMVOC emissions from waste water treatment plants can be of local importance. Activities considered within this sector are biological treatment plants and latrines (storage tanks of human excreta, located under naturally ventilated wooden shelters).

In Iceland, most wastewater is discharged into the sea either untreated or after primary treatment. Only a small amount of wastewater is treated with secondary treatment and latrines are not occurring. Therefore, non-GHG emissions have not been estimated from wastewater handling.

6.7.1 Methodology

No methodology is used due to the lack of relevant activity data.

6.7.2 Activity data

No relevant activity data.

6.7.3 Emission factors

No emission factors used.

6.7.4 Recalculations

No recalculations

6.7.5 Planned improvements

Acquire relevant activity data and estimate whether there might occur NMVOC emissions.

6.8 Other waste (NFR 5E)

This section discusses the emission estimates from other waste and Iceland estimates the following sources of emission:

- Accidental house burning
- Accidental vehicle burning

Emission estimates for all reported pollutants is provided except for NH_3, BC, Se, HCB and PCB where emission factors have not been found or are considered not applicable.

6.8.1 Methodology

For accidental house fires, emission estimates are calculated as the number of fire events times a pollutant specific emission factor from the Tier 2 approach of chapter 5E in the EMEP/EEA 2013 guidebook and the Danish IIR of 2015.

For accidental vehicle fires, emission estimates are calculated as the mass of vehicles burned times a pollutant specific emission factor from the Danish IIR 2015. Weight of different types of vehicles are used in the calculations and taken from table 6-26 of the Danish IIR 2015. The assumption is made that 70% of the total mass is burned.

6.8.2 Activity data

Activity data for vehicle and building fires were obtained for the years 2003 to 2012 from the Capital District Fire and Rescue Service (CDFRS). Data for 2013 was unavailable and is therefore estimated using the historic data from 2003 to 2012. Building fires are classified by duration of response into small, medium and large fires. The data is presented in Table 6.6. As 2/3 of the Icelandic population lives in the capital area, it is assumed that the CDFRS serves 2/3 of the incidents in Iceland. In Table 6.7, data on vehicle and building fires, extrapolated for Iceland, is presented. As the emission factors used comply for full scale building fires, the activity data is scaled as a full scale equivalent where it is assumed that a medium and a small fire leads to 50% and 5% of a large fire respectively, and that a large fire is a full scale fire. Table 6.6 and Table 6.7 show the total scaled building fires. This scaling is similar to the scaling used in the 2011 Danish Informative Inventory Report, although the scaling in Denmark is based on response activity rather than response time. It does though seem appropriate to scale the fires in this way for the Icelandic data. It is further assumed that 10% of the building fires every year, are industrial building fires. In 2004 a major industrial fire broke out at a recycling company (Hringrás). In the fire 300 tonnes of tires, among other separated waste materials, burned. In 2011 a fire broke out at the same company, but that fire is assumed to have been about 10% of the size of the one in 2004. In 2014 a major fire incident occurred when fire broke out in an industrial laundry service. The house had a thick layer of asphalt roll roofing with an estimated weight of around 80 tonnes.

For the year 1990 to 2002 an average of the total scaled building fires (38) and the vehicle fires (60) was used. The possibility to obtain better data for 1990 to 2002 has been further explored. However, the reports on accidental fires for that period are in completely different form, making them both difficult to obtain and interpret. As the extra information gained would not be of that much importance it is not thought to be priority to further explore this subject.

The activity data is calculated as a yearly combusted mass by multiplying the number of different vehicles fires with the average weight of the given vehicle type. As it is not registered at the CDRFS which types of vehicles are caught in fires, the average Danish (2011 Danish Informative Inventory Report) ratio of vehicle fires per vehicle type were taken per vehicle type, excluding motorcycles, as motorcycle fires are very rare in Iceland (passenger cars 83%; buses 8%; light duty vehicles 3%; heavy duty vehicles 7%). The total amount of vehicle mass involved in fires is then calculated from the number of vehicle fires and the average weights of the different vehicle types (also Danish weight, as information was not available). It is assumed that 70% of the total vehicle mass involved in a fire actually burns.

Table 6.6 Vehicle and building fires, capital area.

Year	Vehicle fires	Building fires <60 min	Building fires 60-120 min	Building fires >120 min	Total scaled building fires
2003	36	161	21	4	23
2004	25	153	24	5	25
2005	43	141	24	11	30
2006	34	130	24	9	28
2007	44	142	20	7	24
2008	64	150	25	9	30
2009	46	114	16	12	26
2010	34	118	17	9	24
2011	35	121	10	5	16
2012	36	99	24	9	26
2013	26	85	18	5	18
2014	35	99	20	12	27
2015	36	88	15	3	15

Table 6.7 Vehicle and building fires scaled for Iceland

Year	Vehicle fires	Building fires <60 min	Building fires 60-120 min	Building fires >120 min	Total scaled building fires
2003	54	242	32	6	34
2004	38	230	36	8	38
2005	65	212	36	17	46
2006	51	195	36	14	42
2007	66	213	30	11	37
2008	96	225	38	14	44
2009	69	171	24	18	39
2010	51	177	26	14	36
2011	53	182	15	8	25
2012	54	149	36	14	39
2013	39	128	27	8	28
2014	53	149	30	18	40
2015	54	132	23	5	24

At the major industrial fire at Hringrás in 2004, an estimated amount of 300 tonnes of tires, among other separated waste materials, burned.

For the major industrial fire in 2014, the estimated weight of the asphalt roll roofing burned down was estimated to be around 80 tonnes and was assumed to be a large part of the emissions from this particular fire.

6.8.3 Emission factors

Emission factor for undetached houses is used for all building fires except industrial building fires. This is due to the fact that Icelandic regulation demand more fire resistance than the regulations in the Scandinavian countries. Emission factors for detached building fires are taken from table 3-4 of chapter 5E of the EMEP/EEA 2013 guidebook for all estimated pollutants provided in the guidebook except for dioxin which is taken from the 2015 Danish Informative Inventory Report (IIR) to the UNECE. Other non-estimated sources of the guidebook are taken from the Danish 2015 IIR table 6.20. No emission factors are provided for BC, Ni, Se, Zn, HCB and PCB. NH_3 is considered not applicable as the guidebook suggests.

Similarly, for industrial house fires, emission factors from table 3-6 of chapter 5E of the EMEP/EEA 2013 guidebook is used except for dioxin which is taken from the 2015 Danish Informative Inventory Report (IIR) to the UNECE. Other non-estimated sources of the guidebook are taken from the Danish 2015 IIR table 6.20. No emission factors are provided for BC, Ni, Se, Zn, HCB and PCB. NH_3 is considered not applicable as the guidebook suggests.

For vehicle fires, the burned mass is then multiplied with a pollutant specific emission factor taken from table 6-29 of the Danish IIR 2015.

For the major industrial fire at Hringrás in 2004, an emission factor of 220 µg/(t of tires) from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2005), was taken. Using this factor, this single fire scaled like about 16 industrial building fires and PAH4 emissions were scaled accordingly.

Asphalt roll roofing was assumed to emit dioxin levels comparable to scrap tires which has the emission factor of 220 µg/(t of tires) given in the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2005). Dioxin emissions from other materials that burned were included by assuming such that the fire was comparable to 5 industrial buildings. Thus the emissions from this particular fire corresponds to 5 industrial building fires plus the special assessment of the asphalt roll roofing, in total around 9 industrial fires. Other POP's emission estimates were calculated by using emission factors from table 6-20 of the Annual Danish Informative Inventory Report to the UNECE (National Environmental Research Institute, 2011) for industrial buildings, scaled according to the estimation of corresponding industrial building fires. Emission factors for NO_x, NMVOC, SO_2 and CO are also taken from the Danish IIR table 6-20. Other reported pollutants are taken from the EMEP/EEA guidebook 2013 table 3-6. No emission factors are provided for BC, Ni, Se, Zn, HCB and PCB. NH_3 is considered not applicable as the guidebook suggests.

6.8.4 Recalculations

For the 2017 submission, emission estimates for other pollutants than PAH4 and dioxin are calculated and reported for the first time.

For accidental car burning, Danish IIR Emission factors are used for all calculations where as before, dioxin emissions were calculated before using emission factors from the EMEP/EEA 2013 Guidebook. This results in minor changes of reported dioxin emissions estimates for dioxin.

For major industrial fires, other pollutants than dioxin and PAH4 were calculated and reported for the first time.

6.8.5 Planned improvements

Review of data used for 1990-2002 for the number of accidental house and vehicle fires. General data improvement needed.

6.9 Uncertainties and time series consistency

No uncertainty analysis has been done for the waste sector and work has been done to facilitate such calculations for future submissions. Generally, the uncertainties are considered high due to the lack of historic data and due to a number of assumptions. Timeseries consistency for HCB and PCB is considered not sufficient due to the lack of emission factors for open burning of waste.

6.10 QA/QC and verification

Additional QA/QC procedures have been implemented in the 2017 submission. It involves an assessment of changes in all reported pollutant emissions between the current and last years' submission. Checks on emission estimate trends and notation keys are further used to verify current years' emission estimates. Mass balance check on input data is furthermore laid out when allocating procedures occur. QA/QC procedures implemented in the 2017 submission are planned to be used annually for future submissions.

7 Natural Sources (NFR 11)

7.1 Volcanoes (NFR 11A)

In this chapter emissions from the last three volcanic eruptions are reported. These eruptions are: Eyjafjalljökull eruption, April-May 2010; Grímsvötn eruption, May 2011; and Holuhraun eruption, September 2014-February 2015. As emissions from these eruptions are natural they are reported in this chapter and in the NFR Tables under Memo Item 11A, but are not included in national totals.

7.1.1 Eyjafjallajökull eruption 2010

The Eyjafjallajökull eruption lasted from 14th of April until 23rd of May 2010. For this eruption emissions of sulphur dioxide (SO_2) and particulate matter were estimated and reported. The emissions estimates are based on satellite observation on a daily basis during the eruption (https://wiki.met.no/emep/emep_volcano_plume) and amounted to approx. 127 kt of SO_2, 6000 kt of PM_{10} and 1700 kt. of $PM_{2.5}$. These 6000 kt of PM_{10} were around 3500 times more than total estimated man made PM_{10} emissions in Iceland in 2010.

Figure 7.1 Eyjafjallajökull eruption at its peak in April 2010 (Photo: Þorsteinn Jóhannsson).

7.1.2 Grímsvötn eruption 2011

The Grímsvötn eruption lasted from 21st of May until 28th of May 2011. The eruption at Grímsvötn was much larger than that of Eyjafjallajökull the year before, and it has been estimated that during the first day more sulphur and particulates were emitted than during all the Eyjafjallajökull eruption. SO_2 emissions from Grímsvötn have been estimated to be around 1000 kt. An estimate of the total particulates emitted has not been estimated but the EAI has scaled the emissions of particulates using the ratio of Sulphur emissions from the two eruptions (1000/127). This gives an approximate estimate of 47,000 kt PM_{10} and 13,000 kt of $PM_{2.5}$. Figure 7.2, a NASA MODIS satellite image acquired at 05:15 UTC on May 22, 2011 shows the plume from Grímsvötn casting shadow to the west. (Photo NASA/GSFC/Jeff Schmaltz/MODIS Land Rapid Response Team).

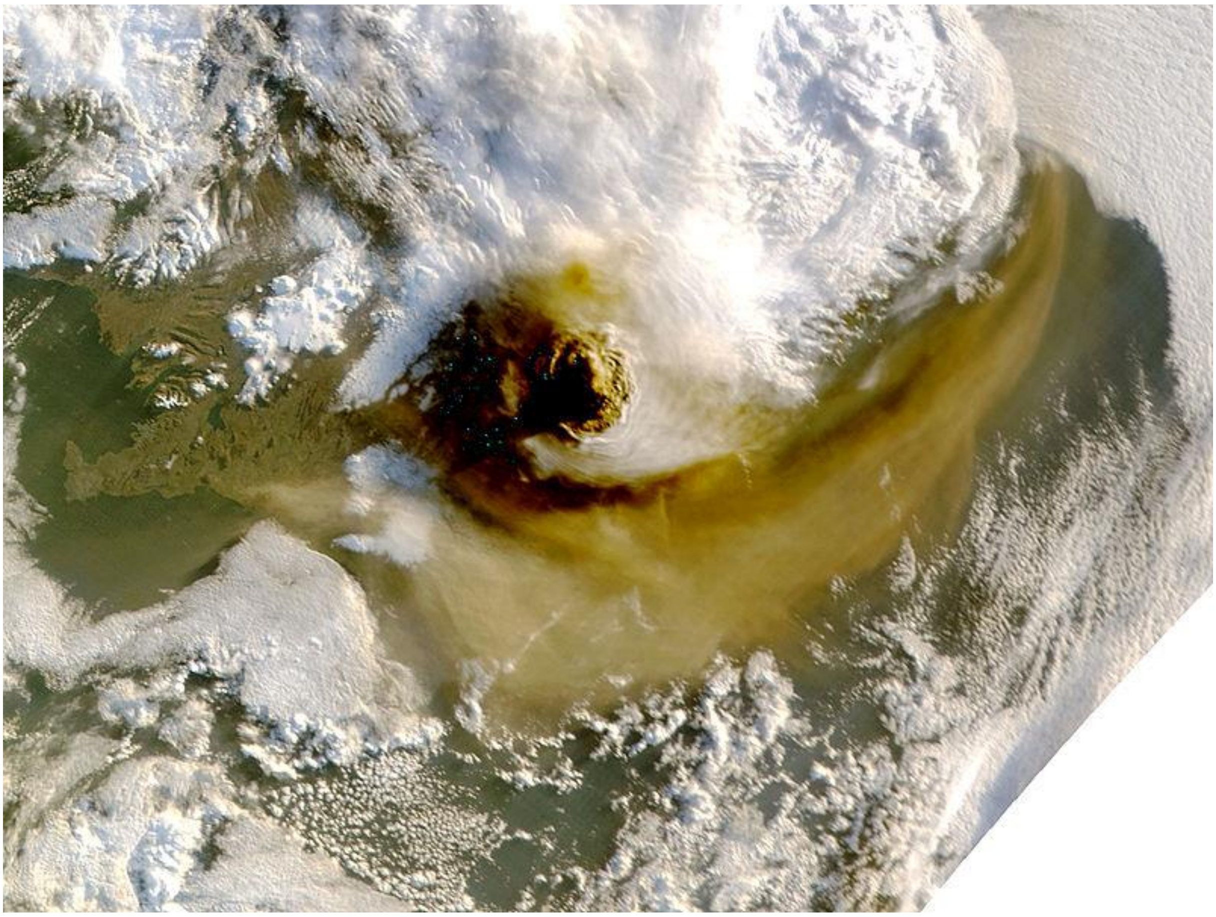

Figure 7.2 Grímsvötn eruption in May 2011.

7.1.3 Holuhraun eruption 2014 - 2015

The eruption in Holuhraun began on August 29th 2014 and ended on February 27th 2015. It was the biggest eruption in Iceland since the Laki eruption 1783.

Emission estimates in the Holuhraun eruption were done by the volcanic hazard team at the Icelandic Met Office. According to information from Sara Barsotti and Melissa Anne Pfeffer the estimates was done as follows: The emission rate of SO_2 was calculated using wind parameters provided by the HARMONIE numerical prediction model and column concentrations of SO_2 detected with different types of DOAS measurements. The DOAS techniques used include two NOVAC scanning DOAS instruments (Galle et al., 2010): one installed 7 km from the main degassing vent, Baugur, but moved during the eruption due to the advancing lava to 10 km from the main vent; and a second scanning DOAS installed 10 km from the main vent, but damaged by advancing lava two weeks after the start of the eruption; campaign DOAS traverses, made as close to the main vent as conditions allowed; and ring road DOAS traverses (Gíslason, 2015). All measurements were analyzed closely to remove the data most impacted by scattering. For all techniques, the good quality measurements were used to calculate daily averages of SO_2 emission rate. On days when good quality data was acquired from more than one DOAS technique, the larger value was used, and then these daily values were used to calculate the monthly averages. Some minor degassing from the cooling lava continued after the end of the eruption (maximum 3 kg/s; Simmons et al., 2016); this contribution to the emissions is not included here.

Total SO_2 emission from this eruption was estimated 12,006 kt. Divided on calendar years 10,880 kt of SO_2 were emitted in the year 2014 and 1,126 kt of SO_2 in the year 2015. To put these numbers in in perspective it can be said that the total SO_2 emission from all the European Union countries for the year 2012 was 4,576 kt. So the emission from the eruption in the year 2014 i.e. from August 29th 2014 to December 31st 2014 was more than twice the total SO_2 emission from all the European Union countries for whole year. For September alone, during the most intensive period of the eruption, the SO_2 emission from the eruption was similar to the annual emission of the European Union.

Negligible emission of ash was from this eruption and it was not estimated. Further information about SO_2 emissions from the eruption are in Table 7.1 below. As these emissions are natural they are not included in national totals.

Table 7.1 Eruption emission parameters.

	Average monthly emission rates [kg/s]	**SO_2 per month [kt]**
August 2014	124	332
September 2014	1708	4427
October 2014	1051	2815
November 2014	1143	2963
December 2014	128	343
January 2015	304	814
February 2015	129	312

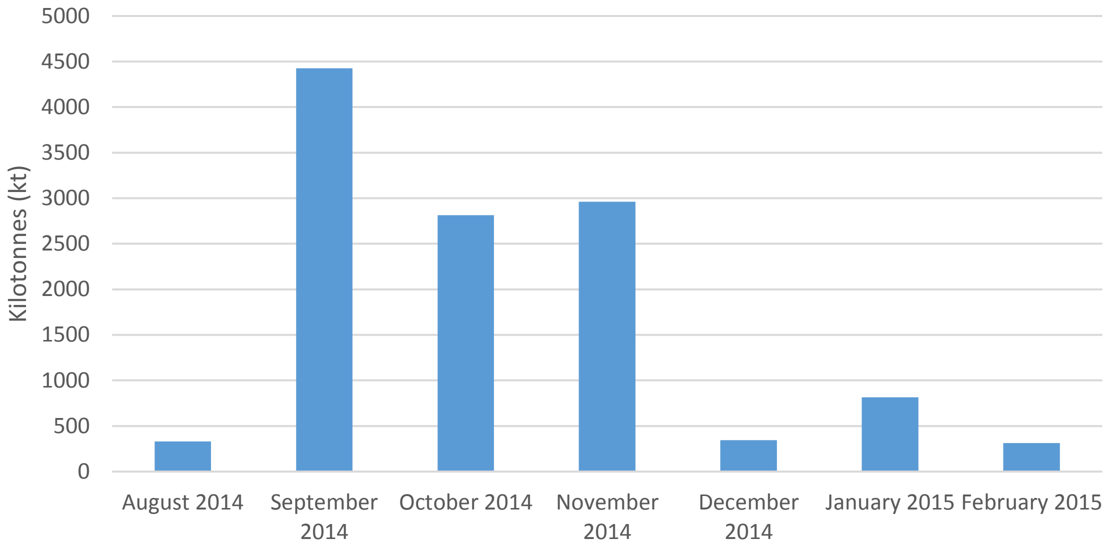

Figure 7.3 Monthly emission from Holuhraun during the eruption.

The eruption caused widespread SO_2 pollution all over Iceland and also in other countries in Europe. During the eruption, various institutions were in charge of disseminating information to the public. The Icelandic Met Office used the CALPUFF modelling system to simulate and forecast the dispersal and concentration of the SO_2 gas at ground level. The forecast was three-day long and was updated twice a day. SO_2 dispersion during the whole eruption modelled by CALPUFF are presented in Figure 7.4 as the frequency of hourly concentrations higher than the EU one hour limit value for SO_2 that is 350 µg/m^3 .The values corresponding to each contour show how many times this concentration has been exceeded at each location during this period. During the eruption, gas pollution was extensive across all of Iceland. The NE part of the country suffered the highest impact from the eruption. The model suggests that the area within 50 km NE of the eruption site exceeded 350 µg/m^3 for up to 20 % of the time (about 30 days in total). The northern part of Vatnajökull and the eastern part of Hofsjökull glaciers were frequently exposed to high ground-level concentrations of SO_2 for up to 15 days.

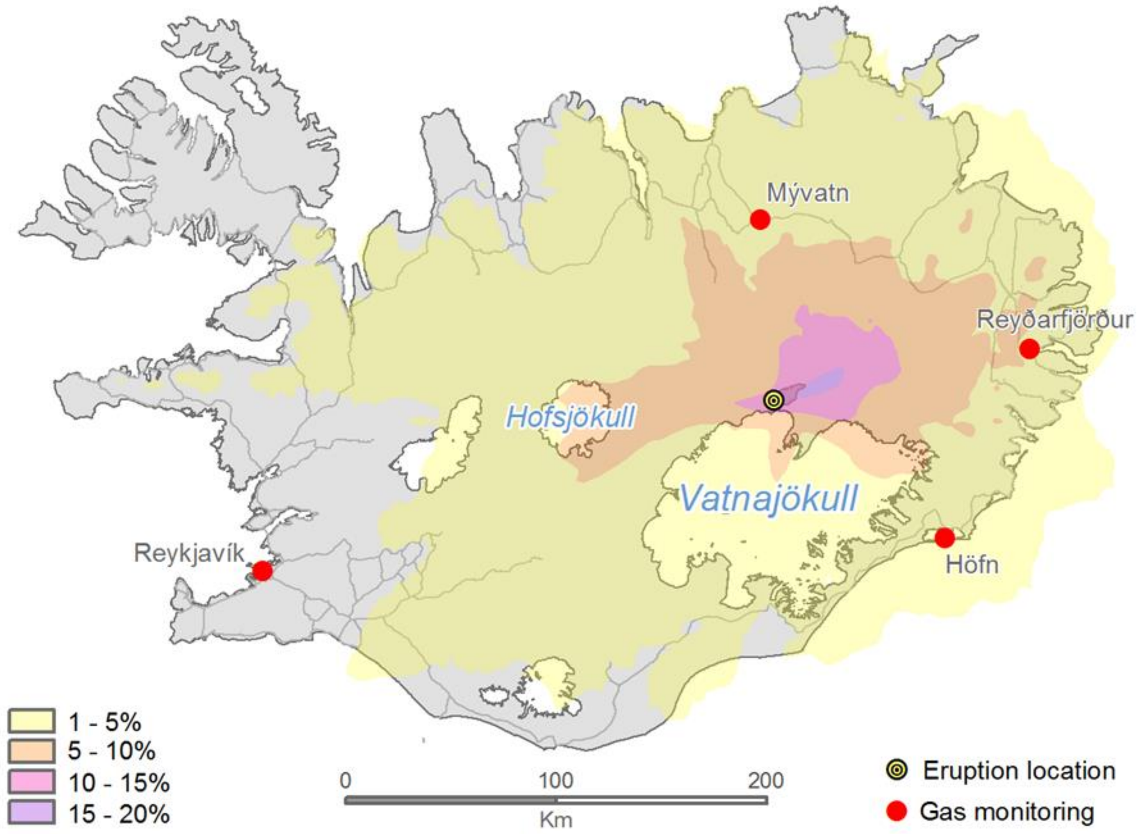

Figure 7.4 SO_2 dispersion during the eruption modelled by CALPUFF, presented as frequency of hourly concentrations higher than the 350 µg/m^3 health limit. The monitoring stations mentioned in the text and in Figure 7.4 are also shown (Gíslason, 2015)

To inform the public about ground level concentration of SO_2 the Environmental Agency of Iceland shared information from SO_2 monitoring stations. At the beginning of the eruption the ambient air concentration of SO_2 was measured at 11 permanent stations across Iceland recording 10 and 60 minutes average concentration. Seven of the stations continuously streamed the results to the website of the Environmental Agency of Iceland (EAI) http://airquality.is. By late January 2015 the number of these stations had risen to 21. All these instruments where trace level (ppb) SO_2 analysers equipped with pulsed fluorescence spectroscopy meters. In addition to these accurate measuring stations around 50 hand held SO_2 meters was distributed throughout the country and they were usually operated by the local police. So the total number of SO_2 monitoring devices was 71, distributed in agglomerations all around the country.

Prior to the Holuhraun eruption, the ground–level concentration of atmospheric SO_2 in Iceland had never been recorded as exceeding the 350 µg/m^3 hourly limit. During the eruption, predicted and measured values repeatedly exceed this limit (see Figure 7.4 and Figure 7.5) Much higher SO_2 peaks, lasting shorter than one hour, were frequently measured on hand held sensors, the highest being 21,000 µg/m^3 in Höfn. Continuous measurements started 28 October 2014 in Höfn as shown in Figure 7.5. There the hourly averaged concentration reached a maximum of 3050 µg/m^3 on 11 January 2015. Over the monitoring periods shown in Figure 7.5, SO_2 exceeded the one hour 350 µg/m^3 threshold 2.0 % of the time at Mývatn (for 17 consecutive hours and a total of 86 hours), 1.4 %

in Reyðarfjörður (for 10 consecutive hours and a total of 58 hours), 1.4 % in Reykjavík (for 8 consecutive hours and a total of 59 hours) and 4.2 % of the time in Höfn (for 16 consecutive hours and a total of 124 hours). The last unambiguous detection of the volcanic plume was at the Mývatn station on February 18.

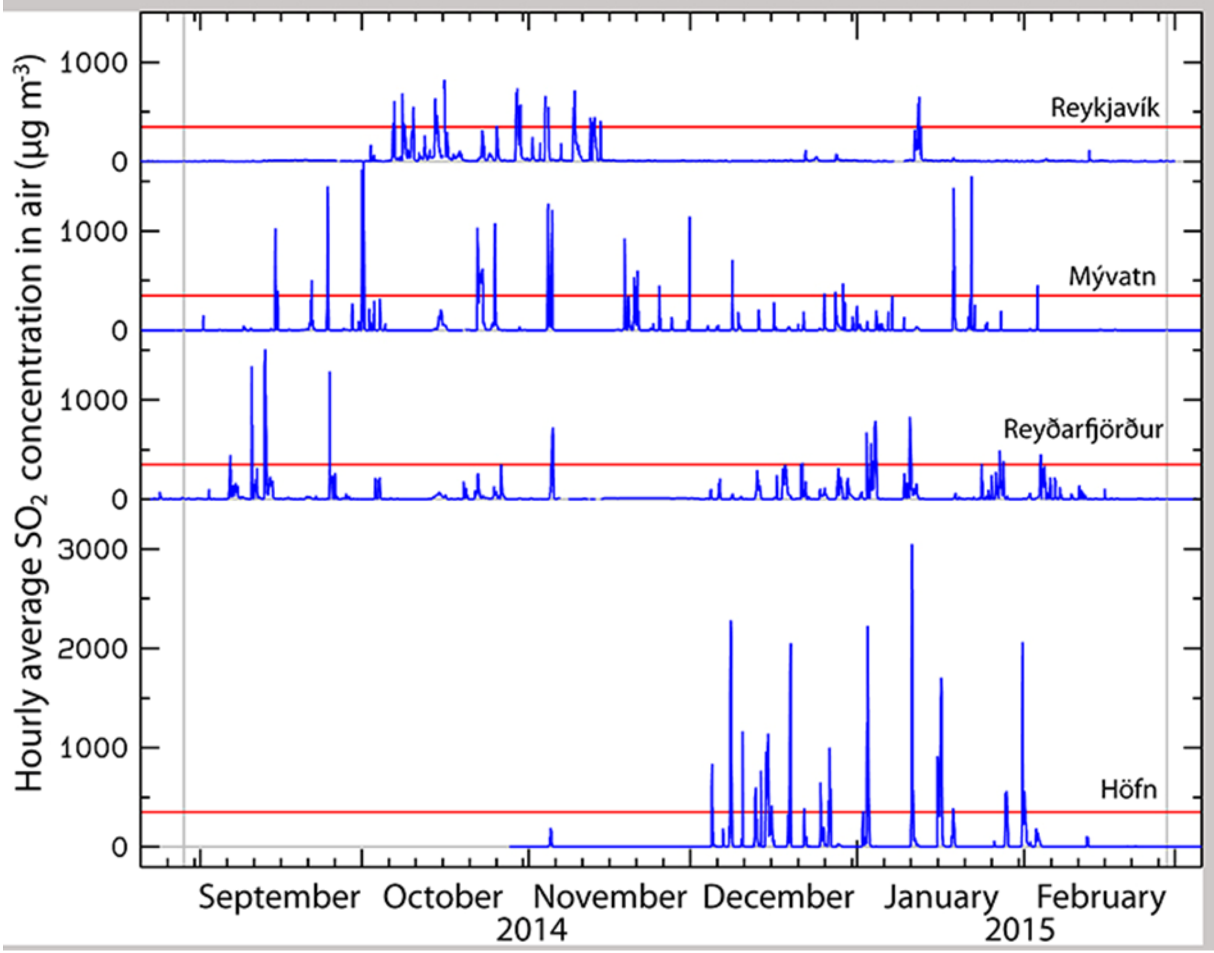

Figure 7.5 The SO_2 concentration in air at four of the permanent gas monitoring stations presented in Figure 7.5. The 350 µg/m^3 health limit is shown by the red horizontal line. The grey vertical lines mark the eruption period. Permanent SO_2 monitoring started at Höfn 28 October 2014. (Gíslason, 2015)

Gas emissions from the Holuhraun eruption resulted in an increase in ground–level SO_2 concentrations in the UK and Ireland during two occasions in September 2014 (Schmidt, 2015). Examples of the highest peaks during these events are shown from two monitoring stations in Ireland in Table 7.2 (taken from http://www.geochemicalperspectivesletters.org/article1509 - TS-2), along with examples from monitoring stations in the Netherlands, Belgium, and Austria. These stations are equipped with pulsed fluorescence spectrometers with similar detection limits and uncertainty as the Icelandic stations. During the 22. of September the ground-level concentrations were highest in Austria at 235 µg/m^3. The Masenberg station in Austria is a background station at a high elevation and far away from local emission sources and rarely records SO_2 concentrations in excess of 30 µg/m^3. On this day unusually high concentrations were measured at most of the 30 monitoring stations in Austria. (Gíslason, 2015).

Table 7.2 Highest one hour SO2 peak by country (Gíslason, 2015)

Counry	Station name	Latitude	Longitude	Height above sea level	Date	Distance from the eruption	Highest one hour SO2 peak
Ireland	Ennis	52.84	-9	16 m	06.09.2014	1407 km	498 µg/m3
Ireland	Portlaoise	53.04	-7.29	98 m	06.09.2014	1420 km	343 µg/m3
Netherlands	Philippine	51.29	3.75	5 m	22.09.2014	1905 km	82 µg/m3
Belgium	Ghent region	51.15	3.81	12 m	22.09.2014	1931 km	87 µg/m3
Britain	Wicken Fen	52.3	0.29	3 m	22.09.2014	1701 km	96 µg/m3
Austria	Masenber	47.35	15.89	1210 m	22.09.2014	2754 km	235 µg/m3

Figure 7.6 Holuhraun eruption in September 2014. The height of the lava fountains were around 100 m (Photo: Ólafur F. Gíslason).

8 Spatially Distributed Emissions on Grid

This chapter includes results of the Icelandic geographically distributed emissions for the years 1990, 1995, 2000, 2005 and 2010 for PAH4 and dioxin. Emission data have been disaggregated to the standard EMEP grid with a resolution of 50 km x 50 km. The reported emissions include gridded data for sector totals as well as national totals. Emissions for aviation, navigation and fishing have not been gridded.

When gridding the data all industrial sources and waste incineration sites (open pit burning and incineration plants) have been mapped with coordinates and projected on the grid. Other emissions like emissions from road transport, accidental fires, and bon fires have been divided on the grid based on population data. Some minor sources like emissions from tobacco smoking have been located where the populations density is highest, i.e. the capital area.

8.1 PAH4 Emissions in 1990, 1995, 2000, 2005 and 2010

Figures 8.1 to 8.5 show national total emissions of PAH4 within the EMEP-Grid in 1990, 1995, 2000, 2005 and 2010.

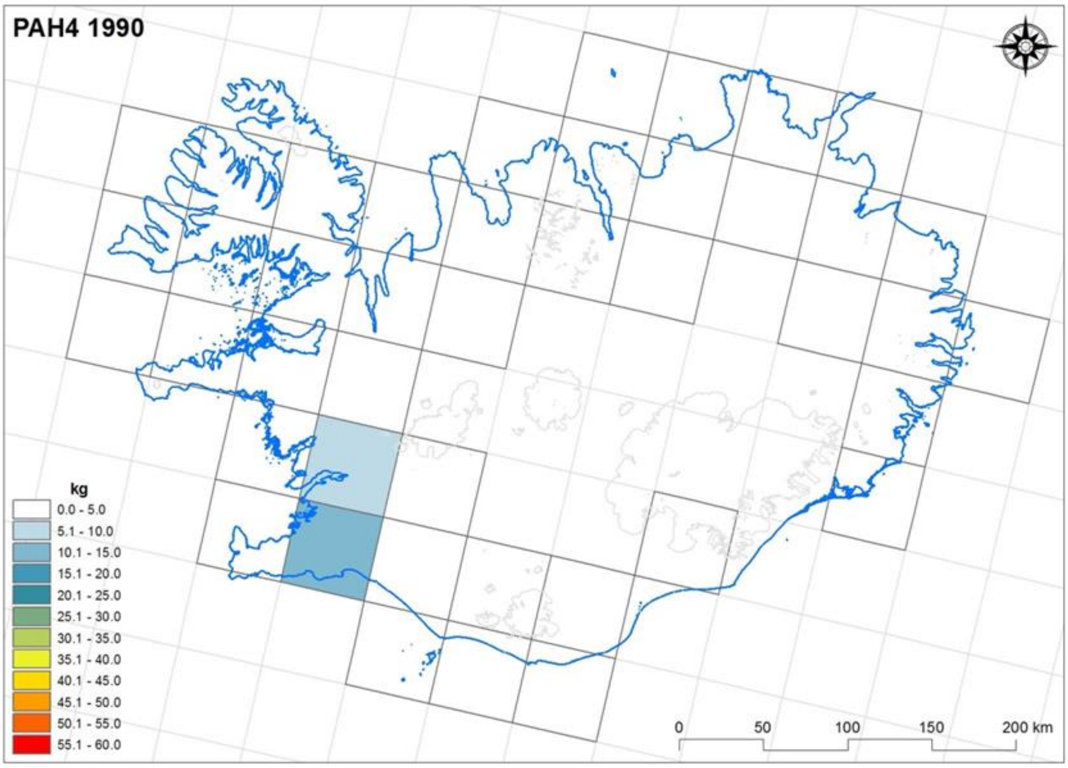

Figure 8.1 Emissions of PAH4 within the EMEP-Grid in 1990.

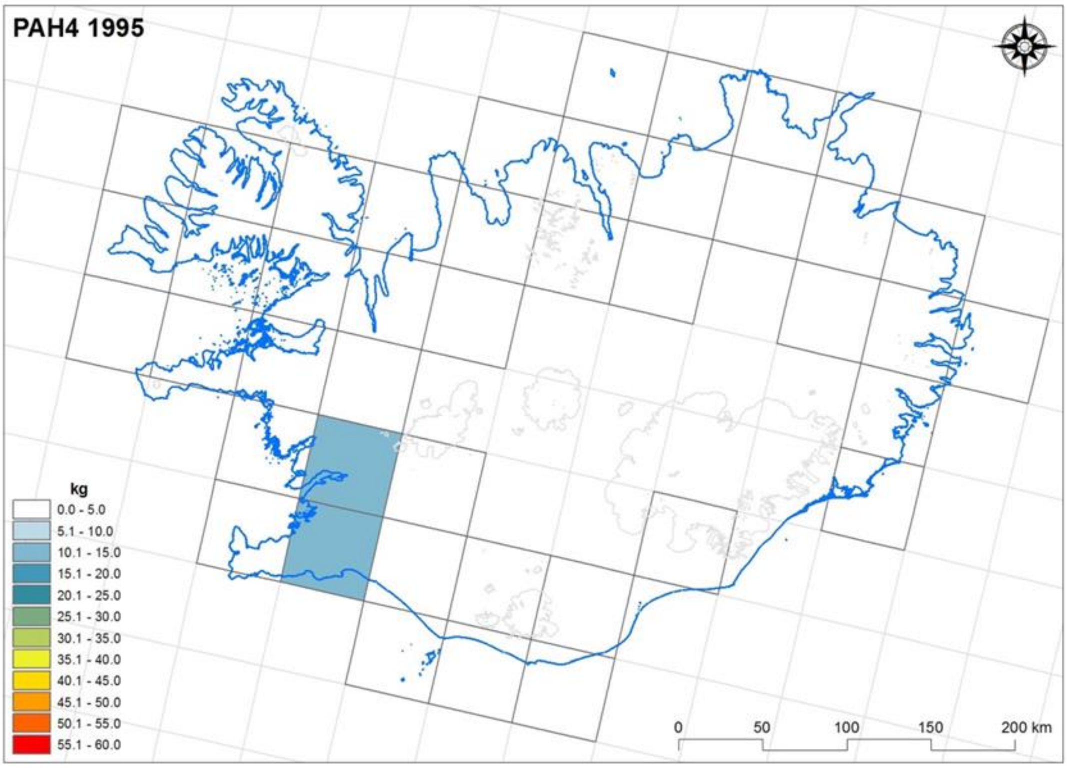

Figure 8.2 Emissions of PAH4 within the EMEP-Grid in 1995.

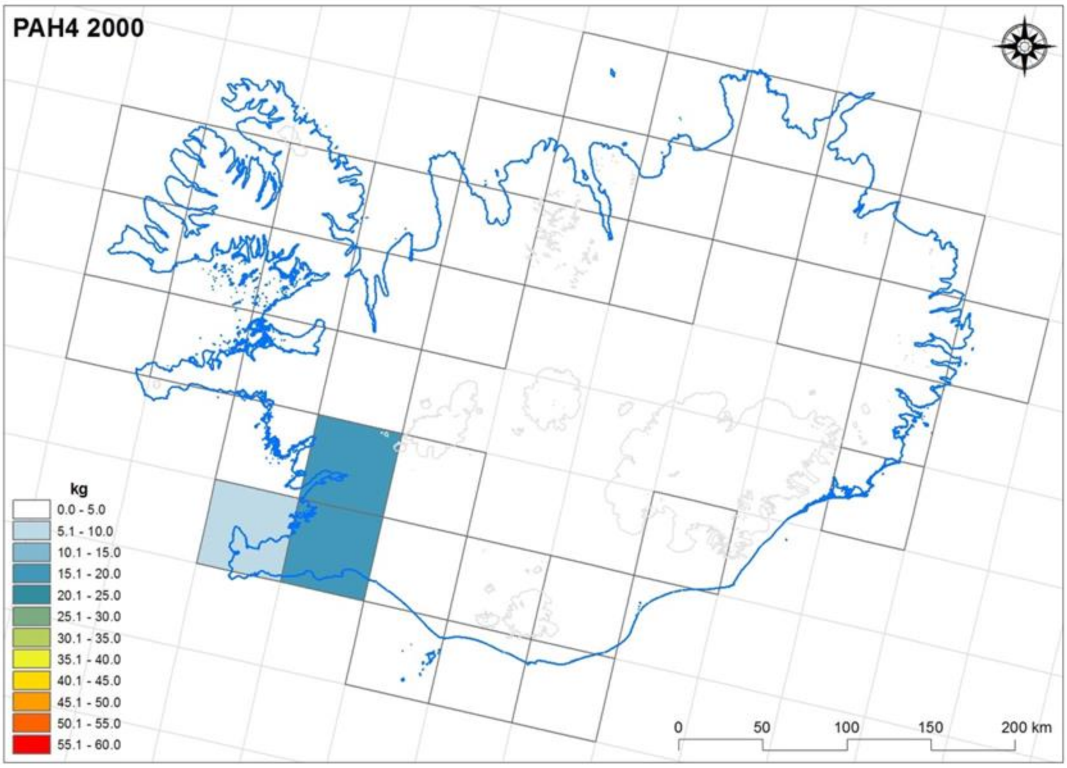

Figure 8.3 Emissions of PAH4 within the EMEP-Grid in 2000.

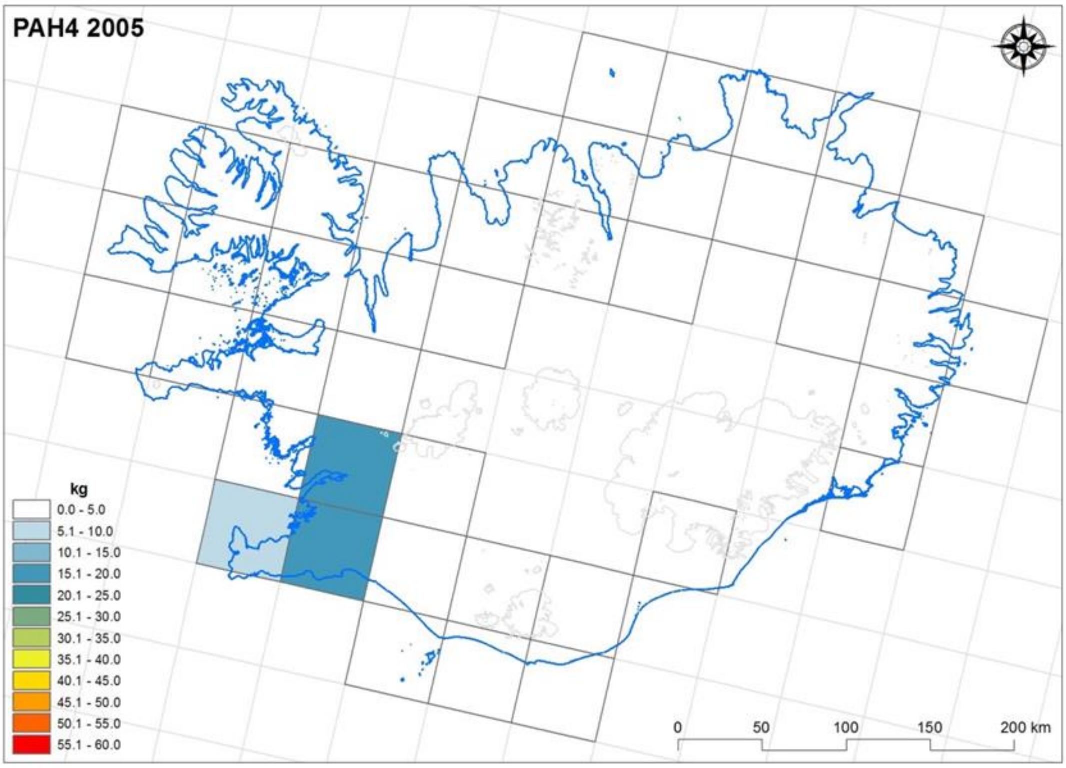

Figure 8.4 emissions of PAH4 within the EMEP-Grid in 2005.

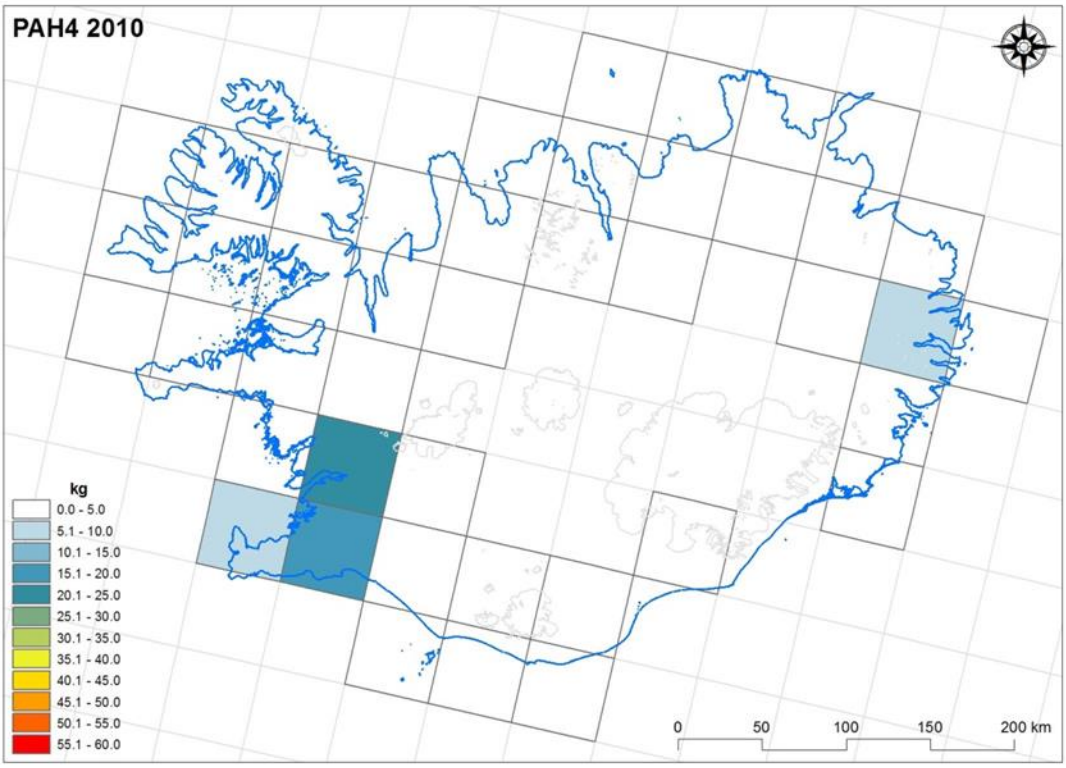

Figure 8.5 Emissions of PAH4 within the EMEP-Grid in 2010.

8.2 Dioxin Emissions in 1990, 1995, 2000, 2005 and 2010

For the distributed national totals, spatial patterns from the major sectors are recognisable. For dioxin the influence of closing down sites for open pit burning results in lower emissions over time. Further the malfunctioning of the incineration plant at Ísafjörður (north-west Iceland, Westfjords) results in higher emissions in 2010 than in the years before. Figures 8.6 to 8.10 show the national total emissions of dioxin within the EMEP-Grid in 1990, 1995, 2000, 2005 and 2010.

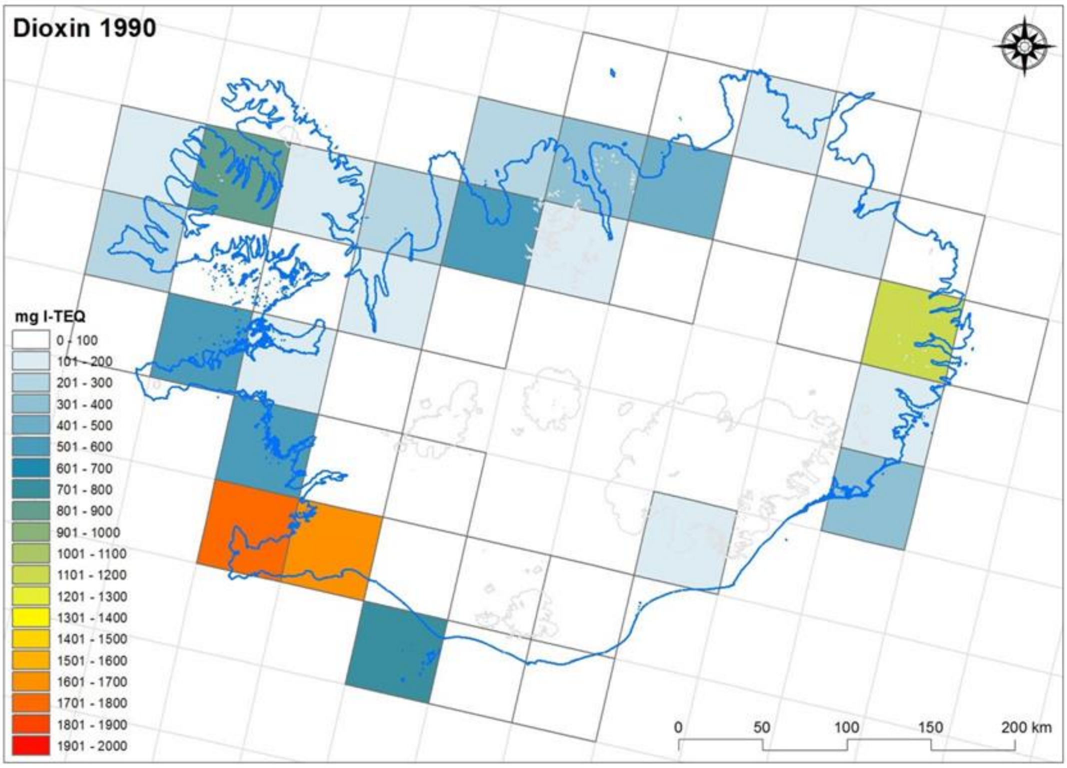

Figure 8.6 Dioxin emissions within the EMEP-Grid in 1990.

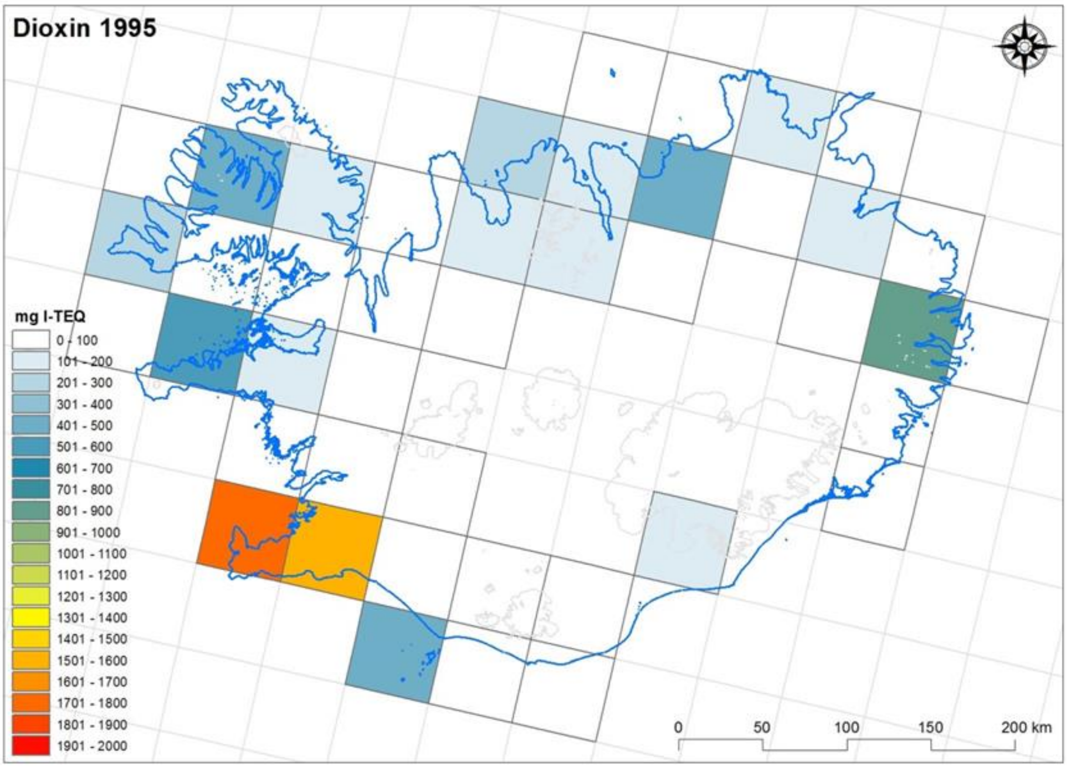

Figure 8.7 Dioxin emissions within the EMEP-Grid in 1995.

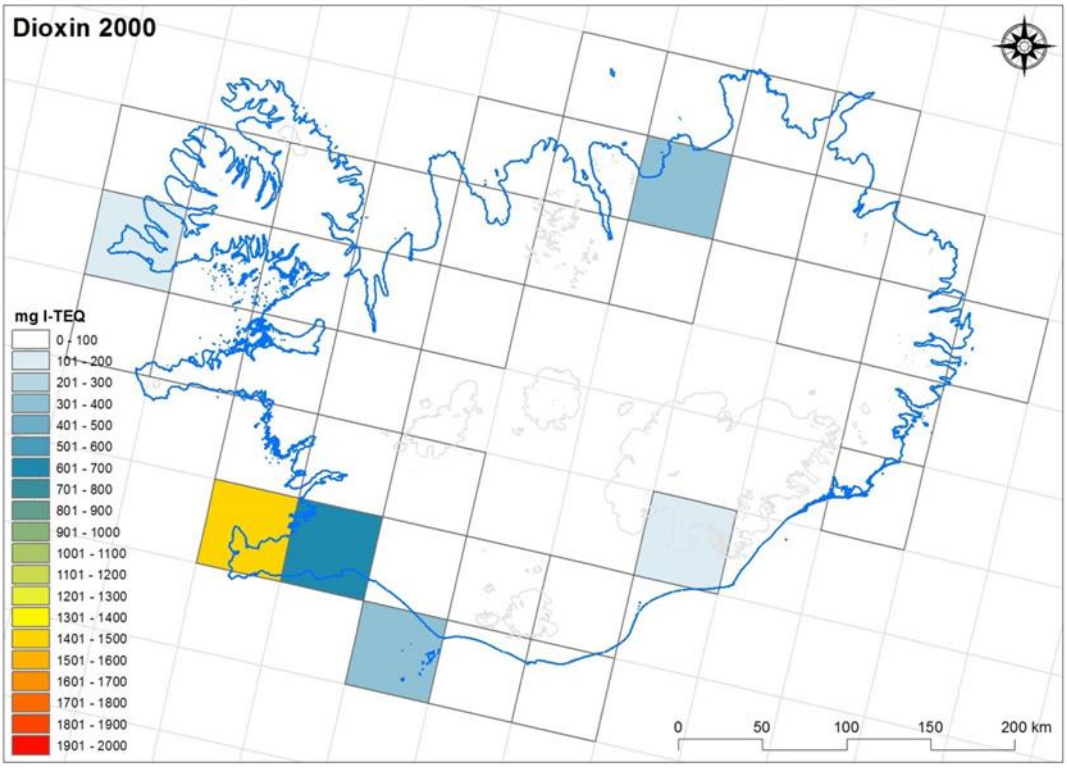

Figure 8.8 Dioxin emissions within the EMEP-Grid in 2000.

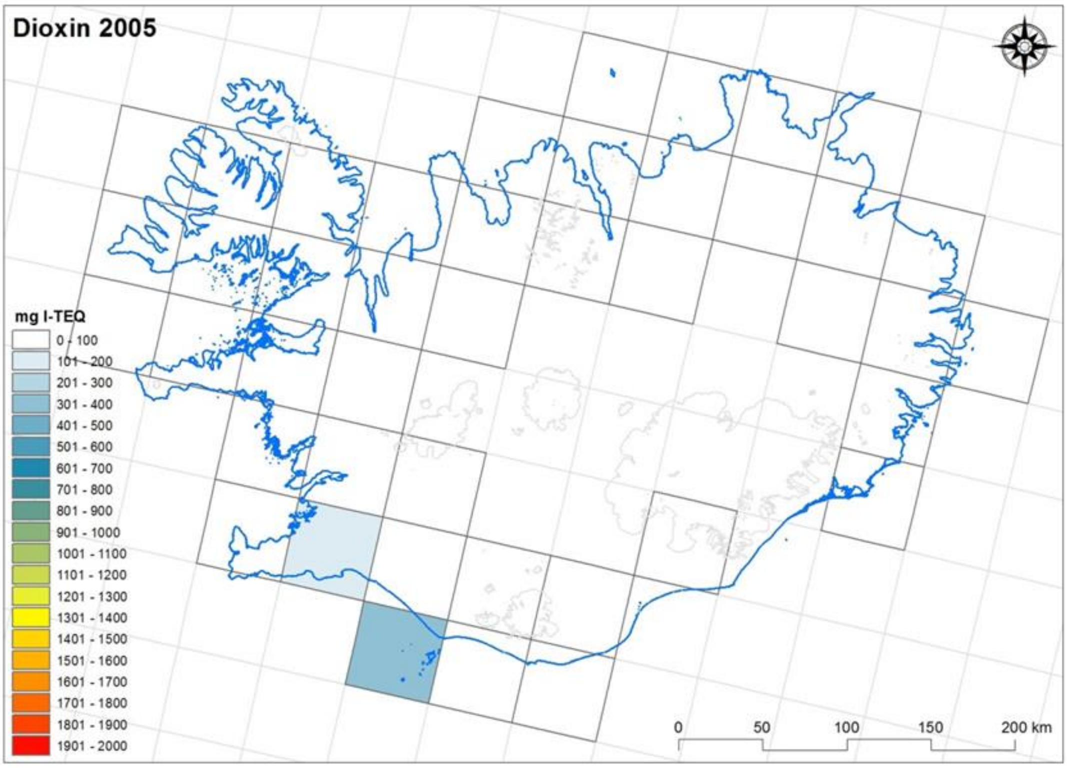

Figure 8.9 Dioxin emissions within the EMEP-Grid in 2005.

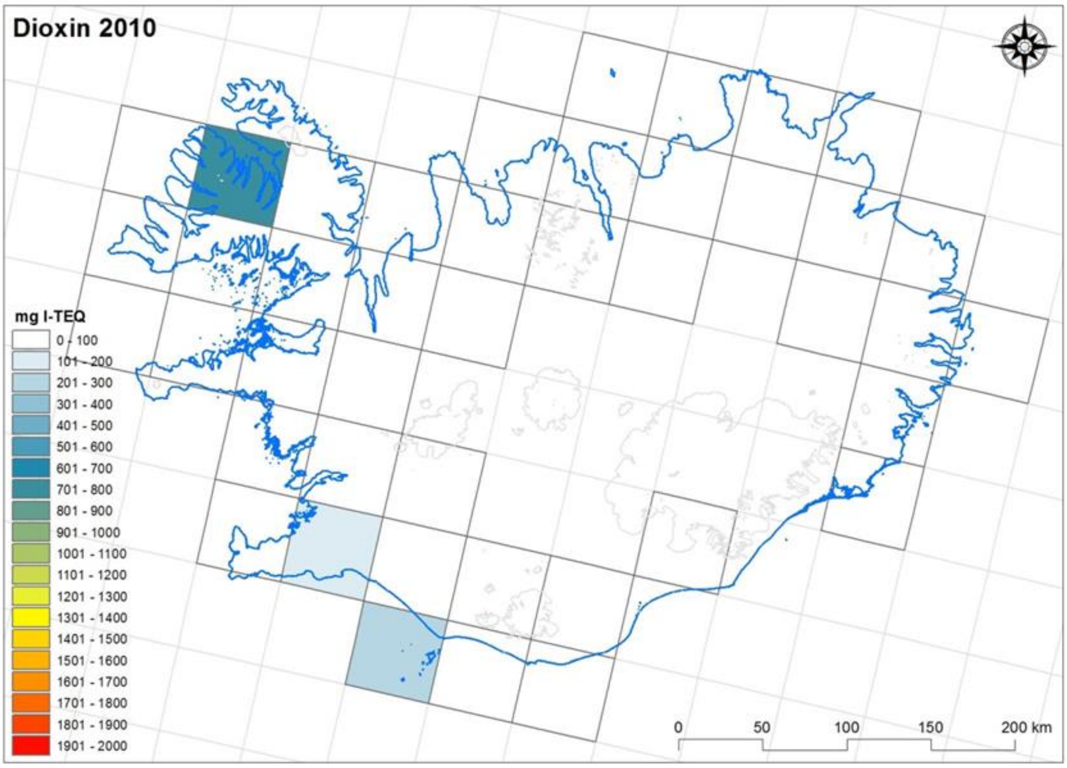

Figure 8.10 Dioxin emissions within the EMEP-Grid in 2010.

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Annex I: Explanation of EAI‘s Adjustment of Data on Fuel Sales by Sector

Fuel sales (gas oil and residual fuel oil) by sectors 1A1a, 1A2 (stationary) and 1A4 (stationary) – as provided by the National Energy Authority

No.	Category	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
		Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Gas/Diesel Oil											
10X40	**house heating and swimming pools**	**10,623**	**8,535**	**7,625**	**4,240**	**1,637**	**1,595**	**1,745**	**1,585**	**3,109**	**1,294**
10X5X	**industry**	**5,072**	**1,129**	**10,253**	**22,177**	**9,391**	**4,919**	**5,412**	**7,575**	**4,571**	**10,161**
10X60	**energy industries**	**1,300**	**1,091**	**1,065**	**21**	**1,012**	**683**	**955**	**1,090**	**1,423**	**1,185**
10X90	**other**	**0**	**458**	**1,386**	**8,928**	**2,728**	**1,136**	**260**	**768**	**214**	**4767**
Residual Fuel Oil											
10840	**house heating and swimming pools**	**2,989**	**3,079**	**122**	**195**	**0**	**0**	**0**	**0**	**191**	**137**
1085X	**industry**	**55,934**	**56,224**	**46,213**	**25,005**	**16,546**	**17,294**	**17,839**	**13,789**	**4,989**	**10,183**
10860	**energy industries**	**0**	**0**	**0**	**0**	**0**	**0**	**135**	**125**	**0**	**0**
10890	**other**	**39**	**52**	**67**	**0**	**1,629**	**780**	**0**	**0**	**0**	**0**

ADJUSTMENTS

For gas oil:

First fuel consumption needed for the known electricity production with fuels is calculated (**1A1a** – electricity production), assuming 34% efficiency, the values calculated are compared with the fuel sales for the category 10X60 Energy industries.

- In years where there is less fuel sale to energy industries as would be needed for the electricity production, the fuel needed is taken from the category 10X90 Other and when that is not sufficient from the category 10X40 House heating and swimming pools.
- In years where there is surplus the extra fuel is added to the category 10X40 House heating and swimming pools.

NEA has estimated the fuel use by swimming pools (**1A4a**). These values are subtracted from the adjusted 10X40 category. The rest of the category is then **1A4c** – Residential.

For years when there is still fuel in the category 10X90 Other, this is added to the 10X5X Industry. This is the fuel use in **1A2** – Industry.

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Swimming pools	1800	1600	1600	1000	300	300	300	300	300	300

For Residual Fuel Oil:

The sectors 10840 and 10860 are added together. This is the fuel use by **1A1a** - public heat plants, In year 1997 four tonnes are subtracted from this category as the category 10890 has minus four tonnes, leaving category 10890 with 0 in 1997. The categories 1085X Industry and 10890 Other are added together, this is the fuel use in **1A2** – industry.

Annex II: Iceland QA/QC checks

A range of QAQC checks have been performed on the Icelandic inventory:

- **Recalculation check** - comparing the values reported in the current (2017) and previous (2016) versions of the inventory.
- **Trends check** - to identify outliers and changes in the trend in the most recent three years of the inventory.
- **Negative and zero values checks** - to highlight the occurrence of negative values (LULUCF is not included) and zero values in the inventory.
- **Notation keys check** - to summarise the occurrence of each notation key to ensure consistency and accuracy in the inventory.
- **PAHs sum check** - to ensure that the sum of the four reported PAHs equals the reported “total” PAH emissions.
- **Particulate Matter check** - to ensure that reported TSP emissions are greater than or equal to PM_{10}, and similarly that reported PM_{10} emissions are greater than or equal to $PM_{2.5}$.

In all cases, the findings of the checks are reviewed, not only to identify where corrections may be required, but also to consider whether there are any steps of the inventory compilation process that need improvement. In addition, reviewing the results also provides information on whether the individual checks are well designed and comprehensive.

This ensures that all results from the QAQC process feed back into the continuous improvement programme.

Recalculation Check

An updated recalculation file has been used for the 2017 submission. This QAQC file compares the emissions between the current and previous submissions, for 2014 and 1990 (the base year). The data has been compiled to enable changes in the data to be easily identified and justifications for change provided where required. The current recalculation check considers all of the reported pollutants and activity data; this includes heavy metals and PCBs which were added to the submission for the first time in 2017.

The recalculations check calculates the actual difference between the current and previous submission. If one or both values are notation keys, and are not the same in both submissions, then this is highlighted. If the values in both submissions are numeric but not equal, then the difference in submissions as a percentage of the current submissions is also shown. In addition, where differences occur the cells are highlighted for ease of reference. This process of identifying recalculation changes and the documentation of changes is in line with Chapter 4 of the 2016 EMEP guidelines[20] regarding the reporting of recalculations. Where a recalculation change occurs, it is necessary to check that the underlying reasons are understood and considered reasonable.

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[20] http://www.eea.europa.eu/publications/emep-eea-guidebook-2016 Accessed 09/03/2017

At present, the recalculations QAQC check only considers the base year and latest year included in both the current and previous submissions. Iceland recognises that the inclusion of additional years as an improvement which will be implemented in subsequent submissions.

Trends Check

For each pollutant and NFR sector a trend QAQC file is used to calculate the percentage change between the latest (2015) and previous year (2014) and the percentage change between 2014 and 2013. The greatest changes are highlighted for ease of reference and comments on these changes are provided where required. This trends QAQC files enables the identification of large “step changes” in recent years, either through large increases or decreases in emission estimates.

This check could be improved through assessing the trend of the whole time series rather than the last three years. Iceland will consider updating this check in future submissions; however given that trends in historic data are rarely revised significantly, this is of lower priority.

Negative and Zero Values Check

Checks were performed to identify whether any negative or zero values occur in the NFR Annex I submission file. No negative or zero values occurred and therefore no further action was needed.

Notation Keys Check

The number of occurrences of notation keys (NO, NE, IE, NA and NR) in the NFR Annex I submission file are presented. This QAQC check is used to ensure that notation keys are applied consistently and accurately within the inventory. The occurrence of notation keys is presented as a count for each NFR code for the years 2004 – 2015 with highlighted cells for ease of reference.

A more complete check of the entire time series will be considered for future versions of the inventory. Then only incremental changes would need to be considered.

PAH Sum Check

This is a sum check to identify whether the sum of the reported emissions for benzo(a) pyrene, benzo(b) fluoranthene, benzo(k) fluoranthene and Indeno (1,2,3-cd) pyrene equals the reported emissions for “total” four PAHs. This check is performed for each reported NFR code and year for the current submission. Where the sum of the PAHs does not equal the “total”, cells are highlighted for ease of reference and where required the cause for differences are documented.

Particulate Matter Check

This check identifies any categories where the emissions reported for TSP are less than PM_{10} emissions and where PM_{10} emissions are less than $PM_{2.5}$ emissions. This enables the identification of errors in reported PM emissions based on the assumption that $TSP >= PM_{10} >= PM_{2.5}$. This check is performed for each reported NFR code and year for the current submission. Where errors in reported PM emissions are identified, cells are highlighted for ease of reference and where required documentation is provided.

Annex III: KCA results for non-POPs pollutants

Key categories for NOx, NMVOC, SOx, NH3, PM2.5, PM10, TSP. BC and CO, 2015

Component	**Key categories** **(Sorted from high to low from left to right and top to bottom)**					**Total (%)**
NOx	*National fishing*	*Road transport: Heavy duty vehicles*	*Road transport: Passenger cars*	*Mobile combustion in manufacturing industries*	*Ferroalloy production*	83.51%
	NFR 1A4ciii	*NFR 1A3biii*	*NFR 1A3bi*	*NFR 1A2gvii*	*NFR 2C2*	
	52.19%	10.11%	8.20%	6.99%	6.01%	
NMVOC	*Road transport: Passenger cars*	*Domestic solvent use*	*Manure managment: horses*	*Road transport: Light duty vehicles*	*Manure management - Dairy cattle*	81.63%
	NFR 1A3bi	*NFR 2D3a*	*NFR 3B4e*	*NFR 1A3bii*	*NFR 3B1a*	
	19.18%	8.58%	8.21%	8.07%	7.05%	
	Manure management - Non-dairy cattle	*Road transport: Heavy duty vehicles*	*Food and beverages industry*	*Coating applications*	*National fishing*	
	NFR 3B1b	*NFR 1A3biii*	*NFR 2H2*	*NFR 2D3d*	*NFR 1A4ciii*	
	6.55%	5.90%	5.01%	4.60%	4.55%	
	Biological treatment of waste					
	NFR 5A					
	3.93%					
SOx	*Other fugitive emissions from energy production (Geothermal energy)*	*Aluminium production*				92.62%
	NFR 1B2d	*NFR 2C3*				
	71.90%	20.72%				
NH₃	*Manure management - Sheep*	*Manure management - Dairy cattle*	*Urine and dung deposited by grazing animals*	*Manure management - Non-dairy cattle*		80.14%
	NFR 3B2	*NFR 3B1a*	*NFR 3Da3*	*NFR 3B1b*		
	33.89%	18.54%	15.22%	12.49%		
PM2.5	*Aluminium production*	*National fishing*	*Ferroalloy production*	*Municipal waste incineration*		80.20%
	NFR 2C3	*NFR 1A4ciii*	*NFR 2C2*	*NFR 5C1a*		
	26.45%	25.59%	20.96%	7.20%		

PM10	*Aluminium production* *NFR 2C3* 25.60%	*National fishing* *NFR 1A4ciii* 21.48%	*Ferroalloy production* *NFR 2C2* 16.17%	*Municipal waste incineration* *NFR 5C1a* 8.27%	*Road transport: Passenger cars* *NFR 1A3bi* 4.92%	80.93%
	Farm-level agricultural operations *NFR 3Dc* 4.49%					
TSP	*Aluminium production* *NFR 2C3* 29.63%	*National fishing* *NFR 1A4ciii* 20.70%	*Ferroalloy production* *NFR 2C2* 16.40%	*Municipal waste incineration* *NFR 5C1a* 10.64%	*Other product use (Fireworks, tobacco)* *NFR 2G* 4.43%	81.79%
BC	*Road transport: Passenger cars* *NFR 1A3bi* 26.47%	*National fishing* *NFR 1A4ciii* 23.42%	*Road transport: Heavy duty vehicles* *NFR 1A3biii* 17.46%	*Road transport: Light duty vehicles* *NFR 1A3bii* 12.07%	*Aluminium production* *NFR 2C3* 6.80%	86.23%
CO	*Aluminium production* *NFR 2C3* 86.24%					86.24%

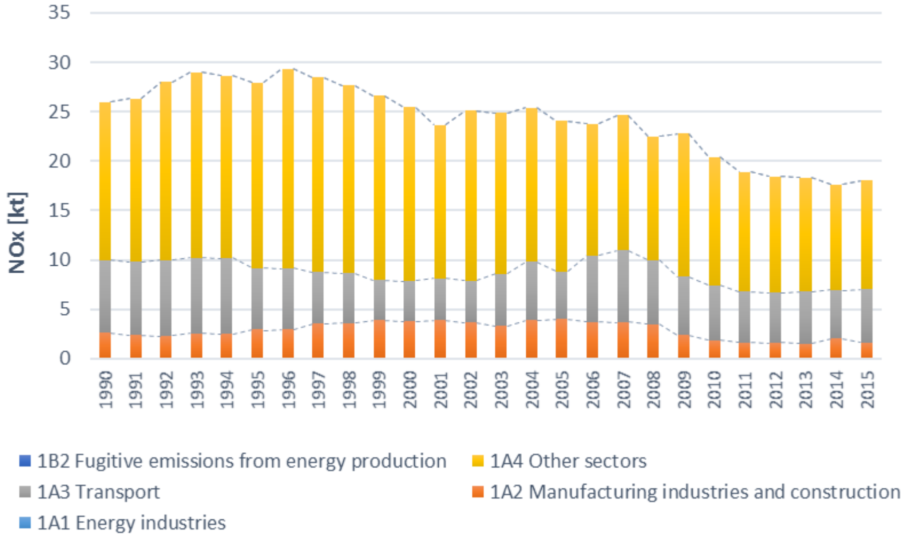
Key categories for heavy metals, 2015

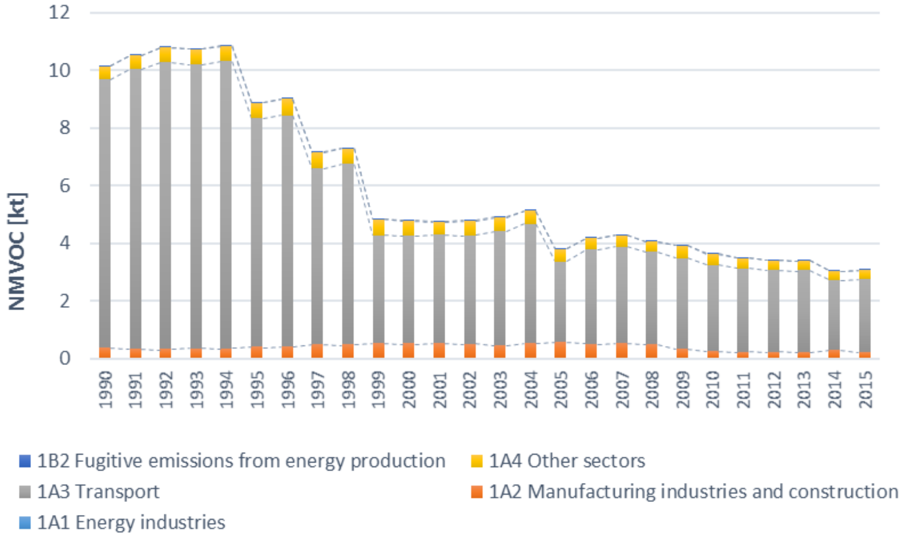
Component	**Key categories (Sorted from high to low from left to right and top to bottom)**		**Total (%)**
Pb	*Municipal waste incineration* *NFR 5C1a* 59.37%	*Other product use (Fireworks, tobacco)* *NFR 2G* 27.88%	87.25%
Cd	*Municipal waste incineration* *NFR 5C1a* 78.06%	*Road transport: Passenger cars* *NFR 1A3bi* 4.40%	82.46%
Hg	*Municipal waste incineration* *NFR 5C1a* 53.61%	*Clinical waste incineration* *NFR 2D3a* 30.68%	84.29%
As	*National fishing* *NFR 1A4ciii* 46.37%	*Municipal waste incineration* *NFR 5C1a* 41.25%	87.62%

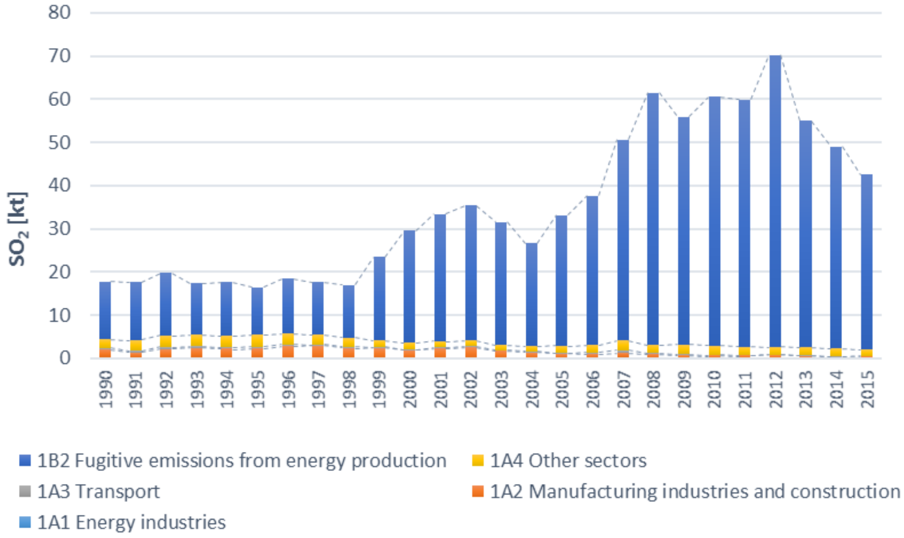
Cr	*National fishing* *NFR 1A4ciii* 32.13%	*Road transport: Passenger cars* *NFR 1A3bi* 30.11%	*Road transport: Heavy duty vehicles* *NFR 1A3biii* 12.12%	*Other product use (Fireworks, tobacco)* *NFR 2G* 11.88%	86.23%
Cu	*Road transport: Passenger cars* *NFR 1A3bi* 44.72%	*Other product use (Fireworks, tobacco)* *NFR 2G* 19.23%	*Road transport: Heavy duty vehicles* *NFR 1A3biii* 17.49%		81.44%
Ni	*National fishing* *NFR 1A4ciii* 93.60%				93.60%
Se	*National fishing* *NFR 1A4ciii* 79.67%	*Road transport: Passenger cars* *NFR 1A3bi* 9.30%			88.98%
Zn	*Accidental fires* *NFR 5E* 27.13%	*Road transport: Passenger cars* *NFR 1A3bi* 26.31%	*National fishing* *NFR 1A4ciii* 14.35%	*Other product use (Fireworks, tobacco)* *NFR 2G* 13.06%	80.87%

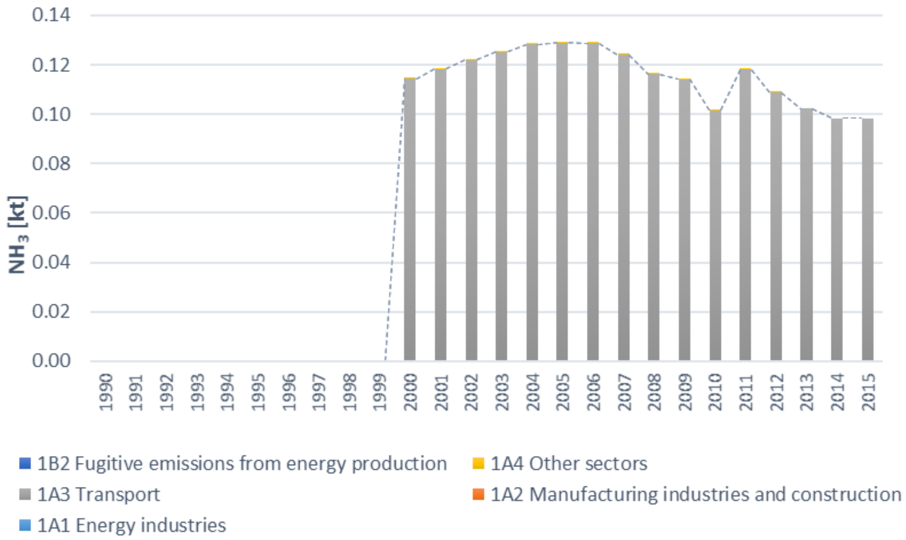
Annex IV: Emission trends 1990-2015 per sector, non-POPs pollutants.

Energy: NOx, NMVOC, SO_2, NH_3, CO and PM





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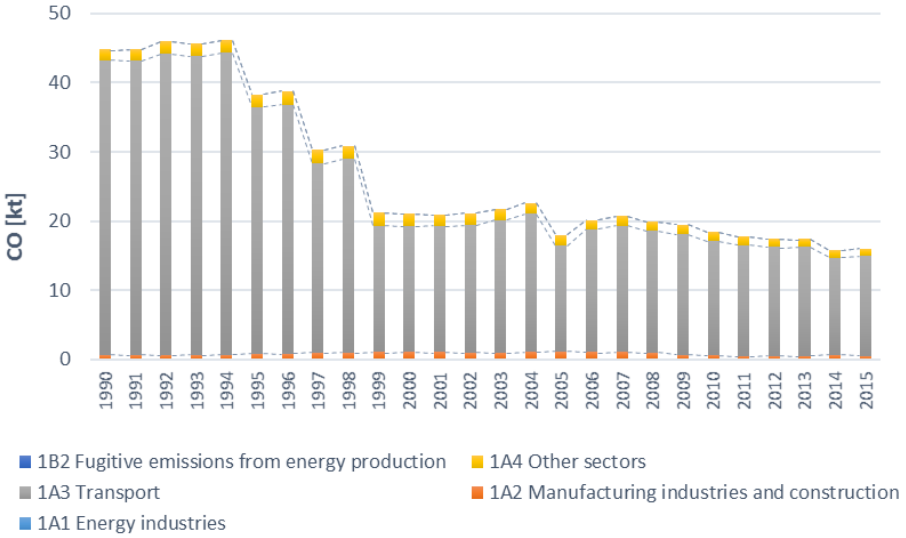
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
1B2 Fugitive emissions from energy production
1A4 Other sectors
1A3 Transport
1A2 Manufacturing industries and construction
1A1 Energy industries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40
30
20
10
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
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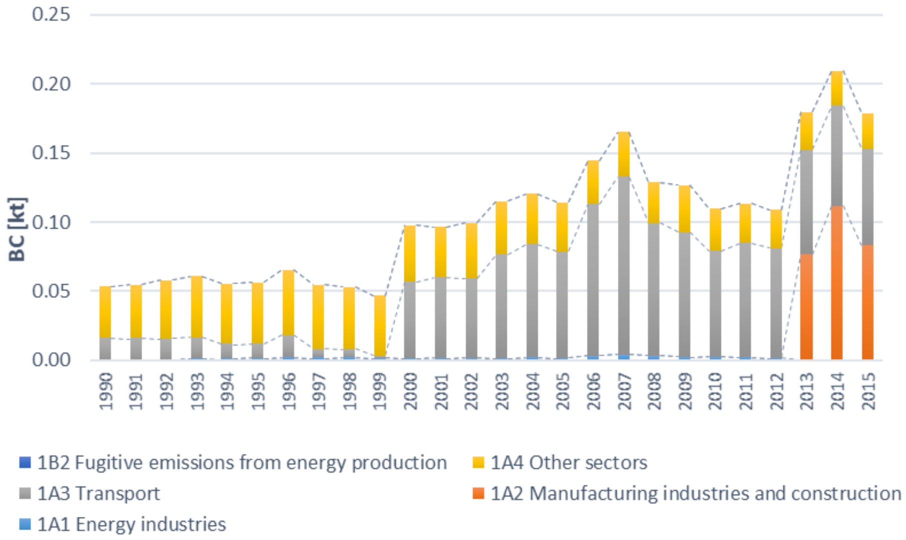
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
1B2 Fugitive emissions from energy production
1A4 Other sectors
1A3 Transport
1A2 Manufacturing industries and construction
1A1 Energy industries


BC [kt]
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0.20
0.15
0.10
0.05
0.00
1990
1991
1992
1993
1994
1995
1996
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1998
1999
2000
2001
2002
2003
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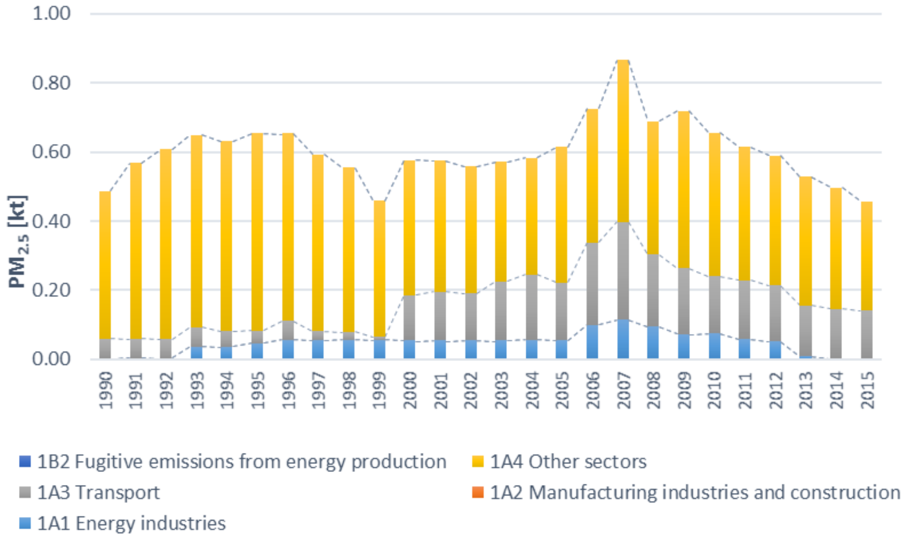
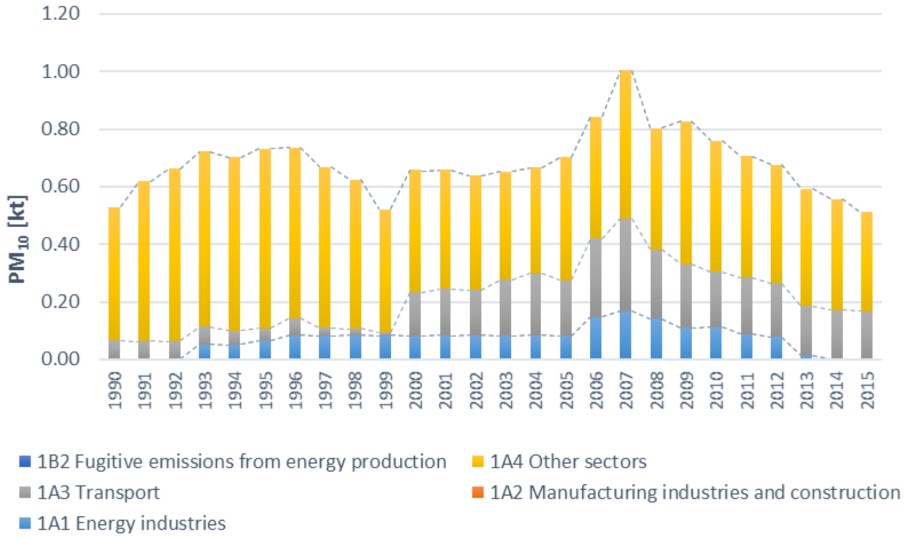
1B2 Fugitive emissions from energy production
1A4 Other sectors
1A3 Transport
1A2 Manufacturing industries and construction
1A1 Energy industries


PM$_{2.5}$ [kt]
1.00
0.80
0.60
0.40
0.20
0.00
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
1B2 Fugitive emissions from energy production
1A4 Other sectors
1A3 Transport
1A2 Manufacturing industries and construction
1A1 Energy industries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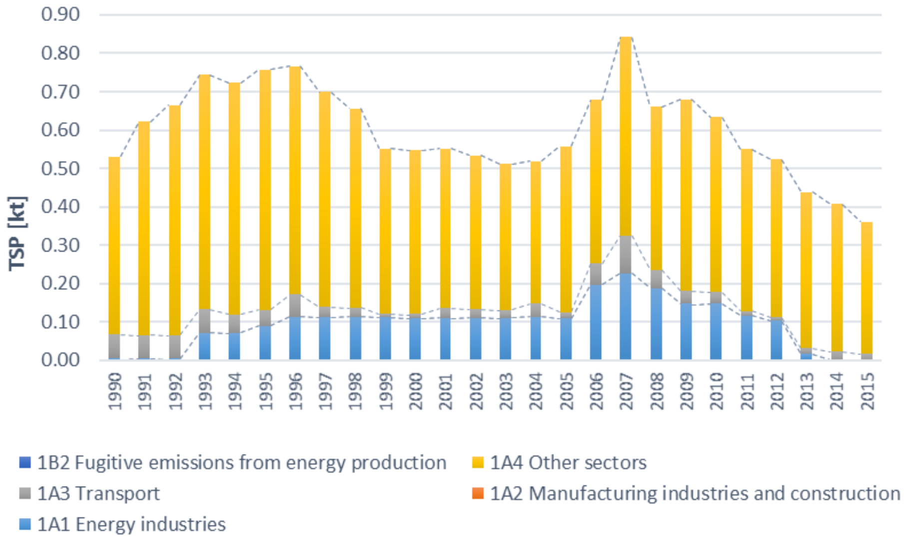
1.00
0.80
0.60
0.40
0.20
0.00
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
1B2 Fugitive emissions from energy production
1A4 Other sectors
1A3 Transport
1A2 Manufacturing industries and construction
1A1 Energy industries


TSP [kt]
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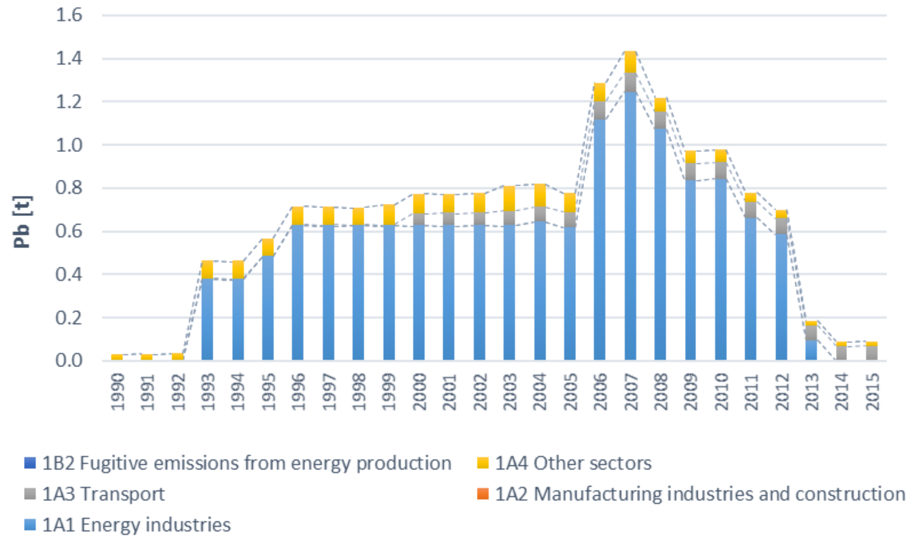
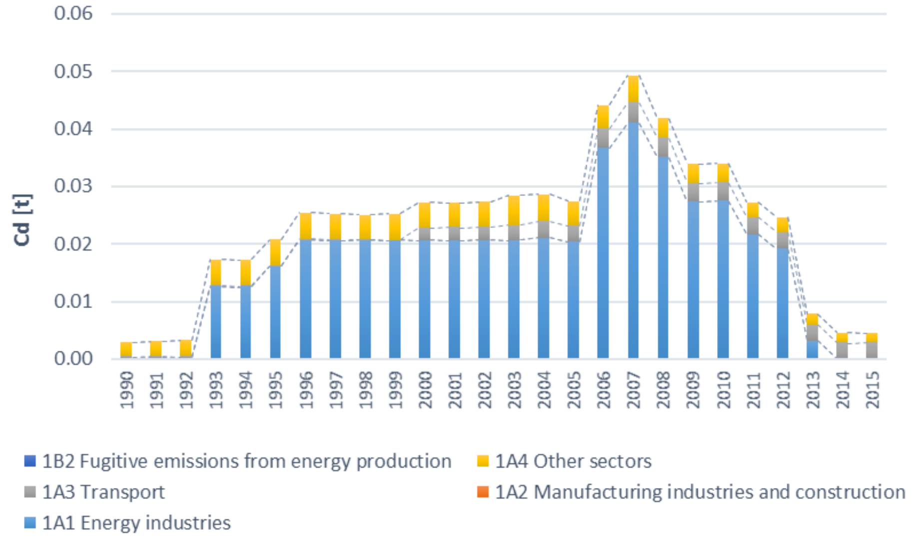
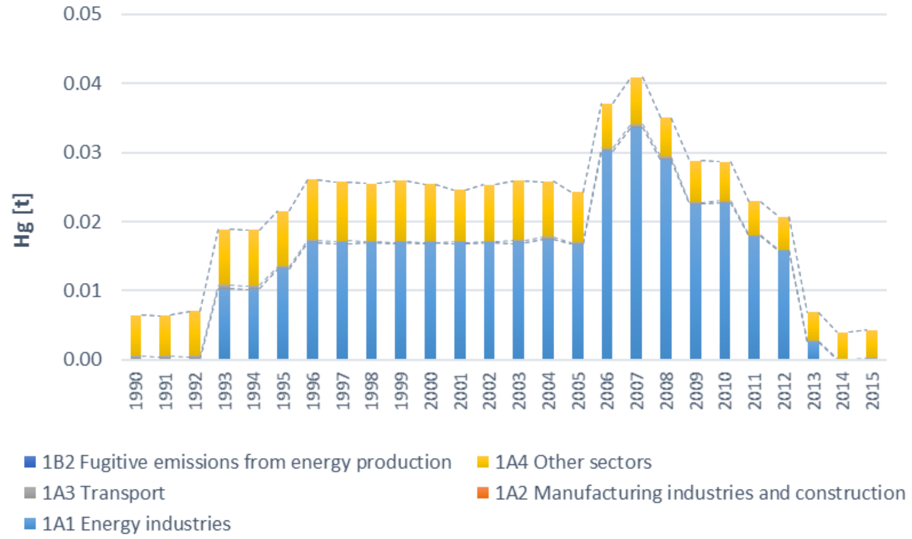
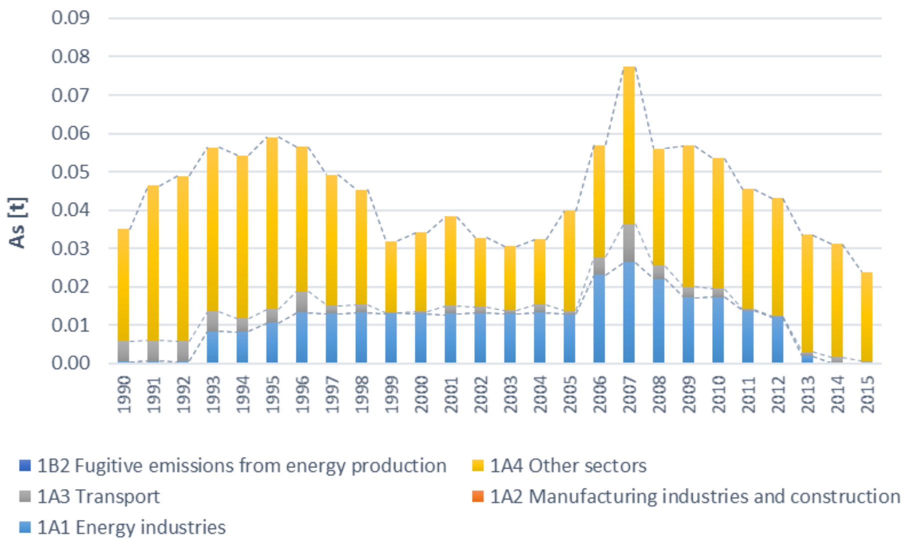
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
1B2 Fugitive emissions from energy production
1A4 Other sectors
1A3 Transport
1A2 Manufacturing industries and construction
1A1 Energy industries

Energy: Heavy metals








As [t]
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0.08
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0.04
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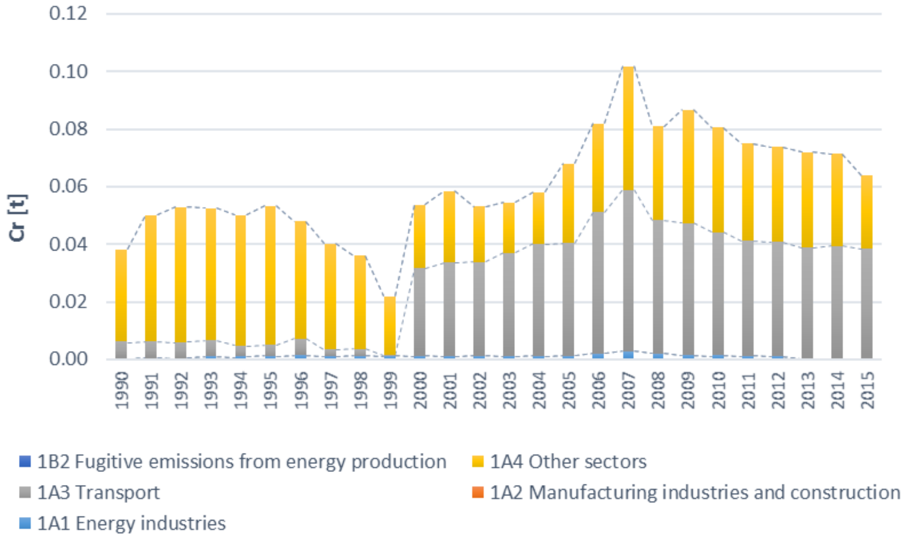
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
1B2 Fugitive emissions from energy production
1A4 Other sectors
1A3 Transport
1A2 Manufacturing industries and construction
1A1 Energy industries


Cr [t]
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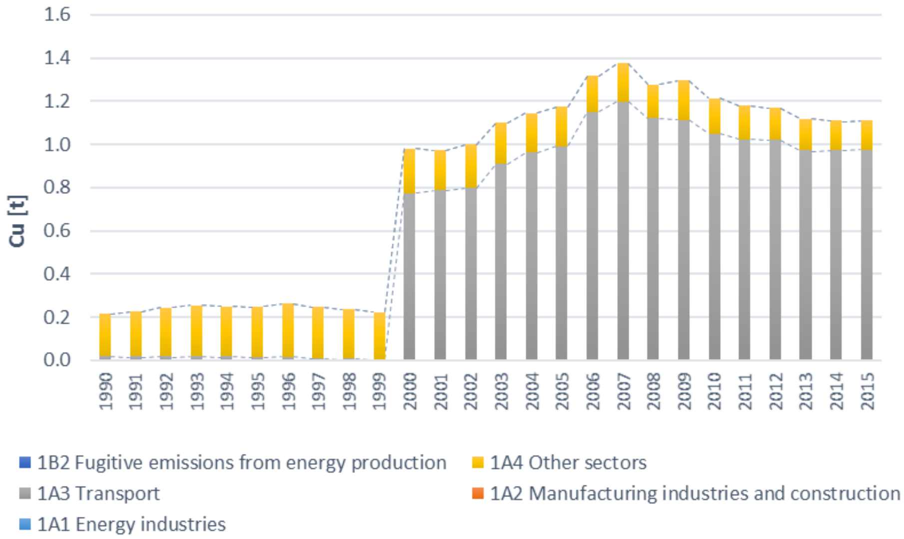
0.10
0.08
0.06
0.04
0.02
0.00
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
1B2 Fugitive emissions from energy production
1A4 Other sectors
1A3 Transport
1A2 Manufacturing industries and construction
1A1 Energy industries


Cu [t]
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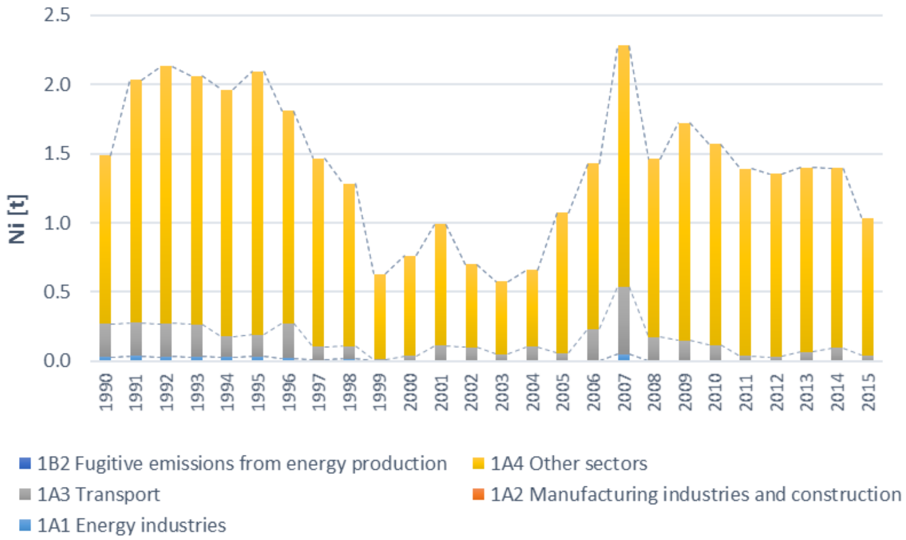
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
1B2 Fugitive emissions from energy production
1A4 Other sectors
1A3 Transport
1A2 Manufacturing industries and construction
1A1 Energy industries


2.5
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Ni [t]
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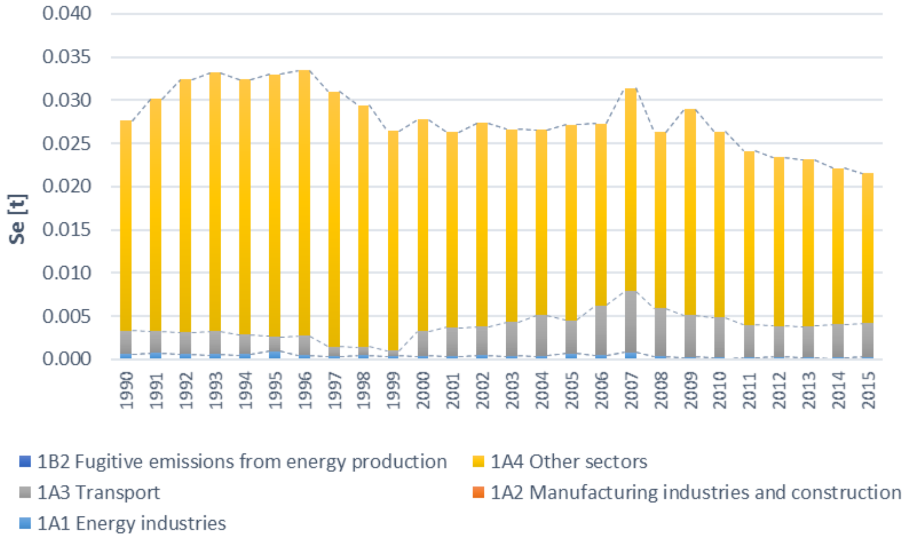
1B2 Fugitive emissions from energy production
1A4 Other sectors
1A3 Transport
1A2 Manufacturing industries and construction
1A1 Energy industries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0.010
0.005
0.000
Se [t]
1990
1991
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1993
1994
1995
1996
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1998
1999
2000
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2015
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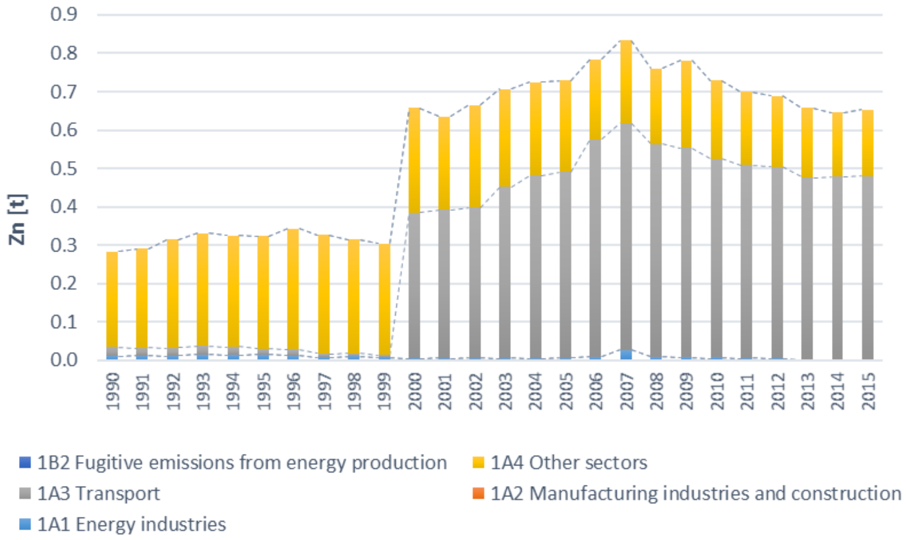
1A4 Other sectors
1A3 Transport
1A2 Manufacturing industries and construction
1A1 Energy industries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Zn [t]
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1991
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1993
1994
1995
1996
1997
1998
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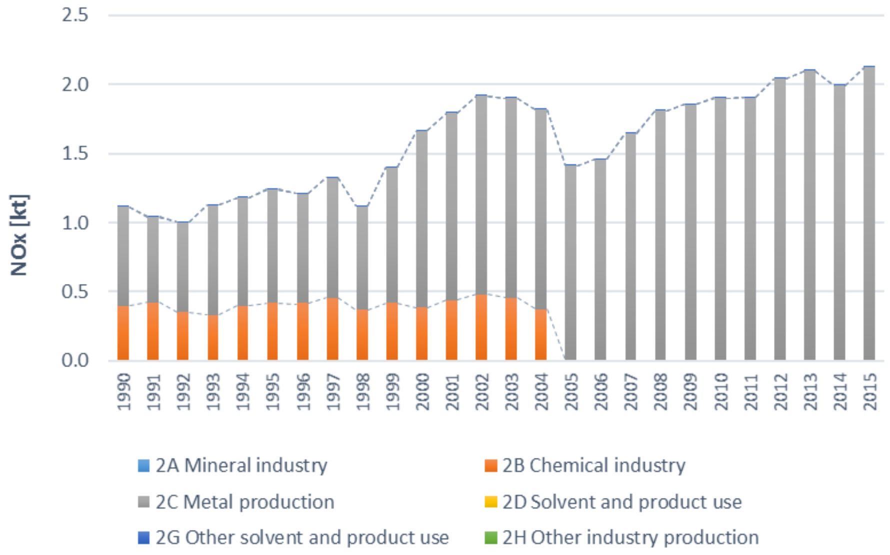
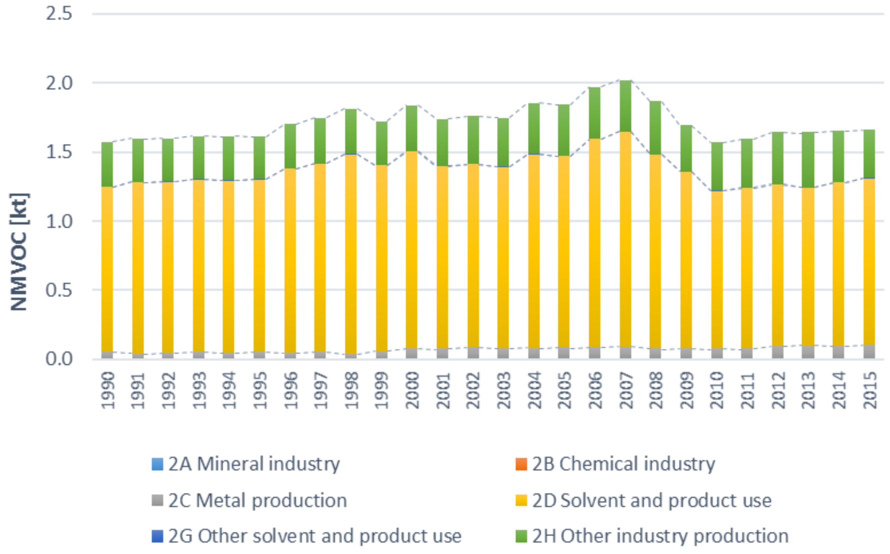
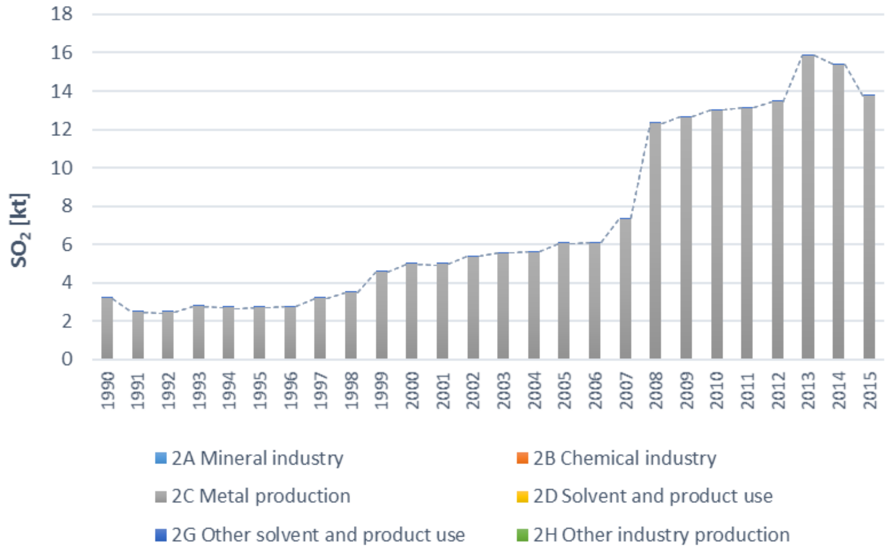
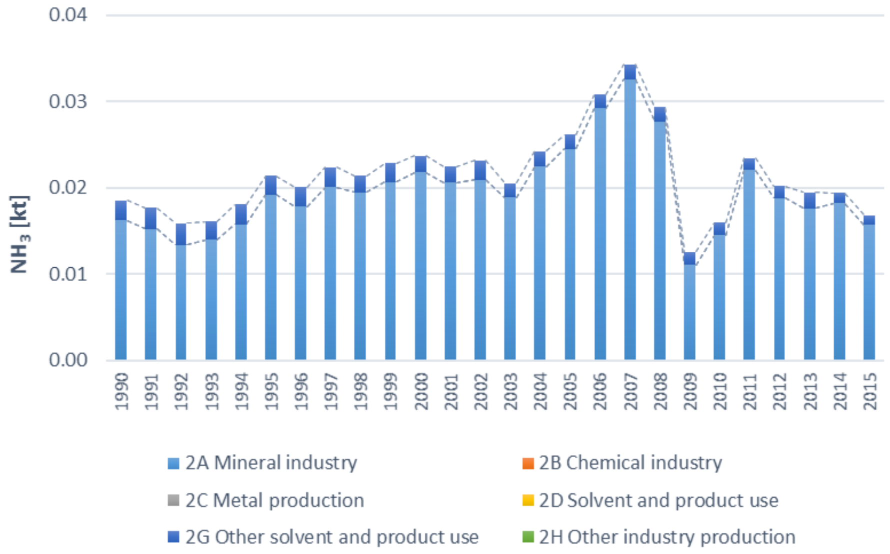
2015
1B2 Fugitive emissions from energy production
1A4 Other sectors
1A3 Transport
1A2 Manufacturing industries and construction
1A1 Energy industries

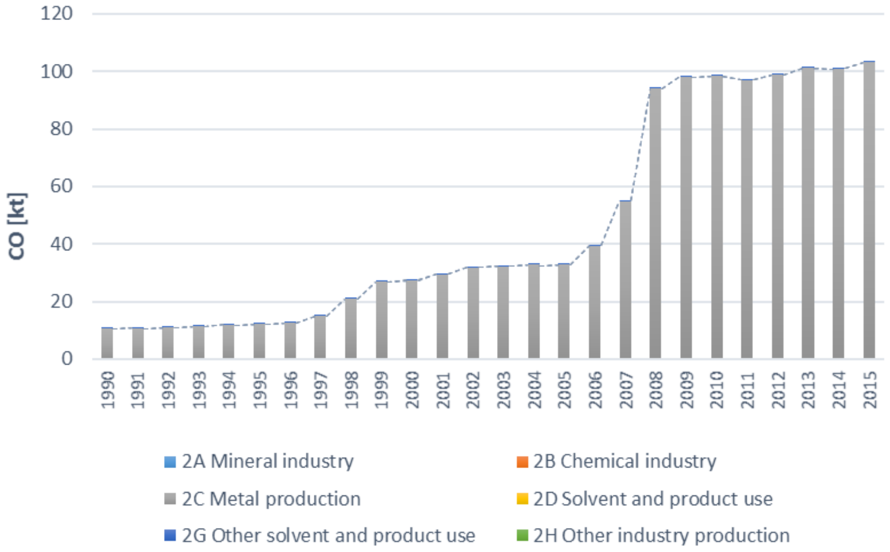
Industry: NOx, NMVOC, SO_2, NH_3, CO and PM








0.04
0.03
0.02
0.01
0.00
NH₃ [kt]
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2A Mineral industry
2B Chemical industry
2C Metal production
2D Solvent and product use
2G Other solvent and product use
2H Other industry production


120
100
80
60
40
20
0
CO [kt]
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
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2007
2008
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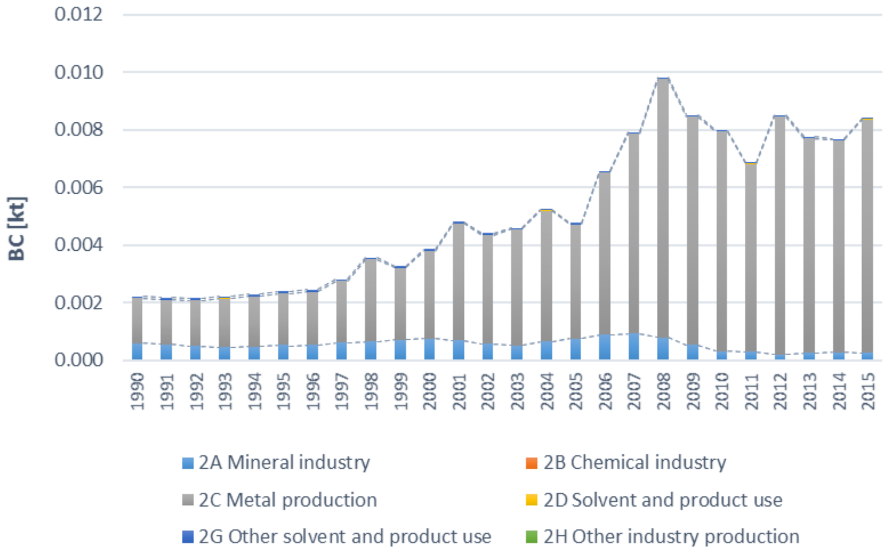
2012
2013
2014
2015
2A Mineral industry
2B Chemical industry
2C Metal production
2D Solvent and product use
2G Other solvent and product use
2H Other industry production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0.008
0.006
0.004
0.002
0.000
BC [kt]
1990
1991
1992
1993
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2009
2010
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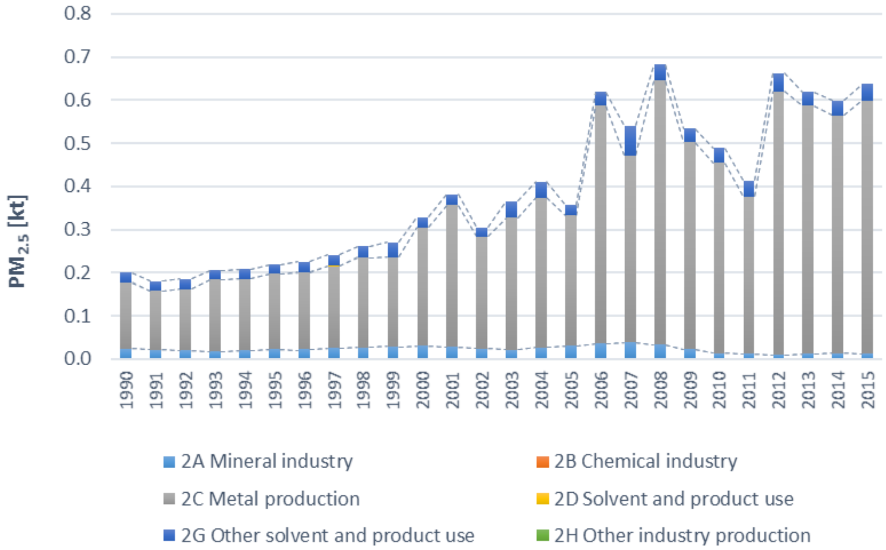
2012
2013
2014
2015
2A Mineral industry
2B Chemical industry
2C Metal production
2D Solvent and product use
2G Other solvent and product use
2H Other industry production


PM2.5 [kt]
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1990
1991
1992
1993
1994
1995
1996
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2010
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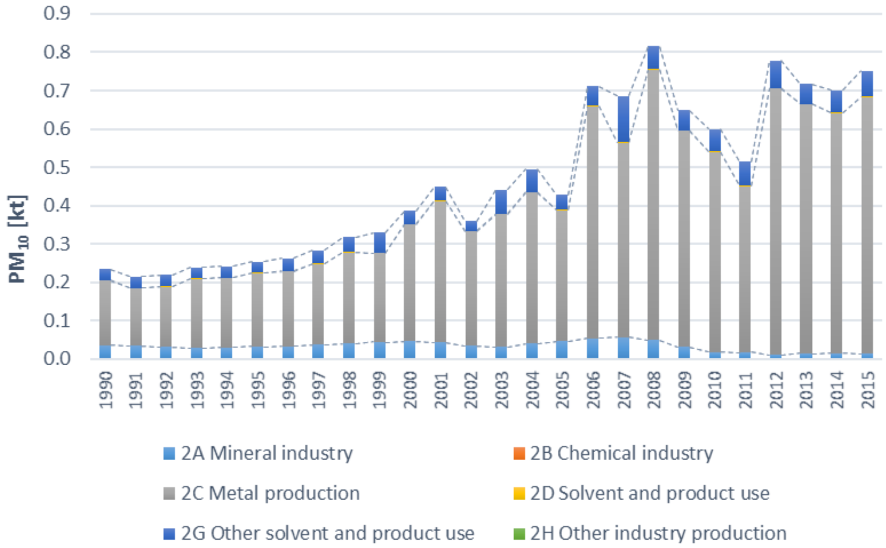
2012
2013
2014
2015
2A Mineral industry
2B Chemical industry
2C Metal production
2D Solvent and product use
2G Other solvent and product use
2H Other industry production


PM10 [kt]
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
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2008
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2010
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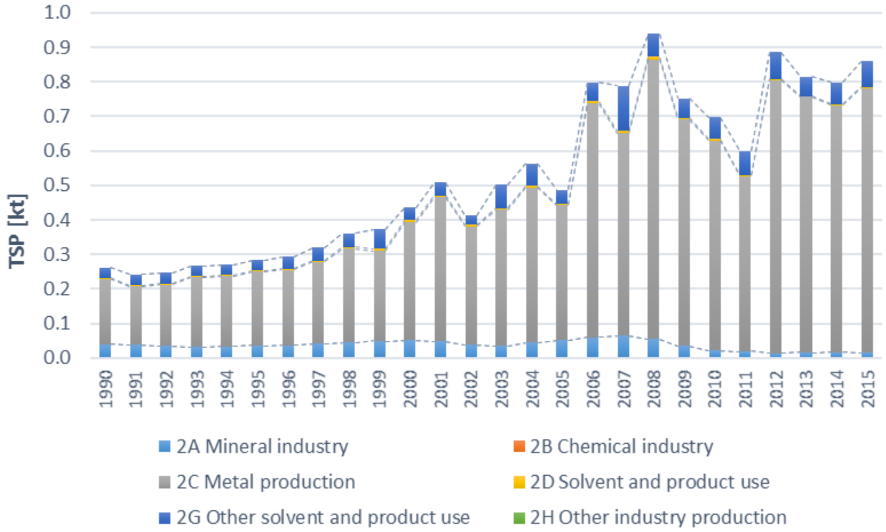
2012
2013
2014
2015
2A Mineral industry
2B Chemical industry
2C Metal production
2D Solvent and product use
2G Other solvent and product use
2H Other industry production


TSP [kt]
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1990
1991
1992
1993
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2004
2005
2006
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2008
2009
2010
2011
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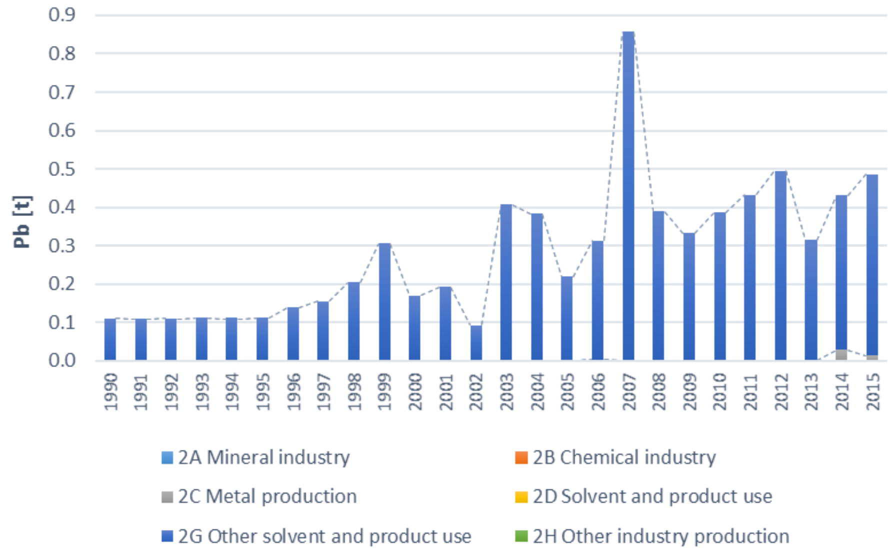
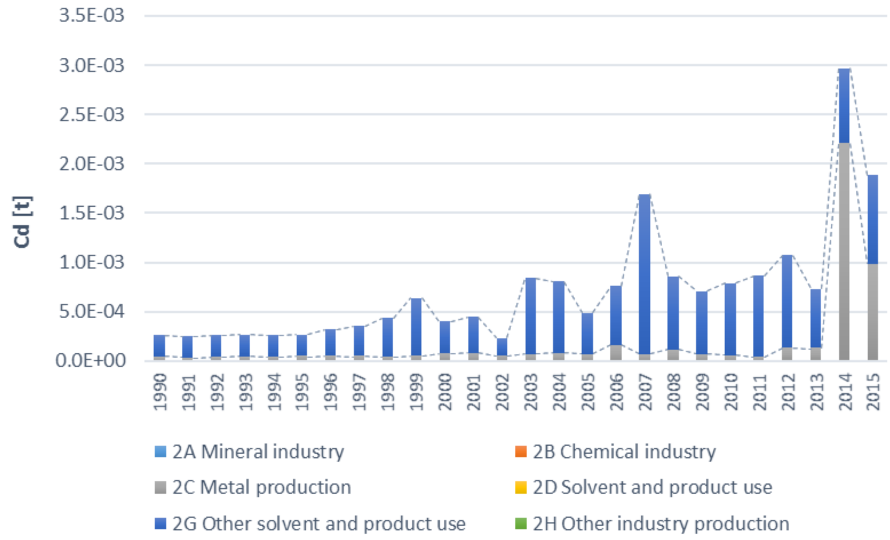
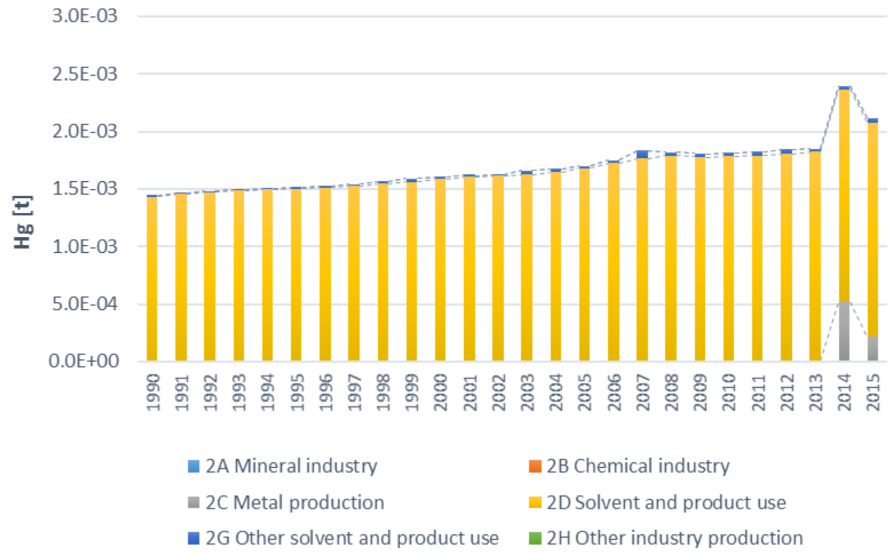
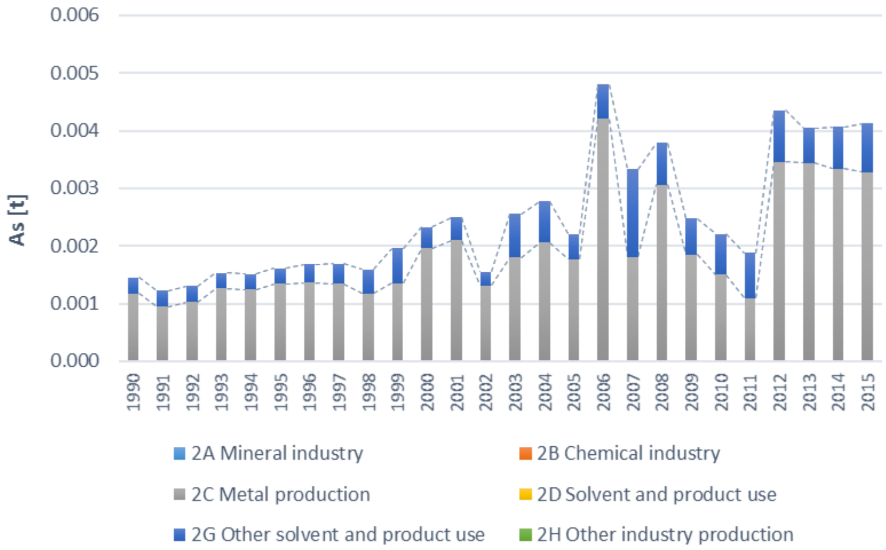
2014
2015
2A Mineral industry
2B Chemical industry
2C Metal production
2D Solvent and product use
2G Other solvent and product use
2H Other industry production

Industry: Heavy Metals








As [t]
0.006
0.005
0.004
0.003
0.002
0.001
0.000
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
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2004
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2008
2009
2010
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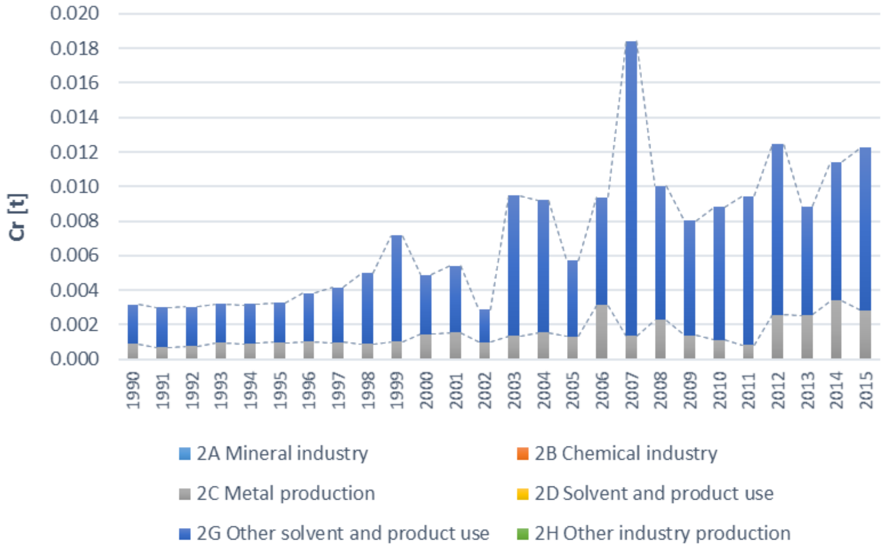
2012
2013
2014
2015
2A Mineral industry
2B Chemical industry
2C Metal production
2D Solvent and product use
2G Other solvent and product use
2H Other industry production


Cr [t]
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
1990
1991
1992
1993
1994
1995
1996
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1998
1999
2000
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2002
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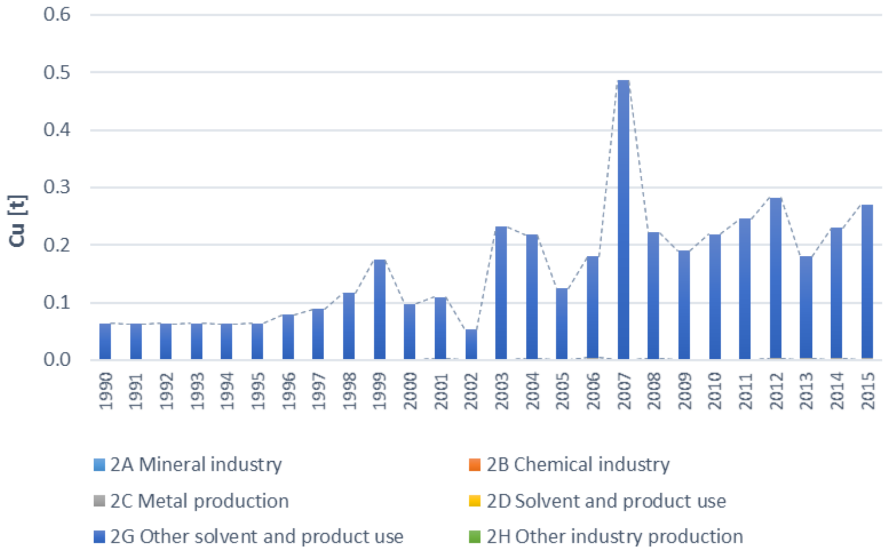
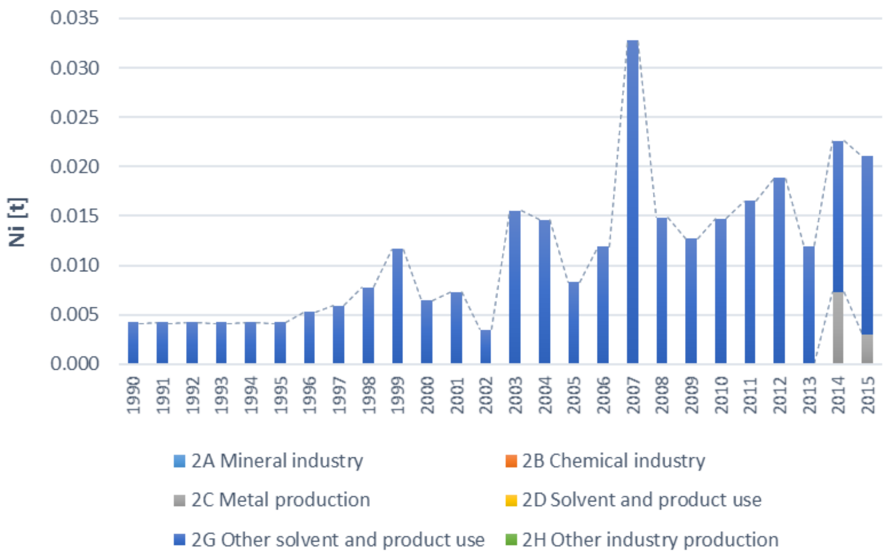
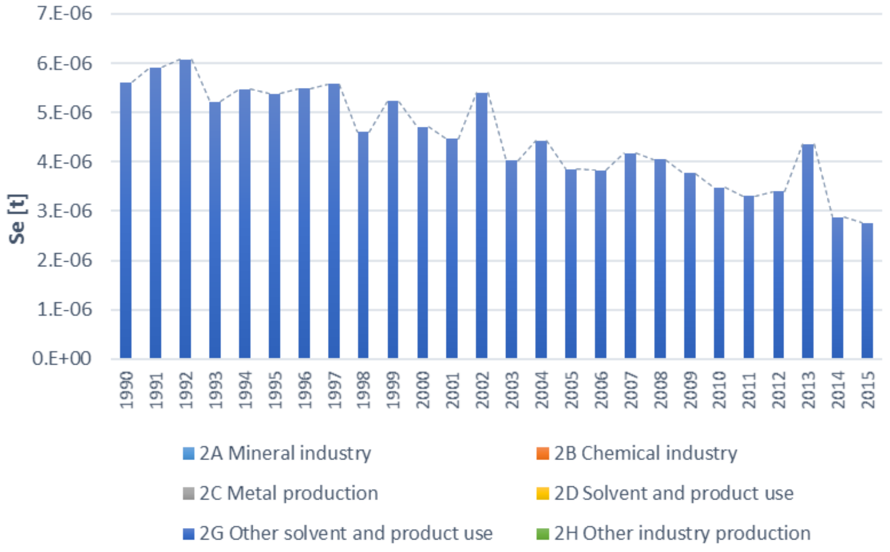
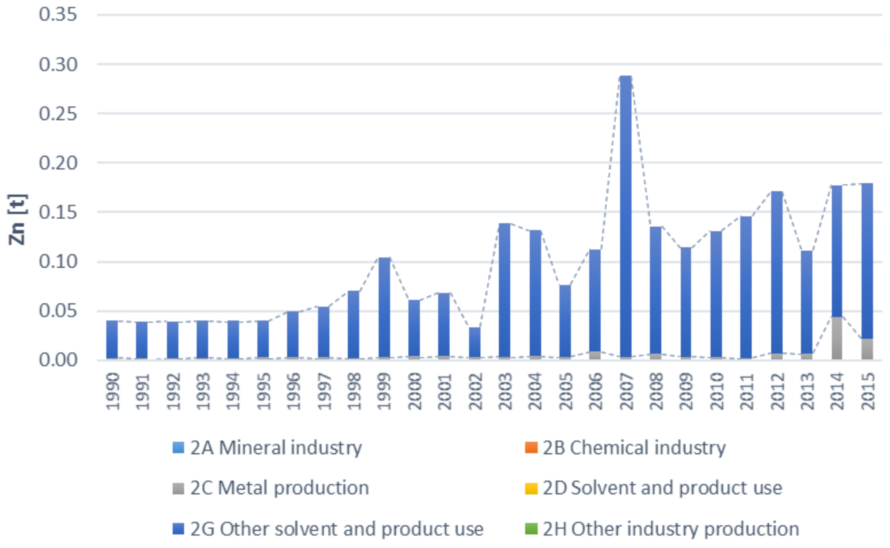
2008
2009
2010
2011
2012
2013
2014
2015
2A Mineral industry
2B Chemical industry
2C Metal production
2D Solvent and product use
2G Other solvent and product use
2H Other industry production

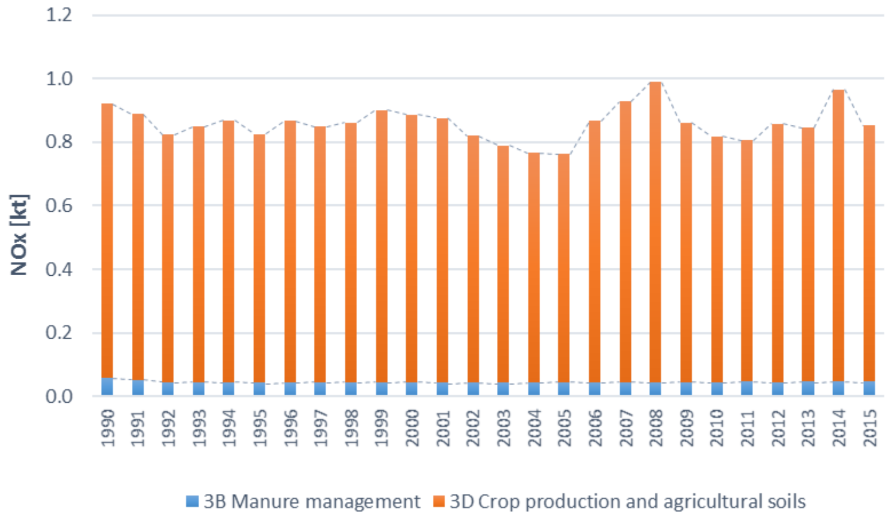

Cu [t]
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2A Mineral industry
2B Chemical industry
2C Metal production
2D Solvent and product use
2G Other solvent and product use
2H Other industry production

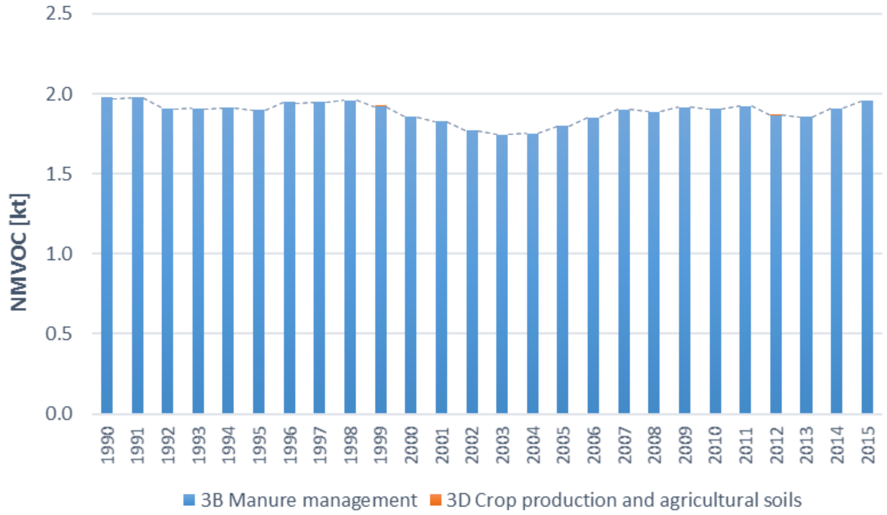

Ni [t]
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2A Mineral industry
2B Chemical industry
2C Metal production
2D Solvent and product use
2G Other solvent and product use
2H Other industry production

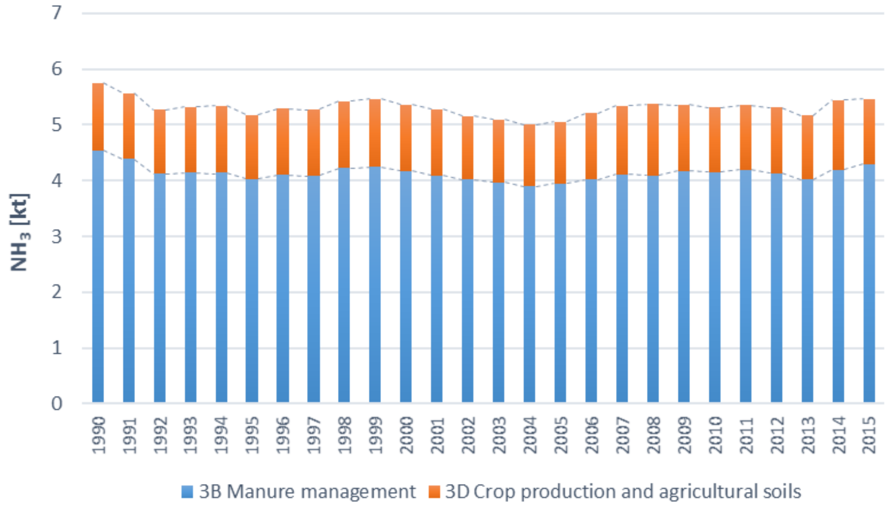

Se [t]
7.E-06
6.E-06
5.E-06
4.E-06
3.E-06
2.E-06
1.E-06
0.E+00
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2A Mineral industry
2B Chemical industry
2C Metal production
2D Solvent and product use
2G Other solvent and product use
2H Other industry production

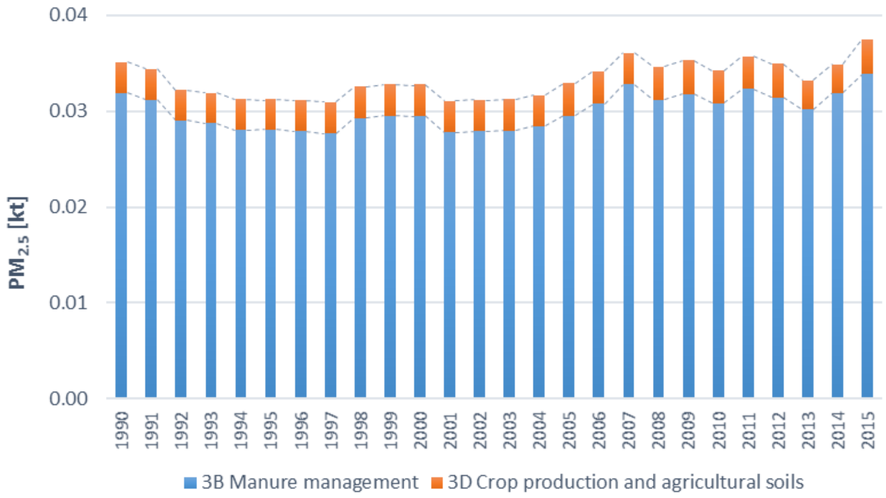

Zn [t]
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2A Mineral industry
2B Chemical industry
2C Metal production
2D Solvent and product use
2G Other solvent and product use
2H Other industry production

Agriculture: NOx, NMVOC, SO$_2$, NH$_3$, CO and PM









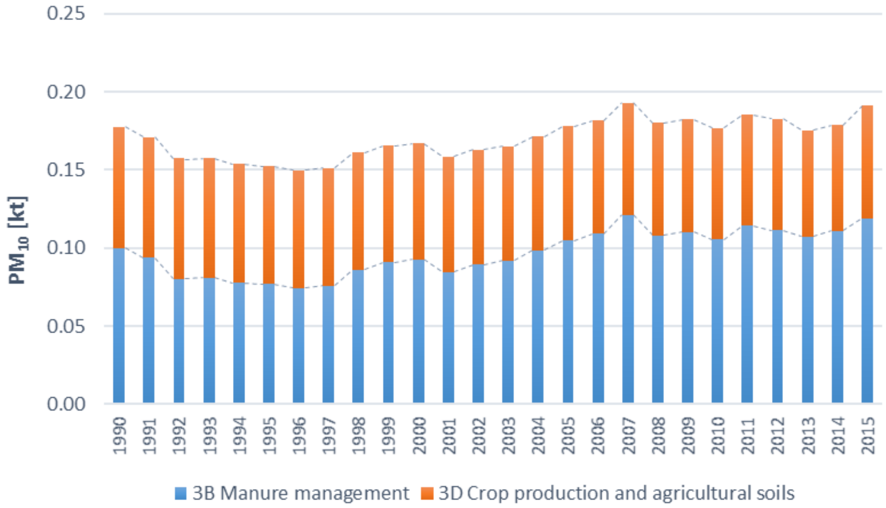
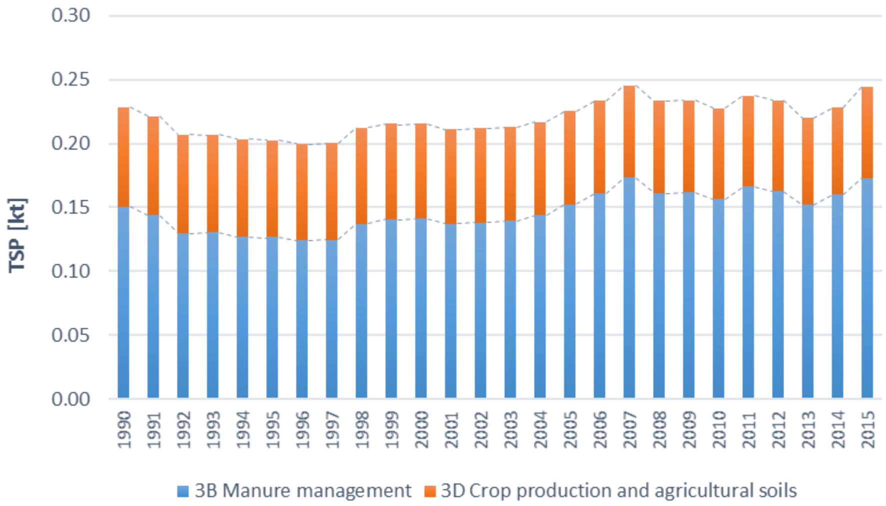
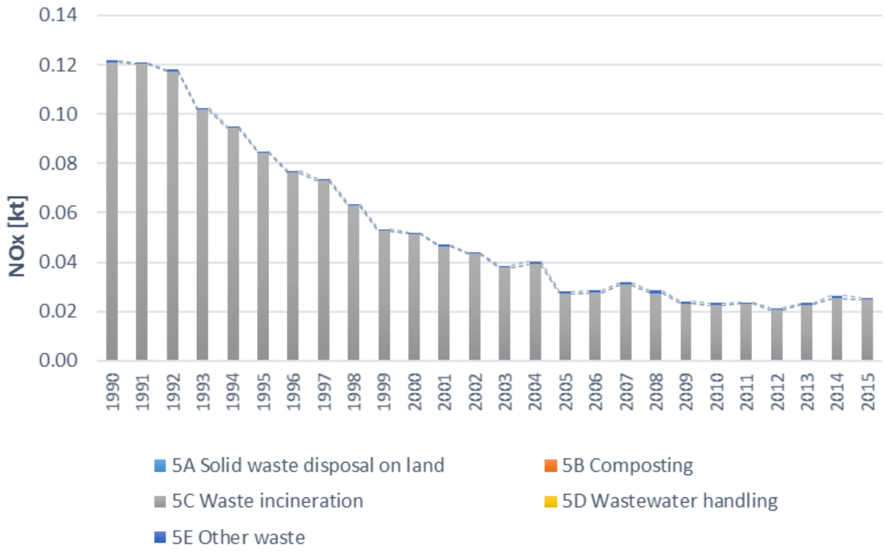
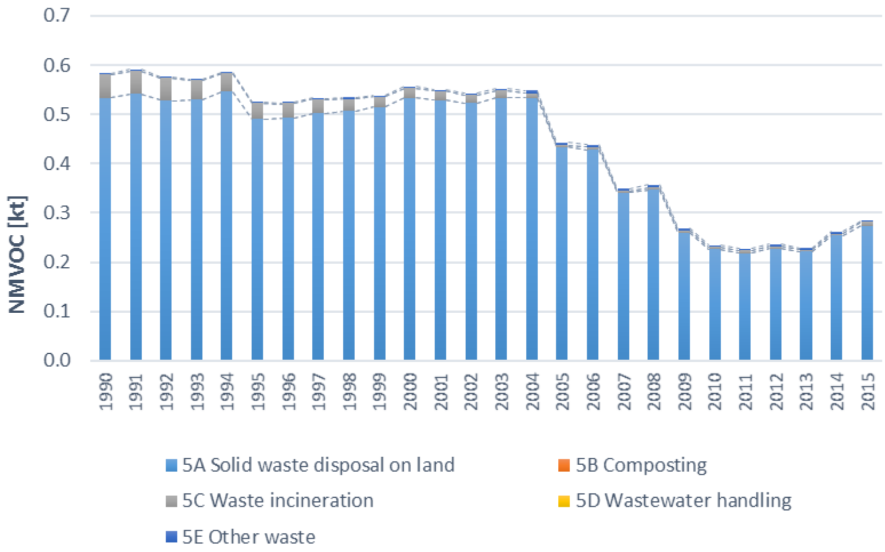


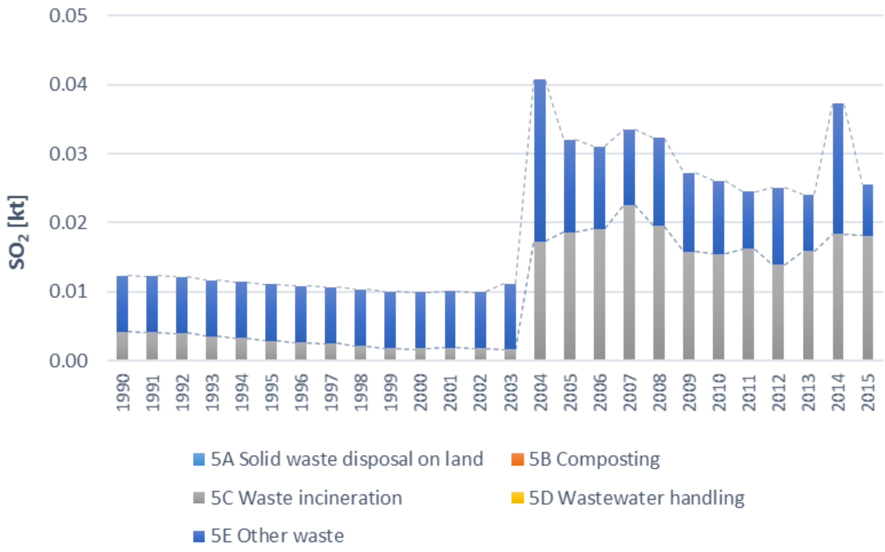
Figure 43 TSP emissions (kt) from Agricultural Sector, 1990- 2015.

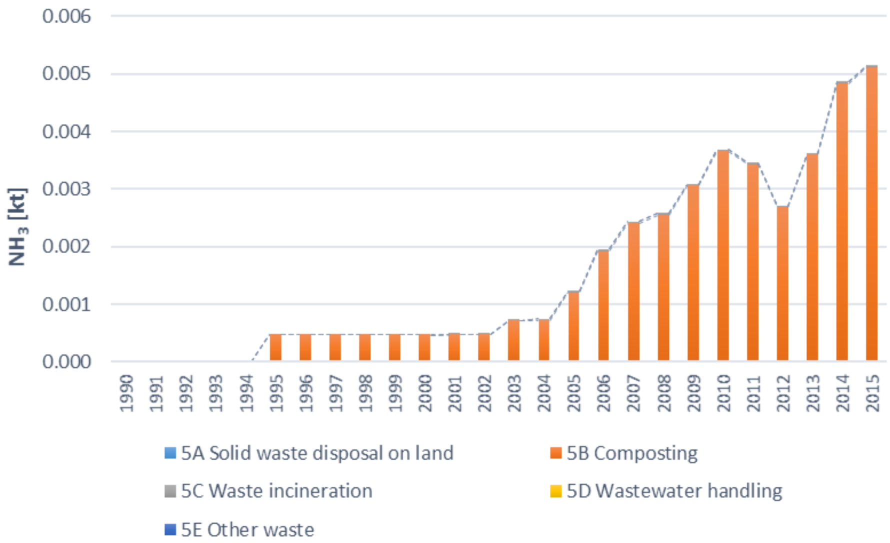


Waste: NOx, NMVOC, SO$_2$, NH$_3$, CO and PM








NH$_3$ [kt]
0.006
0.005
0.004
0.003
0.002
0.001
0.000
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
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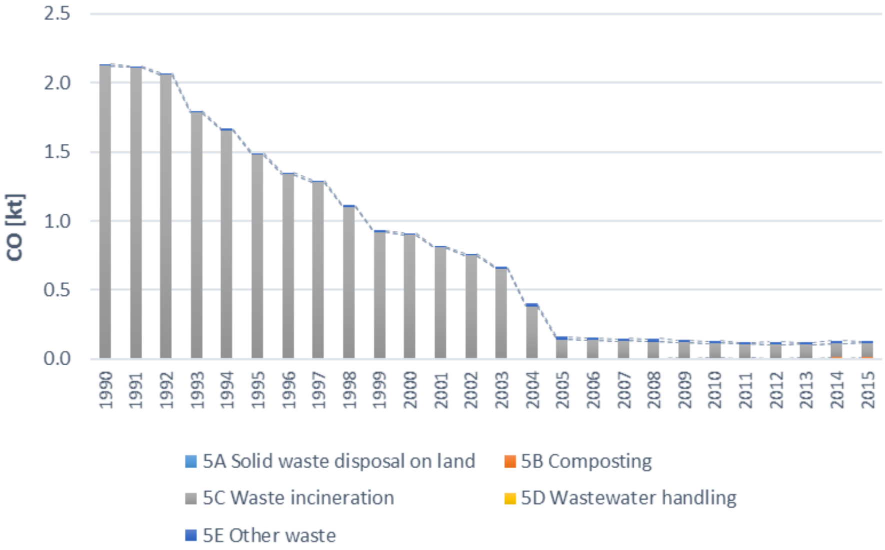
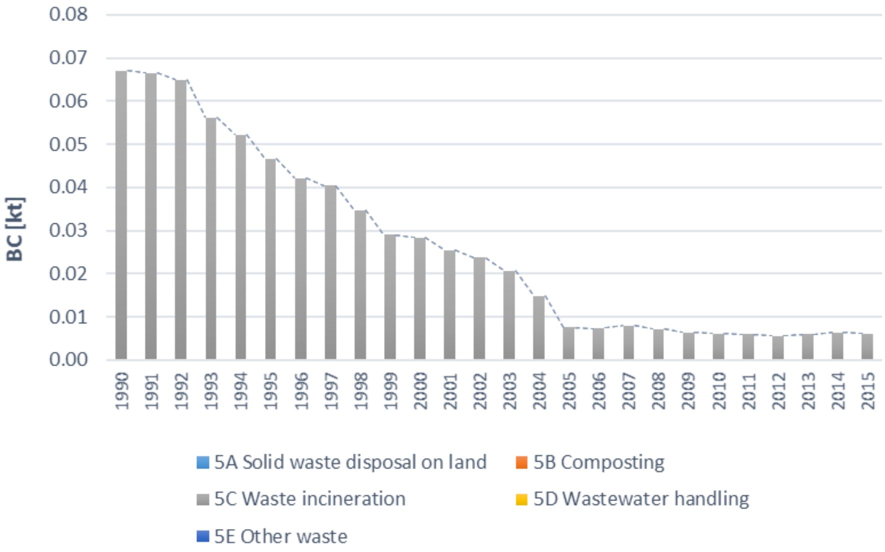
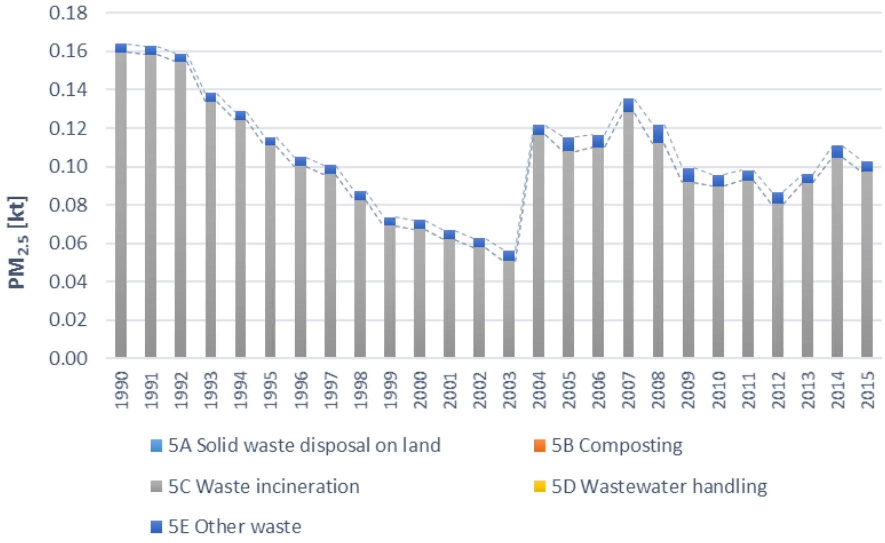
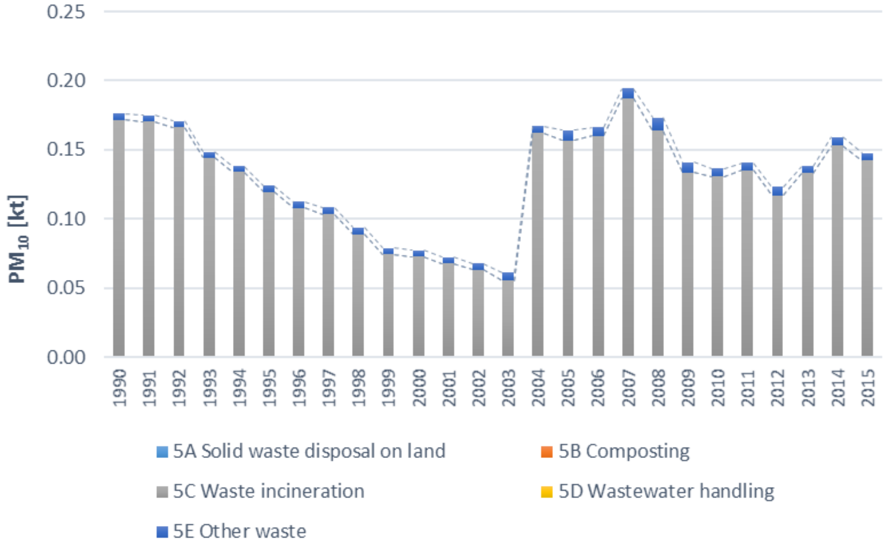
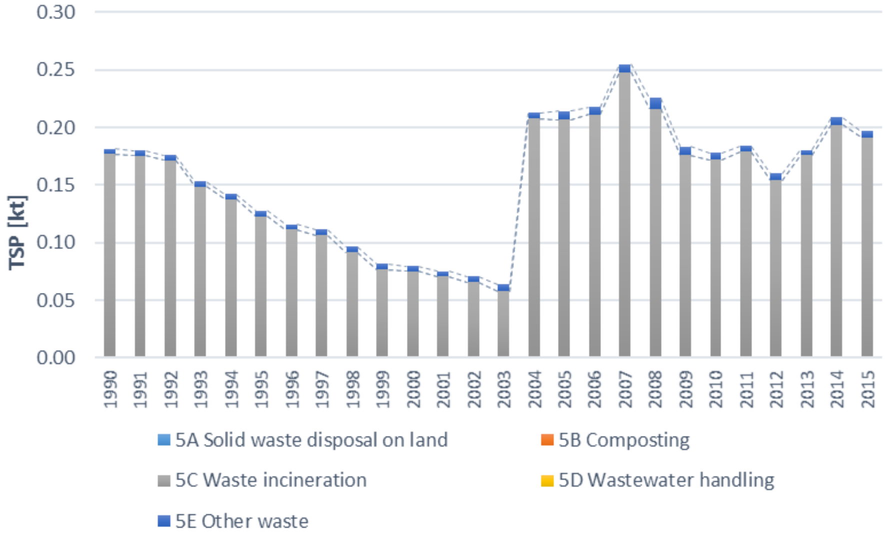
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
5A Solid waste disposal on land
5B Composting
5C Waste incineration
5D Wastewater handling
5E Other waste


CO [kt]
2.5
2.0
1.5
1.0
0.5
0.0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
5A Solid waste disposal on land
5B Composting
5C Waste incineration
5D Wastewater handling
5E Other waste

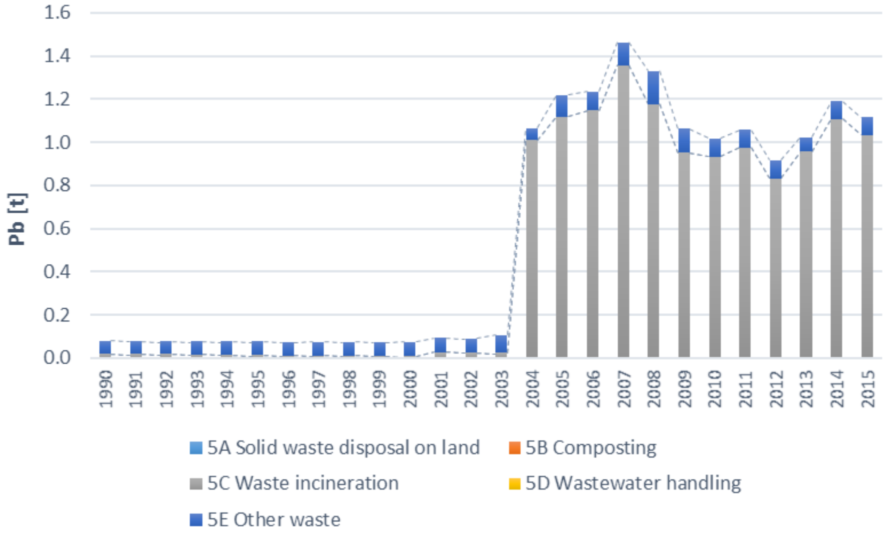

BC [kt]
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
5A Solid waste disposal on land
5B Composting
5C Waste incineration
5D Wastewater handling
5E Other waste

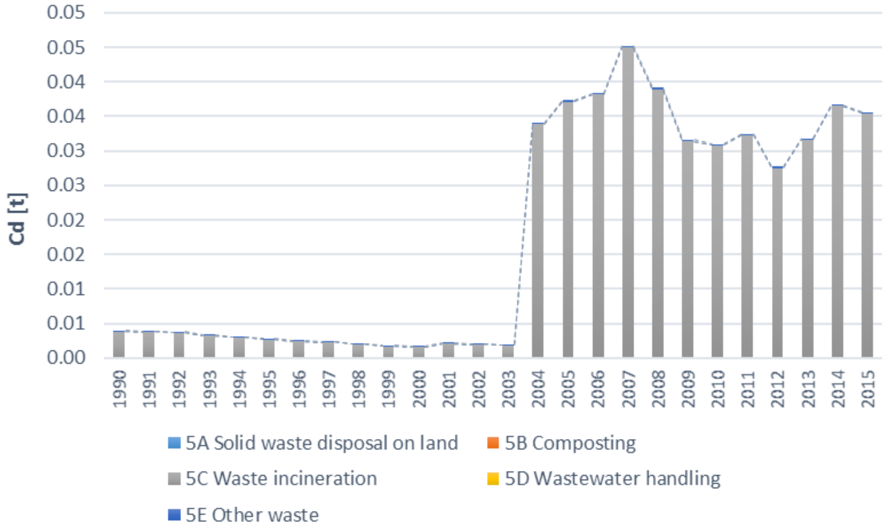

PM$_{2.5}$ [kt]
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
5A Solid waste disposal on land
5B Composting
5C Waste incineration
5D Wastewater handling
5E Other waste

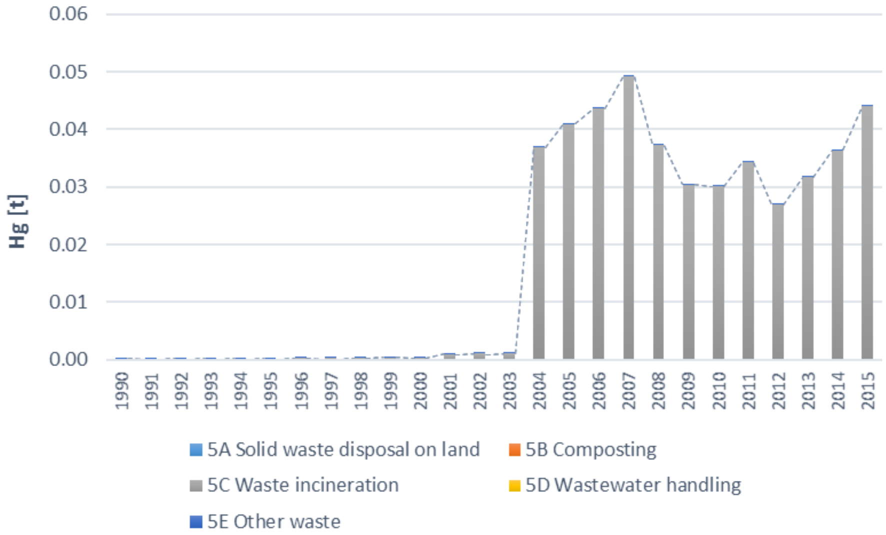

PM$_{10}$ [kt]
0.25
0.20
0.15
0.10
0.05
0.00
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
5A Solid waste disposal on land
5B Composting
5C Waste incineration
5D Wastewater handling
5E Other waste

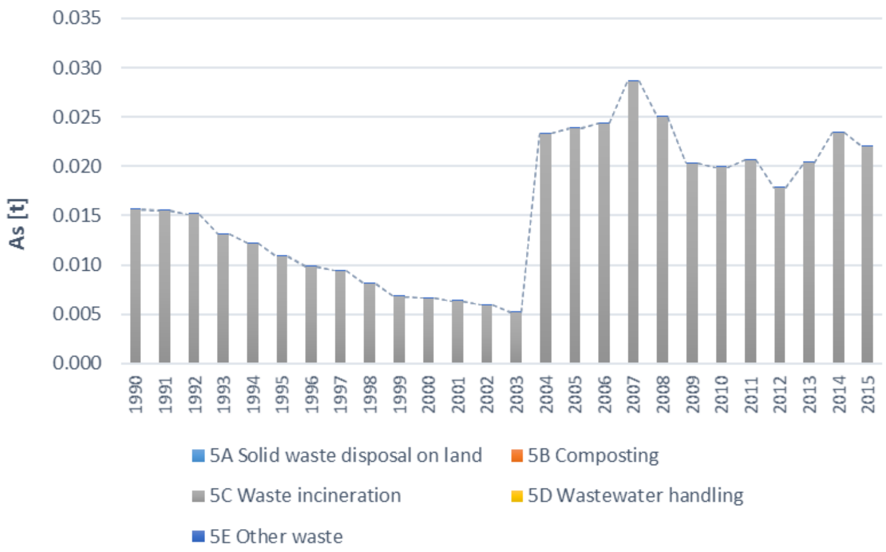

TSP [kt]
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
5A Solid waste disposal on land
5B Composting
5C Waste incineration
5D Wastewater handling
5E Other waste

Waste sector: Heavy Metals









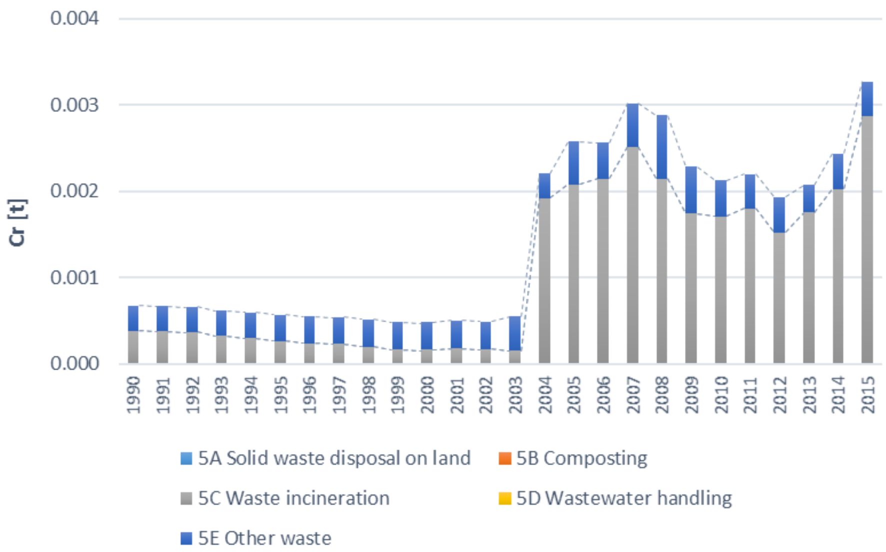
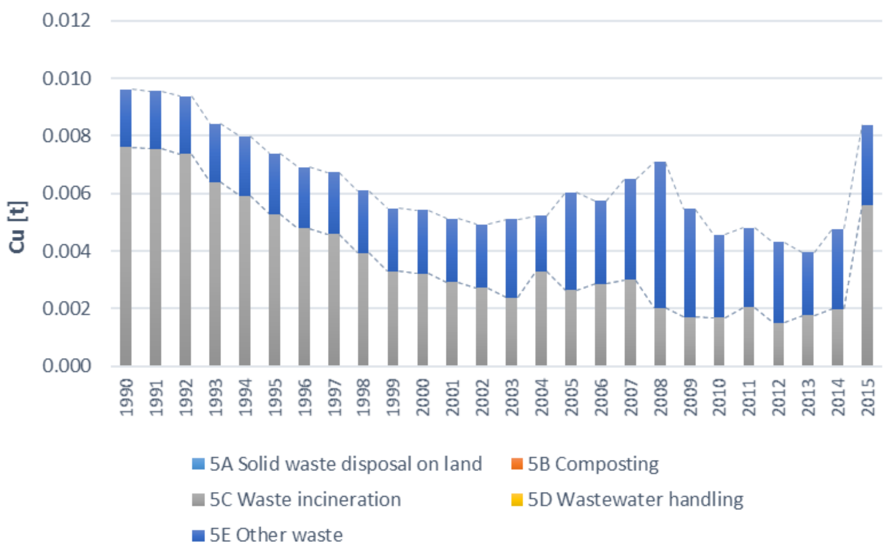
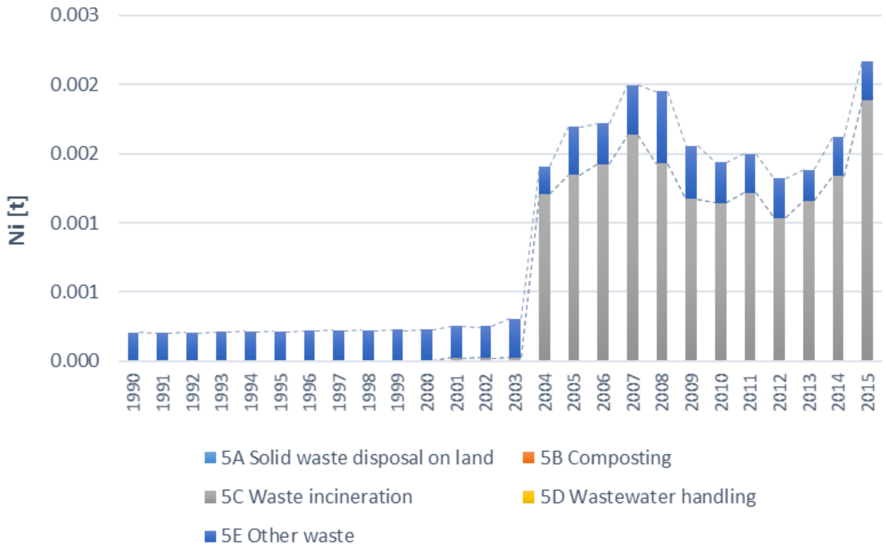
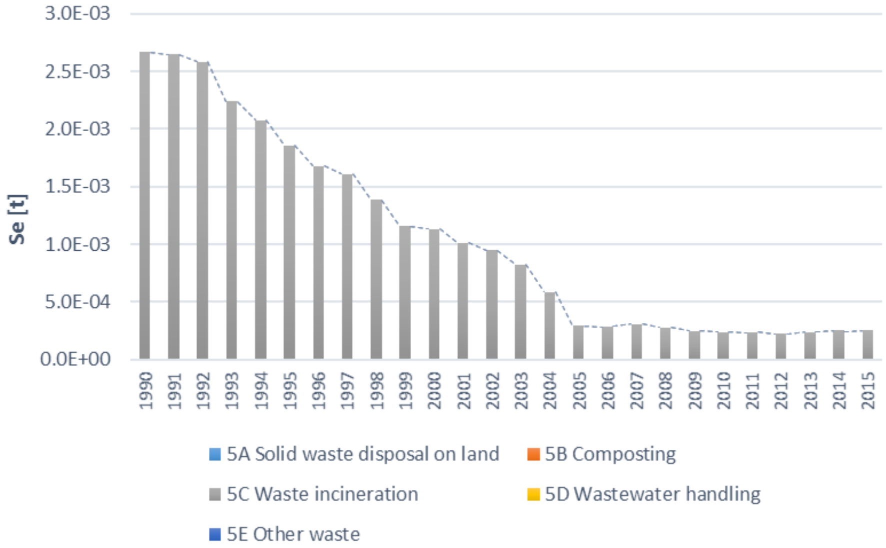
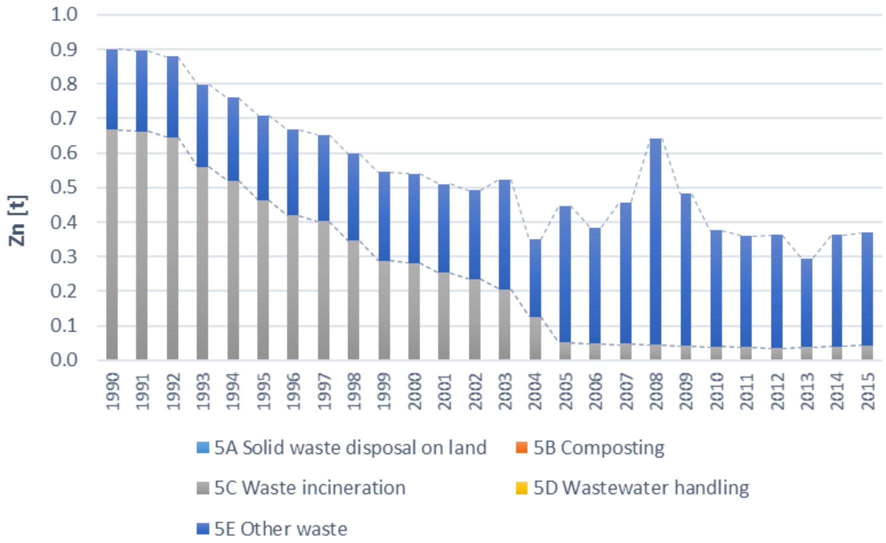


Figure 50.1 Cu emissions (t) from Waste Sector, 1990- 2015.




0.003
0.002
0.002
0.001
0.001
0.000
Ni [t]
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
5A Solid waste disposal on land
5B Composting
5C Waste incineration
5D Wastewater handling
5E Other waste


3.0E-03
2.5E-03
2.0E-03
1.5E-03
1.0E-03
5.0E-04
0.0E+00
Se [t]
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
5A Solid waste disposal on land
5B Composting
5C Waste incineration
5D Wastewater handling
5E Other waste


1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Zn [t]
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
5A Solid waste disposal on land
5B Composting
5C Waste incineration
5D Wastewater handling
5E Other waste