Informative Inventory Report

Emissions of air pollutants in Iceland from 1990 to 2020

Submitted under the Convention on Long-range Transport of Atmospheric Pollutants

2022

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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 Emissions 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, for the year 2010.

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 prepares an Informative Inventory Report (IIR) each year. The IIR together with the associated Nomenclature for Reporting tables (NFR tables) is Iceland's contribution to this round of reporting under the Convention. This report emphasizes emissions of persistent organic pollutants as Iceland has only ratified the Protocol on Persistent Organic Pollutants (POPs) under the CLRTAP. 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 the Holuhraun eruption in 2014 and 2015 are provided.

The IIR is written by staff at the Environment Agency of Iceland (EA).

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List of Abbreviations

AAP	Annual Average Populations
AFOLU	Agriculture Forestry and Other Land Use
BAT	Best Available Technology
BREF	Best Available Techniques Reference
CDFRS	Capital District Fire and Rescue Service
CLRTAP	Convention on Long-Range Transboundary Air Pollution
DOAS	Differential Optical Absorption Spectroscopy
EA	Environment Agency
EEA	European Environment Agency
EF	Emission Factor
EMEP	European Monitoring and Evaluation Programme
E-PRTR	European Pollutant Release and Transfer Register
ERT	Expert Review Team
ETS	Emissions Trading System
EU	European Union
FAI	Farmers Association of Iceland
GHG	Greenhouse Gas
IEF	Implied Emission Factor
IGLUD	Icelandic geographic land use database
IIASA	International Institute for Applied Systems Analysis
IIR	Informative Inventory Report
IPPU	Industrial Processes and Product Use
KC	Key Category
KCA	Key Category Analysis
LTO	Landing and Take-Off
MFAF	Ministry of Food, Agriculture and Fisheries
MMS	Manure Management System
MRV	Measurement, Reporting and Verification
NCV	Net Calorific Value
NEA	National Energy Authority
NECD	National Emission Ceilings Directive
NEX	Nitrogen Excretion Rate
NFR	Nomenclature for Reporting
NK	Nitrogen (N), Potassium (K) ratio
NPK	Nitrogen (N), Phosphorus (P) and Potassium (K) ratio
OECD	Organisation for Economic Co-operation and Development
QA/QC	Quality Assurance Quality Control
SWDS	Solid Waste Disposal Sites
TAN	Total Ammoniacal Nitrogen
TFEIP	Task Force on Emission Inventories and Projections
TRI	Trichloroethylene
UNFCCC	United Nations Framework Convention on Climate Change
XYL	Xylenesa

Pollutants:

BC	Black Carbon
CO	Carbon Monoxide
NH_3	Ammonia
NMVOC	Non-Methane Volatile Organic Compounds
NO_x	Nitrogen Oxides
$PM_{2.5}$	Particulate Matter ≤ 2.5 µm
PM_{10}	Particulate Matter ≤ 10 µm
SO_x	Sulphur Oxides
TSP	Total Suspended Particulate
POPs	Persistent Organic Pollutants
HCB	Hexachlorobenzene
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzo(P)Dioxins
PCDF	Polychlorinated Dibenzofurans
Heavy metals	
As	Arsenic
Cd	Cadmium
Cr	Chromium
Cu	Copper
Hg	Mercury
Ni	Nickel
Pb	Lead
Se	Selenium
Zn	Zinc

Notation keys:

IE	Included Elsewhere
NA	Not Applicable
NE	Not Estimated
NO	Not Occuring

Executive Summary

ES.1 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 incorporated to the EEA agreement, with national emission targets set for Iceland for SO_2, NO_x, NMVOC and NH_3 for the year 2010. At the time of writing, work is underway by the Icelandic government to evaluate and work at the incorporation of the new National Emissions Ceilings Directive (Directive (EU) 2016/2284) into the EEA agreement. In 2020 the International Institute for Applied Systems Analysis (IIASA) carried out an analysis of reduction potentials for Iceland for NO_x, SO_2, NMVOC, NH_3 and $PM_{2.5}$, which was done in a way comparable to the analysis done by IIASA for the EU Member States (see also TSAP Report no 16).

To comply with the requirements of CLRTAP and the NECD, Iceland prepares an Informative Inventory Report (IIR) annually. The IIR together with the associated Nomenclature for Reporting tables (NFR tables) is Iceland's contribution to this round of reporting under the LRTAP Convention and covers emissions in the period 1990 – 2020. This report emphasizes on anthropogenic emissions of persistent organic pollutants (POPs: dioxin, PAH4, HCB and PCB), as Iceland has only ratified the Protocol on POPs. Anthropogenic emissions of the precursors (NO_x, CO, NMVOC, NH_3 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. Emission estimates for particulate matter (PM), black carbon (BC) and heavy metals (HM) are provided for some emission sources.

This report and the NFR tables are available on the Centre on Emission Inventories and Projections (CEIP) webpage: https://www.ceip.at/status-of-reporting-and-review-results/2022-submission

ES.2 Responsible institution

The Environment Agency of Iceland (EA), an agency under the Ministry of the Environment, Energy and Climate, 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 EA participates in meetings under the United Nations Economic Commission for Europe (UNECE) Task Force on Emission Inventories and Projections (TFEIP) and related expert panels, where parties to the convention prepare the guidelines and methodologies on inventories.

ES.3 Overview of POPs emissions

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

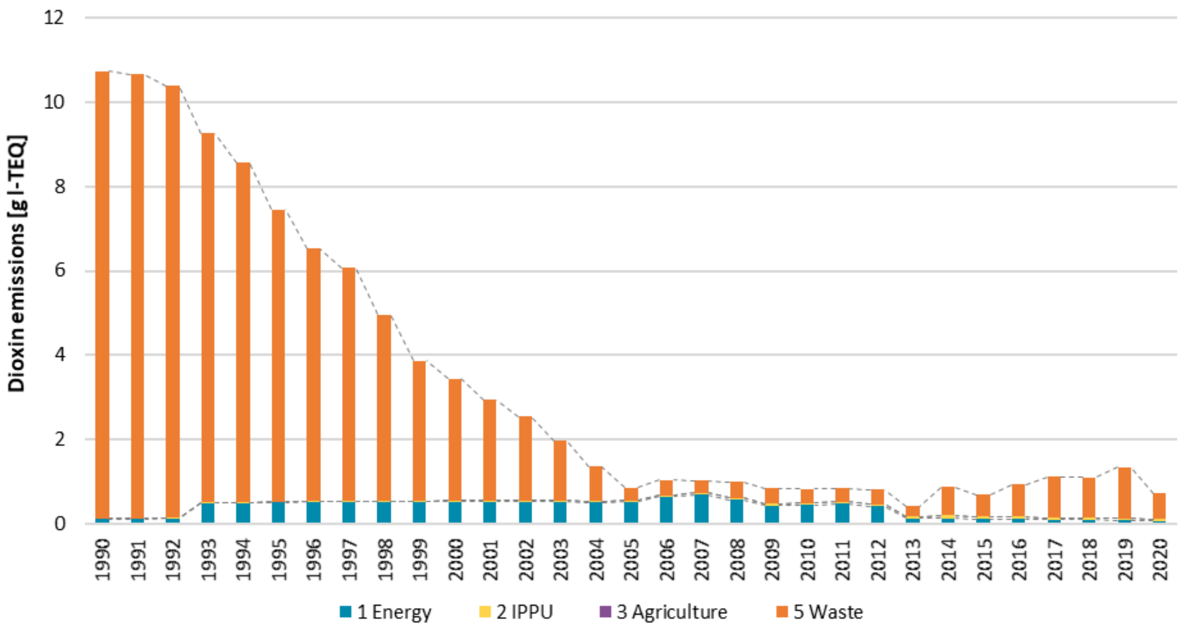


Figure ES. 1 Trends in dioxin emissions by source, since 1990

Dioxin (PCDD/PCDF) emissions decreased substantially over the reported time period (Figure ES. 1), due to a significant decrease in the occurrence of open burning of waste. Open burning of waste was a common waste management practice in Iceland pre-2004. However, an increase in the amount of waste incinerated in incineration plants without energy recovery occurred in 2004 while a reduction of the amount of waste burned in the open occurred in that same year.

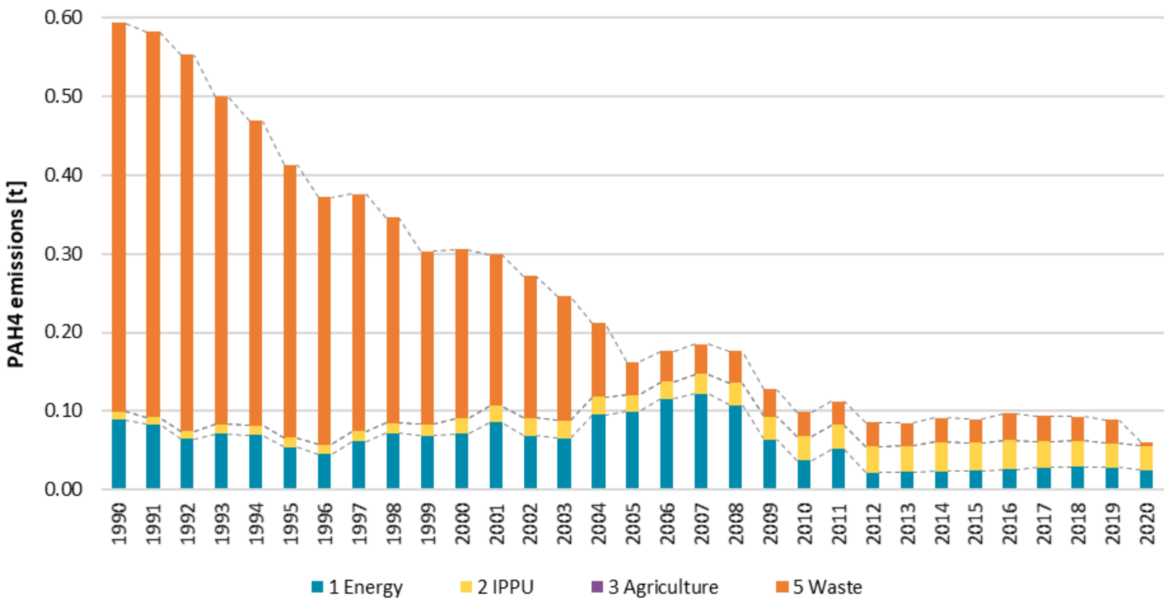


Figure ES. 2 Trends in PAH4 emissions by source, since 1990

PAH4 (Benzo(a)pyrene - BaP, Benzo(b)fluoranthene – BbF, Benzo(k)fluoranthene - BkF, Indeno(1,2,3-cd)pyrene - IPy) emissions from 1990 to the most recent year of the time series also decreased substantially (Figure ES. 2), for the same reason as described above for dioxin emissions. The largest contributors of PAH4 emissions in Iceland in recent years are the metal industry (Industry sector) and road transport (Energy sector). There are no emissions from open burning of waste in 2020 as all New Year‘s Eve fires were cancelled due to COVID-19.

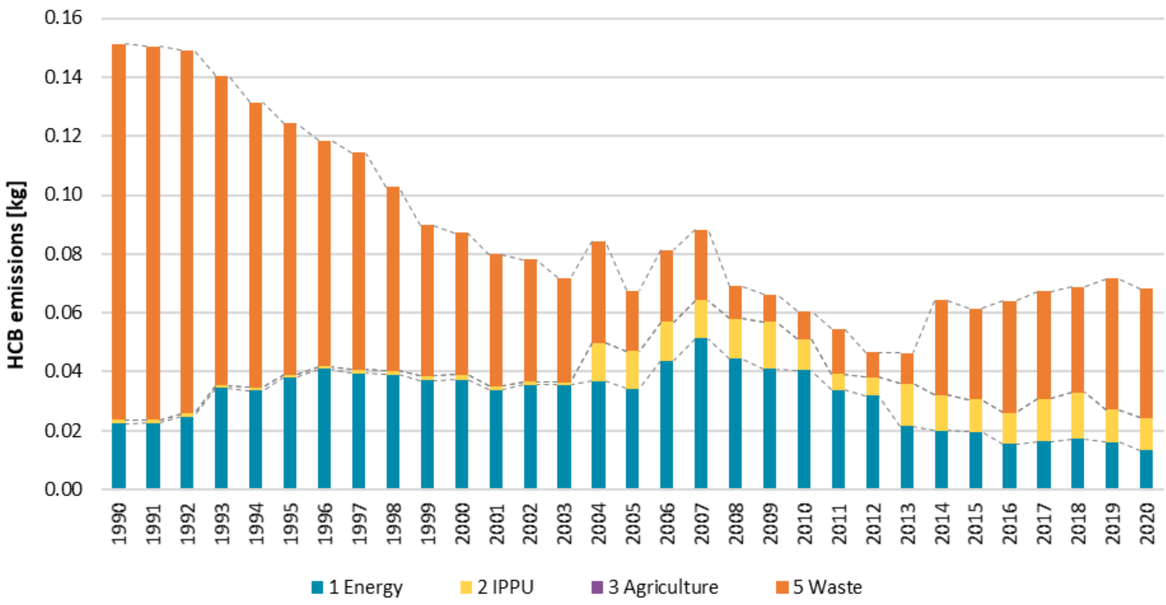


Figure ES. 3 Trends in HCB emissions by sector, since 1990.

The estimated hexachlorobenzene (HCB) emissions decreased markedly over the reported time series (Figure ES. 3). The largest contributor of HCB emissions in Iceland in recent years has been clinical waste incineration followed by emissions originating from metal production (IPPU sector) and from fishing (Energy sector). HCB emissions from the industry sector increased in 2004, following the opening of a secondary aluminium plant. Open burning of waste was a common waste management practice in Iceland pre-2004. However, an increase in the amount of waste incinerated in incineration plants without energy recovery occurred in 2004 while a reduction of the amount of waste burned in the open occurred in that same year. The increase in emissions from the waste sector in 2014 are linked to an increased quantity of clinical waste incinerated.

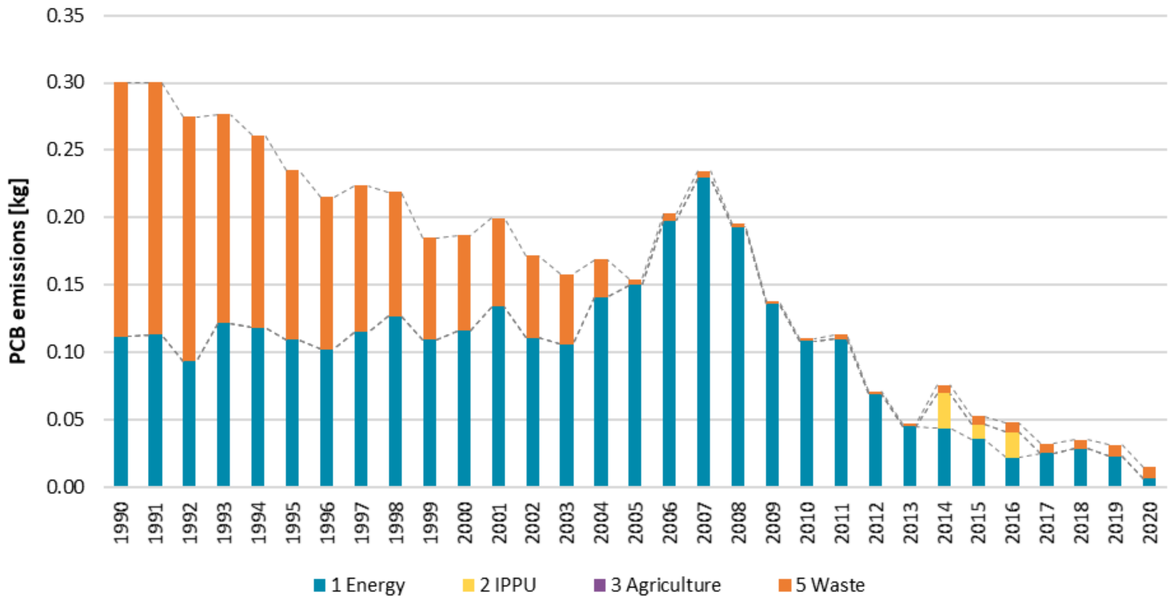


Figure ES. 4 Trends in PCB emissions by sector, since 1990.

Polychlorinated biphenyl (PCB) emissions have decreased across the time series (Figure ES. 4). The largest contributor of PCB emissions in Iceland in recent years is the fishing fleet. The only source of PCB estimated from industrial processes is secondary steel production (2C1), which occurred only for three years (2014 - 2016). Open burning of waste was a common waste management practice in Iceland pre-2004. However, an increase in the amount of waste incinerated in incineration plants without energy 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 undertaken with care as emissions factors are not available for all sources.

1 Introduction

1.1 Background Information

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

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

In 2009, Directive 2001/81/EC[1] was incorporated into the Agreement on the European Economic Area (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, Directive (EU) 2016/2284[2] (National Emission Ceilings Directive, NECD) entered into force in the EU, repealing the previous NEC Directive 2001/81/EC. The new NECD includes the same pollutants as the Directive it replaces, with the addition of CO, Cd, Hg, Pb, POPs (Dioxins/furans, PAH, HCB, PCBs), $PM_{2.5}$, 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 EA and the Icelandic government to evaluate and work towards the incorporation of the new National Emissions Ceiling Directive (Directive (EU) 2016/2284) into the EEA agreement; Iceland-specific targets are yet to be determined. In 2020 the International Institute for Applied Systems Analysis (IIASA) carried out an analysis of reduction potentials for Iceland for NO_x, SO_2, NMVOC, NH_3 and $PM_{2.5}$, which was done in a way comparable to the analysis done by IIASA for the EU Member States (see also TSAP Report no 16[3]).

The present report together with the associated NFR (Nomenclature for Reporting) tables are Iceland's contribution to the 2022 reporting under CLRTAP. A description of the trends and calculation methods is given.

Anthropogenic emissions of the precursors (NO_x, CO, NMVOC, NH_3 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. Emission estimates for particulate matter (PM), black carbon (BC) and heavy metals (HM) are provided for all emission sources where an EF is provided in the 2019 EEA/EMEP Guidebook. A short description of the trends and the calculation methods for those pollutants are given in this report.

Estimates for SO_2, $PM_{2.5}$ and PM_{10} for the volcano Eyjafjallajökull which erupted in 2010, the volcano Grímsvötn which erupted in 2011 and Holuhraun eruption in 2014 and 2015 are also provided (Chapter 6).

[1] Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants.
[2] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC
[3] http://www.iiasa.ac.at/web/home/research/researchPrograms/air/policy/TSAP_16b.pdf

1.2 Protocol on Persistent Organic Pollutants

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 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.

1.3 Institutional Arrangements for Inventory Preparation

Article 36 of the Icelandic Act on Public Health and Pollution Control no 7/1988 (Lög um hollustuhætti og mengunarvarnir) establishes the responsibility of the Environment Agency of Iceland (EA), an agency under the auspices of the Ministry of the Environment, Energy and Climate, for the annual preparation and submission of the national inventory to the CLRTAP. This act also authorises the EA to collect all necessary data and information from authorities, institutions and companies. Figure 1.1 illustrates the flow of information and allocation of responsibilities. The methodologies and data sources used for different sectors are described in more details in the respective sectoral chapters.

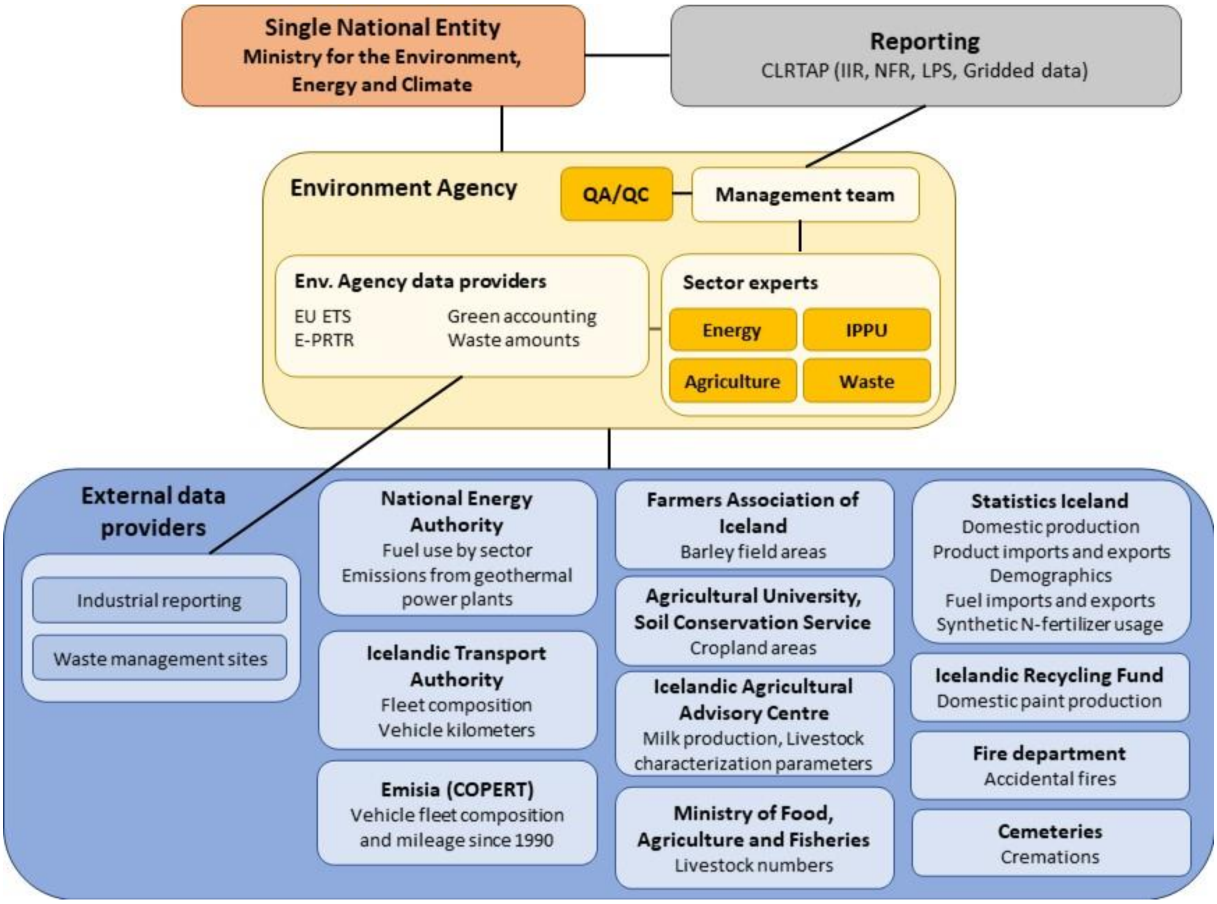


Figure 1.1 Information flow and distribution of responsibilities in the Icelandic emissions inventory system for reporting to the CLRTAP.

1.4 Inventory Preparation

The EA collects the bulk of data necessary to calculate yearly emissions, i.e. activity data and emission factors. Activity data is collected from various institutions and companies. In most cases, the same activity data information is used both for the air pollutants inventory (as per this report) and for the National Greenhouse gas Inventory. Data is gathered according to Icelandic Regulation No. 520/2017 on data collection for the greenhouse gas inventory, as well as provided by various teams within the EA:

1. The National Energy Authority (NEA) collects annual information on fuel sales from the oil companies. This information was until 2008 provided on an informal basis. From 2008 and onwards, Act No. 48/2007 enables the NEA to obtain sales statistics from the oil companies.

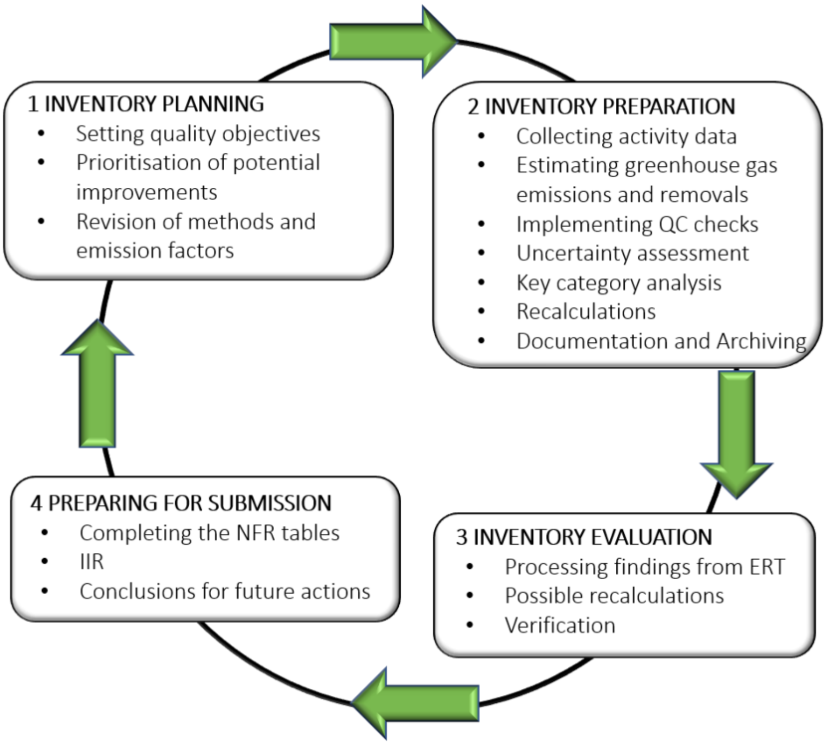
2. Until 2011 the Farmers Association of Iceland (FAI), on behalf of the Ministry of Agriculture, was responsible for assessing the size of the animal population each year, when the Food and Veterinary Authority took over that responsibility. On request from the EA, the FAI assisted the development of a method to account for young animals that are mostly excluded from national statistics on animal population. Animal statistics have been further

developed to better account for replacement animals in accordance with recommendations from the Expert Review Team (ERT) that came to Iceland for an in-country review in 2011.

3. Statistics Iceland provides information on population, GDP, imports and exports of various products, domestic production and domestic usage.
4. The EA collects various additional data through the annual emission reports reported under the European Emissions Trading System (EU ETS (Directive 2003/87/EC) as implemented into Icelandic legislation with Act No. 70/2012 on Climate Change), European Pollutant Release and Transfer Register (E-PRTR (Regulation (EC) no 166/2006, as implemented into Icelandic legislation with Regulation No. 990/2008), Green Accounting reports from industry submitted under Icelandic Regulation No. 851/2002.
5. Data for using the transport model COPERT originates from EMISIA SA[4] and used for emission estimates from road transport (NFR 1A3b) (see more details in the energy sector).
6. Aviation emissions for 2005-2020 are reported using the Eurocontrol dataset.
7. Emission factors are mainly taken from the EMEP/EEA Emission Inventory Guidebook (2019; 2016; 2013) unless otherwise referenced.
8. The EA also collects activity data on waste amounts split by treatment pathways and plant specific emission factors based on measurements from the industry.

The annual inventory cycle (Figure 1.2) describes individual activities performed each year in preparation for next submission of the emission estimates.

Figure 1.2 The annual inventory cycle.



[4] https://www.emisia.com/utilities/copert-data/

A new annual cycle begins with an initial planning of activities for the inventory cycle by the inventory team and major data providers as needed, taking into account the outcome of the internal and external review. The initial planning is followed by a period assigned for compilation of the national inventory and improvement of the National System.

After compilation of activity data, emission estimates are calculated, and quality checks performed to validate results.

A series of internal review activities are carried out annually to detect and rectify any anomalies in the estimates, e.g. time series variations, with priority given to key source categories and those categories where data and methodological changes have recently occurred.

1.5 Key Category Analysis (KCA)

A key category is one that is prioritized within the national inventory system because it has a significant influence on a country's total inventory of a given pollutant in terms of the absolute level of emissions, the trend in emissions, or both. Total emissions from the key categories amount to 80% of the total emissions included in the inventory. The KCA has been undertaken based on Approach 1 outlined in the 2019 EMEP/EEA Guidebook. A KCA has been performed for each pollutant, calculating both the level assessment for the base year (1990) and the most recent inventory year (2020) as well as the trend assessment (1990-2020). Memo items are excluded from the KCA.

Table 1.1, Table 1.2 and Table 1.3 present the results of the key category analysis for main pollutants, POPs and heavy metals, respectively, for the year 2020. The KCA for the above-mentioned pollutant categories in 1990 as well as the 1990-2020 trend assessment are presented in Annex 2: KCA Results for 1990 and Trends 1990-2020.

Table 1.1 Key category analysis for reported main pollutants in 2020.

Component	**Key categories** (Sorted from high to low from left to right and top to bottom)					**Total (%)**
NO_x	National fishing	Ferroalloy production	Road transport: Passenger cars	Aluminium production		80.1%
	NFR 1A4ciii	NFR 2C2	NFR 1A3bi	NFR 2C3		
	64.5%	6.7%	4.6%	4.3%		
NMVOC	Domestic solvent use including fungicides	Manure managment: horses	Manure management - Non-dairy cattle	Manure management - Dairy cattle	Food and beverages industry	82.1%
	NFR 2D3a	NFR 3B4e	NFR 3B1b	NFR 3B1a	NFR 2H2	
	16.7%	10.7%	9.1%	8.6%	8.6%	
	National fishing	Coating applications	Biological treatment of waste - Solid waste disposal on land	Distribution of oil products	Manure management - Sheep	
	NFR 1A4ciii	NFR 2D3d	NFR 5A	NFR 1B2av	NFR 3B2	
	8.3%	8.2%	5.5%	3.3%	3.2%	
SO_x	Other fugitive emissions from energy production (Geothermal energy)	Aluminium production				95.3%
	NFR 1B2d	NFR 2C3				
	76.3%	19.0%				
NH_3	Animal manure applied to soils	Urine and dung deposited by grazing animals	Manure management - Sheep	Manure management - Dairy cattle	Manure management - Non-dairy cattle	87.1%
	NFR 3Da2a	NFR 3Da3	NFR 3B2	NFR 3B1a	NFR 3B1b	
	29.2%	19.0%	15.4%	13.6%	10.0%	
$PM_{2.5}$	Aluminium production	National fishing	Road transport: Automobile road abrasion	Ferroalloy production	Construction and demolition	80.4%
	NFR 2C3	NFR 1A4ciii	NFR 1A3bvii	NFR 2C2	NFR 2A5b	
	27.0%	20.6%	17.2%	6.6%	5.7%	
	Road transport: Automobile tyre and brake wear					
	NFR 1A3bvi					
	3.4%					
PM_{10}	Construction and demolition	Aluminium production	Road transport: Automobile road abrasion	Quarrying and mining of minerals other than coal	National fishing	81.9%
	NFR 2A5b	NFR 2C3	1A3bvii	NFR 2A5a	NFR 1A4ciii	
	25.6%	15.1%	14.2%	13.6%	9.8%	
	Ferroalloys production					
	NFR 2C2					
	3.6%					

Component	Key categories (Sorted from high to low from left to right and top to bottom)					Total (%)
TSP	Construction and demolition	Road transport: Automobile road abrasion	Quarrying and mining of minerals other than coal	Aluminium production		81.8%
	NFR 2A5b	NFR 1A3bvii	NFR 2A5a	NFR 2C3		
	43.7%	14.5%	14.2%	9.3%		
BC	Road transport: Passenger cars	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	Other mobile machinery	National fishing	Road transport: Automobile road abrasion	84.8%
	NFR 1A3bi	NFR 1A4cii	NFR 1A3eii	NFR 1A4ciii	NFR 1A3bvii	
	19.6%	11.4%	10.2%	8.9%	8.4%	
	Aluminium production	Road transport: Heavy duty vehicles and buses	Road transport: Light duty vehicles	Mobile Combustion in manufacturing industries and construction		
	NFR 2C3	NFR 1A3biii	NFR 1A3bii	NFR 1A2gvii		
	7.7%	6.9%	6.0%	5.6%		
CO	Aluminium production					95.2%
	NFR 2C3					
	95.2%					

Table 1.2 Key category analysis for reported POPs in 2020

Component	Key categories (Sorted from high to low from left to right)					Total (%)
DIOX	Hazardous waste incineration	Industrial waste incineration	Accidental fires			81.4%
	NFR 5C1bii	NFR 5C1bi	NFR 5E			
	46.1%	21.2%	14.1%			
PAH4	Aluminium production	Ferroalloys production	Road transport: Passenger cars	Accidental fires	Road transport: Heavy duty vehicles and buses	86.5%
	NFR 2C3	NFR 2C2	NFR 1A3bi	NFR 5E	NFR 1A3biii	
	25.9%	24.8%	20.1%	8.9%	6.8%	
HCB	Clinical waste incineration	Aluminium production	National fishing			95.3%
	NFR 5C1biii	NFR 2C3	NFR 1A4ciii			
	60.5%	18.7%	16.1%			
PCB	Clinical waste incineration	National fishing				95.3%
	NFR 5C1biii	NFR 1A4ciii				
	55.0%	40.3%				

Table 1.3 Key category analysis for reported heavy metals in 2020

Component	Key categories (Sorted from high to low from left to right and top to bottom)				Total (%)
Pb	Other product use (Fireworks, tobacco)	Road transport: Automobil tyre and brake wear			84.6%
	NFR 2G	NFR 1A3bvi			
	69.2%	15.4%			
Cd	National fishing	Ferroalloy production	Other product use (Fireworks, tobacco)	Road transport: Automobil tyre and brake wear	87.5%
	NFR 1A4ciii	NFR 2C2	NFR 2G	NFR 1A3bvi	
	35.2%	26.8%	16.3%	9.1%	
Hg	National fishing	Cremation	Road transport: Passenger cars		84.8%
	NFR 1A4ciii	NFR 5C1bv	NFR 1A3bi		
	54.2%	16.9%	13.7%		
As	National fishing	Road transport: Automobile tyre and brake wear	Ferroalloys production		86.3%
	NFR 1A4ciii	NFR 1A3bvi	NRF 2C2		
	67.8%	10.7%	7.9%		
Cr	Road transport: Automobil tyre and brake wear	National fishing	Other product use (Fireworks, tobacco)		90.5%
	NFR 1A3bvi	NFR 1A4ciii	NFR 2G		
	60.6%	15.2%	14.8%		
Cu	Road transport: Automobil tyre and brake wear	Other product use (Fireworks, tobacco)			82.4%
	NFR 1A3bvi	NFR 2G			
	62.6%	19.8%			
Ni	National fishing				82.8%
	NFR 1A4ciii				
	82.8%				
Se	National fishing				87.9%
	NFR 1A4ciii				
	87.9%				
Zn	Road transport: Automobil tyre and brake wear	National fishing	Accidental fires	Other product use (Fireworks, tobacco)	90.8%
	NFR 1A3bvi	NFR 1A4ciii	NFR 5E	NFR 2G	
	35.2%	23.1%	16.8%	15.6%	

1.6 Quality Assurance & Quality Control (QA/QC)

The objective of QA/QC activities in national inventories is to improve transparency, consistency, comparability, completeness, accuracy, confidence and timeliness.

1.6.1 Background information on Iceland's QA/QC activities

Quality aspects of Iceland's Climate Change and Air Quality Measurement, Reporting and Verification (MRV) system are stored in the QA/QC Hub. The Hub is an online solution, and forms part of its Air Quality and Climate Change Data Portal. The QA/QC Hub provides a centralized basis for the inventory team to design, manage and record its QA/QC activities. The use of the QA/QC hub started in the fall of 2019 and has not yet been fully operationalised; it is expected that it will be fully implemented for the next submission. It is used for reporting on greenhouse gas emissions as well as on air pollutant emissions.

The Hub is focused around three interconnecting elements:

- a record of comments produced by previous review processes
- an area for planning and tracking improvement work; and
- an area for planning QA/QC activities.

The interaction of these elements is outlined in Figure 1.3 below.

The logic of this design is that it will enable the inventory team to link its ongoing review outcomes and internal development ideas to its 'live' improvements list and QA/QC activities. This should ensure that over time, Iceland's inventory submissions continue to evolve in terms of quality. Importantly, the inventory team will be able to provide transparent evidence to the way it handles and prioritizes its inventory improvements and QA/QC activities.

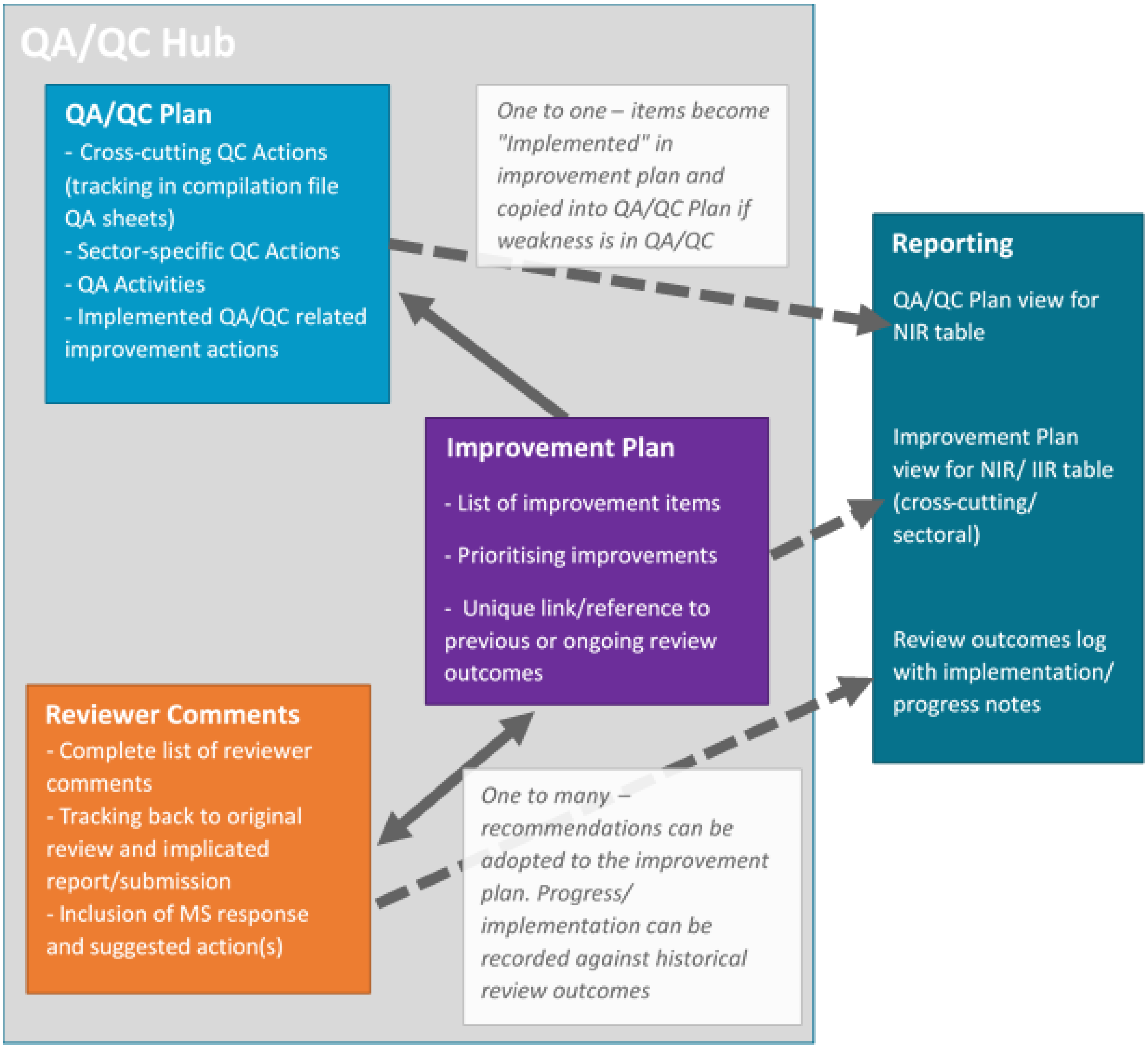


Figure 1.3 Schematic overview of the elements included in the QA/QC activities

The live improvements and QA/QC lists can be viewed and recorded at sectoral or cross-cutting level. Crucially, all activities are designed to be time-bound and signed off as part of the annual inventory cycle. This enables the inventory team to provide an ongoing record of sector-specific and cross-cutting activities through its national inventory reporting. Once fully operationalised, the QA/QC Hub will lead to:

- enhanced transparency of inventory compilation and reporting
- increased documentation and understanding of Iceland's inventory improvement prioritization (taking into account national capacity and feasibility)
- improved response to, and engagement with, the international inventory review processes

The QA/QC Hub also acts as a centralized document library for relevant training material (to identify and track the engagement of key experts and stakeholders with the inventory team); and for the storage of internal document templates and specific QA/QC guidance for e.g. data collection, review and analysis.

1.6.2 Roles and responsibilities overview

The same inventory team takes care of the greenhouse gas (GHG) inventory and the air pollutant inventory. Sectoral experts thus calculate emissions from their respective sector both for GHG and air pollutants.

The overall responsability over the inventory lies with the team leader, who has overall responsibility for the completion of QA/QC activities, submission, improvements planning and review coordination. There are two sectoral subgroups within the team, one Energy/IPPU group and one Agriculture/Waste group. Data collection, processing, QC and improvements are conducted within each group, in collaboration with the team leader. The various roles within the inventory team are described below:

- Inventory team leader - overall responsibility for the accurate and timely production and submission of the inventories, according to the rules and deadlines specified in relevant domestic and international legislation; The team leader is responsible for the communication with the Icelandic government and with data providers, as well as communication with EU and UNFCCC experts/expert review teams.
- IIR coordinator - responsible for leading the work on producing the air pollutants inventory
- NIR coordinator - responsible for leading the work on producing the greenhouse gas inventory
- Sectoral experts - main knowledge holders on individual inventory sectors. They are responsible for completion of day-to-day data processing and QC activities. Each sector comprises 3 to 4 sectoral experts; prior to each submission cycle, it is decided how roles are divided between the sectoral experts, making sure that QC activities are done by someone other than the individual who did the calculations. In addition, each IIR chapter is proof-read by one of the experts not involved in the writing of the chapter.
- Lawyer – responsible for all the legal aspects of the inventory work, such as examining new legal texts, implementing EU regulation into domestic legislation, as well as understanding Iceland‘s various air pollutants and greenhouse gases commitments.
- Communications strategist – responsible for coordinating all media-related activities relating to the inventory work, such as publication of news, website updates, as well as lectures and seminars.

1.6.3 Quality Assurance (QA)

Iceland’s air pollutant inventory was subjected to a Stage 3 review under CLRTAP in 2020. Iceland submitted several revised estimates which were all included in the 2021 submission.

In many categories, activity data used for the air pollutant inventory are the same as those used for the greenhouse gas inventories. Regular reviews of the GHG inventory thus also contributes to increased quality of the air pollutant inventory.

Further Quality Assurance is provided by Iceland’s collaboration with consultants at Aether Ltd., who assist with and review sector-specific methodological choices and calculations. As part of this collaboration, the calculations for the Agriculture and Waste sectors were revised and improved in recent years, whereas the calculations for the Energy sector were revised in 2018.

Furthermore, Iceland participates in a Nordic inventory experts workgroup, funded by the Nordic Council of Ministers, where inventory compilers from Norway, Sweden, Finland, Denmark and

Iceland meet regularly (one physical meeting once a year when there isn't a pandemic, as well as several teleconferences) and discuss various aspects of the inventory compilation, with a strong focus on harmonizing emission factors used across the various Nordic countries.

1.6.4 Quality Control (QC)

The team uses standardised notation protocols in the calculation files to document changes, possible issues and necessary improvements. This is done via an excel tool ("Q Comments"), which allows the documentation of changes and flagging of issues by use of comments starting with hashtags including the initials of the inventory compiler/QC reviewer, the date, and one or more flags pertaining to the type of issue (such as, for instance, potentially identified issue, transparency issue, or reason for change). A summary of all comments can be generated for each calculation file, enabling for instance someone performing QC checks to track and verify changes made to the file, as well as check the status of flagged issues. The issues can then either be marked as resolved, addressed immediately or added to the improvement plan, depending on the type of issue. This tool is an important source of information needed QC activities are performed.

Aether also assists Iceland in the development of QA/QC activities and provided Iceland with several tools running checks on the latest inventory. Those checks include:

- **Recalculation check** - comparing the values reported in the current and previous versions of the inventory.
- **Negative and zero values checks** - to highlight the occurrence of negative values 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 QC process feed back into the continuous improvement programme. Further details are available under Annex II.

Other QC activities include investigating the following:

- Are appropriate activity data, methods, calculations, units, emission factors and notation keys used?
- Are all data sources well referenced/documented?
- Are the emission estimate files consistent with summary files and NFR outputs?
- Are there recalculations since the last submission, and if so, are they properly documented?

As the QA/QC procedure is still being implemented, sector- and subsector specific guidelines on nature and frequency of QC checks are in the process of being developed.

1.6.5 Planned improvements for QA/QC activities

The full operationalising of the QA/QC hub, as described in paragraph 1.6.1 above is still being implemented. A review and possible expansion of sector-specific QA and QC activities is planned for future submissions. In the future, it is also planned to fully document the results of QC activities for each sector and providing evidence of such activities by including screenshots of the Q Comments tool discussed under 1.6.4.

Furthermore, it is planned to interlink QA/QC activities with the key category analysis and the uncertainty analysis in order to prepare a prioritised improvement plan at the sectoral level as well as for the inventory work in general.

1.7 Uncertainty Evaluation

The uncertainty analysis is being developed and will be included in future submissions.

1.8 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. 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 in 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.

1.8.1 Categories not estimated (NE)

In the 2020 Stage 3 review the ERT pointed out to Iceland that NE has a different meaning in the Guidebook and in the NFR tables and that NA is the correct notation key if it is not the responsibility of Iceland that the emissions are not estimated. Therefore, notation keys have been reviewed.

Table 1.4 List of pollutants not estimated by sector

NFR code	NFR category	Pollutants not reported (NE)	Reason
1A3ai(i)	International aviation LTO (civil)	NH_3, B(a)P, B(b)f, B(k)f, Ipy PAHs 1990-2004 : TSP, PM_{10}, $PM_{2.5}$, BC	No T1 EF in GB 2019 From 2005 Eurocontrol estimates TSP, PM_{10}, $PM_{2.5}$, BC
1A3aii(i)	Domestic aviation LTO (civil)	NH_3, B(a)P, B(b)f, B(k)f, Ipy, PAHs 1990-2004 : TSP, PM_{10}, $PM_{2.5}$, BC	No T1 EF in GB 2019 From 2005 Eurocontrol estimates TSP, PM_{10}, $PM_{2.5}$, BC
1A3bvi	Road transport: Automobile tyre and brake wear	B(a)P, B(b)f, B(k)f, Ipy, PAH, dioxin	No T1 EF in GB 2019
1A3bvii	Road transport: Automobile road abrasion	B(a)P, B(b)f, B(k)f, Ipy, PAH, Heavy metals	No T1 EF in GB 2019
5C1bi	Industrail waste incineration (2014-2020)	NH_3, B(a)P, B(b)f, B(k)f, Ipy, Cr, Cu, Se, Zn	No EF in GB 2019

NFR code	NFR category	Pollutants not reported (NE)	Reason
5C1bii	Hazardous waste incineration (2006-2020)	NH_3, B(a)P, B(b)f, B(k)f, Ipy, Cr, Cu, Se, Zn	No EF in GB 2019
5C1biii	Clinical waste incineration (2001-2020)	NH_3, $PM_{2.5}$, PM_{10}, B(a)P, B(b)f, B(k)f, Ipy, Se, Zn	No EF in GB 2019
5C1biv	Sewage sludge incineration (2014-2017, 2019-2020)	NH_3, B(a)P, B(b)f, B(k)f, Ipy, Cr, Cu, Se, Zn	No EF in GB 2019
5C1bv	Cremation	BC	No EF in GB 2019
5D1	Domestic wastewater handling	NMVOC	No relevant activity data
5D2	Industrial wastewater handling	NMVOC	No relevant activity data
5D3	Other wastewater handling	NMVOC	No relevant activity data
5E	Other waste (please specify in IIR)	BC, Se, HCB, PCBs	No EF in GB 2019

1.8.2 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 1.5 Categories included elsewhere.

NFR code	NFR category	Pollutants included elsewhere (IE)	Reported under	
			NFR code	NFR category
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals (Cement)	SO_x	2A1	Cement production
1A2gvii	Transport: Other (1990-2018)	all reported pollutants	1A3eii	Other mobile combustion
1A4bii	Residential: Household and gardening (mobile)	all reported pollutants	1A3eii	Other mobile combustion
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery (1990-2018)	all reported pollutants	1A3eii	Other mobile combustion
2B1	Ammonia production	all reported pollutants	2B10a	Chemical Industry: Other (Fertilizer production)

1.9 Recalculations

A recalculation file is used to identify and document all recalculations. This QC file compares Year x-3 (2019) and the base year (1990) for the current and previous submissions for all pollutants. The data has been compiled to enable any changes in the data to be easily identified and justifications for changes provided where required. As far as possible, the recalculation check includes all reported sectors.

The main sector-specific recalculations and improvements done for this submission are mentioned below for each sector, and all recalculations are described in more details in each subsector in the relevant chapter.

1.9.1 Energy

The main improvements and recalculations in the energy sector are listed below.

- A correction in NCV for biodiesel was done which affects the whole sector. In previous submissions the wrong NCV was applied which caused an overestimation of emissions.
- Petroleum coke used for mineral wool production in 1A2f was removed from the energy sector. It is accounted for inn the IPPU sector and was therefore double counted for previous submissions. This affected all pollutants reported for the years 2013-2019.
- For previous submissions all other off-road mobile machinery was reported under 1A2gvii and is now reported under 1A3eii. What is now reported undri 1A2gvii was previously reported as 1A2gv. This was changed according to a review comment from the UNFCCC expert review team.
- Emissions of all PMs from Road Transport have decreased over the whole timeseries after the emission factor in COPERT was updated with version 5.5.1.
- The NEA reallocated fuel between domestic navigation, international navigation and fishing for 1990-1994. Some of the fuel that was previously attributed to domestic navigation is now attributed to international navigation and fishing.

1.9.2 Industrial processes and product use (IPPU):

The main recalculations and improvements for Industrial processes and product use are:

- In 2A5b, Construction and demolition, the Thornthwaite Precipitation-evaporation Index was recalculated for the whole timeseries. Recalculation was done for TSP, PM_{10} and $PM_{2.5}$.
- In 2A6, Mineral wool production, newer factory based CO measurements are now also used.
- In 2C2, ferroalloy production, the PM_{10} and $PM_{2.5}$ ratios to TSP were updated according to the EMEP/EEA Guidebook (EEA, 2019). Also, data from one factory about the particulate matter distribution was updated. Recalculations were made for PM_{10}, $PM_{2.5}$ and BC.
- In 2C3, activity data was updated for the year 2019. Also, dioxin emissions are now based on measurements on-site for one factory. The dioxin emissions were therefore recalculated.
- In 2D3a there was a tier update from tier 1 to tier 2b. NMVOC recalculation was done.
- In 2H2 there was NMVOC recalculation since the subsector was revised and improved. Now there is internal consistency between differend food/beverages types.

1.9.3 Agriculture

The main recalculation and improvements in the Agriculture sector is the following:

- An update of the livestock categorisation of poultry. A share of poultry previously categorised as broilers should, in fact, be categorised as laying hens for the whole timeseries. This updated categorisation resulted in some changes in the emissions from manure management and from animal manure applied to soils.

1.9.4 Waste

The main recalculation and improvement in the Waste sector is the following:

- The emission factors for industrial waste incineration (5C1bi) were updated for this submission.

1.10 Planned improvements

Various improvements are planned to increase the overall quality of the inventory and the report. Those include:

- Adding a comprehensive uncertainty analysis
- Improving the workflow pertaining to keeping track and acting upon comments received by reviewers
- Operationalizing the QA/QC hub and finalising sector-specific QA/QC
- Reviewing and updating the overall workflow for preparing the inventory, including more quality checks and cross-checks between data sources
- Adding projected emissions for more pollutants.

Furthermore, several sector-specific improvements are planned. The main improvements are mentioned below for each sector, and all planned improvements are described in more details in each subsector in the relevant chapter.

1.10.1 Energy

For future submissions there is need to harmonize energy data processing between various organizations (such as EA, the National Energy Authority and Statistics Iceland) and produce a complete uncertainty analysis. For future submissions it is also planned, in collaboration with the Icelandic Transport Authority, to develop procedures to obtain enhanced data on vehicle stock and mileage data for COPERT.

Moreover, plans are underway to make emission calculations for national navigation, fishing and aviation tier 2 for future submissions.

1.10.2 Industrial processes and product use

The main improvement planned for the IPPU sector consists of harmonising the reporting under CLRTAP with the reports under the E-PRTR Regulation (E-PRTR, according to Icelandic Regulation No. 990/2008, which implements Regulation (EC) no 166/2006 concerning the establishment of a European Pollutant Release and Transfer Register).

1.10.3 Agriculture

The main improvement planned for the Agriculture sector consist of taking the first steps to update the method for calculating NMVOC emissions from manure management from Tier 1 to Tier 2. This requires a detailed investigation into which data are easily available in Iceland and which data need to be collected specifically for this task.

1.10.4 Waste

The main planned improvements in the waste sector are to review all emission factors for incineration of waste for the next submission and to acquire and use facility data for the emissions which are measured on site at the only waste incinerator currently operated in Iceland. For future submissions it is planned to add further information on the methodological information to the IIR, improve activity data and estimates for wastewater handling and review the methodology to estimate emissions from accidental fires.

2 Trends in emissions

2.1 Emission profile in Iceland

The emissions profile for Iceland differs from that of other European countries for a number of reasons:

- Emissions from the generation of **electricity and space heating** are very low due to the use of renewable energy sources. Almost all electricity in Iceland is produced with hydropower (around 70%) and geothermal power (around 30%), with wind power and fossil fuel-derived power accounting for less than 0.1%.
- **Geothermal energy** is used for space heating in over 90% of all homes. It should be noted, however, that significant amounts of sulphur are emitted from geothermal power plants as hydrogen sulphide (H_2S).
- Around 90% of the fuel used in the energy sector is used by **mobile sources** (transport, mobile machinery and fishing vessels).
- Emissions from **industrial processes**, especially from non-ferrous metal production, contribute a higher share of total emissions in Iceland than in most other countries. Around 75% of the electricity produced in Iceland is now used in the metal production industry. The production capacity has increased considerably since 1990.

The emissions profile of Iceland is further influenced by the fact that Iceland was severely hit by the economic downturn in 2008, when its three largest banks collapsed. During the years prior to the crisis the economy experienced a significant upswing, resulting, among other things, in an increase in fuel consumption. The crisis resulted in a serious contraction of the economy and, as a result, oil consumption decreased. The result of this can be seen in several pollutants associated with fuel consumption, with a clear peak in 2007, or the year preceding the crisis. In recent years the economy has been experiencing an upswing and the tourism sector has increased significantly, leading to rising fuel consumption. During the outbreak of the covid pandemic in 2020 the economy had a fallback again.

2.2 Emission trends for SO_x, NO_x, NH_3, NMVOC, Particulate Matter, BC and CO

The total amount of SO_x, NO_x, NH_3, NMVOC, PM_{10}, $PM_{2.5}$, TSP, BC and CO emissions in Iceland in 1990 and the latest year is presented in Table 2.1.

Nitrogen oxides (NO_x), ammonia (NH_3), non-methane volatile organic compounds (NMVOC), particulate matter (TSP, PM_{10}, $PM_{2.5}$) and carbon monoxide (CO) have an adverse effect on human health and the environment. Iceland implemented the National Emissions Ceiling Directive (NECD) 2001/81/EC into its legislation in 2009, with emission target reductions for SO_x, NO_x, NH_3, and NMVOC to be reached by 2010. These pollutants are reported here. Furthermore, emissions of NO_x, CO, NMVOC, SO_2 and NH_3 are also calculated to comply with the reporting requirements of the UNFCCC. An overview of the emissions of these pollutants is provided in Table 2.1 for the base and latest year. The emissions of SO_2 have increased significantly since 1990 levels. This includes H_2S from geothermal plants - all sulphur species emitted are to be reported as SO_2 equivalents. CO emissions have approximately doubled since 1990. The most significant decrease in emissions are NMVOC emissions, which have roughly halved since 1990 levels.

Table 2.1 Emissions of SO_X, NO_X, NH_3, NMVOC, PM, BC and CO in 1990 and 2020.

	SO_X [kt SO_2]	NO_X [kt NO_2]	NH_3 [kt]	NMVOC [kt]	$PM_{2.5}$ [kt]	PM_{10} [kt]	TSP [kt]	BC [kt]	CO [kt]
1990	23.2	30.3	4.91	10.0	1.42	3.02	6.29	0.229	71.7
2020	51.5	19.3	4.41	5.37	1.08	2.42	4.73	0.087	104.7
Change 1990-2020	122%	-36%	-10%	-46%	-24%	-20%	-25%	-62%	46%

For the current inventory year, the emissions of all pollutants included in the NECD 2001/81/EC were below the emission maxima set by the 2001 NECD, as shown in Table 2.2.

Table 2.2 Emissions of SO_X, NO_X, NH_3 and NMVOC compared to their respective NECD 2001/81/EC target.

Pollutant	Target	
SO_x	90 kt	has not been exceeded during the reporting period
NO_x	27 kt	emissions have been below the target since 2009
NH_3	8 kt	emissions have been stable between 4 and 5 kt since 1990
NMVOC	31 kt	emissions have been decreasing steadily since 1992, when the maximum NMVOC emissions occurred (10 kt in that year).

As of February 2022, no emission targets have been set yet for Iceland for 2030 and the incorporation of the new NECD (Directive 2016/2284) into the EEA is still pending.

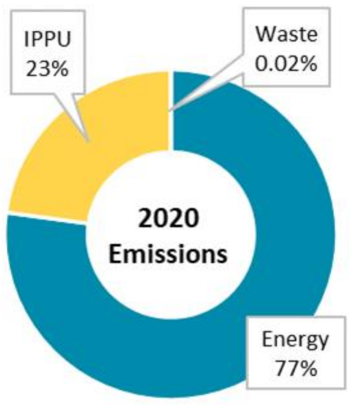
2.2.1 Trends in SO_x emissions

SO_x (SO_2)

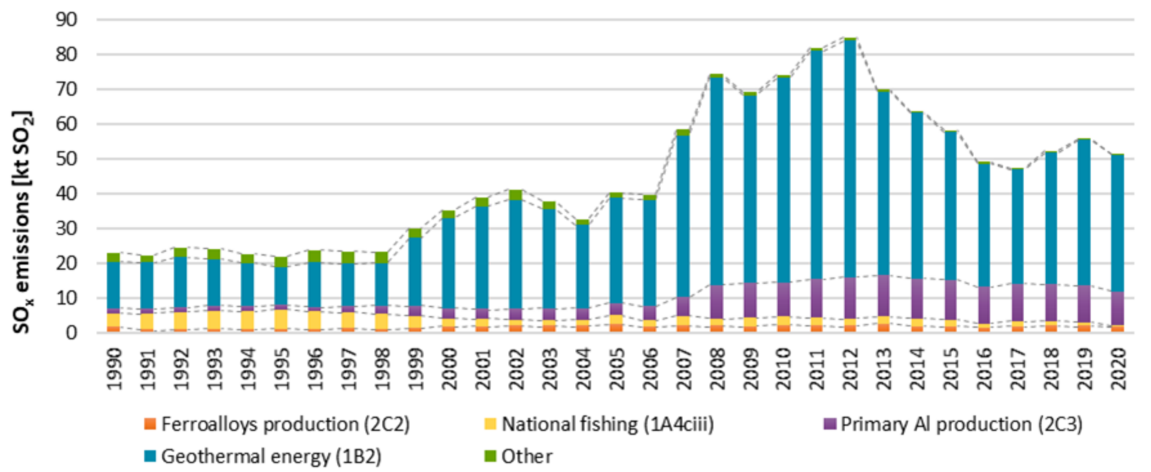
Total emissions in latest inventory year: **51.5 kt**

The main sources for SO_x include:

- **Geothermal energy (1B2d):** Geothermal energy is the largest source of sulphur emissions in Iceland. Emissions have increased substantially since 1990 due to increasing geothermal energy production. In recent years the SO_2 emissions have started decreasing, following the onset in 2014 of a sulphur capture and storage project.
- **Metal production (2C):** Emissions from industrial processes are dominated by aluminium and ferroalloy production. SO_2 emissions were relatively stable until 1996, after which there has been a great expansion of the metal industry. Sulphur comes mostly from impurities in the carbon reductants used in the metal production process.

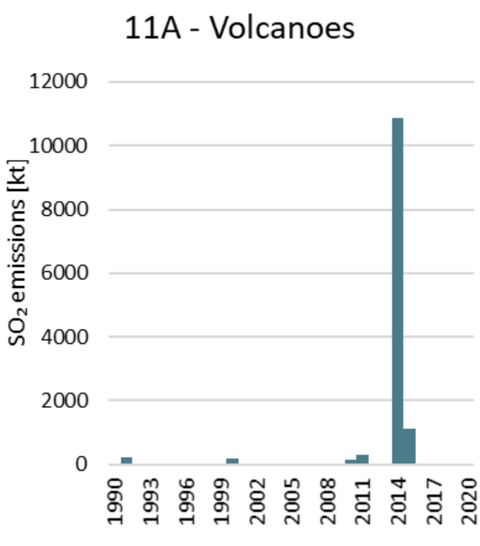


Change over the timeseries: **+ 122 %**



Volcanic eruptions contribute significantly to sulphur emissions (11A, memo). Emissions from this source are reported as a memo item and do not contribute to the national total. The last three eruptions are:

- **2014-2015:** Holuhraun. A large eruption started on 29 August 2014 and ended on 27 February 2015 in the north of the Vatnajökull ice sheet. It was the biggest eruption in Iceland since 1783.
- **2011:** Grímsvötn. The eruption lasted from 21 until 28 May. During that time the SO_2 emitted was 12 times more than total anthropogenic emissions in 2011.
- **2010:** Eyjafjallajökull. The eruption lasted from 14 April until 23 May. The SO_2 emitted was 71% more than total anthropogenic emissions in Iceland in 2010.



The trend overview for SO_x emissions is provided above. The main source of SO_x emission are geothermal power plants. The overall trend in the emissions can mostly be explained by changes within the emissions from the plants. Other sources are metal production and fishing ships. SO_x emissions in Iceland are mainly from the subsectors described below. The emissions from these sources can be seen in Table 2.3.

- **Geothermal energy (1B2d):** Geothermal energy exploitation is the largest source of sulphur emissions in Iceland. Sulphur is emitted from geothermal power plants in the form of H_2S. Emissions have increased substantially since 1990 due to electricity production at geothermal power plants, increasing approximately 15-fold since 1990. However, in recent years the SO_2 emissions have started decreasing following the onset in 2014 of a sulphur capture and storage project (Sulfix) at one of the geothermal power plants (Hellisheiði Power Plant). SulFix consists of separating H_2S from the steam and also reinjecting the gas into the subsurface and mineralizing on contact with the basalt host rock.
- **Aluminium production (2C3):** Aluminium is currently produced at three primary aluminium plants in Iceland. Sulphur emissions are due to the S content of alumina and electrodes in the production process. The emissions rose slightly in 1998 due to the opening of a new facility, and more significantly in the period 2006-2008 due to an expansion of one facility and the onset of operations at a new facility. The emissions from primary Al production have been relatively stable since 2008.
- **Ferroalloys production (2C2):** Currently, two factories produce ferroalloys in Iceland. One company has been producing FeSi75 since 1979 and another one started production of ≥98.5% pure silicon metal in 2018. A third company was operating between 2016-2017 producing silicon metal but has stopped production in 2017. Sulphur emissions are due to the S content of the reducing agents in the production process.
- **National fishing (1A4ciii):** Emissions from the fishing fleet have decreased over the timeline. The reduction is mainly due to lower sulphur content of the fuel and less fuel use.

Table 2.3: SO_x emissions by main sources since 1990 [kt SO_2]

SO_x emissions [kt SO_2]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Geothermal energy (1B2)	13	11	26	30	59	42	42	39	+195%	+30%	-6%
Primary Al production (2C3)	1.3	1.4	2.9	3.4	9.9	11.5	10.5	9.8	+634%	+187%	-6%
Ferroalloys production (2C2)	1.8	1.4	2.0	2.6	2.4	2.1	2.2	2.0	+6%	-26%	-10%
National fishing (1A4ciii)	4.0	5.4	2.2	2.6	2.4	1.9	1.0	0.29	-93%	-89%	-73%
Other	2.7	2.8	2.1	1.4	0.81	0.59	0.45	0.19	-93%	-87%	-58%
Total [kt]	**23**	**22**	**35**	**40**	**74**	**58**	**56**	**51**	**+122%**	**+28%**	**-8%**

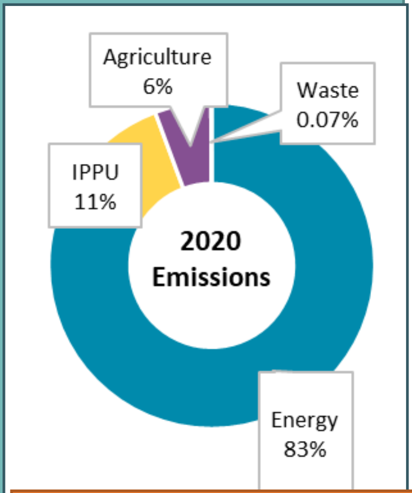
2.2.2 Trends in NO_x emissions

NO_x (NO_2)

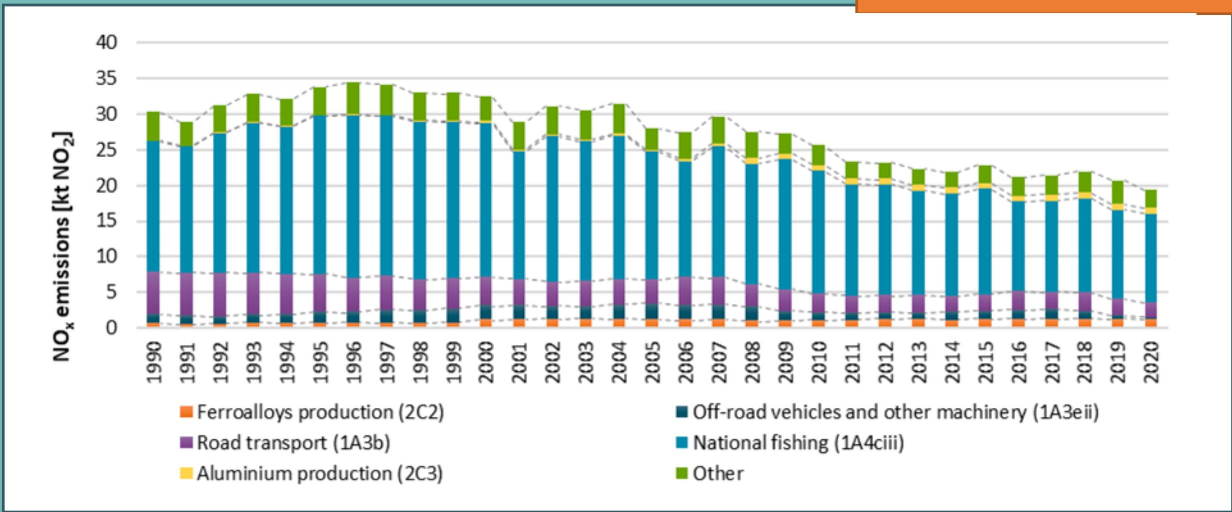
Total emissions in latest inventory year: **19.3 kt**

NO_x emissions are dominated by the energy sector, specifically:

- **Fishing (1A4ciii):** Emissions from fisheries rose between 1990 and 1996 because a substantial portion of the fishing fleet was operating in unusually distant fishing grounds. Since 1996, the emissions have generally been decreasing, with large annual variations due to changes in fish stock size and location. Emissions remain below 1990 levels.
- **Road Transport (1A3b):** Emissions decreased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995, even though fuel consumption has significantly increased. However, the significant expansion of the vehicle fleet over the past few years has caused emissions to rise again.

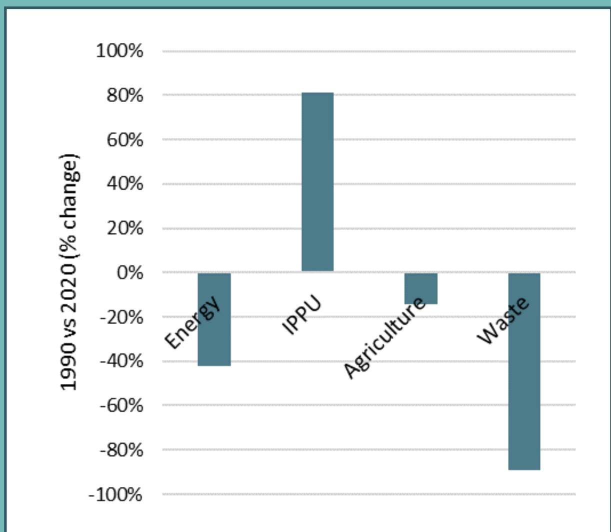


Change over the timeseries:
- 36 %



Other sources of NO_2 emissions include:

- **Metal production (2C):** Since 1990 the production capacity of the metal factories has seen a significant increase, and the NO_x emissions have increased accordingly.
- **Agriculture (3):** The majority of emisions occur due to the application of organic and inorganic fertilisers on agricultual soils.
- **Waste (5):** There are very low emisisons from waste incineration, which have steadily declined since 1990.



The trend overview for NO_x emissions is provided above. The main source of NO_x emissions is the fishing fleet. As fuel is burned, nitrogen monoxide (NO) is formed when nitrogen and oxygen react. In the atmosphere NO oxidises into nitrogen dioxide (NO_2). The overall trend in the emissions can mostly be explained by less fuel usage witin the fishing fleet. Other significant sources are metal production and road transport. NO_x emissions in Iceland are mainly from the subsectors described below. The emissions from these sources can be seen in Table 2.4.

- **National fishing (1A4ciii):** The decrease in emissions over the timline are mainly due to less fuel use within the fishing fleet. However, emissions from fisheries rose from 1990 to 1996 because a substantial portion of the fishing fleet was operating in unusually distant fishing grounds. Since 1996, the emissions have generally been decreasing, with large annual variations, however, due to annual differences in fish stock size and location. Emissions remain below 1990 levels.
- **Road transport (1A3b):** Emissions from Road transport have decreased significantly, especially from passenger cars, due to the use of catalytic converters from 1995 onwards, despite fuel consumption having significantly increased over the timeline.
- **Ferroalloys production (2C2):** Emissions of NO_x from ferroalloys production follow the production amount. Two factories produce ferroalloys in Iceland. One company has been producing FeSi75 since 1979 and another one started production of ≥98.5% pure silicon metal in 2018. A third company was operating between 2016-2017 producing silicon metal but stopped production in 2017.
- **Aluminium production (2C3):** Emissions of NO_x emissions from aluminium production follow the production amount. Aluminium is currently produced at three primary aluminium plants in Iceland. The increase over the timeline mirrors the expansion of the industry.
- **Off-road vehicles and other machinery (1A3eii):** During the economic upswing prior to 2008, there was an increase in fuel use of off-road vehicles and other machinery, which caused an increase in emissions. After the economic crisis in 2008, fuel use and emissions decreased significantly and have remained around the same level as in 1990. Note that emissions in the years 2019 and 2020 are not directly comparable to other years in the timeline for this subsector, see changes in chapter 3.4.1.

Table 2.4: NO_x emissions by main sources since 1990 [kt NO_2]

NO_x emissions [kt NO_2]	1990	1995	2000	2005	2010	2015	2019	2020	Change ‘90-‘20	Change ‘05-‘20	Change ‘19-‘20
National fishing (1A4ciii)	18	22	22	18	17	15	13	12	-32%	-31%	-0.4%
Road transport (1A3b)	5.9	5.3	3.9	3.4	2.6	2.3	2.3	2.1	-65%	-39%	-10.5%
Ferroalloys production (2C2)	0.69	0.79	1.20	1.22	1.12	1.30	1.35	1.30	+88%	+6%	-4.0%
Aluminium production (2C3)	0.088	0.10	0.23	0.27	0.82	0.86	0.83	0.83	+846%	+205%	-0.4%
Off-road vehicles and other machinery (1A3eii)	1.2	1.5	2.0	2.2	1.1	1.1	0.40	0.22	-82%	-90%	-45%
Other	4.0	4.0	3.4	3.0	2.7	2.5	3.3	2.4	-39%	-18%	-26%
Total [kt]	**30**	**34**	**32**	**28**	**26**	**23**	**21**	**19**	**-36%**	**-31%**	**-6.8%**

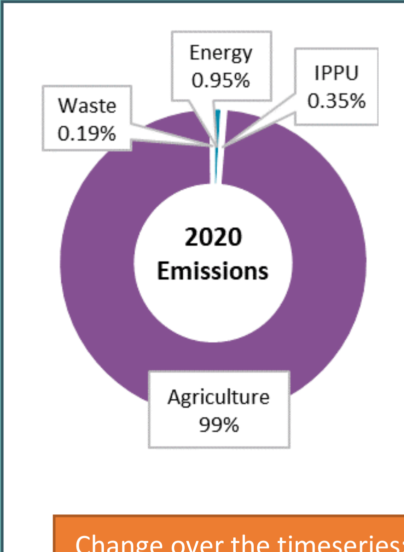
2.2.3 Trends in NH_3 emissions

NH_3

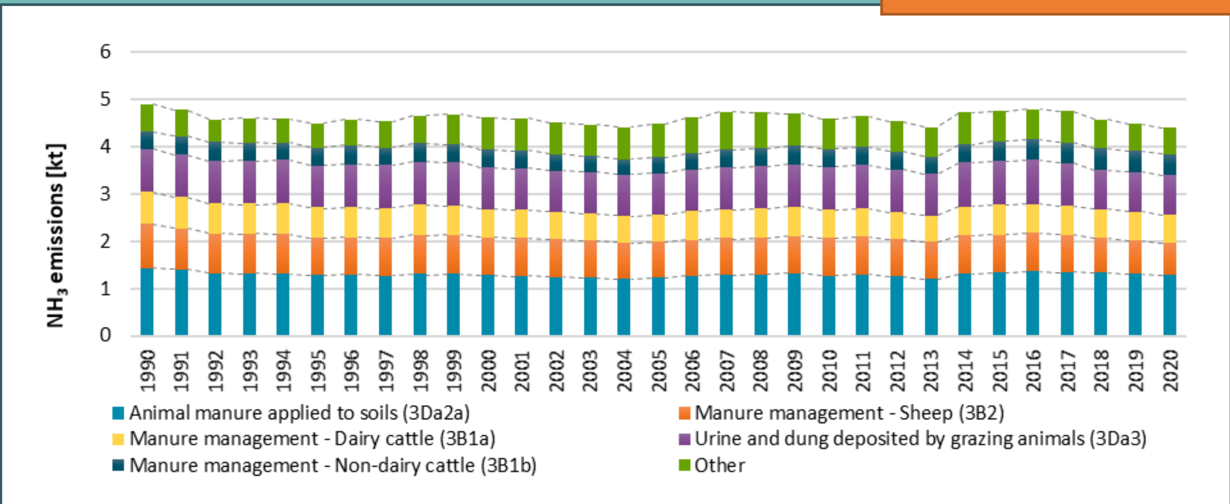
Total emissions in latest year: **4.4 kt**

Ammonia (NH_3) emissions mostly originate from the agriculture sector (3). Emissions have been fluctuating between 5 and 6 kt NH_3 since 1990. The main driver behind the general trend and its oscillations is the trend in livestock population. There is also a small amount of NH_3 from other sources, including:

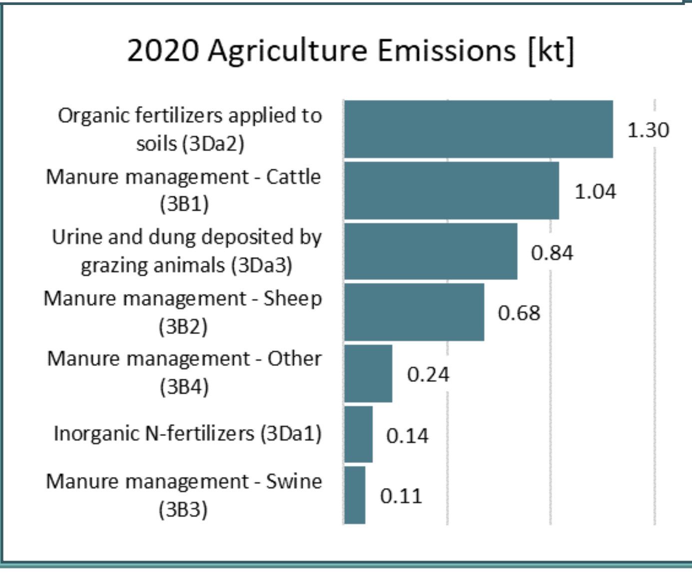
- **Road transport (1A3b):** catalytic converters cause a small amount of NH_3 emissions. Emissions peaked in 2004 due to a reduction of Euro 1 and 2 vehicles on the roads.
- **Mineral products (2A):** mineral wool production.
- **Biological treatment of waste (5B):** NH_3 emissions are released during composting.



Change over the timeseries: **- 10 %**



- Animal manure applied to soils (3Da2), manure management (3B) and manure deposition of grazing animals on pastures (3Da3) are the main sources of NH_3 in Iceland.
- Sheep and cattle are the livestock which have the biggest contribution to ammonia emissions, causing over 80% of NH_3 emissions from manure management.
- NH_3 emissions from inorganic fertilizer application (3Da1) only have a minor contribution to the overall emissions.



The trend overview for ammonia (NH_3) emissions is provided above. The main source of NH_3 is the agriculture sector (3). Most of the emissions come from manure - animal manure applied to soils, manure management and manure deposition of grazing animals on pastures. Emissions have been fluctuating between 4 and 5 kt NH_3 since 1990. The trend in NH_3 emissions is relatively steady which is driven by relatively little overall variability in livestock numbers.

NH_3 emissions in Iceland are mainly from the subsectors described below. The emissions from these sources can be seen inTable 2.5.

- **Manure management (3B):** The main driver behind the general trend and its oscillations is the trend in livestock population of sheep and cattle, as manure management practises have not changed significantly. The population of sheep and dairy cattle has been declining in the past years and the trend in the population of non-dairy cattle is increasing.
- **Animal manure applied to soils (3Da2a):** The main driver behind the general trend and its oscillations is the trend in livestock population as for 3B.
- **Urine and dung deposited by grazing animals (3Da3):** The main driver behind the general trend and its oscillations is the trend in livestock population as for 3B.

Table 2.5: NH_3 emissions by main sources since 1990 [kt]

NH_3 emissions [kt]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Animal manure applied to soils (3Da2a)	1.44	1.28	1.29	1.22	1.27	1.34	1.31	1.29	-10%	+5%	-2.2%
Urine and dung deposited by grazing animals (3Da3)	0.91	0.89	0.88	0.88	0.91	0.92	0.84	0.84	-8%	-5%	-0.3%
Manure management - Sheep (3B2)	0.94	0.78	0.79	0.77	0.80	0.80	0.70	0.68	-28%	-12%	-3.7%
Manure management - Dairy cattle (3B1a)	0.68	0.65	0.60	0.57	0.59	0.64	0.61	0.60	-12%	+5%	-1.4%
Manure management - Non-dairy cattle (3B1b)	0.35	0.37	0.38	0.34	0.39	0.41	0.45	0.44	+25%	+32%	-0.9%
Other	0.60	0.51	0.68	0.70	0.63	0.64	0.58	0.57	-5%	-19%	-1.8%
Total [kt]	**4.91**	**4.49**	**4.62**	**4.48**	**4.59**	**4.75**	**4.49**	**4.41**	**-10%**	**-1.6%**	**-1.8%**

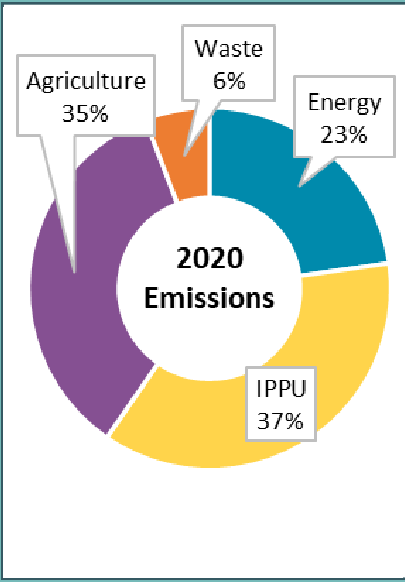
2.2.4 Trends in NMVOC emissions

NMVOC

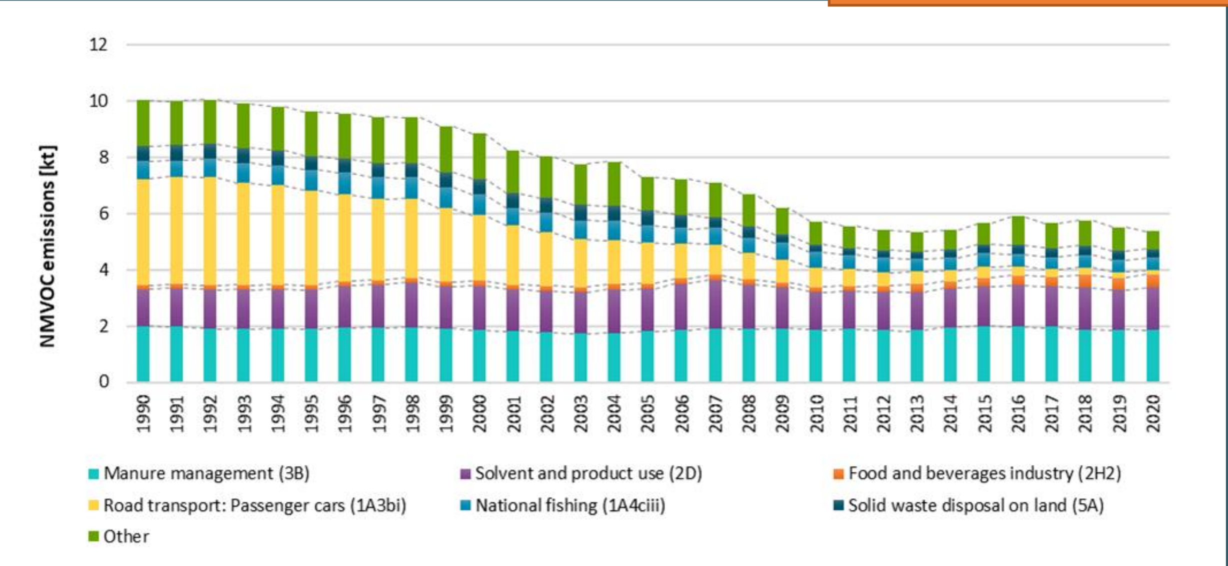
Total emissions in latest inventory year: **5.4 kt**

Many sources contribute to NMVOC emissions in Iceland. The main sources are:

- **Manure management (3B):** Horse and cattle manure management systems are responsible for close to 30% of NMVOC emissions in Iceland. The variations over the years are mostly linked to livestock population fluctuations.
- **Solvent and product use (2D3):** The main source of NMVOC linked to solvent use is domestic solvent use, which in turn is linked to population size. The population in Iceland has been increasing steadily since 1990.
- **Food and beverage industry (2H2):** NMVOC emissions are released during the production of beer and other alcoholic beverages. Emissions have increased in recent years.
- **National fishing (1A4ciii):** Emissions in the latest inventory year were around a third lower than the 1990 level. Annual variations are inherent to the nature of fisheries.
- **Solid waste disposal on land (5A):** Emissions have remained fairly stable over the time series.
- **Road transport (1A3b):** General decrease of emissions over the timeline due to the renewal of the car fleet.



Change over the timeseries: **- 46 %**



The trend overview for non-methane volatile organic compounds (NMVOC) emissions is provided above. NMVOC emissions come from a variety of sources across sectors. The decrease in emission since 1990 is mainly due to the renewal of the car fleet.

NMVOC emissions in Iceland are mainly from the subsectors described below. The emissions from these sources can be seen in Table 2.6.

- **Manure management (3B):** A significant reduction in emissions occurred between 2001-2003, which was mainly caused by a drop in the population of dairy cows, as the manure management practises have not changed substantially.
- **Solvent and product use (2D):** The emissions from solvent and product use have not changed much over the timeline. Some increase is apparent, which can partly be explained by an increasing population and consequent increased usage of solvents.
- **Food and beverages industry (2H2):** The increase in NMVOC emissions from the food and beverage industry is caused by growing spirit production. In the last years, the spirit production has increased much, leading to an export of spirits.
- **National fishing (1A4ciii):** The decrease in emissions over the timeline is mainly due to less fuel use within the fishing fleet. 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. Emissions in the latest year were around a third lower than the 1990 level. Annual variations are inherent to the nature of fisheries.
- **Solid waste disposal on land (5A):** The declining trend in NMVOC emissions in this category is due to a lower amount of waste beeing deposited on land.
- **Road transport: Passenger cars (1A3bi):** The decrease in emissions since 1990 is mainly due to the renewal of the car fleet with the introduction of more cars with higher emission standards.

Table 2.6: NMVOC emissions by main sources since 1990 [kt]

NMVOC emissions [kt]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Manure management (3B)	1.99	1.90	1.86	1.80	1.88	1.99	1.87	1.86	-6%	+3%	-0.6%
Solvent and product use (2D)	1.32	1.41	1.58	1.53	1.34	1.42	1.41	1.51	+15%	-1.0%	7%
Food and beverages industry (2H2)	0.15	0.16	0.17	0.18	0.17	0.30	0.44	0.46	+201%	+162%	6%
National fishing (1A4ciii)	0.63	0.74	0.76	0.61	0.56	0.49	0.43	0.44	-29%	-28%	4%
Solid waste disposal on land (5A)	0.53	0.49	0.53	0.54	0.26	0.31	0.34	0.30	-45%	-45%	-13%
Road transport: Passenger cars (1A3bi)	3.78	3.35	2.33	1.45	0.69	0.40	0.19	0.16	-96%	-89%	-19%
Other	1.63	1.57	1.62	1.18	0.83	0.77	0.85	0.64	-61%	-45%	-24%
Total [kt]	**10.0**	**9.6**	**8.8**	**7.3**	**5.7**	**5.7**	**5.5**	**5.4**	**-46%**	**-26%**	**-3%**

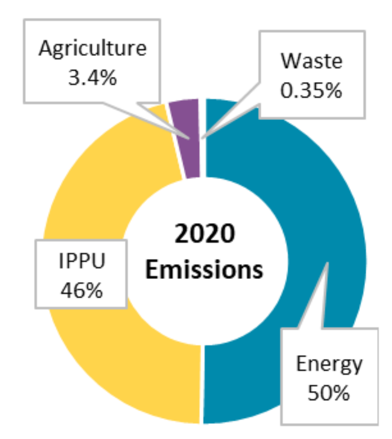
2.2.5 Trends in $PM_{2.5}$ emissions

$PM_{2.5}$

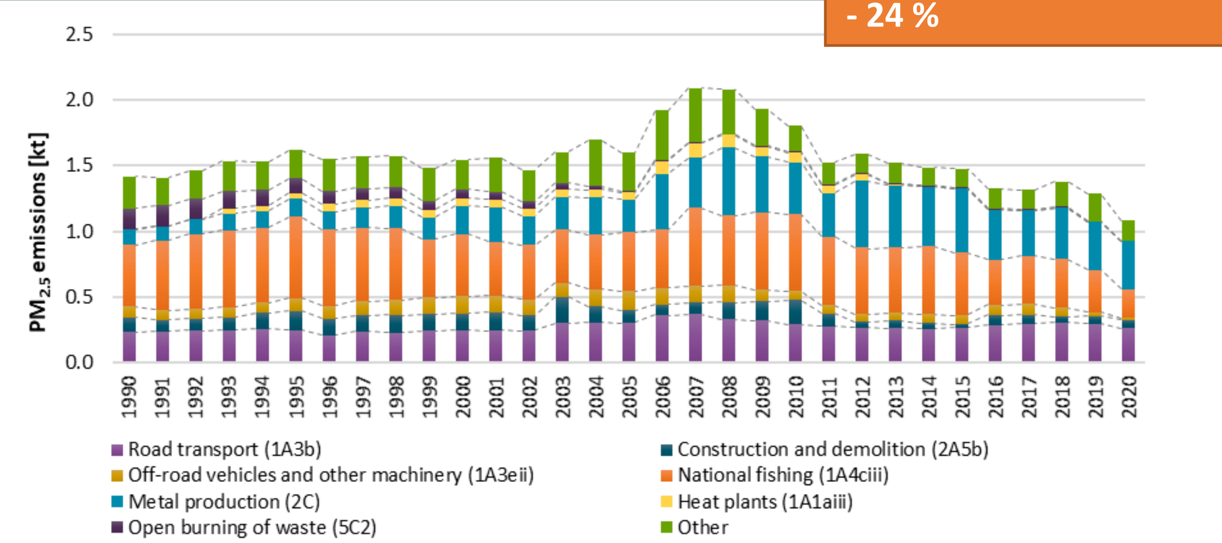
Total emissions in latest inventory year: **1.1 kt**

Emissions of $PM_{2.5}$ are dominated by the energy and IPPU sectors, the main sources are:

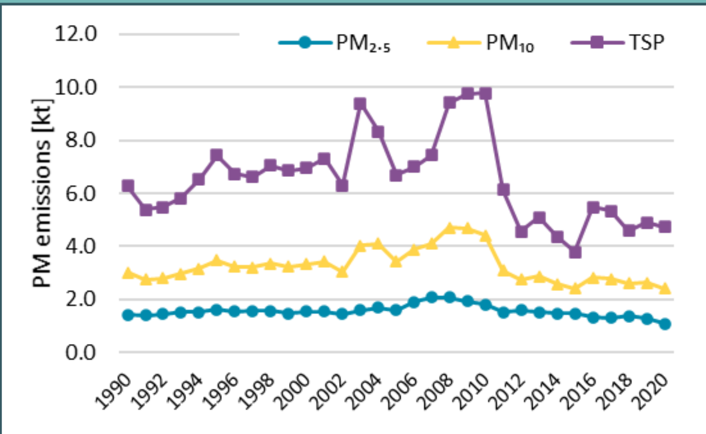
- **Metal production (2C):** Production capacity in the metal production sector has increased substantially.
- **Road Transport (1A3b):** Fluctuations in PM emissions result from the combination of changes in the pollution control standards and an increase in vehicle fleet size.
- **National fishing (1A4ciii):** Emissions remain below 1990 levels, however there are large annual variations due to the inherent nature of fisheries.
- **Construction and demolition (2A5b):** The emissions from this category are from road and building construction.
- **Open burning of waste (5C2):** Open burning of waste resulted in PM emissions in the 1990s.



Change over the timeseries: **- 24 %**



Particulate Matter:
Emissions from PM_{10} and Total Suspended Particulate (TSP) follow the same trend as $PM_{2.5}$ and are dominated by the same main sources.



The trend overview for particulate matter $PM_{2.5}$ emissions is provided above. $PM_{2.5}$ emissions are predominantly derived from metal production, road transport and fishing. The overall decrease in emissions since 1990 can largely be explained by less fuel usage witin the fishing fleet.

$PM_{2.5}$ emissions in Iceland are mainly from the subsectors described below. The emissions from these sources can be seen in Table 2.7.

- **Metal production (2C):** PM emissions from aluminium and ferroalloys production follow the production amount. The increase over the timeline mirrors the expansion of the industry.
- **Road transport (1A3b):** Fluctuations in PM emissions result from the combination of changes in the pollution control standards, increased fuel usage and vehicle kilometres driven.
- **National fishing (1A4ciii):** The decrease in emissions over the timeline is mainly due to less fuel use within the fishing fleet.
- **Construction and demolition (2A5b):** The emissions follow the number of houses built and roads constructed. The main reason for the decrease in PM emissions over the timeline is the reduction in road construction.
- **Off-road vehicles and other machinery (1A3eii):** During the economic upswing prior to 2008, there was an increase in fuel use for off-road vehicles and other machinery, which caused an increase in emissions.
- **Open burning of waste (5C2):** Open pit burning was a common practice in the early nineties, but is not practiced in Iceland anymore. Since 2010 New Year's Eve bonfires, which are heavily restricted, have been the only source of emissions in the category. In 2020 there were no New Year's Eve bonfires due to Covid-19.
- **Heat plants (1A1aiii):** Waste incineration with energy recovery was occurring between 1993-2013, which caused signifcant emissions.

Table 2.7: $PM_{2.5}$ emissions by main sources since 1990 [t]

$PM_{2.5}$ emissions [t]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Metal production (2C)	119	135	216	248	396	490	365	363	+206%	+46%	-0.6%
Road transport (1A3b)	229	246	247	307	290	266	297	262	+14%	-15%	-12%
National fishing (1A4ciii)	469	622	475	450	585	472	326	222	-53%	-51%	-32%
Construction and demolition (2A5b)	117	145	128	93	185	29	58	62	-47%	-33%	8%
Off-road vehicles and other machinery (1A3eii)	80	98	130	143	70	70	26	14	-82%	-90%	-45%
Open burning of waste (5C2)	159	111	67	10	7.6	7.1	7.1	NO	-100%	-100%	-100%
Heat plants (1A1aiii)	2.3	45	56	55	75	0.11	0.012	NO	-100%	-100%	-100%
Other	244	218	226	293	198	140	208	158	-35%	-46%	-24%
Total [t]	**1420**	**1621**	**1545**	**1598**	**1806**	**1475**	**1286**	**1081**	**-24%**	**-32%**	**-16%**

Emissions of PM_{10} can be seen in Table 2.8 and Figure 2.1. Emissions of TSP (total suspended particles) can be seen in Table 2.9 and Figure 2.2. The trend descriptions above are also applicable to PM_{10} and TSP trends.

Table 2.8: PM_{10} emissions by main sources since 1990 [t]

PM_{10} emissions [t]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Construction and demolition (2A5b)	1169	1454	1281	929	1849	287	575	619	-47%	-33%	8%
Road transport (1A3b)	327	350	364	460	452	439	513	451	+38%	-2%	-12%
Aluminium production (2C3)	73	83	145	199	401	410	392	366	+400%	+84%	-7%
Quarrying and mining of minerals other than coal (2A5a)	215	215	215	566	479	169	329	329	+53%	-42%	0.0%
National fishing (1A4ciii)	489	645	501	469	601	487	339	238	-51%	-49%	-30%
Ferroalloys production (2C2)	85	97	141	128	108	232	69	87	+2%	-32%	26%
Open burning of waste (5C2)	172	119	73	11	8.2	7.7	7.7	NO	-100%	-100%	-100%
Other	491	513	610	680	519	381	400	330	-33%	-51%	-17%
Total [t]	**3022**	**3477**	**3330**	**3442**	**4417**	**2413**	**2625**	**2420**	**-20%**	**-30%**	**-8%**

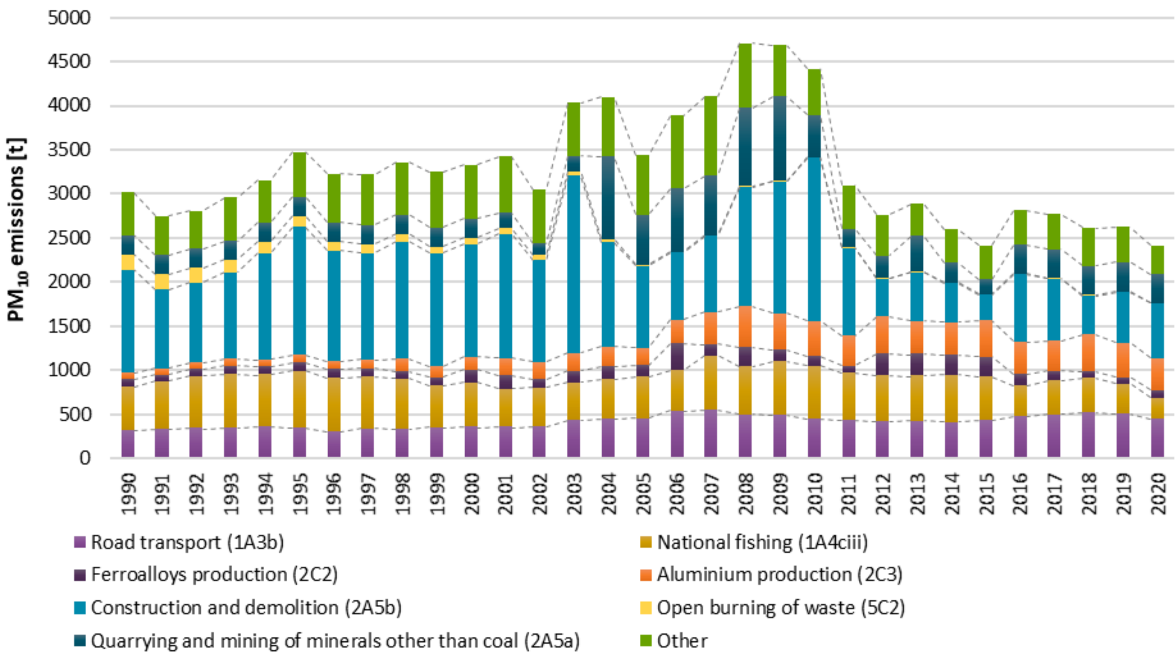


Figure 2.1: PM_{10} emissions by sector, since 1990.

Table 2.9: TSP emissions by main sources since 1990 [t]

TSP emissions [t]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Construction and demolition (2A5b)	3910	4863	4283	3105	6185	960	1921	2066	-47%	-33%	7.5%
Road transport (1A3b)	516	553	593	757	769	776	930	817	+58%	+8%	-12%
Quarrying and mining of minerals other than coal (2A5a)	439	439	439	1155	977	345	671	671	+53%	-42%	0.0%
Aluminium production (2C3)	88	100	174	240	481	492	471	440	+401%	+83%	-6.6%
National fishing (1A4ciii)	489	645	501	469	601	487	339	238	-51%	-49%	-30%
Other	844	844	956	956	765	736	558	495	-41%	-48%	-11%
Total [t]	**6287**	**7444**	**6946**	**6682**	**9778**	**3796**	**4892**	**4728**	**-25%**	**-29%**	**-3.4%**

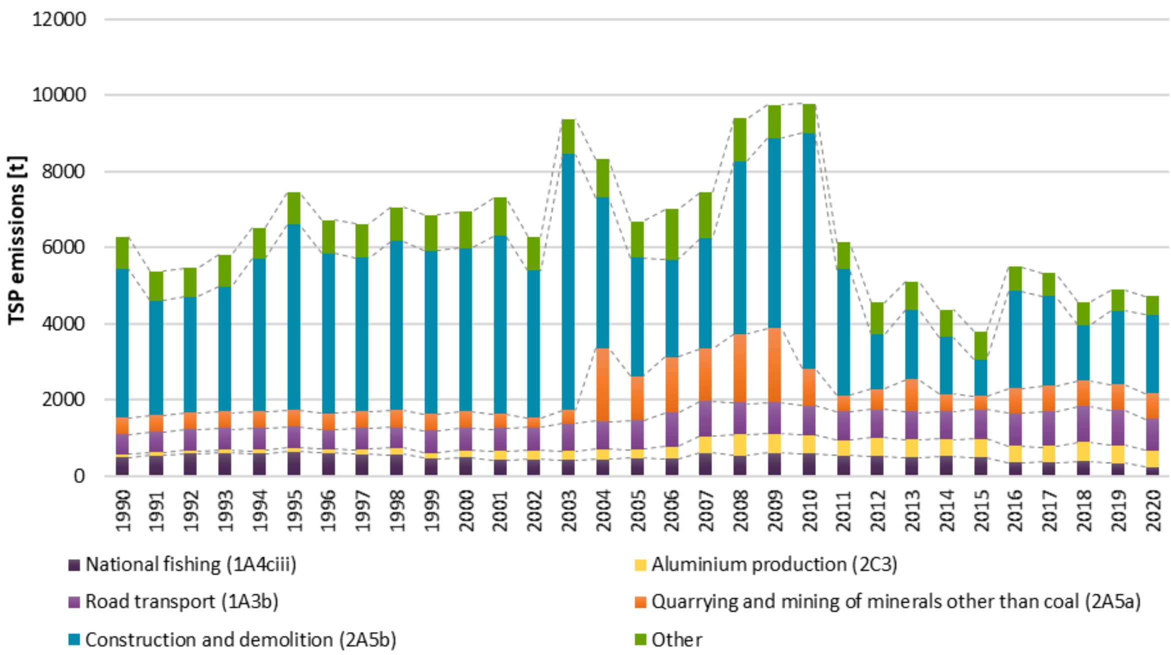


Figure 2.2: TSP emissions by sector, since 1990.

2.2.6 Trends in BC (black carbon) emissions

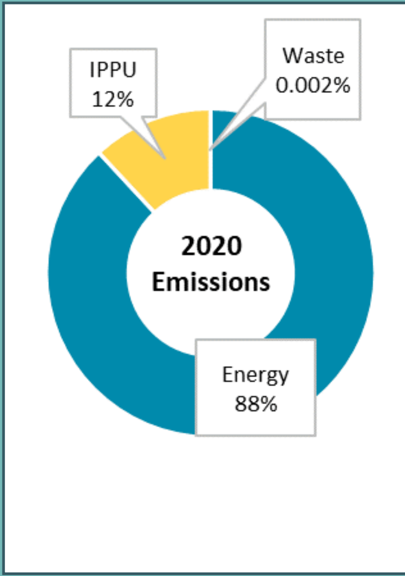
BC

Total emissions in latest inventory year: **87 t**

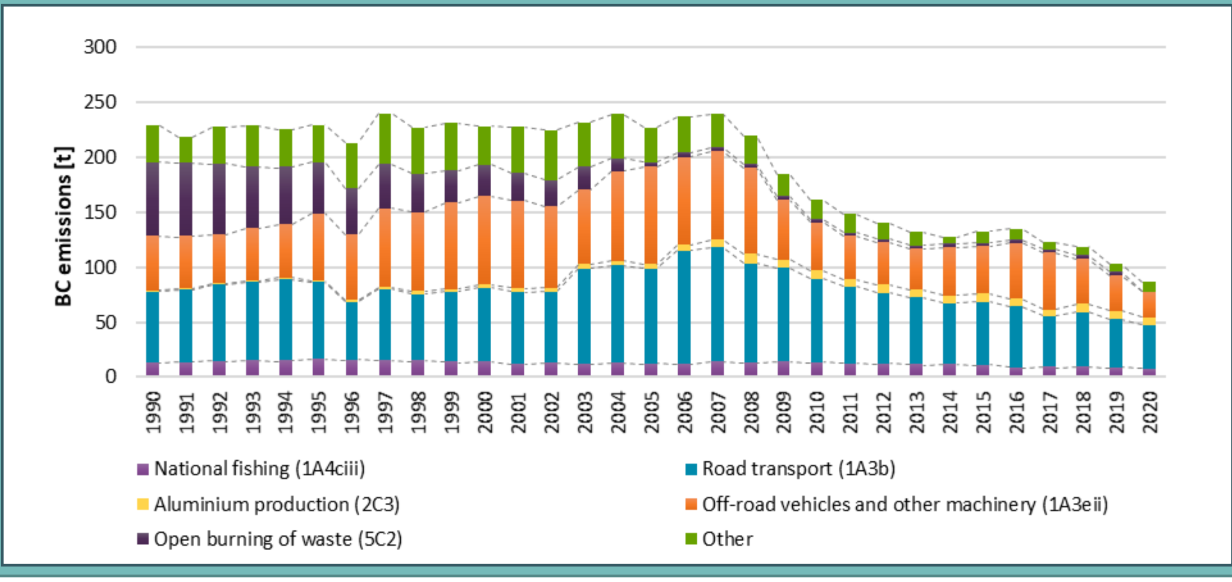
Black carbon contributes relatively few emissions compared to the NECD pollutants. Emissions of black carbon are heavily dominated by the energy sector. As with SO_x there are no emissions of black carbon associated with the agriculture sector. The majority of black carbon emissions are from mobile sources:

- **Road transport (1A3b)**
- **Off-road vehicles and other machinery (1A3eii)**
- **Fishing (1A4ciii)**
- **Off-road vehicles and other machinery (1A4cii)**

After the energy sector, the next biggest source of black carbon emisisons is from primary aluminum production (2C3). Emissions have increased with the expanision of the production capacity of the metal factories.



Change over the timeseries:
- 62 %



The trend overview for black carbon (BC) emissions is provided above. Emissions of black carbon are heavily dominated by the energy sector. As with SO_x there are no emissions of black carbon associated with the agriculture sector. The majority of black carbon emissions are from mobile sources. The overall decrease in emissions since 1990 can mostly be explained by less fuel usage and changes in pollution standards.

BC emissions in Iceland are mainly from the subsectors described below. The emissions from these sources can be seen in Table 2.10.

- **Road transport (1A3b):** Fluctuations in BC emissions result from the combination of changes in the pollution control standards and an increase in vehicle fleet size.
- **Off-road vehicles and other machinery (1A3eii):** During the economic upswing prior to 2008, there was an increase in fuel use for off-road vehicles and other machinery, which caused an increase in emissions.
- **National fishing (1A4ciii):** The decrease in emissions over the timline is mainly due to less fuel use within the fishing fleet.
- **Aluminium production (2C3):** Emissions of BC from aluminium production follow the production amount. Aluminium is currently produced at three primary aluminium plants in Iceland. The increase over the timeline mirrors the expansion of the industry.
- **Open burning of waste (5C2):** Open pit burning was a common procedure in the early nineties but is not practiced in Iceland anymore. Since 2010 New Year's Eve bonfires, which are heavily restricted, have been the only source of emissions in the category. In 2020 there were no New Year's Eve bonfires due to Covid-19.
-

Table 2.10: BC emissions by main sources since 1990 [t]

BC emissions [t]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Road transport (1A3b)	65	70	67	86	76	57	44	40	-38%	-54%	-9%
Off-road vehicles and other machinery (1A3eii)	50	61	81	89	44	43	33	24	-53%	-73%	-28%
National fishing (1A4ciii)	13	16	14	12.6	14.0	11.6	8.9	7.7	-41%	-39%	-14%
Aluminium production (2C3)	1.3	1.5	2.7	3.6	7.3	7.5	7.2	6.7	+398%	+84%	-7%
Open burning of waste (5C2)	67.0	46.6	28.3	4.1	3.2	3.0	3.0	NO	-100%	-100%	-100%
Other	33.5	34.1	35.1	31.6	17.6	10.4	7.4	8.8	-74%	-72%	19%
Total [t]	**229**	**229**	**228**	**227**	**161**	**133**	**103**	**87**	**-62%**	**-62%**	**-16%**

2.2.7 Trends in carbon monoxide (CO) emissions

CO emissions in Iceland are mainly from the subsectors described below. The emissions from these sources can be seen in Table 2.11. Figure 2.3 shows the sectoral emission trends since 1990.

- **Aluminium production (2C3):** The main source of CO is primary aluminium production. The varying increase in emissions from the IPPU sector corresponds to the expansion of production capacity.
- **Road transport (1A3b):** In the earlier part of the time series, more than half of the total CO emissions originated from road transport. Emissions from road transport have been steadily decreasing since 1990 due to advances in pollution control equipment in road vehicles, and now they amount to a small percentage of the total emissions.
- **Aviation (Landing and Take-off):** An apparent sudden decrease in CO emissions from the energy sector between 2004 and 2005 is an artefact caused by the use of different data sets; for the years 1990-2004, emissions are estimated using fuel sales statistics and the Tier 1 emission factor from the 2019 EMEP/EEA Guidelines; for the years since 2005, emissions are reported as provided by Eurocontrol.
- **Open burning of waste (5C2):** Open pit burning was a common procedure in the early nineties but is not practiced in Iceland anymore. Since 2010 New Year's Eve bonfires, which are heavily restricted, have been the only source of emissions in the category. In 2020 there were no New Year's Eve bonfires due to Covid-19.

Table 2.11: CO emissions by main sources since 1990 [kt]

CO emissions [kt]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Aluminium production (2C3)	10.5	12.0	27.2	32.7	98.3	103	100	99.7	+846%	+205%	-0.4%
Road transport (1A3b)	41.8	33.6	22.5	15.1	8.7	5.7	3.9	3.1	-93%	-79%	-20%
International aviation LTO (civil) (1A3ai(i))	8.8	9.5	16.4	0.12	0.07	0.14	0.22	0.10	-99%	-13%	-54%
Domestic aviation LTO (civil) (1A3aii(i))	5.5	4.9	4.6	0.024	0.017	0.015	0.014	0.013	-100%	-45%	-6.8%
Open burning of waste (5C2)	2.1	1.5	0.90	0.13	0.10	0.095	0.095	NO	-100%	-100%	-100%
Other	3.0	3.1	3.5	3.4	2.3	2.1	1.8	1.8	-40%	-47%	-2%
Total [kt]	**72**	**65**	**75**	**51**	**109**	**111**	**106**	**105**	**+46%**	**+104%**	**-1.4%**

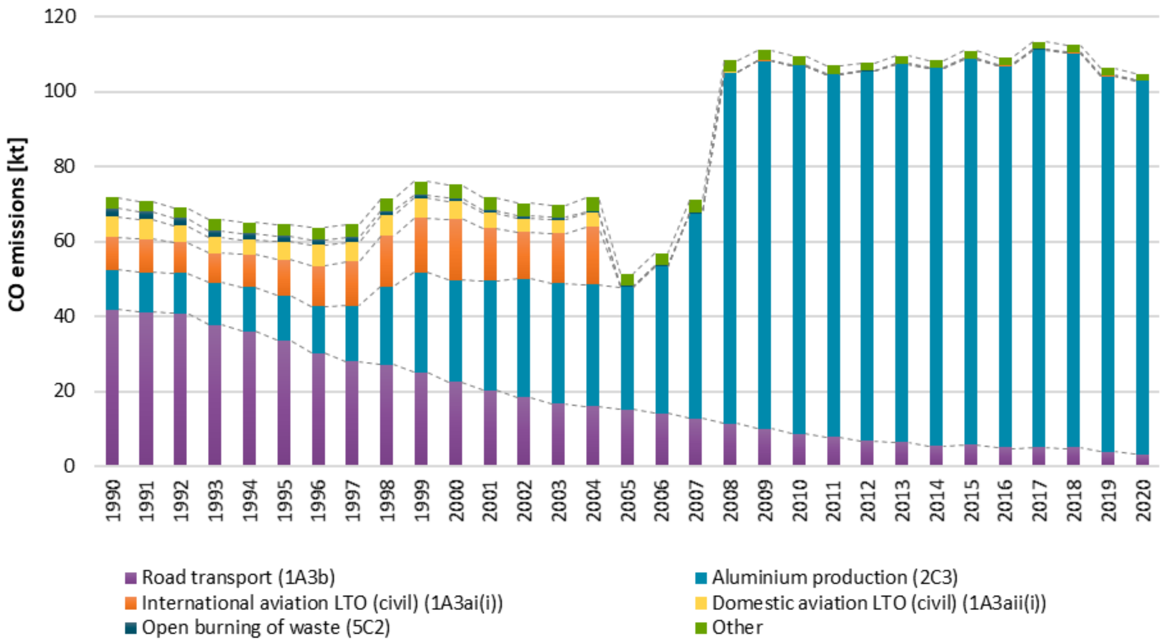


Figure 2.3 CO emissions by sector, since 1990.

2.3 Emission Trends for Persistent Organic Pollutants (POPs)

The total amount of dioxins, PAH4, HCB and PCB emitted in Iceland in 1990 and 2020 is presented in Table 2.12. Emissions of all POPs have significantly decreased since 1990.

Table 2.12 Emissions of POPs in Iceland 1990 and 2020.

Year	Dioxin [g I-TEQ]	PAH4 [t]	HCB [kg]	PCB [kg]
1990	10.72	0.594	0.151	0.300
2020	0.74	0.061	0.068	0.015
Change 1990-2020	-93%	-90%	-55%	-95%

2.3.1 Trends in dioxin emissions

Dioxin emissions in Iceland have decreased by more than 90% since 1990. The main reason for this large reduction of emissions is a significant decrease in open burning of waste between 1990 and 2004. In recent years the main contributors to dioxin emissions have been waste incineration (both hazardous waste (5C1bii) and industrial waste (5C1bi)), accidental fires (reported under NFR 5E) and bonfires (reported under NFR 5C2 open burning of waste).

Dioxin emissions in Iceland are mainly from the subsectors described below. The emissions from these sources can be seen in Table 2.13 and Figure 2.4.

- **Hazardous waste incineration (5C1bii), Industrial waste incineration (5C1bi) and Open burning of waste (5C2):** Practices of waste disposal treatment have undergone a radical change in Iceland since 1990. This is one of the main reasons for the substantial decline in dioxin emissions since 1990. Various factors that have influenced the dioxin emission profile from the waste sector are described below:
    - Open pit burning, which used to be the most common means of waste disposal outside the capital area, has gradually decreased since 1990. Open pit burning is practically non-existent today, the last site was closed by the end of 2010;
    - In recent years, smaller waste incinerators, which had higher emissions, have been closed. Currently, there is only one large incineration plant operating in Iceland. The incineration plant is called Kalka and it does not recover energy.
    - Emissions from bonfires around New Year‘s Eve 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.
    - The total amount of waste being incinerated has decreased.
- **Accidental fires (5E):** A peak in emissions from accidental fires occurred 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 which was estimated to be 10% the size of the fire 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.

- **Public electricity and heat generation (1A1a):** Waste burning with energy recovery occurred in Iceland between 1994 and 2012. Other sources within the energy sector, contributing to dioxin emissions since 2013, are passenger cars and fishing, but in general the emissions from those sources are decreasing.

Table 2.13: Dioxin emissions by main sources since 1990 [g I-TEQ].

Dioxin emissions [g I-TEQ]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Hazardous waste incineration (5C1bii)	NO	NO	NO	NO	0.09	0.26	0.44	0.34			-23%
Accidental fires (5E)	0.085	0.085	0.085	0.14	0.11	0.069	0.11	0.10	+22%	-25%	-9%
Industrial waste incineration (5C1bi)	NO	NO	NO	NO	NO	0.04	0.30	0.16			-48%
Public electricity and heat generation (1A1a)	3.3E-4	0.38	0.39	0.38	0.29	3.9E-5	3.4E-5	1.2E-5	-96%	-100%	-65%
Open burning of waste (5C2)	10.50	6.83	2.80	0.16	0.13	0.11	0.11	NO	-100%	-100%	-100%
Other	0.14	0.16	0.17	0.20	0.21	0.22	0.39	0.14	-0%	-30%	-65%
Total [g I-TEQ]	**10.7**	**7.4**	**3.4**	**0.87**	**0.83**	**0.70**	**1.35**	**0.74**	**-93%**	**-15%**	**-46%**

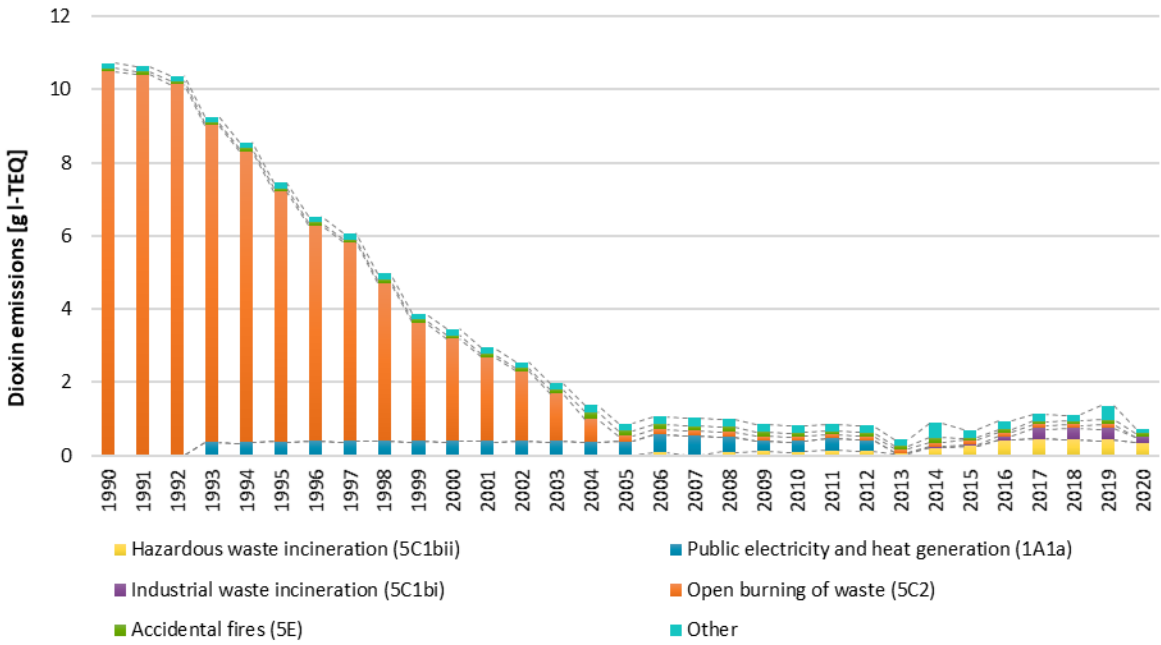


Figure 2.4 Dioxin emissions by main sources since 1990 [g I-TEQ].

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.

2.3.2 Trends in polycyclic aromatic hydrocarbons (PAHs) emissions

Since 1990, total emissions of PAH4 in Iceland have decreased substantially. The main reason for the significant reduction of PAH4 emissions is the significant decrease in open burning of waste between 1990 and 2004. In recent years the main contributors to PAH4 emissions have been Road transport (1A3b), Aluminium production (2C3) and Ferroalloys production (2C2).

PAH4 emissions in Iceland are mainly from the subsectors described below. The emissions from these sources can be seen in Table 2.14 and Figure 2.5.

- **Road transport (1A3b):** Road transport is an important source of PAH4 emissions in Iceland. PAH4 emissions from this sector are estimated to have more than doubled since 1990 due to more vehicle kilometers travelled and consequent increase in fuel usage.
- **Metal production (2C):** Since 2005 PAH4 emissions from industrial processes (Industry) have increased due to substantially increased production capacity in the metal production sector. The contribution of the sector to the total PAH4 emissions has been steadily increasing since 1990. 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.
- **Accidental fires (5E):** A peak in emissions from accidental fires occurred 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 which was estimated to be 10% the size of the fire 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.
- **Stationary combustion: Non-metallic minerals (1A2f):** Significant PAH emissions resulted from the combustion of other bitunimous coal for cement production until 2012 when production was stopped.
- **Open burning of waste (5C2):** PAH4 emissions from waste incineration have decreased much since 1990, partly because outdated incineration plants and open pit burning have been closed down. See a more detailed description of the decrease in waste incineration emissions in section 2.3.1 on dioxin above.

Table 2.14: PAH4 emissions by main sources since 1990 [t].

PAH4 emissions [t]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Road transport (1A3b)	7.6E-3	7.6E-3	7.8E-3	0.010	0.012	0.015	0.021	0.019	+150%	+82%	-8%
Aluminium production (2C3)	1.7E-3	1.9E-3	4.3E-3	0.005	0.016	0.016	0.016	0.016	+846%	+205%	-0%
Ferroalloys production (2C2)	9.0E-3	1.0E-2	1.6E-2	0.016	0.015	0.017	0.014	0.015	+66%	-6%	+4%
Accidental fires (5E)	7.8E-3	7.8E-3	7.1E-3	9.1E-3	6.1E-3	6.5E-3	6.7E-3	5.4E-3	-30%	-40%	-19%
Stationary combustion: Non-metallic minerals (1A2f)	0.070	0.033	0.050	0.076	0.014	9.2E-8	1.1E-7	1.1E-7	-100%	-100%	-2%
Open burning of waste (5C2)	0.486	0.339	0.208	0.033	0.025	0.024	0.024	NO	-100%	-100%	-100%
Other	0.011	0.014	0.013	0.013	0.011	0.012	7.8E-3	5.5E-3	-50%	-57%	-29%
Total [t]	**0.594**	**0.414**	**0.306**	**0.162**	**0.099**	**0.090**	**0.089**	**0.061**	**-90%**	**-63%**	**-32%**

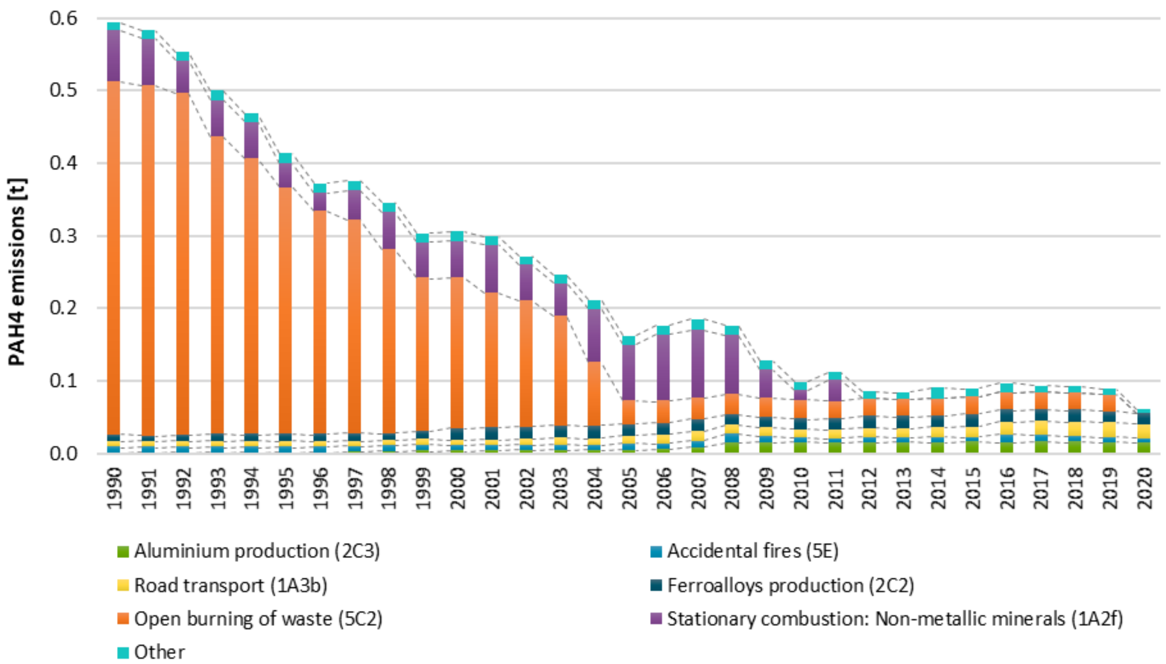


Figure 2.5 PAH4 emissions by sector, since 1990.

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 POPs - Protocol.

2.3.3 Trends in hexachlorobenzene (HCB) emissions

There have been significant changes in HCB emissions since 1990. The main reason for the significant reduction of HCB emissions is a significant decrease in open burning of waste between 1990 and 2004. The main sources of HCB emissions are Clinical waste incineration (5C1biii), National fishing (1A4ciii) and Aluminium production (2C3). PAH4 emissions in Iceland are mainly from the subsectors described below. The emissions from these sources can be seen in Table 2.15 and Figure 2.6.

- **Clinical waste incineration and hazardous waste incineration (5C1biii and 5C1bii):** Waste incineration was responsible for the majority of HCB emissions in Iceland in recent years. The increase in HCB emissions between 2013 and 2014 is due to an increase in incineration of clinical waste.
- **National fishing (1A4ciii):** 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. Since then, emissions have been following a generally decreasing trend, but with fluctuations due to varying conditions in the fishing industry (renewing of fishing fleet, status of fish stocks, etc), as well as different ratios of the use of marine gas oil versus heavy fuel oil.
- **Aluminium production (2C3):** The main HCB source within IPPU was the cement industry until 2004, when a secondary aluminium production facility opened leading to an increase in HCB emissions. From 2009, production started decreasing, until 2013 when another secondary production plant opened, reversing the decreasing trend. HCB emissions from primary aluminium production are not estimated due to the fact that there is no emission factor available in the 2019 EMEP/EEA Guidebook.
- **Open burning of waste (5C2):** HCB emissions from open burning of waste have decreased much since 1990, partly because outdated incineration plants and open pit burning have been closed down. See a more detailed description of the decrease in waste incineration in section 2.3.1 on dioxin above.

Table 2.15: HCB emissions by main sources since 1990 [kg].

HCB emissions [kg]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	'05-'20	'19-'20
Clinical waste incineration (5C1biii)	NO	NO	NO	0.020	8.3E-3	0.029	0.040	0.041		+110%	+4%
National fishing (1A4ciii)	0.021	0.027	0.024	0.021	0.022	0.019	0.015	0.013	-40%	-38%	-13%
Aluminium production (2C3)	NA	NA	NA	0.011	0.010	0.011	0.011	0.011		-2%	+2%
Hazardous waste incineration (5C1bii)	NO	NO	NO	NO	5.4E-4	1.5E-3	2.5E-3	1.9E-3			-23%
Open burning of waste (5C2)	0.128	0.085	0.048	3.8E-4	2.9E-4	1.5E-4	1.5E-4	NO	-100%	-100%	-100%
Other	0.002	0.012	0.015	0.016	0.019	1.4E-3	3.9E-3	1.3E-3	-48%	-92%	-68%
Total [kg]	**0.151**	**0.124**	**0.087**	**0.067**	**0.061**	**0.061**	**0.072**	**0.068**	**-55%**	**+1%**	**-5%**

Hexachlorobenzene (HCB) or perchlorobenzene is a chlorocarbon with the molecular formula C6Cl6. HCB is a fungicide that was first introduced in 1945 for seed treatment, especially for the control of bunt of wheat. HCB is currently emitted as a by-product in the manufacture of several chlorinated solvents. Overall, processes resulting in dioxin formation also result in HCB emissions. HCB is considered to be a probable human carcinogen. HCB is a very persistent environmental chemical due to its chemical stability and resistance to biodegradation.

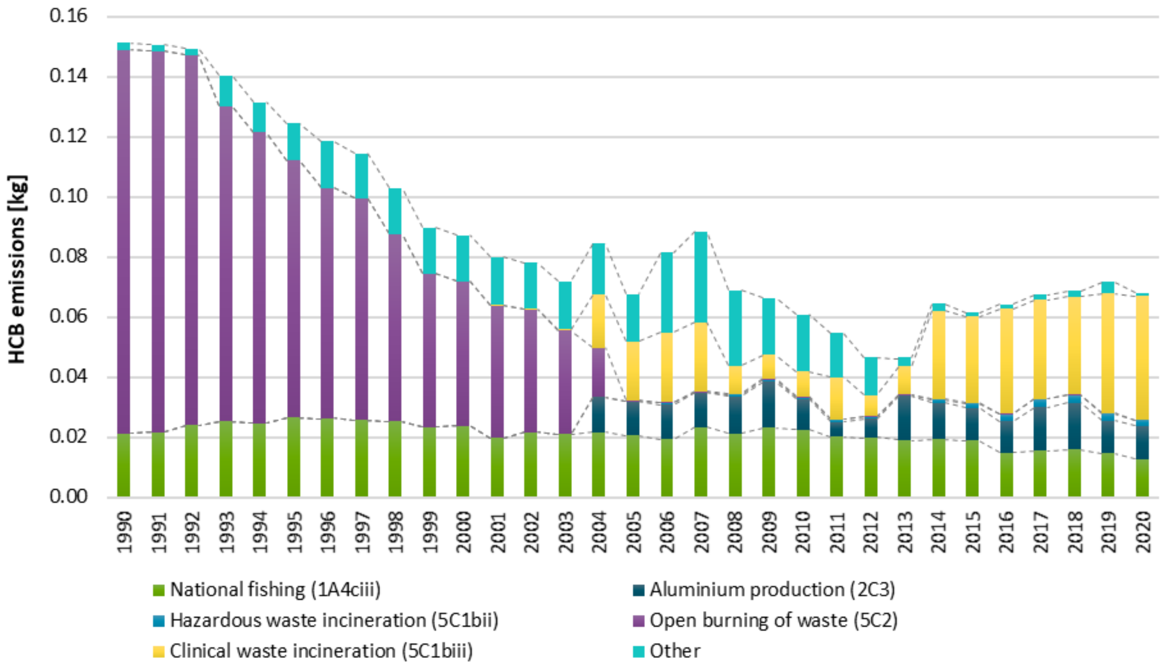


Figure 2.6 HCB emissions by sector, since 1990.

2.3.4 Trends in polychlorinated biphenyl (PCB) emissions

In the early years of the time series, one of the main sources of PCB in Iceland was open burning of waste, following a decreasing trend between 1990 and 2004 as seen above for the other POPs. The other main sources contributing to PCB emission trends are Clinical waste incineration (5C1biii), National fishing (1A4ciii), Stationary combustion: Non-metallic minerals (1A2f) and Heat plants (1A1aiii). 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 and closed in 2016. PCB emissions in Iceland are mainly from the subsectors described below. The emissions from these sources can be seen in Table 2.16 and Figure 2.7.

The analysis of the trends in PCB emissions in Iceland must be interpreted with care as only a few sources have been estimated, which reflects the lack of emission factors in the 2019 EMEP/EEA Guidebook.

- **Clinical waste incineration (5C1biii):** Waste incineration was responsible for the majority of PCB emissions in recent years, as clinical waste was burnt openly in earlier years and the burning of clinical waste in Kalka started in 2011.
- **National fishing (1A4ciii):** 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. Since then, emissions have been following a generally decreasing trend, but with fluctuations due to varying conditions in the fishing industry (renewing of fishing fleet, status of fish stocks, etc.), as well as different ratios of the use of marine gas oil versus residual fuel oil. Those two fuel types have very different emission factors for PCB. Fishing is now the second largest contributor of PCB.
- **Open burning of waste (5C2):** PCB emissions from open burning of waste were the dominating source of emissions in 1990. Open pit burning was occurring between 1990 and 2004. In 2004 the incineration plant Kalka opened and emission factors for PCB emissions from incineration are smaller than from open burning, therefore there is a significant decrease in emissions from waste from 2005.
- **Stationary combustion: Non-metallic minerals (1A2f):** Significant PCB emissions resulted from the combustion of other bitunimous coal for cement production until 2012 when production was stopped.
- **Heat plants (1A1aiii):** Waste incineration with energy recovery, which caused signifcant emissions, was occurring between 1993-2013.

Table 2.16: PCB emissions by main sources since 1990 [kg].

PCB emissions [kg]	1990	1995	2000	2005	2010	2015	2019	2020	Change		
									'90-'20	'05-'20	'19-'20
Clinical waste incineration (5C1biii)	NO	NO	NO	0.004	0.002	0.006	0.008	0.008		+110%	+4%
National fishing (1A4ciii)	0.028	0.041	0.022	0.026	0.046	0.035	0.020	0.006	-78%	-77%	-70%
Open burning of waste (5C2)	0.188	0.126	0.071	0.000	0.000	0.000	0.000	NO	-100%	-100%	-100%
Stationary combustion: Non-metallic minerals (1A2f)	0.082	0.038	0.058	0.088	0.016	NA	NA	NA	-100%	-100%	
Heat plants (1A1aiii)	NA	0.025	0.032	0.032	0.043	NA	NA	NA		-100%	
Other	0.003	0.005	0.004	0.004	0.004	0.012	0.004	0.001	-72%	-82%	-80%
Total [kg]	**0.300**	**0.235**	**0.187**	**0.154**	**0.111**	**0.053**	**0.031**	**0.015**	**-95%**	**-90%**	**-52%**

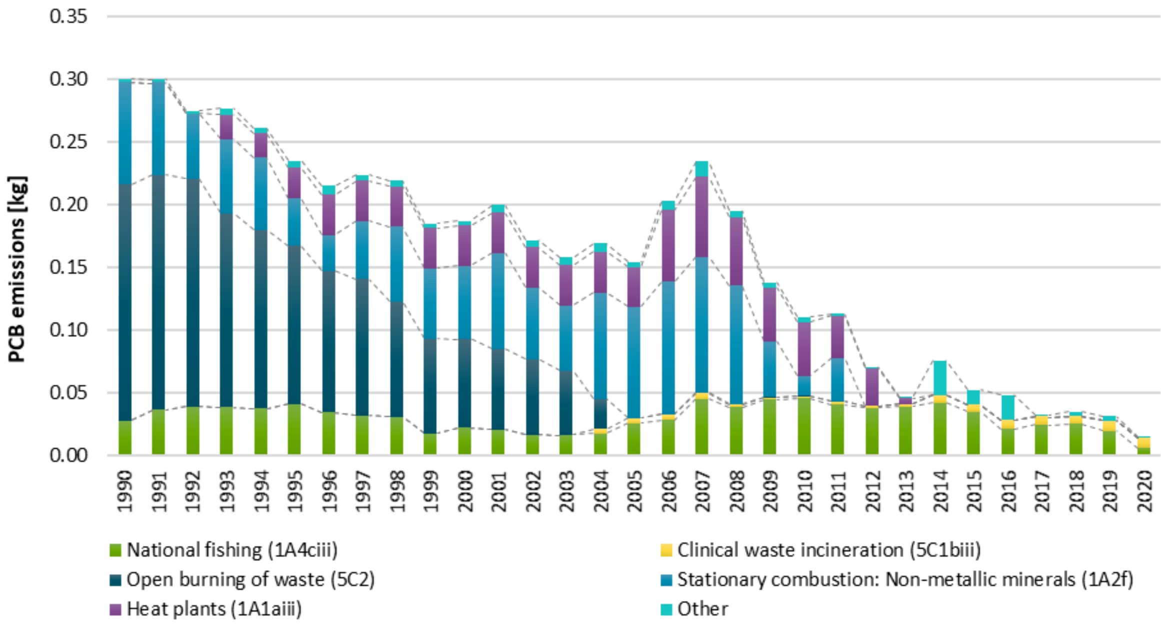


Figure 2.7 PCB emissions by sector, since 1990.

2.4 Emission trends for Heavy Metals

Emission estimates for 1990 and 2020 for priority heavy metals (Pb, Cd and Hg) as well as additional heavy metals (As, Cr, Cu, Ni, Se, Zn) are shown in Table 2.17.

The main sectors contributing to the emissions of heavy metals are energy, industrial processes and waste. According to the 2019 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 from the agriculture sector.

Table 2.17 Estimated emissions of heavy metals, 1990 and 2020.

	Pb [t]	Cd [t]	Hg [t]	As [t]	Cr [t]	Cu [t]	Ni [t]	Se [t]	Zn [t]
1990	0.39	0.0088	0.139	0.031	0.070	0.544	1.536	0.0089	1.59
2020	0.58	0.0047	0.015	0.0094	0.053	1.003	0.192	0.0031	0.83
Change 1990-2020	46%	-47%	-89%	-69%	-25%	85%	-87%	-66%	-48%

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

Pb, Cd and Hg emissions in Iceland are mainly from the subsectors described below. The Pb emissions from the main sources can be seen in Table 2.16 and Figure 2.7. The Cd emissions from the main sources can be seen in Table 2.16 and Figure 2.7. The Hg emissions from the main sources can be seen in Table 2.16 and Figure 2.7.

- **Fireworks (2G):** A prominent contributor to the Pb trend is the use of fireworks (under IPPU). The steady increase since 1990 reflects the growing popularity of fireworks in Iceland (mostly around New Year‘s Eve). A peak in the year 2007 reflects the peak in economic growth that year, before the economic collapse of 2008.
- **Road transport (1A3b):** Emissions from road transport are a part of the current Pb emissions. The emissions have increased over the timeline due to more fuel use.
- **Accidental fires (5E):** Accidental fires cause a part of the Pb emissions. A peak in emissions from accidental fires occurred 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 which was estimated to be 10% the size of the fire 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.
- **Off-road vehicles and other machinery (1A3eii):** Emissions from off-road vehicles and other machinery cause a part of the current Pb emissions. This is due tomore fuel use in the sector.
- **Heat plants (1A1aiii):** In 1993, waste incineration with recovery of energy (included in the Energy sector under 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.
- **National fishing (1A4ciii):** Emissions from commercial fishing are the largest contributor of Cd emissions and the second largest of Hg emissions. Since 1995 the emissions have been following a generally decreasing trend, but with fluctuations due to varying conditions in the fishing industry (renewing of fishing fleet, status of fish stocks, etc.), as well as different ratios of use of marine gas oil versus heavy fuel oil.

- **Ferroalloys production (2C2):** Ferroalloys production is the second largest source of Cd emissions today. It has increased substantially over the timeline due to the expansion of the industry.
- **Open burning of waste (5C2):** The main source of Hg emissions in the 1990s was open burning of waste. It was also a large contributor of Cd emissions. Open pit burning was mostly occurring between 1990 and 2004.
- **Clinical waste incineration (5C1biii):** The largest emission source of Hg in recent years is Clinical waste incineration. Clinical waste was burnt openly, until 2011 when Kalka started handling all of Iceland‘s clinical waste.

Table 2.18: Pb emissions by main sources since 1990 [t].

Pb emissions [t]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Fireworks (2G)	0.089	0.111	0.296	0.500	0.384	0.472	0.368	0.387	+334%	-23%	+5%
Road transport (1A3b)	0.044	0.047	0.053	0.068	0.074	0.079	0.099	0.086	+97%	+26%	-13%
Accidental fires (5E)	0.056	0.056	0.051	0.062	0.041	0.047	0.045	0.036	-36%	-43%	-21%
Off-road vehicles and other machinery (1A3eii)	0.085	0.105	0.139	0.153	0.075	0.075	0.028	0.015	-82%	-90%	-45%
Heat plants (1A1aiii)	0.001	0.484	0.629	0.619	0.843	2.5E-5	5.9E-5	NO	-100%	-100%	-100%
Other	0.120	0.134	0.155	0.167	0.087	0.046	0.061	0.051	-57%	-69%	-16%
Total [t]	**0.394**	**0.937**	**1.323**	**1.569**	**1.504**	**0.718**	**0.601**	**0.575**	**+46%**	**-63%**	**-4%**

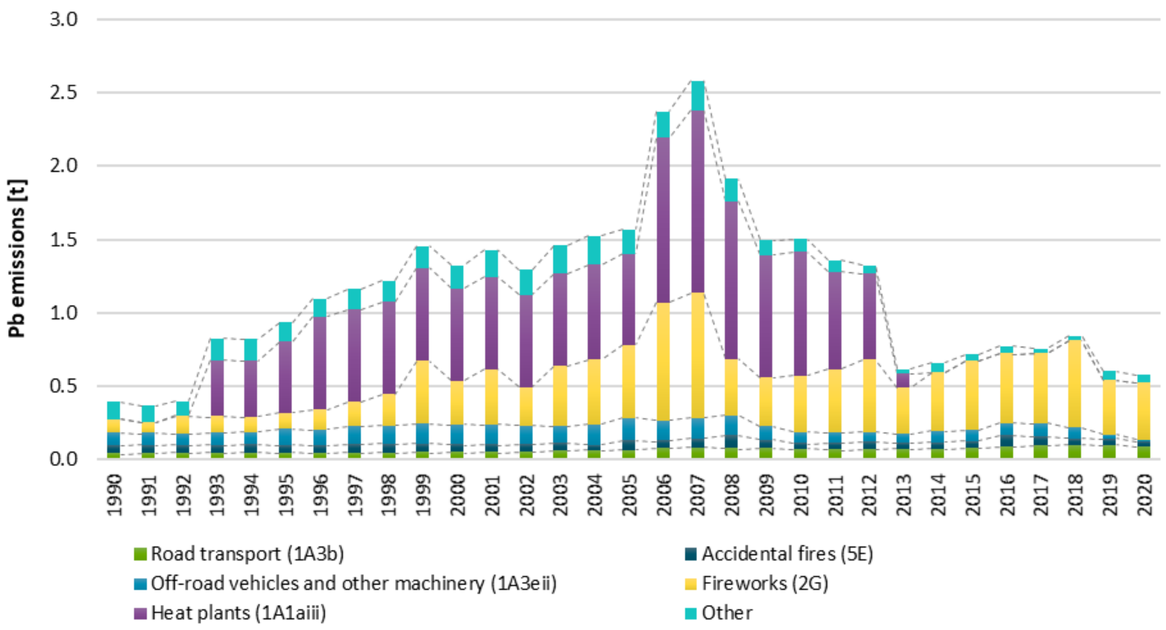


Figure 2.8 Pb emissions by sector, since 1990.

Table 2.19: Cd emissions by main sources since 1990 [kg].

Cd emissions [kg]	1990	1995	2000	2005	2010	2015	2019	2020	Change		
									'90-'20	'05-'20	'19-'20
National fishing (1A4ciii)	2.74	3.46	3.01	2.65	2.98	2.48	1.88	1.59	-42%	-40%	-16%
Ferroalloys production (2C2)	0.046	0.052	0.077	0.069	0.058	0.13	2.09	1.21	+2529%	+1647%	-42%
Fireworks (2G)	0.17	0.21	0.56	0.94	0.73	0.89	0.69	0.73	+334%	-23%	+5%
Heat plants (1A1aiii)	0.14	16.0	20.6	20.2	27.6	0.01	0.020	NO	-100%	-100%	-100%
Open burning of waste (5C2)	3.81	2.65	1.61	0.23	0.18	0.17	0.17	NO	-100%	-100%	-100%
Other	1.91	3.09	3.80	4.30	2.51	2.07	1.66	1.13	-41%	-74%	-32%
Total [kg]	**8.81**	**25.4**	**29.6**	**28.4**	**34.0**	**5.74**	**6.51**	**4.66**	**-47%**	**-84%**	**-28%**

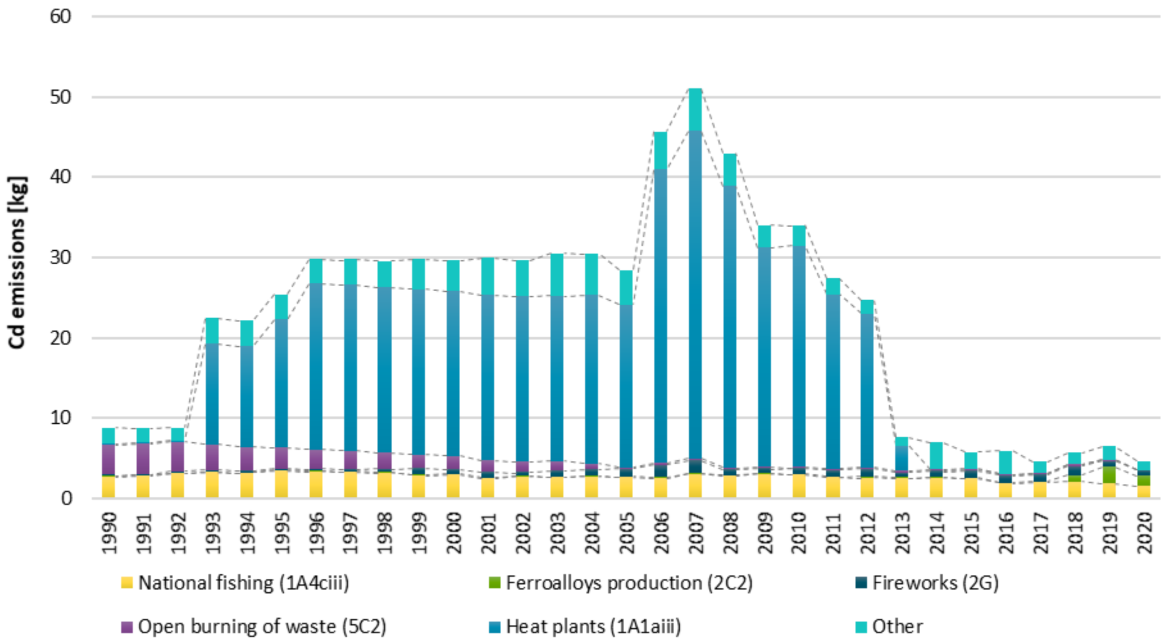


Figure 2.9 Cd emissions by sector, since 1990.

Table 2.20: Hg emissions by main sources since 1990 [kg].

Hg emissions [kg]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Clinical waste incineration (5C1biii)	NO	NO	NO	2.85	1.21	4.18	5.80	6.01		+110%	+4%
National fishing (1A4ciii)	6.79	8.10	8.15	6.65	6.15	5.33	4.62	4.76	-30%	-28%	+3%
Road transport (1A3b)	1.30	1.37	1.49	1.80	1.85	1.94	2.17	1.89	+45%	+5%	-13%
Open burning of waste (5C2)	126	84.1	47.3	0.20	0.17	0.017	0.017	NO	-100%	-100%	-100%
Heat plants (1A1aiii)	0.04	13.1	16.9	16.7	22.7	1.9E-3	0.020	NO	-100%	-100%	-100%
Other	4.71	4.03	5.23	7.02	3.16	1.87	2.38	2.11	-55%	-70%	-11%
Total [kg]	**139**	**111**	**79.1**	**35.2**	**35.2**	**13.3**	**15.0**	**14.8**	**-89%**	**-58%**	**-2%**

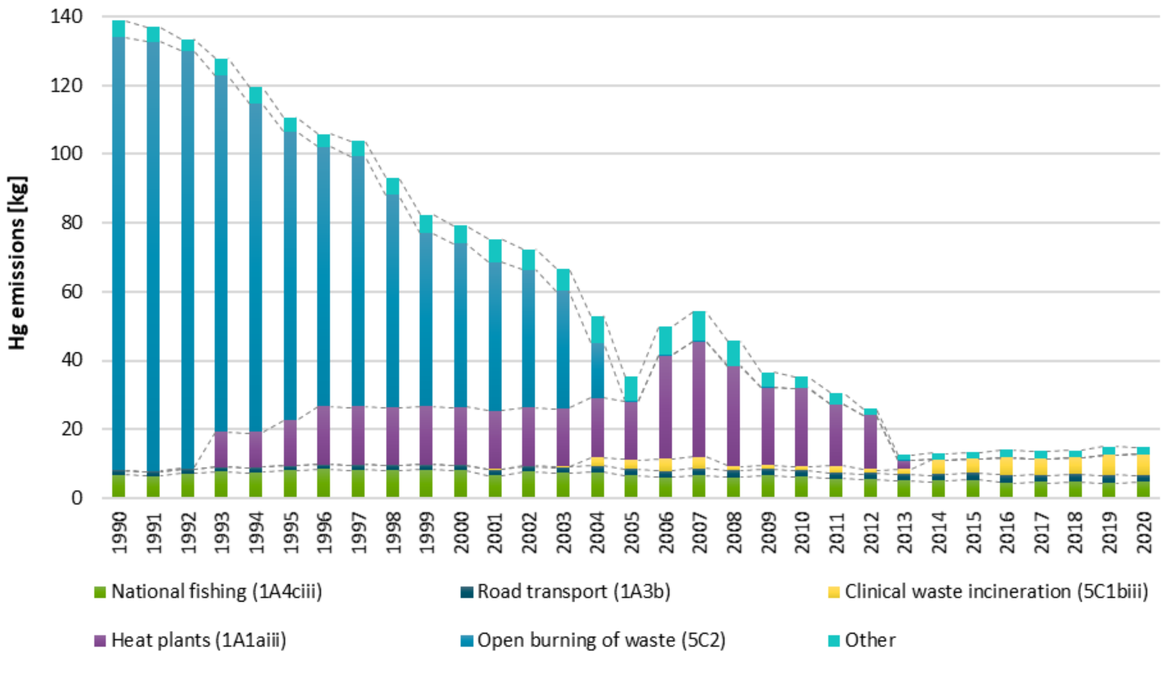


Figure 2.10 Hg emissions by sector, since 1990.

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

The main sectors contributing to the emissions of As, Cr, Cu, Ni, Se and Zn are energy, industrial processes and waste. The trends are overall dominated by emissions from the energy sector. Fishing causes emissions of all heavy metals; Arsenic emissions are influenced by open burning of waste and heat plants, whereas Cr, Cu and Zn are influenced by automobile tyre and brake wear. In the industrial sector, the main source of As emissions is metal production. Non-priority heavy metals are largely produced by fireworks, with a sharp peak in emissions in 2007 when fireworks sales reached an all-time maximum. In the waste sector, heavy metal emissions mostly derive from open burning of waste and accidental fires. As open burning of waste decreased between the years 1990-2004 (as discussed above in the POPs trends), emissions of heavy metals associated with it also decreased, as can be seen for As, Se and Zn.

As, Cr, Cu, Ni, Se and Zn emissions in Iceland are mainly from the subsectors described below. The emissions can be seen in the tables and figures below.

- **National fishing (1A4ciii):** Emissions from commercial fishing are the largest contributor of As, Ni and Se emissions and the second largest of Cr and Zn emissions. Since 1995 the emissions have been following a generally decreasing trend, but with fluctuations due to varying conditions in the fishing industry (renewing of fishing fleet, status of fish stocks, etc), as well as different ratios of use of marine gas oil versus heavy fuel oil.
- **Road transport (1A3b):** Road transport is the largest contributor of Cr, Cu and Zn emissions and the second largest of As and Se emissions. The emissions have increased over the timeline due to more fuel use.
- **Ferroalloys production (2C2):** Ferroalloys production is a source of As emissions. Some fluctuations have occured over the timeline.
- **Heat plants (1A1aiii):** In 1993, waste incineration with recovery of energy started in Iceland, leading to an increase in As emissions. The amount of waste burned with recovery of energy peaked in 2007, and after that decreased until 2013, after which year this activity stopped.
- **Open burning of waste (5C2):** The main source of As emissions in 1990 was open burning of waste. It was also a large contributor of Se and Zn emissions. Open pit burning was mostly occurring between 1990 and 2004.
- **Fireworks (2G):** A contributor to the Cr, Cu, Ni and Zn trend is the use of fireworks (under IPPU). The steady increase since 1990 reflects the growing popularity of fireworks in Iceland (mostly around New Year‘s Eve). A peak in the year 2007 reflects the peak in economic growth that year, before the economic collapse of 2008.
- **National navigation (shipping) (1A3dii):** A contributor to the Cr and Ni trend is national navigation. This is due to fuel use for national navigation.
- **Stationary combustion: Non-metallic minerals (1A2f):** Significant Cr, Se and Zn emissions resulted from the combustion of other bitunimous coal for cement production until 2012 when production was stopped.
- **Off-road vehicles and other machinery (1A3eii):** Emissions from off-road vehicles and other machinery cause a part of the current Pb emissions. This is due to fuel use.
- **Public electricity and heat generation (1A1a):** Emissions from public electricity and heat generation cause a part of the current Se emissions. This is because of diesel used for electricity production.
- **Accidental fires (5E):** Emissions from accidental fires cause a part of Zn emission. A peak in emissions from accidental fires occurred 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 which was estimated to be 10% the size of the fire 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.

Table 2.21: As emissions by main sources since 1990 [kg].

As emissions [kg]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
National fishing (1A4ciii)	9.89	12.13	11.39	9.63	9.82	8.33	6.76	6.35	-36%	-34%	-6%
Road transport (1A3b)	0.55	0.58	0.66	0.84	0.91	0.97	1.21	1.05	+92%	+24%	-13%
Ferroalloys production (2C2)	1.18	1.34	1.96	1.78	1.50	3.22	0.79	0.74	-37%	-58%	-7%
Heat plants (1A1aiii)	0.48	10.45	12.97	12.76	17.35	0.022	0.026	NO	-100%	-100%	-100%
Open burning of waste (5C2)	15.60	10.85	6.60	0.96	0.75	0.70	0.70	NO	-100%	-100%	-100%
Other	2.87	2.88	3.59	4.76	2.54	1.52	1.75	1.25	-56%	-74%	-28%
Total [kg]	**30.6**	**38.2**	**37.2**	**30.7**	**32.9**	**14.7**	**11.2**	**9.4**	**-69%**	**-69%**	**-16%**

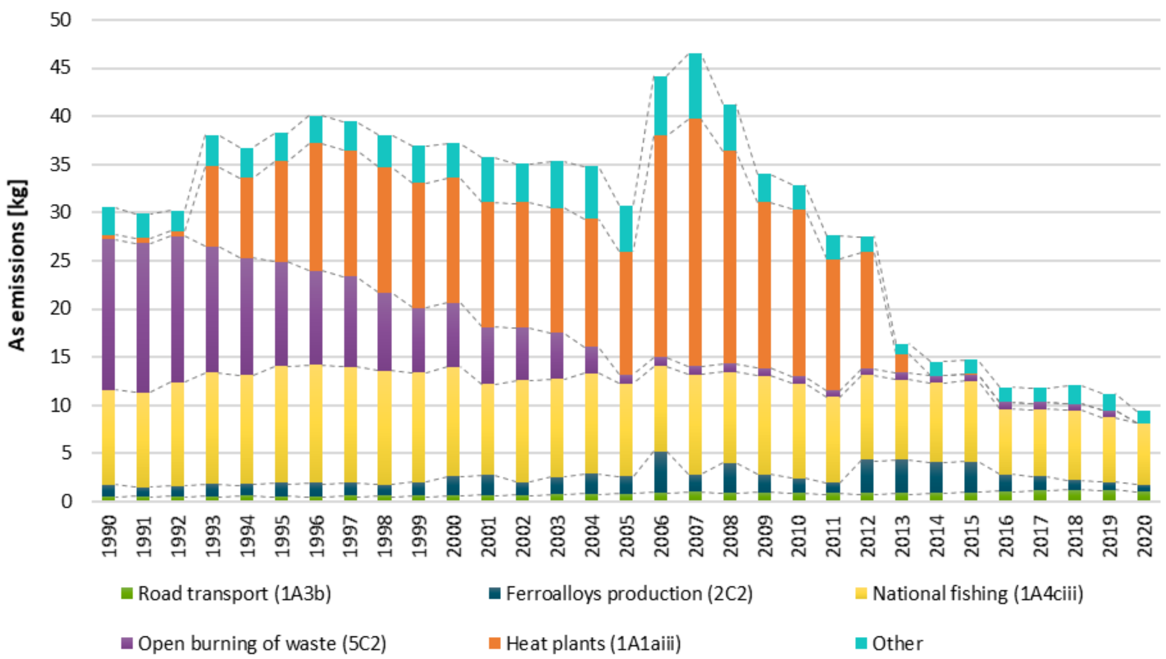


Figure 2.11 As emissions by sector, since 1990.

Table 2.22: Cr emissions by main sources since 1990 [kg].

Cr emissions [kg]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	'05-'20	'19-'20
Road transport (1A3b)	17.3	18.5	20.9	26.9	29.2	31.3	39.6	34.4	+99%	+28%	-13%
National fishing (1A4ciii)	35.8	52.7	28.9	33.5	58.2	44.9	25.4	7.94	-78%	-76%	-69%
Fireworks (2G)	1.78	2.20	5.89	9.95	7.65	9.39	7.32	7.70	+334%	-23%	+5%
National navigation (shipping) (1A3dii)	3.16	3.78	0.56	0.94	2.30	0.71	4.07	3.9E-4	-100%	-100%	-100%
Stationary combustion: Non-metallic minerals (1A2f)	6.48	3.05	4.67	7.04	1.27	9.1E-4	1.1E-3	1.1E-6	-100%	-100%	-100%
Other	5.24	6.50	7.55	7.39	5.21	5.32	2.85	2.58	-51%	-65%	-9%
Total [kg]	**69.7**	**86.8**	**68.4**	**85.7**	**103.8**	**91.6**	**79.3**	**52.6**	**-25%**	**-39%**	**-34%**

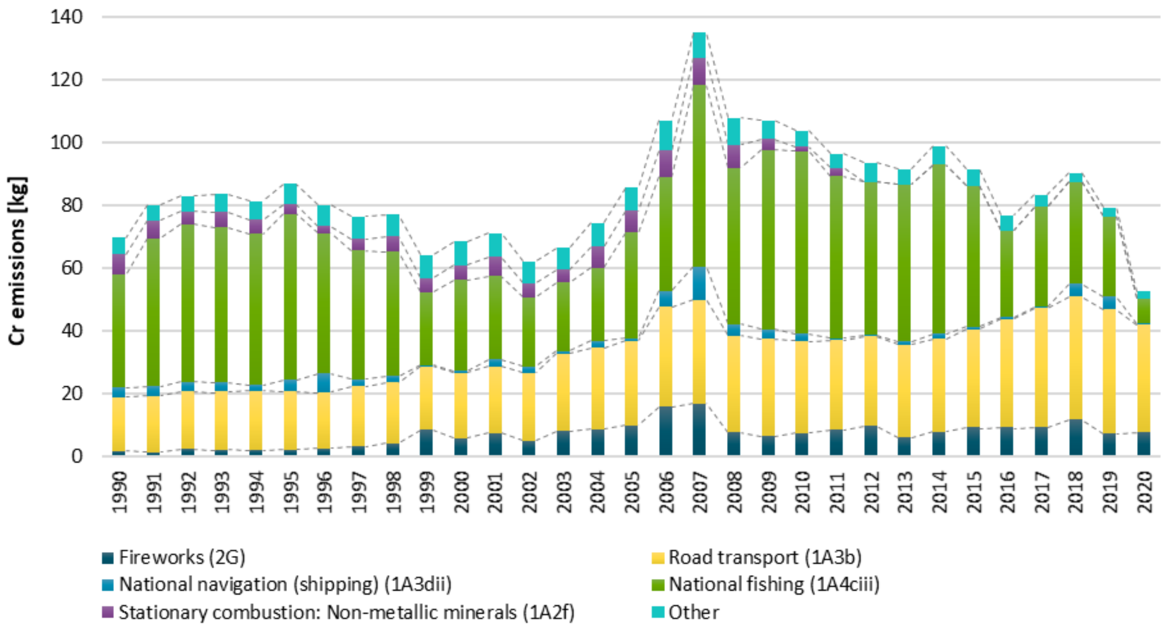


Figure 2.12 Cr emissions by sector, since 1990.

Table 2.23: Cu emissions by main sources since 1990 [t].

Cu emissions [t]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Road transport (1A3b)	0.358	0.384	0.433	0.556	0.604	0.645	0.823	0.713	+99%	+28%	-13%
Fireworks (2G)	0.051	0.063	0.168	0.283	0.218	0.267	0.208	0.219	+334%	-23%	+5%
National fishing (1A4ciii)	0.048	0.058	0.056	0.047	0.046	0.039	0.032	0.032	-33%	-32%	-2%
Off-road vehicles and other machinery (1A3eii)	0.065	0.079	0.105	0.115	0.057	0.057	0.021	0.011	-82%	-90%	-45%
Other	0.023	0.017	0.015	0.016	8.4E-3	7.2E-3	0.036	0.028	+21%	+70%	-24%
Total [t]	**0.544**	**0.601**	**0.777**	**1.017**	**0.932**	**1.015**	**1.122**	**1.003**	**+85%**	**-1%**	**-11%**

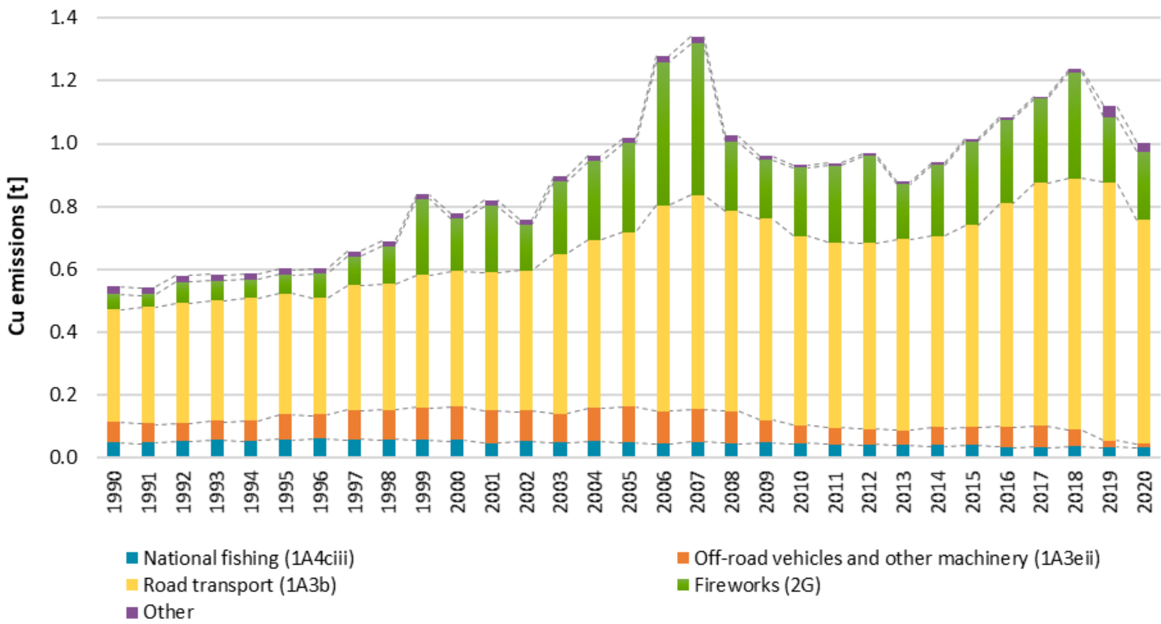


Figure 2.13 Cu emissions by sector, since 1990.

Table 2.24: Ni emissions by main sources since 1990 [t].

Ni emissions [t]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
National fishing (1A4ciii)	1.343	2.061	0.969	1.244	2.395	1.821	0.964	0.159	-88%	-87%	-84%
Fireworks (2G)	0.003	0.004	0.011	0.019	0.015	0.018	0.014	0.015	+334%	-23%	+5%
National navigation (shipping) (1A3dii)	0.133	0.159	0.021	0.034	0.092	0.022	0.166	7.8E-3	-94%	-77%	-95%
Other	0.057	0.054	0.025	0.025	0.012	0.014	0.013	0.011	-81%	-56%	-19%
Total [t]	**1.536**	**2.278**	**1.027**	**1.322**	**2.513**	**1.875**	**1.157**	**0.192**	**-87%**	**-85%**	**-83%**

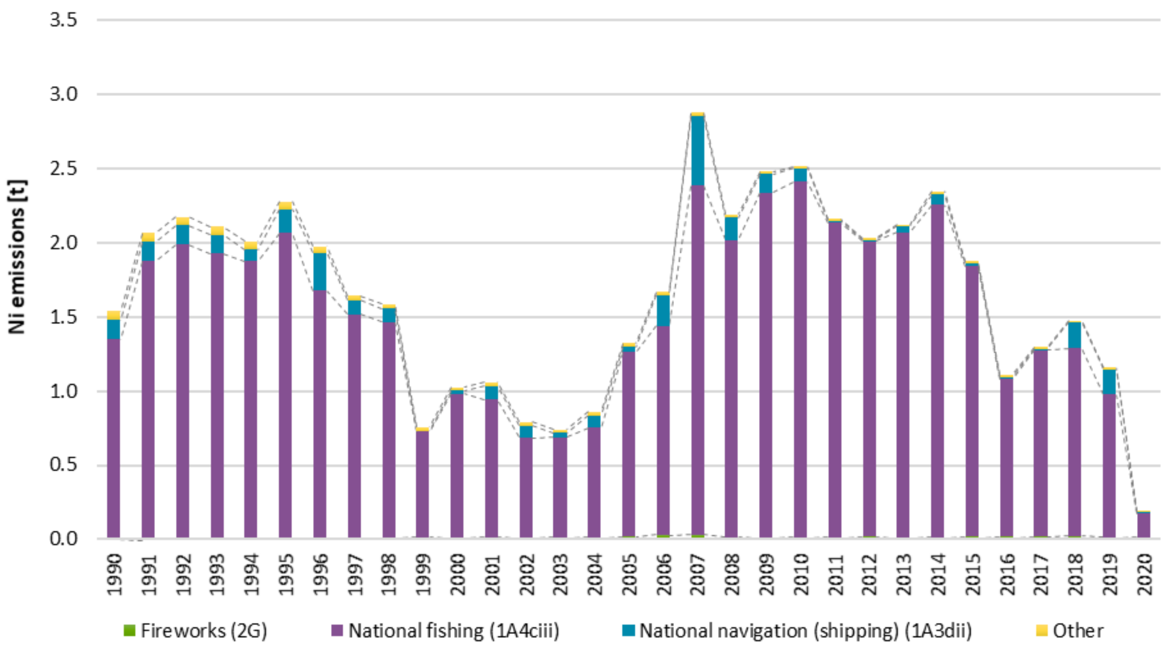


Figure 2.14 Ni emissions by sector, since 1990.

Table 2.25: Se emissions by main sources since 1990 [kg].

Se emissions [kg]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
National fishing (1A4ciii)	3.45	4.60	3.46	3.30	4.38	3.52	2.40	1.59	-54%	-52%	-34%
Road transport (1A3b)	0.44	0.48	0.53	0.66	0.72	0.76	1.02	0.89	+100%	+35%	-13%
Public electricity and heat generation (1A1a)	0.63	0.63	0.39	0.09	0.39	0.36	0.46	0.16	-74%	+77%	-65%
Stationary combustion: Non-metallic minerals (1A2f)	0.87	0.42	0.64	0.94	0.17	0.00	0.00	0.00	-100%	-100%	-2%
Open burning of waste (5C2)	2.66	1.85	1.13	0.16	0.13	0.12	0.12	NO	-100%	-100%	-100%
Other	0.89	1.01	0.96	1.15	0.77	0.65	0.82	0.44	-51%	-62%	-47%
Total [kg]	**8.95**	**9.00**	**7.11**	**6.31**	**6.56**	**5.41**	**4.82**	**3.08**	**-66%**	**-51%**	**-36%**

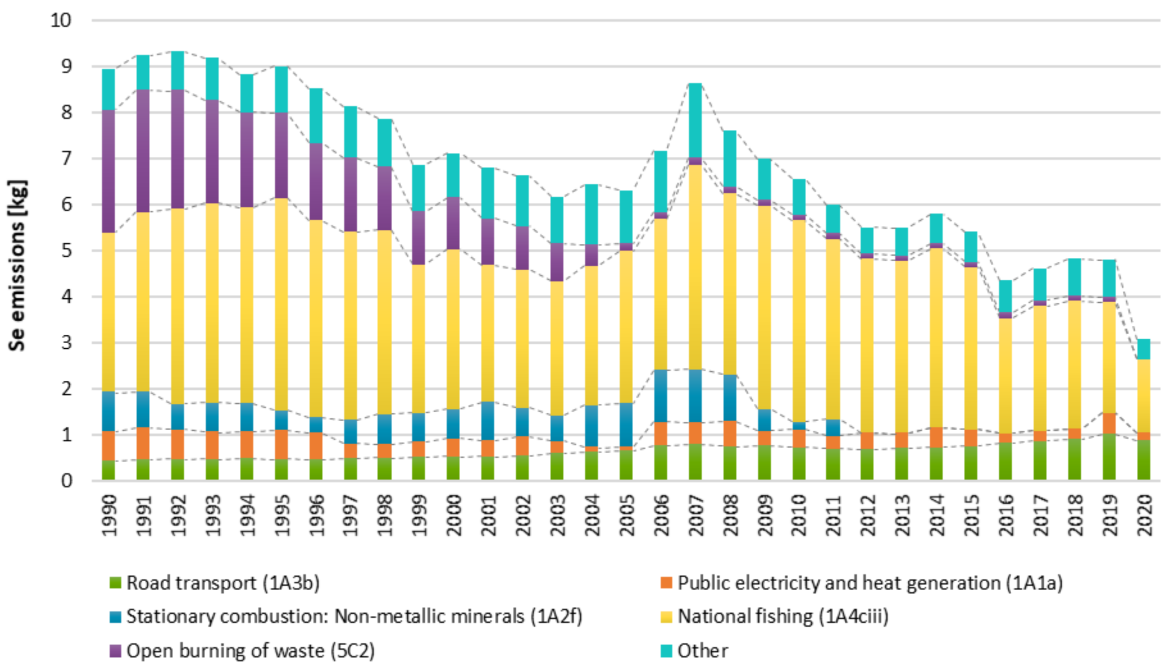


Figure 2.15 Se emissions by sector, since 1990.

Table 2.26: Zn emissions by main sources since 1990 [t].

Zn emissions [t]	1990	1995	2000	2005	2010	2015	2019	2020	Change '90-'20	Change '05-'20	Change '19-'20
Road transport (1A3b)	0.16	0.17	0.19	0.24	0.26	0.27	0.35	0.31	+97%	+29%	-12%
National fishing (1A4ciii)	0.29	0.35	0.33	0.28	0.27	0.23	0.19	0.19	-33%	-32%	-2%
Accidental fires (5E)	0.22	0.22	0.20	0.24	0.16	0.18	0.18	0.14	-36%	-43%	-21%
Stationary combustion: Non-metallic minerals (1A2f)	0.10	0.05	0.08	0.11	0.02	0.00	0.00	0.00	-100%	-100%	-2%
Fireworks (2G)	0.03	0.04	0.10	0.17	0.13	0.16	0.12	0.13	+334%	-23%	+5%
Open burning of waste (5C2)	0.67	0.46	0.28	0.04	0.03	0.03	0.03	NO	-100%	-100%	-100%
Other	0.14	0.15	0.15	0.15	0.09	0.09	0.11	0.07	-50%	-54%	-37%
Total [t]	**1.59**	**1.43**	**1.32**	**1.22**	**0.96**	**0.97**	**0.98**	**0.83**	**-48%**	**-32%**	**-15%**

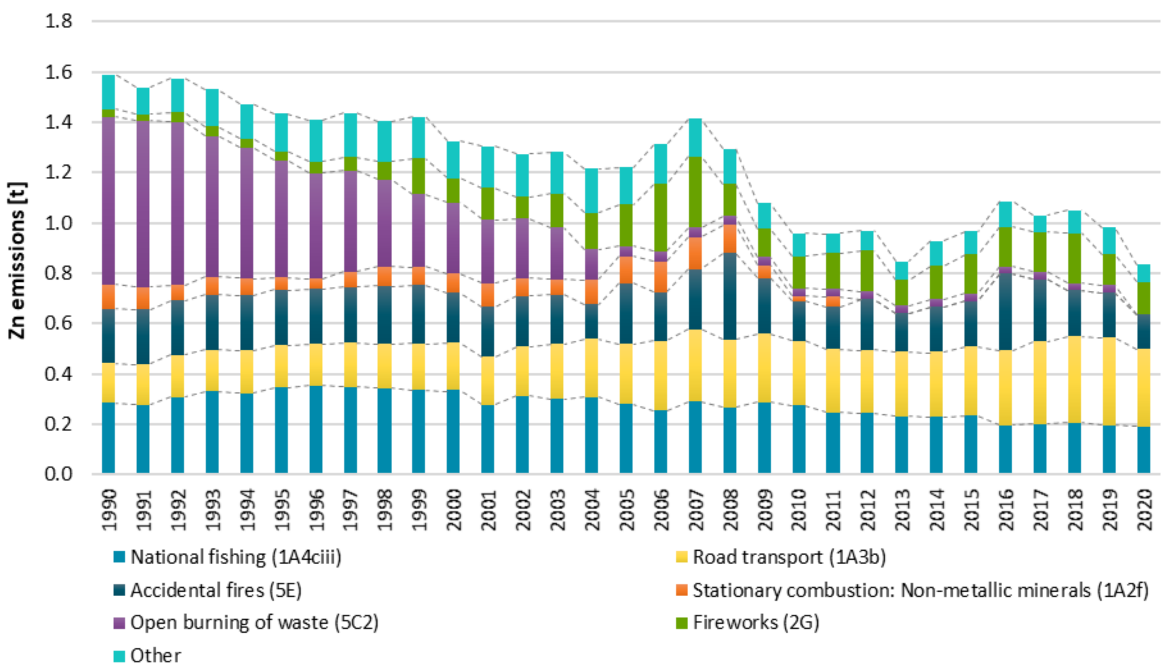


Figure 2.16 Zn emissions by sector, since 1990.

3 Energy (NFR sector 1)

3.1 Overview

The energy sector in Iceland is unique in many ways. Iceland ranks first among Organisation for Economic Co-operation and Development (OECD) countries in the per capita consumption of primary energy. However, the proportion of domestic renewable energy in the total energy budget is approx. 85%, which is a much higher share than in most other countries. The cold climate and sparse population call for high energy use for space heating and transport. Also, key export industries such as fisheries and metal production are energy intensive. The metal production industry uses around three-quarters of the total electricity produced in Iceland. Iceland relies heavily on its geothermal energy sources for space heating (over 90% of all homes) and electricity production (approx. 30% of the electricity) and on hydropower for electricity production (70% of the electricity). Thus, atmospheric pollutant emissions in the energy sector originate predominantly from mobile sources: road transport, fishing and off-road machinery including construction, as well as waste incineration with energy recovery (occurring from 1993-2012). One exception to this is the emission of H_2S from geothermal powerplants, which is by far the largest key category in Iceland´s inventory for sulphur (calculated as SO_2-equivalent).

The EA has been working with a consulting company (Aether Ltd.) since 2015 to improve the Icelandic inventory, and in 2018 a complete review and restructuring of the Energy sector took place in collaboration with experts from Aether, including updating/redesigning calculation spreadsheets as well as checking all emission factors across the sector and replacing by default values where appropriate. Further work is planned, in collaboration with the National Energy Authority, the Icelandic Transport Authority and Statistic Iceland in order to harmonize all datasets used.

The energy chapter is divided into the following subchapters:

- Stationary Combustion (NFR 1A1, 1A2, 1A4 and 1A5)
- Transport and other mobile sources (NFR 1A2, 1A3 and 1A4)
- Fugitive emissions (NFR 1B2) (including emissions from geothermal utilization)

Table 3.1 shows which subsectores in Energy are key categories for which air pollutants. A key category is one that is prioritised within the national inventory system because it is significantly important for one or a number of air pollutants in a country’s national inventory of air pollutants in terms of the absolute level, the trend, or the uncertainty in emissions (EEA, 2019). Categories whose cumulative percentage contribution is greater than 80% should be identified as key.

Table 3.1 Key categories for air pollutants within Energy.

SO_x, NO_x, NH_3, NMVOC, PM, BC and CO	1990	2020	Trend
1A2e Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	BC		NO_x, SO_x, BC
1A2f Stationary combustion in manufacturing industries and construction: Non-metallic minerals	$PM_{2.5}$		$PM_{2.5}$, PM_{10}
1A2gvii Mobile combustion in manufacturing industries and construction	NO_x, $PM_{2.5}$, PM_{10}	BC	PM_{10}, BC
1A3ai(i) International aviation LTO (civil)	CO		
1A3bi Road transport: Passenger cars	NO_x, NMVOC, BC, CO	NO_x, BC	NO_x, NMVOC, BC, CO
1A3bii Road transport: Light duty vehicles		BC	
1A3biii Road transport: Heavy duty vehicles and buses	NO_x, $PM_{2.5}$, BC	BC	$PM_{2.5}$
1A3bv Road transport: Gasoline evaporation	NMVOC		
1A3bvi Road transport: Automobile tyre and brake wear		$PM_{2.5}$	BC
1A3bvii Road transport: Automobile road abrasion	$PM_{2.5}$, PM_{10}, TSP	$PM_{2.5}$, PM_{10}, TSP, BC	$PM_{2.5}$, PM_{10}, TSP, BC
1A3eii Other mobile machinery	BC	BC	NO_x, $PM_{2.5}$, BC
1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery		BC	NO_x
1A4ciii National fishing	NO_x, NMVOC, SO_x, $PM_{2.5}$, PM_{10}, TSP, BC	NO_x, NMVOC, $PM_{2.5}$, PM_{10}, BC	NO_x, SO_x, $PM_{2.5}$, PM_{10}, TSP, BC
1B2av Distribution of oil products		NMVOC	
1B2d Other fugitive emissions from energy production (Geothermal energy)	SO_x	SO_x	SO_x
Persistent Organic Pollutants (POPs)	**1990**	**2020**	**Trend**
1A2f Stationary combustion in manufacturing industries and construction: Non-metallic minerals	PCB		PAH4
1A3bi Road transport: Passenger cars		PAH4	PAH4
1A3biii Road transport: Heavy duty vehicles and buses		PAH4	
1A4ciii National fishing		HCB, PCB	PCB
Heavy Metals (HMs)	**1990**	**2020**	**Trend**
1A1a Public electricity and heat production			Se
1A2f Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Pb, Cd, Cr		Pb, Cd, As, Cr, Se, Zn
1A2gvii Mobile combustion in manufacturing industries and construction	Pb, Cu		Pb, Cu
1A3bi Road transport: Passenger cars		Hg	Hg
1A3bvi Road transport: Automobile tyre and brake wear	Pb, Cr, Cu, Zn	Pb, Cd, As, Cr, Cu, Zn	Cd, As, Cr, Cu, Ni, Se, Zn
1A3dii National navigation (shipping)			Ni
1A4ciii National fishing	Cd, As, Cr, Cu, Ni, Se, Zn	Cd, Hg, As, Cr, Ni, Se, Zn	Cd, Hg, As, Cr, Cu, Ni, Se, Zn

3.2 General Methodology

Emissions from fuel combustion activities are estimated at the sector level based on methodologies suggested by the 2006 IPCC Guidelines and the 2019 EEA/EMEP Guidebook. 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.

Emissions from Road transportation are estimated using COPERT 5.5.1. which follows the methodology presented in 2019 EEA/EMEP Guidebook. More detailed description can be seen in chapter 3.4.3.

For the 2020 submission a comprehensive review was performed on how the fuels sales data from the NEA is attributed to IPCC/NFR sectors. For this submission the review only included the years 2003-2019 because the methodology used to collect the data by the NEA changed between 2002 and 2003. For the 2021 submission the same attribution of fuels to IPCC categories for 1990-2002 was performed with a review of the sales statistics. Consequently, the whole time series has been reviewed and methodologies harmonised from 1990 and onwards. The aim of the review of the fuel sales data from the NEA was to make the adjustments from the sales statistics to the IPCC/NFR categories more transparent. This is what was done for each category to achieve the following:

- 1A1 Energy Industries – sales statistics are used directly, and no adjustments are needed
- 1A2 Manufacturing Industries – adjustments are needed to transform sales statistics into IPCC categories (detailed description below)
- 1A4a and b Commercial/Residential combustion - sales statistics are used directly and no adjustments are needed
- 1A5 Other – all fuels that are categorised as Other in sales statistics without any explanation of use are attributed to this category.

Due to insufficiently detailed splits in the sales statistics between fuel used for different manufacturing industries that belong to NFR category 1A2 some adjustments are needed. To try to have this input data as accurate as possible:

- It is assumed that Green Accounting reports (Regulation 851/2002) and EU ETS Annual Emission Reports from 2013 are correct for each company and that data is used for 1A2a, 1A2b, 1A2c and 1A2f – this is the known usage.
- Because these fuels are purchased from domestic oil companies, they will be subtracted from the sales statistics received from the NEA.
- The difference between known usage and sales statistics is attributed to the category 1A2gviii Other Industry.

These adjustments are described in Figure 3.1. For some fuel types and years, the subtraction of known use from sales statistics does result in a negative number indicating that usage was more than what was sold. It is considered more likely that some data is missing from sales statistics and therefore these values will be input as zero. This will cause more fuel used than what is in the sales statistics, and a possible overestimate of emissions. This is however a very low amount compared to the total energy emissions.

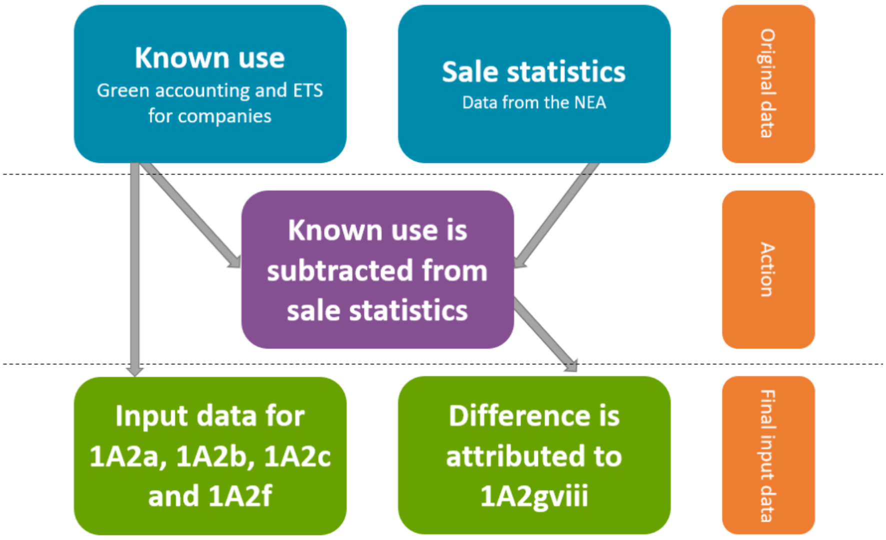


Figure 3.1 Description of adjustments in input data for IPCC category 1A2

In the sales statistics received from the NEA there are unspecified categories for all fuels, labelled as "Other". These fuels are accounted for in NFR category 1A5. For future submissions the EA will work with the NEA to aim to attribute these fuels to specific categories.

3.3 Stationary Combustion (NFR 1A1, 1A2, 1A4 and 1A5)

3.3.1 Electricity & heat (NFR 1A1a)

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_x and NMVOC waste incineration with energy recovery is the main source of emissions for this category. However, waste incineration with energy recovery has not been occurring in Iceland since 2013. Activity data on fuel use for the energy industries are based on data provided by the NEA and adjusted by EA, see chapter 3.2. Activity data on waste is collected by EA directly from the plants.

The main sources of electricity in Iceland are hydropower and geothermal energy. In recent years, wind power development has taken place. As can be seen in Table 3.2, only a very small fraction of electricity is produced with fuel combustion: electricity was produced with fuel combustion at two locations that are located far from the distribution system (two sparsely populated islands, Grimsey and Flatey); furthermore, some public electricity facilities have emergency backup fuel combustion power plants which are used when problems occur in the distribution system. Those plants are, however, very seldom used, apart from testing and during maintenance.

Table 3.2 Electricity production in Iceland [GWh]

	1990	1995	2000	2005	2010	2015	2019	2020
Hydropower	4,159	4,677	6,350	7,015	12,592	13,781	13,462	13,157
Geothermal	283	290	1,323	1,658	4,465	5,003	6,018	5,961
Fuel combustion	4.6	8.4	4.4	7.8	1.7	3.9	2.7	3.1
Wind power	-	-	-	-	-	10.9	6.6	6.7
Total [GWh]	**4,446**	**4,976**	**7,678**	**8,681**	**17,059**	**18,799**	**19,489**	**19,127**

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 burned waste to produce heat and were connected to the local distribution system, however since 2013 no more waste burning with energy recovery is occurring in Iceland. Emissions from these waste incineration plants are reported under Energy Industries.

3.3.1.1 Activity data

Activity data for electricity and heat production with fuel combustion and waste incineration are given in Table 3.3. The use of residual fuel oil for electricity production 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 implied emission factor (IEF). 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 (unfavourable weather conditions for hydropower plants during the winter) and 2007 (explained above).

Table 3.3 Fuel combustion and waste incineration [kt] for electricity and heat production.

	1990	1995	2000	2005	2010	2015	2019	2020
1A1ai - Gas/Diesel oil	1.30	1.09	1.07	0.02	1.01	1.19	1.24	0.56
1A1ai - Residual fuel oil	NO	NO	NO	NO	NO	NO	NO	NO
1A1ai - Biomethane	NO	NO	NO	0.29	NO	NO	NO	NO
1A1ai - Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO
1A1aiii - Gas/Diesel oil	NO	NO	NO	NO	NO	NO	0.33	NO
1A1aiii - Residual fuel oil	2.99	3.08	0.12	0.20	NO	0.14	NO	NO
1A1aiii - Biodiesel	NO	NO	NO	NO	NO	NO	0.02	NO
1A1aiii - Solid Waste	NO	4.65	6.05	5.95	8.11	NO	NO	NO

Emission factors are Tier 1 factors taken from the 2019 EMEP/EEA Guidebook (Chapter 1.A.1. Energy Industries, Tables 3-4 (gaseous fuels), 3-5 (fuel oil) and 3-6 (gas oil and biodiesel)). Emission factors for the burning of waste with energy recovery are taken from Table 3-2 of chapter 5C1a of the 2019 EMEP/EEA Guidebook. Due to the lack of emission factors given in the 2019 Guidebook the following pollutants are not estimated:

- Gas oil: NH_3, PCBs, HCB, BaP, BbF, BkF.
- Residual fuel oil: NH_3, PCBs, BaP, HCB.
- Gaseous fuels (biomethane): NH_3, PCBs, HCB.

3.3.1.2 Recalculations and improvements

1A1ai: Electricity Generation:

There was an error in calculation files and emissions from residual fuel oil were calculated using emission factors for gas/diesel oil, even though emission factors are available for residual fuel oil. For most pollutants this change is minor. This affects all years where residual fuel oil was reported and all pollutants that are reported.

1A1aiii: Heat Plants:

No recalculations were done for this subcategory.

3.3.1.3 Planned improvements

No improvements are planned for this subcategory.

3.3.2 Manufacturing industries, stationary combustion (NFR 1A2, excluding mobile sources)

3.3.2.1 Activity Data

The total amount of fuel sold to the manufacturing industries for stationary combustion was obtained from the National Energy Authority (NEA). The sales statistics do not fully specify by which type of industry the fuel is being purchased. This division is made by the Environment Agency (EA) on the basis of the reported fuel use by all major industrial plants falling under Act 70/2012 and the EU ETS Directive 2003/87/EC (metal production, fish meal production and mineral wool) and from green accounts submitted by the industry in accordance with regulation No 851/2002. All major industries falling under Act 70/2012 report their fuel use to the EA along with other relevant information for industrial processes. The difference between the given total for the sector and the sum of the fuel use as reported by industrial facilities is categorized as 1A2gviii other non-specified industry (see Figure 3.1). The total fuel consumption per fuel type can be seen in Table 3.4.

Emissions from the cement industry (the single operating cement plant was closed down in 2011) and the mineral wool production are reported under 1A2f. 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 3.4 Fuel use [kt], stationary combustion in the manufacturing industry.

	1990	1995	2000	2005	2010	2015	2019	2020
1A2a - Iron and steel								
Gas/Diesel Oil	0.11	0.22	0.56	0.46	0.46	0.29	0.20	0.21
LPG	NO	NO	NO	NO	NO	0.10	0.37	0.20
1A2b - Non-ferrous metals								
Gas/Diesel Oil	NO	NO	0.55	5.37	1.35	0.046	0.62	1.72
Residual Fuel Oil	3.93	5.16	7.51	NO	3.31	1.40	1.80	NO
LPG	0.41	0.31	0.67	0.66	0.61	0.39	0.25	0.23
1A2c - Chemicals								
Residual Fuel Oil	2.38	2.31	2.27	NO	NO	NO	NO	NO
1A2e - Food processing, beverages and tobacco (Fishmeal production)								
Gas/Diesel Oil	NO	NO	NO	NO	2.16	NO	NO	NO
Residual Fuel Oil	41.03	48.54	36.37	5.37	9.61	8.41	0.88	1.22
Waste Oil	NO	NO	NO	NO	1.36	1.59	0.70	0.37
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO
1A2e - Food processing, beverages and tobacco (Other)								

	1990	1995	2000	2005	2010	2015	2019	2020
Gas/Diesel Oil	NO	NO	NO	NO	2.71	3.75	3.26	3.37
Residual Fuel Oil	NO	NO	NO	NO	1.71	0.33	NO	NO
1A2f - Non-metallic minerals (cement)								
Gas/Diesel Oil	NO	NO	6.0E-3	0.019	5.0E-3	NO	NO	NO
Residual Fuel oil	0.06	NO	NO	NO	NO	NO	NO	NO
Petroleum Coke	NO	NO	NO	8.13	NO	NO	NO	NO
Waste Oil	NO	4.99	6.04	1.82	NO	NO	NO	NO
Other Bituminous Coal	18.60	8.65	13.26	9.91	3.65	NO	NO	NO
1A2f - Non-metallic minerals (mineral wool)								
Gas/Diesel Oil	NO	0.15	0.17	0.16	0.074	0.11	0.13	0.13
Residual Fuel Oil	0.59	NO	NO	NO	NO	NO	NO	NO
Petroleum Coke	NO	NO	NO	NO	NO	NO	NO	NO
1A2gviii - Other industry								
Gas/Diesel Oil	4.96	0.76	7.64	9.19	NO	2.92	NO	2.13
Residual Fuel oil	7.91	0.16	1.0E-5	19.64	0.30	0.052	NO	NO
LPG	NO	NO	0.19	0.27	0.44	0.32	0.94	0.57
Other bituminous coal	NO	NO	NO	NO	NO	NO	NO	NO

3.3.2.2 Emission factors

Emission factors for all pollutants are Tier 1 EF from chapter 1.A.2 of the 2019 EMEP/EEA Guidebook. However, it is assumed that the PAH emission factors given in the Table 3-4 should be in µg/GJ rather than mg/GJ (after comparison with Table 3-37, Volume 1.A.4).

Table 3.5 Emission factors for pollutants from stationary combustion in manuf. industry.

	Reference	Exception
Gas/Diesel Oil	Tier 1 EF for liquid fuels from **Table 3-4** from chapter 1.A.2 of the 2019 EMEP/EEA Guidebook	SO_2 emissions calculated based on: 0.2 % suflur content
Residual fuel oil		1.8 % sulfur content
Waste Oil		0.5 % sulfur content
LPG	Tier 1 EF for gaseous fuels from **Table 3-3** from chapter 1.A.2 of the 2019 EMEP/EEA Guidebook	SO_2 emissions calculated based on: 0.1 % sulfur content
Other Bituminous Coal	Tier 1 EF for solid fuels from **Table 3-2** from chapter 1.A.2 of the 2019 EMEP/EEA Guidebook	SO_2 and dioxins: Included in 2A1 in IPPU chapter
Petroleum coke		

Due to the lack of emission factors given in the 2019 Guidebook the following pollutants are not estimated:

- All liquid fuels and LPG: NH_3, PCB, HCB
- Other bituminous coal: NH_3

3.3.2.3 Recalculations and improvements

Two reasons are for recalculations for stationary combustion in 1A2:

- Petroleum coke used for mineral wool production in 1A2f was removed from the energy sector. It is accounted for inn the IPPU sector and was therefore double counted for previous submissions. This affected all pollutants reported for the years 2013-2019.
- LPG use in 1A2gviii other industries was redistributed by the NEA for 2017-2019, which caused recalculations for all pollutants.

- SO_2 emissions from cement production from residual fuel oil for 1990-1994 is now reported under NFR 2A1. This is because SO_2 emissions in 2A1 are based on measurements from the factory, which includes emissions for fuels.

3.3.2.4 Planned improvements
There are no planned improvements.

3.3.3 Commercial / Institutional, Residential and Agricultural Stationary Fuel Combustion (NFR 1A4ai, 1A4bi and 1A4ci)

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.

3.3.3.1 Activity data
Activity data for fuel use is provided by the NEA, which collects data on fuel sales by sector. EA adjusts the data provided by the NEA as further explained in chapter 3.2. Activity data for waste incineration are collected by the EA directly. Activity data for stationary fuel combustion and waste incineration in 1A4 sector are given in Table 3.6

Table 3.6 Fuel use [kt] from stationary combustion from subsectors of NFR 1A4

	1990	1995	2000	2005	2010	2015	2019	2020
1A4ai - Commercial/Institutional								
Gas/Diesel Oil	1.80	1.60	1.60	1.00	0.30	0.30	0.65	0.53
LPG	0.78	0.83	0.46	0.50	0.17	0.37	0.59	0.41
Waste – fossil	NO	0.14	0.19	0.19	0.15	NO	NO	NO
Waste – Biogenic	NO	0.31	0.39	0.39	0.20	NO	NO	NO
1A4bi - Residential								
Gas/Diesel Oil	8.82	6.94	6.03	3.24	1.34	0.99	0.30	0.66
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO
LPG	NO	NO	0.72	0.93	1.42	0.93	1.14	1.10
1A4ci - Agriculture								
LPG	NO	NO	NO	NO	NO	4.0E-3	6.0E-3	8.0E-3

3.3.3.2 Emission factors
Emission factors (EFs) for stationary combustion are taken from the chapter 1A4 Small Combustion in 2019 EMEP/EEA Guidebook except EFs for dioxin from stationary combustion of LPG. They are taken from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002) which is 0.06 μg/t fuel for LPG (Liquified Petroleum Gas).

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.

Table 3.7 Emission factors for 1A4ai, 1A4ci & 1A4bi

	Reference	Exception
1A4ai & 1A4ci		
Gas/Diesel Oil	Tier 1 EF for liquid fuels from **Table 3-9** from chapter 1.A.4 of the 2019 EMEP/EEA Guidebook	SO_2 emissions calculated based on: 0.2 % suflur content
LPG	Tier 1 EF for gaseous fuels from **Table 3-8** from chapter 1.A.4 of the 2019 EMEP/EEA Guidebook	SO_2 emissions calculated based on: 0.1 % sulfur content Dioxin emissions from (Statistics Norway, 2002)
Waste	Tier 2 EF for municipal waste incineration from **Table 3-2** from chapter 5.C.1.a of the 2019 EMEP/EEA Guidebook	NH_3, Se & IpY estimated with T1 EF from **Table 3-1** in same chapter
1A4bi		
Gas/Diesel Oil	Tier 1 EF for liquid fuels from **Table 3-5** from chapter 1.A.4 of the 2019 EMEP/EEA Guidebook	SO_2 emissions calculated based on: 0.2 % suflur content
LPG	Tier 1 EF for gaseous fuels from **Table 3-4** from chapter 1.A.4 of the 2019 EMEP/EEA Guidebook	SO_2 emissions calculated based on: 0.1 % sulfur content Dioxin emissions from (Statistics Norway, 2002)

3.3.3.3 Recalculations and improvements

1A4ai Commercial/Institutional: Recalculations in 1A4ai are due to a change in the NEA data on fuel allocation between sectors in 1A4. Gas/Diesel oil was increased between submissions by 123% in the year 2019 and LPG was increased 333%, 556% and 517% in the years 2017-2019, respectively. This affects all reported pollutants in this subsector.

1A4bi Residential Stationary: Recalculations in 1A4bi occurred in the years 2017-2019 due to reallocation of fuels by the NEA. This caused gas/diesel oil to become reduced in 2019 and LPG reduced in 2017-2019. This affects all reported pollutants in this subsector.

3.3.3.4 Planned improvements

There are no planned improvements.

3.3.4 Other, Stationary (NFR 1A5a)

For the 2020 submission sector 1A5 was reported for the first time for the timeseries 2003-2018 as part of the review of the energy input data. For the 2021 submission a review for the timeseries 1990-2002 was performed. For previous submissions these emissions were reported under NFR category 1A2gvii but after a review of the sales statistics no justification was found for that attribution. Therefore, all fuels categorized as “Other” in sales statistics without any explanation of type of use, are now allocated to CRF category 1A5. For future submissions the EA will work with the NEA to try to investigate where these fuels were used so they can be attributed to the correct categories.

The emissions from this sector are calculated by multiplying energy use with a pollutant specific emission factor from the 2019 EMEP/EEA guidebook.

3.3.4.1 Activity data

Activity data is provided by the NEA, which collects data on fuel sales by sector. All fuels categorized as “Other” in sales statistics without any explanation of which sector it is used in, was allocated to NFR category 1A5.

Table 3.8 Fuel use [kt] from sector 1A5 Other

	1990	1995	2000	2005	2010	2015	2019	2020
Gas/Diesel Oil	NO	0.458	1.386	8.928	2.728	NO	0.393	0.084
Residual Fuel Oil	0.039	0.052	0.067	NO	1.629	NO	0.075	NO
Other Kerosene	NO	NO	NO	0.151	0.047	0.029	0.064	0.030
LPG	NO	NO	NO	NO	NO	0.032	NO	NO
Biodiesel	NO	NO	NO	NO	NO	NO	0.022	0.044
Biomethane	NO	NO	NO	NO	NO	NO	0.091	0.111
Biogasoline	NO	NO	NO	NO	NO	NO	NO	1.0E-3

3.3.4.2 Emission factors

All emission factors are the same as for 1A2 which are presented in Table 3.5.

3.3.4.3 Recalculations and improvements

Recalculations in 1A5 are twofold:

- Firstly, recalculations are due to a correction in the applied NCV for bio-gasoline. In previous submissions the wrong NCV was applied to bio gasoline which caused an overestimation of emissions.
- Secondly, bio methane has now been allocated to the year 2019 in the current submission of activity data from the NEA. This had been reported as NO in the previous submission.

These recalculations affect emissions for all pollutants for the years 2012-2013 and 2016-2019.

3.3.4.4 Planned improvements

For future submissions the EA will work with the NEA to try to investigate where these fuels are used so they can be attributed to correct categories.

3.4 Transport and other mobile sources (CRF 1A2, 1A3 and 1A4)

3.4.1 Mobile machinery (NFR 1A2gvii, 1A3eii and 1A4cii)

This section includes all non-road mobile machinery sources that are included under CRF 1A2, 1A3 and 1A4. What is in included in each subsector can be seen in Table 3.9

Table 3.9 Information on subsectors reported as Mobile Machinery

CRF code	IPCC name	Included
1A2gvii	Off-road vehicles and other machinery in Construction	IE (1990-2018, included in 1A3eii Off-road vehicles and other machinery), Construction from 2019
1A3eii	Off-road vehicles and other machinery	All off-road machinery for 1990-2018 (including from construction and agriculture/forestry subsectors), Other machinery after 2019
1A4cii	Agriculture/forestry/fishing: Off-road vehicles and other machinery	IE (1990-2018, included in 1A3eii Off-road vehicles and other machinery), Mobile machinery used in agriculture from 2019

For previous submissions all other off-road mobile machinery was reported under 1A2gvii and is now reported under 1A3eii. What is now reported undri 1A2gvii was previously reported as 1A2gv. These changes between sectors can be seen in Table 3.10 This was changed according to a review comment from the UNFCCC expert review team.

Table 3.10 Changes in allocation of fuels to NFR categories from this submission

2021 submission		2022 submission
1A2gv – Construction	→	1A2gvii – Mobile machinery in Construction
1A2gvii – Mobile Machinery	→	1A3eii – Other mobile machinery

3.4.1.1 Activity data

1A3eii: Other Off-road vehicles and machinery: Activity data and information available from the NEA for 1990-2018 do not allow the distinction between fuels sold to machinery in construction, agriculture or other uses, but provides data on fuel sold from fuel delivery trucks (as opposed to fuel sold at petrol stations). However, improvements were made in the data gathering by the NEA and it was possible to distinguish between off-road vehicles in agriculture and construction from the inventory years 2019 and onwards.

For this submission, category *1A3eii Other off-road vehicles and machinery* includes all emissions derived from fuels sold to off-road machinery for 1990-2018, including ***Mobile machinery in Construction (1A2gvii), Agriculture/Forestry/Fishing: Off-road vehicles and other machinery (1A4cii)*** as well as transport activities not reported under road transport such as ground activities in airports and harbours (1A3eii). Categories 1A2gvii and 1A4cii are marked as "IE" in the CRF reporter for 1990-2018 and are all included under 1A3eii. For 2019 and onwards Mobile machinery in construction (1A2gvii) and Agriculture/Forestry/Fishing: Off-road vehicles and other machinery (1A4cii) are reported separately but other transport activities not reported under road transport such as ground activities in airports and harbours are still reported under 1A3eii.

Activity data for fuel combustion are given in Table 3.11.

Table 3.11 Fuel use [kt], mobile combustion in the construction industry (1A2gv), Agriculture (1A4cii) and other (1A2gvii).

	1990	1995	2000	2005	2010	2015	2019	2020
1A2gvii - Mobile machinery in Construction								
Gas/Diesel Oil	IE	IE	IE	IE	IE	IE	7.1	3.7
Biodiesel	IE	IE	IE	IE	IE	IE	NO	NO
1A3eii - Other mobile machinery								
Gas/Diesel Oil	38.0	46.7	61.9	67.8	32.2	33.1	12.3	6.4
Other kerosene	NO	NO	NO	0.022	1.17	0.16	0.029	0.33
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO
1A4cii - Mobile machinery in Agriculture								
Gas/Diesel Oil	IE	IE	IE	IE	IE	IE	5.4	7.6
Biodiesel	IE	IE	IE	IE	IE	IE	0.028	NO

3.4.1.2 Emission factors

Emission factors for dioxins from this sector are taken from "Utslipp til luft av dioxiner i Norge" (Statistics Norway, 2002). They are 0.1 µg/t fuel. SO_x emissions are calculated from the S-content of the fuels. All other emission factors are from Table 3-1 from the chapter 1A4 non road mobile machinery in the 2019 EMEP/EEA Guidebook.

Table 3.12 Emission factor information for non-road mobile machinery (NFR 1A2gvii, 1A3eii, 1A4cii)

	Reference	Exception
Gas/Diesel Oil	Tier 1 EF for liquid fuels from **Table 3-1** from chapter *1.A.4 Non road mobile machinery* of the 2019 EMEP/EEA Guidebook	SO_2 emissions calculated based on: 0.2 % sulfur content Dioxin emissions from (Statistics Norway, 2002)
Kerosene	Same EFs as for gas/diesel oil as kerosene is most likely used for similar engines as diesel engines	
Biodiesel	Same EFs as for gas/diesel oil as biodiesel is used in diesel engines	

3.4.1.3 Recalculations and improvements

As can be seen in Table 3.10 allocations of fuels to NFR categories were changed. This did not cause recalculations for total emissions, only where those emissins are reported.

Recalculations are reported here as if the categories had been the same for last submission as they are now.

1A2gvii Mobile machinery in construction (1A2gv in last submission):

Gas/diesel oil allocation for this category changed for 2019, it was 10.3 kt for the last submission but deacresed to 7.1 kt (31%). This was due to an error in our fuel allocation file, which has now been corrected. This caused a 31% descrease in emissions for all pollutants reported for this sector.

1A3eii Other mobile machinery (1A2gvii in last submission):

Gas/diesel oil was reallocated by the NEA for two years, 2014 and 2019 (see Table 3.13). These reallocations caused a change in emission for all pollutants by the same proportion as the change in fuel.

Table 3.13 Reallocations of fuels in 1A3eii

	2014	2019
2021 submission [kt fuel]	40.5	7.12
2022 submission [kt fuel]	33.5	12.3
Difference (%)	-17 %	+73%
Reallocation	Reallocated to 1A3b Road transprot	Reallocated from 1A4cii Agriculture

3.4.1.4 Planned improvements

For future submissions it is planned to extrapolate data regarding the distribution of fuel between the three categories 1A2gvii, 1A3eii and 1A4cii for 1990-2018.

3.4.2 Civil aviation (NFR 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 since 2005 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 NO_x, 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 fuel use 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.

Because of different methodologies being used for the two time periods, there are big changes in emissions of some pollutants between 2004 and 2005.

3.4.2.1 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 data sources 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.
- since 2005: 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 3.14. Note that these are the sales statistics provided by the NEA, and do not include information from Eurocontrol.

Table 3.14 Fuel sales [kt], international and domestic aviation.

	1990	1995	2000	2005	2010	2015	2019	2020
1A3ai International Aviation								
Jet Kerosene	69.4	74.6	129.2	133.2	119.5	213.7	303.3	82.9
Aviation gasoline	0.20	0.18	0.032	0.40	0.010	9.0E-3	NO	NO
1A3aii Domestic aviation								
Jet Kerosene	1.7	1.1	1.1	0.87	0.65	0.50	0.37	0.20
Aviation gasoline	8.9	8.4	7.9	7.4	6.1	6.0	8.4	4.0

3.4.2.2 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 2019 EMEP/EEA Guidebook, nor are those emissions estimated by Eurocontrol.
- SO_x, NO_x, CO and NMVOC emissions were calculated using a tier 1 emission factor from table 3-3 in the 2019 EMEP/EEA guidebook.
- No emission factors are reported for particulate matter in the 2019 EMEP/EEA guidebook and therefore these emissions are NE for this time period.
- In order to allocate emissions to LTO and Cruise, respectively, a distribution factor was calculated using the 2005 Eurocontrol data for fuel use, and this factor was applied to the 1990-2004 fuel sales statistics from the NEA. Emissions were then calculated from that fuel for LTO and cruise.

2005-2020: Emissions were taken from the Eurocontrol dataset without further calculations, with the exception of dioxin and BC for which estimates were not provided in that dataset. Dioxin was therefore calculated in the same way as for the period 1990-2004. BC was estimated for 2005-2020 using the fraction 15% of TSP, which is presented in the 2019 EMEP/EEA guidebook.

3.4.2.3 Recalculations and improvements

No recalculations were done for these sectors

3.4.2.4 Planned improvements

Planned improvements are to enhance this category to tier 2 in future submissions.

3.4.3 Road transport (NFR 1A3b)

Emissions from the road transport category is split into seven subcategories:

- 1A3bi Cars
- 1A3bii Light duty trucks
- 1A3biii Heavy duty trucks and buses
- 1A3biv Motorcycles
- 1A3bv Gasoline evaporation
- 1A3bvi Automobile tyre and break wear
- 1A3bvii Automobile Road abrasion

3.4.3.1 Methodology

The transport model COPERT 5.5.1 (developed by Emisia SA) was used to produce emission estimates for all pollutants for the whole timeseries. The following text is taken from the COPERT website regarding the applied methodology[5]:

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

Results from COPERT model was adjusted to calculate the emission $PM_{2.5}$, PM_{10}, TSP and BC within automobile road abrasion because of studded tyre use.

3.4.3.2 Activity data

Country specific data was used where it was available. That data is:

- Average temperature values were obtained from the Icelandic Met Office.
- Vehicle stock numbers for 2017-2020 were obtained from the Icelandic Transport Authority.
- Measurements collected by the EA for energy content, density and sulphur content were used where available. Calculations of SO_x emissions in COPERT are based on country specific sulphur content in fuels, where it is assumed that all sulphur is converted to SO_x. Country specific measurements are only available from 2006, so for previous years the maximum allowed sulphur content according to European regulations was used as an approximation.
- Total fuel sales were obtained from sales statistics collected by the NEA for the whole timeseries.
- Measurements of carbon content (%C/%H/%O) in gasoline and diesel oil used in road transport were done from fuel samples from 2019. These values were applied for 1990-2019. New measurements were done for 2020.

A comprehensive dataset was purchased from Emisia, the company that develops COPERT. That data was used where country specific data was not available.

Total fuels sales were obtained from sales statistics collected by the NEA for the whole timeseries

In Table 3.15 the total use of diesel oil, gasoline and biofuels can be seen. They are based on the NEA's annual sales statistics for fuels in road transport.

Table 3.15 Fuel use [kt], road transport.

	1990	1995	2000	2005	2010	2015	2019	2020
Gasoline	67.1	117.6	142.6	156.7	148.2	132.5	118.7	91.6
Gasoline, leaded	60.7	18.0	NO	NO	NO	NO	NO	NO
Diesel oil	36.6	36.9	47.5	83.5	106.4	126.4	180.9	167.9
Biomethane	NO	NO	6.0E-3	0.039	0.595	2.18	1.49	1.44
Biodiesel	NO	NO	NO	NO	NO	11.9	14.9	13.0
Biogasoline/Bioethanoll	NO	NO	NO	NO	NO	1.93	6.24	11.0
Hydrogen	NO	NO	NO	9.0E-6	2.2E-3	NO	8.7E-4	4.2E-4

Dataset about usage of studded tyres (for $PM_{2.5}$, PM_{10}, TSP and BC emissions within automobile road abrasion) was obtained from the city of Reykjavík (for 2000-2019) and the city of Akureyri (for 1990-2019).

[5] https://www.emisia.com/utilities/copert/

3.4.3.3 *Emission factors*

All emission factors in COPERT are based on the Tier 3 methodology in the 2019 EMEP/EEA Guidebook which are presented in chapter 3.4 in the guidebook.

Emission factors for automobile road abrasion due to studded tyres are based on a Swedish research on studded tyre wear from pavement (Gustafsson, et al., 2005). Emission factors for studded tyres of passenger cars and light duty trucks and 50 times higher than for non-studded tyres for PM_{10}.

The same particle size fraction factors and BC fraction factors based on 2019 EMEP/EEA Guidebook are used for both studded and non-studded tyres.

The use of studded tyres of passenger cars and light duty trucks is 25% based on following information and assumptions:

- Studded tyres are banned from April 15th to October 31st each year. During this period the usage is assumed to be zero.
- The usage during other times is based on studded tyres counting in two municipalities, one in the capital area and one in Akureyri, in the north.
- Since 1990 the population living in the capital area has been 62% on average. The other 38% are living outside the capital region. There, the studded tyre usage is assumed to be the same as in Akureyri.

Studded tyre usage of heavy duty trucks, buses and motorcycles is very low and considered to be zero in this estimation.

3.4.3.4 *Recalculations and improvements*

The most extensive recalculation in road transport between the 2021 submission and 2022 submission is due to a reallocation of diesel oil in road transport in 2014. Review by the NEA of allocation of diesel between sub-sectors of mobile combustion revealed outliers which the NEA corrected for this submission. Diesel oil utilized in mobile machinery was re-allocated to road transport for 2014 which caused an increase of 295 TJ (+2,8%) for the whole sector. This increased the emissions of all pollutants calculated based on energy consumption.

Calculations of TJ of biomass were altered substantially due to an error found in the NCV for biodiesel in previous submissions. NCV has now been corrected and is aligned with the IPCC default value. This decreased the energy use of biomass by 1 – 84 TJ over the timeline. This effects all pollutants reported for biodiesel, more in the most recent years due to increased use of biofuels.

Other sub-sector specific recalculations are as follows:

1A3bi Passenger Cars: Emissions of all PMs have decreased over the whole timeseries after the emission factor in COPERT was updated with version 5.5.1. The decrease was in the range of 1.8 – 14.9 %.

1A3biii Heavy duty trucks and buses: Emissions of NH_3 have decreased over the whole timeseries after the emission factor in COPERT was updated with version 5.5.1. The decrease was in the range of 69 – 85 % for that subsector.

1A3bvii Automobile road abrasion: Emissions of BC have increased between submissions for 1990-2001. This was because there was an error in the calculation file and these years the emissions were not multiplied by 9.26 (multiplication factor for studded tyres), which they should have been.

3.4.3.5 *Planned improvements*

For future submissions it is planned, in collaboration with the Icelandic Transport Authority, to develop procedures to obtain enhanced data on vehicle stock and mileage data for COPERT.

3.4.4 National navigation (NFR 1A3dii)

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

3.4.4.1 *Activity data*

Total use of residual fuel oil, gas/diesel oil and biodiesel 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	2015	2019	2020
Residual fuel oil	3.94	4.76	0.54	0.88	2.61	0.44	4.82	NO
Gas/Diesel oil	6.40	7.04	3.43	6.20	8.46	7.89	11.88	7.83
Biodiesel	NO	NO	NO	NO	NO	NO	0.0010	NO

3.4.4.2 *Emission factors*

Emission factors for all pollutants are T1 emission factors from the 2019 EMEP/EEA Guidebook on navigation (Shipping). This chapter was updated in december 2021 and all EFs in our calculation fils have been updated accordingly. Emission factors references are presented in Table 3.17.

Table 3.17 Emission factors for national navigation emissions.

	Reference	Exception
Residual fuel oil	Tier 1 EF for bunker fuel oil from **Table 3-1** from chapter *1.A.3.d Navigation* of the 2019 EMEP/EEA Guidebook	
Gas/Diesel Oil	Tier 1 EF for marine diesel oil from **Table 3-2** from chapter *1.A.3.d Navigation* of the 2019 EMEP/EEA Guidebook	It is assumed that TSP = PM_{10} = $PM_{2.5}$
Biodiesel	Same EFs as for gas/diesel oil as biodiesel is used in diesel engines	

3.4.4.3 *Recalculations and improvements*

There are two main reasons for recalculations in this sector:

- The NEA reallocated fuel between domestic navigation, international navigation and fishing for 1990-1994. Some of the fuel that was previously attributed to domestic navigation is now attributed to international navigation and fishing. This causese recalculations for all reported pollutants for this sector for 1990-1994. As can be seen in Table 3.18 the fuel deacresed by 45 – 67 %.

Table 3.18 Reallocation of fuels in Domestic navigation causing recalculations of all pollutants

	1990	1991	1992	1993	1994
2021 submission					
Gas/Diesel Oil [kt]	11.7	10.0	10.7	12.4	14.1
Residual fuel oil [kt]	7.2	7.3	7.1	6.8	4.2
2022 submission					
Gas/Diesel Oil [kt]	6.4	3.3	4.3	6.3	6.2
Residual fuel oil [kt]	3.9	4.0	3.9	3.7	2.3
Difference					
Gas/Diesel Oil [%]	-46%	-67%	-59%	-49%	-56%
Residual fuel oil [%]	-45%	-45%	-45%	-45%	-45%

- The 2019 EMEP/EEA guidebook was updated in December 2021 with new emission factors for domestic navigation. This caused recalculation of NO_x, CO, NMVOC, SO_x, TSP, PM_{10}, $PM_{2.5}$, As, Cu and Se for the whole timeseries.

3.4.4.4 Planned improvements

There are no planned improvements.

3.4.5 International navigation (memo item - NFR 1A3di(i))

The reported fuel use numbers are based on fuel sales data from the retail suppliers. The retail supplier divides their reported fuel sales between international navigation and national navigation based whether the vessel is sailing to an Icelandic or a foreign harbor (regardless of flag). Fuel used for international navigation can be seen in Table 3.19.

Table 3.19 Fuel use [kt], international navigation.

	1990	1995	2000	2005	2010	2015	2019	2020
Residual fuel oil	0.25	NO	2.00	0.44	0.080	13.2	19.3	NO
Gas/Diesel oil	8.53	1.05	15.0	0.12	NO	33.6	45.2	24.3

The emission factors used to estimate emissions from international navigation are the same as those used for national navigation and can be found in Table 3.17.

3.4.6 Fishing (NFR 1A4ciii)

Emissions from the fishing sector in Iceland are significant as the fishing industry is one of the main industries and fish products are one of the main export products in Iceland.

3.4.6.1 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 and includes both national and international fishing. 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	2015	2019	2020
Gas/Diesel oil	35.6	57.2	22.3	32.6	69.9	52.4	25.8	NO
Residual fuel oil	202.6	231.8	256.9	199.9	158.3	142.5	136.6	158.7
Biodiesel	NO	NO	NO	NO	NO	0.094	0.034	0.075

3.4.6.2 Emission factors

Emission factors for all pollutants are the same as for domestic navigation, and can be seen in Table 3.17.

3.4.6.3 Recalculations and improvements

Recalculations in the fishing sector were for the same reasons as for domestic navigation. There are two main reasons for recalculations in this sector:

- The NEA reallocated fuel between domestic navigation, international navigation and fishing for 1990-1994. Some of the fuel that was previously attributed to domestic navigation is now attributed to international navigation and fishing. This causese recalculations for all reported pollutants for this sector for 1990-1994. As can be seen in Table 3.21 the fuel used in the fishing sector increased by 1.3 – 9.3 % for the years 1990-1993, and there was a very minor decrease in residual fuel oil use in 1994.

Table 3.21 Reallocation of fuels in fishing causing recalculations of all pollutants

	1990	1991	1992	1993	1994
2021 submission					
Gas/Diesel Oil [kt]	199.9	174.2	196.8	218.0	212.7
Residual fuel oil [kt]	32.6	49.6	53.0	50.9	51.8
2022 submission					
Gas/Diesel Oil [kt]	202.6	178.8	200.8	221.3	217.6
Residual fuel oil [kt]	35.6	52.9	55.6	53.2	51.6
Difference					
Gas/Diesel Oil [%]	1.3%	2.7%	2.0%	1.5%	2.3%
Residual fuel oil [%]	9.3%	6.6%	5.1%	4.5%	-0.2%

- The 2019 EMEP/EEA guidebook was updated in December 2021 with new emission factors for domestic navigation. This caused recalculation of NO_x, CO, NMVOC, SO_x, TSP, PM_{10}, $PM_{2.5}$, As, Cu and Se for the whole timeseries.

3.5 Fugitive Emissions (NFR 1B2)

In Iceland, fugitive emissions occur only from two sources: Distribution of oil products (1B2av) and Geothermal energy production (1B2d).

3.5.1 Distribution of oil products (NFR 1B2av)

NMVOC emissions from distribution of oil products are estimated by multiplying the total imported fuel with an emission factor.

3.5.1.1 Activity data

The calculations are based on yearly fuel import data provided by Statistics Iceland.

3.5.1.2 Emission factors

The emission factor is taken from Table 4.2.4 2006 IPCC Guidelines Tanker Trucks and Rail Cards and is 0.00025 Gg per 1000 m^3 total oil transported.

3.5.1.3 Recalculations and improvements

No recalculations were performed for this sector.

3.5.1.4 Planned improvements

No improvements are planned for this sector.

3.5.2 Geothermal energy (NFR 1B2d)

Iceland relies heavily on geothermal energy for space heating and to a significant extent for electricity production (27% of the total electricity production in 2016). Geothermal energy is generally considered to have a 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. The H_2S values are stoichiometrically converted to SO_2 and reported as such.

3.5.2.1 Activity data and emissions

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.

The CarbFix project, located at the Hellisheiði Power Plant, has been pioneering CO_2 capture and reinjection on site into the basaltic subsurface, and has proven rapid and complete reaction to calcium carbonate precipitates (Matter, et al., 2016). A sister project, SulFix, consists of separating H_2S from the steam and also reinjecting the gas into the subsurface and mineralizing on contact with the basalt host rock. Injection of H_2S started in 2014 at Hellisheiði. This project has had a significant impact on sulphur emissions from geothermal power production at Hellisheiði.

Table 3.22 shows the electricity production with geothermal energy and the total Sulphur emissions (calculated as SO_2).

Table 3.22 Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2010	2015	2019	2020
Electricity production [GWh]	283	288	1,323	1,655	4,465	5,003	6,018	5,961
Sulphur emissions [kt SO_2]	13.3	11.0	26.0	30.3	58.7	42.4	41.9	39.3

3.5.2.2 Recalculations and improvements

No recalculations were done for this sector.

3.5.2.3 Planned improvements

For future submissions the plan is to differentiate between emissions linked to electricity production and those linked to district heating.

4 Industrial Processes and Product Use (IPPU) (NFR sector 2)

4.1 Overview

As a result of the expansion of the industrial sector, the contribution of this sector to the total emissions has been increasing since 1990. By far the main contributor to the emissions from this sector is metal production (aluminium, ferrosilicon alloy, and silicon metal in recent years). The emission trends of the various pollutants closely match the opening and closing of various facilities.

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

The Industrial Processes and Product Use (IPPU) sector is divided into the following subsectors:

- 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)
- Other industry production (NRF 2H)
- Food & Beverages Industry (NFR 2H2)

Table 3.1 shows which subsectores in IPPU are key categories for which air pollutants. A key category is one that is prioritised within the national inventory system because it is significantly important for one or a number of air pollutants in a country's national inventory of air pollutants in terms of the absolute level, the trend, or the uncertainty in emissions (EEA, 2019). Categories whose cumulative percentage contribution is greater than 80% should be identified as key.

Table 4.1 Key categories for air pollutants within IPPU.

SO_x, NO_x, NH_3, NMVOC, PM, BC and CO			
	1990	2020	Trend
2A5a Quarrying and mining of minerals other than coal	PM_{10}, TSP	PM_{10}, TSP	PM_{10}, TSP
2A5b Construction and demolition	$PM_{2.5}$, PM_{10}, TSP	$PM_{2.5}$, PM_{10}, TSP	$PM_{2.5}$, PM_{10}, TSP
2C2 Ferroalloys production	SO_x, $PM_{2.5}$, PM_{10}	NO_x, $PM_{2.5}$, PM_{10}	NO_x, $PM_{2.5}$, BC
2C3 Aluminium production	$PM_{2.5}$, CO	NO_x, SO_x, $PM_{2.5}$, PM_{10}, TSP, BC, CO	NO_x, SO_x, $PM_{2.5}$, PM_{10}, TSP, BC, CO
2D3a Domestic solvent use including fungicides	NMVOC	NMVOC	NMVOC
2D3d Coating applications	NMVOC	NMVOC	NMVOC
2H2 Food and beverages industry		NMVOC	NMVOC
Persistent Organic Pollutants (POPs)			
	1990	2020	Trend
2C2 Ferroalloys production		PAH4	PAH4

2C3 Aluminium production		PAH4, HCB	PAH4, HCB
Heavy Metals (HMs)			
	1990	2020	Trend
2C2 Ferroalloys production		Cd, As	Cd, As, Zn
2G Other product use (Fireworks, tobacco)	Pb	Pb, Cd, Cr, Cu, Zn	Pb, Cd, As, Cr, Cu, Ni, Zn

4.2 General methodology

Methodology is generally based on the most recent EMEP/EEA air pollutant emission inventory Guidebook (EEA, 2019). In most cases, emissions are calculated by multiplying the quantity of production or product use with pollutant-specific emissions factors. Emissions factors are also taken from the Standardized Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs (UNEP, 2013), 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 (as per Directive 2003/87/EC of the European Parliament and of the Council), Statistics Iceland, Green Accounting or directly from the operators. Detailed, activity-specific methodology for emission estimates is described for each subsector. Work is underway to harmonise this reporting with data reported under the E-PRTR Regulation (Regulation (EC) No 166/2006).

4.3 Mineral Industry (NFR 2A)

4.3.1 Cement production (NFR 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 EA 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 (UNEP, 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 2019 EMEP/EEA Guidebook. 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 under 2A1 Cement production. Emissions of PAH, NO_x, CO and NMVOC originate mainly from combustion and are reported under 1A2f (Stationary combustion in manufacturing industries and construction: non-metallic minerals); process-related emissions for those pollutants are not applicable. All emission factors used are summarized in the table below.

Table 4.2 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 $PM_{2.5}$
Cement production	0.050	11	220	200	100	3.0%

4.3.1.3 Recalculations and improvements
No recalculations were made to cement production (2A1) for this submission.

4.3.1.4 Planned improvements
No improvements are currently planned for this subsector.

4.3.2 Lime production (NFR 2A2)

This activity does not occur in Iceland.

4.3.3 Glass production (NFR 2A3)

This activity does not occur in Iceland.

4.3.4 Quarrying and mining of minerals other than coal (NFR 2A5a)

4.3.4.1 Activity data
The activity data was retrieved from Statistics Iceland who provided a timeseries from 2004-2017 of aggregates with no further distinction of size, used by the Icelandic Road and Coastal Administration for road construction and by the main power company who uses material from quarries to build dams for hydropower plants. Currently no data is available prior to 2004, so the data from 2004 has been used for the years 1990-2003. Data since 2018 is also not available, therefore the value from 2017 is used.

4.3.4.2 Emission factors
The methodology follows Tier 1 of the 2019 EMEP/EEA Guidebook and the applied emission factors are taken from Table 3.1. Only particulate matter emissions, that is TSP, PM_{10} and $PM_{2.5}$ arise from this category.

4.3.4.3 Recalculations and improvements
No recalculations were made for this submission.

4.3.4.4 Planned improvements
For future submissions it is planned to improve the inventory by moving from tier 1 to tier 2 within this subsection.

4.3.5 Construction and demolition (NFR 2A5b)

4.3.5.1 Activity data

To retrieve activity data, the building stock per construction year, subdivided by the type of houses (terraced, detached, semi-detached, apartment buildings, non-residential buildings) is obtained from Registers Iceland for the time series. Data about road construction is retrieved from the Icelandic Road and Coastal Administration for the years since 2003 and for the remaining time series is estimated as average 2003-2011.

4.3.5.2 Emission factors

The methodology follows Tier 1 of the 2019 EMEP/EEA Guidebook. Default values from the Guidebook are used for the duration of construction (houses 0.5, apartment buildings 0.75, non-residential 0.83 and roads 1.00 years), for the control efficiency (houses -, apartment buildings -, non-residential 0.5, roads 0.5), silt content is assumed to be 20% and the Thornthwaite Precipitation-Evaporation Index was calculated with precipitation and temperature data recorded at a weather station in Reykjavík. Only particulate matter emissions, that is TSP, PM_{10} and $PM_{2.5}$ arise from this category.

The implementation of a Tier 3 method it is not possible to source any of the required data. US EPA provides methodologies with AP-42 that require very detailed local data. The 2019 EMEP/EEA Guidebook states that collection of such data is likely to be possible only for individual large point sources. This data is not available for any construction and demolition sites in Iceland.

4.3.5.3 Recalculations and improvements

The Thornthwaite Precipitation-evaporation Index was recalculated for the whole timeseries. It is now based on monthly averages instead of yearly averages. This influences the particulate matter emissions since soil moisture has a strong influence on soil dust sensitivity. The changed in the PE Index as well as the recalculations of TSP, PM_{10} and $PM_{2.5}$ can be seen in Table 4.3.

Table 4.3: Recalculations within 2A5b, Construction and demolition, due to changes in the calculations of the Thornthwaite Precipitation-evaporation Index.

2A5b, Construction and demolition	1990	1995	2000	2005	2010	2015	2018	2019
2021 submission, PE index	126	96	121	107	79	159	158	122
2022 submission, PE index	66	52	63	57	42	85	79	64
2021 submission TSP [kt]	2.05	2.64	2.23	1.65	3.26	0.52	0.73	1.00
2022 submission TSP [kt]	3.91	4.86	4.28	3.11	6.18	0.96	1.46	1.92
Change relative to 2021 submission TSP	91%	85%	92%	88%	90%	86%	101%	92%
2021 submission PM_{10} [kt]	0.61	0.79	0.67	0.49	0.97	0.15	0.22	0.30
2022 submission PM_{10} [kt]	1.17	1.45	1.28	0.93	1.85	0.29	0.44	0.58
Change relative to 2021 submission PM_{10}	91%	85%	92%	88%	90%	86%	101%	92%
2021 submission $PM_{2.5}$ [kt]	0.061	0.079	0.067	0.049	0.097	0.015	0.022	0.030
2022 submission $PM_{2.5}$ [kt]	0.117	0.145	0.128	0.093	0.185	0.029	0.044	0.058
Change relative to 2021 submission $PM_{2.5}$	91%	85%	92%	88%	90%	86%	101%	92%

4.3.5.4 *Planned improvements*
No improvements are currently planned for this subsector.

4.3.6 Storage, Handling and Transport of mineral products (NFR 2A5c)

This activity is currently not estimated. It is planned to include this within the mineral production chapter.

4.3.7 Mineral wool production (NFR 2A6)

There is one mineral wool production plant in operation in Iceland. Although it is an activity falling under Annex I of Directive 2003/87/E (ETS Directive), it is excluded from the EU ETS scheme following the conditions described in Article 27 of the ETS Directive. The operator submits annual emission reports for GHGs to the EA, using the same template as the companies reporting within the EU ETS scheme.

4.3.7.1 *Activity data*
Activity data for the mineral wool plant originates from the annual emission reports mentioned above, as well as annual Green Accounting reports.

4.3.7.2 *Emission factors*
Emissions of dioxins are calculated from the amount (weight) of electrodes used in the production process. The emission factor is taken from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). PAH emissions are not applicable. 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, measurements were available every second year from 2009. For those years the actual measurements were used to derive a year-specific emission factor. For the years in between, 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 available measurements was used. Since 2018 yearly total emissions for NH_3 are communicated from company directly. PM_{10} and $PM_{2.5}$ were calculated from TSP using the TSP vs. PM_{10} vs. $PM_{2.5}$ ratios given in table 3.5 in chapter 2.A.3 in the EMEP/EEA Guidebook (EEA, 2019). BC was calculated using the ratio to $PM_{2.5}$ given in the EMEP/EEA Guidebook (EEA, 2019). NO_x and NMVOC emissions originate from combustion and are reported under sector 1A2f. Table 4.4 shows the emission factors used for mineral wool production.

Table 4.4 Emission factors for mineral wool production (CO and TSP: Values are EF averages for 1990-2019. NH_3: Values are EF averages for 1990-2017).

	NH_3 [t/kt]	CO [t/kt]	TSP [t/kt]	PM_{10} % of TSP	$PM_{2.5}$ % of TSP	BC % of $PM_{2.5}$	Dioxin [µg/t I-TEQ/t]
Mineral wool production	2.65	1.64	2.44	88%	78%	2.0%	1.6

4.3.7.3 *Recalculations and improvements*
On site factory CO measurements from the year 2000 were previously used to calculate an implied emission factor for CO (2.66 kg/t). On site factory CO measurements from the year 2009 are now used for the year 2009 and onwards (5 mg/Nm^3). For the period 2000-2009 a linear interpolation was made between the two emission factors. Table 4.5 shows the effect of the change.

Table 4.5: Recalculations within 2A6, Mineral wool production, due to updated measurements of CO from the factory.

2A6, Mineral wool production	2000	2001	2004	2005	2010	2015	2018	2019
2022 submission EF [kg/t]	2.66	2.44	1.77	1.54	0.92	0.60	0.52	0.50
CO emission 2021 submission CO [t]	21.9	20.8	22.6	24.7	12.6	29.0	25.1	26.6
CO emission 2022 submission CO [t]	21.9	19.0	16.1	15.3	4.8	4.9	5.2	5.3
Change relative to 2021 submission CO	0%	-8.4%	-29%	-38%	-62%	-83%	-79%	-80%

4.3.7.4 Planned improvements

No improvements are currently planned for this subsector.

4.4 Chemical Industry (NFR 2B)

4.4.1 Ammonia production (NFR 2B1)

Ammonia was produced amongst other fertilizers during the period 1990-2001. The associated emissions are marked as Included Elsewhere under 2B1 Ammonia Production and are included in the emissions reported under 2B10a other: Fertilizer Production. The emission estimation methodology associated with ammonia production is also described there.

4.4.2 Nitric acid production (NFR 2B2)

This activity does not occur in Iceland.

4.4.3 Adipic acid production (NFR 2B3)

This activity does not occur in Iceland.

4.4.4 Carbide production (NFR 2B5)

This activity does not occur in Iceland.

4.4.5 Titanium dioxide production (NFR 2B6)

This activity does not occur in Iceland.

4.4.6 Soda ash production (NFR 2B7)

This activity does not occur in Iceland. Emissions from the use of soda ash in the silica (diatomite) industry (NFR 2B10a; reported until 2004) are reported under that NFR code.

4.4.7 Chemical industry: Other (NFR 2B10a)

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

The fertilizer production plant was operational until there was an explosion at the site in 2001. In the early days of the factory, only one type of fertilizer was produced (a nitrogen fertilizer), whereas at the end of its production phase it was producing over 20 different types of fertilizers. CO_2 and CH_4

emissions are considered insignificant, as the fertilizer plant used H_2 produced on-site by electrolysis. Methodology NO_x and N_2O emissions were reported directly by the factory to the EA.

4.4.7.1 Activity data
When the fertilizer production plant was operational it reported its emissions of NO_x and N_2O to the EA. At the diatomite production plant, silica 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 silica production [kt]

	1990	1995	2000	
Fertilizer production [kt]	63.7	58.5	41.5	Facility closed in 2001
Diatomite production [kt]	26.1	28.1	27.6	Facility closed in 2004

4.4.7.2 Emission factors
For diatomite 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 NO_x implied EF for the period 1990-2004 was 15.6 t NO_x/kt Si production. Other emissions from soda ash use were not estimated and are considered to be small.

For the fertilizer production, the average implied EF for NO_x for the period 1990-2001 was 0.296 t NO_x/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.

4.4.7.3 Recalculations and improvements
No recalculations were made for this submission.

4.4.7.4 Planned improvements
No improvements are currently planned for this subsector.

4.5 Metal Production (NFR 2C)

4.5.1 Iron and steel production (NFR 2C1)

From 2014 to 2016 a secondary steelmaking facility was operating. It produced steel from scrap iron and steel from the aluminium smelters. Carbonates and slags were added to the smelting process, which occurred in an electric arc furnace.

4.5.1.1 Activity data
Activity 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 EA.

4.5.1.2 Emission factors
All emissions are calculated using Tier 2 emission factors for electric arc furnaces (Table 3.15 in chapter 2.C.1 from the 2019 EMEP/EEA Guidebook (EEA, 2019)), with the exception of HCB for which there is no Tier 2 estimate. In this case we used the Tier 1 emission factor, which is unrelated to technology.

4.5.1.3 Recalculations and improvements
No recalculations were made for this submission.

4.5.1.4 *Planned improvements*
No improvements are currently planned for this subsector.

4.5.2 Ferroalloys production (NFR 2C2)

Two factories produce ferroalloys in Iceland. One company has been producing FeSi75 since 1979 and another one started production of ≥98.5% pure silicon metal in 2018. A third company was operating between 2016-2017 producing silicon metal but has stopped production in 2017. Both active operators are under the EU Emission Trading Scheme (as per Directive 2003/87/EC).

In both factories, raw ore, carbon material and slag forming materials are mixed and heated to high temperatures for reduction and smelting. For the production of FeSi75 electric (submerged) arc furnaces with consumable Söderberg electrodes are used. The furnaces are semi-covered. The other factory is using submerged arc furnaces using pre-baked graphite 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 EA directly from the plants and provided by the plants through annual emission reports submitted within the EU ETS. Activity data for raw materials and products are given in Table 4.7.

Table 4.7 Raw materials use [kt] and production [kt], ferrosilicon and silicon production.

	1990	1995	2000	2005	2010	2015	2019	2020
Electrodes	3.83	3.88	5.73	6.00	4.79	4.86	4.59	4.82
Coking coal	45.1	52.4	73.2	86.9	96.1	115	142	129
Coke oven coke	24.9	30.1	46.6	42.6	30.3	30.9	21.2	23.5
Charcoal	NA	NA	NA	2.08	NA	NA	3.41	1.67
Wood	16.7	7.7	16.2	15.6	11.3	27.2	78.1	59.9
Limestone	NA	NA	0.47	1.62	0.50	2.19	1.83	0.95
Production (FeSi, Si)	63	71	109	111	102	118	119	116
Microsilica	14.0	15.9	22.7	25.8	18.1	22.2	20.8	20.3
Slag	NA	NA	NA	NA	NA	NA	NA	NA

4.5.2.2 *Emission factors*
FeSi production:

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 factors for CO, NO_x and NMVOC were taken from Table 8.18 of the Best Available Techniques Reference (BREF) document for the non-ferrous metals industries (Cusano, et al., 2017). In the case where a range was given, the highest value of the range was chosen. The 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 8.12 of the BREF document for Best Available Techniques for the non-ferrous metals industries (Cusano, et al., 2017). 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 EA. Emission factor of PM_{10} and $PM_{2.5}$ relative to TSP are Tier 1 default values from the 2019 EMEP/EEA Guidebook (EEA, 2019). The emission factor for BC is taken from (Aasestad, 2013) in accordance with the Norwegian IIR (Norwegian Environment Agency, 2016).

Several heavy metals (As, Cd, Cr, Cu, Hg, Pb and Zn) were measured in silicon dust in the ferrosilicon plant 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 heavy metal contents in silica dust are shown in Table 4.8.

Table 4.8 Heavy metal contents in silica dust in 2014 [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

Si production:

Emission factors for Particulate Matter are Tier 3 plant specific and for BC are Tier 1 default values as published in the 2019 EMEP/EEA Guidebook. The NO_x emission factor is taken from the BREF document on non-ferrous minerals (Cusano, et al., 2017). SO_2 emissions as well as emission of the heavy metals Pb, Cd, Cu and Zn are reported by the operator to the EA in the annual Green Accounting report. Emissions from the other pollutants are not estimated due to lack of available information in the EMEP/EEA Guidebooks and in the BREF document cited above.

All emission factors used for calculating emissions from FeSi and Si production are presented in Table 4.9.

Table 4.9 2020 emission factors from FeSi and Si production.

	NO_x [kg/t]	NMVOC [kg/t]	CO [kg/t]	TSP [kg/t]	PM_{10}	$PM_{2.5}$
FeSi	11	0.045	2.5	6.0E-4	85% of TSP	60% of TSP
Si	13	NA	NA	2.91	2.91 kg/t	2.91 kg/t
	BC % of PM2.5	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	0.23%	0.114	2.79	102	29.7	9.39
Si	10%	NA	NA	NA	NA	NA

4.5.2.3 Recalculations and improvements

Emission factor for PM_{10} and $PM_{2.5}$ for FeSi production were both 95% of TSP. It was changed into 85% and 60% of TSP, according to 2019 EMEP/EEA Guidebook (Table 3.1, chapter 2C2). Also, data about particulate matter emission from the Si production is $PM_{2.5}$ but was regarded as TSP. Furthermore, the PM_{10} and TSP emissions are now estimated as the same as $PM_{2.5}$ according to information from the factory instead of using the ratios from the EMEP/EEA 2019 Guidebook. Recalculations were made for PM_{10}, $PM_{2.5}$ and BC, see Table 4.10.

Table 4.10 Recalculation of PM_{10}, $PM_{2.5}$ and BC for 2C2, Ferroalloys production.

2C2, Ferroalloys production	1990	1995	2000	2005	2010	2015	2018	2019
2021 submission PM_{10} [kt]	95	108	158	143	121	259	86	74
2022 submission PM_{10} [kt]	85	97	141	128	108	232	78	69
Change relative to 2021 submission PM_{10}	-11%	-11%	-11%	-11%	-11%	-11%	-9%	-7%
2021 submission $PM_{2.5}$ [kt]	95	108	158	143	121	259	85	71
2022 submission $PM_{2.5}$ [kt]	60	68	100	90	76	163	57	52
Change relative to 2021 submission $PM_{2.5}$	-37%	-37%	-37%	-37%	-37%	-37%	-33%	-26%
2021 submission BC [kt]	0.22	0.25	0.36	0.33	0.28	0.60	0.47	0.86
2022 submission BC [kt]	0.14	0.16	0.23	0.21	0.18	0.38	0.59	1.28
Change relative to 2021 submission BC	-37%	-37%	-37%	-37%	-37%	-37%	25%	49%

4.5.2.4 Planned improvements

Work is underway to harmonise this reporting with the E-PRTR reports.

4.5.3 Primary aluminium production (NFR 2C3)

Aluminium is currently 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, NO_x, CO, particulate matter and SO_2. Emissions originate from the consumption of electrodes during the electrolysis process.

4.5.3.1 Activity data

The EA 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 Primary aluminium production [kt].

	1990	1995	2000	2005	2010	2015	2018	2019
Primary Al production [kt]	88	100	226	272	819	857	834	831

4.5.3.2 Emission factors

In 2011 emissions of dioxin were measured at one of the aluminium plants. 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 and used for all three factories.

NO_x and CO are Tier 2 EF, taken from Table 3.2 of the 2019 EMEP/EEA Guidebook (EEA, 2019). 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 EA. Ratios of TSP:PM_{10}:$PM_{2.5}$ as well as the BC emission factor were also taken from the 2019 EMEP/EEA Guidebook. Emissions of SO_2 are estimated from S-content of alumina and electrodes for the time prior to reporting of SO_2 emission in the Green Accounts (2003-2013, depending on the company), and from SO_2 emission calculations reported in the Green accounts in the later years. All emission factors are presented in Table 4.12.

Table 4.12 Emission factors, primary aluminium production.

	Dioxin [µg/t Al]	PAH4 [g/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%	8.0%
	CO [kg/t Al]	NO_x [kg/t Al]	PM_{10} % of TSP	$PM_{2.5}$ % of TSP	BC % of $PM_{2.5}$	
Emission factors	120	1.0	83%	67%	2.3%	

4.5.3.3 Recalculations and improvements

Activity data (production amount) for the year 2019 was updated for one of the plant due to error in the calculation files. Primary aluminium production in 2019 is now 834.4 kt instead of 835.7 kt. This recalculation leads to change in emissions within primary aluminium production from particulate matter, NO_x, SO_2, CO, PAH4 and dioxin for the year 2019, see Table 4.13.

Table 4.13 Recalculations for 2019 for Primary aluminium production.

2C3, Primary aluminium production	TSP [t]	PM_{10} [t]	$PM_{2.5}$ [t]	BC [t]	NO_x [t]	SO_2 [kt]	CO [kt]	PAH4 [kg]	PCDD/F [mg]
2021 submission	468	390	312	7.17	836	10.49	100.3	15.8	27.5
2022 submission	467	389	311	7.16	834	10.46	100.1	15.8	27.4
Change relative to 2021 submission	-0.21%	-0.21%	-0.21%	-0.21%	-0.16%	-0.31%	-0.16%	-0.16%	-0.16%

4.5.3.4 Planned improvements

Work is underway to harmonise this reporting with the E-PRTR reports.

4.5.4 Secondary aluminium production (NFR 2C3)

Secondary aluminium production started in 2004. In 2012, a second facility opened. At the end of 2014 the facilities merged and only one production area is active now. The plant recycles aluminium skimmings and scrap aluminium from two primary aluminium plants by melting scrap metal in batches in a rotary kiln. The re-melt process is carried out under a layer of salt and the resulting salt slag traps part of the contaminants. The scrap aluminium is not treated with organic material such as paints, lacquers, oils, and greases prior to recycling and comes directly from the primary aluminium plants.

4.5.4.1 Activity data

All activity data, consisting of produced secondary aluminium, is obtained in Green Accounting reports submitted yearly to the EA, see Table 4.14.

Table 4.14 Secondary aluminium production [kt].

	1990	1995	2000	2005	2010	2015	2019	2020
Secondary Al production [kt]	NO	NO	NO	2.25	2.04	2.20	2.16	2.20

4.5.4.2 Emission factors

Emissions of dioxin, HCB and PM are estimated. The dioxin implied emission factor is based on four on-site measurements at the factory in different years. The average of these four measurements (0.45 µg/t aluminium) is in accordance with the emissions factor from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2013) for production where high efficiency controls are in place (0.5 µg/t aluminium). 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 TSP, PM_{10}, $PM_{2.5}$ and BC emission factors are taken from the Table 3.4 in the EMEP/EEA Guidebook (EEA, 2019).

The emission factor for HCB was chosen as a value in the lower range (0.04-40 mg/t) given in Table 5-9 and Figure 5-18 of BiPRO (2006). As the recycled scrap material is directly coming from the primary aluminium smelters, contamination with organic substances in form of paintings or lacquers is expected to be insignificant and subsequently emissions of organochloride are expected to be low as well. A comparison across Nordic Countries shows that the used emissions factors are 1.365 mg/t in Finland, 1.7 mg/t in Norway and 20 mg/t in Denmark (from the IIR of the respective countries).

Table 4.15 Emission factors, secondary aluminium production.

	Dioxin [µg/t Al]	HCB [mg/t Al]	TSP [kg/t]	PM_{10} [kg/t]	$PM_{2.5}$ [kg/t]	BC % of $PM_{2.5}$
Emission factors	0.45	5.0	2.0	1.4	0.55	2.3%

4.5.4.3 Recalculations and improvements

The dioxin emission factor is now based on measurements on-site. The average of four measurements from 2014, 2016, 2017 and 2018 is used to give the implied emission factor of 0.45

µg/t aluminium. Before a value of 0.50 µg/t aluminium was used (from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2013)). The recalculation was made for the factory that started in 2012 and not for the factory that closed in 2014. Summary of the recalculations for the subsector 2C3 can be seen in Table 4.16.

Table 4.16 Recalculations within 2C3, Secondary aluminium production.

2C3, Secondary aluminium production	2012	2013	2014	2015	2016	2017	2018	2019
2021 submission dioxin [mg]	0.62	1.46	1.21	1.10	1.05	1.46	1.56	1.08
2022 submission dioxin [mg]	0.61	1.36	1.13	1.02	0.94	1.31	1.40	0.97
Change relative to 2021 submission	-1.9%	-6.8%	-6.4%	-7.6%	-10.4%	-10.4%	-10.4%	-10.4%

4.5.4.4 Planned improvements

No improvements are currently planned for this subsector.

4.6 Solvent and Product Use (NFR 2D)

Activities related to 2D Solvent and product use mostly generate NMVOC. 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), and other solvent use (Creosotes - 2D3i - PAH). The categories Coating, 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 2D3a, Domestic solvent use are Tier 2b from the 2019 EMEP/EEA Guidebook (Table 3.5). All other emission factors for subcategories of 2D3 are presented in Table 4.17. References and more details about individual emission factors are included in the respective under chapters.

Table 4.17 Emission factors for sector 2D3.

	unit	NMVOC [g/unit]	TSP [g/unit]	PM_{10} [g/unit]	$PM_{2.5}$ [g/unit]	BC [% of $PM_{2.5}$]
2D3b Road paving with asphalt	t asphalt	16	20	4.3	5.7	5.7%
2D3d Coating applications	kg paint	230	-	-	-	-
2D3e Degreasing	kg cleaning product	460	-	-	-	-
2D3f Dry cleaning	kg textile treated	19.5	-	-	-	-
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	0.0070	-	-	-	-
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	-	-	-	-	-

4.6.1 Domestic solvent use including fungicides (NFR 2D3a)

Domestic solvent use is calculated using a default per capita value, as per Tier 1, Table 3.1 Chapter 2.D.3.a of the Guidebook (EEA, 2019).

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 from Table 3.1, Chapter 2.D.3.a (EEA, 2019).

Hg is not estimated due to uncertainty around the releases according to the 2019 EMEP/EEA Guidebook (EEA, 2019). The Hg emissions may be accounted for elsewhere in the inventory since emissions of Hg could arise from the use of fluorescent tubes.

4.6.1.3 Recalculations and improvements

Recalculation of NMVOC within the 2D3a subsector for this submission is due to a tier change. NMVOC emissions are now calculated based on tier 2b methodology instead of tier 1 (according to the 2019 EMEP/EEA Guidebook (European Environment Agency, 2019)). Table 4.18 shows the emission change due to these recalculations.

Table 4.18 Recalculations of emission within 2D3a (Domestic solvent use Including Fungicides) between 2021 and 2022 submissions

Domestic Solvent use Including Fungicides	1990	1995	2000	2005	2010	2015	2018	2019
2021 submission NMVOC [t]	461	482	510	540	573	599	643	655
2022 submission NMVOC [t]	625	657	687	723	782	810	858	879
Change relative to 2021 submission	36%	36%	35%	34%	36%	35%	34%	34%

4.6.1.4 Planned improvements

No improvements are currently planned for this subsector.

4.6.2 Road paving with asphalt (NFR 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 factor for NMVOC is taken from Table 3.1 in Chapter 2.D.3.b, Tier 1, in the EMEP/EEA Guidebook (EEA, 2019). Emissions factors for TSP are based on measurements from the second-largest asphalt production plant. BC, $PM_{2.5}$ and PM_{10} 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 (EEA, 2019). Emissions of dioxin are based on emission factor 0.007 µg TEQ/t from the Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs (UNEP, 2013). 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 1A2gvii

4.6.2.3 Recalculations and improvements
No recalculations were made for this submission.

4.6.2.4 Planned improvements
No improvements are currently planned for this subsector.

4.6.3 Coating applications (NFR 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/EEA Guidebook (EEA, 2019) 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 from the Icelandic Recycling Fund annual report (Icelandic Recycling Fund, 2019) or via direct communication. 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.

4.6.3.2 Emission factors
The Tier 1 emission factor from the EMEP/EEA Guidebook (EEA, 2019) 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. 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.

4.6.3.3 Recalculations and improvements
No recalculations were made for this submission.

4.6.3.4 Planned improvements
No improvements are currently planned for this subsector.

4.6.4 Degreasing (NFR 2D3e)

Degreasing only generates NMVOC emissions. Emissions are estimated by Tier 1, based on amounts of cleaning products used.

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/EEA 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, 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.

4.6.4.2 Emission factors

The amount of imported solvents for degreasing was multiplied with the NMVOC Tier 1 emission factor from EMEP/EEA Guidebook (EEA, 2019) for degreasing: 460 g/kg cleaning product.

4.6.4.3 Recalculations and improvements

No recalculations were made for this submission.

4.6.4.4 Planned improvements

No improvements are currently planned for this subsector.

4.6.5 Dry cleaning (NFR 2D3f)

Dry cleaning only generates NMVOC emissions. Emissions related to dry cleaning were estimated by Tier 2, based on the default amount of textile cleaned per capita.

4.6.5.1 Activity data

Emissions from dry cleaning were calculated using the Tier 2 emission factor for conventional closed-circuit PER machines with abatement efficiency provided by the EMEP/EEA Guidebook (EEA, 2019). Activity data for calculation of NMVOC emissions is the amount of textile treated annually, which is assumed to be 0.3 kg/head, default value from (EEA, 2019) and calculated using demographic data.

4.6.5.2 Emission factors

The unabated NMVOC emission factor is 177 g/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/EEA Guidebook reduction default value of $\eta_{\text{abatement}} = 89\%$. The abated emission factor is therefore

$$EF_{\text{technology,abated}} = (1 - \eta_{\text{abatement}}) \cdot EF_{\text{technology,unabated}} = (1 - 0.89) \cdot 177 = 19.47 \text{ g/kg}.$$

4.6.5.3 Recalculations and improvements

Recalculation of NMVOC within the 2D3f subsector for this submission was done since the population number was updated to ensure consistency within the inventory. Since NMVOC emissions are calculated based on population data, there were recalculations for the whole timeline within the subsector. Table 4.19 shows the recalculations.

Table 4.19 Recalculations of emission within 2D3f (Dry cleaning) between 2021 and 2022 submissions

Dry cleaning	1990	1995	2000	2005	2010	2015	2018	2019
2021 submission NMVOC [kg]	1495	1565	1655	1752	1860	1942	2085	2127
2022 submission NMVOC [kg]	1482	1559	1630	1715	1855	1922	2035	2085
Change relative to 2021 submission	-0.8%	-0.4%	-1.5%	-2.1%	-0.3%	-1.0%	-2.4%	-2.0%

4.6.5.4 Planned improvements

No improvements are currently planned for this subsector.

4.6.6 Chemical products (NFR 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 Tier 2 of the Guidebook (EEA, 2019).

4.6.6.1 Activity data

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

4.6.6.2 Emission factor

NMVOC emissions from the manufacture of paints were calculated using the 2019 EMEP/EEA Guidebook (EEA, 2019) Tier 2 emission factor of 11 g/kg product.

4.6.6.3 Recalculations and improvements

No recalculations were made for this submission.

4.6.6.4 Planned improvements

No improvements are currently planned for this subsector.

4.6.7 Printing (NFR 2D3h)

4.6.7.1 Activity data

Import data on ink was received from Statistics Iceland.

4.6.7.2 Emission factors

NMVOC emissions for printing were calculated using the 2019 EMEP/EEA Guidebook (EEA, 2019). Tier 1 emission factor of 500 g/kg ink used.

4.6.7.3 Recalculations and improvements

No recalculations were made for this submission.

4.6.7.4 Planned improvements

No improvements are currently planned for this subsector.

4.6.8 Other product use (NFR 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.

4.6.8.1 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.

4.6.8.2 Emission factors
Emission factors for PAH are taken from chapter 2.D.3.i, 2.G of the 2019 EMEP/EEA Guidebook (EEA, 2019). They are 1.05 mg BaP per kg of creosote, 0.53 mg/kg creosote of the other 3 PAH: BbF, BkF and IPy. NMVOC emissions from wood preservation were calculated using the 2019 EMEP/EEA Guidebook Tier 2 emission factors for creosote preservative type (105 g/kg creosote) and organic solvent borne preservative (945 g/kg preservative).

4.6.8.3 Recalculations and improvements
No recalculations were made for this submission.

4.6.8.4 Planned improvements
No improvements are currently planned for this subsector.

4.7 Other solvent and product use (NFR 2G)

The two emission sources estimated in this category are use of tobacco and fireworks.

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. The yearly imported amount of tobacco shows a downward trend over the timeseries, which is reflected also in the emission. Firework imports follow in general the economic development of the country. A prominent peak around 2007 is due to a very sharp rise in the economy leading to the financial collapse of 2008.

4.7.1.1 Activity data
Activity data consist of all smoking tobacco and all fireworks imported and are provided by Statistics Iceland.

4.7.1.2 Emission factors
For tobacco use, tier 2 emission factors for NO_x, CO, NH_3, TSP, PM, BC, NMVOC, dioxin and PAH4 were taken from Table 3-15 in Chapter 2.D.3.i, 2.G in the 2019 EMEP/EEA Guidebook (EEA, 2019). Emission factors for heavy metals are taken from the Danish IIR (Nielsen, et al., 2021), which uses emission factors derived from burning of wood.

For firework use, tier 2 emission factors for SO_2, CO, NO_x, TSP, PM and heavy metals were taken from Table 3-14 in Chapter 2.D.3.i, 2.G of the 2019 EMEP/EEA Guidebook (EEA, 2019). It should be noted that the heavy metal emission factors presented in the 2019 EMEP/EEA Guidebook (2019), in particular that for Pb, might not represent the legislation currently in place, which generally bans lead (Pb) in fireworks. For lack of a better emission factor value Iceland estimates the Pb emissions using the available default value, however this might represent a substantial overestimation of Pb emissions from fireworks. All emission factors are presented in Table 4.20.

Table 4.20 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 $PM_{2.5}$	CO [kg/t]
Tobacco	1.80	4.84	NA	4.15	27	27	27	0.45%	55.1
Fireworks	0.26	NA	3.02	NA	110	100	51.9	NA	7.15

	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	NA	NA	NA	NA	NA

	Pb [g/t]	Cd [g/t]	Hg [g/t]	As [g/t]	Cr [g/t]	Cu [g/t]	Ni [g/t]	Se [g/t]	Zn [g/t]
Tobacco	0.64	0.020	0.010	0.159	0.152	0.354	0.030	0.010	1.61
Fireworks	784	1.48	0.057	1.33	15.6	444	30	NA	260

4.7.1.3 Recalculations and improvements

No recalculations were made for this submission.

4.7.1.4 Planned improvements

Heavy metal emission factor for firework use will be reassessed and revised where necessary.

4.8 Other industry production (NRF 2H)

4.8.1 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.

4.8.1.1 Activity data

Production statistics for animal feed are available for 2005-2013. The statistics were linearly extrapolated for earlier and later years in the timeseries.

Production of bread, cakes/biscuits, meat, fish, poultry, coffee, beer, malt/pilsner and spirits was estimated as follows. The total consumption within the country was estimated by using results of the survey *The Diet of Icelanders* (Embætti Landlæknis, 2011), (Embætti Landlæknis, 2002), (Embætti Landlæknis, 1990). The results give average consumption figures per person for the years 1990, 2002 and 2011. The consumption figures were interpolated for the years in between. The total consumption was calculated by using the population (or adult population in the case of coffee, beer/pilsner and spirits). A waste factor of 33% was also used when produced amounts were calculated from consumption figures (FAO, 2011). In the case of bread, cakes/biscuits, meat, fish and poultry, it is assumed that the total production in Iceland is for the domestic market. There is an export of fish and meat but it is almost exclusively fresh or frozen and therefore not cooked in Iceland. In the case of coffee, beer/pilsner and spirits, the import and export statistics were available from Statistic Iceland. The net import (import minus export) was subtracted from the calculated consumption to estimate the domestic production.

It is not distinguished between industry and household emissions in these calculations. All NMVOC emission from bread and cake baking and fish/meat/poultry cooking is therefore estimated.

4.8.1.2 Emission factors

Emission factor for NMVOC were taken from the 2019 EMEP/EEA Guidebook (EEA, 2019) and are presented in Table 4.21.

Table 4.21 NMVOC emission factors for the production of various food and beverage products

	NMVOC [kg/t produced]
Meat, fish and poultry	0.30
Cakes, biscuits and breakfast cereals	1.0
Beer and malt	0.035
Bread (European)	4.5
Coffee roasting	0.55
Animal feed	1.0

4.8.1.3 Recalculations and improvements

This subsector was revised for this submission. The emission factors remain the same but the activity data has been changed. Since production data was only available for part of the time series, now most of the emissions are estimated the same way, based on consumption figures. In some cases also corrected for import and export figures (see above). Table 4.22 shows the recalculation of the subsector due to these changes.

Table 4.22 Recalculations of emission within 2H2 (Food and beverages industry) between submissions

Food and beverages industry	1990	1995	2000	2005	2010	2015	2018	2019
2021 submission NMVOC [kt]	0.33	0.31	0.33	0.38	0.38	0.38	0.41	0.42
2022 submission NMVOC [kt]	0.15	0.16	0.17	0.18	0.17	0.30	0.46	0.44
Change relative to 2021 submission	-53%	-48%	-49%	-53%	-55%	-22%	13%	5%

4.8.1.4 Planned improvements

No improvements are currently planned for this subsector.

5 Agriculture (NFR sector 3)

5.1 Overview

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 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.

The main pollutant emitted from the agriculture sector is ammonia (NH_3) and the largest source is manure management. NH_3 emissions from the agriculture sector represent 98.5% of all of Iceland's NH_3 emissions across all sectors. Furthermore, one third of all NMVOC emissions come from this sector. This can be seen in Table 5.1 below.

Table 5.1 Contribution from the agriculture sector to the national total for the year 2020.

	NH_3	NO_x	TSP	PM_{10}	$PM_{2.5}$	NMVOC
National total [kt]	4.41	19.3	4.73	2.42	1.08	5.37
Agriculture total [kt]	4.34	1.08	0.26	0.20	0.037	1.86
Agriculture part [%]	98.5	5.58	5.50	8.33	3.39	34.6

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

- Manure Management (NFR 3B)
- Crop Production & Agricultural Soils (NFR 3D)
- Agriculture Other Including Use of Pesticides (NFR 3Df and 3I)

Each of these sources are described in more detail in sections 5.3 to 5.5.

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

Dioxin, PAH4, HCB, PCB and Heavy Metals emissions are not applicable, not occurring or not estimated.

Buffalos, mules and asses are not farmed in Iceland and therefore these animal categories are "NO" (not occurring) in the Icelandic inventory.

Table 3.1 shows which subsectores in Agriculture are key categories for which air pollutants. A key category is one that is prioritised within the national inventory system because it is significantly important for one or a number of air pollutants in a country's national inventory of air pollutants in terms of the absolute level, the trend, or the uncertainty in emissions (EEA, 2019). Categories whose cumulative percentage contribution is greater than 80% should be identified as key.

Table 5.2 Key categories for air pollutants within Agriculture.

SO_x, NO_x, NH_3, NMVOC, PM, BC and CO			
	1990	2020	Trend
3B1a Manure management - Dairy cattle	NMVOC, NH_3	NMVOC, NH_3	NMVOC
3B1b Manure management - Non-dairy cattle	NMVOC	NMVOC, NH_3	NMVOC, NH_3
3B2 Manure management - Sheep	NH_3	NMVOC, NH_3	NH_3
3B3 Manure management - Swine			NH_3
3B4e Manure management - Horses	NMVOC	NMVOC	NMVOC
3B4gi Manure mangement - Laying hens			NH_3
3B4gii Manure mangement - Broilers			NH_3
NFR 3B4h Manure management - Other animals			NH_3
3Da2a Animal manure applied to soils	NH_3	NH_3	
3Da3 Urine and dung deposited by grazing animals	NH_3	NH_3	
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM_{10}		

5.2 General Methodology

The methodology is based on chapters 3B and 3D of the EMEP/EEA air pollutant emission inventory Guidebook (EEA, 2016; EEA, 2019). All equations as well as the majority of emission factors and other parameters stem from the Guidebook chapters correspondingly.

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

For estimating emissions of NH_3 and NO_x in 3B manure management, the flow approach is used as outlined in the 2019 EMEP/EEA Guidebook. This considers the flow of total ammoniacal N (TAN) through the manure management system. In the 2019 EMEP/EEA Guidebook 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 2019 EMEP/EEA Guidebook was applied to more disaggregated livestock categories than the NFR methodology demands as can be seen in Table 5.3. The resulting emissions were then aggregated to the respective NFR categories.

NH_3 and NO_x emissions from grazing animals are part of this N flow approach and are, therefore, calculated in this context, although they are reported under agricultural soils (3D). 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 NO_x. 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

Animal population numbers are directly retrieved from the livestock database (www.bustofn.is) of the Ministry of Food, Agriculture and Fisheries (MFAF) and annual average populations (AAP) are calculated according to IPCC Guidelines. Since the data from the annual census of MFAF 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. The inclusion of young animals leads to livestock populations being considerably higher for some categories than the ones published by the MFAF or by other public sources such as Statistics Iceland[6]. For the complete methodology of calculating the AAP and a comparison with published livestock numbers please refer to Iceland´s 2022 National Inventory Report on Greenhouse Gas Emissions[7].

[6] https://hagstofa.is/talnaefni/atvinnuvegir/landbunadur/bufe-og-uppskera/
[7] https://unfccc.int/documents/273420

Livestock data is available on a more disaggregated level than requested by the reporting requirements as can be seen in Table 5.3. Therefore, the emissions are estimated on a more disaggregated level and then combined to the NFR categories.

Table 5.3 Livestock as reported in NFR tables and as calculated in the Icelandic Inventory on a more disaggregated level.

NFR code		Disaggregation in Icelandic Inventory
3B1a	Dairy cattle	Mature Dairy Cattle
3B1b	Non-dairy cattle	Beef Cattle Calves Heifers 18-27 months Steers for producing meat 12-27 months
3B2	Sheep	Ewes Young female 12 months Rams Lambs
3B3	Swine	Piglets Sows
3B4a	Buffalo	NO
3B4d	Goats	Goats
3B4e	Horses	Horses
3B4f	Mules and asses	NO
3B4gi	Laying hens	Laying hens
3B4gii	Broilers	Chickens Pullets
3B4giii	Turkeys	Turkeys
3B4giv	Other poultry	Geese Ducks
3B4h	Other (fur animals)	Minks Foxes Rabbits

Table 5.4 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 the dairy cattle and sheep populations and an increase in non-dairy, swine and poultry population.

Table 5.4 Annual average population of livestock according to NFR categorization in Iceland.

	1990	1995	2000	2005	2010	2015	2019	2020
3B1a Dairy cattle	32,249	30,428	27,066	24,488	25,379	27,441	26,217	25,763
3B1b Non-dairy cattle	43,299	42,771	45,078	41x,482	47,130	51,335	54,678	54,880
3B2 Sheep	860,988	719,530	729,387	710,953	748,431	745,832	632,937	609,419
3B3 Swine	29,768	30,746	32,242	39,350	38,032	42,542	38,314	39,253
3B4a Buffalo	NO	NO	NO	NO	NO	NO	NO	NO
3B4d Goats	485	511	548	657	1,015	1,476	2,148	2,367
3B4e Horses	73,867	80,246	75,630	76,629	78,849	79,429	72,449	73,584
3B4f Mules and asses	NO	NO	NO	NO	NO	NO	NO	NO
3B4gi Laying hens	506,165	186,295	284,612	212,795	164,374	171,161	267,065	240,853
3B4gii Broilers	163,115	166,919	247,241	553,065	465,884	534,906	643,459	586,649

	1990	1995	2000	2005	2010	2015	2019	2020
3B4giii Turkeys	3,625	3,044	10,908	8,146	8,196	11,810	11,006	11,213
3B4giv Other poultry	5,806	5,270	2,498	1,772	1,347	1,057	835	581
3B4h Other (fur animals)	49,592	37,893	41,431	37,093	39,904	48,038	14,325	15,849

5.3.2 Emission factors and associated parameters

NH_3 and NO Tier 2 emissions depend on the total amounts of nitrogen and total ammoniacal nitrogen (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 2019 EMEP/EEA Guidebook. The nitrogen excretion (Nex) rate per livestock category is calculated using default values from the 2006 IPCC Guidelines (Volume 4, chapter 10) that take animal weight and, therefore, the smaller size of Icelandic breeds into account. For most animal categories the animal parameters are not changing over the timeseries, and the Nex rate is also constant. Exceptions are mature dairy cattle, calculated by the Tier 2 approach, and those animal categories for which the Nex rate has been calculated on a more disaggregated level and reported as a weighted average in relation to the population data (growing cattle, horses, poultry). The calculation method for the Nex rate for mature dairy cattle follows the Tier 2 methodology from the 2006 IPCC Guidelines (Volume 4, chapter 10) by applying Equation 10.31, Equation 10.32 and Equation 10.33 for dairy cows. Detailed calculations and explanations can be found in the newest edition of the National Inventory Report of Iceland.

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. The same is valid for the fractions of the year spent inside versus outside. Two more parameters used in the calculation of TAN mass flow are the amount of straw 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 2019 EMEP/EEA Guidebook default data (Table 3.7) of hay used per day adjusted for the time periods animals stay inside. As an example, sheep have a default housing period of 30 days (Table 3.7 of the 2019 EMEP/EEA Guidebook) but in Iceland it is 200 days. So, the default straw value of 20 kg/yr is multiplied by 200/30 to obtain 133.3 kg/yr. The above-mentioned parameters are summarized in Table 5.5 and Table 5.6. 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 2019 EMEP/EEA Guidebook. In the absence of default values for sheep slurry, 2019 EMEP/EEA Guidebook default values for cattle were used instead.

Table 5.5. Parameters used in the N-flow calculations.

Livestock sector (NFR)	Mean NEX [kg head-1 yr-1]	Prop. TAN(of N)	Fraction slurry	Fraction solid	Housing period [days]	Straw [kg/yr]
3B1a Dairy cattle	79 (60-98)	0.6	1	0	265	
3B1b Non-dairy cattle	33 (15-45)	0.6	1	0	30	
3B2 Sheep	17 (7-29)	0.5	0.35	0.65	200	133.3
3B3 Swine -fattening pigs	7.6	0.7	1	0	365	
3B3 Swine -Sows	23.0	0.7	1	0	365	
3B4d Goats	20.3	0.5	0	1	200	133.3

Livestock sector (NFR)	Mean NEX [kg head-1 yr-1]	Prop. TAN(of N)	Fraction slurry	Fraction solid	Housing period [days]	Straw [kg/yr]
3B4e Horses	19 (6-36)	0.6	0	1	50.7	140.8
3B4gi Laying hens	1.4	0.7	0	1	365	
3B4gii Broilers	0.4 (0.2-0.6)	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)	8 (5-12)	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 (ducks, chickens, pullets and geese); 6 Range given for subcategories (foxes, minks, and rabbits);6 Average given: non-dairy mature cattle 30 days, heifers 245 days, steers 330 days, calves 365 days.

Table 5.6 Emission factors for NH_3, NO and N_2O used in the N-flow methodology.

Livestock sector (NFR)	MMS	EF NH_3-N Housing	EF NH_3-N storage	EF NH_3-N application	EF NO-N storage	EF N_2O-N storage
3B1a Dairy cattle	slurry	0.24	0.25	0.55	0.0001	0.01
	solid	0.08	0.32	0.68	0.01	0.02
3B1b Non-dairy cattle	slurry	0.24	0.25	0.55	0.0001	0.01
	solid	0.08	0.32	0.68	0.01	0.02
3B2 Sheep	slurry					
	solid	0.22	0.32	0.9	0.01	0.02
3B3 Swine - fattening pigs	slurry	0.27	0.11	0.4	0.0001	0
	solid	0.23	0.29	0.45	0.01	0.01
3B3 Swine -Sows	slurry	0.35	0.11	0.29	0.0001	0
	solid	0.24	0.29	0.45	0.01	0.01
3B4d Goats	solid	0.22	0.28	0.9	0.01	0.02
3B4e Horses	solid	0.22	0.35	0.9	0.01	0.02
3B4gi Laying hens	slurry	0.41	0.14	0.69	0.0001	0
	solid	0.2	0.08	0.45	0.01	0.002
3B4gii Broilers	solid	0.21	0.3	0.38	0.01	0.002
3B4giii Turkeys	solid	0.35	0.24	0.54	0.01	0.002
3B4giv Other poultry	solid	0.24	0.24	0.54	0.01	0.002
3B4h Other (fur animals)	solid	0.27	0.09	*	0.01	0.002

** The emission factor is zero in the Guidebook and Iceland does not have a country specific emission factor.*

NMVOC emissions are calculated using the Tier 1 methodology from the 2019 EMEP/EEA Guidebook, applying the default emission factors from Table 3.4. When default emission factors with silage feeding are available, these are used. All used emission factors are reported in Table 5.7.

Table 5.7 Emission factors for NMVOC emissions, Tier 1, taken from Table 3.4 to the 2019 EMEP/EEA Guidebook, when available emission factors with silage feeding are used.

Livestock sector (NFR)	EF NMVOC kg AAP-1a-1
3B1a Dairy cattle	17.937
3B1b Other cattle (includes all other cattle)	8.902
3B2 Sheep	0.279
3B3 Swine -fattening pigs	0.551
3B3 Swine -Sows	1.704
3B4d Goats	0.624
3B4e Horses	7.781
3B4gi Laying hens	0.165
3B4gii Broilers	0.108
3B4giii Turkeys	0.489
3B4giv Other poultry (ducks and geese)	0.489
3B4h Other (fur animals)	1.941
3B4h Other (rabbits)	0.059

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 5.5 above). The applied emission factors are reported in Table 5.8 and derive from the 2019 EMEP/EEA Guidebook and from the 2013 EMEP/EEA Guidebook. In the case of turkeys, the Tier 1 emission factors are applied.

Table 5.8 Emission factors used for calculating the particulate emissions, Tier 2.

Livestock sector (NFR)		MMS	EF TSP kg AAP-1a-1	EF PM_{10} kg AAP-1a-1	EF $PM_{2.5}$ kg AAP-1a-1	Source
3B1a	Dairy cattle	slurry solid	1.81 0.94	0.83 0.43	0. 54 0.28	Table A1.7 2019 EMEP/EEA Guidebook
3B1b	Beef Cattle[1]	slurry solid	0.69 0.52	0.32 0.24	0.21 0.16	Table A1.7 2019 EMEP/EEA Guidebook
3B1b	Calves	slurry solid	0.34 0.35	0.15 0.16	0.1 0.1	Table A1.7 2019 EMEP/EEA Guidebook
3B2	Sheep	slurry solid	/ 0.14	/ 0.056	/ 0.017	Table A1.7 2019 EMEP/EEA Guidebook
3B3	Swine -fattening pigs	slurry solid	0.7 0.83	0.31 0.37	0.06 0.07	Table A3-4 2013 EMEP/EEA Guidebook
3B3	Swine -Sows	slurry solid	1.36 1.77	0.61 0.8	0.11 0.14	Table A3-4 2013 EMEP/EEA Guidebook
3B4d	Goats	solid	0.139	0.056	0.017	Table A1.7 2019 EMEP/EEA Guidebook
3B4e	Horses	solid	0.48	0.22	0.14	Table A1.7 2019 EMEP/EEA Guidebook
3B4gi	Laying hens	solid	0	0	0	Table A3-4 2013 EMEP/EEA Guidebook
3B4gii	Broilers	solid	0.069	0.069	0.009	Table A3-4 2013 EMEP/EEA Guidebook
3B4giii	Turkeys	solid	0.52	0.52	0.07	Table 3.3 2013 EMEP/EEA Guidebook
3B4giv	Other poultry ducks	solid	0.14	0.14	0.018	Table A1.7 2019 EMEP/EEA Guidebook
3B4giv	Other poultry geese	solid	0.24	0.24	0.032	Table A1.7 2019 EMEP/EEA Guidebook
3B4h	Other (fur animals)	solid	0.018	0.0081	0.004	Table A1.7 2019 EMEP/EEA Guidebook

[1] Beef cattle and calves are calculated separately and subsequently aggregated in the category 3B1b Non-Dairy Cattle

5.3.3 Emissions

NH_3 emissions reported under 3B manure management exclude emissions from manure deposited on fields by grazing animals, which are reported under 3D agricultural soils. Total ammonia (NH_3) emissions from manure management have decreased slightly, from 2.38 kt in 1990 to 2.07 kt in 2020. This decrease is mostly due to decreasing emissions from sheep. Sheep account for roughly a third of total NH_3 emissions and cattle for approximately half. Around a third of emissions occur during livestock housing, a quarter during manure storage and 2/5 after spreading of manure. The described trends and fractions can be seen in Figure 5.1.

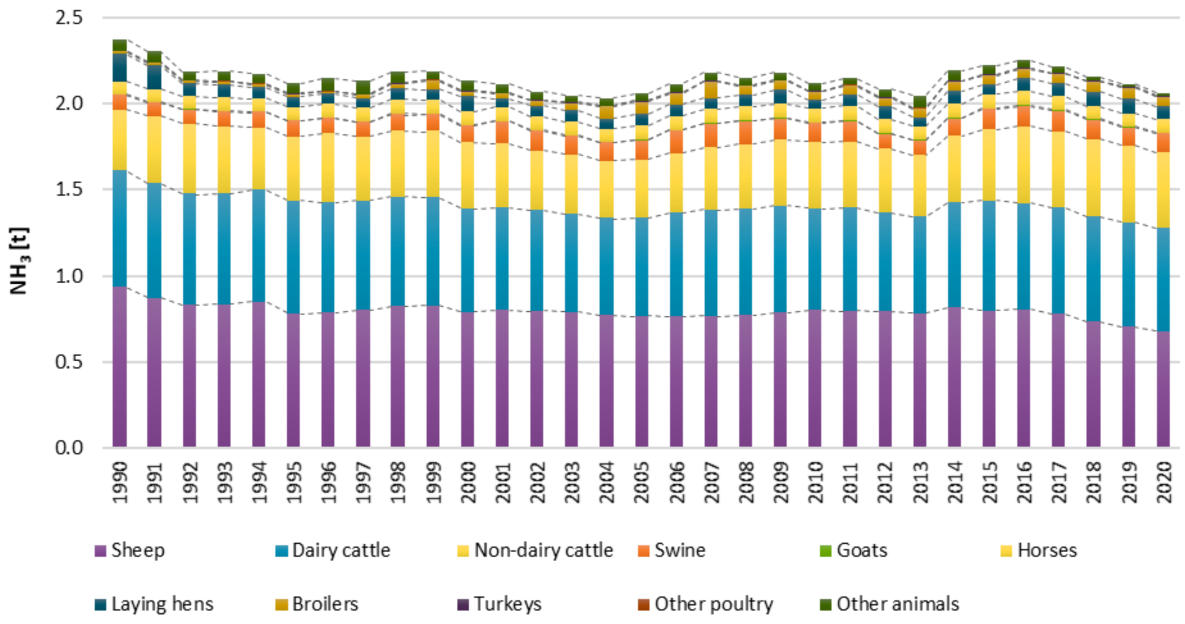


Figure 5.1 Ammonia (NH_3) emissions from animal husbandry and manure management [t].

Nitric oxide emissions, in contrast to ammonia emissions, occur only during storage. They have been decreasing from 58 t in 1990 to 40 t in 2020, or by 31%. This decrease is mainly due to the decrease in sheep population already mentioned above. NO emissions from sheep constitute 68% of total NO emissions from manure management. NO emissions from poultry amount to 23% of total NO emissions. Other livestock categories with considerable shares are fur animals (3%) and horses (6%). 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 1.99 kt for manure management and have decreased slightly since then and are now 1.86 kt. The largest source of NMVOC emissions are cattle 51%, horses 31% and sheep 9%.

PM_{10} emissions decreased from 124 t in 1990 to 121 t in 2020 (2%). Emissions were highest in 2007 at 129 tt. 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 with 34%) are laying hens (24%), cattle (19%), swine (11%) and sheep (7%) in 2020.

Over the times series, 1990-2020, total $PM_{2.5}$ emissions varied between minimum 28 t and 34 t and show no clear trend. In the latest year, emissions from cattle constituted 45% of total emissions followed by laying hens (17%) and broilers (16%) .

TSP emissions have varied between 139 t and 192 t from 1990 and 2020. This difference is mostly due to variations in the poultry and swine populations. Biggest contributors are cattle (28%) followed by broilers (23%), swine (16%) and laying hens (16%).

5.3.4 Recalculations and improvements

5.3.4.1 Recalculations for the 2022 submission

Livestock parameters were sent for review by external experts to ensure their quality for the 2022 submission. During this review an error in the categorisation of poultry was discovered. A share of poultry previously categorised as broilers should, in fact, be categorised as laying hens for the whole timeseries according to the poultry expert veterinarian at the Icelandic Food and Veterinary Authority. Pullets and chickens are still reported under the broiler category. The total number of laying hens and broilers remained the same over the whole timeseries, except for 2018 and 2019, as an updated parameter for age at slaughter was provided for chickens by the poultry expert veterinarian at the Icelandic Food and Veterinary Authority for the years 2018 to 2020.

Table 5.9 Annual average population of chickens according to NFR categorisation in Iceland.

		1990	1995	2000	2005	2010	2015	2019
2021 submission	3B4gi Laying hens	214,975	164,402	193,097	152,217	144,429	119,811	205,091
	3B4gii Broilers[1]	454,305	188,812	338,756	613,643	485,829	586,256	684,757
	Total	669,280	353,214	531,853	765,860	630,258	706,067	889,848
2022 submission	3B4gi Laying hens[2]	506,165	186,295	284,612	212,795	164,374	171,161	267,065
	3B4gii Broilers[3]	163,115	166,919	247,241	553,065	465,884	534,906	643,459
	Total	669,280	353,214	531,853	765,860	630,258	706,067	910,524

[1] In the 2021 submission, the NFR category broilers consists of poultry categorised as broilers, pullets and chickens. [2] In the 2022 submission, the NFR category Laying hens consists of laying hens and the hens previously and erroneously categorised as broilers. [3] In the 2022 submission, the NFR category broilers consists of poultry categorised as pullets and chickens.

This updated livestock categorisation resulted in some changes in the emissions from manure management, as the emission factors used for broilers and laying hens are different and therefore it affected the NO_x, NMVOC, NH_3, $PM_{2.5}$, PM_{10} and TSP emissions.

Table 5.10 Recalculation for NO_x emissions form manure management for poultry due to the update of livestock categorisation for 1990-2019.

NO_x [t]		1990	1995	2000	2005	2010	2015	2019
2021 submission	Laying hens	5.54	4.24	4.98	3.93	3.72	3.09	5.29
	Broilers	9.27	1.45	4.03	5.28	2.82	4.00	4.79
2022 submission	Laying hens	13.05	4.80	7.34	5.49	4.24	4.41	6.89
	Broilers	0.77	0.81	1.36	3.52	2.23	2.50	3.06

Table 5.11 Recalculation for NMVOC emissions from manure management for poultry due to the update of livestock categorisation for 1990-2019.

NMVOC [kt]		1990	1995	2000	2005	2010	2015	2019
2021 submission	Laying hens	0.035	0.027	0.032	0.025	0.024	0.020	0.034
	Broilers	0.049	0.020	0.037	0.066	0.052	0.063	0.074
2022 submission	Laying hens	0.084	0.031	0.047	0.035	0.027	0.028	0.044
	Broilers	0.018	0.018	0.027	0.060	0.050	0.058	0.069

Table 5.12 Recalculation for NH_3 emissions from manure management for poultry due to the update of livestock categorisation for 1990-2019.

NH_3 [t]		1990	1995	2000	2005	2010	2015	2019
2021 submission	Laying hens	67.61	51.71	60.73	47.88	45.43	37.68	64.51
	Broilers	193.79	30.34	84.32	110.49	58.87	83.70	100.26
2022 submission	Laying hens	159.20	58.59	89.52	66.93	51.70	53.83	84.00
	Broilers	16.11	16.98	28.47	73.52	46.70	52.37	64.02

Table 5.13 Recalculation for $PM_{2.5}$ emissions from manure management for poultry due to the update of livestock categorisation for 1990-2019.

$PM_{2.5}$ [t]		1990	1995	2000	2005	2010	2015	2019
2021 submission	Laying hens	4.94	3.78	4.44	3.50	3.32	2.76	4.72
	Broilers	4.09	1.70	3.05	5.52	4.37	5.28	6.16
2022 submission	Laying hens	11.64	4.28	6.55	4.89	3.78	3.94	6.14
	Broilers	1.47	1.50	2.23	4.98	4.19	4.81	5.79

Table 5.14 Recalculation for PM_{10} emissions from manure management for poultry due to the update of livestock categorisation for 1990-2019.

PM_{10} [t]		1990	1995	2000	2005	2010	2015	2019
2021 submission	Laying hens	25.58	19.56	22.98	18.11	17.19	14.26	24.41
	Broilers	31.35	13.03	23.37	42.34	33.52	40.45	47.25
2022 submission	Laying hens	60.23	22.17	33.87	25.32	19.56	20.37	31.78
	Broilers	11.25	11.52	17.06	38.16	32.15	36.91	44.40

Table 5.15 Recalculation for TSP emissions from manure management for poultry due to the update of livestock categorisation for 1990-2019.

TSP [t]		1990	1995	2000	2005	2010	2015	2019
2021 submission	Laying hens	25.58	19.56	22.98	18.11	17.19	14.26	24.41
	Broilers	31.35	13.03	23.37	42.34	33.52	40.45	47.25
2022 submission	Laying hens	60.23	22.17	33.87	25.32	19.56	20.37	31.78
	Broilers	11.25	11.52	17.06	38.16	32.15	36.91	44.40

5.3.4.2 Recalculations for the 2021 submission
For the 2021 submission, parameters, e.g. emission factors used in the N-flow methodology were updated from the 2016 EMEP/EEA Air Pollution Inventory Guidebook to its newest 2019 edition. In particular, emission factors for the NH_3-N emissions in the different stages of manure management systems (housing, storage, application and grazing) and for the manure types slurry and solid changed for some animal categories. Some emission factors increased, some decreased, and some remained unchanged. In addition, the gross energy (GE) for mature dairy cattle was changed for the years 2013-2017 to avoid a step change between 2017 and 2018 and affects all emissions connected to the Nex rate of mature dairy cattle for those years.Regarding NMVOCs the emission factor for rabbits as per the 2019 EMEP/EEA Guidebook was used for the whole time series while in past submissions these emissions were calculated using the emission factor of fur animals.

5.3.5 Planned Improvements

As suggested by the 2020 Step 3 review, it is planned to change from Tier 1 to Tier 2 calculation for NMVOC emissions. As a first step, a detailed investigation will be made about which data are easily available in Iceland and which data need to be collected specifically for this task.

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 (Table 5.16). 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[8]. 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.

Table 5.16 Total amount of synthetic N-fertilizers applied to agricultural soils.

	1990	1995	2000	2005	2010	2015	2019	2020
N content in inorganic N fertilizer, [kt N]	12.47	11.20	12.68	9.78	10.88	11.65	10.38	11.41

Activity data for particulate matter emissions consists of the areas of crops cultivated as can be seen in Table 5.17. The total amount of cropland is recorded in the Icelandic geographic land use database (IGLUD), which is maintained by the Soil Conservation Service of Iceland. Data regarding the area of barley fields comes from the Farmers Association of Iceland[9] and Bragason (written communication). The area of grass fields is calculated by subtracting the area of barley fields from the total cropland

[8] https://www.mast.is/is/um-mast/utgefid-efni/skyrslur
[9] http://www.bondi.is/

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).

Table 5.17 Areas of cropland in Iceland, distinguished by barley cultivation and grassland for haymaking.

	1990	1995	2000	2005	2010	2015	2019	2020
Area Barley cultivation (ha)	200	500	2,000	3,636	4,295	1,558	2,517	2,535
Area Grass cultivation (ha)	147,800	146,200	143,400	140,464	138,505	139,942	137,943	137,925

5.4.2 Emission factors

NH_3 emission factors were taken from Table 3.2 in the 2019 EMEP/EEA Guidebook. 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 1 January have reached 400 °C. According to this definition the mean spring temperature in Iceland is about 9 °C, therefore the emission factors for cool climate and normal pH are applied as can be seen in Table 5.18.

Table 5.18 Emission factors for NH_3 emissions from fertilizers for cool climate and normal pH

	EF NH_3 g [NH_3/ kg N applied]
Ammonium sulphate	90
Ammonium nitrate	15
Calcium ammonium nitrate	8
Anhydrous ammonia	19
Urea	155
Ammonium phosphates	50
Other NK and NPK	33 (average between NK mixtures and NPK mixtures)

The emission factors for NO, NMVOC and NH_3 are taken from the 2019 EMEP/EEA Guidebook and are reported in Table 5.19 with the respective sources and NFR codes.

Table 5.19 Emission factors for NO, NMVOC and NH_3 in NFR category 3D.

	NFR code	EF	Unit	Source
NH3 from sewage sludge	3Da2b	0.13	kg NH3 (kg N applied)-1	Annex 1 2019 EMEP/EEA Guidebook
NH3 from other organic wastes	3Da2c	0.08	kg NH3 (kg N applied)-1	Table 3.1 2019 EMEP/EEA Guidebook
NO from N applied in fertilizer, manure, and excreta	3Da1, 3Da2a, 3Da3	0.04	kg NO2 (kg fertilizer and manure N applied)-1	Table 3.1 2019 EMEP/EEA Guidebook
NO from sewage sludge	3Da2b	0.04	kg NO2 (kg sewage sludge)-1	Annex 2 A2.3 2019 EMEP/EEA Guidebook
NO from other organic wastes	3Da2c	0.04	kg NO2 (kg organic waste)-1	Table 3.1 2019 EMEP/EEA Guidebook
NMVOC from standing crops	3De	0.86	kg ha-1	Table 3.1 2019 EMEP/EEA Guidebook

PM_{10} and $PM_{2.5}$ emission factors for barley and grass were taken from Tables 3.5 and 3.7 of the 2019 EMEP/EEA Guidebook and are reported in Table 5.20.

Table 5.20 Emission factors for agricultural crop operations, PM_{10} and $PM_{2.5}$ in wet climate conditions from the 2019 EMEP/EEA Guidebook.

	Crop	Soil Cultivation	Harvesting	Cleaning	Drying
PM_{10} [kg/ha]	Barley	0.25	2.3	0.16	0.43
PM_{10} [kg/ha]	Grass	0.25	0.25	0	0
$PM_{2.5}$ [kg/ha]	Barley	0.015	0.016	0.008	0.129
$PM_{2.5}$ [kg/ha]	Grass	0.015	0.01	0	0

5.4.3 Emissions

Total NH_3 emissions for crop production and agricultural soils varied between 2.50 and 2.19 kt between 1990 and 2020. In 2020 56% of emissions originate from animal manure applied to soils, 36% originate from manure deposited by livestock during grazing and 6% from inorganic N-fertilizers. Total emissions do not show any discernible trend over time, primarily because the size of (and thus emissions from) the sheep population decreases with time, while the horse population increases.

The emission development of NO and NMVOC are linearly dependent on the application of fertilizer and, therefore, show the same development with a peak in 2004 with 1.2 kt. In 2020 NO emissions amounted to 1 kt and NMVOC emissions from crop production and agricultural soils were 67 g.

In the 2021 submission, other organic fertilizers in the form of bone meal and compost were added to the inventory. Research showed that the organic fertilizers have been applied since 2009, especially for land reclamation purposes carried out by the Soil Conservation Service of Iceland; the resulting NH_3 are between 5 and 16 t over this period and the NO emissions are between 2 and 8 t.

PM_{10} emissions vary between 78 t in 1990 and 80 t in 2020. $PM_{2.5}$ emissions are fairly steady over the time series and were 3.2 t in 1990 and 3.4 t in 2020.

5.4.4 Recalculations and improvements

5.4.4.1 Recalculations for the 2022 submission

Livestock parameters were sent for review by external experts to ensure their quality for the 2022 submission. During this review an error in the categorisation of poultry was discovered. A share of poultry previously categorised as broilers should, in fact, be categorised as laying hens for the whole timeseries (see section 5.3.4.1). The change in livestock numbers affected the emissions from Animal manure applied to soils for NO_x and NH_3 as seen in Table 5.21 and Table 5.22.

Table 5.21 Recalculation for NO_x emissions from manure management for poultry due to the update of livestock categorisation for 1990-2019.

NO_x [kt]		1990	1995	2000	2005	2010	2015	2019
2021 submission	Animal manure applied to soils	0.325	0.283	0.285	0.274	0.284	0.293	0.272
2022 submission	Animal manure applied to soils	0.013	0.005	0.007	0.005	0.004	0.004	0.007

Table 5.22 Recalculation for NH_3 emissions from manure management for poultry due to the update of livestock categorisation for 1990-2019.

NH_3 [kt]	1990	1995	2000	2005	2010	2015	2019

2021 submission	Animal manure applied to soils	1.406	1.280	1.279	1.217	1.269	1.334	1.307
2022 submission	Animal manure applied to soils	1.436	1.282	1.288	1.223	1.271	1.339	1.314

5.4.4.2 Recalculations for the 2021 submission

In the 2021 submission the parameters used in the N-flow methodology were updated from the 2016 to the 2019 EMEP/EEA Guidebook. This also affects subcategories in 3D Agricultural Soils. This can be seen in 3D2a Animal manure applied to soils and 3Da3 Urine and Dung deposited from grazing animals for NO_x and NH_3. In the category 3Da2b Sewage sludge applied to soils an update of activity data for the whole time series lead to recalculations for NO_x and NH_3.

5.4.5 Planned Improvements

There are no planned improvements in this category.

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 3Df of the EMEP/EEA Guidebook not banned until 2009 is lindane, a gamma-Hexachlorocyclohexane (HCH). 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 3Df of the 2013 edition of the EMEP/EEA Guidebook was applied to these values resulting in HCH emissions of 1, 8, 1, and 0.5 kg for the years 1990-1992. HCH is no longer included in the reporting obligations which explains the use of an emission factor from the 2013 EMEP/EEA Guidebook. Table 5.23 gives an overview of the use of pesticides in Iceland.

Table 5.23 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

6.1 Overview

During 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 started operating and most of the waste of the capital´s population was 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 t 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 operational 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 the 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 has 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 the 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 an 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. Kalka is currently the only incineration plant in Iceland.

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 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.

A summary of the categories included in the waste sector by pollutant, including the Tier methodology used, is presented in Table 6.1 to Table 6.3. Anaerobic digestion (5B2) and other waste incineration (5C1bvi) are identified as not occuring (NO) and emission estimates from wastewater handling (5D) are not available (NA) due to lack of activity data.

Table 6.1 Overview table NECD gases, PM and CO.

		NECD gases				PM				
		NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
5A	Solid waste disposal on land	NA	T1	NA	NA	T1	T1	T1	NA	NA
5B1	Composting	NA	NA	NA	T2	NA	NA	NA	NA	T2
5B2	Anaerobic digestion	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1a	Municipal waste incineration	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2
5C1bi	Industrial waste incineration	T1	T1	T1	NA	T1	T1	T1	T1	T1
5C1bii	Hazardous waste incineration	T1	T1	T1	NA	T1	T1	T1	T1	T1
5C1biii	Clinical waste incineration	T1	T1	T1	NA	NA	NA	T1	NA	T1
5C1biv	Sewage sludge incineration	T1	T1	T1	NA	T1	T1	T1	T1	T1
5C1bv	Cremation	T1	T1	T1	NA	T1	T1	T1	NA	T1
5C1bvi	Other waste incineration	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C2	Open burning	T1	T1	T1	T1	T1	T1	T1	T1	T1
5D	Wastewater handling	NA	NA	NA	NA	NA	NA	NA	NA	NA
5E	Other waste	T2	T2	T2	NA	T2	T2	T2	NA	T2

Table 6.2 Overview table POPs

		POPs			
		Dioxin	**PAH**	**HCB**	**PCB**
5A	Solid waste disposal on land	NA	NA	NA	NA
5B1	Composting	NA	NA	NA	NA
5B2	Anaerobic digestion	NO	NO	NO	NO
5C1a	Municipal waste incineration	T1/T2	T1/T2	T1/T2	T1/T2
5C1bi	Industrial waste incineration	T1	T1	T1	NA
5C1bii	Hazardous waste incineration	T1	T1	T1	NA
5C1biii	Clinical waste incineration	T1	T1	T1	T1
5C1biv	Sewage sludge incineration	T1	T1	T1	NA
5C1bv	Cremation	T1	T1	T1	T1
5C1bvi	Other waste incineration	NO	NO	NO	NO
5C2	Open burning	T1	T1	T1	T1
5D	Wastewater handling	NA	NA	NA	NA
5E	Other waste	T2	T2	NA	NA

Table 6.3 Overview table heavy metals

		Heavy metals								
		Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
5A	Solid waste disposal on land	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B1	Composting	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B2	Anaerobic digestion	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1a	Municipal waste incineration	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2	T1/T2
5C1bi	Industrial waste incineration	T1	T1	T1	T1	NA	NA	T1	NA	NA
5C1bii	Hazardous waste incineration	T1	T1	T1	T1	NA	NA	T1	NA	NA
5C1biii	Clinical waste incineration	T1	T1	T1	T1	T1	T1	T1	NA	NA
5C1biv	Sewage sludge incineration	T1	T1	T1	T1	NA	NA	T1	NA	NA
5C1bv	Cremation	T1	T1	T1	T1	T1	T1	T1	T1	T1
5C1bvi	Other waste incineration	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C2	Open burning	T1	T1	T1	T1	T1	T1	T1	T1	T1
5D	Wastewater handling	NA	NA	NA	NA	NA	NA	NA	NA	NA
5E	Other waste	T2	T2	T2	T2	T2	T2	T2	T2	T2

Each of these sources is described in more detail in sections 6.3 to 6.8. Emission estimates for waste incineration without energy recovery are included in this section, while emission estimates for waste incineration with energy recovery are reported under sector 1A Energy.

Table 3.1 shows which subsectores in Waste are key categories for which air pollutants. A key category is one that is prioritised within the national inventory system because it is significantly important for one or a number of air pollutants in a country's national inventory of air pollutants in terms of the absolute level, the trend, or the uncertainty in emissions (EEA, 2019). Categories whose cumulative percentage contribution is greater than 80% should be identified as key.

Table 6.4 Key categories for air pollutants within Waste.

SO_x, NO_x, NH_3, NMVOC, PM, BC and CO			
	1990	2020	Trend
5A Biological treatment of waste - Solid waste disposal on land	NMVOC	NMVOC	
5C2 Open burning of waste	$PM_{2.5}$, PM_{10}, BC		
Persistent Organic Pollutants (POPs)			
	1990	2020	Trend
5C1bi Industrial waste incineration		dioxin	dioxin
5C1bii Hazardous waste incineration		dioxin	dioxin
5C1biii Clinical waste incineration	HCB, PCB		HCB, PCB
5C2 Open burning of waste	dioxin, PAH4, HCB, PCB		
5E Accidental fires		dioxin, PAH4	dioxin, PAH4
Heavy Metals (HMs)			
	1990	**2020**	**Trend**
5C1a Municipal waste incineration			Se
5C1bv Cremation		Hg	Hg
5C2 Open burning of waste	Cd, Hg, As, Zn		
5E Accidental fires	Pb, Zn	Zn	

6.2 General Methodology

The methodology is mainly based on the EMEP air pollutant emission inventory Guidebook (EMEP, 2019). Emissions estimates are calculated by multiplying relevant activity data by source with pollutant specific emissions factors. Emissions factors are taken from the Emissions Inventory Guidebook (EEA, 2019), 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 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.

6.3 Sector specific QA/QC

The QC activities include general methods such as accuracy checks on data acquisition and calculations as well as the use of approved standardized procedures for emission calculations, archiving information and reporting. Further information can be found in Chapter 1.6 on Quality Assurance and Quality Control.

6.4 Solid waste disposal (NFR 5A)

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 started operating and most of the waste generated in the capital area was landfilled there. Prior to that year, the waste of the capital area was landfilled in smaller SWDS.

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 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.

6.4.1 Methodology

The Tier 1 approach of Chapter 5A in the 2019 EMEP/EEA Guidebook 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. The Environment Agency of Iceland (EA) compiles data on total amounts of waste generated since 1995. This data is published by Statistics Iceland (2020). The data for the time-period from 1995 to 2004 relies on assumptions and estimation and is less reliable than the data generated since 2005. Data from 2005-2014 was received from most operators according to the EWC (European Waste Catalogue) categorization.

Smaller operators did not submit data on waste amounts during that period, so some gap-filling estimations were performed by experts at the Environment Agency. From 2014 the Environment Agency has received data according to the WStatR (Waste Statistic Regulation) categorization from all waste operators in Iceland. Waste generation before 1995 was estimated using a linear regression with gross domestic product (GDP) from 1995-2007 as surrogate data. The combination of these different datasets was carried out with the help of an external consultant company, Aether LTD. 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.

6.4.3 Emission factors

Emission factors from the Tier 1 approach of Table 3-1, Chapter 5A in the 2019 EMEP/EEA Guidebook, are used for estimating emissions from solid waste disposal. Emission factors are assumed to be constant for all the years in the calculations. This section discusses the emission estimates from solid waste disposal on land and covers the emissions of NMVOCs, TSP, PM_{10} and $PM_{2.5}$.

The 2019 EMEP/EEA Guidebook mentions the possibility of small quantities of NO_x, NH_3 and CO being emitted from this activity. However, no emission factors are provided in the Guidebook and these emissions have not been estimated in Iceland. Other pollutants are considered not applicable in accordance with that same table.

6.4.4 Emissions

From 1990, the emissions from 5A were increasing in proportion with the increased amount of landfilled waste. This amount peaked in 2005 and, therefore, also the emissions. From 2006, emissions decreased but from 2013 they have slowly been increasing again.

Table 6.5 Emissions from 5A Solid Waste Disposal

	1990	1995	2000	2005	2010	2015	2019	2020
NMVOC [kt]	0.534	0.490	0.534	0.540	0.257	0.305	0.341	0.296
TSP [kt]	1.6E-4	1.5E-4	1.6E-4	1.6E-4	7.6E-5	9.1E-5	1.0E-4	8.8E-5
PM_{10} [kt]	7.5E-5	6.9E-5	7.5E-5	7.6E-5	3.6E-5	4.3E-5	4.8E-5	4.2E-5
$PM_{2.5}$ [kt]	1.1E-5	1.0E-5	1.1E-5	1.1E-5	5.4E-6	6.5E-6	7.2E-6	6.3E-6

6.4.5 Recalculations and improvements

No recalculations were performed for solid waste disposal (5A) for this submission.

6.4.6 Planned improvements

For future submissions it is planned to update the uncertainty analysis for the waste sector and add further information on the methodological information regarding solid waste disposal by e.g. adding details on sources of data.

6.5 Biological treatment of solid waste

6.5.1 Composting

6.5.1.1 Methodology

Recycling and biological treatment of waste started on a larger scale in the middle of the 1990s. Their share of total waste management increased rapidly since then. Emission 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 the amount of waste going to compost production facilities annually. Reliable activity data for the amount of waste composted has, however, only been reported to the EA since 2005. Therefore, the amounts composted from 1995-2004 are estimated to be between 2 and 3 kt. Since 2005 this amount has increased by roughly 2 kt per year and was 34 kt in 2020 The collected data refers to wet weight and is transformed to dry matter. Further information on the annual mass of waste composted and the source of data can be found in Iceland's National Inventory Report on Greenhouse Gas Emissions.

6.5.1.3 Emission factors

For composting, Tier 2 emission factors from Table 3-1 and Table 3-2, Chapter 5B1 in the 2019 EMEP/EEA Guidebook are used for estimating NH_3 and CO emissions. Emission factors for other pollutants are not provided in the 2019 EMEP/EEA Guidebook The emission factors are assumed constant for all the years in the calculations.

6.5.1.4 Emissions

Emissions from composting have been increasing in proportion to the increase in the amount of waste composted.

Table 6.6 Emissions from 5B1 Composting.

	1990	1995	2000	2005	2010	2015	2018	2019
NH_3 [kt]	NO	4.8E-4	4.8E-4	0.0012	0.0037	0.0051	0.0058	0.0057
CO [kt]	NO	0.0011	0.0011	0.0028	0.0085	0.0119	0.0134	0.0134

6.5.1.5 Recalculations and improvements

No recalculations were performed for composting (5B1) for this submission.

6.5.1.6 Planned improvements

There are no planned improvements for this sector.

6.5.2 Anaerobic digestion at biogas facilities (NFR 5B2)

Anaerobic digestion at biogas facilities is currently a non-occurring activity in Iceland.

6.6 Waste incineration and open burning (NFR 5C)

This section discusses the emission estimates from burning of waste, which falls under the subcategories; Waste incineration (NFR 5C1) and Open burning of waste (NFR 5C2). Waste incineration covers the emission estimates from waste incineration plants without energy recovery[10] 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 3.3.1). Waste incineration is separated further into Municipal Waste Incineration (NFR 5C1a), Industrial Waste Incineration (NFR 5C1bi), Hazardous Waste Incineration (NFR 5C1bii), Clinical 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 from 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 which is exported and 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. Waste incineration in incineration plants started in 1993 and from 2004 there has been a single waste incineration plant (Kalka) operating in Iceland. In addition to the plant in Kalka, another plant, in Tálknafjörður, is included in this category which operated from 2001 to 2004. From around 1990, incinerators were built around the country with higher combustion temperatures but still no satisfactory emission controls, especially regarding air pollutants such as dioxin. All these incinerators are considered as open burning and are included in category 5C2 due to the lack of emission controls.

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 2019 EMEP/EEA Guidebook.

Activity data

Activity data on incinerated waste from major incineration plants has been collected by the EA since 2000. There is a sharp increase in the amount of waste incinerated (5C1) and corresponding decrease in waste open burnt (5C2) in 2004 due to the opening of the Kalka plant. This trend is also seen in the emissions.

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

Emission factors (T1) for all pollutants for the incineration plant Kalka are taken from Table 3-1, Chapter 5C1a in the 2019 EMEP/EEA Guidebook. Lower emission factors were used for the Kalka plant than for the other incineration plant. This is due to the following abatement technologies present at the plant:

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

- Dry cleaning process
- Hydrated lime
- Combustion is at approximately 1100°C
- Particle abatement (bag filters with capacity 50 kg/hr)

For the incineration plant in Tálknafjörður Tier 2 emission factors from Table 3-2, Chapter 5C1a in the 2019 EMEP/EEA Guidebook, is used for all pollutants except for NH_3, Se and Indeno(1,2,3-cd)pyrene. As Tier 2 EFs are unavailable for NH_3, Se and Indeno (1,2,3-cd)pyrene the Tier 1 emission factors from Table 3-1, Chapter 5C1a in the 2019 EMEP/EEA Guidebook, have been used. The reason for this is the lack of emission factors given for these pollutants in Table 3-2 of the Guidebook.

From 2004 only one incineration plant (Kalka) handling MSW has been operating in Iceland. The emission factor of 0.5 µg TEQ/t MSW was taken from Table 14 in Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2005).

Recalculations

No recalculations were performed for this sector.

Planned improvements

For the next submission, it is planned to aquire and use facility data for the emissions which are measured on site. For future submissions there is, furthermore, a need to acquire more detailed technology stratification to account for abatement technologies in the Tier 2 methodology of the 2019 EMEP/EEA Guidebook. An uncertainty analysis is, furthermore, in progress.

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 2020. Total reported slaughterhouse waste is multiplied by pollutant specific emission factors to estimate these emissions.

Activity data

Activity data for this category has only been included for the years 2014-2020 while for all previous years it is included in 5C1a.

Emission factors

Emission factors are taken from Table 3-1, Chapter 5C1b in the 2019 EMEP/EEA Guidebook2019.

Recalculations

The emisson factors for industrial waste incineration were updated for this submission. Previously, the same emission factors were used for industrial waste incineration as for MSW, Tier 2 emission factors from Table 3-2, Chapter 5C1a in the 2019 EMEP/EEA Guidebook. They have been changed to the emission factors specified for industrial waste incineration from Table 3-1, Chapter 5C1b in the 2019 EMEP/EEA Guidebook. This was done as it was estimated that the new emission factors are more accurate. In Table 3-1, Chapter 5C1b in the 2019 EMEP/EEA Guidebook, the folowing pollutants are not estimated: NH_3, Cr, Cu, Zn, Se, BaP, BbF, IpY and PCB is not applicable, therefore these pollutants are not included.

Table 6.7 Recalculations within 5C1bi, Industrial waste incineration, due to changes in the emission factor

5C1bi Industrial waste incineration	2014	2015	2016	2017	2018	2019
2021 submission NO_x [kt]	7.7E-5	1.3E-4	3.0E-4	8.7E-4	9.2E-4	9.3E-4
2022 submission NO_x [kt]	6.3E-5	1.1E-4	2.5E-4	7.1E-4	7.5E-4	7.5E-4
Change relative to 2021 submission NO_x	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%
2021 submission NMVOC [kt]	4.2E-7	7.4E-7	1.7E-6	4.8E-6	5.1E-6	5.1E-6
2022 submission NMVOC [kt]	5.3E-4	9.3E-4	2.1E-3	6.0E-3	6.4E-3	6.4E-3
Change relative to 2021 submission NMVOC	0.001%	0.001%	0.001%	0.001%	0.001%	0.001%
2021 submission SO_x [kt]	6.3E-6	1.1E-5	2.5E-5	7.1E-5	7.5E-5	7.5E-5
2022 submission SO_x [kt]	3.4E-6	5.9E-6	1.3E-5	3.8E-5	4.1E-5	4.1E-5
Change relative to 2021 submission SOx	1.85%	1.85%	1.85%	1.85%	1.85%	1.85%
2021 submission NH_3 [kt]	2.2E-7	3.8E-7	8.5E-7	2.4E-6	2.6E-6	2.6E-6
2022 submission NH_3 [kt]	NA	NA	NA	NA	NA	NA
Change relative to 2021 submission NH_3	-	-	-	-	-	-
2021 submission $PM_{2.5}$ [kt]	2.2E-7	3.8E-7	8.5E-7	2.4E-6	2.6E-6	2.6E-6
2022 submission $PM_{2.5}$ [kt]	2.9E-7	5.0E-7	1.1E-6	3.3E-6	3.5E-6	3.5E-6
Change relative to 2021 submission $PM_{2.5}$	0.75%	0.75%	0.75%	0.75%	0.75%	0.75%
2021 submission PM_{10} [kt]	2.2E-7	3.8E-7	8.5E-7	2.4E-6	2.6E-6	2.6E-6
2022 submission PM_{10} [kt]	5.0E-7	8.8E-7	2.0E-6	5.7E-6	6.0E-6	6.1E-6
Change relative to 2021 submission PM_{10}	0.43%	0.43%	0.43%	0.43%	0.43%	0.43%
2021 submission TSP [kt]	2.2E-7	3.8E-7	8.5E-7	2.4E-6	2.6E-6	2.6E-6
2022 submission TSP [kt]	7.2E-7	1.3E-6	2.8E-6	8.2E-6	8.6E-6	8.6E-6
Change relative to 2021 submission TSP	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
2021 submission BC [kt]	7.5E-9	1.3E-8	3.0E-8	8.6E-8	9.1E-8	9.1E-8
2022 submission BC [kt]	1.0E-8	1.8E-8	4.0E-8	1.1E-7	1.2E-7	1.2E-7
Change relative to 2021 submission BC	0.75%	0.75%	0.75%	0.75%	0.75%	0.75%
2021 submission CO [kt]	2.9E-6	5.1E-6	1.2E-5	3.3E-5	3.5E-5	3.5E-5
2022 submission CO [kt]	5.0E-6	8.8E-6	2.0E-5	5.7E-5	6.0E-5	6.1E-5
Change relative to 2021 submission CO	0.59%	0.59%	0.59%	0.59%	0.59%	0.59%
2021 submission Pb [t]	4.2E-6	7.3E-6	1.6E-5	4.7E-5	5.0E-5	5.0E-5
2022 submission Pb [t]	9.3E-5	1.6E-4	3.7E-4	1.1E-3	1.1E-3	1.1E-3
Change relative to 2021 submission Pb	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%
2021 submission Cd [t]	3.3E-7	5.8E-7	1.3E-6	3.8E-6	4.0E-6	4.0E-6
2022 submission Cd [t]	7.2E-6	1.3E-5	2.8E-5	8.2E-5	8.6E-5	8.6E-5
Change relative to 2021 submission Cd	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%
2021 submission Hg [t]	1.4E-6	2.4E-6	5.3E-6	1.5E-5	1.6E-5	1.6E-5
2022 submission Hg [t]	4.0E-6	7.0E-6	1.6E-5	4.6E-5	4.8E-5	4.8E-5
Change relative to 2021 submission Hg	0.34%	0.34%	0.34%	0.34%	0.34%	0.34%
2021 submission As [t]	4.5E-7	7.8E-7	1.8E-6	5.1E-6	5.4E-6	5.4E-6
2022 submission As [t]	1.2E-6	2.0E-6	4.5E-6	1.3E-5	1.4E-5	1.4E-5
Change relative to 2021 submission As	0.39%	0.39%	0.39%	0.39%	0.39%	0.39%
2021 submission Cr [t]	1.2E-6	2.1E-6	4.6E-6	1.3E-5	1.4E-5	1.4E-5

5C1bi Industrial waste incineration	2014	2015	2016	2017	2018	2019
2022 submission Cr [t]	NA	NA	NA	NA	NA	NA
Change relative to 2021 submission Cr	-	-	-	-	-	-
2021 submission Cu [t]	9.9E-7	1.7E-6	3.9E-6	1.1E-5	1.2E-5	1.2E-5
2022 submission Cu [t]	NA	NA	NA	NA	NA	NA
Change relative to 2021 submission Cu	-	-	-	-	-	-
2021 submission Se [t]	1.6E-6	2.7E-6	6.1E-6	1.8E-5	1.9E-5	1.9E-5
2022 submission Se [t]	1.0E-5	1.8E-5	4.0E-5	1.1E-4	1.2E-4	1.2E-4
Change relative to 2021 submission Se	0.15%	0.15%	0.15%	0.15%	0.15%	0.15%
2021 submission Ni [t]	8.4E-7	1.5E-6	3.3E-6	9.6E-6	1.0E-5	1.0E-5
2022 submission Ni [t]	NA	NA	NA	NA	NA	NA
Change relative to 2021 submission Ni	-	-	-	-	-	-
2021 submission Zn [t]	1.8E-6	3.1E-6	6.9E-6	2.0E-5	2.1E-5	2.1E-5
2022 submission Zn [t]	NA	NA	NA	NA	NA	NA
Change relative to 2021 submission Zn	-	-	-	-	-	-
2021 submission PCDD/F [g I-TEQ]	IE	IE	IE	IE	IE	IE
2022 submission PCDD/F [g I-TEQ]	2.5E-2	4.4E-2	9.9E-2	2.9E-1	3.0E-1	3.0E-1
Change relative to 2021 submission PCDD/F	-	-	-	-	-	-
2021 submission BaP [t]	6.0E-10	1.1E-9	2.4E-9	6.9E-9	7.2E-9	7.3E-9
2022 submission BaP [t]	NA	NA	NA	NA	NA	NA
Change relative to 2021 submission BaP	-	-	-	-	-	-
2021 submission BbF [t]	1.3E-9	2.2E-9	5.1E-9	1.5E-8	1.5E-8	1.5E-8
2022 submission BbF [t]	NA	NA	NA	NA	NA	NA
Change relative to 2021 submission BbF	-	-	-	-	-	-
2021 submission BkF [t]	6.8E-10	1.2E-9	2.7E-9	7.8E-9	8.2E-9	8.2E-9
2022 submission BkF [t]	NA	NA	NA	NA	NA	NA
Change relative to 2021 submission BkF	-	-	-	-	-	-
2021 submission IpY [t]	8.3E-10	1.5E-9	3.3E-9	9.5E-9	1.0E-8	1.0E-8
2022 submission IpY [t]	NA	NA	NA	NA	NA	NA
Change relative to 2021 submission IpY	-	-	-	-	-	-
2021 submission HCB [kg]	3.2E-6	5.7E-6	1.3E-5	3.7E-5	3.9E-5	3.9E-5
2022 submission HCB [kg]	1.4E-7	2.5E-7	5.7E-7	1.6E-6	1.7E-6	1.7E-6
Change relative to 2021 submission HCB	22.6%	22.6%	22.6%	22.6%	22.6%	22.6%
2021 submission PCBs [kg]	2.4E-10	4.3E-10	9.6E-10	2.8E-9	2.9E-9	2.9E-9
2022 submission PCBs [kg]	NA	NA	NA	NA	NA	NA
Change relative to 2021 submission PCBs	-	-	-	-	-	-

Planned improvements

For the next submission, it is planned to aquire and use facility data for the emissions which are measured on site. Furthermore, it is planned to acquire data for the years 1990-2013, review the emission factors which are currently used for air pollutants not measured on site and add emission estimates for those pollutants where the 2019 EMEP/EEA Guidebook provides emission factors.

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 2019 EMEP/EEA Guidebook.

Activity data

Activity data for incinerated hazardous waste is available from 2006 and is collected by the EA.

Emission factors

Emission factors are taken from Table 3-1, Chapter 5C1b in the 2019 EMEP/EEA Guidebook.

Recalculations

No recalculations were done for this sector.

Planned improvements

For the next submission, it is planned to aquire and use facility data for the emissions which are measured on site.

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 2019 EMEP/EEA Guidebook.

Activity data

Activity data for incinerated clinical waste under this sector is available from 2001, when the first incineration plant opened.

Emission factors

Emission factors are taken from Table 3-2, Chapter 5Cbiii in the 2019 EMEP/EEA Guidebook. Abatement technologies (rotary kiln) are in place at the incineration plant Kalka and, therefore, abatement efficiencies from Table 3-4 are used for NO_x, CO, SO_x, TSP, Cd, Cr, Cu, Hg, Ni from the year 2004 when Kalka opened. Prior to that no abatement technology is assumed.

Recalculations

No recalculations were done for this sector.

Planned improvements

For the next submission, it is planned to aquire and use facility data for the emissions which are measured on site.

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 sewage sludge incineration was included in NFR sector 5C1a until 2014. This is because it was not possible to distinguish between the waste categories until then, as the EA has only received data according to the WStatR (Waste Statistic Regulation) categorization from all waste operators in Iceland since 2014.

Emission factors

Emission factors are taken from Table 3-1, Chapter 5C1b in the 2019 EMEP/EEA Guidebook.

Recalculations

No recalculations were done to sewage sludge incineration for this submission.

Planned improvements

For the next submission, it is planned to aquire and use facility data for the emissions which are measured on site. In addition, a review of the data for this sector is necessary. Some historic data exists for sewage sludge which needs to be extrapolated until 2014.

6.6.1.6 Cremation (NFR 5C1bv)

Methodology

The total number of bodies incinerated is multiplied by a pollutant specific emission factor from the Tier 1 approach of the 2019 EMEP/EEA Guidebook.

Activity data

Cremation is performed at a single facility located in Reykjavik where human remains are incinerated along with the coffin. The activity data, total number of remains incinerated, is provided by the facility and available online..

Emission factors

Emission factors are taken from Table 3-1, Chapter 5C1bv in the 2019 EMEP/EEA Guidebook.

Recalculations performed between 2021 and 2022 submission

No recalculations were performed for this sector.

Recalculations performed between 2020 and 2021 submission

Two recalculations were performed for this sector in the last submission:

- Emissions for 2018 for all pollutants were recalculated, due to an updated activity data value for 2018. This caused a 70% increase in emissions of all pollutants from this sector.
- In accordance with the 2020 Stage 3 review comment (IS_Waste_2020_Q6_5C1bv), Iceland submitted a revised estimate. There was a unit error in the calculations of emissions of IPy which caused a thousandfold overestimation of the emissions. This was corrected for this submission for all years.

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.

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 reasonable emission factors. In addition, 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 open pit waste burning facilities in Iceland is multiplied with its pollutant specific emission factor as given in Chapter 5C2 in the 2019 EMEP/EEA 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). The same methodology is used for emission estimates from bonfires, with dioxin being calculated differently. See more detailed descriptions in the following sections.

6.6.2.2 Activity data

Historic data on open pit burning was estimated with the assumption that 500 kg of waste has been incinerated, per inhabitant, in the communities where waste is known to have been incinerated. The estimate was made for the years 1990, 1995 and 2000 and interpolated for the years in between. These communities were mapped by the EA in the respective years. The EA has information on the dates 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 be still occurring at various rural sites, but this has not been estimated and no public statistics or estimations are currently available. The amount of waste burned in open pits has decreased rapidly since the early 1990s, when more than 30,000 t of waste were burned. Between 2005 and 2010 there was only one site left which was burning waste openly, on the island of Grímsey. This site was closed by the end of 2010. Based on the population, it was assumed that around 50 t of waste was burned there annually.

For New Year's Eve bonfires, activity data is not easily obtained. In 2011 the EA, along with the municipality of Reykjavík, decided to weigh all the material of a single bonfire. Then the piled material was photographed and its height, width and length measured. The weight was then correlated to the more readily measurable parameters pile height and diameter. The Environmental and Public Health Offices were asked to measure the height and diameter of the bonfires in their areas, take photos and send them to the 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. This tradition as well as the number of bonfires has remained consistent in Iceland and, therefore, the same estimate is used for all years since 2011. The year 2020 is an exception because, due to the Covid-19 pandemic, all New Year's Eve bonfires were cancelled that year. Emissions from bonfires for 2020 are, consequently, not occurring.

6.6.2.3 Emission factors

For open pit burning, the dioxin emission factor is taken from Table 54, Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, 2005). The emission factor is 300 µg/t waste (given for uncontrolled domestic waste burning). Tier 2 emission factors, from Table 3-2, 5C1a., 2019 EMEP/EEA Guidebook, are used for NH_3, Hg, Ni, I(1, 2, 3-cd)P, HCB and PCB emissions. Emission factors for the remaining pollutants are taken from Table 3-1, Chapter 5C2 in the 2019 EMEP/EEA Guidebook.

For bonfires, the dioxin emission factor has been estimated historically, based on assumptions. From 2003 onwards an emission factor of 60 µg/t is used. For 1990 to 1995 an emission factor of 400 µg/t of burnt material was used. Both factors are taken from Table II.6.5, Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2012), and is given for open burning of wood and accidental fires in houses. This relates to the fact that the burnt material was very miscellaneous at that time. It was common practice to burn tires, discarded home interiors and even boats at the bonfires. Furthermore, some business/es used the opportunity to get rid of all kinds of waste. Therefore, this dioxin emission factor was considered suitable for open pit burning for the years 1990 to 1995. The emission factor was then interpolated from 400 µg to 60 µg/t burnt material from 1996 to 2003. The emission factors for pollutants, other than dioxin, are taken from Table 3-1, Chapter 5C2 in the 2019 EMEP/EEA Guidebook.

6.6.2.4 Recalculations performed between 2021 and 2022 submission

No recalculations were performed for this sector.

6.6.2.5 Recalculations performed between 2020 and 2021 submission

During the 2020 Stage 3 review Iceland submitted a revised estimate for dioxin emissions from open pit burning for 1990-2003. It was recommended that Iceland use an emission factor of 400 µg/t for 1990-1995 which is presented in the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases from 2012. This caused recalculations for 1990 to 1995, and also for 1996 to 2002 as those years are extrapolated from 1995.

6.6.2.6 Planned improvements

No planned improvements.

6.7 Wastewater handling (NFR 5D)

According to Chapter 5D in the 2019 EMEP/EEA Guidebook, wastewater handling is an insignificant source of air pollutants. However, in urban areas, NMVOC emissions from wastewater 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 and improvements

No recalculations were performed for wastewater handling (5D) for this submission.

6.7.5 Planned improvements

It is planned to contact the relevant companies and investigate if it is possible to get the relevant data about the volume of handled wastewater. This would make it possible to report the NMVOC emissions from wastewater handling.

6.8 Other waste (NFR 5E)

This section discusses the emission estimates from other waste, for which Iceland estimates emissions from accidental house and vehicle burning. Emission estimates for all reported pollutants are 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 follows: the number of fire events multiplied with a pollutant specific emission factor from the Tier 2 approach of Chapter 5E in the 2019 EMEP/EEA Guidebook and the the most recent Danish Informative Inventory Report (IIR).

For accidental vehicle fires, emission estimates are calculated as the mass of vehicles burned multiplied with a pollutant specific emission factor from the the most recent Danish IIR. The weight of different types of vehicles is used in the calculations and taken from Table 6-26 of the the most recent Danish IIR. 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 2020 from the Capital District Fire and Rescue Service (CDFRS). Building fires are classified by duration of response into small, medium and large fires. The data is presented in Table 6.8. 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 6.9, 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 6.8 and

Table 6.9 show the total scaled building fires. This scaling is similar to the scaling used in the 2011 Danish IIR, although the scaling in Denmark is based on response activity rather than response time.

It does, however, seem appropriate to scale the fires in this way for the Icelandic data. It is further assumed that 10% of each year's building fires, are industrial building fires.

In 2004, a major industrial fire broke out at a recycling company (Hringrás). In the fire 300 t 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 (Fönn). The house had a thick layer of asphalt roll roofing with an estimated weight of around 80 t.

For the years 1990 to 2002, an average of the total scaled building fires (38) and 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 a completely different format, making them both difficult to obtain and interpret. As the extra information gained would not be of that much importance, it is not a priority to further explore this subject.

The yearly combusted mass is calculated by multiplying the number of different vehicles fires with the average weight of the given vehicle type.

As the types of vehicles that have caught fire are not registered at the CDFRS, the average ratio of vehicle type caught on fire are taken from the 2020 Danish IIR. Motorcycles are excluded, as motorcycle fires are very rare in Iceland. The ratios are:

- 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 (weight is also taken from the Danish IIR, as national data was not available). It is assumed that 70% of the total vehicle mass involved in a fire actually burns.

Table 6.8 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
2005	43	141	24	11	29
2010	34	118	17	9	23
2015	37	88	14	3	25
2019	34	71	17	13	23
2020	27	69	13	13	18

Table 6.9 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
2005	65	212	36	17	43
2010	51	177	26	14	34
2015	56	132	21	5	37
2019	57	111	17	17	34
2020	51	107	26	20	27

6.8.3 Emission factors

The emission factor for undetached houses is used for all building fires, except for industrial building fires. This is because Icelandic regulations demand more fire resistance than the regulations in other Scandinavian countries. Emission factors for undetached building fires are taken from Table 3-4, Chapter 5E in the 2019 EMEP/EEA Guidebook, for all estimated pollutants provided in the Guidebook except for dioxin, which is taken from the the most recent Danish IIR. Other non-estimated sources of the 2019 EMEP/EEA Guidebook are taken from Table 6.24 in the most recent Danish IIR. No emission factors are provided for BC, Ni, Se, Zn, HCB and PCB. NH_3 is considered not applicable as the 2019 EMEP/EEA Guidebook suggests.

Similarly, for industrial building fires, emission factors from Table 3-6, Chapter 5E in the 2019 EMEP/EEA Guidebook is used except for dioxin which is taken from the the most recent Danish IIR. Other non-estimated sources of the 2019 EMEP/EEA Guidebook are taken from Table 6.24 in the most recent Danish IIR. No emission factors are provided for BC, Ni, Se, Zn, HCB and PCB. NH_3 is considered not applicable as the 2019 EMEP/EEA Guidebook suggests.

For vehicle fires, the burned mass is multiplied with a pollutant specific emission factor taken from Table 6.32 of the the most recent Danish IIR.

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 was estimated to be the size of around 16 industrial building fires and other emissions were scaled accordingly.

Asphalt roll roofing, which burned in the 2014 industrial laundry fire (Fönn), was assumed to emit dioxin levels comparable to scrap tires and, therefore, the same emission factor for dioxin was used as for the industrial fire at the recycling company (Hringrás). Dioxin emissions from other materials that burned were included by assuming that the scale of 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 6.24 in the most recent Danish IIR 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 Table 6.24 in the most recent Danish IIR. Other reported pollutants are taken from Table 3-6, Chapter 5E in the 2019 EMEP/EEA Guidebook. No emission factors are provided for BC, Ni, Se, Zn, HCB and PCB. NH_3 is considered not applicable as the 2019 EMEP/EEA Guidebook suggests.

6.8.4 Recalculations and improvements

No recalculations were done for this submission.

6.8.5 Planned improvements

Review of the data used for 1990 to 2002 for the number of accidental house and vehicle fires. General data improvement needed. There were two larger fires in 2018, which have yet to be researched further. The Environment Agency has been in touch with the Capital´s Fire Department and the large fires are included here under the category “building fires <120 min”. A further collaboration is being set up with the Iceland Building Authority with the aim of providing better estimates of emissions from building fires.

7 Natural Sources (NFR 11)

7.1 Volcanoes (NFR 11A)

Volcanic emissions are frequent in Iceland and both remote and in-situ analytical techniques allow a good estimation of associated emissions. While the following chapters describe the three latest eruptions (from 2010) in detail, the Table 7.1 reports the emissions for the whole time series and the respective sources of information. 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.

Table 7.1 Volcanic eruptions and associated SO_X and particulate emissions from 1990.

Year	Volcano	Emissions [kt]			Measurement method/ Source
		SO_x	$PM_{2.5}$	PM_{10}	
1991	Hekla	230			Satellite Nimbus-7 TOMS, https://volcano.si.edu/volcano.cfm?vn=372070&vtab=Emissions
1996	Grimsvötn	10			Satellite Aura OMI https://volcano.si.edu/volcano.cfm?vn=373010&vtab=Emissions
2000	Hekla	183			Satellite Earth Probe TOMS https://volcano.si.edu/volcano.cfm?vn=372070&vtab=Emissions
2004	Grimsvötn	30			Satellite Aura OMI https://volcano.si.edu/volcano.cfm?vn=373010&vtab=Emissions
2010	Eyjafjallajökull	127	1,673	5,970	See Section 7.1.1
2011	Grimsvötn	300	13,184	47,039	Satellite Aura OMI https://volcano.si.edu/volcano.cfm?vn=373010&vtab=Emissions
2014-2015	Holuhraun	12,006	N/A	N/A	See Section 7.1.3

The last three volcanic eruptions (Eyjafjallajökull eruption, April-May 2010; Grímsvötn eruption, May 2011; and Holuhraun eruption, September 2014-February 2015) are reported in more detail below.

7.1.1 Eyjafjallajökull eruption 2010

The Eyjafjallajökull eruption lasted from 14 April until 23 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[11] 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 anthropogenic PM_{10} emissions in Iceland in 2010.

[11] https://wiki.met.no/emep/emep_volcano_plume

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

7.1.2 Grímsvötn eruption 2011

Grimsvötn volcano lays below the biggest glacier in Iceland, Vatnajökull in the southeast of the country, and reaches 1725 m above sea level. It is one of Iceland's most active volcanoes, and has erupted frequently in recent time (1934, 1983, 1996, 1998, 2004 and 2011)

The 2011 Grímsvötn eruption lasted from 21 May until 28 May. 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 the entire Eyjafjallajökull eruption. SO_2 emissions from Grímsvötn have been estimated to be around 1000 kt. The total mass of particulates emitted has not been estimated but the EA 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 22 May, 2011 shows the plume from Grímsvötn casting shadow to the west.

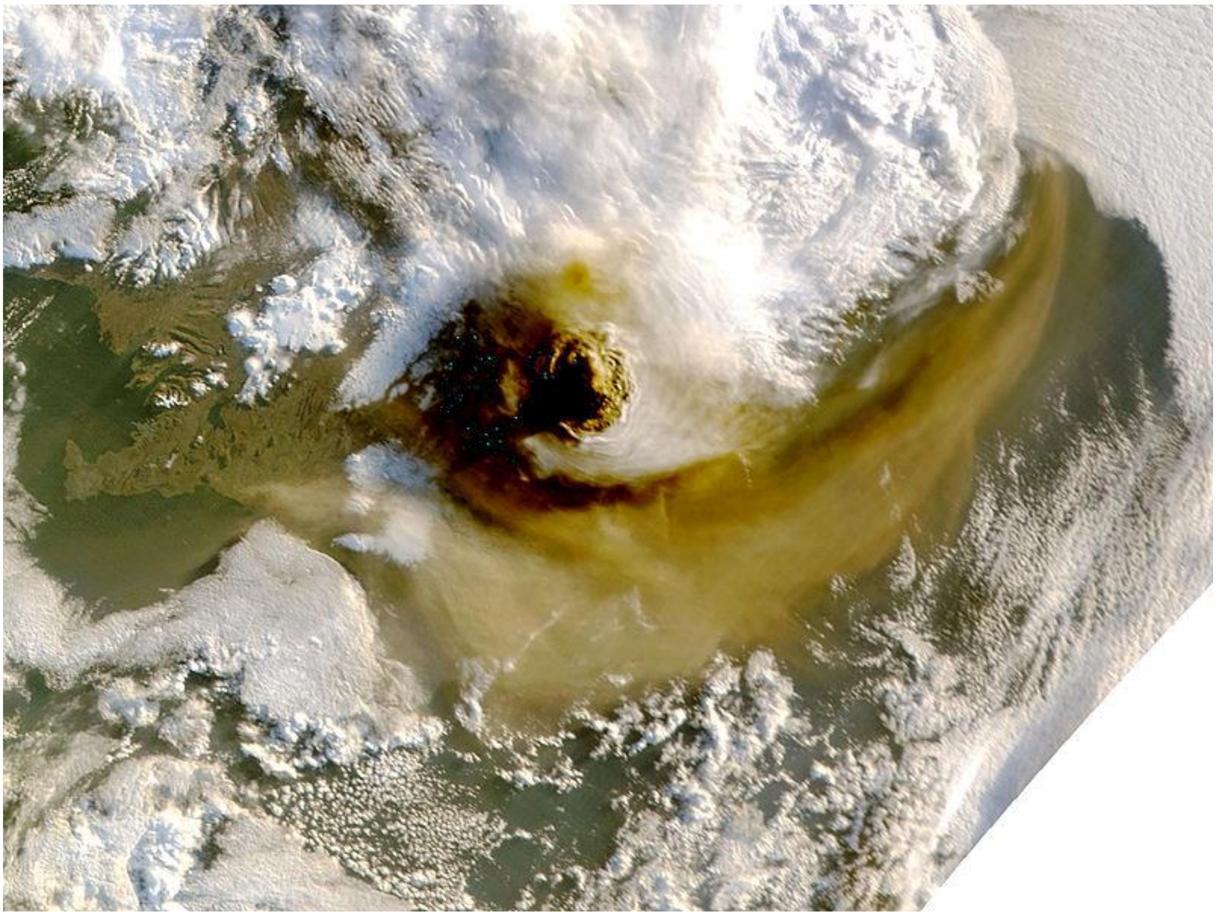


Figure 7.2 Grímsvötn eruption in May 2011. (Photo NASA/GSFC/Jeff Schmaltz/MODIS Land Rapid Response Team).

7.1.3 Holuhraun eruption 2014 - 2015

Holuhraun is located to the north of the glacier Vatnajökull, and is associated with the volcano Bárðabunga situated under Vatnajökull. Prior to the eruption, seismic measurements showed the emplacement of a dike, originating from the Bárðabunga caldera and migrating to the north-east over the course of a few weeks. The eruption in Holuhraun began on 31 August 2014, just to the north of the northern edge of Vatnajökull, and ended on 27 February 2015. It was the biggest eruption in Iceland since the Laki eruption 1783.

Emission estimates from the Holuhraun eruption were done by the volcanic hazard team at the Icelandic Met Office (IMO). According to information from Sara Barsotti and Melissa Anne Pfeffer, specialists at the IMO, the estimates were 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 Differential Optical Absorption Spectroscopy (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 analysed 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, as communicated in 2016 by the IMO. 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. This means that the emissions from the eruption in the year 2014 (i.e. from 29 August 2014 to 31 December 2014) were 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 SO_2 emissions of the European Union.

Because the eruption occured in an area free of ice, emissions of ash were negligible. Further information about SO_2 emissions from the eruption are in Table 7.2 below. As these emissions are natural they are not included in national totals.

Table 7.2 Monthly emission rates (Pfeffer (Icelandic Meteorological Office), 2016, email communication).

	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

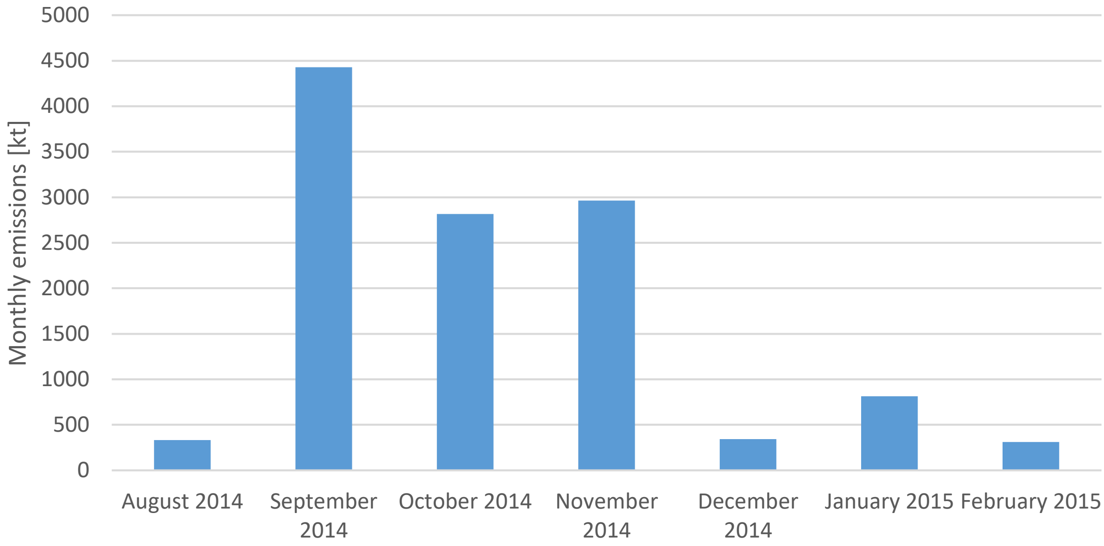


Figure 7.3 Monthly emission from Holuhraun during the eruption.

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.

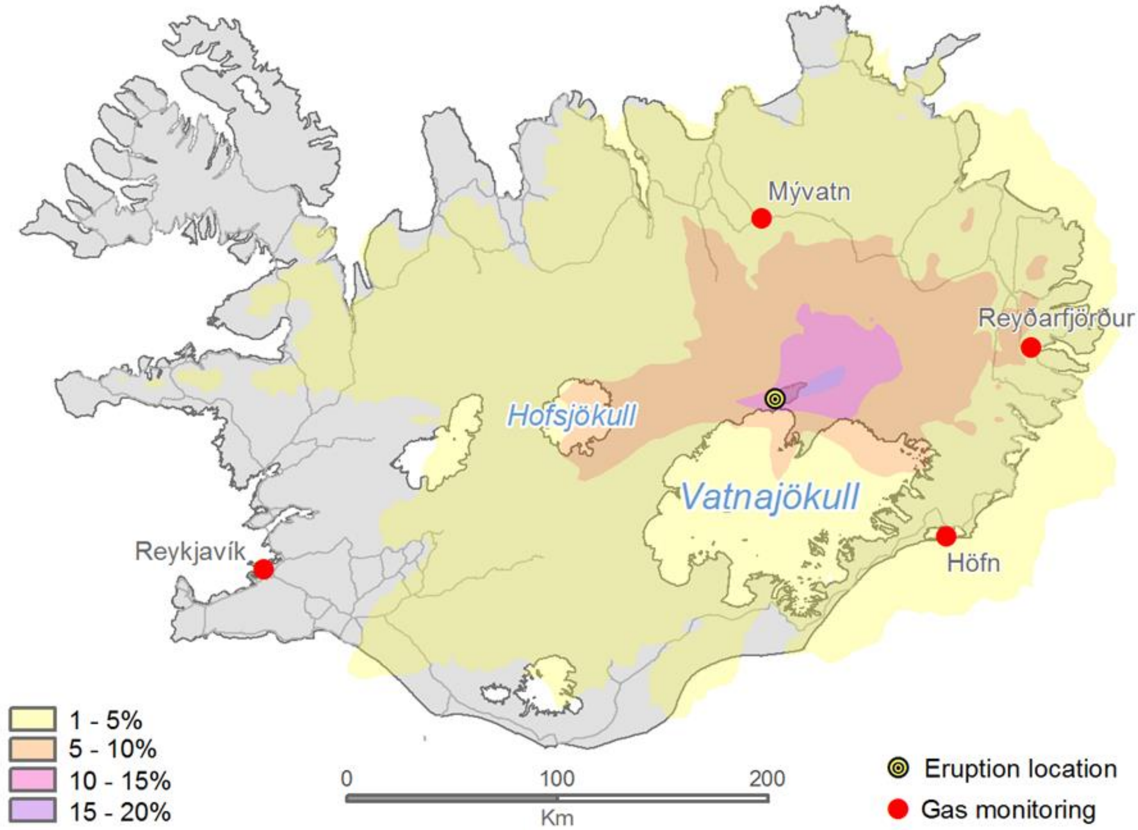


Figure 7.4 SO_2 dispersion during the eruption modelled by CALPUFF, presented as frequency of hourly concentrations higher than the 350 µg/m^3 health limit. The monitoring stations mentioned in the text and in Figure 7.5 are also shown (Gíslason, 2015)

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[12] of the Environmental Agency of Iceland. 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 handheld sensors, the highest being 21,000 µg/m^3 in Höfn (SE of the country). 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

[12] http://airquality.is

hour 350 µg/m³ threshold 2.0 % of the time at Mývatn (NE) (for 17 consecutive hours and a total of 86 hours), 1.4 % in Reyðarfjörður (E) (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 18 February.

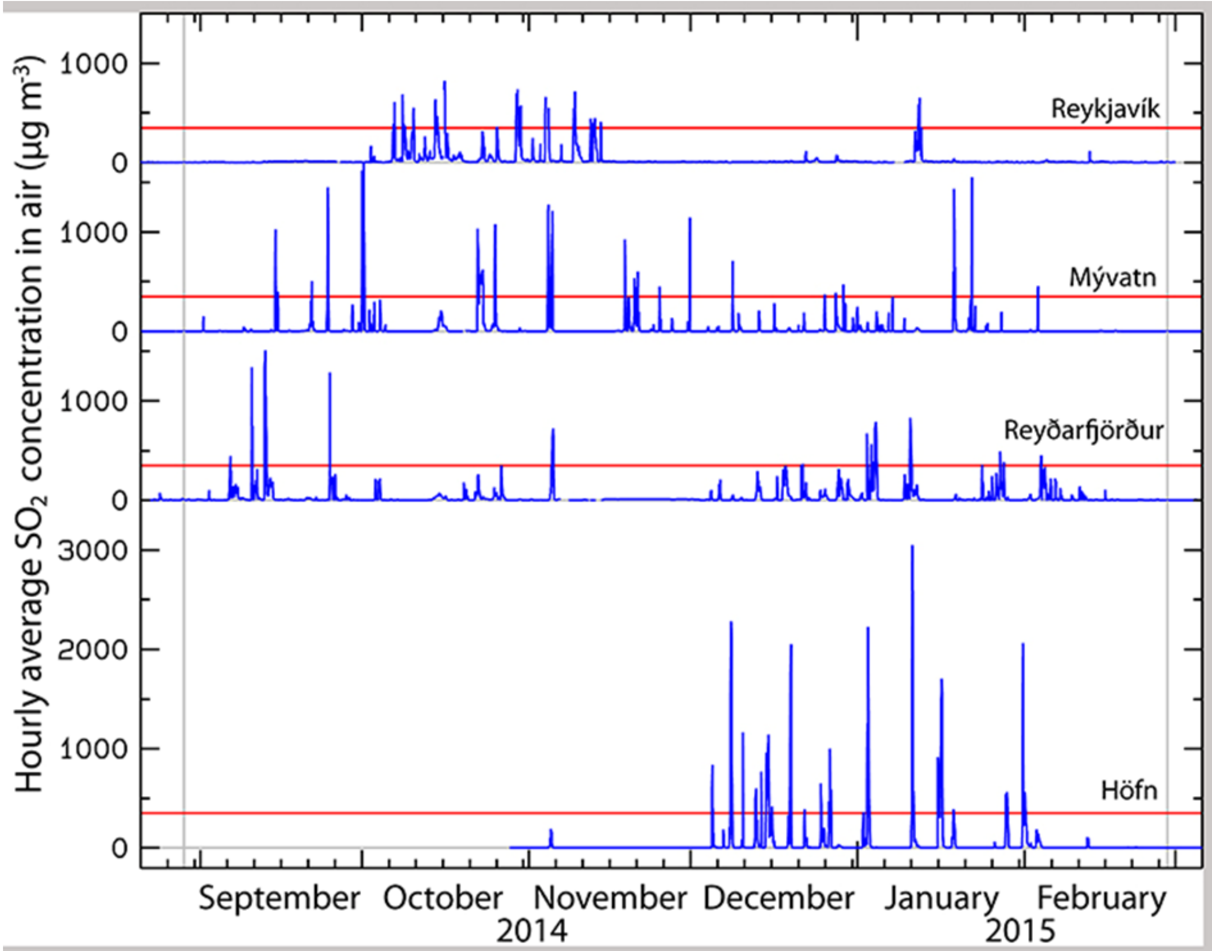


Figure 7.5 The SO_2 concentration in air at four of the permanent gas monitoring stations presented in Figure 7.4. The 350 µg/m³ health limit is shown by the red horizontal line. The grey vertical lines mark the eruption period. Permanent SO_2 monitoring started at Höfn 28 October 2014. (Gíslason, 2015)

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 7.3 (Gíslason, 2015), 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 September the ground-level concentrations were highest in Austria at 235 µg/m³. 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/m³. On this day unusually high concentrations were measured at most of the 30 monitoring stations in Austria. (Gíslason, 2015).

Table 7.3 Highest one hour SO_2 peak by country (Gíslason, 2015).

Country	Station name	Latitude	Longitude	Height above sea level	Date	Distance from the eruption	Highest one hour SO_2 peak
Ireland	Ennis	52.84	-9	16 m	06.09.2014	1407 km	498 µg/m^3
Ireland	Portlaoise	53.04	-7.29	98 m	06.09.2014	1420 km	343 µg/m^3
Netherlands	Philippine	51.29	3.75	5 m	22.09.2014	1905 km	82 µg/m^3
Belgium	Ghent region	51.15	3.81	12 m	22.09.2014	1931 km	87 µg/m^3
Britain	Wicken Fen	52.3	0.29	3 m	22.09.2014	1701 km	96 µg/m^3
Austria	Masenber	47.35	15.89	1210 m	22.09.2014	2754 km	235 µg/m^3

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

8 Spatially Distributed Emissions on Grid

8.1 Scope

The present document provides explanations about the methodology and the data sources used. Gridded emissions were reported in 2021 for the years 2015 and 2019 and for the following components: PCDD/PCDF (dioxins/furans), PAHs, HCB and PCB.

The gridded emissions were aggregated into the following GNFR sectors: A_PublicPower, B_Industry, C_OtherStationaryComb, E_Solvents, F_RoadTransport, G_Shipping, H_Aviation, I_Offroad, J_Waste. POPs emissions do not originate in the Agriculture sector therefore no emissions are reported under the GNFR codes K_AgriLivestock and L_AgriOther.

As a geographical basis the EMEP grid with resolution of 0.1°x 0.1° was used for the first time, as in the 2016 submission the former 50 km x 50 km grid was used.

8.2 Methodology

The methodology follows the approach described in the EMEP/EEA air pollutant emission inventory guidebook 2019. Following steps were carried out in order to provide a spatial allocation of the emissions reported in the NFR tables:

- Understand type and origin of emissions (point or diffuse source)
- Associate geographical locations
- Find proxy datasets for the emissions which could not be allocated to a location
- Assign to each grid cell of the EMEP 0.1°x 0.1° resolution grid a unique number (2273 grid cells in total)
- Allocate the emissions to the grid cells subdivided per GNFR code
- Sum emissions within one grid cell to obtain total emission within that grid cell
- Consistency check: crosscheck sum of emissions of all grid cells with national total emissions reported in NFR tables

The spatially distributed emissions are based on the data collected for the Informative Inventory Report with addition of geographical datasets which can be downloaded from the website of the National Land Survey of Iceland[13]. Population density maps, location of major ports and airports were extracted from these datasets with the help of a GIS software. Locations of point locations were extracted from the EPRTR registry. Some statistical data (tonnage of fish landed, farm numbers per region) was retrieved from Statistics Iceland[14]. Flight statistics for international and domestic flights were collected from ISAVIA[15], the operator of all airports and manager of air traffic in Iceland. In some cases, expert judgement from the national inventory compiler was applied to ensure a correct allocation of emissions.

The following table summarises source of the datasets and proxy spatial dataset used, if necessary.

[13] https://www.lmi.is/
[14] https://statice.is/
[15] https://www.isavia.is/en

Table 8.1 Summary of the source of emission allocation and/or proxy spatial dataset used for the spatial mapping of emissions.

GNFR code	NFR code	Long name	Source and proxy spatial dataset used
A_PublicPower	1A1a	Public electricity and heat production	Energy Authority, two main areas in Iceland where electricity is still produced by fossil fuels, 80% assigned to Grímsey and 20% to Grímsstaðir. The third area, Flatey, is an island which is not inhabited all year round.
B_Industry	1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	Fuel consumption of Ferroalloy producers known, Energy Authority – NIR/IIR, EPRTR registry
B_Industry	1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	Fuel consumption of Aluminium producers known, Energy Authority – NIR/IIR, EPRTR registry
B_Industry	1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	These emissions stem from the fishmeal factories, the oil consumption numbers were looked up from their annual Green reports and the emissions distributed accordingly.
B_Industry	1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Fuel consumption of mineral wool producers known, Energy Authority – NIR/IIR, EPRTR registry
I_Offroad	1A2gvii	Mobile combustion in manufacturing industries and construction	Population density used as proxy spatial dataset, dataset from National Land Survey of Iceland
B_Industry	1A2gviii	Stationary combustion in manufacturing industries and construction: Other	This category is not very well defined and the origin of emissions is not clearly stated by the Energy Authority, so it was decided to split these emissions onto all known big industries.
H_Aviation	1A3ai(i)	International aviation LTO (civil)	Flight statistics published from ISAVIA, the operator of all airports and manager of air traffic in Iceland. Exact location of airports from dataset from National Land Survey of Iceland.
H_Aviation	1A3aii(i)	Domestic aviation LTO (civil)	Flight statistics published from ISAVIA, the operator of all airports and manager of air traffic in Iceland. Exact location of airports from dataset from National Land Survey of Iceland.
F_RoadTransport	1A3bi	Road transport: Passenger cars	Population density used as proxy, dataset from National Land Survey of Iceland
F_RoadTransport	1A3bii	Road transport: Light duty vehicles	Population density used as proxy, dataset from National Land Survey of Iceland
F_RoadTransport	1A3biii	Road transport: Heavy duty vehicles and buses	Population density used as proxy, dataset from National Land Survey of Iceland
F_RoadTransport	1A3biv	Road transport: Mopeds & motorcycles	Population density used as proxy, dataset from National Land Survey of Iceland
G_Shipping	1A3dii	National navigation (shipping)	This category comprises ferries, whale watching boats and probably the coast guard, even though there are no information on the latter. From NIR/IIR data the annual fuel use was split between ferries and whale watching (the consumption of the main ferry to Westman Islands is known). Expert judgement from the energy sector compiler split then the fuel to the rest of ferries/whale watching ports.

GNFR code	NFR code	Long name	Source and proxy spatial dataset used
C_OtherStationaryComb	1A4ai	Commercial/Institutional: Stationary	This category comprises pools heated by fossil fuels and according to the Energy Authority there is only one public pool left heated with fossil fuels (Grundarfjörður and the school building as well).
C_OtherStationaryComb	1A4bi	Residential: Stationary	Population density used as proxy, dataset from National Land Survey of Iceland
C_OtherStationaryComb	1A4ci	Agriculture/Forestry/Fishing: Stationary	A) farm numbers per region for sheep and cattle farmers retrieved from Statistics Iceland, combined percentage per region calculated. B) in GIS all houses located (no info about farm houses available) and intersected with the regions. C) grid cells with less than 10 houses excluded. D) Percentage from A assigned to each grid cell within a region having >10 houses according to the houses present in one grid cell. Geographical dataset from National Land Survey of Iceland
I_Offroad	1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	A) farm numbers per region for sheep and cattle farmers retrieved from Statistics Iceland, combined percentage per region calculated. B) in GIS all houses located (no info about farm houses available) and intersected with the regions. C) grid cells with less than 10 houses excluded. D) Percentage from A assigned to each grid cell within a region having >10 houses according to the houses present in one grid cell. Geographical dataset from National Land Survey of Iceland
I_Offroad	1A4ciii	Agriculture/Forestry/Fishing: National fishing	Main ports defined from the tonnage landed, dataset from National Statistics Iceland and emissions split accordingly.
C_OtherStationaryComb	1A5a	Other stationary (including military)	Population density used as proxy, dataset from National Land Survey of Iceland
B_Industry	2A6	Other mineral products (please specify in the IIR)	Fuel consumption from the mineral wool producers are known, Energy Authority – NIR/IIR
B_Industry	2C2	Ferroalloys production	Fuel consumption from the ferroalloys producers are known, Energy Authority – NIR/IIR
B_Industry	2C3	Aluminium production	Fuel consumption from the aluminium producers are known, Energy Authority – NIR/IIR
B_Industry	2D3b	Road paving with asphalt	The asphalt production is known and the emissions distributed accordingly. – NIR/IIR
E_Solvents	2G	Other product use (please specify in the IIR)	Population density used as proxy, dataset from National Land Survey of Iceland
J_Waste	5C1a	Municipal waste incineration	All incineration occurs in one incinerator in the Reykjanes peninsula.
J_Waste	5C1bi	Industrial waste incineration	All incineration occurs in one incinerator in the Reykjanes peninsula.
J_Waste	5C1bii	Hazardous waste incineration	All incineration occurs in one incinerator in the Reykjanes peninsula.
J_Waste	5C1biii	Clinical waste incineration	All incineration occurs in one incinerator in the Reykjanes peninsula.
J_Waste	5C1biv	Sewage sludge incineration	All incineration occurs in one incinerator in the Reykjanes peninsula.
J_Waste	5C1bv	Cremation	Cremation occurs only in one crematory in Reykjavik.

GNFR code	NFR code	Long name	Source and proxy spatial dataset used
J_Waste	5C2	Open burning of waste	This comprises the yearly New Year‘s eve bonfires. Locations have been determined by searching newspapers and local news, 76 locations determined; emissions split equally as no information about size of single bonfires is known.
J_Waste	5E	Other waste	Population density used as proxy, dataset from National Land Survey of Iceland

8.3 Emissions 2019

The following figures show the national total emissions of dioxin/furans, PAHs, HCB and PCB for the year 2019.

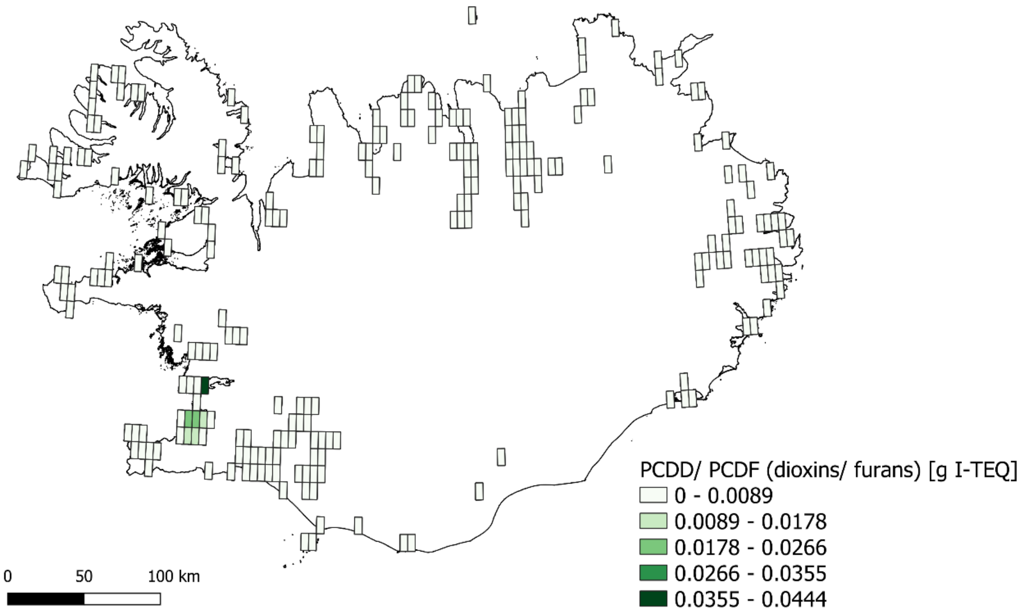


Figure 8.1 Emissions of dioxin/furans 2019 [g I-TEQ].

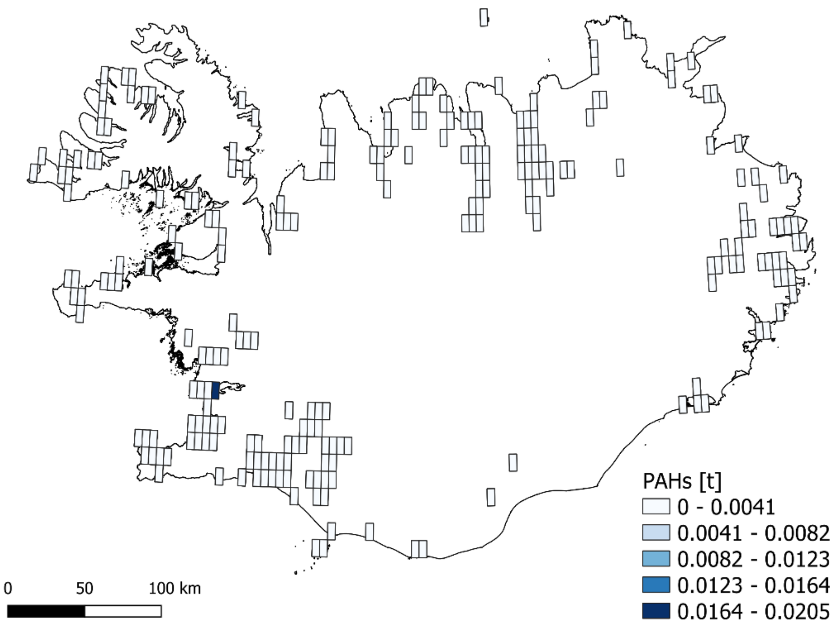


Figure 8.2 Emissions of PAHs [t] in 2019.

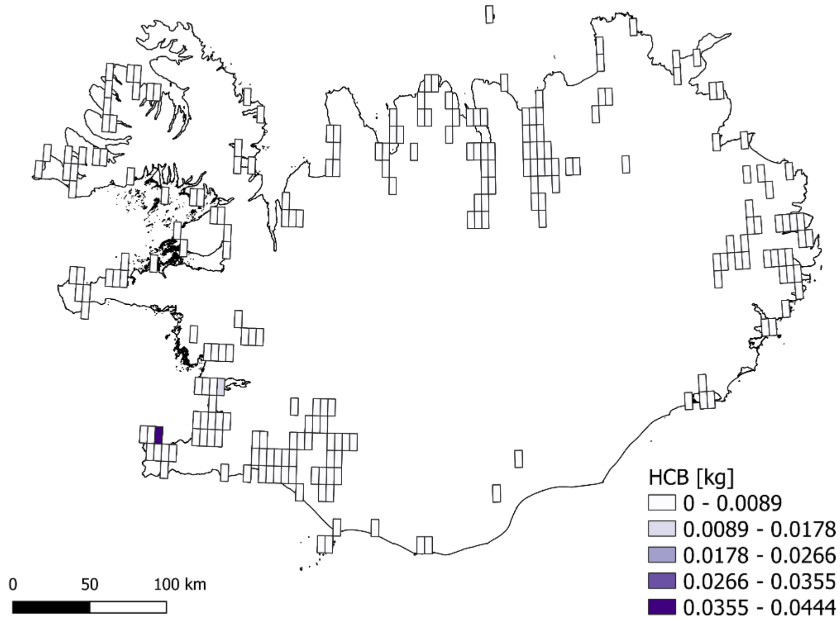


Figure 8.3 Emissions of HCB [kg] in 2019.

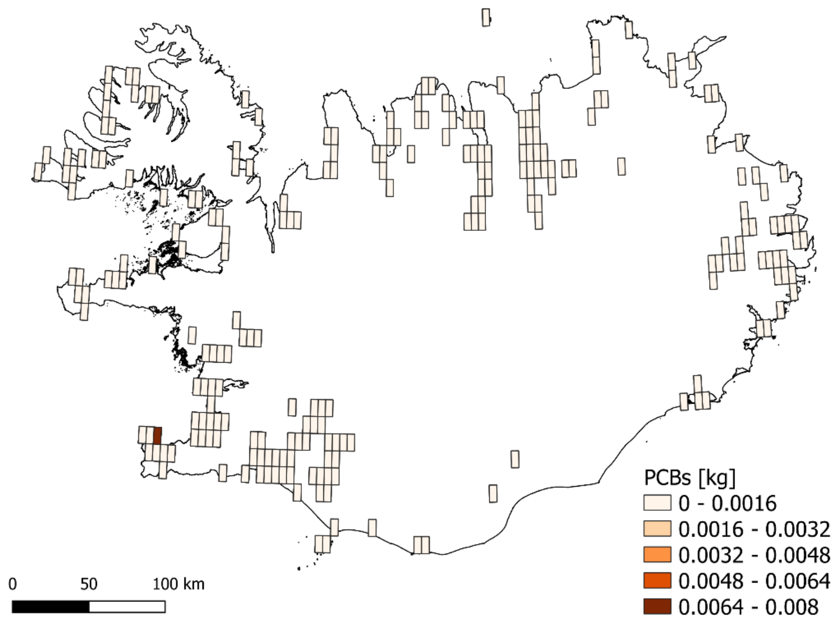


Figure 8.4 Emissions of PCBs [kg] in 2019.

8.4 Emissions 2015

The following figures show the national total emissions of dioxin/furans, PAHs, HCB and PCB for the year 2015.

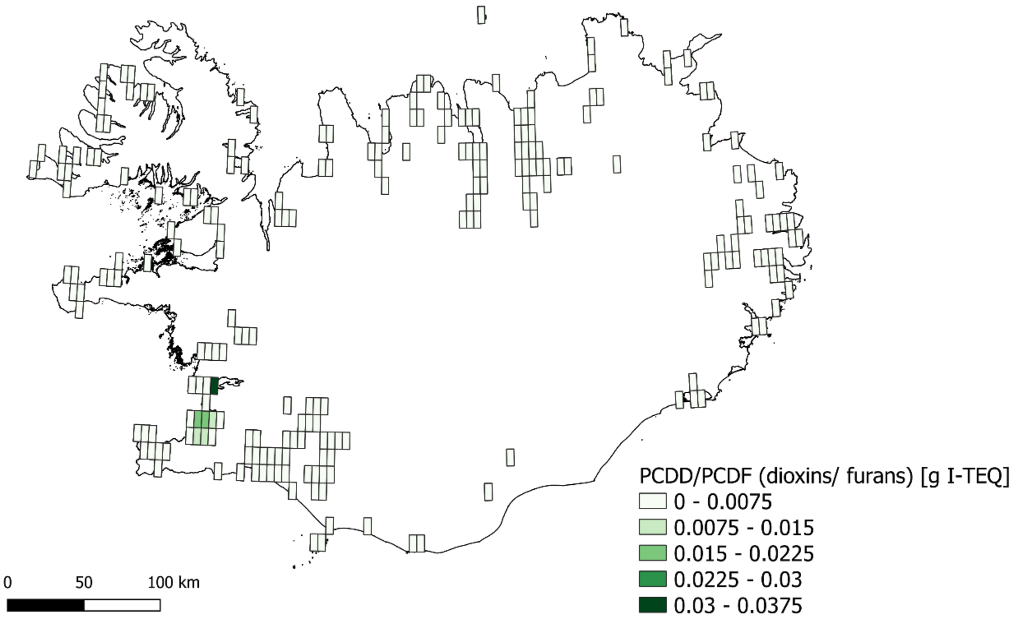


Figure 8.5 Emissions of Dioxin/furans 2015 in [g I-TEQ].

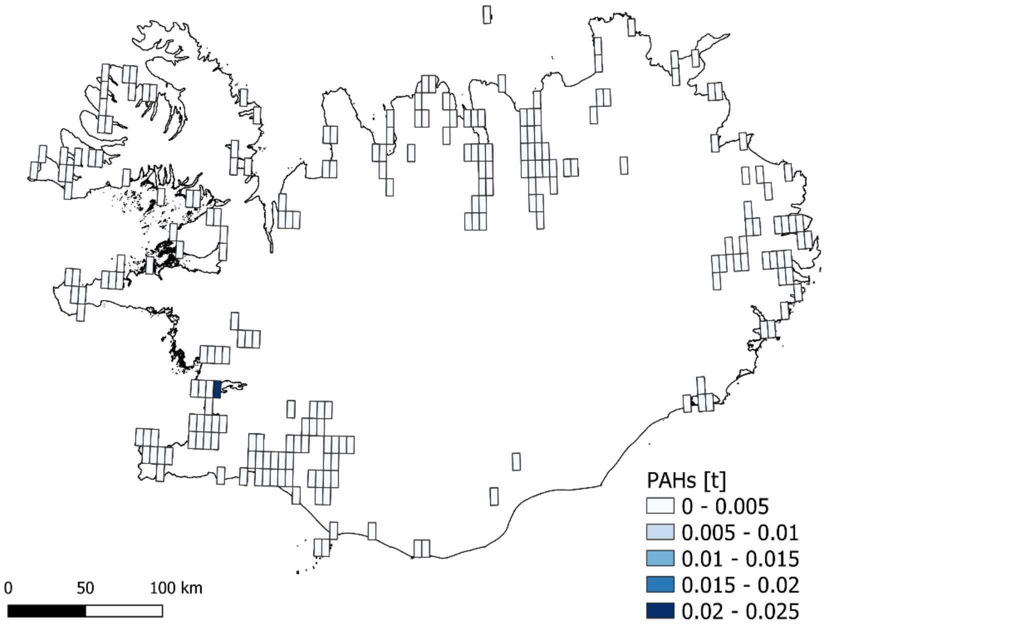


Figure 8.6 Emissions of PAHs [t] in 2015.

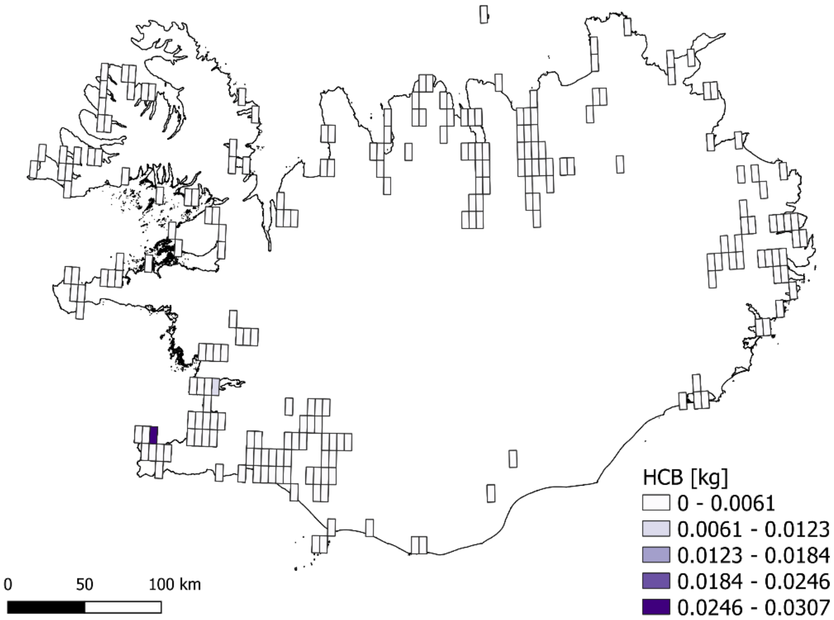


Figure 8.7 Emissions of HCB [kg] in 2015.

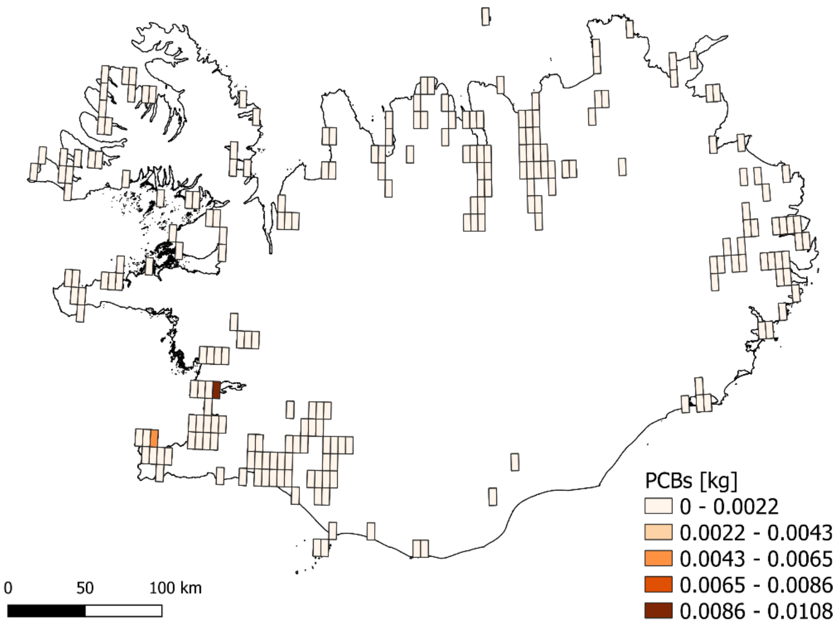


Figure 8.8 Emissions of PCBs [kg] in 2015.

9 Projections

Air pollutant projections are now included in the IIR for the first time. Projections will be made by the EA on a regular basis in the future. The emissions of NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$ and BC are projected until 2030. The projections are predominantly based on historical trends. A summary of the projected emissions for these pollutants is presented in Table 9.1. The projections are built on one scenario, the with (existing) measures (W(E)M) scenario. The projections, therefore, include existing measures based on current legislation. Additional measures to reduce emissions are not included in the projections. The trend by pollutant is presented in chapter 9.1. The methodology and underlying assumptions for the projections are presented for each sector in the following subchapters.

Table 9.1: Emissions of six air pollutants. Historical data for 2005 and 2020 and projected emissions for 2030.

Pollutant	Unit	2005	2020	2030	Change 2020-2030	Change 2005-2030
NO_x	**[kt NO_2]**	28.0	19.3	18.1	-6%	-35%
NMVOC	**[kt]**	7.29	5.37	5.17	-4%	-29%
SO_x	**[kt SO_2]**	40.4	51.5	40.8	-21%	+1%
NH_3	**[kt]**	4.48	4.41	4.19	-5%	-7%
$PM_{2,5}$	**[kt]**	1.60	1.08	1.11	+3%	-30%
BC	**[kt]**	0.23	0.087	0.079	-8%	-65%

9.1 Trend by pollutant

9.1.1 Nitrogen oxides, NO_x

The projected decrease in emissions in the next decade is due to a decrease in fuel use and no residual fuel oil use after 2020. Figure 9.1 shows historical NO_x emissions and projected from 2021.

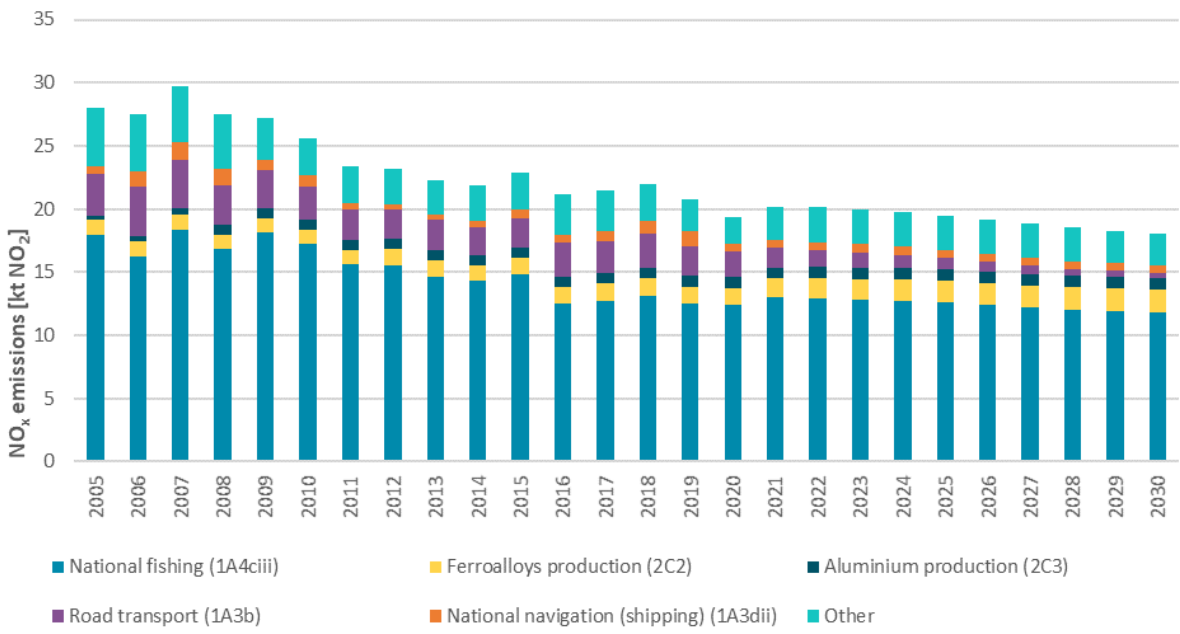


Figure 9.1: NO_x emissions by main sources. Historical data until 2020 and projections until 2030.

9.1.2 Non methane volatile organic compounds, NMVOC

The decrease in emissions since 2005 is mainly due to less fuel use within road transport and due to the renewal of the car fleet. This trend is projected to continue from 2021 to 2030. A further decrease in NMVOC emissions is due to reduced emissions from waste. One reason for the projected reduction in waste emissions is a ban on landfilling organic waste in the year 2023. An increase in the emissions from food and beverages is due to increased production and export of spirits. Figure 9.2 shows the historical NMVOC emissions from 2005 and the projected emissions from 2021.[16]

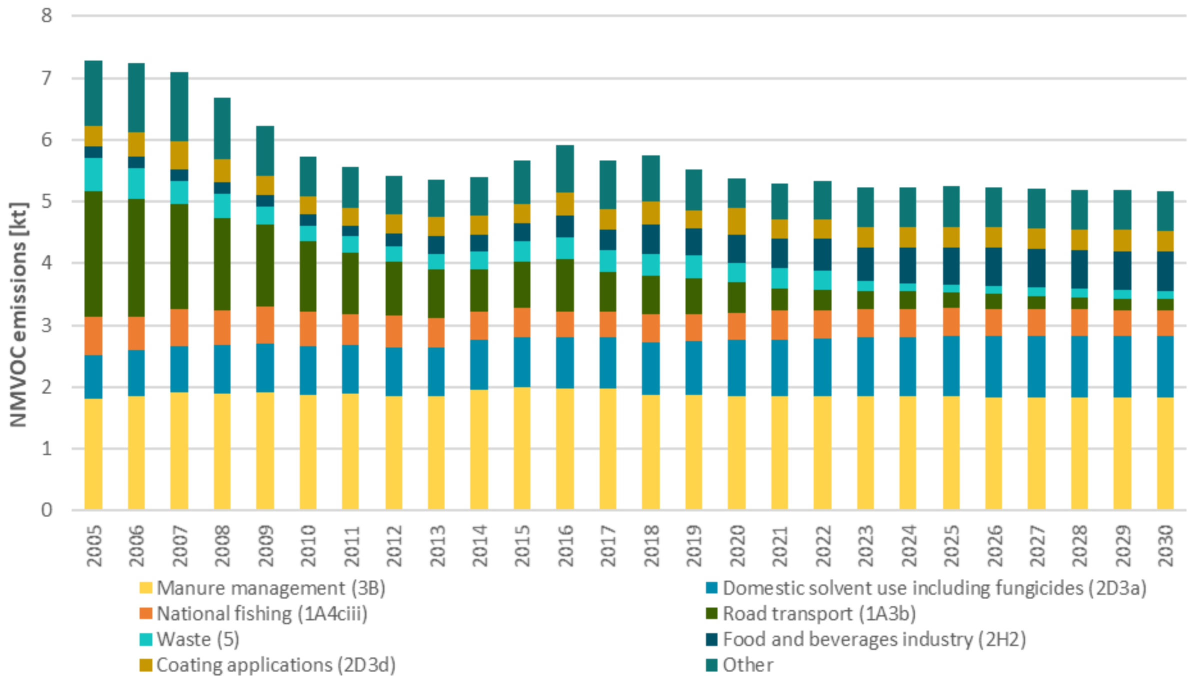


Figure 9.2: NMVOC emissions by main sources. Historical data until 2020 and projections until 2030.

[16] The figure include emissions from manure management (3B) and agricultural soils (3D) but these emissions are not accounted for in the national emission reduction commitments (see Article 4, paragraph 3d of Directive (EU) 2016/2284). At the time of writing, work is underway by the Icelandic government to evaluate and work at the incorporation of the new National Emissions Ceilings Directive (Directive (EU) 2016/2284) into the EEA agreement.

9.1.3 Sulfur oxides, SO_x

Geothermal energy exploitation is the largest source of sulphur emissions in Iceland. Sulphur is emitted from geothermal power plants in the form of H_2S. Emissions from this source (shown as „Other fugitive emissions from energy production (1B2d)“ in Figure 9.3) have increased substantially since 2005 due to an increase in electricity production at geothermal power plants. However, in recent years the SO_2 emissions have started decreasing following the onset in 2014 of a sulphur capture and storage project (Sulfix) at one of the geothermal power plants (Hellisheiði Power Plant).

Further capture and storage is planned at the Hellisheiði Power Plant and another geothermal plant (Nesjavellir Power Plant). That explains the projected decrease in emissions over the next decade. Figure 9.3 shows the historical SO_x emissions from 2005 and the projected emissions from 2021.

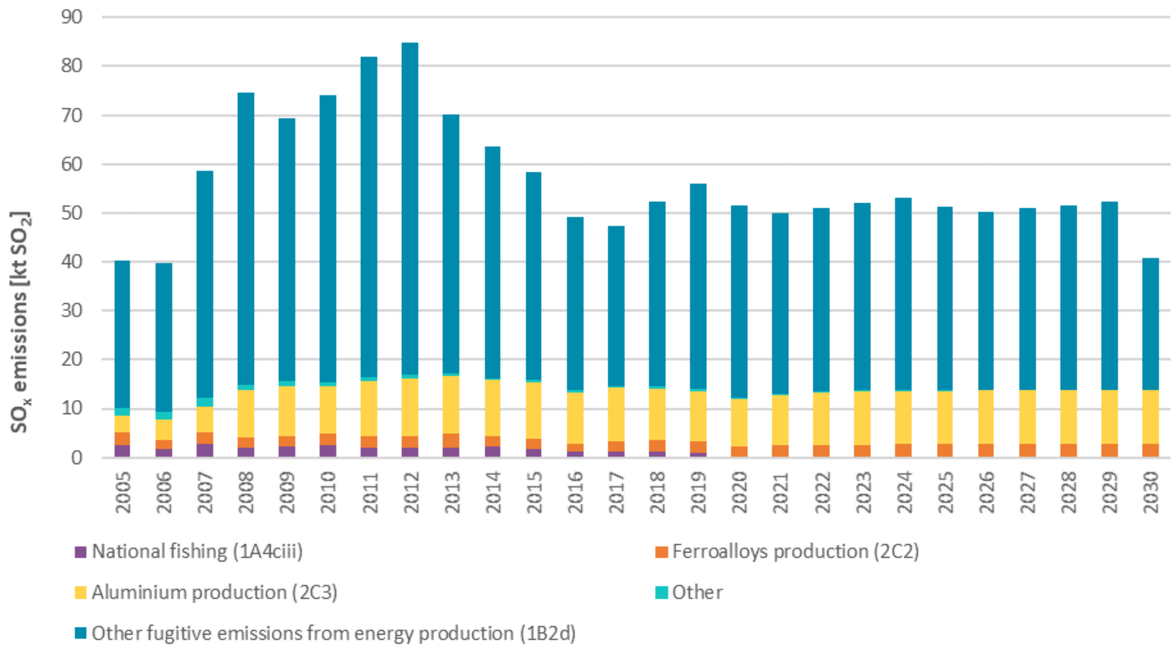


Figure 9.3: SO_x emissions by main sources. Historical data until 2020 and projections until 2030.

9.1.4 Ammonia, NH_3

Projected emissions of NH_3 are expected to decrease over the next decade due to a decrease in livestock numbers. Figure 9.4 shows historical NH_3 emissions from 2005 and projected from 2021.

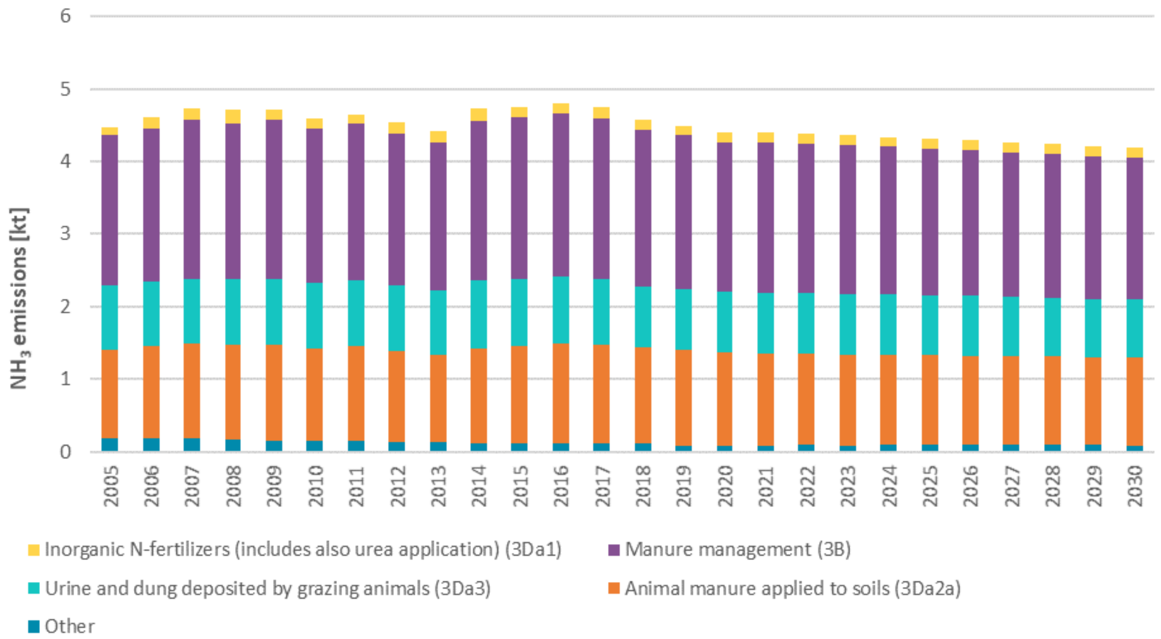


Figure 9.4: NH_3 emissions by main sources. Historical data until 2020 and projections until 2030.

9.1.5 Particulate matter ($PM_{2.5}$)

Particulate matter emissions are projected to remain relatively constant the next decade. Figure 9.5 shows the historical $PM_{2.5}$ emissions from 2005 and the projected emissions from 2021.

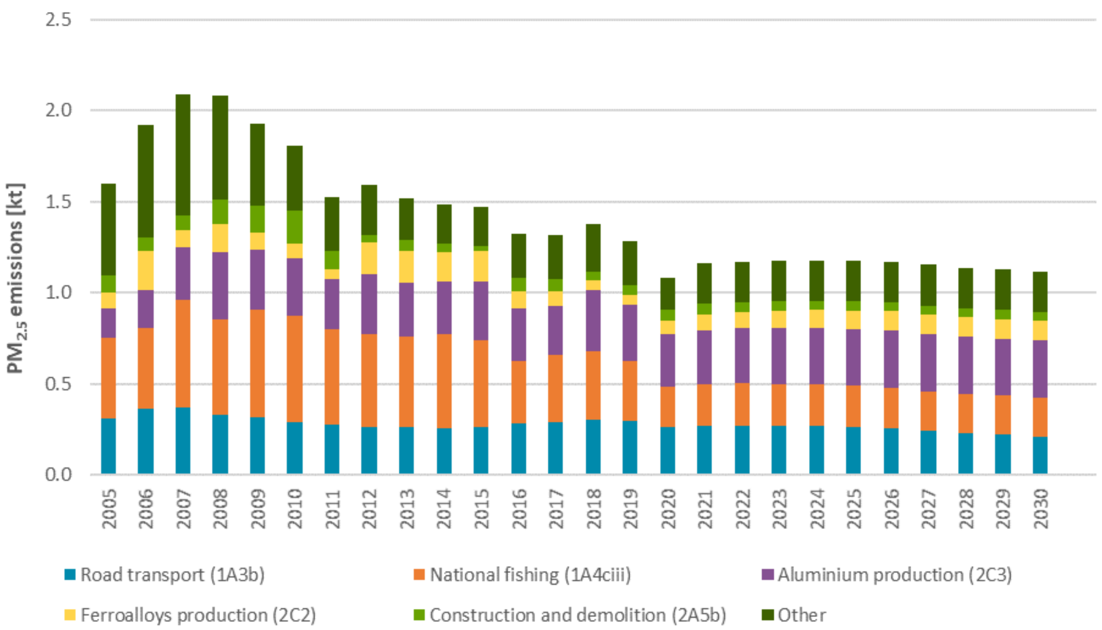


Figure 9.5: $PM_{2.5}$ emissions by main sources. Historical data until 2020 and projections until 2030.

9.1.6 Black carbon (BC)

Black carbon emissions have decreased in the last years and are projected to decrease further. The main reason for the expected decrease is that emission control systems in vehicle engines have improved. Figure 9.6 shows the historical BC emissions from 2005 and the projected emissions from 2021.

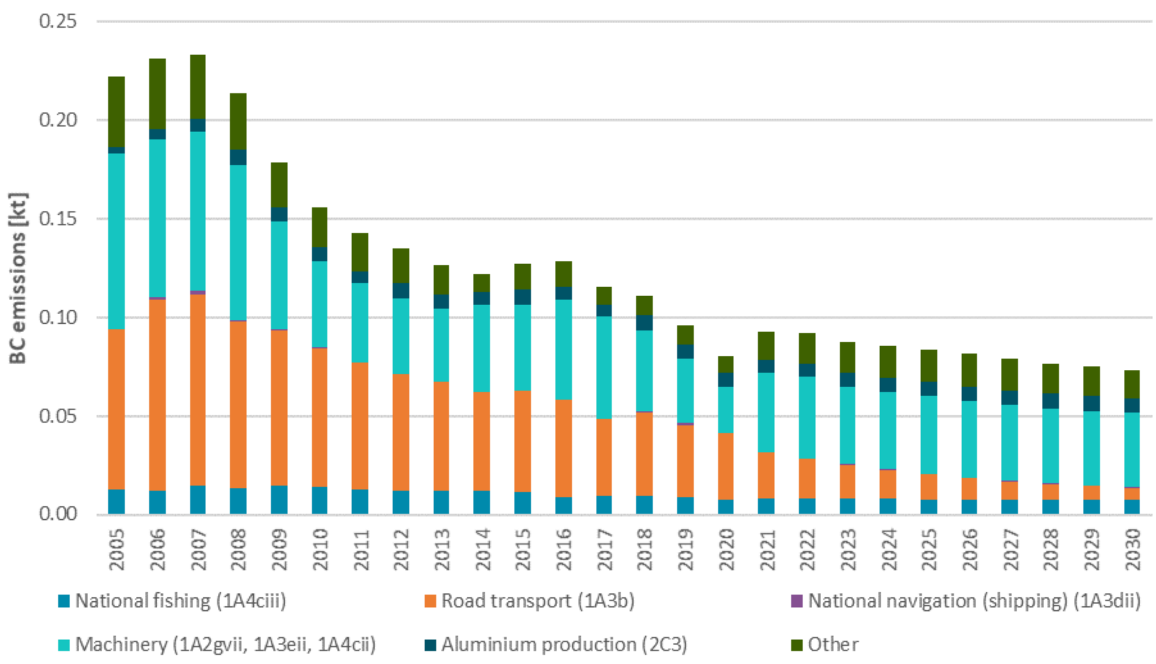


Figure 9.6: BC emission by main sources. Historical data until 2020 and projections until 2030.

9.2 Energy

9.2.1 Methodology

The methods used in the emission projections follow the methodologies for emission inventory as described in chapter 2.

9.2.2 Activity data

Projections for the energy sector are based on fuel projections generated by the the National Energy Authority in the Fuel Use Projection 2021-2060 (Orkustofnun, 2021). The Fuel Use Projection 2021-2060 is based on existing projections and assumptions about economic development, energy transition and oil use. The projection is as well based on existing laws and regulations which impact oil use, such as a recent ban on the use of residual fuel oil within Icelandic territorial waters (Orkustofnun, 2021). Fuel projections were available by fuel type and activity.

Activity data for the geothermal energy (1B2d) is based on a geothermal energy consumption projections by the National Energy Authority.[17] The main assumptions of the projection are population growth, economic development, development of the total size of apartments, offices and other heated space, and development of economic sectors using geothermal energy. Data from individual geothermal power companies about projected amounts of sulphur captured and stored was also collected for the SO_x emission projection.

Emissions from Road transport (1A3b) are estimated using COPERT 5.5.1. which follows the methodology presented in 2019 EEA/EMEP Guidebook. Projected fuel use was obtained from the The Fuel Use Projection 2021-2060 while activity data on vehicle stock numbers by vehicle type and other road transport activity data for COPERT was obtained from the SIBYL baseline.[18]

9.2.3 Emission factors

The emission factors used in the emission projections are the same as in for emission inventory as described in chapter 2 for the last historical year of the inventory.

9.3 Industrial Processes and Product Use (IPPU)

9.3.1 Methodology

The methods used in the emission projections follow the methodologies for emission inventory as described in chapter 2.

9.3.2 Activity data

For the ferroalloys (2C2) and primary aluminium (2C3), the projected production amount is communicated from the individual companies. For activity within other subsectors (2A, 2D, 2G, 2H and secondary aluminium (2C3)), the projected activity data is in some cases assumed to be the same as the average of the activity data in the past (3, 5 or 10 year average). In other cases, where there is good correlation in the past with proxy data, the projected proxy data is used as a proxy to project the activity data. The most common proxy data is population number and GDP. The projected population is from Statistics Iceland (Hagstofa Íslands, 2021) and the GDP projection used by the National Energy Authority in the Fuel Use Projection 2021-2060 (Orkustofnun, 2021). See more details in chapter about IPPU in Iceland's Report on Policies and Measures and Projections.

9.3.3 Emission factors

The emission factors used in the emission projections are the same as in for emission inventory as described in chapter 2 for the last historical year of the inventory. Communication between the EA and the primary aluminium and ferroalloys plants was made to examine if other emission factors are expected in the future. That is not the case for this projection.

[17] Orkustofnun, 2021, unpublished.
[18] https://www.emisia.com/utilities/sibyl-baseline/

9.4 Agriculture

9.4.1 Methodology

The methods used in the emission projections follow the methodologies for emission inventory as described in chapter 4.

9.4.2 Activity data

The projections on how the Icelandic agriculture sector will develop have been based on historical trends in the activity data and expert judgment. The trend in livestock populations has been predicted by extrapolation to 2040 based on the historical available data. The historical data is collected from the Ministry of Food, Agriculture and Fisheries (MFAF) and are the same numbers which are used for agriculture calculations in the latest IIR.

To assess the best possible trends considering the variability of the historical data, experts from the MFAF, which has responsibility for the agriculture sector, were consulted. Those experts determined the most representative projections for each livestock category, based on their expectation of future developments in each agricultural sector. Impacts of agricultural contracts, consumer behaviour and the level of imports of agricultural goods were also taken into consideration. The agricultural contracts will be reviewed again in 2023 and renegotiated in 2026, at which point the projections in each livestock category may change.

The conclusion was that livestock numbers for cattle were linearly projected based on the timeseries 1980-2020 and the composition of this category (dairy cattle, other mature cattle, growing cattle) was calculated based on the average of the years 2016-2020. Horses were also extrapolated using the available historical data (1990-2020), as were fur animals (incl. minks and rabbits). In the category sheep (mature ewes, other mature sheep, animals for replacement, lambs), the livestock numbers were projected using a 10-year trend (2011-2020) as the more recent years reflect the actual development in sheep farming better. Swine, goats and poultry are also calculated using the 10-year trend.

All other parameters necessary for livestock characterization (such as pregnancy rates, days on pastures/in housing, feed digestibility, weight, age at slaughter) were kept constant over the projected time series and correspond to the values in the latest IIR submission, except for the milk yield. Because the milk yield per dairy cow has historically been increasing, the milk yield per dairy cow was slightly raised to reach 6,500 kg per year and then kept constant as it is not known how the development of feeding practices translates into milk yield.

Other sources of emissions, such as the use of organic and inorganic N-fertilizers, liming, and the use of urea are predicted by linear interpolation of historical trends. The areas for the calculations of emissions from drained organic soils are communicated from the Soil Conservation Service of Iceland which is calculating projections for the LULUCF sector.

9.4.3 Emission factors

The emission factors used in the emission projections are the same as in the emission inventory as described in chapter 4.

9.5 Waste

9.5.1 Methodology

The methods used in the emission projections follow the methodologies for emission inventory as described in chapter 5.

9.5.2 Activity data

The projections in the waste sector, for the subcategories solid waste disposal (5A), biological treatment of solid waste (5B) and incineration and open burning of waste (5C) are based on the same principle of a mass balance of the annual amount of waste produced, projected in correlation with population projections made available by the Energy Authority. The historical waste generation data as reported in the NIR (1990-2020) was correlated with the population data to calculate the overall waste generation until 2030. This projected annual waste amount was consequently allocated to the three subcategories, taking into account the existing policies and operation permits of waste handling companies.

9.5.3 Emission factors

The emission factors and parameters used in the emission projections are the same as in the emission inventory as described in chapter 5.

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Annexes to the national inventory report

Annex 1: Iceland QA/QC checks

A range of QA/QC checks have been performed on the Icelandic inventory:

- Recalculation check - comparing the values reported in the current (2022) and previous (2021) versions of the inventory for the base year (1990) and the most recent year covered by both versions (2019).
- Negative and zero values checks - to highlight the occurrence of negative values 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 QA/QC process feed back into the continuous improvement programme.

Recalculation Check

A recalculation file has been used for the 2021 submission. This QA/QC file compares the emissions between the current and previous submissions, for 2019 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.

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 2019 EMEP/EEA Guidebook regarding the reporting of recalculations. Where a recalculation change occurs, it is necessary to check that the underlying reasons are understood and considered reasonable.

At present, the recalculations QA/QC 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.

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 (NA, NE, NO and IE) in the NFR Annex I submission file are presented. This QA/QC 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 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.

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 2: KCA Results for 1990 and Trends 1990-2020

NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC and CO:

Table A2. 1 Key categories for NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC and CO, 1990

Component	Key categories (Sorted from high to low from left to right and top to bottom)					Total (%)
NO_x	National fishing	Road transport: Passenger cars	Mobile combustion in manufacturing industries and construction	Road transport: Heavy duty vehicles and buses		83.3%
	NFR 1A4ciii	NFR 1A3bi	NFR 1A2gvii	NFR 1A3biii		
	60.6%	15.2%	4.1%	3.5%		
NMVOC	Road transport: Passenger cars	National fishing	Domestic solvent use including fungicides	Manure management - Horses	Manure management - Dairy cattle	80.2%
	NFR 1A3bi	NFR 1A4ciii	NFR 2D3a	NFR 3B4e	NFR 3B1a	
	37.7%	6.3%	6.2%	5.7%	5.7%	
	Biological treatment of waste - Solid waste disposal on land	Coating applications	Road transport: Gasoline evaporation	Manure management - Non-dairy cattle		
	NFR 5A	NFR 2D3d	NFR 1A3bv	NFR 3B1b		
	5.3%	5.1%	4.3%	3.8%		
SO_x	Other fugitive emissions from energy production (Geothermal energy)	National fishing	Ferroalloys production			82.5%
	NFR 1B2d	NFR 1A4ciii	NFR 2C2			
	57.5%	17.0%	8.0%			
NH_3	Animal manure applied to soils	Manure management - Sheep	Urine and dung deposited by grazing animals	Manure management - Dairy cattle		80.6%
	NFR 3Da2a	NFR 3B2	NFR 3Da3	NFR 3B1a		
	29.2%	19.1%	18.6%	13.8%		
$PM_{2.5}$	National fishing	Open burning of waste	Construction and demolition	Road transport: Automobile road abrasion	Mobile combustion in manufacturing industries and construction	80.3%
	NFR 1A4ciii	NFR 5C2	NFR 2A5b	NFR 1A3bvii	NFR 1A2gvii	
	33.0%	11.2%	8.2%	6.8%	5.6%	
	Ferroalloy production	Aluminium production	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Road transport: Heavy duty vehicles and buses		
	NFR 2C2	NFR 2C3	NFR 1A2f	NFR 1A3biii		
	4.2%	4.1%	3.7%	3.4%		

Component	Key categories	Total (%)

(Sorted from high to low from left to right and top to bottom)						
PM_{10}	Construction and demolition	National fishing	Quarrying and mining of minerals other than coal	Road transport: Automobile road abrasion	Open burning of waste	81.6%
	NFR 2A5b	NFR 1A4ciii	NFR 2A5a	NFR 1A3bvii	NFR 5C2	
	38.7%	16.2%	7.1%	5.9%	5.7%	
	Ferroalloy production	Mobile combustion in manufacturing industries and construction	Farm-level agricultural operations including storage, handling and transport of agricultural products			
	NFR 2C2	NFR 1A2gvii	NFR 3Dc			
	2.8%	2.6%	2.6%			
TSP	Construction and demolition	National fishing	Quarrying and mining of minerals other than coal	Road transport: Automobile road abrasion		82.6%
	NFR 2A5b	NFR 1A4ciii	NFR 2A5a	NFR 1A3bvii		
	62.2%	7.8%	7.0%	5.7%		
BC	Open burning of waste	Other mobile machinery	Road transport: Heavy duty vehicles and buses	Road transport: Passenger cars	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	85.5%
	NFR 5C2	NFR 1A3eii	NFR 1A3biii	NFR 1A3bi	NFR 1A2e	
	29.2%	21.6%	10.4%	10.4%	8.1%	
	National fishing					
	NFR 1A4ciii					
	5.7%					
CO	Road transport: Passenger cars	Aluminium production	International aviation LTO (civil)			81.5%
	NFR 1A3bi	NFR 2C3	NFR 1A3ai(i)			
	54.5%	14.7%	12.3%			

Table A2. 2 Key categories for NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC and CO, Trend 1990-2020

Component	Key categories (Sorted from high to low from left to right and top to bottom)					Total (%)
NO_x	Road transport: Passenger cars	Ferroalloy production	Aluminium production	National fishing	Other mobile machinery	82.2%
	NFR 1A3bi	NFR 2C2	NFR 2C3	NFR 1A4ciii	NFR 1A3eii	
	29.5%	12.4%	11.2%	10.9%	8.2%	
	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery				
	NFR 1A2e	NFR 1A4cii				
	6.3%	3.57%				
NMVOC	Road transport: Passenger cars	Domestic solvent use including fungicides	Food and beverages industry	Manure management - Non-dairy cattle	Manure managment: horses	81.1%
	NFR 1A3bi	NFR 2D3a	NFR 2H2	NFR 3B1b	NFR 3B4e	
	41.1%	12.4%	8.3%	6.2%	5.8%	
	Coating applications	Manure management - Dairy cattle				
	NFR 2D3d	NFR 3B1a				
	3.7%	3.5%				
SO_x	Other fugitive emissions from energy production (Geothermal energy)	National fishing	Aluminium production	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco		85.8%
	NFR 1B2d	NFR 1A4ciii	NFR 2C3	NFR 1A2e		
	29.4%	25.8%	20.8%	9.8%		
NH_3	Manure management - Sheep	Manure management - Non-dairy cattle	Manure mangement - Laying hens	Manure management - Other animals	Manure mangement - Broilers	80.4%
	NFR 3B2	NFR 3B1b	NFR 3B4gi	NFR 3B4h	NFR 3B4gii	
	28.0%	21.5%	11.6%	7.2%	7.0%	
	Manure management - Swine					
	NFR 3B3					
	5.2%					

Component	Key categories (Sorted from high to low from left to right and top to bottom)					Total (%)
$PM_{2.5}$	Aluminium production	National fishing	Road transport: Automobile road abrasion	Other mobile machinery	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	80.6%
	NFR 2C3	NFR 1A4ciii	NFR 1A3bvii	NFR 1A3eii	NFR 1A2f	
	30.2%	16.5%	13.7%	5.7%	4.9%	
	Construction and demolition	Ferroalloys production	Road transport: Heavy duty vehicles and buses			
	NFR 2A5b	NFR 2C2	NFR 1A3biii			
	3.3%	3.3%	3.1%			
PM_{10}	Construction and demolition	Aluminium production	Road transport: Automobile road abrasion	National fishing	Quarrying and mining of minerals other than coal	80.3%
	NFR 2A5b	NFR 2C3	NFR 1A3bvii	NFR 1A4ciii	NFR 2A5a	
	20.7%	20.0%	13.1%	10.2%	10.0%	
	Mobile combustion in manufacturing industries and construction	Stationary combustion in manufacturing industries and construction: Non-metallic minerals				
	NFR 1A2gvii	NFR 1A2f				
	3.2%	2.9%				
TSP	Construction and demolition	Road transport: Automobile road abrasion	Aluminium production	Quarrying and mining of minerals other than coal		83.4%
	NFR 2A5b	NFR 1A3bvii	NFR 2C3	NFR 2A5a		
	34.1%	16.4%	14.6%	13.3%		
BC	Other mobile machinery	National fishing	Road transport: Passenger cars	Aluminium production	Road transport: Automobile road abrasion	84.1%
	NFR 1A3eii	NFR 1A4ciii	NFR 1A3bi	NFR 2C3	NFR 1A3bvii	
	15.0%	14.9%	12.0%	9.3%	8.8%	
	Mobile combustion in manufacturing industries and construction	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	Ferroalloys production	Road transport: Automobile tyre and brake wear		
	NFR 1A2gvii	NFR 1A2e	NFR 2C2	NFR 1A3bvi		
	7.3%	7.0%	5.1%	4.7%		
CO	Aluminium production	Road transport: Passenger cars				84.2%
	NFR 2C3	NFR 1A3bi				
	50.8%	33.4%				

Persistant Organic Pollutants (POPs)

Table A2. 3 Key categories for POPs, 1990

Component	Key categories (Sorted from high to low from left to right)		Total (%)
DIOX	Open burning of waste		97.9%
	NFR 5C2		
	97.9%		
PAH4	Open burning of waste		81.9%
	NFR 5C2		
	81.9%		
HCB	Open burning of waste		84.4%
	NFR 5C2		
	84.4%		
PCB	Open burning of waste	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	89.8%
	NFR 5C2	NFR 1A2f	
	62.7%	27.2%	

Table A2. 4 Key categories for POPs, Trend 1990-2020

Component	Key categories (Sorted from high to low from left to right)					Total (%)
DIOX	Hazardous waste incineration	Industrial waste incineration	Accidental fires			82.3%
	NFR 5C1bii	NFR 5C1bi	NFR 5E			
	47.1%	21.6%	13.6%			
PAH4	Aluminium production	Ferroalloys production	Road transport: Passenger cars	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Accidental fires	82.8%
	NFR 2C3	NFR 2C2	NFR 1A3bi	NFR 1A2f	NFR 5E	
	24.2%	22.0%	18.2%	11.2%	7.2%	
HCB	Clinical waste incineration	Aluminium production				89.9%
	NFR 5C1biii	NFR 2C3				
	71.0%	18.9%				
PCB	Clinical waste incineration	National fishing				95.7%
	NFR 5C1biii	NFR 1A4ciii				
	61.2%	34.4%				

Priority heavy metals (Pb, Cd, Hg) and additional heavy metals (As, Cr, Cu, Ni, Se, Zn)

Table A2. 5 Key categories for heavy metals, 1990

Component	Key categories (Sorted from high to low from left to right and top to bottom)					Total (%)
Pb	Other product use (Fireworks, tobacco)	Mobile Combustion in manufacturing industries and construction	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Accidental fires	Road transport: Automobile tyre and brake wear	85.9%
	NFR 2G	NFR 1A2gvii	NFR 1A2f	NFR 5E	NFR 1A3bvi	
	22.8%	21.7%	16.3%	14.1%	11.0%	
Cd	Open burning of waste	National fishing	Stationary combustion in manufacturing industries and construction: Non-metallic minerals			84.1%
	NFR 5C2	NFR 1A4ciii	NFR 1A2f			
	43.2%	31.1%	9.8%			
Hg	Open burning of waste					90.7%
	NFR 5C2					
	90.7%					
As	National fishing	Open burning of waste				86.4%
	NFR 1A4ciii	NFR 5C2				
	58.3%	28.1%				
Cr	National fishing	Road transport: Automobil tyre and brake wear	Stationary combustion in manufacturing industries and construction: Non-metallic minerals			83.5%
	NFR 1A4ciii	NFR 1A3bvi	NFR 1A2f			
	51.3%	22.9%	9.3%			
Cu	Road transport: Automobil tyre and brake wear	National fishing	Mobile Combustion in manufacturing industries and construction			87.6%
	NFR 1A3bvi	NFR 1A4ciii	NFR 1A2gvii			
	48.1%	30.6%	8.9%			
Ni	National fishing					87.4%
	NFR 1A4ciii					
	87.4%					
Se	National fishing					80.5%
	NFR 1A4ciii					
	80.5%					
Zn	Open burning of waste	National fishing	Accidental fires	Road transport: Automobil		82.8%

Component	Key categories (Sorted from high to low from left to right and top to bottom)					Total (%)
				tyre and brake wear		
	NFR 5C2	NFR 1A4ciii	NFR 5E	NFR 1A3bvi		
	42.0%	18.0%	13.7%	9.2%		

Table A2. 6 Key categories for heavy metals, trend 1990-2020

Component	Key categories (Sorted from high to low from left to right and top to bottom)					Total (%)
Pb	Other product use (Fireworks, tobacco)	Mobile Combustion in manufacturing industries and construction	Stationary combustion in manufacturing industries and construction: Non-metallic minerals			80.0%
	NFR 2G	NFR 1A2gvii	NFR 1A2f			
	44.9%	19.4%	15.8%			
Cd	Ferroalloy production	Other product use (Fireworks, tobacco)	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Road transport: Automobil tyre and brake wear	National fishing	83.2%
	NFR 2C2	NFR 2G	NFR 1A2f	NFR 1A3bvi	NFR 1A4ciii	
	35.7%	19.4%	13.3%	9.2%	5.6%	
Hg	National fishing	Cremation	Road transport: Passenger cars			82.0%
	NFR 1A4ciii	NFR 5C1bv	NFR 1A3bi			
	51.2%	17.4%	13.5%			
As	Road transport: Automobile tyre and brake wear	National fishing	Other product use (Fireworks, tobacco)	Ferroalloys production	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	88.2%
	NFR 1A3bvi	NFR 1A4ciii	NFR 2G	NRF 2C2	NFR 1A2f	
	24.2%	23.6%	17.4%	14.4%	8.6%	
Cr	Road transport: Automobil tyre and brake wear	National fishing	Other product use (Fireworks, tobacco)	Stationary combustion in manufacturing industries and construction: Non-metallic minerals		88.2%
	NFR 1A3bvi	NFR 1A4ciii	NFR 2G	NFR 1A2f		
	34.9%	33.5%	11.2%	8.6%		
Cu	National fishing	Road transport: Automobil tyre	Other product use (Fireworks, tobacco)	Mobile Combustion in manufacturing		92.1%

Component	Key categories (Sorted from high to low from left to right and top to bottom)					Total (%)
		and brake wear		industries and construction		
	NFR 1A4ciii	NFR 1A3bvi	NFR 2G	NFR 1A2gvii		
	30.9%	25.0%	22.0%	14.2%		
Ni	Other product use (Fireworks, tobacco)	National fishing	National navigation (shipping)	Road transport: Automobil tyre and brake wear		81.6%
	NFR 2G	NFR 1A4ciii	NFR 1A3dii	NFR 1A3bvi		
	31.9%	19.8%	19.3%	10.6%		
Se	National fishing	Road transport: Automobil tyre and brake wear	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Municipal waste incineration	Public electricity and heat production	84.4%
	NFR 1A4ciii	NFR 1A3bvi	NFR 1A2f	NFR 5C1a	NFR 1A1a	
	42.1%	17.0%	14.3%	5.8%	5.2%	
Zn	Road transport: Automobil tyre and brake wear	Other product use (Fireworks, tobacco)	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	National fishing	Ferroalloys production	81.6%
	NFR 1A3bvi	NFR 2G	NFR 1A2f	NFR 1A4ciii	NRF 2C2	
	39.1%	20.6%	9.1%	7.7%	5.0%	