ENVIRONMENT AGENCY OF ICELAND

2023

Informative Inventory Report

Emissions of Air Pollutants in Iceland from 1990 to 2021

Submitted under the Convention on Long-Range Transboundary Air Pollution

The Environment Agency of Iceland
Telephone +354 591 2000
E-mail: ust@ust.is
Address: Suðurlandsbraut 24, 108 Reykjavik, Iceland
Website: www.ust.is

Cover photo: Vestrahorn, Iceland. Photo by Gwenn Klabbers on Unsplash

Publication ID: UST-2023:05

Authors:
Nicole Keller, Environment Agency of Iceland
Brian Charles Barr, Environment Agency of Iceland
Birgir Urbancic Ásgeirsson, Environment Agency of Iceland
Sigríður Rós Einarsdóttir, Environment Agency of Iceland
Ásta Karen Helgadóttir, Environment Agency of Iceland
Rafn Helgason, Environment Agency of Iceland
Diljá Helgadóttir, Environment Agency of Iceland
Inga Rún Helgadóttir, Environment Agency of Iceland
Chanee Jónsdóttir Thianthong, Environment Agency of Iceland
Kristinn Már Hilmarsson, Environment Agency of Iceland

Reykjavík, 15 March 2023

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, NMVOCs, 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 emphasises emissions of persistent organic pollutants (POPs), 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 NMVOCs), 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 are provided for SO_2, $PM_{2.5}$, and PM_{10} for the volcanic eruptions at Eyjafjallajökull (2010), Grímsvötn (2011), Holuhraun (2014-2015), and Fagradalsfjall (2021).

The IIR is written by staff at the Environment Agency of Iceland (*Umhverfisstofnun*) (EAI).

Table of Contents

Index of Figures

Index of Tables

Index of Annex Tables

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
EAI	Environment Agency of Iceland (*Umhverfisstofnun*)
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 (*Bændasamtök Íslands*)
GHG	Greenhouse Gas
IEF	Implied Emission Factor
IGLUD	Icelandic Geographic Land-use Database
IIASA	International Institute for Applied Systems Analysis
IIR	Informative Inventory Report
IMO	Icelandic Meteorological Office (*Veðurstofa Íslands*)
IPPU	Industrial Processes and Product Use
IRCA	Icelandic Road and Coastal Administration (*Vegagerðin*)
ITA	Icelandic Transport Authority (*Samgöngustofa*)
KC	Key Category
KCA	Key Category Analysis
LTO	Landing and Take-Off
MAST	Icelandic Food and Veterinary Authority (*Matvælastofnun*)
MFAF	Ministry of Food, Agriculture, and Fisheries (*Matvælaráðuneytið*)
MMS	Manure Management System
MRV	Measurement, Reporting, and Verification
NCV	Net Calorific Value
NEA	National Energy Authority (*Orkustofnun*)
NECD	National Emission Ceilings Directive
NLSI	National Land Survey of Iceland (*Landmælingar Íslands*)
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
SCSI	Soil Conservation Service of Iceland (*Landgræðslan*)
SI	Statistics Iceland (*Hagstofa Íslands*)
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	Xylenes

Pollutants:

Main 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 Occurring

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, NMVOCs, 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, NMVOCs, 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 1990-2021. This report emphasises anthropogenic emissions of persistent organic pollutants (POPs: dioxin, PAH4, HCB, and PCBs), as Iceland has only ratified the Protocol on POPs. Anthropogenic emissions of the precursors (NO_x, CO, NMVOCs, 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.

This report and the associated NFR tables, as well as reports and data from previous years, are available on the Centre on Emission Inventories and Projections (CEIP) webpage: https://www.ceip.at/status-of-reporting-and-review-results

ES.2 Responsible Institution

The Environment Agency of Iceland (*Umhverfisstofnun*) (EAI), an agency under the Ministry of the Environment, Energy, and Climate (*Umhverfis-, orku- og loftslagsráðuneytið*), is responsible for the annual preparation and submission of the Icelandic IIR and NFR tables to the CLRTAP. The EAI 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, Industry, and Waste sectors; activities belonging to the Agriculture sector do not generate POPs emissions.

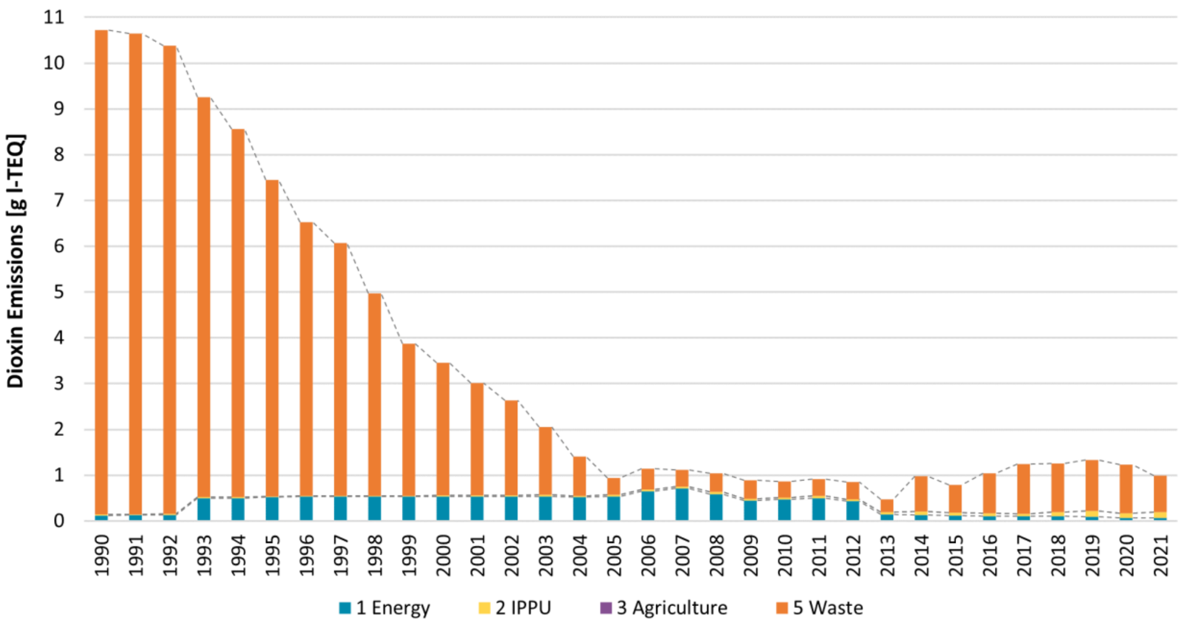


Figure ES. 1 Trends in dioxin emissions by source, since 1990.

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 before 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.

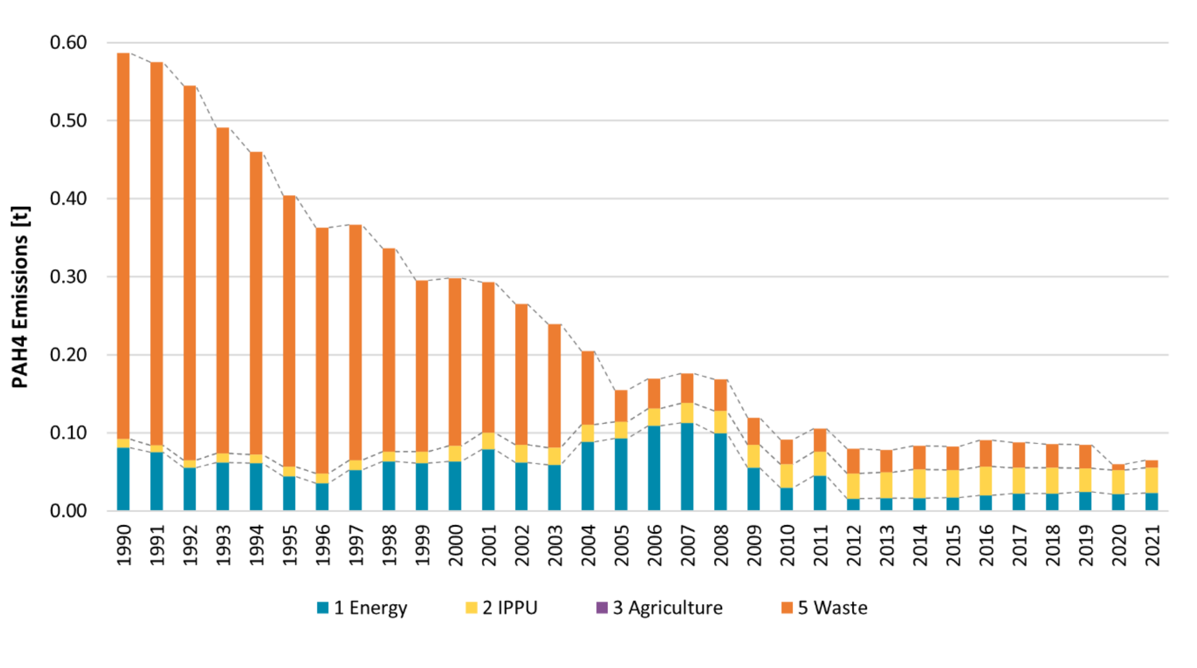


Figure ES. 2 Trends in PAH4 emissions by source, since 1990.

PAH4 (Benzo(a)pyrene-BaP, Benzo(b)fluoranthene-BbF, Benzo(k)fluoranthene-BkF, Indeno(1,2,3-cd)pyrene-IPy) emissions also decreased substantially over the reported time period (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.

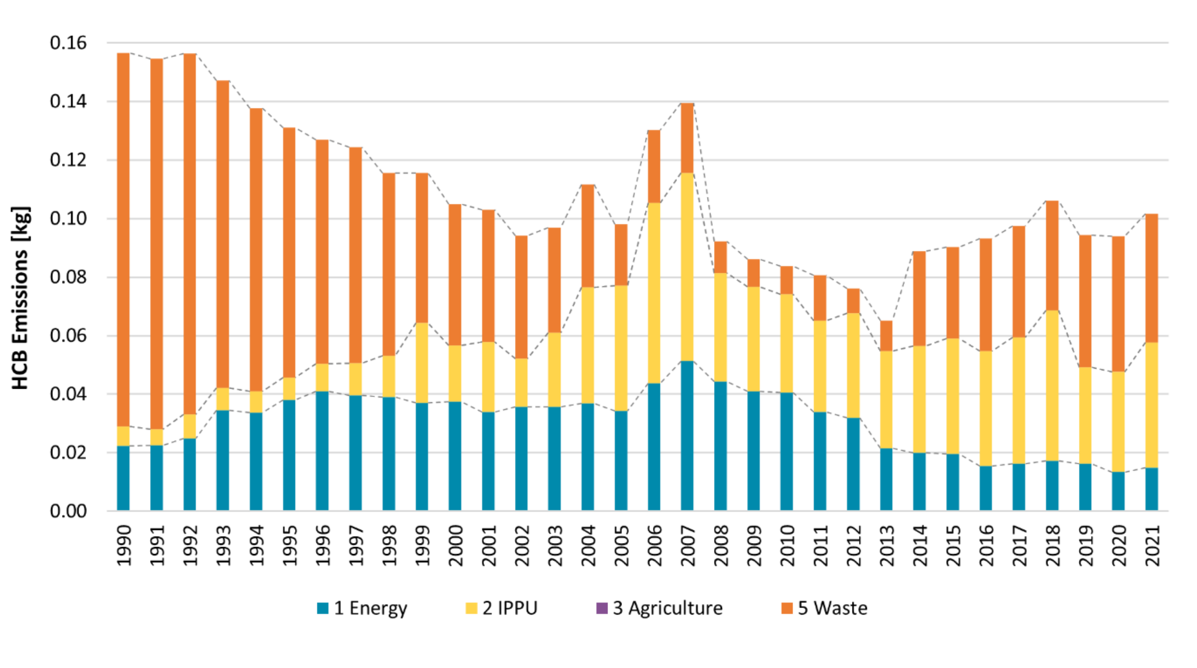


Figure ES. 3 Trends in HCB emissions by sector, since 1990.

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 (Waste sector) followed by emissions originating from the Metal Industry (Industry 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 before 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 is linked to an increased quantity of clinical waste incinerated.

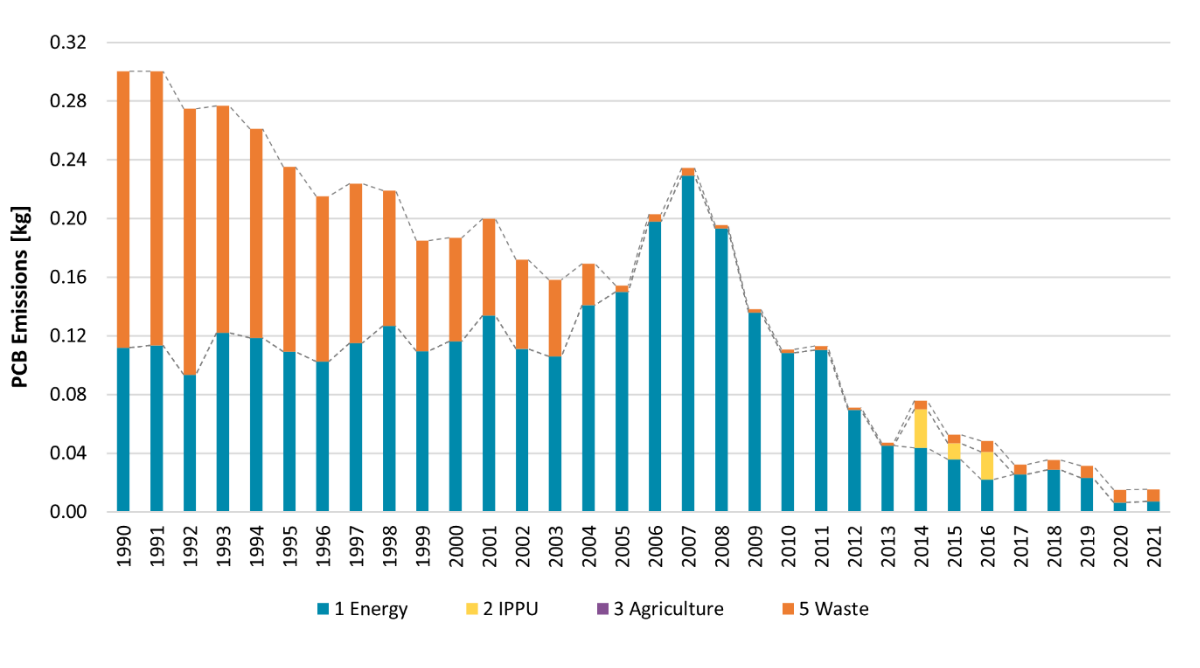


Figure ES. 4 Trends in PCB emissions by sector, since 1990.

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 before 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 (EEA), with national emission targets set for Iceland for SO_2, NO_x, NMVOCs, 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 additions 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 EAI 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, NMVOCs, NH_3, and $PM_{2.5}$, which was done in a way comparable to the analysis done by IIASA for the European Union (EU) Member States (see also TSAP Report no 16[3]).

The present report and associated NFR (Nomenclature for Reporting) tables are Iceland's contribution to the 2023 reporting under CLRTAP. A description of the trends and calculation methods is given.

Anthropogenic emissions of the precursors (NO_x, CO, NMVOCs, 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 volcanic eruptions at Eyjafjallajökull (2010), Grímsvötn (2011), Holuhraun (2014-2015), and Fagradalsfjall (2021) are also provided (Chapter 6).

1.2 Protocol on Persistent Organic Pollutants

The Protocol on Persistent Organic Pollutants (POPs) was adopted on 24 June 1998 and 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 11 pesticides, two industrial chemicals, and three by-products/contaminants. The ultimate objective is to eliminate any discharges, emissions, and losses of

[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

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, PCBs). 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 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. PCBs were 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 (*Umhverfisstofnun*) (EAI), an agency under the the Ministry of the Environment, Energy, and Climate (*Umhverfis-, orku- og loftslagsráðuneytið*), for the annual preparation and submission of the national inventory to the CLRTAP. This act also authorises the EAI to collect all necessary data and information from relevant 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.

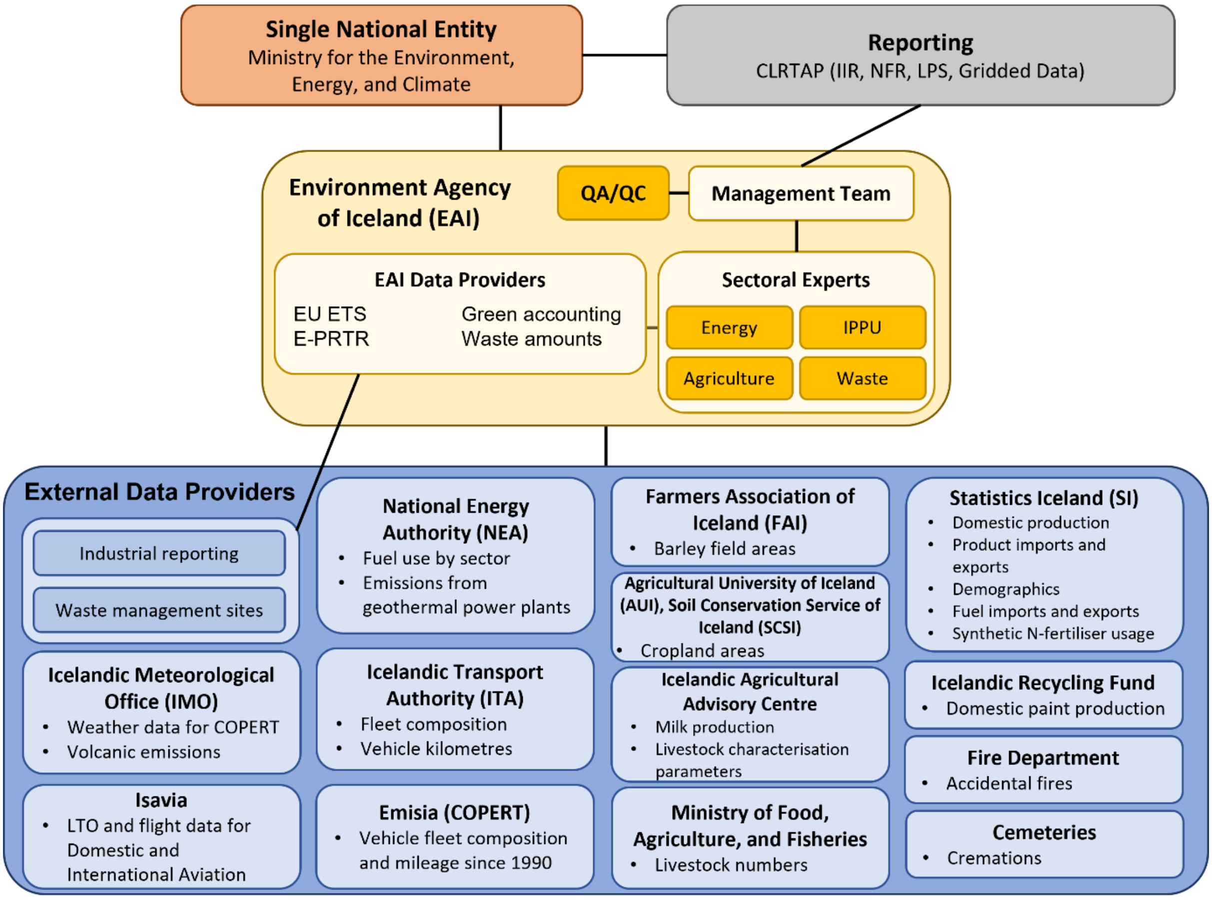


Figure 1.1 Information flow and distribution of responsibilities in the Icelandic emissions inventory system for reporting to the CLRTAP.

1.4 Inventory Preparation

The EAI 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 submitted to the EU according to Regulation 2018/1999 and to the UNFCCC. 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 EAI:

1. The National Energy Authority (*Orkustofnun*) (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 formally obtain sales statistics from the oil companies.
2. Until 2011, the Farmers Association of Iceland (*Bændasamtök Íslands*) (FAI), on behalf of the Ministry of Agriculture, was responsible for assessing the size of the animal population each year; this responsibility was taken over by the Icelandic Food and Veterinary Authority (*Matvælastofnun*) (MAST) after 2011. On request by the EAI, 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 (*Hagstofa Íslands*) (SI) provides information on population, GDP, imports and exports of various products, domestic production, and domestic usage.

4. The EAI 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), and Green Accounting reports from industry submitted under Icelandic Regulation No. 851/2002.

5. Data for using the transport model COPERT originates from the NEA, the Icelandic Transport Authority (*Samgöngustofa)* (ITA), the Icelandic Meteorological Office (*Veðurstofa Íslands*) (IMO), and EMISIA SA[4] and used for emission estimates from Road Transport (NFR 1A3b) (see more details in the Energy sector).

6. Aviation emissions are calculated using LTO and flight data provided by ISAVIA, the national airport and air navigation service of Iceland.

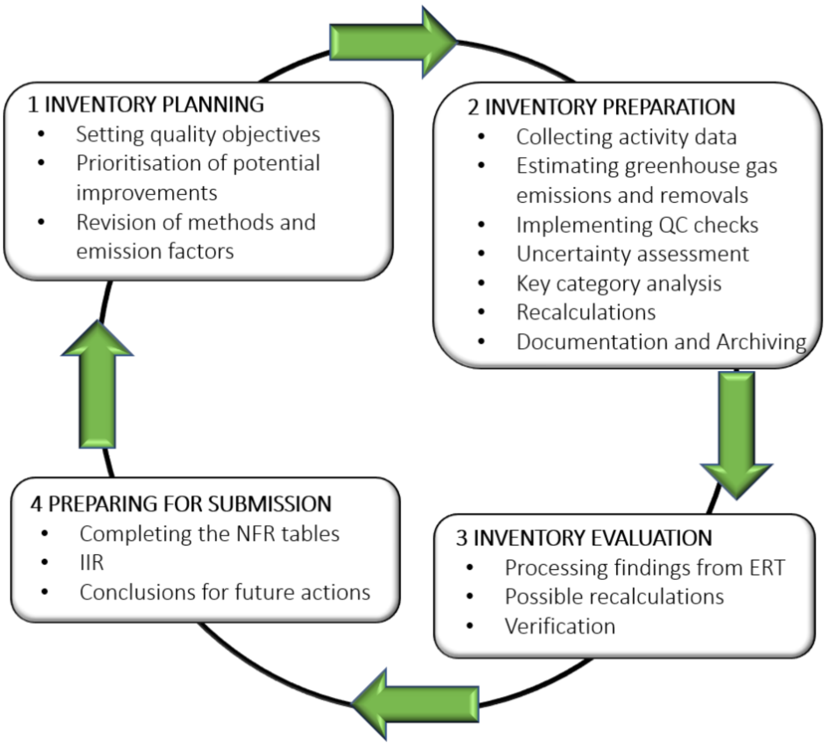
7. Emission factors are mainly taken from the EMEP/EEA Emission Inventory Guidebook (European Environment Agency, 2019) unless otherwise referenced.

8. The EAI 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.

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

Figure 1.2 The annual inventory cycle.



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 prioritised 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 (2021) as well as the trend assessment (1990-2021). Memo items are excluded from the KCA.

Table 1.1, Table 1.2, and Table 1.3 present the results of the KCA for main pollutants, POPs, and heavy metals, respectively, for the year 2021. The KCAs for the above-mentioned pollutant categories in 1990 as well as the 1990-2021 trend assessment are presented in Annex 2: KCA Results for 1990 and Trends 1990-2021.

Table 1.1 Key Category Analysis for reported main pollutants in 2021.

Component	Key Categories (Sorted from high to low, from left to right, and from top to bottom)					Total (%)
NO_x	National Fishing	Ferroalloy Production	Aluminium Production	Road Transport: Passenger Cars		82.0%
	NFR 1A4ciii	NFR 2C2	NFR 2C3	NFR 1A3bi		
	66.2%	7.6%	4.3%	3.9%		
NMVOC	Domestic Solvent Use Including Fungicides	Manure Management: Horses	Food and Beverages Industry	Manure Management - Non-dairy Cattle	Manure Management - Dairy Cattle	82.7%
	NFR 2D3a	NFR 3B4e	NFR 2H2	NFR 3B1b	NFR 3B1a	
	15.7%	9.5%	8.8%	8.4%	8.0%	
	Coating Applications	Road Transport: Passenger Cars	National Fishing	International Aviation LTO (Civil)	Biological Treatment of Waste - Solid Waste Disposal on Land	
	NFR 2D3d	NFR 1A3bi	NFR 1A4ciii	NFR 1A3ai(i)	NFR 5A	
	7.1%	6.9%	5.4%	4.9%	4.7%	
	Distribution of Oil Products					
	NFR 1B2av					
	3.3%					
SO_x	Other Fugitive Emissions from Energy Production (Geothermal Energy)	Aluminium Production				96.0%
	NFR 1B2d	NFR 2C3				
	78.8%	17.2%				
NH_3	Animal Manure Applied to Soils	Urine and Dung Deposited by Grazing Animals	Manure Management - Dairy Cattle	Manure Management - Sheep	Manure Management - Non-dairy Cattle	83.2%
	NFR 3Da2a	NFR 3Da3	NFR 3B1a	NFR 3B2	NFR 3B1b	
	29.4%	16.5%	15.3%	11.4%	10.6%	
$PM_{2.5}$	Aluminium Production	Road Transport: Automobile Road Abrasion	National Fishing	Construction and Demolition	Ferroalloy Production	83.2%
	NFR 2C3	NFR 1A3bvii	NFR 1A4ciii	NFR 2A5b	NFR 2C2	
	28.6%	20.1%	18.6%	6.5%	5.0%	
	Road Transport: Automobile Tyre and Brake Wear					
	NFR 1A3bvi					
	4.4%					
PM_{10}	Construction and Demolition	Road Transport: Automobile Road Abrasion	Aluminium Production	National Fishing	Road Transport: Automobile Tyre and Brake Wear	80.0%
	NFR 2A5b	NFR 1A3bvii	NFR 2C3	NFR 1A4ciii	NFR 1A3bvi	
	31.7%	18.0%	17.3%	9.0%	4.1%	

Component	Key Categories (Sorted from high to low, from left to right, and from top to bottom)					Total (%)
TSP	Construction and Demolition	Road Transport: Automobile Road Abrasion	Aluminium Production			80.7%
	NFR 2A5b	NFR 1A3bvii	NFR 2C3			
	52.5%	17.9%	10.3%			
BC	Mobile Combustion in Manufacturing Industries and Construction	Road Transport: Automobile Tyre and Brake Wear	Road Transport: Passenger Cars	National Fishing	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	83.6%
	NFR 1A2gvii	NFR 1A3bvi	NFR 1A3bi	NFR 1A4ciii	NFR 1A4cii	
	15.2%	12.5%	12.0%	10.2%	9.9%	
	Road Transport: Automobile Road Abrasion	Aluminium Production	Road Transport: Heavy-duty Vehicles and Buses			
	NFR 1A3bvii	NFR 2C3	NFR 1A3biii			
	9.6%	8.0%	6.0%			
CO	Aluminium Production					96.1%
	NFR 2C3					
	96.1%					

Table 1.2 Key Category Analysis for reported POPs in 2021.

Component	Key categories (Sorted from high to low and from left to right)					Total (%)
DIOX	Industrial Waste Incineration	Hazardous Waste Incineration	Clinical Waste Incineration	Accidental Fires	Ferroalloys Production	88.8%
	NFR 5C1bi	NFR 5C1bii	NFR 5C1biii	NFR 5E	NFR 2C2	
	35.7%	16.6%	16.4%	10.7%	9.5%	
PAH4	Ferroalloys Production	Aluminium Production	Road Transport: Passenger Cars	Accidental Fires		80.9%
	NFR 2C2	NFR 2C3	NFR 1A3bi	NFR 5E		
	25.1%	24.3%	18.1%	13.4%		
HCB	Clinical Waste Incineration	Other Product Use (Fireworks, Tobacco)	Aluminium Production			81.8%
	NFR 5C1biii	NFR 2G	NFR 2C3			
	39.6%	24.4%	17.8%			
PCB	Clinical Waste Incineration	National Fishing				96.1%
	NFR 5C1biii	NFR 1A4ciii				
	52.0%	44.1%				

Table 1.3 Key Category Analysis for reported heavy metals in 2021.

Component	Key categories (Sorted from high to low, from left to right, and from top to bottom)				Total (%)
Pb	Road Transport: Automobile Tyre and Brake Wear	Accidental Fires			80.3%
	NFR 1A3bvi	NFR 5E			
	67.6%	12.8%			
Cd	National Fishing	Road transport: Automobile Tyre and Brake Wear	Other Product Use (Fireworks, Tobacco)	Ferroalloys Production	85.2%
	NFR 1A4ciii	NFR 1A3bvi	NFR 2G	NFR 2C2	
	33.4%	27.1%	14.6%	10.1%	
Hg	National Fishing	Road Transport: Passenger Cars	Cremation		81.4%
	NFR 1A4ciii	NFR 1A3bi	NFR 5C1bv		
	53.5%	14.1%	13.8%		
As	National Fishing	Road Transport: Automobile Tyre and Brake Wear	Ferroalloys Production		91.7%
	NFR 1A4ciii	NFR 1A3bvi	NRF 2C2		
	46.8%	24.4%	20.5%		
Cr	Road Transport: Automobile Tyre and Brake Wear				81.9%
	NFR 1A3bvi				
	81.9%				
Cu	Road Transport: Automobile Tyre and Brake Wear				85.8%
	NFR 1A3bvi				
	85.8%				
Ni	National Fishing				80.4%
	NFR 1A4ciii				
	80.4%				
Se	National Fishing				83.8%
	NFR 1A4ciii				
	83.8%				
Zn	Road Transport: Automobile Tyre and Brake Wear	Accidental Fires	National Fishing		86.6%
	NFR 1A3bvi	NFR 5E	NFR 1A4ciii		
	57.5%	15.4%	13.7%		

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

team. The web application *Notion* developed by Notion Labs inc. is now used as a QA/QC systems management. It provides a centralised basis for the inventory team to design, manage, and record its QA/QC activities and improvement plan.

Each sector has a live improvement plan. Every item on the plan includes a record of which review report suggested the improvement, if relevant, and is assigned to a sectoral expert. The sectoral expert is then responsible for assessing the feasibility and timeframe of the improvement at the end of the submission period. This should ensure that over time, Iceland's inventory submissions continue to improve in quality.

QC procedures are outlined in a general guidance document, where general and sector-specific QC activities are listed.The QC guidance document is in line with the QC activities listed in Table 6.1 in the 2006 IPCC guidelines. QC activities are clearly outlined in detail and documented in the guidance document in a centralised location (Notion) along with the live improvement plan.

Each subsector has a live progress list for every step of the inventory cycle:

- Implementation of planned improvements
- Compilation of the input data and calculations of emissions
- QC activities
- Report writing

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 responsibility for the inventory lies with the team leader, who is responsible for the completion of QA/QC activities, submission, improvements planning, and review coordination. There are two sectoral subgroups within the team, one Energy/Industrial Processes and Product Use (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 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 three to four 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 has been undergoing regular CLRTAP reviews in recent years. It was subjected to a Stage 3 in-depth review in 2020, as well as Stage 3 ad-hoc review in 2022; the inventory is scheduled to again undergo a Stage 3 ad-hoc review in 2023 after this round of 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, and QA of the GHG inventory often leads to QA of the air pollutant inventory.

Further QA 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, as well as the aviation subsector (under Energy) for this submission.

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 per year, as well as several teleconferences) and discuss various aspects of the inventory compilation, with a strong focus on harmonising 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?

1.6.5 Planned Improvements for QA/QC Activities

It is planned to interlink QA/QC activities with the KCA 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

Work on the uncertainty analysis has started and will be included in next year's submission.

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 IIR. 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 Estimated (NE)	Reason
1A3ai(i)	International Aviation LTO (Civil)	NH_3, B(a)P, B(b)f, B(k)f, Ipy PAHs	Not included in EMEP/EEA emissions calculator
1A3aii(i)	Domestic Aviation LTO (Civil)	NH_3, B(a)P, B(b)f, B(k)f, Ipy, PAHs	Not included in EMEP/EEA emissions calculator
1A3bvi	Road Transport: Automobile Tyre and Brake Wear	B(a)P, B(b)f, B(k)f, Ipy, PAHs, dioxin	No T1 EF in GB 2019

NFR code	NFR Category	Pollutants Not Estimated (NE)	Reason
1A3bvii	Road Transport: Automobile Road Abrasion	B(a)P, B(b)f, B(k)f, Ipy, PAHs, Heavy metals	No T1 EF in GB 2019
1A3dii	National Navigation (Shipping)	B(a)P, B(b)f, B(k)f, Ipy	No T1 EF in GB 2019
1A4ciii	Agriculture/Forestry/Fishing: National Fishing	B(a)P, B(b)f, B(k)f, Ipy	No T1 EF in GB 2019
5B2a	Composting: Anaerobic Digestion	NH_3	No relevant activity data
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

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
5C1bi	Industrial Waste Incineration	NO_x, SO_2, PM, CO	5C1a	Municipal Waste Incineration
5C1bii	Hazardous Waste Incineration	NO_x, SO_2, PM, CO	5C1a	Municipal Waste Incineration
5C1biii	Clinical Waste Incineration	NO_x, SO_2, PM, CO	5C1a	Municipal Waste Incineration
5C1biv	Sewage Sludge Incineration	NO_x, SO_2, PM, CO	5C1a	Municipal Waste Incineration

1.9 Recalculations

A recalculation file is used to identify and document all recalculations. This QC file compares Year x-3 (2020) and the base year (1990) for the current and previous submissions for all pollutants. The data have 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 and biomethane was done which affects the whole sector. In previous submissions the wrong NCV was applied which caused an overestimation of emissions.
- Some diesel oil was allocated in error to 1A4ai when it should have been allocated to 1A4bi; this caused recalculations.
- In previous submissions, fuel usage for 1A2gvii and 1A4cii was reported as IE and reported under 1A3eii. However, speciated fuel data for these three categories was available for the years 2019-2021, and this data was used to perform a backwards extrapolation that allowed for 1A2gvii and 1A4cii to no longer be reported as IE, but rather to now have fuel use, and thus emissions, under these categories. This extrapolation caused recalculations for each of these three sectors.

- An error occurred in the allocation of fuels between 1A2gvii and 1A3eii for 2019 and 2020; this error was corrected and thus triggered recalculations. It should be noted that this error was corrected before the extrapolation of fuels mentioned in the previous point in this section was performed.
- The methodology used to calculate emissions for Domestic and International Aviation was upgraded from Tier 1 to Tier 3 and no longer use Eurocontrol data, but rather use country-specific flight data. This caused large recalculations for these subsectors.
- The COPERT software that is used to calculate emissions for Road Transport was updated to a newer version (5.6.1), which now has updated emission factors for most pollutants. This caused recalculations across the Road Transport subsectors.
- Last year, some diesel oil was incorrectly allocated to Motorcycles (1A3biv); motorcycles do not use diesel oil. This fuel was reallocated to other subsectors in Road Transport, thus causing some minor recalculations.
- Road transport emissions are affected due to revisions to vehicle kilometres in light-duty vehicles.
- The EMEP/EEA 2019 Guidebook includes some new EFs for Domestic and International Navigation for the following pollutants: NO_x, CO, NMVOCs, TSP, PM_{10}, $PM_{2.5}$, Cu, As, and Se. These updated EFs caused recalculations.
- There was a minor file linking issue that caused an error in some of fuel allocations for Domestic and International navigation for 1990-1994; this has been corrected and caused some minor recalculations.

1.9.2 Industrial Processes and Product Use (IPPU):

The main recalculations and improvements for IPPU are:

- In 2A5a, Quarrying and Mining of Minerals other than Coal, there was a tier upgrade from Tier 1 to Tier 2. This update led to recalculations for the whole timeseries for TSP, PM_{10}, and $PM_{2.5}$.
- In 2A5b, Construction and Demolition, there was an update in activity data that led to recalculation for the whole timeseries for TSP, PM_{10}, and $PM_{2.5}$.
- In 2A6, Mineral Wool Production, the data about number of hours/year the factory is in operation was updated. Also, there were changes in the PM assumptions. This led to recalculations for the whole timeseries for PM, CO, and NH_3.
- In 2C2, Ferroalloy Production, new heavy metal emission measurements resulted in recalculations for some years. Additionally, dioxin emissions were reported for the first time for one plant that led to recalculations for the years 2018-2020.
- In 2C3, Secondary Aluminium Production, the PM emissions are now based on on-site measurements instead of default emissions factors from the 2019 EMEP/EEA Guidebook. Recalculations were therefore made for the years 2012-2020 for TSP, PM_{10}, $PM_{2.5}$, and BC.
- In 2C7c, Capacitor Production, NH_3 emissions are now reported for the first time since 2009.
- In 2D3, some recalculations were done for NMVOCs due to updated import/export data from SI. This applies to various years in the timeline.
- In 2G, Other Solvent and Product Use, the emission factor for Pb for fireworks is now country specific and based on a sample measurements but was from the EMEP/EEA Guidebook in the last submission. This led to recalculations for the whole timeseries. Emissions of HCB were also added for the first time for fireworks. Updated import/export data also led to recalculations for all air pollutants in 2003, 2005, 2013, and 2019, both for fireworks and tobacco.
- In 2H2, Food and Beverages, there were NMVOC recalculations since the subsector was revised and improved based on a new survey on food consumption. The recalculation is for NMVOC for the years 2013-2020.

1.9.3 Agriculture

The main recalculations and improvements in the Agriculture sector are as follows:

- Livestock numbers for cattle, sheep, horses, and poultry were updated before the 2023 submission, as well as other livestock parameters for cattle and sheep. This change affected the reported NO_x, NMVOC, NH_3, $PM_{2.5}$, PM_{10}, and TSP emissions over the whole timeline in 3B Manure Management, 3Da2a Livestock Manure Applied to Soils and, 3Da3 Urine and Dung Deposited by Grazing Livestock.
- Fertiliser activity data was updated for Urea and CAN, along with a split into N-fertiliser type over the whole timeline. This affected NH_3 emissions from 3Da1 Inorganic N-fertilisers.
- The cropland area was updated, affecting particulate matter and NMVOC emissions from 3D Crop Production and Agricultural Soils over the whole timeline. The methodology for calculating NMVOC emissions was changed from being based on fertiliser use to the method where the NMVOC emissions are calculated based on land area cultivated.

1.9.4 Waste

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

- Late arrival of the total amount of waste in 2020 caused changes in 5A1a Managed Waste Disposal sites, 5A2 Unmanaged Waste Disposal sites, 5B1 Composting, 5C1a Municipal Waste Incineration, 5C1bi Industrial Waste Incineration, and 5C1bii Hazardous Waste Incineration.
- A correction in the total amount of waste in 2019 caused recalculation for 5A1a Managed Waste Disposal sites, 5A2 Unmanaged Waste Disposal sites, and 5C1a Municipal Waste Incineration.
- Emissions from NO_x, SO_2, PM, and CO were recalculated due to continuous emissions being available in Iceland's waste incineration plant (*Kalka*) Green Accounting affecting 5C1a Municipal Waste Incineration back to 2004 when *Kalka* opened.
- Emissions from NO_x, SO_2, PM, and CO are now obtained from emission data reported by *Kalka*. These emissions were previously included in 5C1bi Industrial Waste Incineration and 5C1biv Sewage Sludge Incineration from 2014, 5C1bii Hazardous Waste Incineration from 2006, and 5C1biii Clinical Waste Incineration from 2004, and are now reported as IE, as these waste categories are incinerated together which makes it impossible to differentiate emissions from one waste category to another. They are now reported in 5C1a Municipal Waste Incineration.
- The notation keys for NH_3, BaP, BbF, BkF, IPy, Cr, Cu, Se, and Zn changed from NE to NA, as the 2019 EMEP/EEA Guidebook does not estimate the emissions from these pollutants in 5C1. This affects 5C1bi Industrial Waste Incineration, 5C1bii Hazardous Waste Incineration, 5C1biii Clinical Waste Incineration, and 5C1biv Sewage Sludge Incineration.
- In 5C1bi Industrial Waste Incineration HCB emissions were reported as tons instead of kilograms from 2014.
- A unit error has been fixed and a Tier 2 default abatement efficiency from Table 3-5, Chapter 5C1biii in 2019 EMEP/EEA Guidebook has been applied for dioxin in 5C1biii Clinical Waste Incineration.
- In 5C1biii Clinical Waste Incineration, abatement efficiencies for Pb, Cd, Hg, As, Cr, Cu, and Ni were updated with Tier 2 default values from Table 3-3, Chapter 5C1biii in 2019 EMEP/EEA Guidebook now being used instead of those from Table 3-4, Chapter 5C1biii in 2016 EMEP/EEA Guidebook.
- In 5C1biv Sewage Sludge Incineration, NMVOC, Pd, Cd, Hg, As, Ni, dioxin, and HCB emissions were recalculated for the year 2019. The cause was a unit error of the amount of incinerated sewage sludge for 2019.
- In 5C1bv Cremation BC is reported as NA instead of NE, as Table 3-1, Chapter 5C1bv in the 2019 EMEP/EEA Guidebook does not estimate the emissions of BC.
- It was previously assumed that no bonfires occurred due to COVID-19 gathering restrictions. However, bonfires did in fact occur in 2020 on 6 January (a traditional night for bonfires to be held in Iceland), right before the pandemic began, leading to recalculations in 5C2 Open Burning of Waste.
- In 5C2 Open Burning of Waste, recalculations occurred specifically for dioxin emissions for 2001-2020. This sector previously included dioxin emissions from Tálknafjörður Incineration Plant and from *Kalka*. However, these emissions do not belong in this sector as they are not emissions from open burning.

- Changes in input values for mass of vehicles burned affected the whole timeline for all pollutants in 5E Other Waste.
- In 5E, the notation keys for BC, Ni, Se, Zn, HCB, PCBs changed from NE to NA, as the 2019 EMEP/EEA Guidebook does not estimate the emissions from these pollutants in 5E.

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;
- 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 harmonise energy data processing between various organizations (such as EAI, NEA, ITA, SI, and Isavia) and produce a complete uncertainty analysis. For future submissions it is also planned, in collaboration with the ITA, to develop procedures to obtain enhanced data on vehicle stock and mileage data for COPERT.

Moreover, plans are underway to upgrade methodology for Navigation and Fishing.

1.10.2 Industrial Processes and Product Use (IPPU)

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 consists 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. Furthermore, it is planned to improve the registration of different inorganic N fertiliser types in our inventory for future submissions.

1.10.4 Waste

For future submissions it is planned to improve activity data and estimates for wastewater handling and review the methodology to estimate emissions from accidental fires. Furthermore, it is planned to get the total amount of N in the feedstock, to be able to estimate NH_3 emissions in 5B2.

2 Trends in Emissions

2.1 Emissions 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 low due to the widespread 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 affected by a financial collapse in 2008, when its three largest banks collapsed. In the years preceding the crisis, the economy experienced a significant upswing, resulting 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 years preceding the crisis. In recent years, the economy has recovered, and the tourism sector has increased significantly, leading to rising fuel consumption. In 2020, the country again experienced an economic downturn as a result of the COVID-19 Pandemic.

2.2 Emission Trends for SO_x, NO_x, NH_3, NMVOC, PM, 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.

Sulphur oxides (SO_x), 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 adverse effects 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 2021.

	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	28.9	4.85	9.80	1.44	3.01	6.39	0.232	56.3
2021	60.5	19.6	4.37	5.79	1.04	2.16	4.35	0.085	104.4
Change 1990-2021	161%	-32%	-10%	-41%	-27%	-28%	-32%	-63%	86%

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	Notes
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 March 2023, 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.

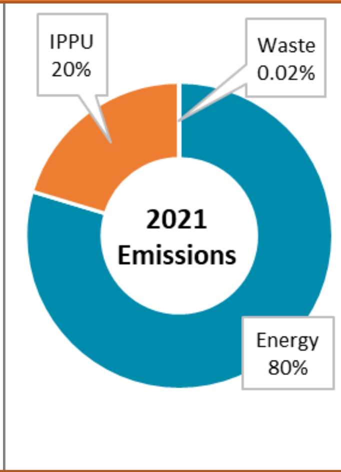
2.2.1 Trends in SO_x Emissions

Total emissions in this inventory year: **60.5 kt**

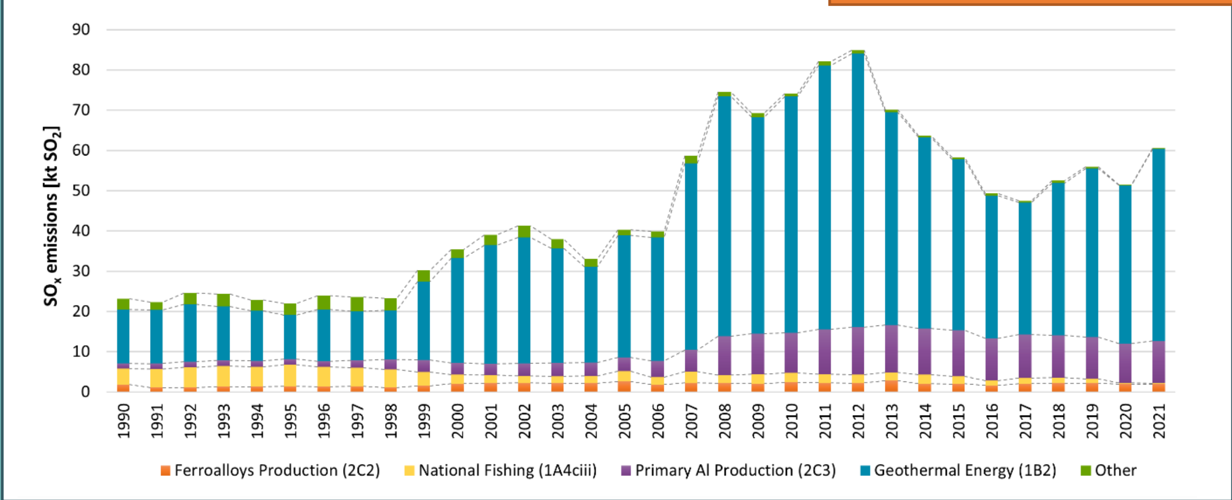
SO_x (SO_2)

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, 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.

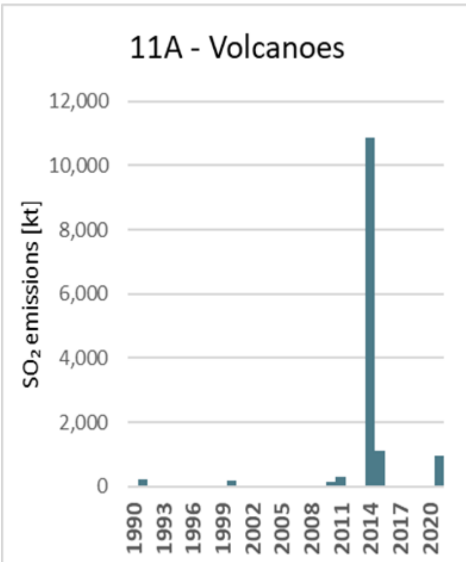


Change over the timeseries:
+ 161 %



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:

- **2021:** Fagradalsfjall. A fissure eruption that started in March and lasted until September. The first eruption on the Reykjanes peninsula since the 12th century.
- **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.



The trend overview for SO_x emissions is provided above. The main source of SO_x emissions is geothermal power plants. The overall trend in the emissions can mostly be explained by changes within the emissions from the geothermal power 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 implementation 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 mineralising 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 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.

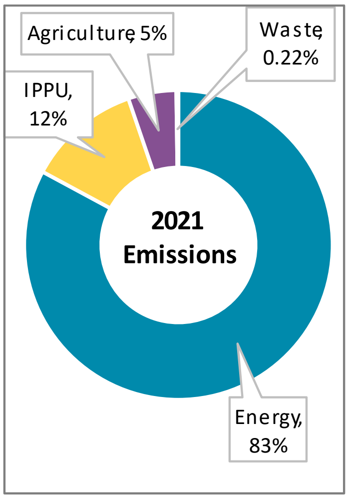
Table 2.3: SO_x emissions by main sources since 1990 [kt SO_2].

SO_x Emissions [kt SO_2]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Geothermal Energy (1B2)	13.3	11.0	26.0	30.3	58.7	42.4	39.3	47.7	+258%	+57%	+22%
Primary Al Production (2C3)	1.34	1.36	2.94	3.41	9.93	11.5	9.80	10.4	+679%	+205%	+6.1%
Ferroalloys Production (2C2)	1.85	1.38	2.04	2.64	2.37	2.06	1.95	1.90	+3.0%	-28%	-2.4%
National Fishing (1A4ciii)	3.95	5.40	2.23	2.56	2.41	1.86	0.29	0.32	-92%	-87%	+13%
Other	2.71	2.80	2.14	1.43	0.81	0.60	0.19	0.20	-93%	-86%	+4.0%
Total [kt]	**23.2**	**21.9**	**35.4**	**40.4**	**74.2**	**58.3**	**51.5**	**60.5**	**+161%**	**+50%**	**+18%**

2.2.2 Trends in NO_x Emissions

NO_x (NO_2)

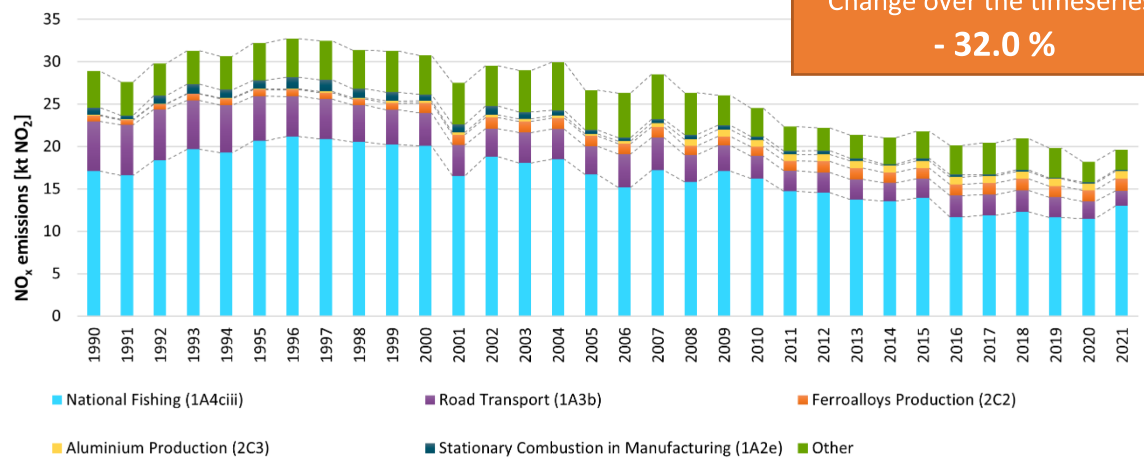
Total emissions in this inventory year: **19.6 kt**



NO_x emissions are dominated by the Energy sector, specifically:

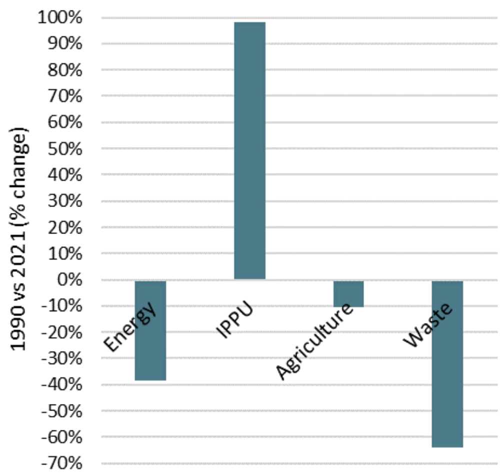
- **Fishing (1A4ciii)**: Emissions from fisheries rose between 1990 and 1996 because a substantial portion of the fishing fleet was operating in unusually distant fishing grounds. Since 1996, the emissions have generally been decreasing, with large annual variations due to changes in fish stock size 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: **- 32.0 %**



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 emissions occur due to the application of organic and inorganic fertilisers on agricultural soils.
- **Waste (5):** There are very low emissions 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 within 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 timeline 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, however, with large annual variations 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.
- **Food Processing (1A2e):** This sector is primarily comprised of fishmeal production and other food processing. Fishmeal production is a large industry in Iceland and has historically had relatively high emissions, but in recent years many fishmeal factories have been using electricity instead of fossil fuels, leading to a general downward trend in emissions for this sector.

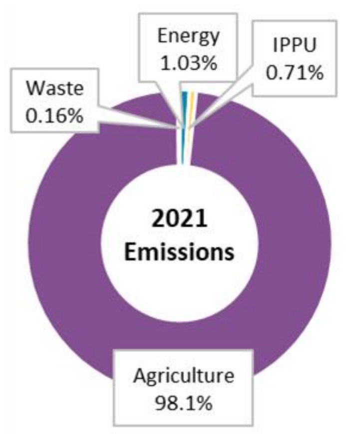
Table 2.4: NO_x emissions by main sources since 1990 [kt NO_2].

NO_x Emissions [kt NO_2]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
National Fishing (1A4ciii)	17.1	20.7	20.1	16.7	16.3	13.9	11.5	13.0	-24%	-22%	+13.3%
Road Transport (1A3b)	5.86	5.27	3.92	3.41	2.50	2.50	1.81	1.76	-70%	-48%	-2.7%
Ferroalloys Production (2C2)	0.69	0.79	1.20	1.22	1.12	1.30	1.30	1.50	+117%	+23%	+15.3%
Aluminium Production (2C3)	0.09	0.10	0.23	0.27	0.82	0.86	0.83	0.84	+852%	+207%	+0.6%
Stationary Combustion in Manufacturing (1A2e)	0.85	1.01	0.75	0.44	0.37	0.30	0.11	0.15	-82%	-65%	+44%
Other	4.27	4.38	4.64	4.68	3.36	3.18	2.43	2.39	-44%	-49%	-1.5%
Total [kt]	**28.9**	**32.2**	**30.8**	**26.7**	**24.4**	**22.1**	**17.9**	**19.6**	**-32%**	**-27%**	**+9.4%**

2.2.3 Trends in NH_3 Emissions

NH_3

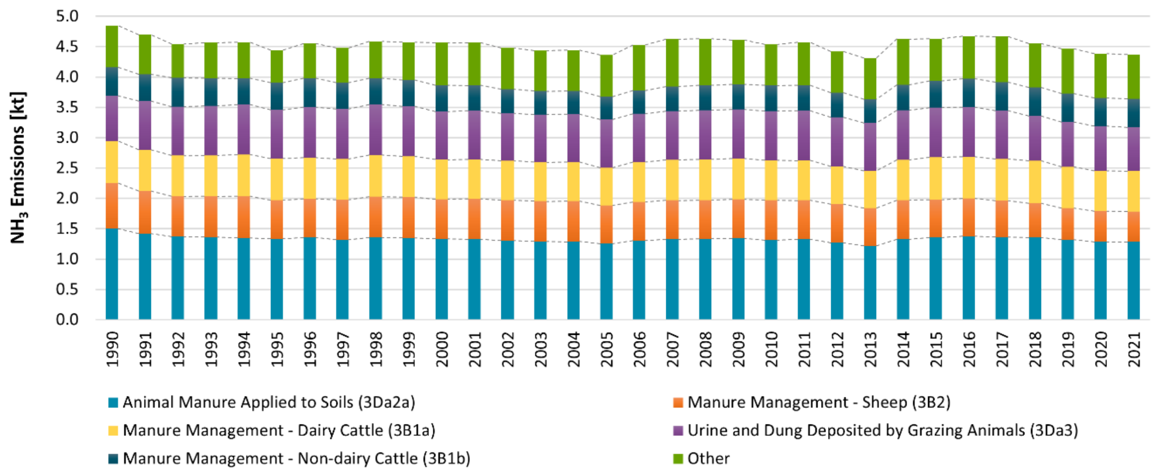
Total emissions in this inventory year: **4.4 kt**



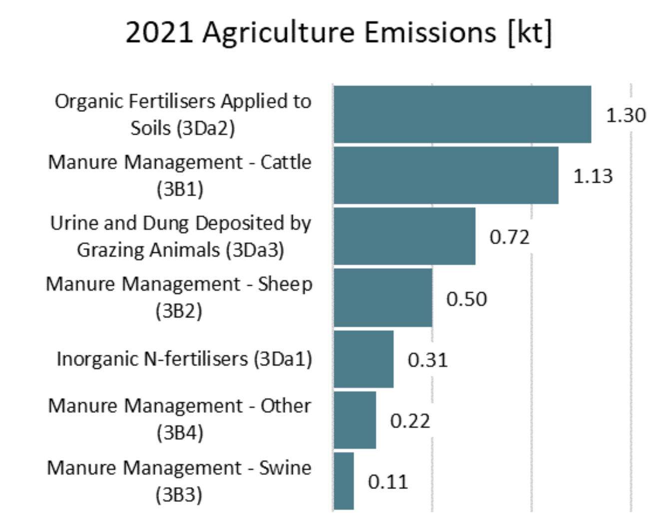
Change over the timeseries: **-9.84 %**

Ammonia (NH_3) emissions mostly originate from the Agriculture sector. 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.



- 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 Fertiliser 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. Most of the emissions come from 3Da2 Organic Fertilisers Applied to Soils (although most of this is attributable to livestock), 3B Manure Management and 3Da3 Urine and Dung Deposited by Grazing Animals. 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 in Table 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 practices have not changed significantly. The population of sheep and dairy cattle has been declining in recent years and the trend in the population of non-dairy cattle is increasing.
- **Organic Fertilisers 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	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Organic Fertilisers Applied to Soils (3Da2a)	1.50	1.33	1.34	1.26	1.31	1.35	1.29	1.28	-15%	+2.0%	-0.3%
Urine and Dung Deposited by Grazing Animals (3Da3)	0.75	0.81	0.79	0.79	0.81	0.81	0.73	0.72	-3.4%	-9.2%	-2.0%
Manure Management - Sheep (3B2)	0.75	0.63	0.65	0.63	0.66	0.62	0.50	0.50	-33%	-21%	-0.6%
Manure Management - Dairy Cattle (3B1a)	0.69	0.69	0.66	0.62	0.66	0.70	0.66	0.67	-3.3%	+8.2%	+0.8%
Manure Management - Non-dairy Cattle (3B1b)	0.47	0.45	0.43	0.38	0.42	0.44	0.47	0.46	-2.1%	+22%	-0.5%
Other	0.68	0.53	0.70	0.69	0.68	0.69	0.73	0.73	+7.1%	+6.5%	-0.1%
Total [kt]	**4.85**	**4.44**	**4.56**	**4.37**	**4.54**	**4.63**	**4.39**	**4.37**	**-9.8%**	**+0.1%**	**-0.4%**

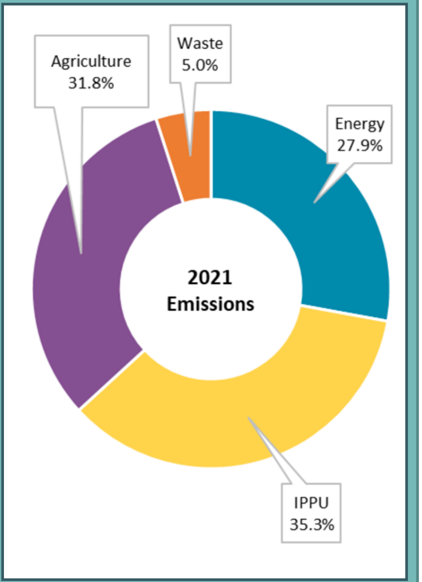
2.2.4 Trends in NMVOC Emissions

NMVOC

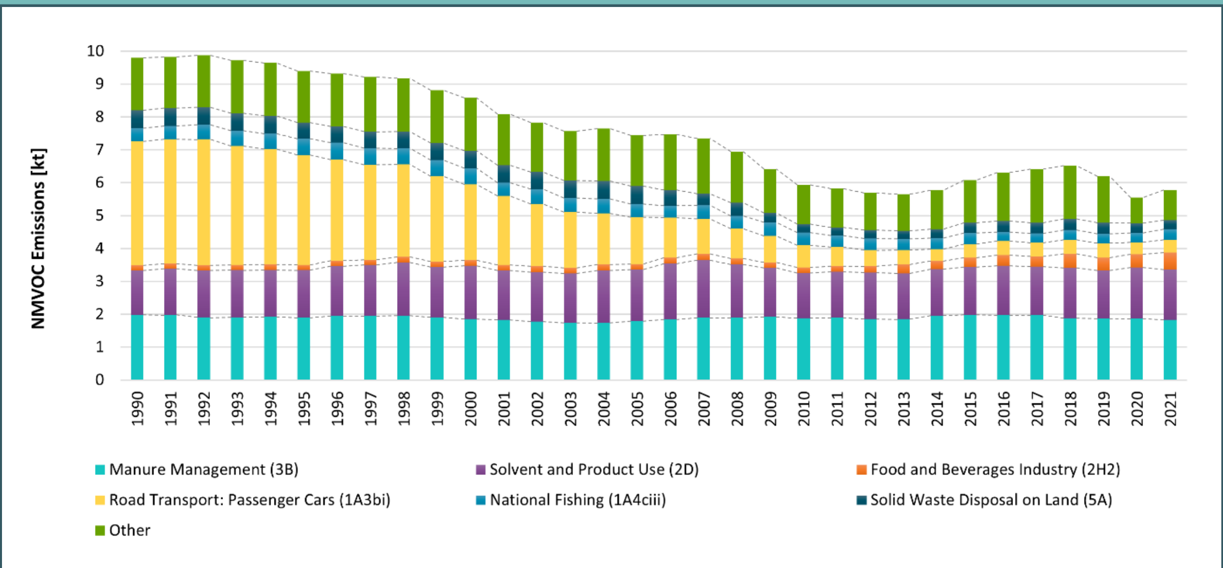
Total emissions in latest inventory year: **5.8 kt**

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 NMVOCs 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):** A general decrease in emissions over the timeline exists due to improved emissions-limiting technologies in newer vehicles.



Change over the timeseries: **- 40.9 %**



The trend overview for NMVOC emissions is provided above. NMVOC emissions come from a variety of sources across sectors. The decrease in emissions since 1990 is mainly due to the increased use of newer vehicles with higher emissions standards and emission-reducing technologies.

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 recent years, spirit production has increased, leading to an increase in exports 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 from 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 being deposited on land.
- **Road Transport: Passenger Cars (1A3bi):** The decrease in emissions since 1990 is mainly due to the modernisation of the car fleet with the introduction of more cars with higher emission standards and improved emission-reducing technologies.

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

NMVOC Emissions [kt]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Manure Management (3B)	1.98	1.90	1.86	1.79	1.88	1.99	1.87	1.83	-7.7%	+2.4%	-1.9%
Solvent and Product Use (2D)	1.35	1.45	1.61	1.56	1.37	1.45	1.55	1.53	+13%	-2.1%	-1.3%
Food and Beverages Industry (2H2)	0.15	0.16	0.17	0.18	0.17	0.28	0.40	0.51	+232%	+189%	+26%
National Fishing (1A4ciii)	0.41	0.50	0.49	0.40	0.39	0.34	0.28	0.31	-24%	-22%	+13%
Solid Waste Disposal on Land (5A)	0.53	0.49	0.53	0.54	0.26	0.31	0.30	0.27	-49%	-50%	-7.7%
Road Transport: Passenger Cars (1A3bi)	3.76	3.33	2.31	1.42	0.67	0.42	0.37	0.40	-89%	-72%	+6.5%
Other	1.60	1.57	1.60	1.55	1.20	1.30	0.79	0.93	-42%	-40%	+19%
Total [kt]	**9.80**	**9.40**	**8.58**	**7.44**	**5.94**	**6.08**	**5.55**	**5.79**	**-41%**	**-22%**	**+4.3%**

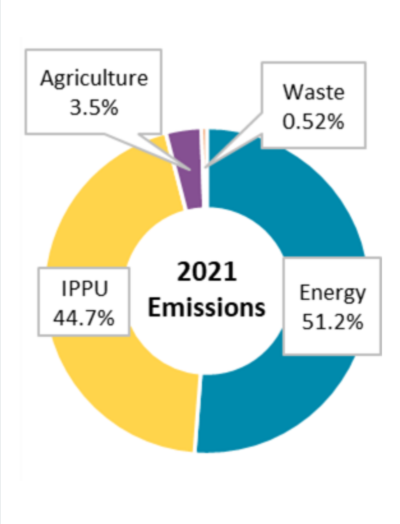
2.2.5 Trends in $PM_{2.5}$ Emissions

Total emissions in latest inventory year: **1.04 kt**

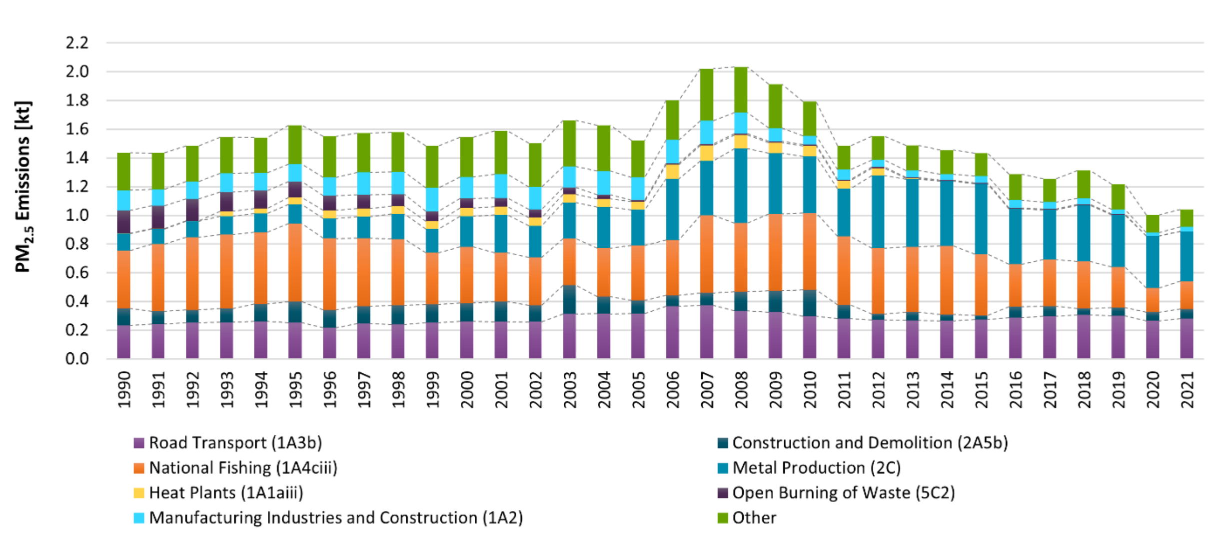
$PM_{2.5}$

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

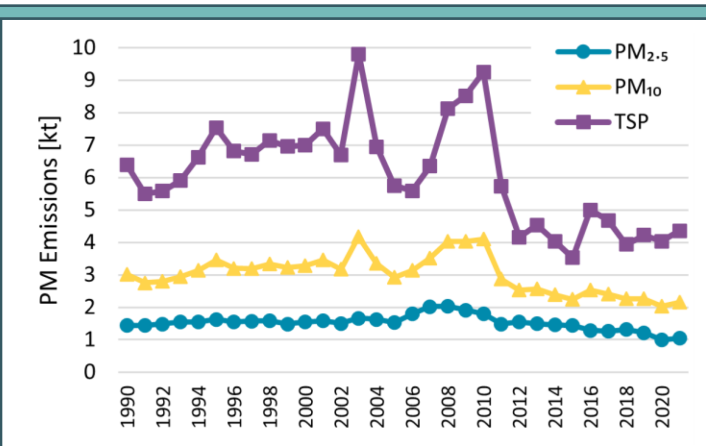
- **Metal Production (2C):** Production capacity in the metal production sector has increased substantially.
- **Road Transport (1A3b):** Fluctuations in PM emissions result from the combination of changes in the pollution control standards and an increase in vehicle fleet size.
- **National Fishing (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:
- 27.4 %



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 $PM_{2.5}$ emissions is provided above. $PM_{2.5}$ emissions are predominantly derived from 2C Metal Production, 1A3b Road Transport, and 1A4ciii Fishing. The overall decrease in emissions since 1990 can largely be explained by less fuel usage within 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 Iceland the early nineties but has since been stopped. Since 2010, New Year's Eve bonfires, which are heavily regulated, monitored, and restricted, have been the only source of emissions in this category.
- **Heat Plants (1A1aiii):** Waste incineration with energy recovery was occurring between 1993-2013, which caused significant 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	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Metal Production (2C)	119	135	216	248	396	490	361	348	+193%	+40%	-3.8%
Road Transport (1A3b)	235	252	261	315	297	275	264	281	+19%	-11%	+6.3%
National Fishing (1A4ciii)	402	545	391	384	533	425	170	192	-52%	-50%	+13%
Construction and Demolition (2A5b)	117	145	128	93	185	29	62	68	-42%	-27%	+9.4%
Manufacturing Industries and Construction (1A2)	140	122	149	159	62	49	21	32	-77%	-80%	+49%
Open Burning of Waste (5C2)	159	111	67	9.8	7.6	7.1	0.85	3.6E-4	-100%	-100%	-100%
Heat Plants (1A1aiii)	2.3	45	56	55	75	0.11	0.00	2.1E-6	-100%	-100%	-100%
Other	261	270	278	259	239	159	123	122	-53%	-53%	-1.4%
Total [t]	**1,436**	**1,626**	**1,545**	**1,522**	**1,793**	**1,433**	**1,003**	**1,042**	**-27%**	**-32%**	**3.9%**

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	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Construction and Demolition (2A5b)	1,169	1,454	1,280	929	1,849	288	620	678	-42%	-27%	+9.4%
Road Transport (1A3b)	337	362	385	476	467	462	466	500	+48%	+5.1%	+7.3%
Aluminium Production (2C3)	73	83	145	199	401	408	363	371	+406%	+86%	+2.0%
Quarrying and Mining of Minerals Other than Coal (2A5a)	308	308	293	163	251	62	19	35	-89%	-78%	+82.5%
National Fishing (1A4ciii)	402	545	391	384	533	425	170	192	-52%	-50%	+13%
Ferroalloys Production (2C2)	85	97	141	128	108	232	87	69	-19%	-46%	-20%
Open Burning of Waste (5C2)	172	119	73	11	8.2	7.7	0.92	0.0004	-100%	-100%	-100%
Other	464	482	574	632	489	353	308	313	-33%	-51%	+1.6%
Total [t]	**3,011**	**3,451**	**3,282**	**2,921**	**4,106**	**2,237**	**2,034**	**2,159**	**-28%**	**-26%**	**6.1%**

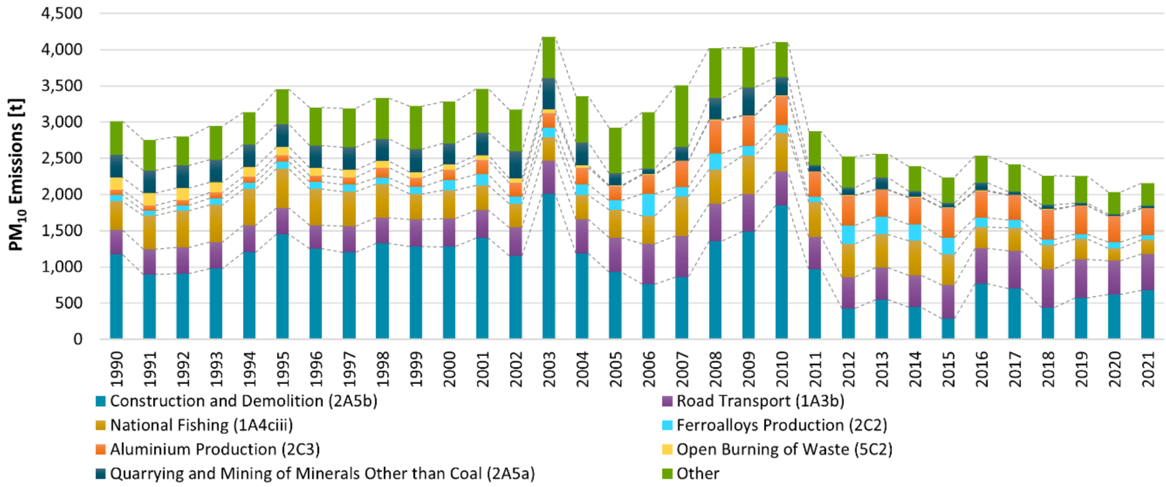


Figure 2.1: PM$_{10}$ emissions by sector, since 1990.

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

TSP Emissions [t]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Construction and Demolition (2A5b)	3,910	4,863	4,279	3,103	6,186	961	2,071	2,266	-42%	-27%	+9.4%
Road Transport (1A3b)	527	564	615	776	782	813	844	912	+73%	+17%	+8.1%
Quarrying and Mining of Minerals Other than Coal (2A5a)	651	651	619	344	531	130	41	74	-89%	-78%	+82.5%
Aluminium Production (2C3)	88	100	174	240	481	490	436	445	+407%	+85%	+2.0%
National Fishing (1A4ciii)	402	545	391	384	533	425	170	192	-52%	-50%	+13%
Other	815	811	920	901	735	710	476	463	-43%	-49%	-2.7%
Total [t]	**6,393**	**7,535**	**6,997**	**5,747**	**9,248**	**3,529**	**4,037**	**4,353**	**-32%**	**-24%**	**+7.8%**

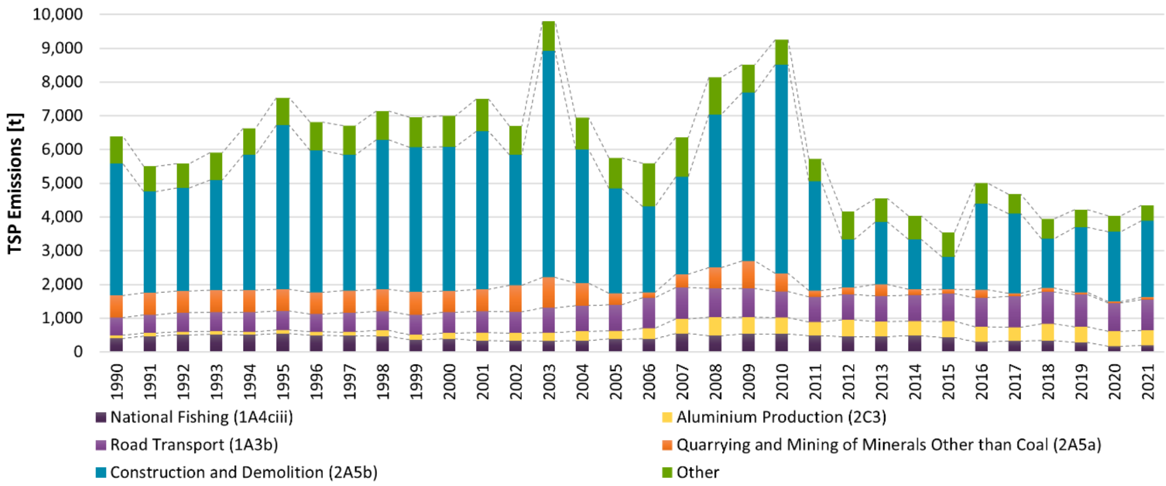


Figure 2.2: TSP emissions by sector, since 1990.

2.2.6 Trends in BC (Black Carbon) Emissions

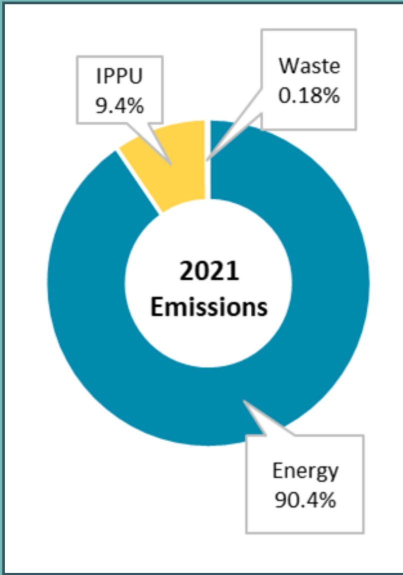
BC

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

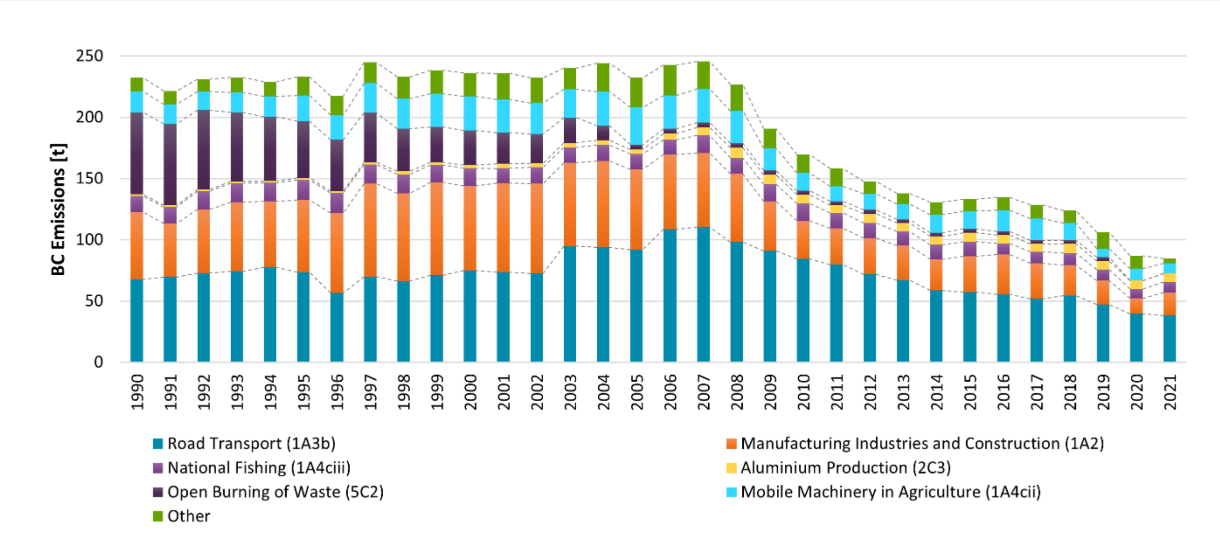
Black carbon contributes relatively few emissions compared to the NECD pollutants. Emissions of black carbon are heavily dominated by the Energy sector. As with SO_x, there are no emissions of black carbon associated with the Agriculture sector. The following sources comprise the majority of black carbon emissions:

- **Road Transport (1A3b)**
- **Fishing (1A4ciii)**
- **Mobile Machinery in Agriculture (1A4cii)**
- **Manufacturing Industries and Construction (1A2)**

After the Energy sector, the next biggest source of black carbon emissions is from Aluminium Production (2C3). Emissions have increased with the expansion of the production capacity of the metal factories.



Change over the timeseries:
- 63.5 %



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.
- **Mobile Machinery in Construction (1A2gvii) and Agriculture (1A4cii):** 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 timeline 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 practice in Iceland the early nineties but has since been stopped. Since 2010, New Year's Eve bonfires, which are heavily regulated, monitored, and restricted, have been the only source of emissions in this category.

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

BC Emissions [t]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Road Transport (1A3b)	68	74	75	92	84	57	40	38	-44%	-59%	-3.9%
Mobile Machinery in Agriculture (1A4cii)	17	21	28	30	14	15	9.9	8.4	-50%	-72%	-15%
Manufacturing Industries and Construction (1A2)	55	59	69	65	31	29	13	19	-65%	-71%	+49%
National Fishing (1A4ciii)	13	16	14	13	14	12	7.7	8.7	-33%	-31%	+13%
Aluminum Production (2C3)	1.3	1.5	2.7	3.6	7.3	7.5	6.7	6.8	+406%	+87%	+2.0%
Open Burning of Waste (5C2)	67	47	28	4.1	3.2	3.0	0.36	0.15	-100%	-96%	-58%
Other	11	15	19	24	15	9.6	9.9	3.8	-67%	-84%	-62%
Total [t]	**232**	**233**	**236**	**232**	**170**	**133**	**87**	**85**	**-63%**	**-63%**	**-2.2%**

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. It should be noted that in previous years, 1A3ai(i) International Aviation LTO and 1A3aii(i) Domestic Aviation LTO were two of the largest sources of CO, however due to a methodology upgrade in how emissions from these sectors are calculated, they are no longer considered top sources of CO in Iceland.

- **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. This sector accounts for over 96% of Iceland's CO emissions.
- **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 vehicles, and now they amount to a small percentage of the total emissions.
- **Manufacturing Industries and Construction (1A2):** Although this sector accounts for <1% of Iceland's CO emissions, it (comprised of its subsectors) is the third largest source of CO.
- **Open Burning of Waste (5C2):** Open pit burning was a common practice in Iceland the early nineties but has since been stopped. Since 2010, New Year's Eve bonfires, which are heavily regulated, monitored, and restricted, have been the only source of emissions in this category.

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

CO Emissions [kt]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Aluminium Production (2C3)	10.5	12.0	27.2	32.7	98.3	103	100	100.3	+852%	+207%	+0.6%
Road Transport (1A3b)	41.3	33.1	22.1	14.7	8.4	5.6	2.6	2.5	-94%	-83%	-4.4%
Manufacturing Industries and Construction (1A2)	0.81	0.62	0.80	0.95	0.32	0.22	0.096	0.14	-82%	-85%	+49%
Open Burning of Waste (5C2)	2.1	1.5	0.90	0.13	0.10	0.095	0.011	0.005	-100%	-96%	-58%
Other	1.5	1.8	2.0	1.9	1.6	1.6	1.3	1.4	-7.5%	-24%	13%
Total [kt]	**56**	**49**	**53**	**50**	**109**	**110**	**104**	**104**	**+85%**	**+107%**	**0.7%**

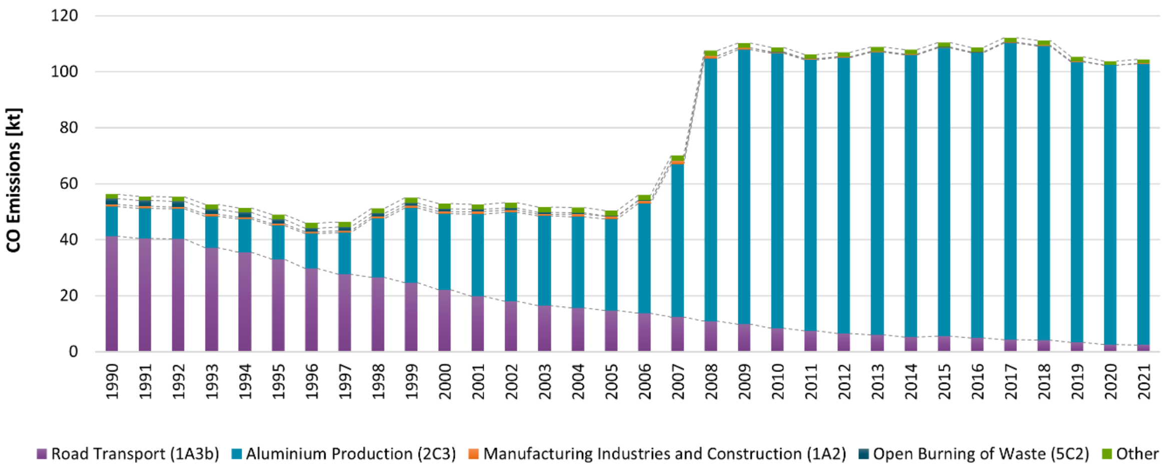


Figure 2.3 CO emissions by sector, since 1990.

2.3 Emission Trends for Persistent Organic Pollutants (POPs)

The total amount of dioxins, PAH4, HCB, and PCB emitted in Iceland in 1990 and 2021 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	0.587	0.157	0.300
2021	0.98	0.065	0.102	0.015
Change 1990-2021	-91%	-89%	-35%	-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 (5C1bi Industrial Waste, 5C1bii Hazardous Waste, and 5C1biii Clinical Waste), Accidental Fires (reported as 5E Other Waste), and Bonfires (reported as 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 and Figure 2.5.

- **Industrial Waste Incineration (5C1bi), Hazardous Waste Incineration (5C1bii), Clinical Waste Incineration (5C1biii), 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 Region, has gradually decreased since 1990. Open pit burning is practically non-existent today, as 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 tyres, 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 2004 fire. 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 Road Transport and Fishing, but the emissions from these sources are generally 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	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Industrial Waste Incineration (5C1bi)	NO	NO	NO	NO	NO	0.04	0.37	0.35	---	---	-4.2%
Hazardous Waste Incineration (5C1bii)	NO	NO	NO	NO	0.09	0.26	0.42	0.16	---	---	-61%
Clinical Waste Incineration (5C1biii)	NO	NO	NO	0.08	0.03	0.11	0.16	0.16	---	+105%	-2.4%
Open Burning of Waste (5C2)	10.5	6.8	2.8	0.15	0.12	0.10	0.01	0.01	-100%	-97%	-58%
Accidental Fires (5E)	0.09	0.09	0.09	0.14	0.11	0.07	0.10	0.11	+23%	-24%	+1.7%
Metal Production (2C)	0.01	0.01	0.02	0.02	0.04	0.06	0.09	0.12	+1,114%	+437%	+38%
Other	0.13	0.52	0.54	0.55	0.47	0.15	0.08	0.08	-41%	-86%	+0.1%
Total [g I-TEQ]	**10.7**	**7.5**	**3.4**	**0.94**	**0.87**	**0.79**	**1.2**	**0.98**	**-91%**	**+4.7%**	**-20%**

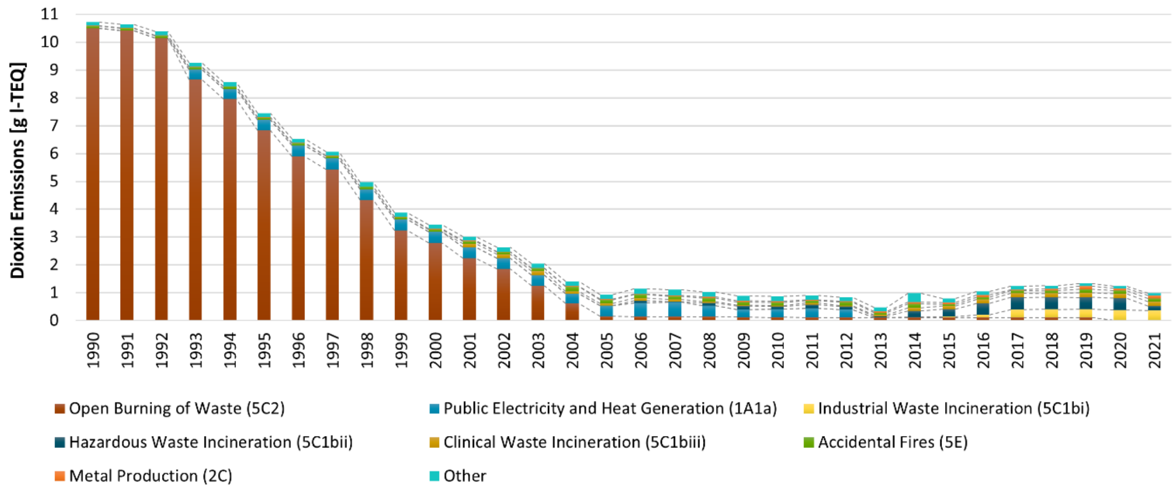


Figure 2.4 Dioxin emissions by main sources since 1990 [g I-TEQ].

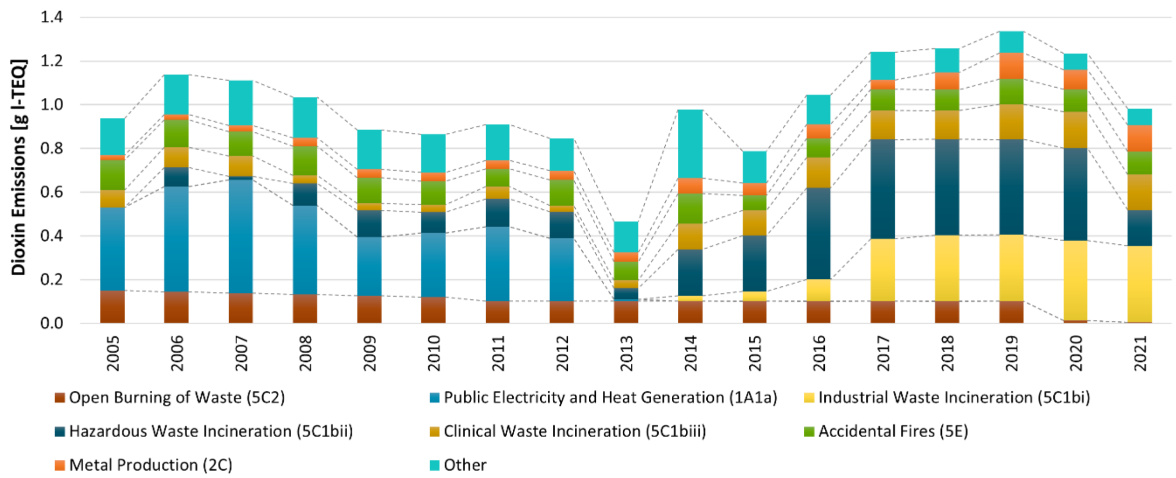


Figure 2.5 Dioxin emissions by main sources since 2005 [g I-TEQ].

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 bioaccumulate 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 2.6.

- **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 kilometres 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 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 industries. In 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 PAH4 emissions resulted from the combustion of other bituminous 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 discontinued. A more detailed description of the decrease in Waste Incineration emissions is in Section 2.3.1 above.

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

PAH4 Emissions [t]	1990	1995	2000	2005	2010	2015	2020	2021	Change		
									'90-'21	'05-'21	'20-'21
Road Transport (1A3b)	0.008	0.008	0.008	0.011	0.013	0.014	0.018	0.019	+152%	+76%	+5.7%
Aluminium Production (2C3)	0.002	0.002	0.004	0.005	0.016	0.016	0.016	0.016	+852%	+207%	+0.6%
Ferroalloys Production (2C2)	0.009	0.010	0.016	0.016	0.015	0.017	0.015	0.016	+81%	+2.5%	+8.8%
Accidental Fires (5E)	0.008	0.008	0.007	0.008	0.006	0.006	0.004	0.009	+12%	+11%	+104%
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%	+0.3%
Open Burning of Waste (5C2)	0.49	0.34	0.21	0.033	0.025	0.024	0.003	0.001	-100%	-96%	-58%
Other	0.004	0.004	0.005	0.006	0.003	0.005	0.004	0.004	+9.1%	-33%	+11%
Total [t]	**0.587**	**0.404**	**0.298**	**0.155**	**0.091**	**0.082**	**0.060**	**0.065**	**-89%**	**-58%**	**+9.4%**

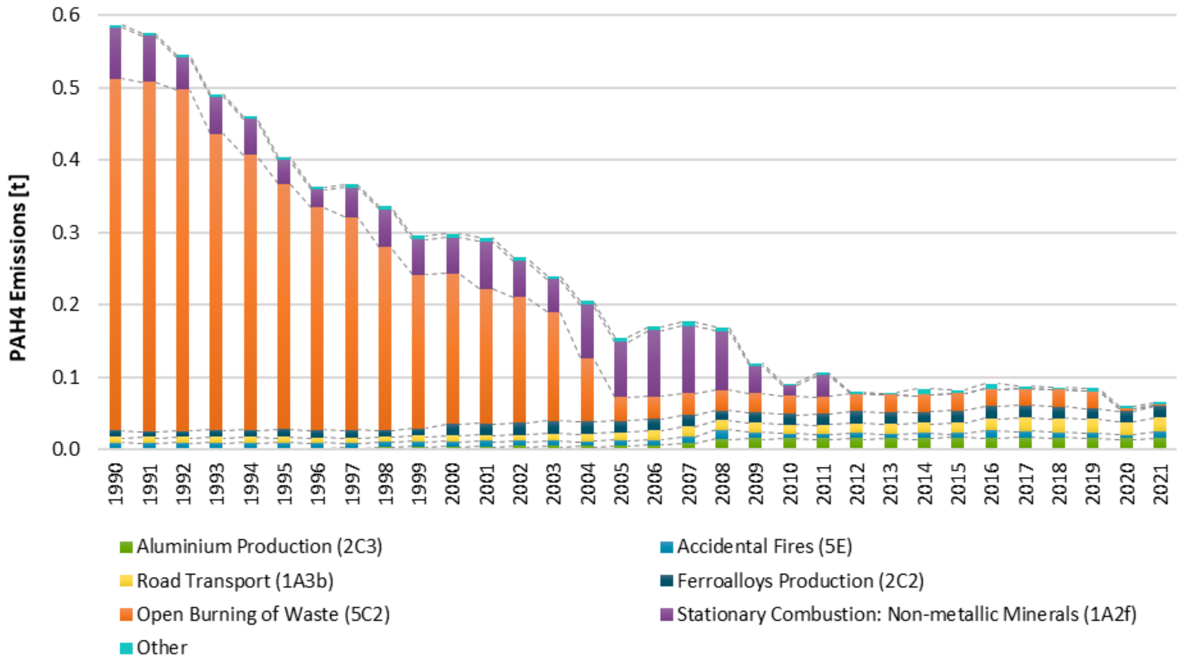


Figure 2.6 PAH emissions by sector, since 1990

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 2.7.

- **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 from 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.
- **Fireworks (2G):** Fireworks now use a country specific emission factor based on measurements of the average Pb and HCB taking from samples of different fireworks sold in Iceland in 2018. The new emissions factors indicate that fireworks are now a key category for HCB emissions. It is worth noting that fireworks are only legal to use in Iceland around New Year’s, but their usage during this time is widespread and extremely high.

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

HCB Emissions [kg]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	'05-'21	'20-'21
Clinical Waste Incineration (5C1biii)	NO	NO	NO	0.020	0.008	0.029	0.041	0.040	---	+105%	-2.4%
National Fishing (1A4ciii)	0.021	0.027	0.024	0.021	0.022	0.019	0.013	0.014	-32%	-30%	+13%
Fireworks (2G)	0.005	0.007	0.018	0.030	0.023	0.028	0.023	0.025	+362%	-18%	+6.5%
Aluminium Production (2C3)	NA	NA	NA	0.011	0.010	0.011	0.011	0.018	---	+60%	+64%
Hazardous Waste Incineration (5C1bii)	NO	NO	NO	NO	5.4E-4	0.001	0.002	9.3E-4	---	---	-61%
Open Burning of Waste (5C2)	0.128	0.085	0.048	3.8E-4	2.9E-4	1.5E-4	1.8E-5	7.7E-6	-100%	-98%	-58%
Other	0.002	0.012	0.015	0.016	0.019	0.002	0.003	0.003	+31%	-80%	-6.1%
Total [kg]	**0.157**	**0.131**	**0.105**	**0.098**	**0.084**	**0.090**	**0.094**	**0.102**	**-35%**	**+4.1%**	**+8.1%**

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.

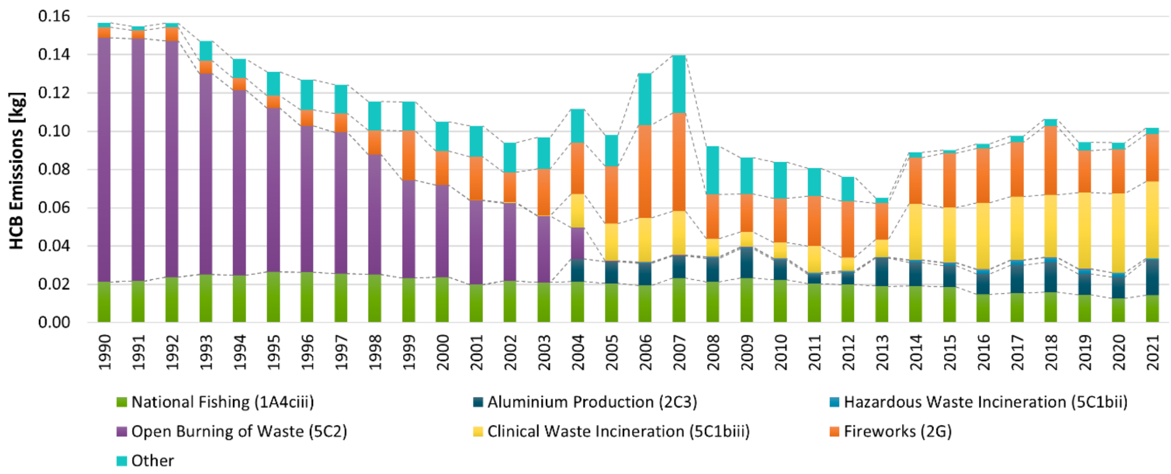


Figure 2.7 HCB emissions by sector, since 1990.

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 2.8.

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 this sector since 2005.
- **Stationary Combustion: Non-metallic Minerals (1A2f):** Significant PCB emissions resulted from the combustion of other bituminous coal for cement production until 2012 when production was stopped.
- **Heat Plants (1A1aiii):** Waste incineration with energy recovery, which caused significant 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	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Clinical Waste Incineration (5C1biii)	NO	NO	NO	0.004	0.002	0.006	0.008	0.008	---	+105%	-2.4%
National Fishing (1A4ciii)	0.028	0.041	0.022	0.026	0.046	0.035	0.006	0.007	-76%	-74%	+13%
Open Burning of Waste (5C2)	0.188	0.126	0.071	2.6E-4	2.5E-4	1.8E-6	2.2E-7	9.2E-8	-100%	-100%	-58%
Stationary Combustion: Non-metallic Minerals (1A2f)	0.082	0.038	0.058	0.088	0.016	NA	NA	NA	-100%	-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	0.001	0.001	-77%	-85%	-15%
Total [kg]	**0.300**	**0.235**	**0.187**	**0.154**	**0.111**	**0.053**	**0.015**	**0.015**	**-95%**	**-90%**	**+3.3%**

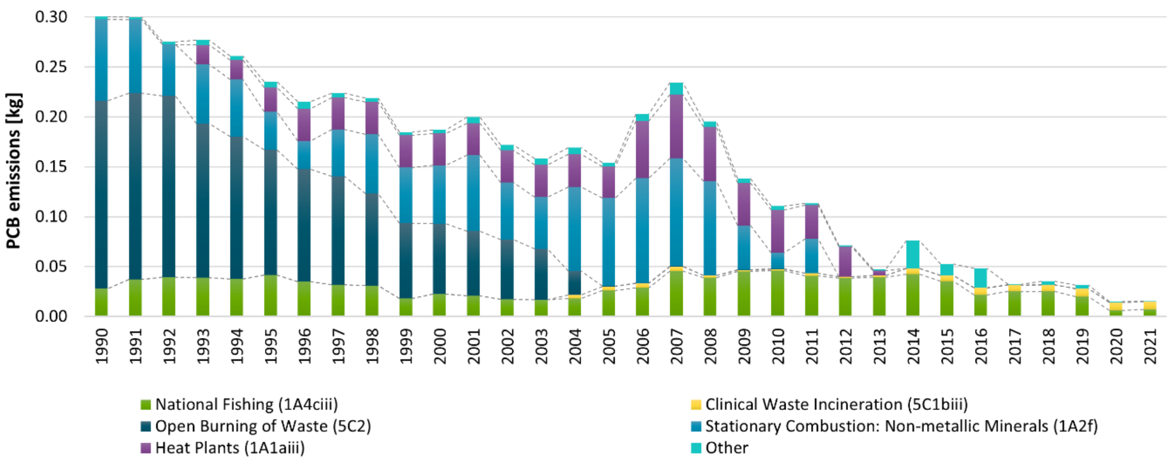


Figure 2.8 PCB emissions by sector, since 1990.

2.4 Emission Trends for Heavy Metals

Emission estimates for 1990 and 2021 for priority heavy metals (Pb, Cd, and Hg) as well as additional heavy metals (As, Cr, Cu, Ni, Se, and 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 2021.

	Pb [t]	Cd [t]	Hg [t]	As [t]	Cr [t]	Cu [t]	Ni [t]	Se [t]	Zn [t]
1990	0.43	0.0093	0.140	0.057	0.114	1.69	1.54	0.035	1.87
2021	0.49	0.0054	0.010	0.015	0.149	3.12	0.22	0.021	1.57
Change 1990-2021	13%	-42%	-93%	-73%	31%	84%	-85%	-39%	-16%

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 2.8. The Cd emissions from the main sources can be seen in Table 2.16 and Figure 2.8. The Hg emissions from the main sources can be seen in Table 2.16 and Figure 2.8.

- **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% of the size of the 2004 fire. 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 to more 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, at which point 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	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Fireworks (2G)	0.006	0.007	0.018	0.031	0.024	0.029	0.024	0.026	+362%	-18%	+6.5%
Road Transport (1A3b)	0.162	0.175	0.199	0.253	0.272	0.281	0.307	0.328	+103%	+30%	+7.0%
Accidental Fires (5E)	0.056	0.058	0.051	0.053	0.041	0.045	0.026	0.062	+10%	+18%	+136%
National Fishing (14Aciii)	0.033	0.040	0.037	0.032	0.033	0.028	0.021	0.023	-29%	-27%	+13%
Heat Plants (1A1aiii)	0.001	0.484	0.629	0.619	0.843	2.5E-5	NO	1.1E-5	-98%	-100%	---
Other	0.172	0.199	0.257	0.287	0.129	0.094	0.049	0.046	-73%	-84%	-5.7%
Total [t]	**0.429**	**0.963**	**1.191**	**1.275**	**1.342**	**0.477**	**0.426**	**0.485**	**+13%**	**-62%**	**+14%**

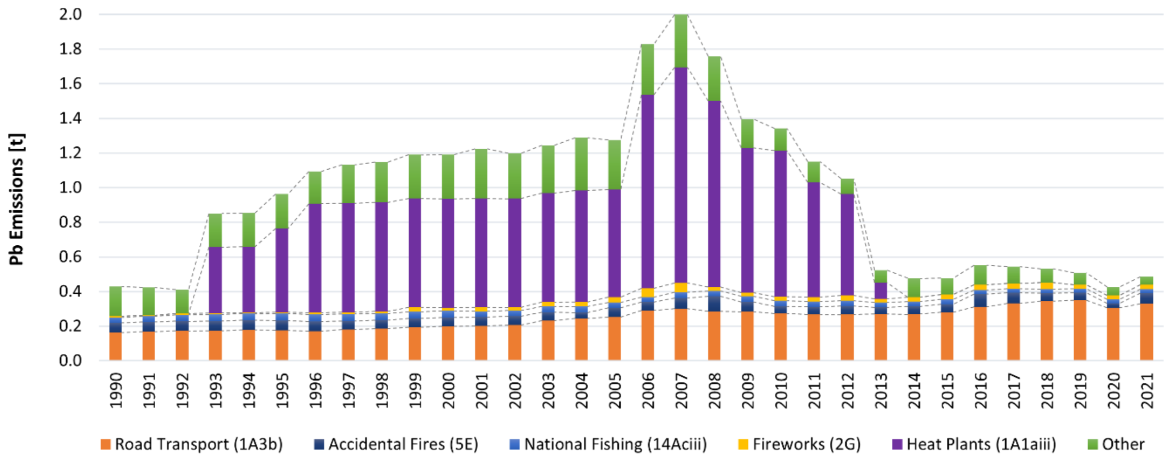


Figure 2.9 Pb emissions by sector, since 1990.

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

Cd Emissions [kg]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
National Fishing (1A4ciii)	2.74	3.46	3.01	2.65	2.98	2.48	1.59	1.80	-34%	-32%	+13%
Automobile Tyre and Brake Wear (1A3bvi)	0.71	0.77	0.87	1.11	1.20	1.23	1.36	1.45	+105%	+31%	+7.2%
Ferroalloys Production (2C2)	0.046	0.052	0.077	0.069	0.058	0.13	1.22	0.54	+1,082%	+686%	-55%
Fireworks (2G)	0.17	0.21	0.56	0.94	0.73	0.89	0.73	0.78	+362%	-18%	+6.5%
Heat Plants (1A1aiii)	0.14	16.0	20.6	20.2	27.6	0.01	NO	3.6E-6	-100%	-100%	-100%
Open Burning of Waste (5C2)	3.81	2.65	1.61	0.23	0.18	0.17	0.02	8.5E-6	-100%	-100%	-100%
Other	1.65	2.82	3.50	3.93	2.11	1.67	0.79	0.80	-52%	-80%	+1.5%
Total [kg]	**9.27**	**25.9**	**30.2**	**29.2**	**34.8**	**6.58**	**5.70**	**5.38**	**-42%**	**-82%**	**-5.7%**

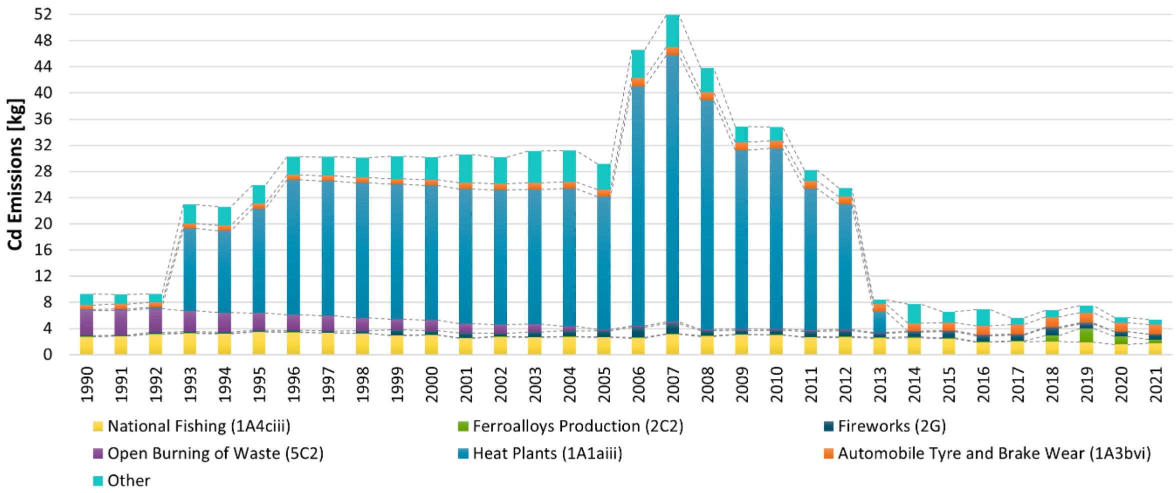


Figure 2.10 Cd emissions by sector, since 1990.

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

Hg Emissions [kg]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	'05-'21	'19-'21
Clinical Waste Incineration (5C1biii)	NO	NO	NO	0.32	0.13	0.46	0.67	0.65	---	+105%	-2.4%
Cremation (5C1bv)	1.9E-4	2.5E-4	3.2E-4	0.52	0.67	0.94	1.45	1.40	+743,551%	+167%	-4.0%
National Fishing (1A4ciii)	6.79	8.10	8.15	6.65	6.15	5.33	4.76	5.39	-21%	-19%	+13%
Road Transport (1A3b)	1.30	1.37	1.49	1.80	1.85	1.90	1.85	1.99	+53%	+10%	+7.7%
Open Burning of Waste (5C2)	126	84.1	47.3	0.20	0.17	0.017	0.002	8.6E-7	-100%	-100%	-100%
Heat Plants (1A1aiii)	0.04	13.1	16.9	16.7	22.7	0.0019	NO	3.6E-6	-100%	-100%	-100%
Other	5.61	5.05	6.72	7.86	3.63	2.90	0.71	0.66	-88%	-92%	-7.9%
Total [kg]	**140**	**112**	**80.6**	**34.0**	**35.3**	**11.5**	**9.45**	**10.1**	**-93%**	**-70%**	**+6.8%**

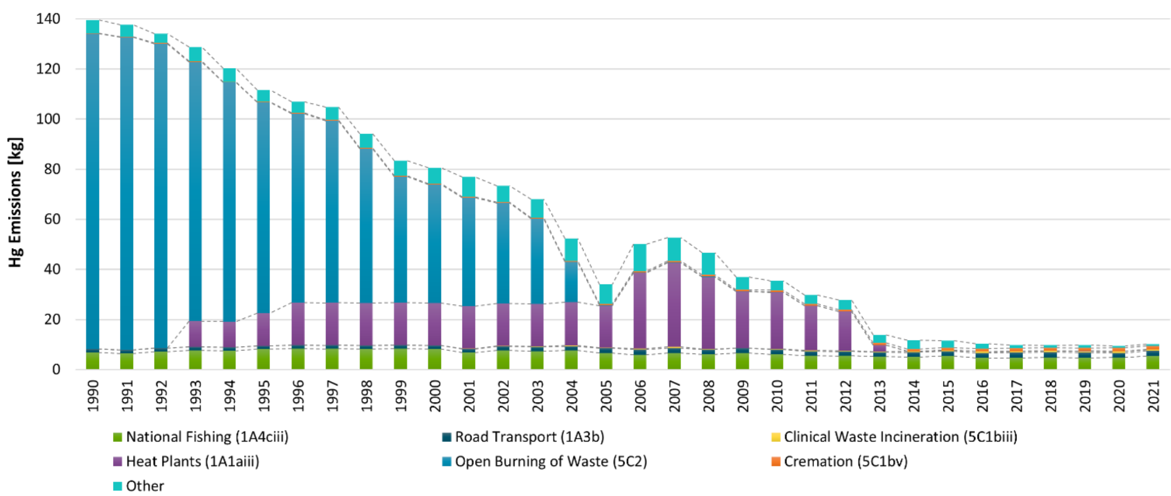


Figure 2.11 Hg emissions by sector, since 1990.

2.4.2 Trends in Additional Heavy Metals (As, Cr, Cu, Ni, Se, and 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 5C2 Open Burning of Waste and 1A1aiii Heat Plants, whereas Cr, Cu, and Zn are influenced by 1A3bvi Automobile Tyre and Brake Wear. In the Industrial sector, the main source of As emissions is 2C Metal Production. Non-priority heavy metals are largely produced by 2G 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 5C2 Open Burning of Waste and 5E 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 occurred 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 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 bituminous 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 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.

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

As Emissions [kg]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	'05-'21	'20-'21
National Fishing (1A4ciii)	32.3	48.1	25.4	30.2	53.9	41.4	6.35	7.19	-78%	-76%	+13%
Road Transport (1A3b)	1.89	2.05	2.32	2.95	3.17	3.26	3.56	3.81	+101%	+29%	+7.0%
Ferroalloys Production (2C2)	1.18	1.34	1.96	1.78	1.50	3.84	2.37	3.15	+167%	+77%	+33%
Heat Plants (1A1aiii)	0.48	10.4	13.0	12.8	17.3	0.022	NO	4.7E-6	-100%	-100%	---
Open Burning of Waste (5C2)	15.6	10.9	6.60	0.96	0.75	0.70	0.08	3.5E-5	-100%	-100%	-100%
Other	5.35	5.88	3.93	5.29	4.18	1.77	1.22	1.23	-77%	-77%	+0.9%
Total [kg]	**56.9**	**78.7**	**53.2**	**53.9**	**80.8**	**51.0**	**13.6**	**15.4**	**-73%**	**-71%**	**+13%**

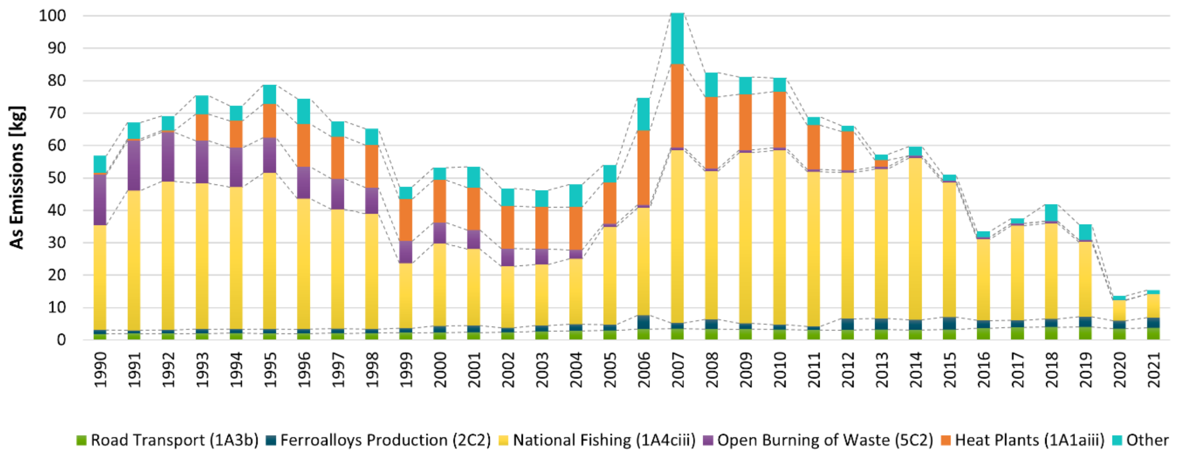


Figure 2.12 As emissions by sector, since 1990.

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

Cr emissions [kg]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Road Transport (1A3b)	61.5	66.4	75.4	96.1	103	107	116	124	+103%	+30%	+7.0%
National Fishing (1A4ciii)	35.8	52.7	28.9	33.5	58.2	44.9	7.94	8.99	-75%	-73%	+13%
Fireworks (2G)	1.78	2.20	5.89	9.95	7.65	9.39	7.70	8.21	+362%	-18%	+6.5%
National Navigation (Shipping) (1A3dii)	3.16	3.78	0.56	0.94	2.30	0.71	0.39	2.7E-4	-100%	-100%	-100%
Stationary Combustion: Non-metallic Minerals (1A2f)	6.48	3.05	4.67	7.04	1.27	9.1E-4	0.0011	1.1E-6	-100%	-100%	-100%
Other	5.25	6.51	7.55	7.34	5.21	8.05	5.25	7.46	+42.2%	+1.6%	+42%
Total [kg]	**114**	**135**	**123**	**155**	**178**	**170**	**138**	**149**	**+31%**	**-3.7%**	**+8.4%**

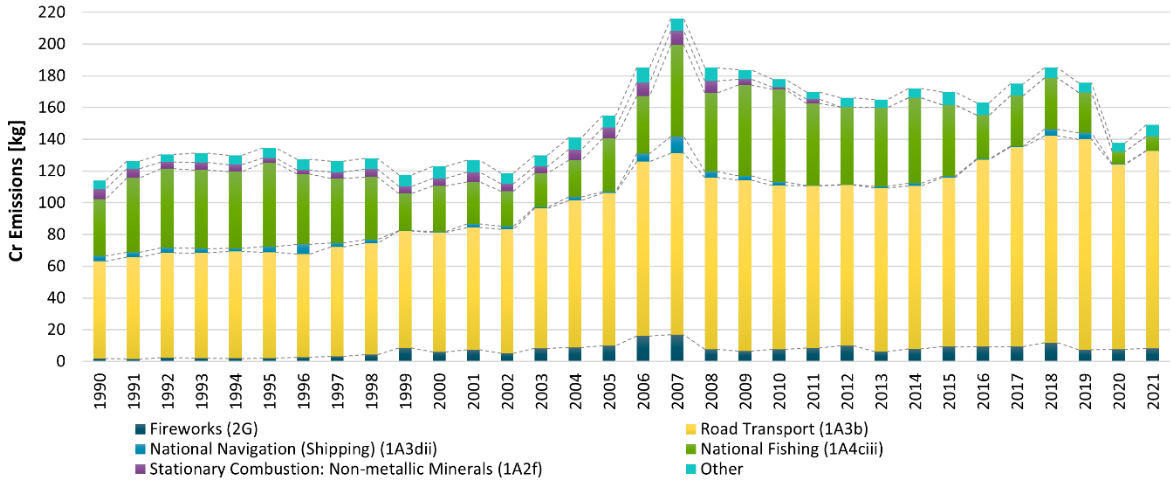


Figure 2.13 Cr emissions by sector, since 1990.

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

Cu Emissions [t]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
Road Transport (1A3b)	1.33	1.43	1.63	2.07	2.23	2.30	2.51	2.68	+102%	+29%	+7.0%
Fireworks (2G)	0.051	0.063	0.168	0.283	0.218	0.267	0.219	0.234	+362%	-18%	+6.5%
National Fishing (1A4ciii)	0.223	0.275	0.254	0.217	0.227	0.191	0.140	0.158	-29%	-27%	+13%
Mobile Machinery in Construction (1A2gvii)	0.031	0.038	0.050	0.055	0.026	0.027	0.011	0.017	-46%	-70%	+54%
Other	0.065	0.068	0.073	0.082	0.048	0.051	0.044	0.033	-48%	-59%	-23%
Total [t]	**1.69**	**1.88**	**2.17**	**2.71**	**2.75**	**2.84**	**2.92**	**3.12**	**+84%**	**+15%**	**+7.0%**

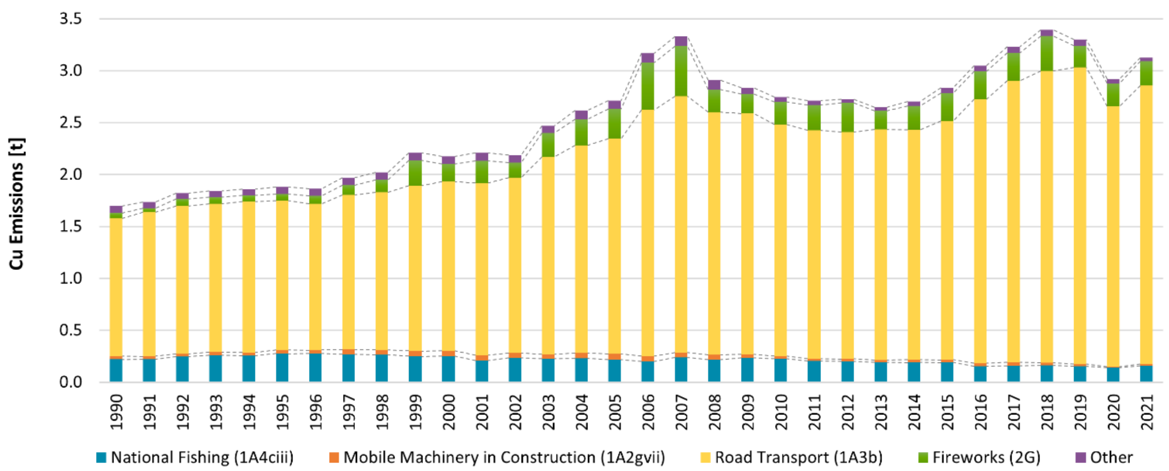


Figure 2.14 Cu emissions by sector, since 1990.

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

Ni Emissions [t]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
National Fishing (1A4ciii)	1.34	2.06	0.969	1.24	2.39	1.82	0.159	0.180	-87%	-86%	+13%
Fireworks (2G)	0.003	0.004	0.011	0.019	0.015	0.018	0.015	0.016	+362%	-18%	+6.5%
National Navigation (Shipping) (1A3dii)	0.133	0.159	0.021	0.034	0.092	0.022	0.008	0.005	-96%	-84%	-30%
Road Transport (1A3b)	0.010	0.010	0.012	0.015	0.016	0.016	0.018	0.019	+100%	+29%	+7.1%
Other	0.054	0.050	0.021	0.020	0.007	0.009	0.003	0.003	-94%	-83%	+25%
Total [t]	**1.54**	**2.28**	**1.03**	**1.33**	**2.52**	**1.89**	**0.202**	**0.224**	**-85%**	**-83%**	**+11%**

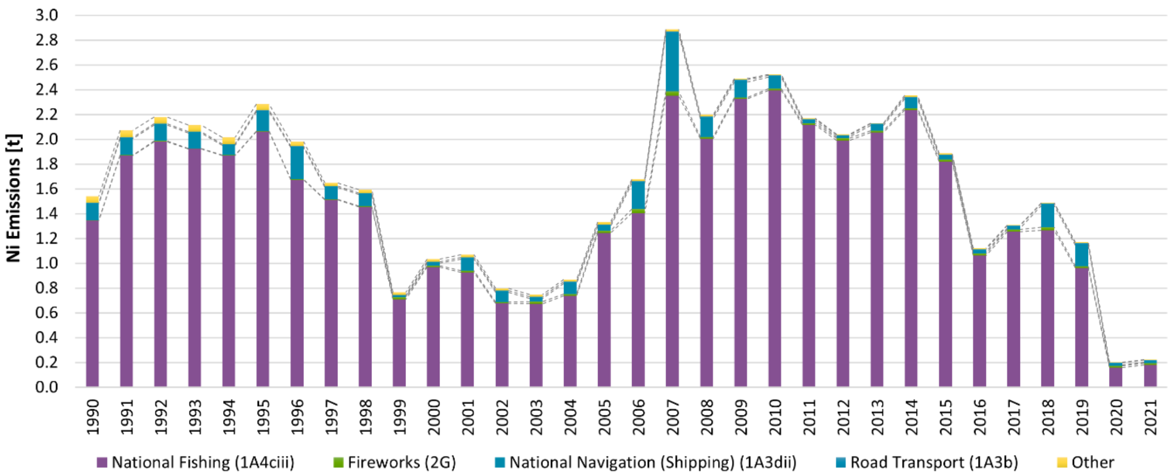


Figure 2.15 Ni emissions by sector, since 1990.

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

Se Emissions [kg]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '05-'21	Change '20-'21
National Fishing (1A4ciii)	27.7	35.2	30.4	26.8	30.5	25.3	15.9	18.0	-35%	-33%	+13%
Road Transport (1A3b)	1.10	1.20	1.36	1.72	1.86	1.91	2.14	2.30	+108%	+33%	+7.5%
Public Electricity and Heat Generation (1A1a)	0.63	0.63	0.39	0.09	0.39	0.36	0.16	0.24	-63%	+156%	+45%
Stationary Combustion: Non-metallic Minerals (1A2f)	0.87	0.42	0.64	0.94	0.17	5.0E-7	6.0E-7	6.1E-7	-100%	-100%	+0.3%
Open Burning of Waste (5C2)	2.66	1.85	1.13	0.16	0.13	0.12	0.014	6.0E-6	-100%	-100%	-100%
Other	2.14	2.45	1.36	1.86	1.98	1.43	1.15	0.95	-56%	-49%	-17%
Total [kg]	**35.1**	**41.7**	**35.2**	**31.6**	**35.0**	**29.1**	**19.3**	**21.5**	**-39%**	**-32%**	**+11%**

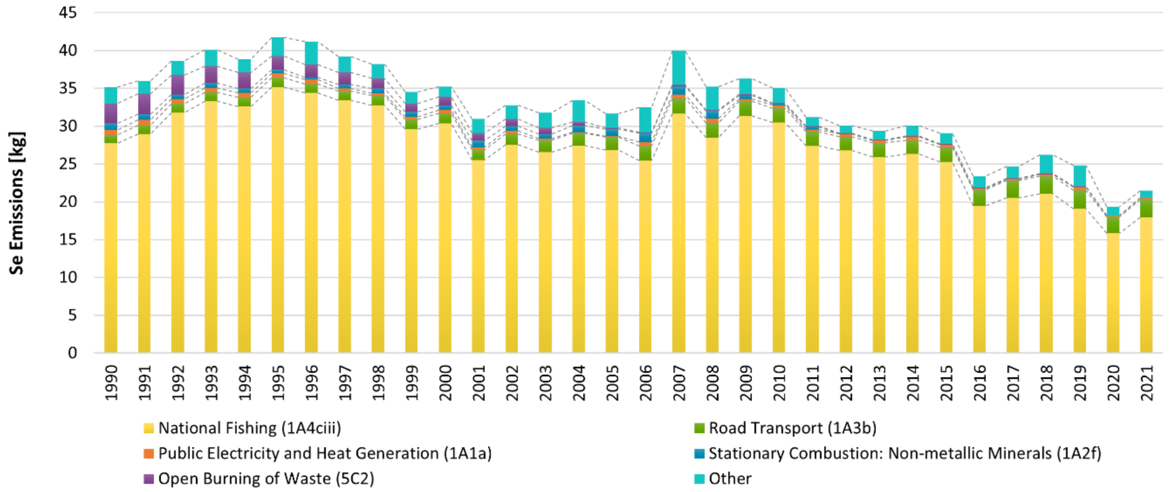


Figure 2.16 Se emissions by sector, since 1990.

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

Zn Emissions [t]	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	'05-'21	'20-'21
Road Transport (1A3b)	0.44	0.47	0.54	0.68	0.74	0.76	0.85	0.91	+108%	+33%	+7.4%
National Fishing (1A4ciii)	0.29	0.35	0.33	0.28	0.27	0.23	0.19	0.22	-25%	-23%	+13%
Accidental Fires (5E)	0.22	0.22	0.20	0.21	0.16	0.18	0.10	0.24	+10%	+18%	+136%
Stationary Combustion: Non-metallic Minerals (1A2f)	0.097	0.051	0.076	0.11	0.019	1.3E-4	1.6E-4	1.6E-4	-100%	-100%	+0.3%
Fireworks (2G)	0.030	0.037	0.098	0.17	0.13	0.16	0.13	0.14	+362%	-18%	+6.5%
Open Burning of Waste (5C2)	0.67	0.46	0.28	0.041	0.032	0.030	0.0036	0.0015	-100%	-96%	-58%
Other	0.14	0.15	0.15	0.15	0.091	0.099	0.081	0.065	-53%	-56%	-20%
Total [t]	**1.87**	**1.74**	**1.67**	**1.63**	**1.44**	**1.45**	**1.35**	**1.57**	**-16%**	**-3.5%**	**+16%**

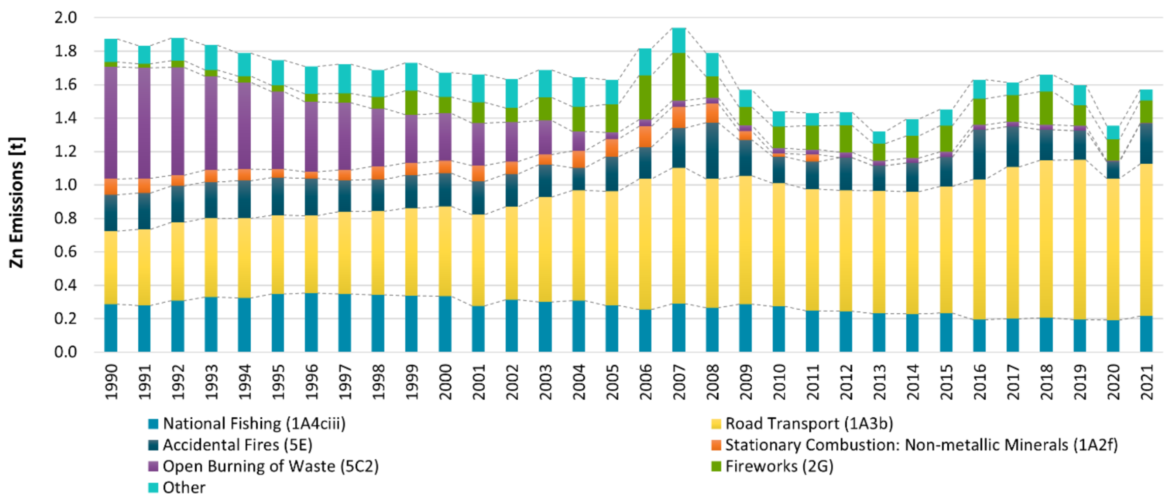


Figure 2.17 Zn emissions by sector, since 1990.

3 Energy (NFR Sector 1)

3.1 Overview

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 approximately 85%, which is a much higher share than that of 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_2e).

The EAI 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. Further work is planned in collaboration with the National Energy Authority (*Orkustofnun*) (NEA), the Icelandic Transport Authority (*Samgöngustofa*) (ITA), and Statistics Iceland (*Hagstofa Íslands*) (SI) in order to harmonise 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 utilisation)

Table 3.1 illustrates the key categories of air pollutants within the Energy sector, as determined by their significance in terms of absolute level, trend, or uncertainty in emissions within the national inventory system (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, NMVOCs, PM, BC, and CO	1990	2021	Trend
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	BC		BC
1A3ai(i) International Aviation LTO (Civil)		NMVOCs	NMVOCs
1A3bi Road Transport: Passenger Cars	NO_x, NMVOCs, $PM_{2.5}$, BC, CO	NO_x, NMVOCs, BC	NO_x, NMVOCs, CO
1A3biii Road Transport: Heavy-duty Vehicles and Buses	NO_x, $PM_{2.5}$, BC	NO_x, BC	$PM_{2.5}$, BC
1A3bv Road Transport: Gasoline Evaporation	NMVOCs		NMVOC
1A3bvi Road Transport: Automobile Tyre and Brake Wear		$PM_{2.5}$, PM_{10}, BC	$PM_{2.5}$, PM_{10}, 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
1A4cii Agriculture/Forestry/Fishing: Off-road Vehicles and other machinery	BC	BC	
1A4ciii National Fishing	NO_x, NMVOCs, SO_2, $PM_{2.5}$, PM_{10}, TSP, BC	NO_x, NMVOCs, $PM_{2.5}$, PM_{10}, BC	NO_x, SO_x, $PM_{2.5}$, PM_{10}, TSP, BC
1B2av Distribution of Oil Products		NMVOCs	
1B2d Other Fugitive Emissions from Energy Production (Geothermal Energy)	SO_x	SO_x	SO_x
Persistent Organic Pollutants (POPs)	**1990**	**2021**	**Trend**
1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals	PCB		
1A3bi Road Transport: Passenger Cars		PAH4	PAH4
1A4ciii National Fishing		PCB	PCB
Heavy Metals (HMs)	**1990**	**2021**	**Trend**
1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals	Cd, Pb		Cd, Cr, Pb, Se
1A2gvii Mobile Combustion in Manufacturing Industries and construction	Pb		Pb
1A3bi Road Transport: Passenger Cars		Hg	
1A3bvi Road Transport: Automobile Tyre and Brake Wear	Cd, Cr, Cu, Pb, Zn	As, Cd, Cr, Cu, Pb, Zn	As, Cd, Cr, Cu, Ni, Pb, Se, Zn
1A3dii National Navigation (Shipping)			Ni
1A4ciii National Fishing	As, Cd, Cr, Cu, Ni, Pb, Se, Zn	As, Cd, Hg, Ni, Se, Zn	As, Cr, Cu, Hg, Ni, Se

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 NEA, which collects data from the oil companies on fuel sales by sector.

Emissions from Road Transportation are estimated using COPERT 5.6.1, which follows the methodology presented in the 2019 EEA/EMEP Guidebook. A more detailed description is provided 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 2022 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 1A4b 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.

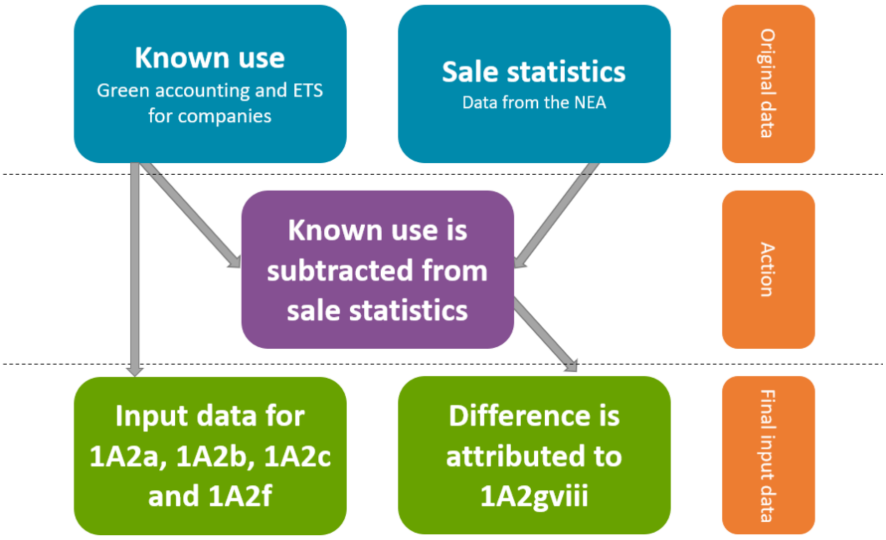


Figure 3.1 Description of adjustments in input data for IPCC category 1A2.

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 EAI 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 and Heat (NFR 1A1a)

Energy Industries include emissions from Electricity and Heat production. Iceland has extensively utilised 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 the EAI, see Chapter 3.2. Activity data on waste is collected by EAI 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 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, Grímsey and Flatey); furthermore, some public electricity facilities have emergency backup fuel combustion power plants which are used if problems occur in the distribution system. Those plants are seldom used apart from testing and during maintenance.

Table 3.2 Electricity production in Iceland [GWh]

	1990	1995	2000	2005	2010	2015	2020	2021
Hydropower	4,159	4,677	6,350	7,015	12,592	13,781	13,157	13,804
Geothermal	283	290	1,323	1,658	4,465	5,003	5,961	5,802
Fuel Combustion	4.6	8.4	4.4	7.8	1.7	3.9	3.1	2.5
Wind Power	-	-	-	-	-	10.9	6.7	6.1
Total [GWh]	**4,446**	**4,976**	**7,678**	**8,681**	**17,059**	**18,799**	**19,127**	**19,614**

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. These 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 that was purpose-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) affects 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 were 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	2020	2021
1A1ai – Gas/Diesel Oil	1.30	1.09	1.07	0.02	1.01	1.19	0.56	0.75
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	NO	0.06
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	NO	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:

A recalculation was done in 1A1ai due to an error in the calculations of pollutants from biofuels. In previous submissions, NCV for diesel was used to calculate the amount of biomethane. This increased the activity data from 43TJ/kt to 50.4 TJ/kt. Consequently, all air pollutants that are estimated for biomethane increased in relation to that increase in activity data for the years 2003-2007 where biomethane is reported. Furthermore, the NCV for diesel was used to calculate the implied emission factor for both diesel and biodiesel in previous submission for NOx, CO, NMVOC and dioxin. This caused a minor change where biodiesel was present in 2017-2018. However, the recalculation is relatively minor, a decrease in emissions of the abovementioned pollutants by 1.7% and 0.8% in 2017 and 2018, respectively.

1A1aiii: Heat Plants:

A minor recalculation of SO_2 is present in this category. This only applies to the year 2019 which is the only year were biodiesel is utilised. In previous submission the emission factor for SO_2 for biodiesel was linked incorrectly. This caused an increase in SO_2 by 5.2% in 2019.

1A1aiii	2019
2022 Submission [kt SO_2]	0.0152
2023 Submission [kt SO_2]	0.0160
Change relative to 2022 Submission [kt SO_2]	0.0008
Change relative to 2022 Submission [%]	5.2%

Recalculations from the 2022 Submission

There was an error in calculation files and emissions from residual fuel oil in 1A1ai 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.

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 NEA. The sales statistics do not fully specify by which type of industry the fuel is being purchased. This division is made by the EAI 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 EAI 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 categorised 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	2020	2021
1A2a - Iron and Steel								
Gas/Diesel Oil	0.11	0.22	0.56	0.46	0.46	0.29	0.21	0.24
LPG	NO	NO	NO	NO	NO	0.10	0.20	0.14
1A2b - Non-ferrous Metals								
Gas/Diesel Oil	NO	NO	0.55	5.37	1.35	0.046	1.72	2.70
Residual Fuel Oil	3.93	5.16	7.51	NO	3.31	1.40	NO	NO
LPG	0.41	0.31	0.67	0.66	0.61	0.39	0.23	0.21
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	1.10
Residual Fuel Oil	41.03	48.54	36.37	21.44	9.61	8.41	1.22	0.54
Waste Oil	NO	NO	NO	NO	1.36	1.59	0.37	2.34
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO
1A2e - Food processing, Beverages, and Tobacco (Other)								
Gas/Diesel Oil	NO	NO	NO	NO	2.71	3.75	3.37	3.22
Residual Fuel Oil	NO	NO	NO	NO	1.71	0.33	NO	NO
1A2f - Non-metallic Minerals (Cement)								
Gas/Diesel Oil	NO	NO	0.006	0.019	0.005	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	2.13	2.57
Residual Fuel Oil	7.91	0.16	0.00001	3.56	0.30	0.052	NO	NO
LPG	NO	NO	0.19	0.27	0.44	0.32	0.57	0.21
Other Bituminous Coal	NO	NO	NO	NO	NO	NO	NO	NO

3.3.2.2 Emission Factors

Emission factors (EFs) for all pollutants are Tier 1 EFs 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 the Manufacturing 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 % sulphur content
Residual Fuel Oil		1.8 % sulphur content
Waste Oil		0.5 % sulphur 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% sulphur 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

No recalculations or improvements were done for this subcategory.

Recalculations from the 2022 Submission

There were two reasons are for recalculations for 1A2 Stationary Combustion in 2022:

- Petroleum coke used for mineral wool production in 1A2f was removed from the Energy sector. It is accounted for in 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 subsidised and occurs in areas far from public heat plants. Previously, there were two waste incineration plants that used waste to produce heat. One of them used the heat for heating a swimming pool and a school building (*Skaftárhreppur*, closed in December 2012), and the other one used the heat for heating a swimming pool (*Svínafell*, closed 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. The EAI adjusts the data provided by the NEA, as further explained in Chapter 3.2. Activity data for waste incineration is collected by the EAI directly. Activity data for stationary fuel combustion and waste incineration in 1A4 are given in Table 3.6. It should be noted that data reported by the NEA indicates negligible solid fuel use for subcategory 1A4bi, and by extension condensables are also negligible.

Table 3.6 Fuel use [kt] from Stationary Combustion from subsectors of NFR 1A4.

	1990	1995	2000	2005	2010	2015	2020	2021
1A4ai - Commercial/Institutional								
Gas/Diesel Oil	1.80	1.60	1.60	1.00	0.30	0.30	0.13	0.12
LPG	0.78	0.83	0.46	0.50	0.17	0.37	0.41	0.46
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	1.06	0.63
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO
LPG	NO	NO	0.72	0.93	1.42	0.93	1.10	1.06
1A4ci - Agriculture								
LPG	NO	NO	NO	NO	NO	0.004	0.008	0.007

3.3.3.2 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 dioksiner 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 pool, school building). The IEF for dioxin for waste is considerably higher than for liquid fuel.

Table 3.7 Emission factors for 1A4ai, 1A4ci, and 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 % sulphur 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 % sulphur 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 % sulphur content

	Reference	Exception
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 % sulphur content. Dioxin emissions from (Statistics Norway, 2002)

3.3.3.3 Recalculations and Improvements

1A4ai Commercial/Institutional: The reason for recalculations in 1A4ai is an error that occurred in the allocation of fuels between 1A4ai and 1A4bi. Diesel oil was wrongly reported under this subsector when it should instead have been reported under 1A4bi Residential Stationary; this caused recalculations for 2019 and 2020. The recalculation is minor in the context of the Energy sector, but major in the context of this subsector, i.e., the change in activity data is between -0.35 kt and -0.4 kt of gas/diesel oil with consequent changes for all air pollutants. This is partly explained by the reallocation of gas/diesel oil between 1A4ai and 1A4bi.

1A4bi Residential Stationary: There are two reasons for recalculations in 1A4bi. Firstly, an error occurred in the allocation of fuels between 1A4ai and 1A4bi, as mentioned in the previous subchapter. Diesel oil was wrongly reported under 1A4ai Commercial/Institutional when it should instead have been reported under this subsector; this caused recalculations for 2019 and 2020. The recalculation is minor in the context of the Energy sector but major in the context of this sub-sector, i.e., the change in activity data is between 0.3 kt and 0.65 kt of gas/diesel oil with consequent changes for all air pollutants. Secondly, charcoal usage was added to this sector for the first time, but only for the years 2019-2021. Although usage is low, this contributed to small changes in the emissions totals, and thus recalculations were warranted. The increase in total activity data was between 5% and 8% for 2019-2021, with a corresponding increase in emissions.

Recalculations from the 2022 Submission

1A4ai Commercial/Institutional: Recalculations in 1A4ai in the 2022 Submission were 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 2019 and LPG was increased 333%, 556%, and 517% in 2017-2019, respectively. This affects all reported pollutants in this subsector.

1A4bi Residential Stationary: Recalculations in 1A4bi in the 2022 Submission occurred in 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 categorised as “Other” in sales statistics without any explanation of type of use, are now allocated to CRF Category 1A5. For future submissions, the EAI 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 categorised 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	2020	2021
Gas/Diesel Oil	NO	0.458	1.386	8.928	2.728	NO	0.084	0.517
Residual Fuel Oil	0.039	0.052	0.067	NO	1.629	NO	NO	NO
Other Kerosene	NO	NO	NO	0.151	0.047	0.029	0.030	0.284
LPG	NO	NO	NO	NO	NO	0.032	NO	NO
Biodiesel	NO	NO	NO	NO	NO	NO	0.044	0.035
Biomethane	NO	NO	NO	NO	NO	NO	0.111	0.066
Biogasoline	NO	NO	NO	NO	NO	NO	0.001	NO

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
A minor recalculation in this sector is due to revisions to the activity data of biomethane in 2016 and 2017, by the NEA. This caused an increase in all air pollutants, relevant to biomethane, by between 0.0001%-0.13%. This revision was caused by a software error where the number of decimal places was incorrectly selected.

Recalculations from the 2022 Submission

Recalculations in 1A5 in the 2022 Submission were twofold:

- Firstly, recalculations were 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 had then been allocated to the year 2019 in the 2022 Submission of activity data from the NEA. This had been reported as NO in the 2021 Submission.

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

3.3.4.4 Planned Improvements
There are no planned improvements for this sector.

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.

3.4.1.1 Activity Data
Activity data and information available from the NEA for 1990-2018 did not allow for the distinction between fuels sold to machinery in construction, agriculture, or other uses, but did provide 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 the previous submission, Category 1A3eii Other Off-road Vehicles and Machinery included all emissions derived from fuels sold to off-road machinery for 1990-2018, including 1A2gvii Mobile Machinery in Construction and 1A4cii Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery, as well as transport activities not reported under Road Transport (such as ground activities in airports and harbours (1A3eii)). Categories 1A2gvii and 1A4cii were marked as “IE” in the CRF reporter for 1990-2018 and were all included under 1A3eii.

For this submission, an extrapolation was made for 1990-2018 to split the gas/diesel oil previously reported under 1A3eii to the other categories for Mobile Machinery. An average proportion of each category was calculated based on the split for 2019-2021. Thus, Categories 1A2gvii and 1A4cii are no longer marked as “IE” and are no longer included under 1A3eii. The categorical proportions used to extrapolate for 1990-2018 can be seen in Table 3.9.

Table 3.9 Proportion used for 1990-2018 extrapolation of Mobile Machinery.

CRF code	IPCC name	Proportion used for 1990-2018 extrapolation
1A2gvii	Off-road Vehicles and Other Machinery in Construction	48%
1A3eii	Off-road Vehicles and Other Machinery	18%
1A4cii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	34%

Since 2019, 1A2gvii Mobile Machinery in Construction and 1A4cii Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery are reported separately by the NEA, but other transport activities not reported under Road Transport (such as ground activities in airports and harbours) are still reported under 1A3eii Other Mobile Machinery.

Activity data for fuel combustion is given in Table 3.10.

Table 3.10 Fuel use [kt] for Mobile Machinery in Construction (1A2gvii), Other Mobile Machinery (1A3eii), and Agriculture (1A4cii).

	1990	1995	2000	2005	2010	2015	2020	2021
1A2gvii - Mobile Machinery in Construction								
Gas/Diesel Oil	18.2	22.4	29.6	32.5	15.4	15.8	6.4	9.9
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO
1A3eii - Other Mobile Machinery								
Gas/Diesel Oil	6.8	8.4	11.1	12.2	5.8	6.0	3.7	0.73
Other Kerosene	NO	NO	NO	0.02	1.17	0.16	0.33	0.16
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO
1A4cii - Mobile Machinery in Agriculture								
Gas/Diesel Oil	13.0	15.9	21.1	23.1	11.0	11.3	7.6	6.5
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO

3.4.1.2 Emission Factors

Emission factors for dioxins from this sector are taken from *Utslipp til luft av dioksiner 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 Chapter 1A4 Non-road Mobile Machinery in the 2019 EMEP/EEA Guidebook. Emission factor information can be found in Table 3.11.

Table 3.11 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 % sulphur 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 explained above, an extrapolation of data from 2019-2021 was performed for the years in the timeseries where data was not available (1990-2018). This did not cause any changes to the total emissions, but rather only changed where those emissions are reported, see Table 3.12.

1A2gvii Mobile Machinery in Construction: In previous submissions, this category was reported as "IE" and its emissions were reported under 1A3eii. However, due to the aforementioned extrapolation of gas/diesel oil sales, data now exists for the entire timeseries and thus recalculations have occurred for each year from 1990-2018 for all pollutants, although these recalculations merely indicate a change from IE, and the total yearly emissions are not affected.

Moreover, an error in the fuel allocation between this category and 1A3eii for 2019-2020 caused recalculations for these years in the timeseries. This error was corrected before the extrapolation was performed.

1A3eii Other Mobile Machinery: In previous submissions, this category was included all emissions from fuels sold to off-road machinery (including fuels used for Construction and Agriculture), but in the most recent submission, data became available that speciated off-road machinery gas/diesel oil sales between 1A2gvii, 1A3eii, and 1A4cii. Due to the aforementioned extrapolation, fuel that was reported under this category for 1990-2018 was reallocated to 1A2gvii and 1A4cii for these years, and thus recalculations occurred for these years in the timeseries.

Moreover, an error in the fuel allocation between this category and 1A2gvii for 2019-2020 caused recalculations for these years in the timeseries. This error was corrected before the extrapolation was performed.

1A4cii Mobile Machinery in Agriculture: In previous submissions, this category was reported as "IE" and its emissions were reported under 1A3eii. However, due to the aforementioned extrapolation of gas/diesel oil sales, data now exists for the entire timeseries and thus recalculations have occurred for each year from 1990-2018 for all pollutants, although these recalculations merely indicate a change from IE, and the total yearly emissions are not affected.

Table 3.12 Reallocations of gas/diesel oil sales in 1A2gvii, 1A3eii, and 1A4cii.

Category	Submission	Gas/Diesel Oil [kt]							
		1990	1995	2000	2005	2010	2015	2019	2020
1A2gvii Construction	2022	IE	IE	IE	IE	IE	IE	7.1	3.7
	2023	18.2	22.4	29.6	32.5	15.4	15.8	12.3	6.4
	2022	38.0	46.7	61.9	67.8	32.2	33.1	12.3	6.4

<table>
<tr><th rowspan="2">Category</th><th rowspan="2">Submission</th><th colspan="8">Gas/Diesel Oil [kt]</th></tr>
<tr><th>1990</th><th>1995</th><th>2000</th><th>2005</th><th>2010</th><th>2015</th><th>2019</th><th>2020</th></tr>
<tr><td>1A3eii Other Mobile Machinery</td><td>2023</td><td>6.8</td><td>8.4</td><td>11.1</td><td>12.2</td><td>5.8</td><td>6.0</td><td>7.1</td><td>3.7</td></tr>
<tr><td rowspan="2">1A4cii Agriculture</td><td>2022</td><td>IE</td><td>IE</td><td>IE</td><td>IE</td><td>IE</td><td>IE</td><td>5.4</td><td>7.6</td></tr>
<tr><td>2023</td><td>13.0</td><td>15.9</td><td>21.1</td><td>23.1</td><td>11.0</td><td>11.3</td><td>5.4</td><td>7.6</td></tr>
</table>

Recalculations from the 2022 Submission

1A3eii: Other Off-road Vehicles and Machinery: Activity data and information available from the NEA for 1990-2018 did not allow for the distinction between fuels sold to machinery in construction, agriculture, or other uses, but provided 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 became possible to distinguish between off-road vehicles in agriculture and construction from the inventory years 2019 and onwards.

For the 2022 submission, 1A3eii Other Off-road Vehicles and Machinery included all emissions derived from fuels sold to off-road machinery for 1990-2018, including 1A2gvii Mobile Machinery in Construction, 1A4cii Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery, 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, 1A2gvii Mobile Machinery in Construction and 1A4cii Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery was to be reported separately, and other transport activities not reported under Road Transport such as ground activities in airports and harbours would still be reported under 1A3eii.

3.4.1.4 Planned Improvements

For future submissions, EAI plans to improve the accuracy of the extrapolation regarding the distribution of gas/diesel oil. The extrapolation for 1990-2018 was based on an average of the gas/diesel oil allocation for 2019-2021; in the next submission, there will be an extra year of data available which will provide a more accurate average between the three categories.

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 Climb, Cruise, and Descent (CCD) (1A3ai(ii), and Domestic CCD (1A3aii(ii)). As defined by Eurocontrol, LTO includes taxi out, take off, climb out (up to a height of 3,000 ft.), final approach (from a height of 3,000 ft), landing, and taxi in. CCD includes climb from a height of 3,000 ft up to the cruise level, cruise, and descent down to a height of 3,000 ft. Emissions occurring during LTO of both domestic and international flights are included in national totals, whereas emissions occurring during the CCD part of the flights are reported as “memo” items and are thus not counted in the national totals.

A Tier 3 methodology was developed for reporting in this submission, which uses a complete flight list containing data on the origin and destination airport, aircraft type, and date of each flight for a range of years for both domestic and international flights. The EMEP/EEA master emissions calculator tool, attached as an annex to the 2019[5] EMEP/EEA guidebook, was used to obtain estimates for NO_x, SO_x,

[5] The 2016 version of the tool was used due to access problems with the 2019 version.

CO, and PM emissions based on flight distances and aircraft types. International and domestic flight totals were used as proxies to project the results backwards to years pre-2011 in the case of domestic flights, and pre-1998 for international flights, as complete detailed flight data is not available for these years.

BC emissions are estimated using the suggested fraction of PM equal to 0.15 that is provided in the 2019 EMEP/EEA Guidebook. The ratio of $PM_{2.5}$ to PM_{10} emissions is assumed to be 1.

A Tier 1 method is used for NMVOC and dioxins using fuel consumption data, as these pollutants are not included in the EMEP/EEA calculator.

Ammonia, heavy metals, and PAHs are currently reported as NE due to lack of available emission factors.

3.4.2.1 Activity Data

In Iceland, there is one main airport for international flights, Keflavík International Airport (KEF). Under normal circumstances almost all international flights to and from Iceland depart and arrive from KEF, except for flights to Greenland, the Faroe Islands, and some flights with private airplanes which depart and arrive from Reykjavík Airport. Domestic flights sometimes depart from KEF in case of special weather conditions.

Activity data is provided by Isavia, the national airport and air navigation service provider of Iceland. This is in the form of Station Reports comprising detailed, timestamped data on every flight passing through each of Iceland's airports. This data includes the origin and destination airports, and aircraft type used for each flight. It is therefore straightforward to distinguish between national and international flights using the Origin and Destination fields. This detailed data is available for the years 2011-2021 for domestic flights, and 1998-2021 for international flights. International and domestic flight totals are provided from 1993-2006 and 2008, which are used as a proxy to project emissions backwards where full flight data is not available, using linear extrapolation. For 2007, 2009, and 2010, estimates are linearly interpolated for domestic flights.

For domestic flights, the average emissions for the years 1993-2000 are reported in 1990-1992 because a linear trend is not observed. For international flights, the range 1993-1995 is linearly extrapolated back to 1990 for reporting, following the observed trend.

Flight distances are obtained by using an online great circle distance (GCD) calculator tool, which assumes the Earth to be a perfect sphere, for each origin/destination combination. In a few cases where the distance is unable to be found in this way, a conservative figure of the width of Iceland is applied for domestic flights, and the average figure found for the relevant country in the case of international flights. Some manual matching of aircraft types was also performed in cases where aircrafts may be referred to by multiple equivalent codes.

For the Tier 1 method for NMVOC and dioxins, fuel consumption data from the NEA is used.

3.4.2.2 Emission Factors

LTO and CCD Emissions are calculated using the emission factors inherent in the 2016 EMEP/EEA master emissions calculator for the years where full detailed flight data is available. Emissions were not able to be calculated using this method for a fraction of the flights, due to missing aircraft codes, limitations of the tool, and also a small number of flights for which distances weren't found. This equates to 30.6% of domestic flights and 29.5% of international flights for LTO emissions, and 53.4%

of domestic flights and 33.2% of international flights for CCD emissions, with the larger gaps appearing in the earlier years in the time series. The emissions totals were therefore afterwards multiplied by a correction factor based on the total number of flights in that year and category, which is equivalent to assigning the average amount of emissions produced by a flight in the same year and category, to each missing flight. In this way, complete estimates are provided for NO_x, SO_x, CO, and PM emissions.

For NMVOC emissions, the default emission factor from the EMEP/EEA Guidebook 2019 is used, from Table 3.3.

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 dioksiner i Norge* (Statistics Norway, 2002).

3.4.2.3 Recalculations and Improvements

By using actual flight data, these estimates provide a more accurate description of emissions emanating from Iceland's aviation sector. In some cases, they show a more probable trend, with the large change in emissions from 2004 to 2005 (which was very noticeable for CO emissions for example) from the previous method no longer observed. This has resulted in some large recalculations from the previous submission, with examples shown in Table 3.13 to Table 3.16 below. The methodology is now also more transparent than it had been with previous extensive use of Eurocontrol data. PM_{10}, $PM_{2.5}$, TSP, and BC emissions for the years 1990-2004 are estimated for the first time in this submission. Dioxin emissions were also recalculated for the whole timeseries for two reasons; see Table 3.17 and Table 3.18. The main reasons for this were an error in unit conversion resulting in an increase by a factor of one thousand, and a small change in the emission factor (from 2.2 to 2.0 μg/tonne).

Table 3.13 Recalculations for International LTO (1A3ai(i)) due to tier upgrade.

Category International LTO	Submission	Emissions [kt]							
		1990	1995	2000	2005	2010	2015	2019	2020
PM	2022	NE	NE	NE	0.00135	0.00112	0.00225	0.00314	0.00127
	2023	0.00082	0.00096	0.00139	0.00173	0.00167	0.00275	0.00365	0.00114
CO	2022	8.81312	9.47490	16.35867	0.11527	0.07448	0.14041	0.21688	0.10040
	2023	0.06202	0.07384	0.10654	0.13379	0.12809	0.21247	0.32530	0.10696
NO_x	2022	0.02938	0.03158	0.05453	0.12700	0.11377	0.23104	0.35514	0.14046
	2023	0.05915	0.07638	0.13036	0.16510	0.15640	0.27422	0.40637	0.12755
SO_x	2022	0.00734	0.00790	0.01363	0.00949	0.00773	0.01517	0.02196	0.00893
	2023	0.00581	0.00685	0.00994	0.01243	0.01174	0.01967	0.02703	0.00856

Table 3.14 Recalculations for International CCD (1A3ai(ii)) due to tier upgrade.

Category International CCD	Submission	Emissions [kt]							
		1990	1995	2000	2005	2010	2015	2019	2020
PM	2022	NE	NE	NE	0.019	0.016	0.034	0.051	0.021
	2023	0.009	0.011	0.020	0.023	0.022	0.039	0.053	0.017
CO	2022	74.703	80.313	138.662	0.289	0.253	0.438	0.638	0.301
	2023	0.111	0.132	0.198	0.238	0.229	0.383	0.581	0.182
NO_x	2022	0.249	0.268	0.462	1.083	0.997	2.081	3.469	1.465
	2023	0.359	0.519	1.100	1.306	1.204	2.236	3.553	1.100

Category International CCD	Submission	Emissions [kt] 1990	1995	2000	2005	2010	2015	2019	2020
SO_x	2022	0.062	0.067	0.116	0.080	0.075	0.152	0.235	0.102
	2023	0.043	0.052	0.087	0.102	0.093	0.163	0.236	0.073

Table 3.15 Recalculations for Domestic LTO (1A3aii(i)) due to tier upgrade.

Category Domestic LTO	Submission	Emissions [kt] 1990	1995	2000	2005	2010	2015	2019	2020
PM	2022	NE	NE	NE	NO	1.2E-7	7.2E-7	6.0E-7	6.1E-8
	2023	3.4E-5	3.5E-5	3.4E-5	3.5E-5	3.5E-5	5.3E-5	2.2E-5	9.8E-6
CO	2022	5.4673	4.9190	4.6292	0.0243	0.0169	0.0149	0.0142	0.0132
	2023	0.0658	0.0621	0.0629	0.0546	0.0607	0.0502	0.1041	0.0537
NO_x	2022	0.0182	0.0164	0.0154	0.0232	0.0219	0.0183	0.0135	0.0131
	2023	0.0427	0.0406	0.0410	0.0364	0.0398	0.0368	0.0475	0.0265
SO_x	2022	0.0046	0.0041	0.0039	0.0021	0.0020	0.0017	0.0011	0.0010
	2023	0.0042	0.0040	0.0040	0.0035	0.0039	0.0035	0.0050	0.0028

Table 3.16 Recalculations for Domestic CCD (1A3aii(ii)) due to tier upgrade.

Category Domestic CCD	Submission	Emissions [kt] 1990	1995	2000	2005	2010	2015	2019	2020
PM	2022	NE	NE	NE	NO	2.4E-7	2.1E-6	1.4E-6	1.3E-7
	2023	1.2.E-4	1.2.E-4	1.2.E-4	1.2.E-4	1.2.E-4	2.0.E-4	1.0.E-4	3.5.E-5
CO	2022	7.2527	6.5254	6.1408	4.1383	0.0085	0.0077	0.0126	0.0126
	2023	0.1501	0.1457	0.1467	0.1369	0.1441	0.1395	0.1216	0.0518
NO_x	2022	0.0242	0.0218	0.0205	0.0464	0.0410	0.0364	0.0535	0.0531
	2023	0.1240	0.1196	0.1206	0.1109	0.1181	0.1144	0.1290	0.0745
SO_x	2022	0.0060	0.0054	0.0051	0.0028	0.0025	0.0023	0.0030	0.0030
	2023	0.0085	0.0082	0.0083	0.0076	0.0081	0.0076	0.0095	0.0056

Table 3.17 Recalculations of dioxin emissions within 1A3ai International Aviation between the 2022 and 2023 submissions.

1A3ai International Aviation	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission LTO dioxin [g]	4.86E-7	5.15E-7	8.25E-7	9.35E-7	6.75E-7	1.17E-6	1.55E-6	4.01E-7
2023 Submission LTO dioxin [g]	5.45E-4	5.60E-4	8.00E-4	9.55E-4	8.04E-4	1.39E-3	1.87E-3	5.21E-4
Change relative to the 2022 Submission LTO dioxin	112,146%	108,485%	96,825%	101,955%	119,072%	118,779%	120,433%	130,002%
2022 Submission Cruise dioxin [g]	4.12E-6	4.37E-6	6.99E-6	7.93E-6	6.52E-6	1.17E-5	1.66E-5	4.57E-6
2023 Submission Cruise dioxin [g]	4.02E-3	4.29E-3	7.01E-3	7.83E-3	6.39E-3	1.15E-2	1.63E-2	4.45E-3
Change relative to the 2022 Submission Cruise dioxin	97,488%	98,045%	100,171%	98,659%	97,884%	98,001%	97,984%	97,262%

Table 3.18 Recalculations of dioxin emissions within 1A3aii Domestic Aviation between the 2022 and 2023 submissions.

1A3aii Domestic Aviation	1990	1995	2000	2005	2010	2015	2019	2020
2022 submission LTO dioxin [g]	1.82E-6	1.29E-6	1.25E-6	1.02E-6	7.87E-7	6.25E-7	3.45E-7	1.72E-7
2023 submission LTO dioxin [g]	1.28E-3	9.00E-4	8.73E-4	6.96E-4	5.38E-4	4.28E-4	4.26E-4	2.11E-4
Change relative to the 2022 Submission LTO dioxin	70,215%	69,862%	69,975%	68,502%	68,280%	68,424%	123,347%	122,721%
2022 submission Cruise dioxin [g]	2.4E-6	1.7E-6	1.7E-6	1.3E-6	1.0E-6	8.4E-7	9.7E-7	5.0E-7
2023 submission Cruise dioxin [g]	2.6E-3	1.9E-3	1.8E-3	1.5E-3	1.1E-3	9.3E-4	8.2E-4	4.2E-4
Change relative to the 2022 Submission Cruise dioxin	108,349%	109,287%	109,114%	110,618%	111,790%	111,397%	83,967%	84,122%

3.4.2.4 Planned Improvements

There are a few possible improvements planned for the next submission, as follows:

- The most up to date EMEP/EEA 2019 Master Emissions Calculator (rather than the 2016 version) could be used in future submissions if access problems faced in this submission are resolved. This could potentially help in being able to calculate emissions directly for a larger proportion of flights in the detailed list, rather than these having to be averaged to come up with the final estimates.
- Data on total flight numbers for domestic and international flights will be sought for 2007, 2009, and 2010, which would enable better backwards projections of results.
- The flight totals data provided suggest that a number of test and "other" flights are happening in the country, which are not being accounted for in either the new or previous estimates. This could be clarified with data providers for future submissions, but we believe this would have a very small impact on emissions.

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 Brake Wear
- 1A3bvii Automobile Road Abrasion

3.4.3.1 Methodology

The transport model COPERT 5.6.1 (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[6]: "The COPERT methodology is part of the EMEP/EEA air pollutant emission inventory Guidebook for the calculation of air pollutant emissions." Results from the COPERT model were adjusted to calculate the emissions of $PM_{2.5}$, PM_{10}, TSP, and BC within Automobile Road Abrasion because of studded tyre use. It should be noted that condensable PM is included in COPERT calculations.

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 Meteorological Office (*Veðurstofa Íslands*) (IMO).
- Vehicle stock numbers for 2017-2021 were obtained from the ITA.
- Measurements collected by the EAI 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, 2020, and 2021. The 2019 value was applied for 1990-2019. The measurements for gasoline were done on 5% blended fuel. A correction was made before emissions were calculated so that the carbon content represents pure fossil gasoline.

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 3.19 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 3.19 Fuel use [kt], Road Transport.

	1990	1995	2000	2005	2010	2015	2020	2021
Gasoline	67.1	117.6	142.6	156.7	148.2	132.5	91.6	84.8
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	167.9	183.2
Biomethane	NO	NO	0.006	0.039	0.595	2.18	1.44	1.73
Biodiesel	NO	NO	NO	NO	NO	11.9	13.0	11.9
Biogasoline/Bioethanol	NO	NO	NO	NO	NO	1.93	11.04	25.6
Hydrogen	NO	NO	NO	9.0E-06	0.002	NO	4.2E-04	2.4E-04

A dataset about the 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).

[6] 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. The updated version of COPERT does, however, use updated emission factors.

Emission factors for 1A3bvii Automobile Road Abrasion due to studded tyres are based on Swedish research on studded tyre wear from pavement (Gustafsson, et al., 2005). The emission factor for PM_{10} for studded tyres for passenger cars and light-duty trucks is 50 times higher than for non-studded tyres.

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 on passenger cars and light duty trucks is 25% based on following information and assumptions:

- Studded tyres are banned in Iceland from 15 April to 31 October each year. During this period, the usage is assumed to be zero.
- Usage during studded tyre season (1 November to 14 April) is based on counting of studded tyres in two municipalities, one in the greater Reykjavík area and one in Akureyri, a city in the north of approximately 20,000 people.
- Since 1990, the percentage of the Icelandic population living in the Capital Region has been 62% on average. The other 38% of the population live outside of the Capital Region. There, 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

Several minor recalculations are due to the update of COPERT, which is done annually to reflect the latest science in emissions from the sector. For this submission, COPERT version 5.6.1 was used, and the methodological changes made from the last version can be seen on Emisia's website[7], the company that develops COPERT. These updated emission factors affected all pollutants in 1A3bi, 1A3bii, 1A3biii, and 1A3biv, as well as NMVOCs for 1A3bv, and BC and heavy metals for 1A3bvi and 1A3bvii. Additionally, changes to kilometres driven in COPERT affected 1A3bv, 1A3bvi, and 1A3bvii (Table 3.21).

Additionally, recalculations occurred due to the incorrect allocation of diesel fuel to 1A3biv Motorcycles in the previous submission. This subcategory does not use diesel fuel, and the fuel that was improperly allocated to it was reallocated to other sectors (Table 3.20). This caused an increase of emissions from gasoline fuel in 1A3biv and an increase in diesel emissions from 1A3bi, 1A3bii, and 1A3biii. The changes from this reallocation are minor.

A comprehensive review of all air pollutant recalculation in total can be seen in Table 3.22. The majority of minor recalculations can be traced to revisions of emission factors in COPERT while major recalculations are likely due to revisions of vehicle activity (mainly due to changes to 1A3bii Light-duty Trucks). The reason for a revision of activity, in terms of vehicle kilometres, in 1A3bii Light-duty Trucks was that the data set received from COPERT was not accurately representing the average utilisation of the aforementioned vehicle types.

[7] https://www.emisia.com/utilities/copert/versions/

Table 3.20 Reallocation of fuel between sub-sectors in Road Transport.

	1A3b Road Transport	1990	1995	2000	2005	2010	2015	2019	2020
Passenger Cars	2022 Submission Liquid Fuels [TJ]	5,651	6,075	6,688	7,896	7,717	7,803	8,107	7,027
	2023 Submission Liquid Fuels [TJ]	5,625	6,041	6,652	7,847	7,923	7,247	8,931	7,584
	Change relative to the 2022 Submission [TJ]	-26	-33	-35	-48	206	-555	824	557
Light-duty Trucks	2022 Submission Liquid Fuels [TJ]	372	384	436	667	1,070	1,169	1,964	1,743
	2023 Submission Liquid Fuels [TJ]	401	420	479	717	1,274	1,014	1,208	1,174
	Change relative to the 2022 Submission [TJ]	29	36	43	49	205	-155	-756	-569
Heavy-duty Trucks	2022 Submission Liquid Fuels [TJ]	1,156	1,080	1,178	1,913	2,217	2,177	2,873	2,386
	2023 Submission Liquid Fuels [TJ]	1,156	1,080	1,178	1,913	1,810	2,901	2,841	2,425
	Change relative to the 2022 Submission [TJ]	-0.47	-0.55	-0.27	0.15	-408	724	-32	39
Motorcycles	2022 Submission Liquid Fuels [TJ]	34	36	43	46	130	145	58	46
	2023 Submission Liquid Fuels [TJ]	31	33	35	45	127	132	23	17
	Change relative to the 2022 Submission [TJ]	-2.8	-2.5	-7.9	-1.0	-3.4	-14	-36	-29
Total	2022 Submission Liquid Fuels [TJ]	7,213	7,574	8,344	10,522	11,134	11,294	13,003	11,202
	2023 Submission Liquid Fuels [TJ]	7,213	7,574	8,344	10,522	11,134	11,294	13,002	11,200
	Change relative to the 2022 Submission [TJ]	0.004	-0.06	-0.12	-0.14	-0.18	-0.03	-0.43	-1.51

Table 3.21 Change in total vehicle activity between 2023 and 2022 submissions.

1A3b Road Transport	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission vehicle activity [mkm]	2,104	2,312	2,606	3,185	3,306	3,485	4,233	3,751
2023 Submission vehicle activity [mkm]	2,100	2,303	2,610	3,219	3,454	3,355	4,371	3,900
Change relative to the 2022 Submission [mkm]	-4.7	-8.8	4.1	33	148	-130	138	149
Change relative to the 2022 Submission [%]	-0.22%	-0.38%	0.16%	1.05%	4.48%	-3.73%	3.27%	3.97%

Table 3.22 Recalculations in Road Transport due to COPERT update and change in vehicle kilometers between subsectors.

1A3b Road Transport	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission NO_x [kt]	5.92	5.31	3.91	3.36	2.61	2.31	2.31	2.07
2023 Submission NO_x [kt]	5.86	5.27	3.92	3.41	2.50	2.50	2.11	1.81
Change relative to the 2022 Submission [kt]	-0.06	-0.04	0.01	0.05	-0.11	0.19	-0.20	-0.25
Change relative to the 2022 Submission [%]	-1.0%	-0.8%	0.2%	1.5%	-4.2%	8.3%	-8.6%	-12.3%
2022 Submission NMVOC [kt]	4.67	4.18	3.03	2.02	1.13	0.75	0.59	0.49
2023 Submission NMVOC [kt]	4.62	4.14	3.01	2.00	1.12	0.78	0.71	0.60
Change relative to the 2022 Submission [kt]	-0.05	-0.04	-0.02	-0.02	-0.01	0.03	0.13	0.11
Change relative to the 2022 Submission [%]	-1.2%	-0.9%	-0.7%	-1.0%	-0.5%	3.7%	21.5%	22.1%
2022 Submission SO_x [kt]	0.071	0.074	0.065	0.019	0.0031	0.0043	0.005	0.0041
2023 Submission SO_x [kt]	0.071	0.074	0.065	0.019	0.0031	0.0043	0.005	0.0041
Change relative to the 2022 Submission [kt]	2.9E-8	-4.5E-7	-7.2E-7	-2.5E-7	-6.5E-8	-9.8E-9	-1.5E-7	-4.2E-7

1A3b Road Transport	1990	1995	2000	2005	2010	2015	2019	2020
Change relative to the 2022 Submission [%]	4E-5%	-0.001%	-0.001%	-0.001%	-0.002%	-0.0002%	-0.003%	-0.01%
2022 Submission NH_3 [kt]	0.0072	0.037	0.14	0.16	0.13	0.083	0.052	0.042
2023 Submission NH_3 [kt]	0.0070	0.036	0.13	0.15	0.12	0.082	0.054	0.043
Change relative to the 2022 Submission [kt]	-0.00023	-0.001	-0.002	-0.004	-0.004	-0.001	0.002	0.002
Change relative to the 2022 Submission [%]	-3.26%	-2.77%	-1.73%	-2.54%	-2.87%	-1.23%	3.55%	3.96%
2022 Submission $PM_{2.5}$ [kt]	0.229	0.246	0.247	0.307	0.290	0.266	0.297	0.262
2023 Submission $PM_{2.5}$ [kt]	0.235	0.252	0.261	0.315	0.297	0.275	0.301	0.264
Change relative to the 2022 Submission [kt]	0.006	0.006	0.014	0.008	0.007	0.008	0.004	0.002
Change relative to the 2022 Submission [%]	2.5%	2.4%	5.8%	2.5%	2.5%	3.1%	1.2%	0.7%
2022 Submission PM_{10} [kt]	0.327	0.350	0.364	0.460	0.452	0.439	0.513	0.451
2023 Submission PM_{10} [kt]	0.337	0.362	0.385	0.476	0.467	0.462	0.529	0.466
Change relative to the 2022 Submission [kt]	0.010	0.011	0.021	0.017	0.015	0.022	0.016	0.015
Change relative to the 2022 Submission [%]	3.2%	3.2%	5.7%	3.6%	3.2%	5.1%	3.1%	3.4%
2022 Submission TSP [kt]	0.516	0.553	0.593	0.757	0.769	0.776	0.930	0.817
2023 Submission TSP [kt]	0.527	0.564	0.615	0.776	0.782	0.813	0.953	0.844
Change relative to the 2022 Submission [kt]	0.010	0.011	0.022	0.019	0.013	0.037	0.023	0.026
Change relative to the 2022 Submission [%]	2.0%	2.0%	3.7%	2.6%	1.7%	4.7%	2.5%	3.2%
2022 Submission BC [kt]	0.065	0.070	0.067	0.086	0.076	0.057	0.044	0.0398
2023 Submission BC [kt]	0.068	0.074	0.075	0.092	0.084	0.057	0.047	0.0396
Change relative to the 2022 Submission [kt]	0.003	0.004	0.008	0.005	0.009	0.000	0.003	-0.0003
Change relative to the 2022 Submission [%]	4.9%	5.1%	12.1%	6.3%	11.4%	0.8%	6.9%	-0.7%
2022 Submission CO [kt]	41.8	33.6	22.5	15.1	8.7	5.7	3.9	3.1
2023 Submission CO [kt]	41.3	33.1	22.1	14.7	8.4	5.6	3.4	2.6
Change relative to the 2022 Submission [kt]	-0.6	-0.5	-0.4	-0.4	-0.3	-0.1	-0.6	-0.5
Change relative to the 2022 Submission [%]	-1.3%	-1.5%	-1.8%	-2.5%	-3.0%	-2.1%	-14.2%	-16.4%
2022 Submission Pb [t]	0.04	0.05	0.05	0.07	0.07	0.08	0.10	0.09
2023 Submission Pb [t]	0.16	0.18	0.20	0.25	0.27	0.28	0.35	0.31
Change relative to the 2022 Submission [t]	0.12	0.13	0.15	0.19	0.20	0.20	0.25	0.22
Change relative to the 2022 Submission [%]	272%	275%	277%	271%	270%	256%	252%	256%
2022 Submission Cd [t]	2.8E-4	3.0E-4	3.3E-4	4.0E-4	4.5E-4	4.7E-4	6.4E-4	5.6E-4
2023 Submission Cd [t]	7.4E-4	8.0E-4	9.0E-4	1.1E-3	1.2E-3	1.3E-3	1.6E-3	1.4E-3
Change relative to the 2022 Submission [t]	4.6E-4	5.0E-4	5.7E-4	7.5E-4	7.8E-4	8.0E-4	9.3E-4	8.3E-4
Change relative to the 2022 Submission [%]	164%	164%	173%	187%	175%	171%	145%	149%
2022 Submission Hg [t]	1.3E-3	1.4E-3	1.5E-3	1.8E-3	1.9E-3	1.9E-3	2.2E-3	1.9E-3
2023 Submission Hg [t]	1.3E-3	1.4E-3	1.5E-3	1.8E-3	1.9E-3	1.9E-3	2.1E-3	1.9E-3

1A3b Road Transport	1990	1995	2000	2005	2010	2015	2019	2020
Change relative to the 2022 Submission [t]	7.6E-10	-1.2E-8	-2.4E-8	-2.7E-8	-3.6E-8	-3.7E-5	-4.6E-5	-3.8E-5
Change relative to the 2022 Submission [%]	0.0001%	-0.001%	-0.002%	-0.001%	-0.002%	-1.9%	-2.1%	-2.0%
2022 Submission As [t]	5.5E-4	5.8E-4	6.6E-4	8.4E-4	9.1E-4	9.7E-4	1.2E-3	1.0E-3
2023 Submission As [t]	1.9E-3	2.0E-3	2.3E-3	2.9E-3	3.2E-3	3.3E-3	4.1E-3	3.6E-3
Change relative to the 2022 Submission [t]	1.3E-3	1.5E-3	1.7E-3	2.1E-3	2.3E-3	2.3E-3	2.8E-3	2.5E-3
Change relative to the 2022 Submission [%]	247%	250%	252%	249%	249%	238%	236%	240%
2022 Submission Cr [t]	0.017	0.019	0.021	0.027	0.029	0.031	0.040	0.034
2023 Submission Cr [t]	0.061	0.066	0.075	0.096	0.103	0.107	0.133	0.116
Change relative to the 2022 Submission [t]	0.044	0.048	0.055	0.069	0.074	0.075	0.093	0.082
Change relative to the 2022 Submission [%]	255%	259%	261%	257%	254%	241%	235%	238%
2022 Submission Cu [t]	0.36	0.38	0.43	0.56	0.60	0.65	0.82	0.71
2023 Submission Cu [t]	1.33	1.43	1.63	2.07	2.23	2.30	2.86	2.51
Change relative to the 2022 Submission [t]	0.97	1.05	1.20	1.52	1.62	1.65	2.04	1.79
Change relative to the 2022 Submission [%]	270%	273%	276%	273%	269%	256%	247%	251%
2022 Submission Ni [t]	0.003	0.003	0.004	0.005	0.005	0.005	0.007	0.006
2023 Submission Ni [t]	0.010	0.010	0.012	0.015	0.016	0.016	0.020	0.018
Change relative to the 2022 Submission [t]	0.006	0.007	0.008	0.010	0.011	0.011	0.013	0.012
Change relative to the 2022 Submission [%]	201%	202%	210%	218%	210%	204%	186%	190%
2022 Submission Se [t]	0.0004	0.0005	0.0005	0.0007	0.0007	0.0008	0.0010	0.0009
2023 Submission Se [t]	0.0011	0.0012	0.0014	0.0017	0.0019	0.0019	0.0024	0.0021
Change relative to the 2022 Submission [t]	0.0007	0.0007	0.0008	0.0011	0.0011	0.0011	0.0014	0.0012
Change relative to the 2022 Submission [%]	149%	149%	154%	163%	158%	151%	137%	141%
2022 Submission Zn [t]	0.16	0.17	0.19	0.24	0.26	0.27	0.35	0.31
2023 Submission Zn [t]	0.44	0.47	0.54	0.68	0.74	0.76	0.96	0.85
Change relative to the 2022 Submission [t]	0.28	0.30	0.35	0.44	0.48	0.48	0.61	0.54
Change relative to the 2022 Submission [%]	181%	181%	184%	186%	186%	177%	173%	176%
2022 Submission Dioxin [t]	0.0641	0.0696	0.0884	0.1019	0.1005	0.0822	0.060	0.053
2023 Submission Dioxin [t]	0.0640	0.0693	0.0877	0.1051	0.1096	0.0723	0.053	0.044
Change relative to the 2022 Submission [t]	-0.0002	-0.0003	-0.0007	0.0032	0.0091	-9.95E-3	-0.007	-0.009
Change relative to the 2022 Submission [%]	-0.3%	-0.4%	-0.8%	3.1%	9.0%	-12.1%	-10.9%	-17.2%
2022 Submission B(a)P [t]	1.3E-3	1.3E-3	1.5E-3	2.0E-3	2.3E-3	2.9E-3	4.3E-3	4.0E-3
2023 Submission B(a)P [t]	1.3E-3	1.3E-3	1.5E-3	2.1E-3	2.7E-3	2.7E-3	4.1E-3	3.8E-3
Change relative to the 2022 Submission [t]	-1.0E-6	-1.4E-6	3.2E-5	9.2E-5	3.4E-4	-2.8E-4	-1.6E-4	-2.1E-4
Change relative to the 2022 Submission [%]	-0.08%	-0.10%	2.15%	4.54%	14.76%	-9.37%	-3.73%	-5.30%
2022 Submission B(b)F [t]	2.5E-3	2.5E-3	2.5E-3	3.3E-3	3.8E-3	4.5E-3	6.4E-3	5.9E-3

1A3b Road Transport	1990	1995	2000	2005	2010	2015	2019	2020
2023 Submission B(b)F [t]	2.5E-3	2.5E-3	2.5E-3	3.4E-3	3.9E-3	4.6E-3	6.2E-3	5.6E-3
Change relative to the 2022 Submission [t]	-6.7E-7	8.6E-7	3.9E-5	1.1E-4	1.8E-4	5.0E-5	-2.8E-4	-2.8E-4
Change relative to the 2022 Submission [%]	-0.03%	0.03%	1.58%	3.25%	4.87%	1.10%	-4.35%	-4.78%
2022 Submission B(k)F [t]	1.5E-3	1.6E-3	1.8E-3	2.8E-3	3.3E-3	4.0E-3	5.6E-3	5.0E-3
2023 Submission B(k)F [t]	1.5E-3	1.6E-3	1.9E-3	2.9E-3	3.4E-3	4.2E-3	5.3E-3	4.8E-3
Change relative to the 2022 Submission [t]	2.4E-7	-7.7E-7	2.8E-5	8.2E-5	5.7E-5	1.8E-4	-2.5E-4	-2.4E-4
Change relative to the 2022 Submission [%]	0.02%	-0.05%	1.55%	2.91%	1.70%	4.60%	-4.49%	-4.73%
2022 Submission I(1,2,3)p [t]	2.3E-3	2.2E-3	2.0E-3	2.4E-3	2.5E-3	3.1E-3	4.5E-3	4.1E-3
2023 Submission I(1,2,3)p [t]	2.3E-3	2.2E-3	2.1E-3	2.5E-3	2.8E-3	2.9E-3	4.3E-3	4.0E-3
Change relative to the 2022 Submission [t]	-1.7E-6	5.7E-7	3.2E-5	8.8E-5	3.0E-4	-2.1E-4	-1.6E-4	-1.9E-4
Change relative to the 2022 Submission [%]	-0.08%	0.03%	1.60%	3.73%	11.63%	-6.86%	-3.57%	-4.61%
2022 Submission PAH [t]	7.6E-3	7.6E-3	7.8E-3	1.0E-2	1.2E-2	1.5E-2	2.1E-2	1.9E-2
2023 Submission PAH [t]	7.6E-3	7.6E-3	7.9E-3	1.1E-2	1.3E-2	1.4E-2	2.0E-2	1.8E-2
Change relative to the 2022 Submission [t]	-3.2E-6	-7.0E-7	1.3E-4	3.7E-4	8.8E-4	-2.5E-4	-8.5E-4	-9.2E-4
Change relative to the 2022 Submission [%]	-0.04%	-0.01%	1.69%	3.52%	7.34%	-1.73%	-4.09%	-4.84%
2022 Submission HCB [t]	5.8E-5	6.4E-5	8.4E-5	9.8E-5	9.8E-5	8.0E-5	5.7E-5	5.0E-5
2023 Submission HCB [t]	5.8E-5	6.4E-5	8.3E-5	1.0E-4	1.1E-4	7.0E-5	5.1E-5	4.2E-5
Change relative to the 2022 Submission [t]	-1.7E-7	-3.1E-7	-7.5E-7	3.2E-6	9.5E-6	-1.0E-5	-5.3E-6	-7.9E-6
Change relative to the 2022 Submission [%]	-0.29%	-0.49%	-0.89%	3.26%	9.61%	-13.0%	-9.34%	-15.7%
2022 Submission PCBs [t]	1.4E-5	1.5E-5	1.9E-5	2.1E-5	2.1E-5	1.6E-5	1.2E-5	1.1E-5
2023 Submission PCBs [t]	1.4E-5	1.6E-5	1.9E-5	2.2E-5	2.3E-5	1.4E-5	1.0E-5	8.5E-6
Change relative to the 2022 Submission [t]	6.6E-7	6.9E-7	4.6E-7	1.1E-6	2.1E-6	-2.0E-6	-1.5E-6	-2.0E-6
Change relative to the 2022 Submission [%]	4.82%	4.61%	2.46%	5.22%	10.3%	-12.2%	-12.4%	-18.7%

Recalculations from the 2022 Submission

The most extensive recalculation in Road Transport between the 2021 and 2022 Submissions was due to a reallocation of diesel oil in Road Transport in 2014. Review by the NEA of allocation of diesel between subsectors of mobile combustion revealed outliers which the NEA corrected for this submission. Diesel oil utilised 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 affects all pollutants reported for biodiesel, more in the most recent years due to increased use of biofuels.

Other subsector specific recalculations are as follows:

1A3bi Passenger Cars: Emissions of all PMs have decreased over the whole timeseries after the emission factors 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 ITA, to develop procedures to obtain enhanced data on vehicle stock and mileage data for COPERT. Moreover, as Iceland has over 7,000 km of unpaved/gravel roads, and the EAI will explore options for calculating PM emissions from these roads.

3.4.4 Domestic 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 Domestic Navigation is based on the NEA's annual sales statistics for fossil fuels. Activity data for fuel combustion is given in Table 3.23.

Table 3.23 Fuel use [kt], Domestic Navigation.

	1990	1995	2000	2005	2010	2015	2020	2021
Residual Fuel Oil	3.94	4.76	0.54	0.88	2.61	0.44	NO	NO
Gas/Diesel Oil	6.40	7.04	3.43	6.20	8.46	7.89	7.83	5.48
Biodiesel	NO	NO	NO	NO	NO	NO	NO	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 EAI's calculation files have been updated accordingly. Emission factor references are presented in Table 3.24.

Table 3.24 Emission factors for Domestic 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 are used in diesel engines.	

3.4.4.3 Recalculations and Improvements

The 2019 EMEP/EEA guidebook was updated in December 2021 with new emission factors for domestic navigation. This caused recalculations of NO_x, CO, NMVOC, TSP, PM_{10}, $PM_{2.5}$, Cu, As, and Se for the whole timeseries, see Table 3.25. Furthermore, in this update of the guidebook, emission factors for BaP, BbF, BkF, and Ipy are no longer estimated. Additionally, some very minor recalculations occurred due to a linking issue for 1990-1994 that affected all pollutants.

Table 3.25 Recalculations within 1A3dii Domestic Navigation, due to Guidebook revisions of emissions factors.

1A3dii Domestic Navigation	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission NO_x [kt]	0.775	0.881	0.306	0.547	0.845	0.650	1.266	0.615
2023 Submission NO_x [kt]	0.735	0.837	0.285	0.508	0.792	0.600	1.191	0.566
Change relative to the 2022 Submission NO_x	-5.2%	-5.0%	-7.0%	-7.1%	-6.3%	-7.6%	-5.9%	-8.0%
2022 Submission CO [kt]	0.062	0.070	0.027	0.049	0.072	0.060	0.106	0.058
2023 Submission CO [kt]	0.039	0.044	0.015	0.027	0.042	0.032	0.063	0.030
Change relative to the 2022 Submission CO	-37%	-36%	-45%	-45%	-42%	-47%	-40%	-48%
2022 Submission NMVOC [kt]	0.025	0.028	0.010	0.019	0.028	0.023	0.041	0.022
2023 Submission NMVOC [kt]	0.018	0.020	0.007	0.012	0.019	0.015	0.029	0.014
Change relative to the 2022 Submission NMVOC	-27%	-27%	-34%	-35%	-32%	-36%	-30%	-38%
2022 Submission TSP [kt]	0.030	0.035	0.008	0.014	0.026	0.014	0.043	0.012
2023 Submission TSP [kt]	0.027	0.032	0.006	0.011	0.023	0.011	0.038	0.008
Change relative to the 2022 Submission NMVOC	-9.1%	-8.6%	-19%	-19%	-14%	-24%	-12%	-29%
2022 Submission PM_{10} [kt]	0.030	0.035	0.008	0.014	0.026	0.014	0.043	0.012
2023 Submission PM_{10} [kt]	0.027	0.032	0.006	0.011	0.023	0.011	0.038	0.008
Change relative to the 2022 Submission PM_{10}	-9.1%	-8.6%	-19%	-19%	-14%	-24%	-12%	-29%
2022 Submission $PM_{2.5}$ [kt]	0.029	0.035	0.008	0.014	0.026	0.014	0.043	0.012
2023 Submission $PM_{2.5}$ [kt]	0.027	0.032	0.006	0.011	0.023	0.011	0.038	0.008
Change relative to the 2022 Submission $PM_{2.5}$	-7.2%	-8.6%	-19%	-19%	-14%	-24%	-12%	-29%
2022 Submission As [t]	0.0005	0.0005	0.0002	0.0003	0.0005	0.0003	0.0007	0.0003
2023 Submission As [t]	0.0029	0.0035	0.0005	0.0008	0.0021	0.0006	0.0038	0.0003
Change relative to the 2022 Submission As	548%	577%	208%	190%	351%	82%	424%	0%
2022 Submission Cu [t]	0.002	0.002	0.001	0.001	0.002	0.002	0.003	0.002
2023 Submission Cu [t]	0.011	0.012	0.004	0.007	0.011	0.007	0.016	0.007

1A3dii Domestic Navigation	1990	1995	2000	2005	2010	2015	2019	2020
Change relative to the 2022 Submission Cu	411%	415%	365%	363%	384%	350%	393%	340%
2022 Submission Se [t]	0.0002	0.0003	0.0001	0.0001	0.0002	0.0001	0.0003	0.0001
2023 Submission Se [t]	0.0015	0.0017	0.0005	0.0008	0.0014	0.0009	0.0022	0.0008
Change relative to the 2022 Submission Se	562%	553%	716%	728%	638%	813%	606%	900%

Recalculations from the 2022 Submission

For the 2022 Submission, 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. Consequently, activity data for this sector decreased by 45% to 67% in these years. This caused recalculations for all reported pollutants for this sector for 1990-1994.

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 and Domestic Navigation based whether the vessel is sailing to an Icelandic or a foreign harbour (regardless of flag). Fuel used for International Navigation can be seen in Table 3.26.

Table 3.26 Fuel use [kt], International Navigation.

	1990	1995	2000	2005	2010	2015	2020	2021
Residual Fuel Oil	0.25	NO	2.00	0.44	0.08	13.2	NO	3.48
Gas/Diesel Oil	8.53	1.05	15.0	0.12	NO	33.6	24.3	35.3

The emission factors used to estimate emissions from International Navigation are the same as those used for Domestic Navigation and can be found in Table 3.24.

3.4.5.1 Recalculations and Improvements

The 2019 EMEP/EEA guidebook was updated in December 2021 with new emission factors for domestic navigation. This caused recalculations of NO_x, CO, NMVOC, TSP, PM_{10}, $PM_{2.5}$, Cu, As, and Se for the whole timeseries, see Table 3.27. Furthermore, in this update of the guidebook, emission factors for BaP, BbF, BkF, and Ipy are no longer estimated. Additionally, some very minor recalculations occurred due to a linking issue for 1990-1994 that affected all pollutants.

Table 3.27 Recalculations within 1A3di(i) International Navigation, due to Guidebook revisions of emissions factors.

1A3di(i) International Navigation	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission NO_x [kt]	0.69	0.083	1.32	0.0394	0.006	3.55	4.88	1.91
2023 Submission NO_x [kt]	0.63	0.076	1.22	0.0386	0.006	3.34	4.60	1.75
Change relative to the 2022 Submission NO_x	-7.8%	-8.0%	-7.2%	-1.9%	0.0%	-6.0%	-5.8%	-8.0%
2022 Submission CO [kt]	0.064	0.0078	0.119	0.0025	0.00029	0.30	0.41	0.18

1A3di(i) International Navigation	1990	1995	2000	2005	2010	2015	2019	2020
2023 Submission CO [kt]	0.034	0.0040	0.065	0.0021	0.00029	0.18	0.24	0.09
Change relative to the 2022 Submission CO	-47%	-48%	-45%	-17%	0.0%	-40%	-40%	-48%
2022 Submission NMVOC [kt]	0.024	0.0029	0.045	0.0011	0.0001	0.12	0.16	0.068
2023 Submission NMVOC [kt]	0.015	0.0018	0.030	0.0009	0.0001	0.08	0.11	0.042
Change relative to the 2022 Submission NMVOC	-37%	-38%	-35%	-12%	0.0%	-30%	-30%	-38%
2022 Submission TSP [kt]	0.0141	0.0016	0.033	0.0025	0.0004	0.119	0.168	0.036
2023 Submission TSP [kt]	0.0104	0.0011	0.026	0.0024	0.0004	0.105	0.149	0.026
Change relative to the 2022 Submission TSP	-26%	-29%	-20%	-2.0%	0.0%	-12%	-12%	-29%
2022 Submission PM_{10} [kt]	0.0141	0.0016	0.033	0.0025	0.0004	0.119	0.168	0.036
2023 Submission PM_{10} [kt]	0.0104	0.0011	0.026	0.0024	0.0004	0.105	0.149	0.026
Change relative to the 2022 Submission PM_{10}	-26%	-29%	-20%	-2.0%	0.0%	-12%	-12%	-29%
2022 Submission $PM_{2.5}$ [kt]	0.013	0.0015	0.031	0.00244	0.0004	0.116	0.164	0.034
2023 Submission $PM_{2.5}$ [kt]	0.010	0.0011	0.026	0.00240	0.0004	0.105	0.149	0.026
Change relative to the 2022 Submission $PM_{2.5}$	-21%	-24%	-16%	-1.6%	0.0%	-9.6%	-9.1%	-24%
2022 Submission As [t]	0.00035	0.00004	0.00070	0.00003	0.000004	0.0020	0.0028	0.00097
2023 Submission As [t]	0.00051	0.00004	0.00196	0.00030	0.000054	0.0104	0.0150	0.00097
Change relative to the 2022 Submission As	45%	0.0%	179%	1,040%	1,260%	416%	439%	0.0%
2022 Submission Cu [t]	0.0018	0.00021	0.0034	0.00011	0.00002	0.0094	0.013	0.0049
2023 Submission Cu [t]	0.0078	0.00093	0.0157	0.00065	0.00010	0.0461	0.064	0.0214
Change relative to the 2022 Submission Cu	345%	340%	362%	486%	525%	392%	395%	340%
2022 Submission Se [t]	0.00010	0.00001	0.00023	0.00002	0.00000	0.00087	0.0012	0.00024
2023 Submission Se [t]	0.00091	0.00011	0.00192	0.00010	0.00002	0.00614	0.0086	0.00243
Change relative to the 2022 Submission Se	850%	900%	735%	454%	425%	609%	600%	900%

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 Iceland's primary exports.

3.4.6.1 Activity Data

Total use of residual fuel oil and gas/diesel oil for commercial fishing is based on the NEA's annual sales statistics for fossil fuels and includes both Domestic and International Fishing. Activity data for fuel combustion in the Fishing sector is given in Table 3.28.

Table 3.28 Fuel use [kt], Fishing sector.

	1990	1995	2000	2005	2010	2015	2020	2021
Residual Fuel Oil	35.6	57.2	22.3	32.6	69.9	52.4	NO	NO
Gas/Diesel Oil	202.6	231.8	256.9	199.9	158.3	142.5	158.7	179.7
Biodiesel	NO	NO	NO	NO	NO	0.094	0.075	0.065

3.4.6.2 Emission Factors

Emission factors for all pollutants are the same as for Domestic Navigation, and can be seen in Table 3.24.

3.4.6.3 Recalculations and Improvements

The 2019 EMEP/EEA guidebook was updated in December 2021 with new emission factors for domestic navigation. This caused recalculations of NO_x, CO, NMVOC, TSP, PM_{10}, $PM_{2.5}$, Cu, As, and Se for the whole timeseries, see Table 3.29. Furthermore, in this update of the guidebook, emission factors for BaP, BbF, BkF, and Ipy are no longer estimated. Additionally, some very minor recalculations occurred due to a linking issue for 1990-1994 that affected all pollutants.

Table 3.29 Recalculations within 1A4ciii Fishing, due to Guidebook revisions of emissions factors.

1A4ciii Fishing	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission NO_x [kt]	18.4	22.1	21.7	17.9	17.3	14.8	12.5	12.5
2023 Submission NO_x [kt]	17.1	20.7	20.1	16.7	16.3	13.9	11.7	11.5
Change relative to the 2022 Submission NO_x	-6.9%	-6.6%	-7.5%	-7.0%	-5.8%	-6.1%	-6.9%	-8.0%
2022 Submission CO [kt]	1.63	1.93	1.98	1.60	1.43	1.25	1.11	1.17
2023 Submission CO [kt]	0.91	1.10	1.07	0.89	0.86	0.74	0.62	0.61
Change relative to the 2022 Submission CO	-44%	-43%	-46%	-45%	-39%	-41%	-44%	-48%
2022 Submission NMVOC [kt]	0.63	0.74	0.76	0.61	0.56	0.49	0.43	0.44
2023 Submission NMVOC [kt]	0.41	0.50	0.49	0.40	0.39	0.34	0.28	0.28
Change relative to the 2022 Submission NMVOC	-34%	-43%	-46%	-45%	-39%	-41%	-44%	-48%
2022 Submission TSP [kt]	0.49	0.64	0.50	0.47	0.60	0.49	0.34	0.24
2023 Submission TSP [kt]	0.40	0.55	0.39	0.38	0.53	0.43	0.28	0.17
Change relative to the 2022 Submission TSP	-18%	-43%	-46%	-45%	-39%	-41%	-44%	-48%
2022 Submission PM_{10} [kt]	0.49	0.64	0.50	0.47	0.60	0.49	0.34	0.24
2023 Submission PM_{10} [kt]	0.40	0.55	0.39	0.38	0.53	0.43	0.28	0.17
Change relative to the 2022 Submission PM_{10}	-18%	-43%	-46%	-45%	-39%	-41%	-44%	-48%
2022 Submission $PM_{2.5}$ [kt]	0.47	0.62	0.48	0.45	0.58	0.47	0.33	0.22
2023 Submission $PM_{2.5}$ [kt]	0.40	0.55	0.39	0.38	0.53	0.43	0.28	0.17
Change relative to the 2022 Submission $PM_{2.5}$	-14%	-43%	-46%	-45%	-39%	-41%	-44%	-48%
2022 Submission As [t]	0.010	0.012	0.011	0.010	0.010	0.008	0.007	0.01
2023 Submission As [t]	0.032	0.048	0.025	0.030	0.054	0.041	0.023	0.01
Change relative to the 2022 Submission As	227%	297%	123%	213%	448%	397%	241%	0.0%
2022 Submission Cu [t]	0.048	0.058	0.056	0.047	0.046	0.039	0.032	0.032
2023 Submission Cu [t]	0.223	0.275	0.254	0.217	0.227	0.191	0.153	0.140
Change relative to the 2022 Submission Cu	368%	377%	355%	366%	397%	390%	369%	340%
2022 Submission Se [t]	0.0035	0.0046	0.0035	0.0033	0.0044	0.0035	0.0024	0.0016
2023 Submission Se [t]	0.0277	0.0352	0.0304	0.0268	0.0305	0.0253	0.0191	0.0159
Change relative to the 2022 Submission Se	704%	664%	778%	712%	597%	617%	695%	900%

Recalculations from the 2022 Submission

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 caused recalculations for all reported pollutants for this sector for 1990-1994 relative to the fuel reallocation. Subsequently, fuel in the Fishing sector increased by between 1.3-9.3% for 1990-1993, and there was a very minor decrease in residual fuel oil use in 1994.

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 SI.

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 1,000 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 3.30 shows the electricity production with geothermal energy and the total sulphur emissions (calculated as SO_2).

Table 3.30 Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2010	2015	2020	2021
Electricity production [GWh]	283	290	1,323	1,658	4,465	5,003	5,961	5,802
Sulphur emissions [kt SO_2]	13.3	11.0	26.0	30.3	58.7	42.4	39.3	47.7

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 Capacitor Production, 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 and Beverages Industry (NFR 2H2)

A summary of the categories included in the IPPU sector by pollutant, including the tier methodology used, is presented in Table 4.1 to Table 4.3.

Table 4.1 Overview table NECD gases, PM, and CO (NA – not available, NO – not occurring).

Sector		NECD Gases				PM				
		NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
2A1	Cement Production[1]	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A2	Lime Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A3	Glass production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A5a	Quarrying and Mining of Minerals other than Coal	NA	NA	NA	NA	T2	T2	T2	NA	NA
2A5b	Construction and Demolition	NA	NA	NA	NA	T1	T1	T1	NA	NA
2A5c	Storage, Handling, and Transport of Mineral Products	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A6	Other Mineral Products (Mineral Wool)	NA	NA	T3	T3	T2	T3	T2	T2	T3
2B1	Ammonia Production[2]	IE	IE	IE	IE	IE	IE	IE	IE	IE
2B2	Nitric Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B3	Adipic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B5	Carbide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO

	Sector	NECD Gases				PM				
		NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
2B6	Titanium Dioxide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B7	Soda Ash Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10a	Diatomite[3]	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10a	Fertiliser[2]	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10b	Storage, Handling, and Transport of Chemical Products	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C1	Iron and Steel Production[4]	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C2	Ferroalloys Production	T2	T2	T3	NA	T1/T3	T1/T3	T3	T1	T2
2C3	Primary Aluminium Production	T2	NA	T3	NA	T2	T2	T3	T2	T2
2C3	Secondary Aluminium Production	NA	NA	NA	NA	T2	T2	T3	T2	NA
2C4	Magnesium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5	Lead Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C6	Zinc Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7a	Copper Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7b	Nickel Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7c	Capacitor Production	NA	NA	NA	T3	NA	NA	NA	NA	NA
2C7d	Storage, Handling, and Transport of Metal Products	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3a	Domestic Solvent Use Including Fungicides	NA	T2b	NA	NA	NA	NA	NA	NA	NA
2D3b	Road Paving with Asphalt	NA	T1	NA	NA	T1	T1	T3	T1	NA
2D3c	Asphalt Roofing	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3d	Coating Applications	NA	T2	NA	NA	NA	NA	NA	NA	NA
2D3e	Degreasing	NA	T1	NA	NA	NA	NA	NA	NA	NA
2D3f	Dry Cleaning	NA	T2	NA	NA	NA	NA	NA	NA	NA
2D3g	Chemical Products	NA	T2	NA	NA	NA	NA	NA	NA	NA
2D3h	Printing	NA	T1	NA	NA	NA	NA	NA	NA	NA
2D3i	Creosotes[5]	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3i	Organic Solvent-borne Preservatives	NA	T2	NA	NA	NA	NA	NA	NA	NA
2D3i	Aircraft De-icing	NA	T2	NA	NA	NA	NA	NA	NA	NA
2G4	Tobacco	T2	T2	NA	T2	T2	T2	T2	T2	T2
2G4	Fireworks	T2	NA	T2	NA	T2	T2	T2	NA	T2
2H1	Pulp and Paper Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
2H2	Food and Beverages Industry	NA	T2	NA	NA	NA	NA	NA	NA	NA
2H3	Other Industrial Processes	NO	NO	NO	NO	NO	NO	NO	NO	NO
2I	Wood Processing	NO	NO	NO	NO	NO	NO	NO	NO	NO
2J	Production of POPs	NO	NO	NO	NO	NO	NO	NO	NO	NO

	Sector	NECD Gases				PM				
		NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
2K	Consumption of POPs and Heavy Metals	NO	NO	NO	NO	NO	NO	NO	NO	NO
2L	Other Production, Consumption, Storage, Transportation, or Handling of Bulk Products	NO	NO	NO	NO	NO	NO	NO	NO	NO

[1]Cement Production was operational until 2011 and used Tier 3 and Tier 1 methodology.
[2]Fertiliser Production (2B10a) was operational until 2001 and used Tier 3 methodology (NO_x only).
[3]Diatomite Production was operational until 2004 and used Tier 3 methodology (NO_x only).
[4]Iron Production was operational from 2014 to 2016 and used Tier 2 methodology for all pollutants except HCB which used Tier 1 methodology.
[5]Creosotes were imported until 2011 and used Tier 2 methodology.

Table 4.2 Overview table POPs (NA – not available, NO – not occurring).

	Sector	POPs			
		Dioxin	PAH	HCB	PCB
2A1	Cement Production	NO	NO	NO	NO
2A2	Lime Production	NO	NO	NO	NO
2A3	Glass Production	NO	NO	NO	NO
2A5a	Quarrying and Mining of Minerals other than Coal	NA	NA	NA	NA
2A5b	Construction and Demolition	NA	NA	NA	NA
2A5c	Storage, Handling, and Transport of Mineral Products	NO	NO	NO	NO
2A6	Other Mineral Products (Mineral Wool)	T1	NA	NA	NA
2B1	Ammonia Production	IE	IE	IE	IE
2B2	Nitric Acid Production	NO	NO	NO	NO
2B3	Adipic Acid Production	NO	NO	NO	NO
2B5	Carbide Production	NO	NO	NO	NO
2B6	Titanium Dioxide Production	NO	NO	NO	NO
2B7	Soda Ash Production	NO	NO	NO	NO
2B10a	Diatomite	NO	NO	NO	NO
2B10a	Fertiliser	NO	NO	NO	NO
2B10b	Storage, Handling, and Transport of Chemical Products	NO	NO	NO	NO
2C1	Iron and Steel Production	NO	NO	NO	NO
2C2	Ferroalloys Production	T3	T3	NA	NA
2C3	Primary Aluminium Production	T2/T3	T2/T3	NA	NA
2C3	Secondary Aluminium Production	T3	NA	T2	NA
2C4	Magnesium Production	NO	NO	NO	NO
2C5	Lead Production	NO	NO	NO	NO
2C6	Zinc Production	NO	NO	NO	NO
2C7a	Copper Production	NO	NO	NO	NO
2C7b	Nickel Production	NO	NO	NO	NO
2C7c	Capacitor Production	NA	NA	NA	NA
2C7d	Storage, Handling, and Transport of Metal Products	NO	NO	NO	NO

Sector		POPs			
		Dioxin	PAH	HCB	PCB
2D3a	Domestic Solvent Use Including Fungicides	NA	NA	NA	NA
2D3b	Road Paving with Asphalt	T2	NA	NA	NA
2D3c	Asphalt Roofing	NO	NO	NO	NO
2D3d	Coating Applications	NA	NA	NA	NA
2D3e	Degreasing	NA	NA	NA	NA
2D3f	Dry Cleaning	NA	NA	NA	NA
2D3g	Chemical Products	NA	NA	NA	NA
2D3h	Printing	NA	NA	NA	NA
2D3i	Creosotes	NO	NO	NO	NO
2D3i	Organic Solvent-borne Preservatives	NA	NA	NA	NA
2D3i	Aircraft De-icing	NA	NA	NA	NA
2G4	Tobacco	T2	T2	NA	NA
2G4	Fireworks	NA	NA	T3	NA
2H1	Pulp and Paper Industry	NO	NO	NO	NO
2H2	Food and Beverages Industry	NA	NA	NA	NA
2H3	Other Industrial Processes	NO	NO	NO	NO
2I	Wood Processing	NO	NO	NO	NO
2J	Production of POPs	NO	NO	NO	NO
2K	Consumption of POPs and Heavy Metals	NO	NO	NO	NO
2L	Other Production, Consumption, Storage, Transportation, or Handling of Bulk Products	NO	NO	NO	NO

Table 4.3 Overview table heavy metals (NA – not available, NO – not occurring).

Sector		Heavy Metals								
		Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
2A1	Cement Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A2	Lime Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A3	Glass Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A5a	Quarrying and Mining of Minerals other than Coal	NA	NA	NA	NA	NA	NA	NA	NA	NA
2A5b	Construction and Demolition	NA	NA	NA	NA	NA	NA	NA	NA	NA
2A5c	Storage, Handling, and Transport of Mineral Products	NO	NO	NO	NO	NO	NO	NO	NO	NO
2A6	Other Mineral Products (Mineral Wool)	NA	NA	NA	NA	NA	NA	NA	NA	NA
2B1	Ammonia Production	IE	IE	IE	IE	IE	IE	IE	IE	IE
2B2	Nitric Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B3	Adipic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B5	Carbide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B6	Titanium Dioxide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B7	Soda Ash Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10a	Diatomite	NO	NO	NO	NO	NO	NO	NO	NO	NO

	Sector	Heavy Metals								
		Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
2B10a	Fertiliser	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B10b	Storage, Handling, and Transport of Chemical Products	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C1	Iron and Steel Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C2	Ferroalloys Production	T3	T3	T3	T3	T3	T3	T3	NA	T3
2C3	Primary Aluminium Production	NA	NA	NA	NA	NA	NA	NA	NA	NA
2C3	Secondary Aluminium Production	NA	NA	NA	NA	NA	NA	NA	NA	NA
2C4	Magnesium Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C5	Lead Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C6	Zinc Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7a	Copper Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7b	Nickel Production	NO	NO	NO	NO	NO	NO	NO	NO	NO
2C7c	Capacitor Production	NA	NA	NA	NA	NA	NA	NA	NA	NA
2C7d	Storage, Handling, and Transport of Metal Products	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3a	Domestic Solvent Use Including Fungicides	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3b	Road Paving with Asphalt	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3c	Asphalt Roofing	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3d	Coating Applications	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3e	Degreasing	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3f	Dry Cleaning	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3g	Chemical Products	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3h	Printing	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3i	Creosotes	NO	NO	NO	NO	NO	NO	NO	NO	NO
2D3i	Organic Solvent-borne Preservatives	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3i	Aircraft De-icing	NA	NA	NA	NA	NA	NA	NA	NA	NA
2G4	Tobacco	T2	T2	T2	T2	T2	T2	T2	T2	T2
2G4	Fireworks	T3	T2	T2	T2	T2	T2	T2	NA	T2
2H1	Pulp and Paper Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
2H2	Food and Beverages Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA
2H3	Other Industrial Processes	NO	NO	NO	NO	NO	NO	NO	NO	NO
2I	Wood Processing	NO	NO	NO	NO	NO	NO	NO	NO	NO
2J	Production of POPs	NO	NO	NO	NO	NO	NO	NO	NO	NO
2K	Consumption of POPs and Heavy Metals	NO	NO	NO	NO	NO	NO	NO	NO	NO
2L	Other Production, Consumption, Storage, Transportation, or Handling of Bulk Products	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 4.4 shows which subsectors 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 4.4 Key categories for air pollutants within IPPU.

SO_x, NO_x, NH_3, NMVOC, PM, BC, and CO			
	1990	2021	Trend
2A5a Quarrying and Mining of Minerals other than Coal	$PM_{2.5}$, PM_{10}, TSP		
2A5b Construction and Demolition	$PM_{2.5}$, PM_{10}, TSP	$PM_{2.5}$, PM_{10}, TSP	PM_{10}, TSP
2C2 Ferroalloys Production	SO_x, $PM_{2.5}$, PM_{10}	NO_x, $PM_{2.5}$	NO_x
2C3 Aluminium Production	$PM_{2.5}$, PM_{10}, 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	
2H2 Food and Beverages Industry		NMVOC	NMVOC
Persistent Organic Pollutants (POPs)			
	1990	**2021**	**Trend**
2C2 Ferroalloys Production		PAH4	PAH4
2C3 Aluminium Production		PAH4, HCB	PAH4
2G Other Product Use (Fireworks, tobacco)		HCB	HCB
Heavy Metals (HMs)			
	1990	**2021**	**Trend**
2C2 Ferroalloys Production		Cd, As	Cd, As
2G Other Product Use (Fireworks, Tobacco)		Cd	Pb, Cd, 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 dioksiner 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 (*Hagstofa Íslands*) (SI), 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 Environment Agency of Iceland (*Umhverfisstofnun*) (EAI) directly from the cement production plant.

4.3.1.2 Emission Factors

Emission factor for dioxin is taken from the Toolkit for Identification and Quantification of Dioxin and Furan Releases (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 summarised in the table below.

Table 4.5 Emission factors for 2A1 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 the Icelandic Road and Coastal Administration (*Vegagerðin*) (IRCA) who provided a timeseries from 1999 of aggregates with used by the IRCA for road construction, divided by the nature of the deposit. Currently no data is available prior to 1999, so the average 1999-

2001 has been used for the years 1990-1999. Data from the IRCA was also used to estimate which proportion of aggregate production is used by others (municipalities, private companies, etc.).

4.3.4.2 Emission Factors

Only particulate matter emissions, that is TSP, PM_{10}, and $PM_{2.5}$ arise from this category. The methodology follows Tier 2 technology-specific approach of the 2019 EMEP/EEA Guidebook and divides the emission into drilling and blasting, material processing, internal transport, material handling operations, and wind erosion from stockpiles.

The parameters to calculate the emission factors are taken from Section 3.3, Chapter 2.A.5.a of the Guidebook. Parameters concerning the nature of the quarries within Iceland were retrieved from the IRCA. Where country-specific parameters are not available, the sample parameters based on French context from the 2019 EMEP/EEA Guidebook are used. Average values are used as an input in the spreadsheet model provided by the 2019 EMEP/EEA Guidebook to calculate the emission factors used. All quarries in Iceland are small quarries (yearly production less than 100 kt). No data is available on the amount of recycled aggregate, produced from Construction and Demolition residues. Therefore, the emissions from recycled aggregate is not estimated. No data is available on the distance travelled by dumpers within the quarries and the emissions from that part is therefore not estimated. Table 4.6 shows the emission factors used that show the emissions per tonne of aggregate production.

Table 4.6: Emission factors used within 2A5a Quarrying and Mining of Minerals.

Emission Factors – Quarrying and Mining (2A5a)	Drilling and Blasting	Material Processing		Internal Transport	Material Handling Operation		Wind Erosion from Stockpiles	
	Crushed Rock	Crushed Rock	Sand & Gravel		Crushed Rock	Sand & Gravel	Crushed Rock	Sand & Gravel
TSP [g/t]	1.23	10.45	5.72	NE	10.66	2.29	41.3	20.7
PM_{10} [g/t]	0.65	3.79	2.17	NE	5.04	1.08	20.7	10.3
$PM_{2.5}$ [g/t]	0.64	0.68	0.58	NE	0.76	0.16	8.26	4.13

4.3.4.3 Recalculations and Improvements

Since last submission there has been a tier upgrade from Tier 1 to Tier 2, see Table 4.7.

Table 4.7: Recalculations within 2A5a Quarrying and Mining of Minerals other than Coal, due to tier upgrade.

2A5b, Construction and Demolition	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission TSP [kt]	0.44	0.44	0.44	1.15	0.98	0.35	0.671	0.671
2023 Submission TSP [kt]	0.65	0.65	0.62	0.34	0.53	0.13	0.066	0.041
Change relative to the 2022 Submission TSP	48%	48%	41%	-70%	-46%	-62%	-90%	-94%
2022 Submission PM_{10} [kt]	0.22	0.22	0.22	0.57	0.48	0.17	0.329	0.329
2023 Submission PM_{10} [kt]	0.31	0.31	0.29	0.16	0.25	0.06	0.031	0.019
Change relative to the 2022 Submission PM_{10}	43%	43%	36%	-71%	-48%	-64%	-90%	-94%
2022 Submission $PM_{2.5}$ [kt]	0.022	0.022	0.022	0.057	0.048	0.017	0.033	0.033
2023 Submission $PM_{2.5}$ [kt]	0.109	0.109	0.103	0.057	0.089	0.022	0.011	0.007
Change relative to the 2022 Submission $PM_{2.5}$	405%	405%	380%	1.4%	85%	29%	-66%	-79%

4.3.4.4 Planned Improvements

No improvements are currently planned for this subsector.

4.3.5 Construction and Demolition (NFR 2A5b)

4.3.5.1 Activity Data

To retrieve activity data, the amount of buildings per construction year, subdivided by the type of houses (terraced, detached, semi-detached, apartment buildings, non-residential buildings) is obtained from the Housing and Construction Authority. Data about road construction is retrieved from the IRCA 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 0, apartment buildings 0, 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

Recalculation has been made for the whole timeseries due to updated activity data about constructed buildings from the Housing and Construction Authority. The effects can be seen in Table 4.8.

Table 4.8: Recalculations within 2A5b Construction and Demolition due to updated activity data.

2A5b, Construction and Demolition	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission TSP [kt]	3.9103	4.863	4.283	3.105	6.185	0.960	1.921	2.066
2023 Submission TSP [kt]	3.9098	4.863	4.279	3.103	6.186	0.961	1.921	2.071
Change relative to the 2022 Submission TSP	-0.013%	-0.010%	-0.080%	-0.072%	0.014%	0.152%	-0.036%	0.212%
2022 Submission PM_{10} [t]	1.1692	1.4539	1.2812	0.9295	1.8492	0.2872	0.5753	0.6187
2023 Submission PM_{10} [t]	1.1691	1.4537	1.2801	0.9288	1.8494	0.2877	0.5751	0.6200
Change relative to the 2022 Submission PM_{10}	-0.013%	-0.010%	-0.081%	-0.072%	0.014%	0.153%	-0.036%	0.208%
2022 Submission $PM_{2.5}$ [t]	0.11692	0.14539	0.12812	0.09295	0.18492	0.02872	0.05753	0.06187
2023 Submission $PM_{2.5}$ [t]	0.11691	0.14537	0.12801	0.09288	0.18494	0.02877	0.05751	0.06200
Change relative to the 2022 Submission $PM_{2.5}$	-0.013%	-0.010%	-0.081%	-0.072%	0.014%	0.153%	-0.036%	0.208%

Recalculations from the 2022 Submission

The Thornthwaite Precipitation-evaporation Index was recalculated for the whole timeseries for the 2022 Submission. 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.

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 emissions within the sector are insignificant and therefore not estimated.

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 EAI, 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 dioksiner 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 PM_{10} were calculated based on measurements at the factory. In the case of NH_3 and PM_{10}, 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 IEF of measurements 2009, 2011, 2013, and 2015 was used. Since 2018 yearly total emissions for NH_3 are communicated from company directly. TSP and $PM_{2.5}$ were calculated from PM_{10} 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 1A2f. Table 4.9 shows the emission factors used for Mineral Wool Production.

Table 4.9 Emission factors for Mineral Wool Production (for NH_3, CO, TSP, and PM_{10} the values are IEF averages for the whole timeline).

	NH_3 [t/kt]	CO [t/kt]	TSP % of PM_{10}	PM_{10} [t/kt]	$PM_{2.5}$ % of TSP	BC % of $PM_{2.5}$	Dioxin [µg/t I-TEQ/t]
Mineral Wool Production	1.12	1.40	114%	1.01	78%	2.0%	1.6

4.3.7.3 Recalculations and Improvements

PM, CO, and NH_3 (prior to 2018) emissions are calculated based on number of hours/year the factory is in operation. Until now, a whole year production was assumed. Now, factory data about number of hours/year in production are used. This data is available since 2015. Before 2015, the average production per hour for 2015-2019 is used to calculate production hours per year. Since number of production hours is less than total hours, these recalculations led to reduction in emission.

In addition, the factory data about PM emissions were assumed to be TSP but are PM_{10}. This was now corrected in the inventory and TSP and $PM_{2.5}$ are calculated from the PM_{10} using the ratios from the 2019 EMEP/EEA Guidebook as described above. Table 4.10 shows the effect of the change.

Table 4.10: Recalculations within 2A6 Mineral Wool Production, due to updated data of PM, CO, and NH_3 from the factory as well as correction of size distribution.

2A6 Mineral Wool Production	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission TSP [t]	15.8	18.7	21.2	25.4	14.4	16.7	30.5	9.7
2023 Submission TSP [t]	4.9	5.8	6.5	5.8	6.1	9.7	21.6	6.6
Change relative to the 2022 Submission TSP	-69%	-69%	-69%	-77%	-57%	-42%	-29%	-31%
2022 Submission PM_{10} [t]	13.9	16.4	18.6	22.4	12.6	14.7	26.8	8.5
2023 Submission PM_{10} [t]	4.3	5.1	5.8	5.1	5.4	8.6	19.0	5.8
Change relative to the 2022 Submission PM_{10}	-69%	-69%	-69%	-77%	-57%	-42%	-29%	-31%
2022 Submission $PM_{2.5}$ [t]	12.2	14.5	16.4	19.7	11.1	12.9	23.7	7.5
2023 Submission $PM_{2.5}$ [t]	3.8	4.5	5.1	4.5	4.7	7.5	16.8	5.2
Change relative to the 2022 Submission $PM_{2.5}$	-69%	-69%	-69%	-77%	-57%	-42%	-29%	-31%
2022 Submission BC [t]	0.24	0.29	0.33	0.39	0.22	0.26	0.47	0.15
2023 Submission BC [t]	0.08	0.09	0.10	0.09	0.09	0.15	0.34	0.10
Change relative to the 2022 Submission BC	-69%	-69%	-69%	-77%	-57%	-42%	-29%	-31%
2022 Submission CO [t]	16.4	19.4	21.9	15.3	4.8	4.9	5.3	5.3
2023 Submission CO [t]	16.4	19.4	21.9	13.2	1.5	2.5	3.3	3.2
Change relative to the 2022 Submission CO	0.0%	0.0%	0.0%	-14%	-68%	-49%	-38%	-40%
2022 Submission NH_3 [t]	16.2	19.2	21.8	26.2	14.9	15.7	14.0	14.4
2023 Submission NH_3 [t]	6.3	7.5	8.5	13.8	5.2	8.1	14.0	14.4
Change relative to the 2022 Submission NH_3	-61%	-61%	-61%	-47%	-65%	-49%	0.0%	0.0%

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 fertilisers 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: Fertiliser 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 fertiliser and diatomite. The fertiliser 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 fertiliser 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 fertiliser was produced (a nitrogen fertiliser), whereas at the end of its production phase it was producing over 20 different types of fertilisers. CO_2 and CH_4 emissions are considered insignificant, as the fertiliser plant used H_2 produced on-site by electrolysis. Methodology NO_x and N_2O emissions were reported directly by the factory to the EAI.

4.4.7.1 Activity Data

When the fertiliser production plant was operational it reported its emissions of NO_x and N_2O to the EAI. 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 4.11.

Table 4.11 Production data for 1990, 1995, and 2000 for fertiliser and silica production [kt].

	1990	1995	2000	Notes
Fertiliser 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 fertiliser production, the average implied EF for NO_x for the period 1990-2001 was 0.296 t NO_x/kt fertiliser production. As there is no data readily available about the types of fertilisers produced at the time, no other pollutants were estimated for this industry.

4.4.7.3 Recalculations and Improvements

Recalculations were made due to an oversight from previous calculations, where NO_x emissions from Diatomite production for the years 2005 and 2006 were included. The production had ceased at this point, see Table 4.12.

Table 4.12 Recalculations of NO_x emissions for 2B10a Diatomite Production.

2B10a Diatomite Production	2005	2006
2022 Submission NO_x [kt]	0.32	0.48
2023 Submission NO_x [kt]	0.00	0.00
Change relative to the 2022 Submission NO_x	-100%	-100%

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 EAI.

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. It should be noted that Tier 1 and Tier 2 exclude condensable PM.

4.5.1.3 Recalculations and Improvements
The HCB emissions were missing in the inventory due to a mistake. Now they are included, see Table 4.13.

Table 4.13 Recalculation of HCB for 2C1, Iron and Steel Production.

2C1, Iron and Steel Production	2014	2015	2016
2022 Submission HCB [kg]	NO	NO	NO
2023 Submission HCB [kg]	0.0003126	0.000129	0.000228
Change relative to the 2022 Submission HCB	-	-	-

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 is collected by the EAI 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 4.14.

Table 4.14 Raw materials use [kt] and production [kt], ferrosilicon and silicon production.

	1990	1995	2000	2005	2010	2015	2020	2021
Electrodes	3.83	3.88	5.73	6.00	4.79	4.86	4.82	5.15
Coking coal	45.1	52.4	73.2	86.9	96.1	115	129	146
Coke oven coke	24.9	30.1	46.6	42.6	30.3	30.9	23.5	23.6
Charcoal	NA	NA	NA	2.08	NA	NA	1.67	4.21
Wood	16.7	7.7	16.2	15.6	11.3	27.2	59.9	77.9
Limestone	NA	NA	0.47	1.62	0.50	2.19	0.95	2.09
Production (FeSi, Si)	63	71	109	111	102	118	116	133
Microsilica	14.0	15.9	22.7	25.8	18.1	22.2	20.3	19.5
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 4.16. 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. The 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 (8,760 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 2002-2006. Microsilica (fine and coarse) production rate and production per furnace were extrapolated for the years 1990 to 2001 based on total produced FeSi at the plant each year. Since 2012, TSP are obtained from the yearly Green Accounting report submitted to EAI. Emissions factors of PM_{10} and $PM_{2.5}$ relative to TSP are Tier 1 default values from the 2019 EMEP/EEA Guidebook (EEA, 2019); this excludes condensable PM. The emission factor for BC is taken from (Aasestad, 2013) in accordance with the Norwegian IIR (Norwegian Environment Agency, 2020).

Several heavy metals (As, Cd, Cr, Cu, Hg, Pb, and Zn) were measured in silicon dust in the ferrosilicon plant in 2014 and 2019. 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 2014 and <0.1 mg/kg in 2019) in all samples. Prior to 2014 the values from the 2014 measurements are used, after 2019 the values from the 2019 measurements are used and between 2014 and 2019 a linear interpolation of the IEF from 2014 and 2019 was done. The heavy metal contents in silica dust are shown in Table 4.15.

Table 4.15 Heavy metal contents in silica dust in 2014 and 2019 [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 2014	11.8	0.46	8.8	10.8	< 9	8.7	25.2
Content in silicon dust 2019	23.3	0.60	59	160.7	< 0.1	41.7	186.7

Si Production: Emission factors for filterable particulate matter, excluding condensables, are Tier 3 plant specific and for BC are Tier 1 default values as published in the 2019 EMEP/EEA Guidebook based on the ratio of BC to $PM_{2.5}$. 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 and dioxin are reported by the operator to the EAI 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 4.16.

Table 4.16 2021 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	0.62	85% of TSP	60% of TSP
Si	13	NA	NA	0.49	0.49 kg/t	0.49 kg/t
	BC % of $PM_{2.5}$	**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%	4.23	NA	NA	NA	NA

4.5.2.3 Recalculations and Improvements

Three changes resulted in recalculations. First, the result of heavy metal measurements at the FeSi plant from 2019 was now added to the inventory. Since the earlier measurement was from 2014, a linear interpolation from the 2014 IEF to the 2019 IEF was made for the years between. The 2019 IEF is used for the years after 2019. This leads to recalculation of the heavy metals, see Table 4.17. In addition, Pb emissions were estimated to be zero since the measurements were below the detection limits. For the approach to be conservative, the detection limit is now used as an emission estimate instead of zero. This leads to recalculation of Pb for the whole timeline.

Dioxin emissions were reported for the first time for the Si plant in the annual Green Accounting report. Assuming same IEF in past years, recalculations were made for dioxin emissions for the years 2018-2020, see Table 4.17.

Second, the production amount for the year 2012 was corrected from 118.358 kt. To 118.359 kt. This led to recalculations for all air pollutants for the year 2012, see Table 4.17.

Third, measurements for As, Cr, and Ni at the Si plant were used to calculate an implied emission factor and applied to the whole timeline. This means Ni is included in this sector for the first time.

Table 4.17 Recalculations of dioxin and heavy metals for 2C2 Ferroalloys Production.

2C2 Ferroalloys Production	1990	1995	2000	2005	2010	2012	2015	2019	2020
2022 Submission TSP [kt]	0.100	0.114	0.166	0.150	0.127	0.293528	0.272	0.079	0.096
2023 Submission TSP [kt]	0.100	0.114	0.166	0.150	0.127	0.293530	0.272	0.079	0.096
Change relative to the 2022 Submission TSP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	0.0%	0.0%	0.0%
2022 Submission PM_{10} [kt]	0.085	0.097	0.141	0.128	0.108	0.249499	0.232	0.069	0.087
2023 Submission PM_{10} [kt]	0.085	0.097	0.141	0.128	0.108	0.249501	0.232	0.069	0.087
Change relative to the 2022 Submission PM_{10}	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	0.0%	0.0%	0.0%
2022 Submission $PM_{2.5}$ [kt]	0.060	0.068	0.100	0.090	0.076	0.176117	0.163	0.052	0.071
2023 Submission $PM_{2.5}$ [kt]	0.060	0.068	0.100	0.090	0.076	0.176118	0.163	0.052	0.071
Change relative to the 2022 Submission $PM_{2.5}$	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	0.0%	0.0%	0.0%
2022 Submission BC [t]	0.14	0.16	0.23	0.21	0.18	0.405068	0.38	1.28	3.42
2023 Submission BC [t]	0.14	0.16	0.23	0.21	0.18	0.405071	0.38	1.28	3.42
Change relative to the 2022 Submission BC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	0.0%	0.0%	0.0%
2022 Submission NO_x [g]	0.69	0.79	1.20	1.22	1.12	1.30194	1.30	1.35	1.30
2023 Submission NO_x [g]	0.69	0.79	1.20	1.22	1.12	1.30195	1.30	1.35	1.30
Change relative to the 2022 Submission NO_x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	0.0%	0.0%	0.0%
2022 Submission NMVOC [kt]	0.0028	0.0032	0.0049	0.0050	0.0046	0.005326	0.0053	0.0045	0.0047
2023 Submission NMVOC [kt]	0.0028	0.0032	0.0049	0.0050	0.0046	0.005326	0.0053	0.0045	0.0047
Change relative to the 2022 Submission NMVOC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	0.0%	0.0%	0.0%
2022 Submission SO_2 [kt]	1.8	1.4	2.0	2.6	2.4	2.24880	2.1	2.2	2.0
2023 Submission SO_2 [kt]	1.8	1.4	2.0	2.6	2.4	2.24882	2.1	2.2	2.0
Change relative to the 2022 Submission SO_2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	0.0%	0.0%	0.0%
2022 Submission CO [kt]	0.16	0.18	0.27	0.28	0.26	0.295895	0.29	0.25	0.26
2023 Submission CO [kt]	0.16	0.18	0.27	0.28	0.26	0.295898	0.29	0.25	0.26
Change relative to the 2022 Submission CO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	0.0%	0.0%	0.0%
2022 Submission PAH4 [kg]	6.4	7.3	11.1	11.3	10.4	12.0987	12.1	10.248	10.686
2023 Submission PAH4 [kg]	6.4	7.3	11.1	11.3	10.4	12.0988	12.1	10.248	10.686
Change relative to the 2022 Submission PAH4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	0.0%	0.0%	0.0%
2022 Submission dioxin [g]	0.0072	0.0082	0.0124	0.0127	0.0117	0.014	0.0	0.011	0.012
2023 Submission dioxin [g]	0.0072	0.0082	0.0124	0.0127	0.0117	0.014	0.0	0.093	0.060
Change relative to the 2022 Submission dioxin	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	0.0%	709%	405%
2022 Submission Pb [kg]	0.87	0.99	1.45	1.31	1.10	2.55369	2.37	1.97	1.35
2023 Submission Pb [kg]	0.87	0.99	1.45	1.31	1.10	2.55371	4.17	4.19	3.42

2C2 Ferroalloys Production	1990	1995	2000	2005	2010	2012	2015	2019	2020
Change relative to the 2022 Submission Pb	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	76%	112%	154%
2022 Submission Cd [kg]	0.05	0.05	0.08	0.07	0.06	0.135023	0.125	2.09	1.21
2023 Submission Cd [kg]	0.05	0.05	0.08	0.07	0.06	0.135024	0.133	2.10	1.22
Change relative to the 2022 Submission Cd	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	6.1%	0.4%	0.7%
2022 Submission Hg [kg]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2023 Submission Hg [kg]	0.90	1.02	1.50	1.35	1.14	2.64	1.97	0.007	0.006
Change relative to the 2022 Submission Hg	-	-	-	-	-	-	-	-	-
2022 Submission As [kg]	1.18	1.34	1.96	1.78	1.50	3.4636	3.22	0.79	0.74
2023 Submission As [kg]	1.18	1.34	1.96	1.78	1.50	3.4637	3.84	3.09	1.46
Change relative to the 2022 Submission As	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	19%	290%	97%
2022 Submission Cr [kg]	0.88	1.00	1.46	1.32	1.12	2.5830	2.40	0.59	0.55
2023 Submission Cr [kg]	0.88	1.00	1.46	1.32	1.12	2.5831	5.13	5.23	3.70
Change relative to the 2022 Submission Cr	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	114%	785%	570%
2022 Submission Cu [kg]	1.08	1.23	1.80	1.62	1.37	3.17010	2.94	9.24	5.31
2023 Submission Cu [kg]	1.08	1.23	1.80	1.62	1.37	3.17013	11.11	19.30	14.71
Change relative to the 2022 Submission Cu	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	278%	109%	177%
2022 Submission Ni [kg]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2023 Submission Ni [kg]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.45
Change relative to the 2022 Submission Ni	-	-	-	-	-	-	-	-	-
2022 Submission Zn [kg]	2.52	2.86	4.19	3.79	3.20	7.3969	6.87	51.70	28.48
2023 Submission Zn [kg]	2.52	2.86	4.19	3.79	3.20	7.3970	15.67	62.55	38.61
Change relative to the 2022 Submission Zn	0.0%	0.0%	0.0%	0.0%	0.0%	0.0008%	128%	21%	36%

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 EAI collects annual process specific data from the three operators through EU ETS and Green Accounting reports. The total production of the three aluminium plants is given in Table 4.18.

Table 4.18 Primary Aluminium Production [kt].

	1990	1995	2000	2005	2010	2015	2020	2021
Primary Al Production [kt]	88	100	226	272	819	857	831	836

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 4.19 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 EAI. Ratios of TSP:PM_{10}:$PM_{2.5}$ as well as the BC emission factor were also taken from the 2019 EMEP/EEA Guidebook. Green Accounting includes filterable PM, condensable PM is therefore excluded. 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. Emission factors are presented in Table 4.19.

Table 4.19 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

Recalculations were made for the year 2008 due to a typing error of activity data from one smelter, see Table 4.20.

Table 4.20: Recalculations in 2C3 Aluminium Production for the year 2008.

2C3 Aluminium Production	2008
2022 Submission TSP [kt]	0.545706
2023 Submission TSP [kt]	0.545722
Change relative to the 2022 Submission TSP	0.0029%
2022 Submission PM_{10} [kt]	0.454755
2023 Submission PM_{10} [kt]	0.454768
Change relative to the 2022 Submission PM_{10}	0.0029%
2022 Submission $PM_{2.5}$ [kt]	0.363804
2023 Submission $PM_{2.5}$ [kt]	0.363815
Change relative to the 2022 Submission $PM_{2.5}$	0.0029%
2022 Submission BC [kt]	0.008367
2023 Submission BC [kt]	0.008368
Change relative to the 2022 Submission BC	0.0029%
2022 Submission NO_x [kt]	0.781133
2023 Submission NO_x [kt]	0.781151
Change relative to the 2022 Submission NO_x	0.0023%
2022 Submission CO [kt]	93.735960

2C3 Aluminium Production	2008
2023 Submission CO [kt]	93.738120
Change relative to the 2022 Submission CO	0.0023%
2022 Submission PAH4 [kg]	14.794117
2023 Submission PAH4 [kg]	14.794458
Change relative to the 2022 Submission PAH4	0.0023%
2022 Submission BaP [kg]	1.964809
2023 Submission BaP [kg]	1.964855
Change relative to the 2022 Submission BaP	0.0023%
2022 Submission BbF[kg]	9.067857
2023 Submission BbF [kg]	9.068066
Change relative to the 2022 Submission BbF	0.0023%
2022 Submission BkF [kg]	2.633645
2023 Submission BkF [kg]	2.633706
Change relative to the 2022 Submission BkF	0.0023%
2022 Submission Ipy [kg]	1.127806
2023 Submission Ipy [kg]	1.127832
Change relative to the 2022 Submission Ipy	0.0023%
2022 Submission PCDD/F [g]	0.025673
2023 Submission PCDD/F [g]	0.025674
Change relative to the 2022 Submission PCDD/F	0.0023%

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 EAI, see Table 4.21.

Table 4.21 Secondary Aluminium Production [kt].

	1990	1995	2000	2005	2010	2015	2020	2021
Secondary Al Production [kt]	NO	NO	NO	2.25	2.04	2.20	2.20	3.61

4.5.4.2 Emission Factors

Emissions of dioxin, HCB, and PM (excluding condensable 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 emissions are based on on-site measurements in 2014 and every year since 2016. For the year 2015, the average of the implied emission factor for 2014 and 2016 is used. For the years 2012 and 2013 the implied emission factor for 2014 is used. For the first factory (before 2004) the emission factors are taken from the Table 3.4 in the EMEP/EEA Guidebook (EEA, 2019). The PM_{10} and $PM_{2.5}$ emission factors are based on the same ratios to TSP as in Table 3.4 in the EMEP/EEA Guidebook. The BC emission factor is taken from the same table.

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 4.22 Emission factors, Secondary Aluminium Production. TSP IEF is the average of the years 2012-2021.

	Dioxin [µg/t Al]	HCB [mg/t Al]	TSP [kg/t]	PM_{10} [% of TSP]	$PM_{2.5}$ [% of TSP]	BC [% of $PM_{2.5}$]
Emission factors	0.45	5.0	0.40	70%	27.5%	2.3%

4.5.4.3 Recalculations and Improvements

The particulate matter emissions are now based on measurements on-site but not the default emission factor from the 2019 EMEP/EEA Guidebook. However, the emissions of PM_{10}, $PM_{2.5}$, and BC as a fraction of TSP according to the ratios in the Guidebook are unchanged. 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 4.23.

Table 4.23 Recalculations within 2C3, Secondary Aluminium Production.

2C3 Secondary Aluminium Production	2012	2013	2014	2015	2016	2017	2018	2019	2020
2022 Submission TSP [t]	0.46	3.80	2.96	3.20	4.20	5.83	6.25	4.33	4.39
2023 Submission TSP [t]	0.08	0.69	0.54	0.96	1.76	1.20	0.45	0.83	0.52
Change relative to the 2022 Submission TSP	-82%	-82%	-82%	-70%	-58%	-79%	-93%	-81%	-88%
2022 Submission PM_{10} [t]	0.32	2.66	2.07	2.24	2.94	4.08	4.37	3.03	3.07
2023 Submission PM_{10} [t]	0.06	0.48	0.38	0.67	1.23	0.84	0.32	0.58	0.36
Change relative to the 2022 Submission PM_{10}	-82%	-82%	-82%	-70%	-58%	-79%	-93%	-81%	-88%

2C3 Secondary Aluminium Production	2012	2013	2014	2015	2016	2017	2018	2019	2020
2022 Submission $PM_{2.5}$ [t]	0.13	1.05	0.81	0.88	1.16	1.60	1.72	1.19	1.21
2023 Submission $PM_{2.5}$ [t]	0.02	0.19	0.15	0.26	0.48	0.33	0.12	0.23	0.14
Change relative to the 2022 Submission $PM_{2.5}$	-82%	-82%	-82%	-70%	-58%	-79%	-93%	-81%	-88%
2022 Submission BC [t]	0.003	0.024	0.019	0.020	0.027	0.037	0.040	0.027	0.028
2023 Submission BC [t]	0.001	0.004	0.003	0.006	0.011	0.008	0.003	0.005	0.003
Change relative to the 2022 Submission BC	-82%	-82%	-82%	-70%	-58%	-79%	-93%	-81%	-88%

4.5.4.4 Planned Improvements

No improvements are currently planned for this subsector.

4.5.5 Magnesium Production (NFR 2C4)

This activity does not occur in Iceland.

4.5.6 Lead Production (NFR 2C5)

This activity does not occur in Iceland.

4.5.7 Zinc Production (NFR 2C6)

This activity does not occur in Iceland.

4.5.8 Capacitor Production (NFR 2C7c)

Production of the dielectric of aluminium electrolytic capacitor started in the year 2009 in a single plant and achieved full capacity in 2011. The plant receives aluminium sheets and a thin layer of aluminium oxide “forms” on the surface of the etched aluminium foil during a process called “formation.” During the formation the aluminium sheet is submerged in a liquid bath and ammonium hydroxide is used to control the pH level of the liquid.

4.5.8.1 Activity Data

All activity data, consisting of used ammonium hydroxide, is obtained in Green Accounting reports submitted yearly to the EAI, see Table 4.24.

Table 4.24 Ammonium hydroxide used during production [kt].

	2009	2010	2015	2020	2021
Ammonium hydroxide used [kt]	0.0509	0.1119	0.0654	0.0494	0.0452

4.5.8.2 Emission Factors

The plant only emits NH_3. In Green Accounting, the concentration, and thereby the emission factor of NH_3, of the ammonium hydroxide is given as 24.5%.

4.5.8.3 Recalculations

No recalculations were made for this submission. These emissions were added for the first time in the 2023 Submission.

4.5.8.4 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 SI.

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 4.25. References and more details about individual emission factors are included in the respective subchapters.

Table 4.25 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	-	-	-	-
2D3i Aircraft De-icing	kg de-icing fluid	53	-	-	-	-
	Unit	**Dioxin [µg I-TEQ/unit]**	**BaP [mg/unit]**	**BbF [mg/unit]**	**BkF [mg/unit]**	**Ipy [mg/unit]**
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	-	-	-	-	-
2D3i Aircraft De-icing	kg de-icing fluid	-	-	-	-	-

4.6.1 Domestic Solvent Use Including Fungicides (NFR 2D3a)

Domestic solvent use is calculated using a default per capita value, as per Tier 2b, Table 3.5 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 SI.

4.6.1.2 Emission Factors

The emission factor for NMVOC for different products and product types per person was taken from Table 3.5, 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

No category-specific recalculations were done for the current submission.

Recalculations from the 2022 Submission:

Recalculations of NMVOC within the 2D3a subsector for the 2022 submission were 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 (EEA, 2019)).

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 SI until 2011, and directly from the companies producing asphalt since 2012, see Table 4.26.

Table 4.26 Production of asphalt for road paving [kt].

	1990	1995	2000	2005	2010	2015	2020	2021
Road Paving with Asphalt Production [kt]	172.44	172.44	323.52	334.97	234.51	193.99	240.00	272.65

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), this excludes condensable PM. 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, see Table 4.27. 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.

Table 4.27 Total solvent-based paint (domestic production and imports) [kt].

	1990	1995	2000	2005	2010	2015	2020	2021
Total solvent-based paint [kt]	2.21	2.38	2.44	1.49	1.26	1.38	1.92	1.78

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*
Recalculations were made due to updates in import/export data from SI, see Table 4.28.

Table 4.28 Recalculations of emissions within 2D3d Coating for 1999, 2009, 2012, 2015, and 2019 between the 2022 and 2023 Submissions.

2D3d Coating	1999	2009	2012	2015	2019
2022 Submission NMVOC [kg]	527,909.8	326,528.9	320,252.9	318,266.6	292,725.1
2023 Submission NMVOC [kg]	527,908.2	326,523.6	320,249.2	318,265.0	300,885.8
Change relative to the 2022 Submission	-0.0003%	-0.0016%	-0.0011%	-0.0005%	2.8%

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 SI; see Table 4.29. 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 with more accuracy and 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). However, the use of PER in Dry Cleaning 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.

Table 4.29 Imports of cleaning products [kt].

	1990	1995	2000	2005	2010	2015	2020	2021
Cleaning product imports [kt]	0.17	0.12	0.19	0.13	0.08	0.10	0.09	0.11

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

Recalculations were made due to updates in import/export data from SI, see Table 4.30.

Table 4.30 Recalculations of emissions within 2D3e (Degreasing) for 2010, 2014, and 2019 between the 2022 and 2023 Submissions.

2D3e Degreasing	2010	2014	2019
2022 Submission NMVOC [kg]	37,950.5	36,988.6	58,183.6
2023 Submission NMVOC [kg]	37,950.0	36,985.8	57,822.0
Change relative to the 2022 Submission	-0.001%	-0.007%	-0.6%

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

No category-specific recalculations were done for the current submission.

Recalculation from the 2022 Submission:

Recalculations 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.

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 4.6.3 Coating Applications, see Table 4.31.

Table 4.31 Domestically produced solvent-based paint [kt].

	1990	1995	2000	2005	2010	2015	2020	2021
Solvent-based Paint Domestic Production [kt]	1.42	1.42	1.11	0.49	0.29	0.30	0.72	0.36

4.6.6.2 Emission Factors

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 SI, see Table 4.32.

Table 4.32 Total imports of ink [kt]

	1990	1995	2000	2005	2010	2015	2020	2021
Print/ink import [kt]	0.15	0.22	0.40	0.61	0.38	0.41	0.16	0.17

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

Recalculations were made due to updates in import/export data from Statistics Iceland, see Table 4.33.

Table 4.33 Recalculations of emissions within 2D3h Printing for 1999, 2000, 2013, 2014, and 2019 between the 2022 and 2023 Submissions.

2D3h Printing	1999	2000	2013	2014	2019
2022 Submission NMVOC [kg]	193,804	198,183	196,022	208,905	125,882
2023 Submission NMVOC [kg]	193,794	198,147	195,992	208,935	126,734
Change relative to the 2022 Submission	-0.01%	-0.02%	-0.02%	0.01%	0.68%

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. De-icing fluid is used to de-ice aircrafts at airports. NMVOC emissions occur from the propylene glycol in the de-icing fluid.

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. Data on de-icing fluid used was sent by e-mail from Icelandair/Jet Centre and Airport Associates Keflavík.

Table 4.34 Total import of preservatives [kg] and total de-icing fluid used [l].

	1990	1995	2000	2005	2010	2015	2020	2021
Creosote preservative import [kg]	12,450	6,930	2,245	300	1,968	0	0	0
Organic solvent-borne preservative import [kg]	7,795	19,021	26,666	90,871	32,513	28,019	39,799	43,628
De-icing fluid used [l]	664,772	664,772	664,772	664,772	664,772	570,614	690,152	424,670

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

Recalculations were made due to updates in import/export data of Organic Solvent-borne Preservatives from Statistics Iceland, see Table 4.35.

Table 4.35 Recalculation of emission within 2D3i Total Wood Preservation for 2019 between the 2022 and 2023 Submissions.

2D3i Total Wood Preservation	2019
2022 Submission NMVOC [kg]	47,739
2023 Submission NMVOC [kg]	47,689
Change relative to the 2022 Submission	-0.10%

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 IPPU 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 (except Pb) were taken from Table 3-14 in Chapter 2.D.3.i, 2.G of the 2019 EMEP/EEA Guidebook (EEA, 2019). The emissions factors for Pb and HCB are based on measurements of the average Pb and HCB content in a sample of different fireworks sold in Iceland from 2018. All emission factors are presented in Table 4.36.

Table 4.36 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]	HCB [g/t]
Tobacco	100	0.111	0.045	0.045	0.045	NA
Fireworks	NA	NA	NA	NA	NA	0.047

	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	48.5	1.48	0.057	1.33	15.6	444	30	NA	260

4.7.1.3 Recalculations and Improvements

There were two reasons for recalculations. First, the Pb EF for fireworks is now country specific, based on sample measurements, but was from the EMEP/EEA Guidebook in the last submission. Emissions of HCB were also added for the first time, based on sample measurements of fireworks in Iceland. Second, there were updates in import/export data from Statistics Iceland. The recalculations can be seen in Table 4.37, Table 4.38 and Table 4.39.

Table 4.37 Recalculations of emission within 2G4 (Tobacco) for the years 2003, 2005, 2013, and 2019 between 2022 and 2023 Submissions.

2G4 Tobacco	2003	2005	2013	2019
2022 Submission TSP [t]	10.8666	10.38582	11.90	5.77598
2023 Submission TSP [t]	10.8667	10.38574	8.05	5.77970
Change relative to the 2022 Submission TSP	0.001%	-0.001%	-32%	0.06%
2022 Submission PM_{10} [t]	10.86656	10.38582	11.90	5.77598
2023 Submission PM_{10} [t]	10.86672	10.38574	8.05	5.77970
Change relative to the 2022 Submission PM_{10}	0.001%	-0.001%	-32%	0.06%
2022 Submission $PM_{2.5}$ [t]	10.86656	10.38582	11.90	5.77598
2023 Submission $PM_{2.5}$ [t]	10.86672	10.38574	8.05	5.77970
Change relative to the 2022 Submission $PM_{2.5}$	0.001%	-0.001%	-32%	0.06%
2022 Submission BC [t]	0.048899	0.0467362	0.05	0.02599
2023 Submission BC [t]	0.048900	0.0467358	0.04	0.02601
Change relative to the 2022 Submission BC	0.001%	-0.001%	-32%	0.06%
2022 Submission NO_x [t]	0.72444	0.69239	0.79	0.38507
2023 Submission NO_x [t]	0.72445	0.69238	0.54	0.38531
Change relative to the 2022 Submission NO_x	0.001%	-0.001%	-32%	0.06%
2022 Submission NMVOC [t]	1.94793	1.86175	2.13	1.03540

2G4 Tobacco	2003	2005	2013	2019
2023 Submission NMVOC [t]	1.94796	1.86174	1.44	1.03606
Change relative to the 2022 Submission NMVOC	0.001%	-0.001%	-32%	0.06%
2022 Submission CO [t]	22.17582	21.19477	24.28	11.78727
2023 Submission CO [t]	22.17615	21.19460	16.42	11.79487
Change relative to the 2022 Submission CO	0.001%	-0.001%	-32%	0.06%
2022 Submission NH_3 [t]	1.67023	1.59634	1.83	0.88779
2023 Submission NH_3 [t]	1.67025	1.59633	1.24	0.88836
Change relative to the 2022 Submission NH_3	0.001%	-0.001%	-32%	0.06%
2022 Submission PAH4 [kg]	0.0990064	0.0946264	0.11	0.052626
2023 Submission PAH4 [kg]	0.0990079	0.0946256	0.07	0.052659
Change relative to the 2022 Submission PAH4	0.001%	-0.001%	-32%	0.06%
2022 Submission BaP [kg]	0.0446736	0.0426973	0.05	0.023746
2023 Submission BaP [kg]	0.0446743	0.0426969	0.03	0.023761
Change relative to the 2022 Submission BaP	0.001%	-0.001%	-32%	0.06%
2022 Submission BbF [kg]	0.0181109	0.0173097	0.02	0.009627
2023 Submission BbF [kg]	0.0181112	0.0173096	0.01	0.009633
Change relative to the 2022 Submission BbF	0.001%	-0.001%	-32%	0.06%
2022 Submission BkF [kg]	0.0181109	0.0173097	0.02	0.009627
2023 Submission BkF [kg]	0.0181112	0.0173096	0.01	0.009633
Change relative to the 2022 Submission BkF	0.001%	-0.001%	-32%	0.06%
2022 Submission Ipy [kg]	0.0181109	0.0173097	0.02	0.009627
2023 Submission Ipy [kg]	0.0181112	0.0173096	0.01	0.009633
Change relative to the 2022 Submission Ipy	0.001%	-0.001%	-32%	0.06%
2022 Submission PCDD/F [g]	4.02465E-05	3.84660E-05	4.41E-05	2.139E-05
2023 Submission PCDD/F [g]	4.02471E-05	3.84657E-05	2.98E-05	2.141E-05
Change relative to the 2022 Submission PCDD/F	0.001%	-0.001%	-32%	0.06%
2022 Submission Pb [g]	257.57760	246.18240	281.98	136.912
2023 Submission Pb [g]	257.58144	246.18048	190.76	137.000
Change relative to the 2022 Submission Pb	0.001%	-0.001%	-32%	0.06%
2022 Submission Cd [g]	8.04930	7.69320	8.81	4.279
2023 Submission Cd [g]	8.04942	7.69314	5.96	4.281
Change relative to the 2022 Submission Cd	0.001%	-0.001%	-32%	0.06%
2022 Submission Hg [g]	4.02465	3.84660	4.41	2.139
2023 Submission Hg [g]	4.02471	3.84657	2.98	2.141
Change relative to the 2022 Submission Hg	0.001%	-0.001%	-32%	0.06%
2022 Submission As [g]	63.99194	61.16094	70.06	34.014
2023 Submission As [g]	63.99289	61.16046	47.39	34.036
Change relative to the 2022 Submission As	0.001%	-0.001%	-32%	0.06%
2022 Submission Cr [g]	61.17468	58.46832	66.97	32.517
2023 Submission Cr [g]	61.17559	58.46786	45.30	32.538
Change relative to the 2022 Submission Cr	0.001%	-0.001%	-32%	0.06%
2022 Submission Cu [g]	142.47261	136.16964	155.97	75.729
2023 Submission Cu [g]	142.47473	136.16858	105.51	75.778
Change relative to the 2022 Submission Cu	0.001%	-0.001%	-32%	0.06%
2022 Submission Ni [g]	12.07395	11.53980	13.22	6.418
2023 Submission Ni [g]	12.07413	11.53971	8.94	6.422

2G4 Tobacco	2003	2005	2013	2019
Change relative to the 2022 Submission Ni	0.001%	-0.001%	-32%	0.06%
2022 Submission Se [g]	4.02465	3.84660	4.41	2.139
2023 Submission Se [g]	4.02471	3.84657	2.98	2.141
Change relative to the 2022 Submission Se	0.001%	-0.001%	-32%	0.06%
2022 Submission Zn [g]	647.96865	619.30260	709.36	344.419
2023 Submission Zn [g]	647.97831	619.29777	479.87	344.641
Change relative to the 2022 Submission Zn	0.001%	-0.001%	-32%	0.06%

Table 4.38 Recalculations of emissions within 2G4 Fireworks for the years 2012, 2013, and 2019, between the 2022 and 2023 Submissions.

2G4 Fireworks	2012	2013	2019
2022 Submission TSP [t]	68.97653	43.6513	51.537508
2023 Submission TSP [t]	68.97533	43.6828	51.537398
Change relative to the 2022 Submission TSP	-0.002%	0.07%	-0.0002%
2022 Submission PM_{10} [t]	62.75276	39.7126	46.887260
2023 Submission PM_{10} [t]	62.75166	39.7413	46.887160
Change relative to the 2022 Submission PM_{10}	-0.002%	0.07%	-0.0002%
2022 Submission $PM_{2.5}$ [t]	32.61988	20.6432	24.372741
2023 Submission $PM_{2.5}$ [t]	32.61931	20.6581	24.372689
Change relative to the 2022 Submission $PM_{2.5}$	-0.002%	0.07%	-0.0002%
2022 Submission NO_x [t]	0.16329	0.1033	0.1220045
2023 Submission NO_x [t]	0.16328	0.1034	0.1220042
Change relative to the 2022 Submission NO_x	-0.002%	0.07%	-0.0002%
2022 Submission SO_2 [t]	1.89665	1.2003	1.417129
2023 Submission SO_2 [t]	1.89662	1.2011	1.417126
Change relative to the 2022 Submission SO_2	-0.002%	0.07%	-0.0002%
2022 Submission CO [t]	4.49041	2.8417	3.355123
2023 Submission CO [t]	4.49034	2.8438	3.355116
Change relative to the 2022 Submission CO	-0.002%	0.07%	-0.0002%
2022 Submission As [g]	835.280	528.60	624.100
2023 Submission As [g]	835.265	528.98	624.099
Change relative to the 2022 Submission As	-0.002%	0.07%	-0.0002%
2022 Submission Cd [g]	929.484	588.22	694.487
2023 Submission Cd [g]	929.468	588.64	694.486
Change relative to the 2022 Submission Cd	-0.002%	0.07%	-0.0002%
2022 Submission Cr [g]	9,797.268	6,200.13	7,320.269
2023 Submission Cr [g]	9,797.096	6,204.60	7,320.253
Change relative to the 2022 Submission Cr	-0.002%	0.07%	-0.0002%
2022 Submission Cu [g]	278,845.320	176,465.14	208,346.112
2023 Submission Cu [g]	278,840.436	176,592.56	208,345.668
Change relative to the 2022 Submission Cu	-0.002%	0.07%	-0.0002%
2022 Submission Hg [g]	35.798	22.65	26.74714
2023 Submission Hg [g]	35.797	22.67	26.74708
Change relative to the 2022 Submission Hg	-0.002%	0.07%	-0.0002%
2022 Submission Ni [g]	18,840.900	11,923.32	14,077.440

2G4 Fireworks	2012	2013	2019
2023 Submission Ni [g]	18,840.570	11,931.93	14,077.410
Change relative to the 2022 Submission Ni	-0.002%	0.07%	-0.0002%
2022 Submission Zn [g]	163,287.800	103,335.44	122,004.480
2023 Submission Zn [g]	163,284.940	103,410.06	122,004.220
Change relative to the 2022 Submission Zn	-0.002%	0.07%	-0.0002%

Table 4.39 Recalculations of Pb emission within 2G4 (Fireworks) between 2022 and 2023 Submissions.

2G4 Fireworks	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission Pb [g]	89,294	110,691	296,171	500,147	384,469	471,738	367,890	387,214
2023 Submission Pb [g]	5,527	6,851	18,332	30,957	23,797	29,199	22,771	23,967
Change relative to the 2022 Submission Pb	-94%	-94%	-94%	-94%	-94%	-94%	-94%	-94%

4.7.1.4 Planned Improvements

No improvements are currently planned for this subsector.

4.8 Other Industry Production (NRF 2H)

4.8.1 Food and 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, 2022) (Embætti Landlæknis, 2011), (Embætti Landlæknis, 2002), (Embætti Landlæknis, 1990). The results give average consumption figures per person for the years 1990, 2002, 2011, and 2020. 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.

There is no distinction made 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 factors for NMVOC were taken from the 2019 EMEP/EEA Guidebook (EEA, 2019) and are presented in Table 4.40.

Table 4.40 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

There was recalculation for the years 2013-2020 due to updated activity data which is based on a new survey on food consumption, see Table 4.41.

Table 4.41 Recalculations of emission within 2H2 Food and Beverages Industry between submissions.

2H2 Food and Beverages Industry	2013	2014	2015	2016	2017	2018	2019	2020
2022 submission NMVOC [kt]	0.2798	0.2518	0.3015	0.3535	0.3491	0.4622	0.4369	0.4610
2023 submission NMVOC [kt]	0.2735	0.2390	0.2820	0.3272	0.3155	0.4205	0.3867	0.4024

2H2 Food and Beverages Industry	2013	2014	2015	2016	2017	2018	2019	2020
Change relative to the 2022 Submission	-2%	-5%	-6%	-7%	-10%	-9%	-11%	-13%

Recalculations from the 2022 Submission

This subsector was revised for the 2022 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).

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. Almost all of Iceland's NH_3 emissions come from the Agriculture sector. 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 2021.

	NH_3	NO_x	NMVOC	TSP	PM_{10}	$PM_{2.5}$
National Total [kt]	4.23	19.6	5.78	4.27	2.12	1.02
Agriculture Total [kt]	4.15	0.99	1.84	0.24	0.18	0.037
Agriculture Sector [%]	98.3	5.07	31.9	5.65	8.56	3.59

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

- Manure Management (NFR 3B)
- Crop Production and 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, NMVOCs, 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. Field Burning of Agricultural Residues (3F) is also identified as not occurring (NO) in Iceland.

A summary of the categories included in the Agriculture sector by pollutant, including the Tier methodology used, is presented in Table 5.2.

Table 5.2 Overview table NECD gases and PM (NA – not available, NO – not occurring).

Sector		NECD Gases				PM	
		NO_x	NMVOC	NH_3	$PM_{2.5}$	PM_{10}	TSP
3B1a	Manure Management – Dairy cattle	T2	T1	T2	T2	T2	T2
3B1b	Manure Management – Non-dairy Cattle	T2	T1	T2	T2	T2	T2
3B2	Manure Management – Sheep	T2	T1	T2	T2	T2	T2

	Sector	NECD Gases			PM		
		NO_x	NMVOC	NH_3	$PM_{2.5}$	PM_{10}	TSP
3B3	Manure Management – Swine	T2	T1	T2	T2	T2	T2
3B4a	Manure Management – Buffalo	NO	NO	NO	NO	NO	NO
3B4d	Manure Management – Goats	T2	T1	T2	T2	T2	T2
3B4e	Manure Management – Horses	T2	T1	T2	T2	T2	T2
3B4f	Manure Management – Mules and Asses	NO	NO	NO	NO	NO	NO
3B4gi	Manure Management – Laying Hens	T2	T1	T2	T2	T2	T2
3B4gii	Manure Management – Broilers	T2	T1	T2	T2	T2	T2
3B4giii	Manure Management – Turkeys	T2	T1	T2	T1	T1	T1
3B4giv	Manure Management – Other Poultry	T2	T1	T2	T1	T1	T1
3B4h	Manure Management – Other Animals (Fur Animals)	T2	T1	T2	T2	T2	T2
3Da1	Inorganic N-fertilisers (incl. Urea Application)	T1	NA	T2	NA	NA	NA
3Da2a	Animal Manure Applied to Soils	T1	NA	T2	NA	NA	NA
3Da2b	Sewage Sludge Applied to Soils	T1	NA	T1	NA	NA	NA
3Da2c	Other Organic Fertilisers Applied to Soils (incl. Compost)	T1	NA	T1	NA	NA	NA
3Da3	Urine and Dung Deposited by Grazing Animals	T1	NA	T2	NA	NA	NA
3Da4	Crop Residues Applied to Soils	NA	NA	NA	NA	NA	NA
3Db	Indirect Emissions from Managed Soils	NA	NA	NA	NA	NA	NA
3Dc	Farm-level Agricultural Operations incl. Storage, Handling, and Transport of Agricultural Products	NA	NA	NA	T2	T2	T2
3Dd	Off-farm Storage, Handling, and Transport of Bulk Agricultural Products	NA	NA	NA	NA	NA	NA
3De	Cultivated Crops	NA	T1	NA	NA	NA	NA
3Df	Use of Pesticides	NA	NA	NA	NA	NA	NA
3F	Field Burning of Agricultural Residues	NO	NO	NO	NO	NO	NO

Table 5.3 shows which subsectors 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 5.3 Key categories for air pollutants within Agriculture.

NO_x, NH_3, NMVOC, and PM			
Sector	1990	2021	Trend
3B1a Manure Management – Dairy Cattle	NMVOC, NH_3	NMVOC, NH_3	NMVOC, NH_3
3B1b Manure Management – Non-dairy Cattle	NMVOC, NH_3	NMVOC, NH_3	NMVOC, NH_3
3B2 Manure Management – Sheep	NH_3	NH_3	NH_3
3B3 Manure Management – Swine			NH_3
3B4e Manure Management – Horses	NMVOC	NMVOC	NMVOC
3B4gi Manure Management – Laying Hens			NH_3
3B4gii Manure Management – Broilers			NH_3
3B4h Manure Management – Other Animals			NH_3

NO_x, NH_3, NMVOC, and PM Sector	1990	2021	Trend
3Da2a Animal Manure Applied to Soils	NH_3	NH_3	NH_3
3Da3 Urine and Dung Deposited by Grazing Animals	NH_3	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 2013 and 2019 EMEP/EEA Guidebook (EEA, 2013; EEA, 2019). All equations as well as the majority of Emission Factors (EF) and other parameters stem from the EMEP/EEA Guidebook chapters correspondingly.

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 5.4. 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 fertiliser 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.

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 (*Matvælaráðuneytið*) (MFAF) and annual average populations (AAP) are calculated according to the 2006 IPCC Guidelines. Since the data from the annual census of MFAF represents livestock populations at a certain point in time (in November) 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 (*Hagstofa Íslands*) (SI)[8]. 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[9].

[8] https://hagstofa.is/talnaefni/atvinnuvegir/landbunadur/bufe-og-uppskera/
[9] https://unfccc.int/documents/614626

Livestock data is available on a more disaggregated level than requested by the reporting requirements as can be seen in Table 5.4. Therefore, the emissions are estimated on a more disaggregated level and then combined to the NFR categories.

Table 5.4 Livestock as reported in NFR tables and as calculated in the Icelandic inventory on a more disaggregated level.

NFR Code	Animal Category	Disaggregation in Icelandic Inventory
3B1a	Dairy Cattle	Mature Dairy Cattle
3B1b	Non-dairy Cattle	Other Mature Cattle; Calves; Pregnant Heifers; Steers and Non-inseminated Heifers
3B2	Sheep	Ewes; Animals for Replacement; 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 5.5 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 populations.

Table 5.5 Annual average population of livestock according to NFR categorisation in Iceland.

NFR Code	Animal Category	1990	1995	2000	2005	2010	2015	2020	2021
3B1a	Dairy Cattle	32,249	30,428	27,066	24,488	25,379	27,441	25,896	25,772
3B1b	Non-dairy Cattle	43,299	42,771	45,078	41,482	47,130	51,335	55,134	54,791
3B2	Sheep	858,008	718,544	730,177	713,419	753,120	752,515	635,832	612,590
3B3	Swine	29,768	30,746	32,242	39,350	38,032	42,542	39,253	38,381
3B4a	Buffalo	NO	NO	NO	NO	NO	NO	NO	NO
3B4d	Goats	485	511	548	657	1,015	1,476	2,367	2,442
3B4e	Horses	73,867	80,246	75,630	76,629	78,849	79,392	73,397	70,507
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	240,853	230,383
3B4gii	Broilers	149,103	150,688	210,468	433,237	423,187	490,669	548,121	553,337
3B4giii	Turkeys	3,534	3,044	10,908	8,146	9,148	11,810	12,406	11,414
3B4giv	Other Poultry	5,806	5,270	2,498	1,772	1,347	1,057	581	609
3B4h	Other (Fur Animals)	49,592	37,893	41,431	37,093	39,904	48,038	15,849	16,659

5.3.2 Emission Factors and Associated Parameters

NH_3 and NO Tier 2 emissions depend on the total amounts of nitrogen (N) and total ammoniacal nitrogen (TAN) in manure. Total N is calculated by multiplying livestock AAP with the nitrogen excretion (Nex) rate per animal. TAN is calculated by multiplying total N with livestock specific TAN fractions provided in the 2019 EMEP/EEA Guidebook. The 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 other than Cattle and Sheep, the animal parameters are not changing over the timeseries, and the Nex rate is, therefore, also constant. Cattle and Sheep subcategories have variable Nex rate over the timeline, since they are calculated by the Tier 2 approach, and for Horses and Poultry the Nex rate has been calculated on a more disaggregated level and reported as a weighted average in relation to the population data. The calculation method for the Nex rate for Cattle and Sheep follows the Tier 2 methodology from the 2006 IPCC Guidelines by applying Equation 10.31, Equation 10.32[10], and Equation 10.33 for cattle and $N_{retention\_frac}$ of 0.10 from Table 10.20 for Sheep. 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). Calves are the only cattle subcategory whose manure is stored in solid storage. In 2022, the Icelandic Agricultural Advisory Centre (*Ráðgjafamiðstöð landbúnaðarins*) interviewed farmers on their use of straw for bedding for calves and came up with the estimate of 350 kg straw/animal/year for 2021, which is an increase from 47 kg/animal/year in 1990, when only 10% of calf manure was stored in solid storage. Straw 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 summarised in Table 5.6.

Table 5.6 Parameters used in the N-flow calculations, for the year 2021.

NFR Code	Animal Category	Nex [kg head^{-1} yr^{-1}]	Prop. TAN (of N)	Fraction Slurry	Fraction Solid	Housing Period [days]	Straw [kg/yr]
3B1a	Dairy Cattle	94	1	1	0	309	
3B1b	Non-dairy Cattle[1]	37	0.6	0.70	0.30	305	7,778,050
3B2	Sheep[2]	10	0.5	0.35	0.65	200	33,379,466
3B3	Swine	8.8	0.7	1	0	365	
3B4d	Goats	20	0.5	0	1	200	325,494
3B4e	Horses	28	0.6	0	1	51	8,864,943
3B4f	Mules and Asses	1.4	0.7	0	1	365	
3B4gi	Laying Hens	0.2	0.7	0	1	365	
3B4gii	Broilers	1.4	0.7	0	1	365	
3B4giii	Turkeys	1.2	0.7	0	1	365	
3B4giv	Other Poultry	4.6	0.6	0	1	365	

[1] Values for Non-dairy Cattle are weighted averages for the subcategories Other Mature Cattle, Pregnant Heifers, Steers and Non-inseminated Heifers, and Calves.

[2] Values for Sheep are weighted averages for the subcategories Ewes, Animals for Replacement, Rams, and Lambs. However, lambs are not taken into account for the housing period. Lambs only live 4.5 months in Iceland, over the summer, and spend all their days outside.

[10] According to the 2019 refinements to the 2006 IPCC Guidelines, Eq. 10.32 is valid for Cattle, Sheep, and Goats.

All manure is assumed to be stored before spreading. Emission factors for animal manure, either managed as slurry or solid manure during housing and storage, as well as EFs for manure spreading and manure deposited by grazing animals, 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. The emissions factors are shown in Table 5.7.

Table 5.7 Emission factors for NH_3, NO, and N_2O used in the N-flow methodology.

NFR Code	Animal Category	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[1]	0.24	0.25	0.55	0.0001	0.01
		Solid	0.22	0.32	0.9	0.01	0.02
3B3	Swine – Piglets	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	0.01	0.002

[1] No EFs exist for NH_3 emissions from slurry for Sheep in the 2019 EMEP/EEA Guidebook. Hence, the EFs for Cattle are applied.
* The emission factor is zero in the 2019 EMEP/EEA 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, shown here in Table 5.8. When default emission factors with silage feeding are available, these are used.

Table 5.8 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.

Animal Category (NFR)	EF NMVOC [kg AAP^{-1} a^{-1}]
3B1a Dairy Cattle	17.937
3B1b Other Cattle (includes all Other Cattle)	8.902
3B2 Sheep	0.279
3B3 Swine – Piglets	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

Animal Category (NFR)	EF NMVOC [kg AAP^{-1} a^{-1}]
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 5.6 above). The applied emission factors are reported in Table 5.9 and derive from the 2019 EMEP/EEA Guidebook and from the 2013 EMEP/EEA Guidebook. In the case of Turkeys, Ducks, and Geese, the Tier 1 emission factors are applied.

Table 5.9 Emission factors used for calculating the particulate emissions, Tier 2.

NFR Code	Animal Category	MMS	EF TSP [kg AAP^{-1} a^{-1}]	EF PM_{10} [kg AAP^{-1} a^{-1}]	EF $PM_{2.5}$ [kg AAP^{-1} a^{-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	Non-dairy Cattle	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 – Piglets	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	0.0	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] Non-dairy Cattle and Calves are calculated separately and subsequently aggregated in the category 3B1b Non-Dairy Cattle.

5.3.3 Recalculations and Improvements

Livestock numbers for cattle, sheep, horses, and poultry were updated before the 2023 Submission, as well as a number of other livestock parameters for Cattle and Sheep. This change affected the reported NO_x, NMVOC, NH_3, $PM_{2.5}$, PM_{10}, and TSP emissions, over the whole timeline as shown in Table 5.10.

Table 5.10 Recalculations for NO_x, NMVOC, NH_3, $PM_{2.5}$, PM_{10}, and TSP due to updated livestock numbers for Cattle, Sheep, Horses, and Poultry, as well as because of updated livestock parameters for Cattle and Sheep, affecting the whole timeline.

3B Manure Management	1990	1995	2000	2005	2010	2015	2020
2022 Submission NO_x [kt]	0.058	0.044	0.047	0.046	0.045	0.046	0.040
2023 Submission NO_x [kt]	0.038	0.027	0.032	0.031	0.032	0.032	0.028
Change relative to the 2022 Submission NO_x	-34%	-37%	-32%	-33%	-29%	-30%	-30%
2022 Submission NMVOC [kt]	1.99	1.90	1.86	1.80	1.88	1.99	1.86
2023 Submission NMVOC [kt]	1.98	1.90	1.86	1.79	1.88	1.99	1.87
Change relative to the 2022 Submission NMVOC	-0.12%	-0.11%	-0.20%	-0.68%	-0.15%	-0.16%	0.38%
2022 Submission NH_3 [kt]	2.38	2.12	2.14	2.06	2.12	2.22	2.07
2023 Submission NH_3 [kt]	2.32	2.07	2.08	1.98	2.07	2.13	1.97
Change relative to the 2022 Submission NH_3	-2.5%	-2.4%	-2.5%	-3.8%	-2.6%	-4.3%	-4.7%
2022 Submission $PM_{2.5}$ [kt]	0.037	0.029	0.031	0.031	0.030	0.033	0.033
2023 Submission $PM_{2.5}$ [kt]	0.037	0.029	0.032	0.031	0.031	0.034	0.035
Change relative to the 2022 Submission $PM_{2.5}$	0.1%	1.1%	1.4%	-0.1%	3.7%	4.1%	4.7%
2022 Submission PM_{10} [kt]	0.124	0.083	0.103	0.113	0.103	0.113	0.121
2023 Submission PM_{10} [kt]	0.122	0.082	0.101	0.106	0.102	0.113	0.122
Change relative to the 2022 Submission PM_{10}	-1.01%	-0.92%	-1.65%	-6.19%	-0.61%	-0.62%	0.46%
2022 Submission TSP [kt]	0.187	0.142	0.161	0.171	0.162	0.177	0.180
2023 Submission TSP [kt]	0.185	0.142	0.160	0.166	0.163	0.179	0.183
Change relative to the 2022 Submission TSP	-0.8%	-0.3%	-0.5%	-3.3%	0.8%	1.0%	1.9%

Recalculations from the 2022 Submission

In 2022, a share of Poultry previously categorised as Broilers should have been categorised as Laying Hens for the whole timeseries. 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. This updated livestock categorisation affected the NO_x, NMVOC, NH_3, $PM_{2.5}$, PM_{10}, and TSP emissions.

5.3.4 Planned Improvements

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

5.4 Crop Production and Agricultural Soils (NFR 3D)

5.4.1 Activity Data

Activity data for NH_3 and NO emissions consist of the amount of fertiliser nitrogen applied to agricultural soils (Table 5.11). For NH_3 this amount is divided into type of fertiliser N. The total amount of N in fertiliser is obtained from SI[11]. No official data exists that provides information on the types of N fertilisers used. However, for this submission a fertiliser expert at the Icelandic Food and Veterinary

[11] https://hagstofa.is/talnaefni/atvinnuvegir/landbunadur/aburdur/

Authority (*Matvælastofnun*) (MAST) helped provide a rudimentary split into ammonium nitrate, calcium ammonium nitrate, urea, and other N fertiliser. The fraction of each type varies over the timeline, as shown in Table 5.11. The fertiliser type data is still incomplete and will be improved for future submissions.

Table 5.11 Total amount of synthetic N fertilisers applied to Agricultural Soils.

	1990	1995	2000	2005	2010	2015	2020	2021
N content in inorganic N fertiliser [kt N]	12.47	11.20	12.68	9.78	10.88	11.65	11.41	12.25
Ammonium nitrate [%]	67%	0.0%	0.0%	0.0%	0.0%	7.6%	16%	17%
Calcium ammonium nitrate [%]	0.0%	67%	67%	67%	65%	54%	44%	42%
Urea [%]	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.2%	4.8%
Other NK and NPK [%]	33%	33%	33%	33%	35%	38%	34%	36%

In the 2021 Submission, other organic fertilisers in the form of bone meal and compost were added to the inventory. Research showed that the organic fertilisers had been applied on a small scale since 2009, especially for land reclamation purposes carried out by the Soil Conservation Service of Iceland (*Landgræðslan*) (SCSI). Their use is still small compared to other fertilisers, but are taken into account for the calculation of NH_3 and NO_x emissions from agricultural soils.

Activity data for PM and NMVOC emissions consists of the areas of crops cultivated as can be seen in Table 5.12. The total amount of cropland is recorded in the Icelandic Geographic Land-use Database (IGLUD), which is maintained by the SCSI. Data regarding the area of barley fields comes from the Farmers Association of Iceland (*Bændasamtök Íslands*) (FAI)[12] and Bragason (written communication). The area of grass fields is calculated by subtracting the area of barley fields from the total cropland area. Barley fields are cultivated and harvested once a year and the produce is cleaned and dried. Grass fields are cultivated about once every 10 years and hay is cut twice per year on average (Brynjólfsson, written communication). The total area of active cropland is used to estimate the NMVOC emissions.

Table 5.12 Areas of cropland in Iceland, distinguished by barley cultivation and grassland for haymaking.

	1990	1995	2000	2005	2010	2015	2020	2021
Area Barley Cultivation [ha]	0	144	900	2,892	3,898	1,455	1,500	2,216
Area Grass Cultivation [ha]	122,602	116,597	110,804	105,655	103,737	106,069	105,925	105,189

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 5.13.

Table 5.13 Emission factors for NH_3 emissions from fertilisers for cool climate and normal pH used in Iceland.

	EF [g NH_3/ kg N applied]
Ammonium Nitrate	15
Calcium Ammonium Nitrate	8

12 http://www.bondi.is/

	EF [g NH3/ kg N applied]
Urea	155
Other NK and NPK[1]	33

[1] 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 5.14 with the respective sources and NFR codes. The biggest contributor to the Tier 1 emissions factor for NMVOC is grass at 25°C, which is not relevant for Iceland, where the average temperature during the summer is 10°C. Grass for hay making is, however, the greatest source of NMVOC emissions in Iceland and hence the EF for NMVOC emissions from grass at 15°C is used.

Table 5.14 Emission factors for NO, NMVOC, and NH_3 in NFR category 3D.

	NFR Code	EF	Unit	Source
NH_3 from Sewage Sludge	3Da2b	0.13	kg NH_3 (kg N applied)$^{-1}$	Annex 1 2019 EMEP/EEA Guidebook
NH_3 from Other Organic wastes	3Da2c	0.08	kg NH_3 (kg N applied)$^{-1}$	Table 3.1 2019 EMEP/EEA Guidebook
NO from N Applied in Fertiliser, Manure, and Excreta	3Da1, 3Da2a, 3Da3	0.04	kg NO_2 (kg fertiliser and manure N applied)$^{-1}$	Table 3.1 2019 EMEP/EEA Guidebook
NO from Sewage Sludge	3Da2b	0.04	kg NO_2 (kg sewage sludge)$^{-1}$	Annex 2 A2.3 2019 EMEP/EEA Guidebook
NO from Other Organic Wastes	3Da2c	0.04	kg NO_2 (kg organic waste)$^{-1}$	Table 3.1 2019 EMEP/EEA Guidebook
NMVOC from Standing Crops	3De	0.10	kg ha^{-1}	Table 3.3 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 5.15.

Table 5.15 Emission factors for agricultural crop operations, in kg ha^{-1} PM_{10} and $PM_{2.5}$ in wet climate conditions from the 2019 EMEP/EEA Guidebook.

Air Pollutant	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	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	0.0

5.4.3 Recalculations and Improvements

Three updates were done for the 2023 Submission affecting the emissions from Crop Production and Agricultural Soils. They are:

- Updated livestock numbers for Cattle, Sheep, Horses, and Poultry, as well as updated livestock parameters for Cattle and Sheep. These updates affect NO_x and NH_3 emissions from 3Da2a Livestock Manure Applied to Soils and 3Da3 Urine and Dung Deposited by Grazing Livestock, over the whole timeline, as shown in Table 5.16.
- Fertiliser activity data was updated for Urea and CAN, along with the split into N fertiliser type over the whole timeline. Affecting NH_3 emissions from 3Da1 Inorganic N-fertilisers as shown in Table 5.17.
- The cropland area was updated, affecting PM and NMVOC emissions from 3D Crop Production and Agricultural Soils over the whole timeline. The methodology for calculating NMVOC emissions was changed from the 2009 EMEP/EEA Guidebook, where the emissions are calculated based on fertiliser

use, to the method listed in the 2019 EMEP/EEA Guidebook, where the NMVOC emissions are calculated the same way as PM emissions, i.e., based on land area cultivated. The recalculations are shown in Table 5.18.

Table 5.16 Recalculations for NO_x and NH_3 emissions from 3Da2a Livestock Manure Applied to Soils and 3Da3 Urine and Dung Deposited by Grazing Livestock.

3Da2a + 3Da3	1990	1995	2000	2005	2010	2015	2020
2022 Submission NO_x [kt]	0.70	0.62	0.62	0.61	0.63	0.65	0.57
2023 Submission NO_x [kt]	0.57	0.51	0.51	0.50	0.52	0.53	0.47
Change relative to the 2022 Submission NO_x	-19%	-18%	-18%	-18%	-17%	-19%	-19%
2022 Submission NH_3 [kt]	2.35	2.17	2.16	2.11	2.18	2.26	2.12
2023 Submission NH_3 [kt]	2.25	2.14	2.13	2.05	2.12	2.17	2.02
Change relative to the 2022 Submission NH_3	-4.3%	-1.4%	-1.8%	-2.6%	-2.6%	-4.2%	-4.7%

Table 5.17 Recalculations for NH_3 due to updated activity data on fertiliser types used, affecting NH_3 emissions from 3Da1 Inorganic N fertilisers over the whole timeline.

3Da1 Inorganic N Fertilisers	1990	1995	2000	2005	2010	2015	2020
2022 Submission NH_3 [kt]	0.15	0.14	0.16	0.12	0.13	0.14	0.14
2023 Submission NH_3 [kt]	0.26	0.18	0.20	0.16	0.18	0.21	0.30
Change relative to the 2022 Submission NH_3	68%	30%	30%	30%	34%	45%	116%

Table 5.18 Recalculations for NMVOC, $PM_{2.5}$, and PM_{10}, due to updated cropland area, affecting the whole timeline, and additionally, for NMVOC due to an updated methodology used to estimate the emissions.

3Dc + 3De	1990	1995	2000	2005	2010	2015	2020
2022 Submission NMVOC [kt]	7.4.E-8	6.7.E-8	7.6.E-8	5.8.E-8	6.5.E-8	6.9.E-8	6.8.E-8
2023 Submission NMVOC [kt]	0.012	0.012	0.011	0.011	0.011	0.011	0.011
Change relative to the 2022 Submission NMVOC	160,000%	170,000%	150,000%	190,000%	170,000%	150,000%	160,000%
2022 Submission $PM_{2.5}$ [kt]	0.0032	0.0032	0.0034	0.0036	0.0037	0.0033	0.0034
2023 Submission $PM_{2.5}$ [kt]	0.0026	0.0025	0.0025	0.0027	0.0029	0.0025	0.0025
Change relative to the 2022 Submission $PM_{2.5}$	-19%	-22%	-26%	-25%	-22%	-23%	-26%
2022 Submission PM_{10} [kt]	0.078	0.078	0.082	0.085	0.086	0.078	0.08
2023 Submission PM_{10} [kt]	0.064	0.061	0.061	0.064	0.066	0.06	0.06
Change relative to the 2022 Submission PM_{10}	-18%	-22%	-26%	-25%	-23%	-24%	-25%

Recalculations from the 2022 Submission

In the 2022 Submission, the share of Poultry previously categorised as Broilers should have been categorised as Laying Hens for the whole timeseries. The change in livestock numbers affected the emissions from Animal Manure Applied to Soils for NO_x and NH_3.

5.4.4 Planned Improvements

Improvements are planned for the registration of different inorganic N fertiliser types in Iceland's inventory for future submissions.

5.5 Other Agriculture 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 kg/kg, as listed in Table 3.1 in Chapter 3Df in the 2013 EMEP/EEA Guidebook, was applied to these values resulting in HCH emissions of 1, 8, 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 5.19 gives an overview of the use of pesticides in Iceland.

Table 5.19 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 (NRF Sector 5)

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 from the capital was landfilled there. Prior to that year, the waste from the capital area was landfilled in smaller SWDs.

Until the 1970s, the most common form of waste management outside of 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 an incineration plant in Vestmannaeyjar, an archipelago to the south of Iceland with a population of over 4,000. In 2004, the incineration plant *Kalka*, located at the southwest part of Iceland, opened; 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 to the north of Iceland, 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.

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 (*Úrvinnslusjóður*) in late 2002.

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

The trend in waste management practices has been toward managed SWDs as municipalities have increasingly cooperated with each other on running waste collection schemes and operating joint landfill sites. This 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.

Summaries of the categories included in the Waste sector by pollutants, including the Tier methodologies used, are presented in Table 6.1, Table 6.2, and Table 6.3.

Table 6.1 Overview table NECD gases, PM, and CO (NA – not available, NE – not estimated, NO – not occurring, IE – included elsewhere).

Sector		NECD gases				PM			BC	CO
		NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP		
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
5B2a	Anaerobic Digestion – MSW	NA	NA	NA	NE	NA	NA	NA	NA	NA
5B2b	Anaerobic Digestion – Other	NO	NO	NA	NO	NA	NA	NA	NA	NO
5C1a	MSW Incineration – *Kalka*	T1	T1	T1	T1	T1	T1	T1	T1	T1
5C1a	MSW Incineration – Other	NO	NO	NO	NO	NO	NO	NO	NO	NO
5C1bi	Industrial Waste Incineration	IE[1]	T1	IE[1]	NA	IE[1]	IE[1]	IE[1]	IE[1]	IE[1]
5C1bii	Hazardous Waste Incineration	IE[1]	T1	IE[1]	NA	IE[1]	IE[1]	IE[1]	IE[1]	IE[1]
5C1biii	Clinical Waste Incineration	IE[1]	T2	IE[1]	NA	IE[1]	IE[1]	IE[1]	IE[1]	IE[1]
5C1biv	Sewage Sludge Incineration	IE[1]	NO	IE[1]	NO	IE[1]	IE[1]	IE[1]	IE[1]	IE[1]
5C1bv	Cremation	T1	T1	T1	T1	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
5D1	Domestic Wastewater Handling	NA	NE	NA	NA	NA	NA	NA	NA	NA
5D2	Industrial Wastewater Handling	NA	NE	NA	NA	NA	NA	NA	NA	NA
5D3	Other Wastewater Handling	NA	NE	NA	NA	NA	NA	NA	NA	NA
5E	Other Waste	T2	T2	T2	NA	T2	T2	T2	NE	T2

[1] Included in 5C1a

Table 6.2 Overview table POPs (NA – not available, NO – not occurring).

Sector		POPs			
		Dioxin	PAH	HCB	PCB
5A	Solid Waste Disposal on Land	NA	NA	NA	NA
5B1	Composting	NA	NA	NA	NA
5B2a	Anaerobic Digestion – MSW	NA	NA	NA	NA
5B2b	Anaerobic Digestion – Other	NA	NA	NA	NA
5C1a	MSW Incineration – *Kalka*	T1	T1	T1	T1
5C1a	MSW Incineration – Other	NO	NO	NO	NO
5C1bi	Industrial Waste Incineration	T1	T1	T1	NA
5C1bii	Hazardous Waste Incineration	T1	T1	T1	NA
5C1biii	Clinical Waste Incineration	T2	T2	T2	T2
5C1biv	Sewage Sludge Incineration	NO	NO	NO	NO
5C1bv	Cremation	T1	T1	T1	T1
5C1bvi	Other Waste Incineration	NO	NO	NO	NO
5C2	Open Burning	T1	T1	T1	T1

Sector		POPs			
		Dioxin	PAH	HCB	PCB
5D1	Domestic Wastewater Handling	NA	NA	NA	NA
5D2	Industrial Wastewater Handling	NA	NA	NA	NA
5D3	Other Wastewater Handling	NA	NA	NA	NA
5E	Other Waste	T2	T2	NE	NE

Table 6.3 Overview table heavy metals (NA – not available, NO – not occurring).

Sector		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
5B2a	Anaerobic Digestion – MSW	NA	NA	NA	NA	NA	NA	NA	NA	NA
5B2b	Anaerobic Digestion – Other	NA	NA	NA	NA	NA	NA	NA	NA	NA
5C1a	MSW Incineration – *Kalka*	T1	T1	T1	T1	T1	T1	T1	T1	T1
5C1a	MSW Incineration – Other	NO	NO	NO	NO	NO	NO	NO	NO	NO
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	NO	T2	T2	T2	T2	T2	T2	NA	NA
5C1biv	Sewage Sludge Incineration	NO	NO	NO	NO	NO	NO	NO	NO	NO
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
5D1	Domestic Wastewater Handling	NA	NA	NA	NA	NA	NA	NA	NA	NA
5D2	Industrial Wastewater Handling	NA	NA	NA	NA	NA	NA	NA	NA	NA
5D3	Other Wastewater Handling	NA	NA	NA	NA	NA	NA	NA	NA	NA
5E	Other Waste	T2	T2	T2	T2	T2	T2	T2	NE	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 6.4 shows which subsectors 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	2021	Trend
5A	Biological Treatment of Waste – Solid Waste Disposal on Land	NMVOC	NMVOC	
5C2	Open Burning of Waste	$PM_{2.5}$, PM_{10}, BC		$PM_{2.5}$, PM_{10}, BC
		Persistent Organic Pollutants (POPs)		
		1990	**2021**	**Trend**
5C1bi	Industrial Waste Incineration		Dioxin	Dioxin

	SO_x, NO_x, NH_3, NMVOC, PM, BC, and CO			
		1990	2021	Trend
5C1bii	Hazardous Waste Incineration		Dioxin	Dioxin
5C1biii	Clinical Waste Incineration	PCB	Dioxin, HCB, PCB	Dioxin, HCB, PCB
5C2	Open Burning of Waste	Dioxin, PAH4, HCB		Dioxin, PAH4, HCB, PCB
5E	Accidental Fires		Dioxin, PAH4	
	Heavy Metals (HMs)			
		1990	**2021**	**Trend**
5C1biii	Clinical Waste Incineration		Hg	
5C1bv	Cremation		Hg	Hg
5C2	Open Burning of Waste	Cd, Hg, As, Se, Zn		Pb, Cd, Hg, As, Se, Zn
5E	Accidental Fires	Pb, Zn	Pb, Zn	

6.2 General Methodology

The methodology is mainly based on the EMEP/EEA air pollutant emission inventory Guidebook (EEA, 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 (Nielsen, et al., 2021) 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 Environment Agency of Iceland (*Umhverfisstofnun*) (EAI). 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 standardised procedures for emission calculations, archiving information, and reporting. Further information can be found in 1.6 on Quality Assurance and Quality Control.

6.4 Solid Waste Disposal (NFR 5A)

For most of the 20th century, 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 EAI compiles data on total amounts of waste generated since 1995. This data is published by Statistics Iceland (*Hagstofa Íslands*) (SI)[13]. The data for the time-period from 1995 to 2004 relies on assumptions and estimations, and is less reliable than the data generated since 2005. Data from 2005-2014 was received from most operators according to the European Waste Catalogue (EWC) categorisation. Smaller operators did not submit data on waste amounts during that period, so some gap-filling estimations were performed by experts at the EAI. From 2014, the EAI has received data according to the Waste Statistic Regulation (WStatR) categorisation 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 Recalculations and Improvements

For this submission, recalculations were performed on both subsectors of 5A. The cause was late arrival (post-2022 submission date) of the final amount of waste at SWDs in 2020 and the corrected amount of waste at SWDs in 2019. The amount of waste at managed SWDs in 2019 was corrected from 170.89 kt to 170.87 kt, leading to overall smaller emissions for that year (see Table 6.5).

Table 6.5 Recalculations in Sector 5A1a due to a change in activity data.

5A1a Managed Waste Disposal Sites – Anaerobic	2019
2022 Submission NMVOC [kt]	0.26658
2023 Submission NMVOC [kt]	0.26656

13 Available at https://statice.is/statistics/environment/material-flow/waste/

5A1a Managed Waste Disposal Sites – Anaerobic	2019
Change relative to the 2022 Submission	-0.0071%
2022 Submission TSP [kt]	7.912.E-05
2023 Submission TSP [kt]	7.911.E-05
Change relative to the 2022 Submission	-0.0071%
2022 Submission PM_{10} [kt]	3.7424.E-05
2023 Submission PM_{10} [kt]	3.7421.E-05
Change relative to the 2022 Submission	-0.0071%
2022 Submission $PM_{2.5}$ [kt]	5.6392.E-06
2023 Submission $PM_{2.5}$ [kt]	5.6388.E-06
Change relative to the 2022 Submission	-0.0071%

Similarly, the amount of waste at unmanaged SWDs in 2019 was corrected from 47,719 t to 4,7718 t and the amount in 2020 was updated from 43,570 t to 43,080 t, leading to overall smaller emissions for those two years (see Table 6.6).

Table 6.6 Recalculations in Sector 5A2 due to changes in activity data.

5A2 Unmanaged Waste Disposal Sites	2019	2020
2022 Submission NMVOC [kt]	7.4442E-2	0.068
2023 Submission NMVOC [kt]	7.4441E-2	0.067
Change relative to the 2022 Submission NMVOC	-0.0021%	-1.1%
2022 Submission TSP [kt]	2.20941E-5	2.02E-5
2023 Submission TSP [kt]	2.20936E-5	1.99E-5
Change relative to the 2022 Submission TSP	-0.0021%	-1.1%
2022 Submission PM_{10} [kt]	1.04506E-5	9.5E-6
2023 Submission PM_{10} [kt]	1.04503E-5	9.4E-6
Change relative to the 2022 Submission PM_{10}	-0.0021%	-1.1%
2022 Submission $PM_{2.5}$ [kt]	1.57474E-6	1.44E-6
2023 Submission $PM_{2.5}$ [kt]	1.57471E-6	1.42E-6
Change relative to the 2022 Submission $PM_{2.5}$	-0.0021%	-1.1%

6.4.5 Planned Improvements

For future submissions, it is planned to update the uncertainty analysis for the Waste sector.

6.5 Biological Treatment of Solid Waste (NRF 5B)

6.5.1 Composting (NRF 5B1)

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. The Tier 2 approach of Chapter 5B1 in the 2019 EMEP/EEA Guidebook is used for the emission estimates in which 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 EAI 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 EAI since 2005. Therefore, the amounts composted from 1995-2004 are estimated to be between 2 and 3 kt each year. 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. The emission factors are assumed constant between years. Emission factors for other pollutants are not provided in the 2019 EMEP/EEA Guidebook.

6.5.1.4 Recalculations and improvements

For this submission, recalculations were performed on sector 5B1. The cause was late arrival (post-2022 submission date) of the final annual amount of MSW composted in 2020. The amount was updated from 34.1 kt to 31.7 kt, leading to smaller NH_3 and CO_2 emission for the year 2020 (see Table 6.7).

Table 6.7 Recalculations in Sector 5B1 due to a change in activity data.

5B1 Composting – MSW	2020
2022 Submission NH_3 [kt]	0.0082
2023 Submission NH_3 [kt]	0.0076
Change relative to the 2022 Submission NH_3	-7.1%
2022 Submission CO [kt]	0.019
2023 Submission CO [kt]	0.018
Change relative to the 2022 Submission CO	-7.1%

6.5.1.5 Planned Improvements

There are no planned improvements for this sector.

6.5.2 Anaerobic Digestion at Biogas Facilities (NFR 5B2)

In 2020, the gas and composting facility *GAJA* started operating. *GAJA* is located in Reykjavík and is the only one of its kind in Iceland. In *GAJA*, organic waste from the capital area is processed into CH_4 gas and soil amendment. *GAJA* is currently not operating at its full capacity.

6.5.2.1 Methodology

The Tier 1 approach of Chapter 5B2 in the 2019 EMEP/EEA Guidebook is used for the emission estimates. The approach only takes NH_3 into account, other pollutants are either not applicable (NA) or not estimated (NE). Equation 1 from Chapter 5B2 is used to calculate the NH_3 emissions.

6.5.2.2 Activity Data

The Tier 1 method requires the total annual amount of N in the feedstock entering the biogas plants to be known. However, this information is currently not available.

6.5.2.3 Emission Factors

Tier 1 emission factor from Table 3-1, Chapter 5B2 in the 2019 EMEP/EEA Guidebook are used for estimating NH_3.

6.5.2.4 Recalculations and improvements

No recalculations were done for this submission.

6.5.2.5 Planned Improvements

For the future submissions, it is planned to estimate NH_3 emissions. To be able to do so, the total amount of N in the feedstock is required from *GAJA*.

6.6 Waste Incineration and Open Burning (NFR 5C)

This section discusses the emission estimates from burning of waste, which falls under the subcategories; 5C1 Waste Incineration and 5C2 Open Burning of Waste. Waste Incineration covers the emission estimates from waste incineration plants without energy recovery[14] 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 5C1a Municipal Waste Incineration, 5C1bi Industrial Waste Incineration, 5C1bii Hazardous Waste Incineration, 5C1biii Clinical Waste Incineration, 5C1biv Sewage Sludge Incineration, 5C1bv Cremation, and 5C1bvi Other Waste Incineration.

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 EAI annually by the waste burning facilities. Data on waste generation and waste management practices is published by SI.

6.6.1 Municipal Waste Incineration (NFR 5C1a)

Waste Incineration in incineration plants started in 1993 in Iceland and waste incineration in incineration plants without energy recovery started in 2001. Sector 5C1a includes emissions from two incineration plants, the plant in Tálknafjörður which operated from 2001 to 2004 and *Kalka* incineration plant which has been operating from 2004. Since 2004, *Kalka* has been the only operating waste incineration plant in Iceland. 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.

6.6.1.1 Methodology

The Tier 1 approach of Chapter 5C1a in the 2019 EMEP/EEA Guidebook is used for the emission estimates. The total amount of waste incinerated in all waste incineration plants without energy recovery in Iceland is multiplied with its pollutant-specific emission factor. This applies to all pollutants except NO_x, SO_2, PM ($PM_{2.5}$, PM_{10}, TSP, and BC), and CO emissions from *Kalka* as *Kalka* runs continuous measurements for these pollutants.

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

6.6.1.2 *Activity Data*

Activity data on incinerated waste from major incineration plants has been collected by the EAI since 2000. There is a sharp increase in the amount of 5C1 Waste Incinerated (5C1) and corresponding decrease in 5C2 Open Burning of Waste in 2004 due to the opening of the *Kalka* plant. This trend is also seen in the emissions. Furthermore, emission amounts for NO_x, SO_2, PM, and CO from *Kalka* are reported to the EAI as activity data.

Historic data which was not reported to the EAI was estimated using the assumption of 500 kg of waste per inhabitant in communities where waste is known to have been incinerated.

6.6.1.3 *Emission Factors*

Emission factors (T1) for all pollutants except NO_x, SO_2, PM, and CO for *Kalka* are taken from Table 3-1, Chapter 5C1a in the 2019 EMEP/EEA Guidebook. Lower emission factors were used for *Kalka* than for the Tálknafjörður plant due to the following abatement technologies present at *Kalka*:

- Dry cleaning process;
- Hydrated lime;
- Combustion at approximately 1,100°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 emission factors 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.

6.6.1.4 *Recalculations and Improvements*

Recalculations were performed on Sector 5C1a for two reasons. First, emissions from NO_x, SO_2, PM, and CO were recalculated back to 2004 due to the methodological change made in 5C1a, for NO_x, SO_2, PM, and CO emissions from *Kalka*. These emissions were previously calculated by multiplying the incinerated waste amount with emission factors from Table 3-1 in 2019 EMEP/EEA Guidebook. The emission values are now available in *Kalka's* Green Accounting back to 2004. Furthermore, emissions from all pollutants for 2019 and 2020 were recalculated due to the late arrival of the final annual amount of waste at SWDs in 2020 and corrected numbers for 2019. The results of these recalculations are shown in Table 6.8.

Table 6.8 Recalculations in Sector 5C1a due to a change in methodology and updates in activity data.

5C1a MSW Incineration – *Kalka*	2004	2005	2010	2015	2019	2020
2022 Submission NO_x [kt]	0.01	0.011	0.0096	0.01	0.018	0.01
2023 Submission NO_x [kt]	0.031	0.046	0.02	0.027	0.033	0.048
Change relative to the 2022 Submission NO_x	201%	305%	109%	163%	86%	379%
2022 Submission NMVOC [kt]					9.9E-5	5.5E-5
2023 Submission NMVOC [kt]					1.1E-4	5.6E-5
Change relative to the 2022 Submission NMVOC					11.7%	1.3%
2022 Submission SO_2 [kt]	8.3E-4	9.3E-4	7.8E-4	8.3E-4	1.5E-3	8.1E-4
2023 Submission SO_2 [kt]	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026
Change relative to the 2022 Submission SO_2	212%	178%	232%	210%	77%	218%
2022 Submission NH_3 [kt]					5.0E-5	2.8E-5
2023 Submission NH_3 [kt]					5.6E-5	2.8E-5

5C1a MSW Incineration – *Kalka*	2004	2005	2010	2015	2019	2020
Change relative to the 2022 Submission NH_3					11.7%	1.3%
2022 Submission $PM_{2.5}$ [kt]	2.9E-5	3.2E-5	2.7E-5	2.9E-5	5.0E-5	2.8E-5
2023 Submission $PM_{2.5}$ [kt]	3.4E-4	6.1E-5	2.2E-5	5.4E-5	1.2E-4	1.1E-4
Change relative to the 2022 Submission $PM_{2.5}$	1,098%	90%	-18%	88%	137%	297%
2022 Submission PM_{10} [kt]	2.9E-5	3.2E-5	2.7E-5	2.9E-5	5.0E-5	2.8E-5
2023 Submission PM_{10} [kt]	3.4E-4	6.1E-5	2.2E-5	5.4E-5	1.2E-4	1.1E-4
Change relative to the 2022 Submission PM_{10}	1,098%	90%	-18%	88%	137%	297%
2022 Submission TSP [kt]	2.9E-5	3.2E-5	2.7E-5	2.9E-5	5.0E-5	2.8E-5
2023 Submission TSP [kt]	3.4E-4	6.1E-5	2.2E-5	5.4E-5	1.2E-4	1.1E-4
Change relative to the 2022 Submission TSP	1,098%	90%	-18%	88%	137%	297%
2022 Submission BC [kt]	1.0E-6	1.0E-6	1.0E-6	1.0E-6	1.0E-6	1.0E-6
2023 Submission BC [kt]	1.2E-5	2.1E-6	7.7E-7	1.9E-6	4.2E-6	3.9E-6
Change relative to the 2022 Submission BC	1,098%	114%	-23%	89%	317%	289%
2022 Submission CO [kt]	3.9E-4	4.4E-4	3.7E-4	3.9E-4	6.9E-4	3.8E-4
2023 Submission CO [kt]	3.4E-4	6.4E-4	5.8E-4	2.2E-4	4.1E-4	3.0E-4
Change relative to the 2022 Submission CO	-14%	46%	58%	-44%	-41%	-21%
2022 Submission PCDD/F [g]					8.8E-4	4.9E-4
2023 Submission PCDD/F [g]					9.8E-4	5.0E-4
Change relative to the 2022 Submission PCDD/F					12%	1.3%
2022 Submission BaP [t]					1.4E-7	7.8E-8
2023 Submission BaP [t]					1.6E-7	7.9E-8
Change relative to the 2022 Submission BaP					11.7%	1.3%
2022 Submission BbF [t]					3.0E-7	1.7E-7
2023 Submission BbF [t]					3.3E-7	1.7E-7
Change relative to the 2022 Submission BbF					12%	1.3%
2022 Submission BkF [t]					1.6E-7	8.9E-8
2023 Submission BkF [t]					1.8E-7	9.0E-8
Change relative to the 2022 Submission BkF					11.7%	1.3%
2022s Submission IPy [t]					1.9E-7	1.1E-7
2023 Submission IPy [t]					2.2E-7	1.1E-7
Change relative to the 2022 Submission IPy					12%	1.3%
2022 Submission PAH4 [t]					7.9E-7	4.4E-7
2023 Submission PAH4 [t]					8.8E-7	4.5E-7
Change relative to the 2022 Submission PAH4					12%	1.3%
2022 Submission HCB [kg]					7.6E-4	4.2E-4
2023 Submission HCB [kg]					8.4E-4	4.3E-4
Change relative to the 2022 Submission HCB					12%	1.3%
2022 Submission PCB [kg]					5.7E-8	3.2E-8
2023 Submission PCB [kg]					6.3E-8	3.2E-8
Change relative to the 2022 Submission PCB					12%	1.3%
2022 Submission Pb [t]					9.7E-4	5.4E-4
2023 Submission Pb [t]					0.0011	5.5E-4
Change relative to the 2022 Submission Pb					12%	1.3%
2022 Submission Cd [t]					7.7E-5	4.3E-5
2023 Submission Cd [t]					8.6E-5	4.3E-5
Change relative to the 2022 Submission Cd					12%	1.3%
2022 Submission Hg [t]					3.1E-4	1.8E-4

5C1a MSW Incineration – *Kalka*	2004	2005	2010	2015	2019	2020
2023 Submission Hg [t]					3.5E-4	1.8E-4
Change relative to the 2022 Submission Hg					11.7%	1.3%
2022 Submission As [t]					1.0E-4	5.8E-5
2023 Submission As [t]					1.2E-4	5.9E-5
Change relative to the 2022 Submission As					12%	1.3%
2022 Submission Cr [t]					2.7E-4	1.5E-4
2023 Submission Cr [t]					3.1E-4	1.5E-4
Change relative to the 2022 Submission Cr					11.7%	1.3%
2022 Submission Cu [t]					2.3E-4	1.3E-4
2023 Submission Cu [t]					2.6E-4	1.3E-4
Change relative to the 2022 Submission Cu					12%	1.3%
2022 Submission Ni [t]					3.6E-4	2.0E-4
2023 Submission Ni [t]					4.0E-4	2.0E-4
Change relative to the 2022 Submission Ni					12%	1.3%
2022 Submission Se [t]					2.0E-4	1.1E-4
2023 Submission Se [t]					2.2E-4	1.1E-4
Change relative to the 2022 Submission Se					12%	1.3%
2022 Submission Zn [t]					4.1E-4	2.3E-4
2023 Submission Zn [t]					4.6E-4	2.3E-4
Change relative to the 2022 Submission Zn					12%	1.3%

6.6.1.5 Planned Improvements

An uncertainty analysis is in progress.

6.6.2 Industrial Waste Incineration (NFR 5C1bi)

6.6.2.1 Methodology

The Tier 1 approach of Chapter 5C1b in the 2019 EMEP/EEA Guidebook is used for the emission estimates. Slaughterhouse waste is the only type of waste that is assumed to be constituting Industrial Waste Incineration for the year 2021. Total reported slaughterhouse waste is multiplied by pollutant specific emission factors to estimate these emissions.

6.6.2.2 Activity Data

Activity data for this category has been included for the year 2014 onward. Activity data for previous years are included in 5C1a.

6.6.2.3 Emission Factors

Emission factors (T1) are taken from Table 3-1, Chapter 5C1b in the 2019 EMEP/EEA Guidebook for all pollutants, except for NO_X, SO_2, PM, and CO as they are included in 5C1a.

6.6.2.4 Recalculations and Improvements

Recalculations were performed on 5C1bi for the year 2014 to 2020. Firstly, *Kalka* provides continuous emission measurements for these pollutants, but all waste categories are incinerated together at *Kalka*. This makes it impossible to differentiate emissions from one waste category to another. However, it is known that the majority, or about 70% of all waste incinerated in *Kalka*, is household waste. As such, emissions from NO_x, SO_2, PM, and CO from industrial waste are now included in 5C1a MSW Incineration, leading to recalculations for these pollutants back to 2014. Secondly, prior to the

2022 Submission, 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). For the 2022 Submission, emission factors for Industrial Waste Incineration were updated to the emission factors specified for Industrial Waste Incineration from Table 3-1, Chapter 5C1b in the 2019 EMEP/EEA Guidebook as they are considered to be more accurate. However, in Table 3-1, the pollutants NH_3, BaP, BbF, BkF, IPy, Cr, Cu, Se, and Zn are not estimated. As such, the notation key NE was chosen to represent these pollutants. This has been reconsidered and the notation key for NH_3, BaP, BbF, BkF, IPy, Cr, Cu, Se, and Zn was changed to NA. Thirdly, the amount incinerated industrial waste for 2020 was updated from approximately 864 t to 1,046 t, leading to 134% higher NMVOC, dioxin, PAH4, HCB, Pb, Cd, Hg, As, and Ni emissions in 2020. Additionally, HCB emissions were reported as tons instead of kilograms from 2014. The results of these recalculations are shown in Table 6.9.

Table 6.9 Recalculations in Sector 5C1bi due to changes in methodology, an update in activity data.

5C1bi Industrial Waste Incineration	2014	2015	2016	2017	2018	2019	2020
2022 Submission NO_x [kt]	6.3E-5	1.1E-4	2.5E-4	7.1E-4	7.5E-4	7.5E-4	3.9E-4
2023 Submission NO_x [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission NMVOC [kt]							0.0033
2023 Submission NMVOC [kt]							0.0077
Change relative to the 2022 Submission NMVOC							134%
2022 Submission SO_2 [kt]	3.4E-6	5.9E-6	1.3E-5	3.8E-5	4.1E-5	4.1E-5	2.1E-5
2023 Submission SO_2 [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission NH_3 [kt]	NE	NE	NE	NE	NE	NE	NE
2023 Submission NH_3 [kt]	NA	NA	NA	NA	NA	NA	NA
2022 Submission $PM_{2.5}$ [kt]	2.9E-7	5.0E-7	1.1E-6	3.3E-6	3.5E-6	3.5E-6	1.8E-6
2023 Submission $PM_{2.5}$ [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission PM_{10} [kt]	5.0E-7	8.8E-7	2.0E-6	5.7E-6	6.0E-6	6.1E-6	3.1E-6
2023 Submission PM_{10} [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission TSP [kt]	7.2E-7	1.3E-6	2.8E-6	8.2E-6	8.6E-6	8.6E-6	4.5E-6
2023 Submission TSP [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission BC [kt]	1.0E-8	1.8E-8	4.0E-8	1.1E-7	1.2E-7	1.2E-7	6.2E-8
2023 Submission BC [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission CO [kt]	5.0E-6	8.8E-6	2.0E-5	5.7E-5	6.0E-5	6.1E-5	3.1E-5
2023 Submission CO [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission PCDD/F [g]							0.16
2023 Submission PCDD/F [g]							0.37
Change relative to the 2022 Submission PCDD/F							134%
2022 Submission BaP [t]	NE	NE	NE	NE	NE	NE	NE
2023 Submission BaP [t]	NA	NA	NA	NA	NA	NA	NA
2022 Submission BbF [t]	NE	NE	NE	NE	NE	NE	NE
2023 Submission BbF [t]	NA	NA	NA	NA	NA	NA	NA
2022 Submission BkF [t]	NE	NE	NE	NE	NE	NE	NE
2023 Submission BkF [t]	NA	NA	NA	NA	NA	NA	NA
2022 Submission IPy [t]	NE	NE	NE	NE	NE	NE	NE
2023 Submission IPy [t]	NA	NA	NA	NA	NA	NA	NA
2022 Submission PAH4 [t]							8.9E-6
2023 Submission PAH4 [t]							2.1E-5

5C1bi Industrial Waste Incineration	2014	2015	2016	2017	2018	2019	2020
Change relative to the 2022 Submission PAH4							134%
2022 Submission HCB [kg]	1.4E-7	2.5E-7	5.7E-7	1.6E-6	1.7E-6	1.7E-6	8.9E-7
2023 Submission HCB [kg]	1.4E-4	2.5E-4	5.7E-4	0.0016	0.0017	0.0017	0.0021
Change relative to the 2022 Submission HCB	99,900%	99,900%	99,900%	99,900%	99,900%	99,900%	234,395%
2022 Submission Pb [t]							5.8E-4
2023 Submission Pb [t]							0.0014
Change relative to the 2022 Submission Pb							134%
2022 Submission Cd [t]							4.5E-5
2023 Submission Cd [t]							1.0E-4
Change relative to the 2022 Submission Cd							134%
2022 Submission Hg [t]							2.5E-5
2023 Submission Hg [t]							5.9E-5
Change relative to the 2022 Submission Hg							134%
2022 Submission As [t]							7.1E-6
2023 Submission As [t]							1.7E-5
Change relative to the 2022 Submission As							134%
2022 Submission Cr [t]	NE	NE	NE	NE	NE	NE	NE
2023 Submission Cr [t]	NA	NA	NA	NA	NA	NA	NA
2022 Submission Cu [t]	NE	NE	NE	NE	NE	NE	NE
2023 Submission Cu [t]	NA	NA	NA	NA	NA	NA	NA
2022 Submission Ni [t]							6.2E-5
2023 Submission Ni [t]							1.5E-4
Change relative to the 2022 Submission Ni							134%
2022 Submission Se [t]	NE	NE	NE	NE	NE	NE	NE
2023 Submission Se [t]	NA	NA	NA	NA	NA	NA	NA
2022 Submission Zn [t]	NE	NE	NE	NE	NE	NE	NE
2023 Submission Zn [t]	NA	NA	NA	NA	NA	NA	NA

Recalculations from the 2022 Submission

The emission factors for 5C1bi Industrial Waste Incineration were updated for the 2022 Submission, thus causing recalculations.

6.6.2.5 Planned Improvements

There are no planned improvements for this sector.

6.6.3 Hazardous Waste Incineration (NFR 5C1bii)

6.6.3.1 Methodology

The Tier 1 approach of Chapter 5C1b in the 2019 EMEP/EEA Guidebook is used for the emission estimates. Total amount of hazardous waste is multiplied by a pollutant specific emission factor.

6.6.3.2 Activity Data

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

6.6.3.3 Emission Factors

Emission factors (T1) are taken from Table 3-1, Chapter 5C1b in the 2019 EMEP/EEA Guidebook for all pollutants, except for NO_X, SO_2, PM, and CO as they are included in 5C1a.

6.6.3.4 Recalculations and Improvements

Recalculations were performed on 5C1bii for the year 2006 to 2020. The reasons for the recalculations are the same for 5C1bi: emissions from NO_X, SO_2, PM, and CO are now included in 5C1a; the notation key for NH_3, BaP, BbF, BkF, IPy, Cr, Cu, Se, and Zn was changed from NE to NA as NA is considered more appropriate; the amount incinerated hazardous waste for 2020 was updated from approx. 971 t to 1,213 t, leading to 25% higher NMVOC, dioxin, PAH4, HCB, Pb, Cd, Hg, As, and Ni emissions in 2020. The results of these recalculations are shown in Table 6.10.

Table 6.10 Recalculations in Sector 5C1bii due to changes in methodology and an update in activity data.

5C1bii Hazardous Waste Incineration	2006	2010	2015	2019	2020
2022 Submission NO_x [kt]	2.2E-4	2.4E-4	6.4E-4	0.0011	8.5E-4
2023 Submission NO_x [kt]	IE	IE	IE	IE	IE
2022 Submission NMVOC [kt]					0.0072
2023 Submission NMVOC [kt]					0.009
Change relative to the 2022 Submission NMVOC					25%
2022 Submission SO_2 [kt]	1.2E-5	1.3E-5	3.4E-5	5.9E-5	4.6E-5
2023 Submission SO_2 [kt]	IE	IE	IE	IE	IE
2022 Submission NH_3 [kt]	NE	NE	NE	NE	NE
2023 Submission NH_3 [kt]	NA	NA	NA	NA	NA
2022 Submission $PM_{2.5}$ [kt]	1.0E-6	1.1E-6	2.9E-6	5.0E-6	3.9E-6
2023 Submission $PM_{2.5}$ [kt]	IE	IE	IE	IE	IE
2022 Submission PM_{10} [kt]	1.7E-6	1.9E-6	5.1E-6	8.8E-6	6.8E-6
2023 Submission PM_{10} [kt]	IE	IE	IE	IE	IE
2022 Submission TSP [kt]	2.5E-6	2.7E-6	7.3E-6	1.3E-5	9.7E-6
2023 Submission TSP [kt]	IE	IE	IE	IE	IE
2022 Submission BC [kt]	3.5E-8	3.8E-8	1.0E-7	1.8E-7	1.4E-7
2023 Submission BC [kt]	IE	IE	IE	IE	IE
2022 Submission CO [kt]	1.7E-5	1.9E-5	5.1E-5	8.8E-5	6.8E-5
2023 Submission CO [kt]	IE	IE	IE	IE	IE

5C1bii Hazardous Waste Incineration	2006	2010	2015	2019	2020
2022 Submission PCDD/F [g]					0.34
2023 Submission PCDD/F [g]					0.42
Change relative to the 2022 Submission PCDD/F					25%
2022 Submission BaP [t]	NE	NE	NE	NE	NE
2023 Submission BaP [t]	NA	NA	NA	NA	NA
2022 Submission BbF [t]	NE	NE	NE	NE	NE
2023 Submission BbF [t]	NA	NA	NA	NA	NA
2022 Submission BkF [t]	NE	NE	NE	NE	NE
2023 Submission BkF [t]	NA	NA	NA	NA	NA
2022 Submission IPy [t]	NE	NE	NE	NE	NE
2023 Submission IPy [t]	NA	NA	NA	NA	NA
2022 Submission PAH4 [t]					1.9E-5
2023 Submission PAH4 [t]					2.4E-5
Change relative to the 2022 Submission PAH4					25%
2022 Submission HCB [kg]					0.0019
2023 Submission HCB [kg]					0.0024
Change relative to the 2022 Submission HCB					25%
2022 Submission Pb [t]					0.0013
2023 Submission Pb [t]					0.0016
Change relative to the 2022 Submission Pb					25%
2022 Submission Cd [t]					9.7E-5
2023 Submission Cd [t]					1.2E-4
Change relative to the 2022 Submission Cd					25%
2022 Submission Hg [t]					5.4E-5
2023 Submission Hg [t]					6.8E-5
Change relative to the 2022 Submission Hg					25%
2022 Submission As [t]					1.6E-5
2023 Submission As [t]					1.9E-5
Change relative to the 2022 Submission As					25%
2022 Submission Cr [t]	NE	NE	NE	NE	NE
2023 Submission Cr [t]	NA	NA	NA	NA	NA
2022 Submission Cu [t]	NE	NE	NE	NE	NE
2023 Submission Cu [t]	NA	NA	NA	NA	NA
2022 Submission Se [t]	NE	NE	NE	NE	NE
2023 Submission Se [t]	NA	NA	NA	NA	NA
2022 Submission Ni [t]					1.4E-4
2023 Submission Ni [t]					1.7E-4
Change relative to the 2022 Submission Ni					25%
2022 Submission Zn [t]	NE	NE	NE	NE	NE
2023 Submission Zn [t]	NA	NA	NA	NA	NA

6.6.3.5 Planned Improvements

There are no planned improvements for this sector.

6.6.4 Clinical Waste Incineration (NFR 5C1biii)

6.6.4.1 Methodology

The Tier 2 approach of Chapter 5C1b in the 2019 EMEP/EEA Guidebook is used for the emission estimates. Total amount of clinical waste is multiplied by a pollutant-specific emission factor.

6.6.4.2 Activity Data

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

6.6.4.3 Emission Factors

The emission factors (T2) are taken from Table 3-2, Chapter 5Cbiii in the 2019 EMEP/EEA Guidebook. As for abatement efficiencies, default abatement efficiencies (T2) from Table 3-3, Chapter 5C1biii in 2019 EMEP/EEA Guidebook are used for Pb, Cd, Hg, As, Cr, Cu, and Ni from the year 2004 (when *Kalka* opened) and the default abatement efficiencies (T2) from Table 3-5, Chapter 5C1biii in 2019 EMEP/EEA Guidebook are used for dioxin. The emission factors and abatement efficiencies for NO_X, SO_2, PM, and CO are included in 5C1a.

6.6.4.4 Recalculations and Improvements

Recalculations were performed on 5C1biii for the years 2001 to 2020. For the same reason as in 5C1bi and 5C1bii, NO_x, SO_2, PM, and CO emissions are now included in 5C1a. In the previous submission, NH_3, BaP, BbF, BkF, IPy, Se, and Zn were represented by the notation key NE as they are not estimated in Table 3-2, Chapter 5Cbiii in the 2019 EMEP/EEA Guidebook. However, the notation key has been changed to NA for this submission as it is considered more appropriate. As for dioxin, the emissions were reported as kilograms instead of grams and no abatement was applied. The unit error has been fixed and a Tier 2 default abatement efficiency from Table 3-5, Chapter 5C1biii in 2019 EMEP/EEA Guidebook has been applied. As for Pb, Cd, Hg, As, Cr, Cu, and Ni, abatement efficiencies were updated with Tier 2 default values from Table 3-3, Chapter 5C1biii in 2019 EMEP/EEA Guidebook now being used instead of those from Table 3-4, Chapter 5C1biii in 2016 EMEP/EEA Guidebook. The results of these recalculations are shown in Table 6.11.

Table 6.11 Recalculations in Sector 5C1biii, mainly due to changes in methodology.

5C1biii Clinical Waste Incineration	2001	2005	2010	2015	2019	2020
2022 Submission NO_x [kt]		3.5E-4	1.5E-4	5.2E-4	7.2E-4	7.4E-4
2023 Submission NO_x [kt]		IE	IE	IE	IE	IE
2022 Submission SO_2 [kt]		8.8E-5	3.7E-5	1.3E-4	1.8E-4	1.9E-4
2023 Submission SO_2 [kt]		IE	IE	IE	IE	IE
2022 Submission NH_3 [kt]	NE	NE	NE	NE	NE	NE
2023 Submission NH_3 [kt]	NA	NA	NA	NA	NA	NA
2022 Submission $PM_{2.5}$ [kt]	NE	NE	NE	NE	NE	NE
2023 Submission $PM_{2.5}$ [kt]	NA	IE	IE	IE	IE	IE
2022 Submission PM_{10} [kt]	NE	NE	NE	NE	NE	NE
2023 Submission PM_{10} [kt]	NA	IE	IE	IE	IE	IE
2022 Submission TSP [kt]		4.5E-6	1.9E-6	6.6E-6	9.2E-6	9.5E-6
2023 Submission TSP [kt]		IE	IE	IE	IE	IE
2022 Submission BC [kt]		1.0E-7	4.4E-8	1.5E-7	2.1E-7	2.2E-7
2023 Submission BC [kt]		IE	IE	IE	IE	IE
2022 Submission CO [kt]		3.5E-5	1.5E-5	5.2E-5	7.2E-5	7.4E-5

5C1biii Clinical Waste Incineration	2001	2005	2010	2015	2019	2020
2023 Submission CO [kt]		IE	IE	IE	IE	IE
2022 Submission PCDD/F [g]	1.3E-04	0.0078	0.0033	0.011	0.016	0.016
2023 Submission PCDD/F [g]	0.13	0.078	0.033	0.11	0.16	0.16
Change relative to the 2022 Submission PCDD/F	99,900%	900%	900%	900%	900%	900%
2022 Submission BaP [t]	NE	NE	NE	NE	NE	NE
2023 Submission BaP [t]	NA	NA	NA	NA	NA	NA
2022 Submission BbF [t]	NE	NE	NE	NE	NE	NE
2023 Submission BbF [t]	NA	NA	NA	NA	NA	NA
2022 Submission BkF [t]	NE	NE	NE	NE	NE	NE
2023 Submission BkF [t]	NA	NA	NA	NA	NA	NA
2022 Submission IPy [t]	NE	NE	NE	NE	NE	NE
2023 Submission IPy [t]	NA	NA	NA	NA	NA	NA
2022 Submission Pb [t]		0	0	0	0	0
2023 Submission Pb [t]		NO	NO	NO	NO	NO
2022 Submission Cd [t]		0	0	0	0	0
2023 Submission Cd [t]		2.3E-5	1.0E-5	3.4E-5	4.8E-5	4.9E-5
2022 Submission Hg [t]		2.9E-3	1.2E-3	4.2E-3	5.8E-3	6.0E-3
2023 Submission Hg [t]		3.2E-4	1.3E-4	4.6E-4	6.4E-4	6.7E-4
Change relative to the 2022 Submission Hg		-89%	-89%	-89%	-89%	-89%
2022 Submission As [t]		2.0E-5	8.3E-6	2.9E-5	4.0E-5	4.1E-5
2023 Submission As [t]		2.0E-7	8.3E-8	2.9E-7	4.0E-7	4.1E-7
Change relative to the 2022 Submission As		-99%	-99%	-99%	-99%	-99%
2022 Submission Cr [t]		1.6E-6	6.6E-7	2.3E-6	3.2E-6	3.3E-6
2023 Submission Cr [t]		3.1E-6	1.3E-6	4.6E-6	6.4E-6	6.6E-6
Change relative to the 2022 Submission Cr		100%	100%	100%	100%	100%
2022 Submission Cu [t]		0	0	0	0	0
2023 Submission Cu [t]		4.8E-4	2.0E-4	7.1E-4	9.8E-4	1.0E-3
2022 Submission Ni [t]		5.9E-7	2.5E-7	8.6E-7	1.2E-6	1.2E-6
2023 Submission Ni [t]		5.9E-5	2.5E-5	8.6E-5	1.2E-4	1.2E-4
Change relative to the 2022 Submission Ni		9,900%	9,900%	9,900%	9,900%	9,900%
2022 Submission Se [t]	NE	NE	NE	NE	NE	NE
2023 Submission Se [t]	NA	NA	NA	NA	NA	NA
2022 Submission Zn [t]	NE	NE	NE	NE	NE	NE
2023 Submission Zn [t]	NA	NA	NA	NA	NA	NA

6.6.4.5 Planned Improvements

There are no planned improvements for this sector.

6.6.5 Sewage Sludge Incineration (NFR 5C1biv)

6.6.5.1 Methodology

The Tier 1 approach of Chapter 5C1b in the 2019 EMEP/EEA Guidebook is used for the emission estimates. Total amount of sewage sludge is multiplied by a pollutant-specific emission factor.

6.6.5.2 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 EAI has only received data according to the WStatR categorisation from all waste operators in Iceland since 2014.

6.6.5.3 *Emission Factors*

Emission factors (T1) are taken from Table 3-1, Chapter 5C1b in the 2019 EMEP/EEA Guidebook, except for NO_X, SO_2, PM, and CO as they are included in 5C1a.

6.6.5.4 *Recalculations and Improvements*

Recalculations were performed on 5C1biii for the years 2014 to 2020. For the same reason as in 5C1bi, 5C1bii, and 5C1biii, NO_X, SO_2, PM, and CO emissions are now included in 5C1a and the notation keys for NH_3, BaP, BbF, BkF, IPy, Cr, Cu, Se, and Zn were changed from NE to NA. NMVOC, Pd, Cd, Hg, As, Ni, dioxin, and HCB emissions were recalculated for the year 2019. The cause was a unit error of the amount of incinerated sewage sludge for 2019. The results of these recalculations are shown in Table 6.12.

Table 6.12 Recalculations in sector 5C1biv due to changes in methodology and a correction in activity data.

5C1biv Sewage Sludge Incineration	2014	2015	2016	2017	2018	2019	2020
2022 Submission NO_x [kt]	4.5E-4	5.7E-5	6.5E-5	4.7E-5	NO	5.7E-4	1.7E-6
2023 Submission NO_x [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission NMVOC [kt]						4.9E-3	
2023 Submission NMVOC [kt]						4.9E-6	
Change relative to the 2022 Submission NMVOC						-100%	
2022 Submission SO_2 [kt]	2.4E-5	3.1E-6	3.5E-6	2.5E-6	NO	3.1E-5	9.1E-8
2023 Submission SO_2 [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission NH_3 [kt]	NE	NE	NE	NE	NO	NE	NE
2023 Submission NH_3 [kt]	NA	NA	NA	NA	NO	NA	NA
2022 Submission $PM_{2.5}$ [kt]	2.1E-6	2.6E-7	3.0E-7	2.1E-7	NO	2.6E-6	7.8E-9
2023 Submission $PM_{2.5}$ [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission PM_{10} [kt]	3.6E-6	4.6E-7	5.3E-7	3.8E-7	NO	4.6E-6	1.4E-8
2023 Submission PM_{10} [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission TSP [kt]	5.2E-6	6.6E-7	7.5E-7	5.4E-7	NO	6.6E-6	1.9E-8
2023 Submission TSP [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission BC [kt]	7.2E-8	9.2E-9	1.1E-8	7.5E-9	NO	9.2E-8	2.7E-10
2023 Submission BC [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission CO [kt]	3.6E-5	4.6E-6	5.3E-6	3.8E-6	NO	4.6E-5	1.4E-7
2023 Submission CO [kt]	IE	IE	IE	IE	IE	IE	IE
2022 Submission PCDD/F [g]						0.23	
2023 Submission PCDD/F [g]						2.3E-04	
Change relative to the 2022 Submission PCDD/F						-99.9%	
2022 Submission BaP [t]	NE	NE	NE	NE	NO	NE	NE
2023 Submission BaP [t]	NA	NA	NA	NA	NO	NA	NA
2022 Submission BbF [t]	NE	NE	NE	NE	NO	NE	NE
2023 Submission BbF [t]	NA	NA	NA	NA	NO	NA	NA
2022 Submission BkF [t]	NE	NE	NE	NE	NO	NE	NE
2023 Submission BkF [t]	NA	NA	NA	NA	NO	NA	NA
2022 Submission IPy [t]	NE	NE	NE	NE	NO	NE	NE
2023 Submission IPy [t]	NA	NA	NA	NA	NO	NA	NA
2022 Submission PAH4 [t]						1.3E-5	
2023 Submission PAH4 [t]						1.3E-8	
Change relative to the 2022 Submission PAH4						-100%	

5C1biv Sewage Sludge Incineration	2014	2015	2016	2017	2018	2019	2020
2022 Submission HCB [kg]						1.3E-3	
2023 Submission HCB [kg]						1.3E-6	
Change relative to the 2022 Submission HCB						-100%	
2022 Submission Pb [t]						8.6E-4	
2023 Submission Pb [t]						8.6E-7	
Change relative to the 2022 Submission Pb						-100%	
2022 Submission Cd [t]						6.6E-5	
2023 Submission Cd [t]						6.6E-8	
Change relative to the 2022 Submission Cd						-100%	
2022 Submission Hg [t]						3.7E-5	
2023 Submission Hg [t]						3.7E-8	
Change relative to the 2022 Submission Hg						-100%	
2022 Submission As [t]						1.1E-5	
2023 Submission As [t]						1.1E-8	
Change relative to the 2022 Submission As						-100%	
2022 Submission Cr [t]	NE	NE	NE	NE	NO	NE	NE
2023 Submission Cr [t]	NA	NA	NA	NA	NO	NA	NA
2022 Submission Cu [t]	NE	NE	NE	NE	NO	NE	NE
2023 Submission Cu [t]	NA	NA	NA	NA	NO	NA	NA
2022 Submission Ni [t]						9.2E-5	
2023 Submission Ni [t]						9.2E-8	
Change relative to the 2022 Submission Ni						-100%	
2022 Submission Se [t]	NE	NE	NE	NE	NO	NE	NE
2023 Submission Se [t]	NA	NA	NA	NA	NO	NA	NA
2022 Submission Zn [t]	NE	NE	NE	NE	NO	NE	NE
2023 Submission Zn [t]	NA	NA	NA	NA	NO	NA	NA

6.6.5.5 Planned Improvements

There are no planned improvements for this sector.

6.6.6 Cremation (NFR 5C1bv)

6.6.6.1 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, Chapter 5C1bv.

6.6.6.2 Activity Data

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

6.6.6.3 Emission Factors

Emission factors (T1) are taken from Table 3-1, Chapter 5C1bv in the 2019 EMEP/EEA Guidebook.

6.6.6.4 Recalculations and Improvements

BC emissions were recalculated for the whole timeline. As Table 3-1, Chapter 5C1bv in the 2019 EMEP/EEA Guidebook do not estimate the emission of BC, BC was initially represented as NE in previous submission. This has been reconsidered and the notation key NA is now used instead. The results of these recalculations are shown in Table 6.13.

Table 6.13 Recalculations in Sector 5C1bv due to a change in methodology.

5C1bv Cremation	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission BC [kt]	NE	NE	NE	NE	NE	NE	NE	NE
2023 Submission BC [kt]	NA	NA	NA	NA	NA	NA	NA	NA

6.6.6.5 Planned Improvements

There are no planned improvements for this sector.

6.6.6.6 Other Waste Incineration (NFR 5C1bvi)

Data for other waste incineration is not available for the time being.

6.6.7 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 characterised 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 1990s. 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. All these factors influence the dioxin formation and therefore it can be hard to come up with reasonable emission factors. In addition, the activity data is quite uncertain, as no official statistics are available.

It is a tradition in Iceland to light bonfires on New Year's Eve (31 December) and Epiphany/Twelfth Night (6 January). These are quite common throughout the country. In the early 1990s, there were no restrictions and no supervision with these bonfires. In the early 1990s, 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 EAI, 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. Additionally, the Environmental and Public Health Offices supervise all bonfires. Now bonfires are fewer and better organised.

6.6.7.1 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.

6.6.7.2 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 EAI in the respective years. The EAI 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 31 December and 6 January bonfires, activity data is not easily obtained. In 2011 the EAI, along with the municipality of Reykjavík, decided to weigh all the material of a single bonfire. Then the piled material was photographed, and 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 EAI. 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 with the exception of 2020, as the COVID-19 pandemic caused all bonfires to be cancelled. Emissions from bonfires for 2020 are consequently distinctively low.

6.6.7.3 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.

6.6.7.4 Recalculations and Improvements

Recalculations were performed in Sector 5C2 MSW, specifically for dioxin emissions for the years 2001-2020. This sector previously included dioxin emissions from Tálknafjörður incineration plant and from *Kalka*. However, these emissions do not belong in this sector as they are not emissions from open burning. As such dioxin emissions from Tálknafjörður and *Kalka* were removed from the sector, resulting in less emissions between 2001-2010 and none from 2011. The results of these recalculations are shown in Table 6.14.

Table 6.14 Recalculations in Sector 5C2 MSW due to a methodological change.

5C2 Open Burning – MSW	2001	2005	2010	2015	2019	2020
2022 Submission PCDD/F [g]	1.884	0.019	0.019	0.005	0.010	0.000
2023 Submission PCDD/F [g]	1.829	0.014	0.014	NO	NO	NO
Change relative to the 2022 Submission PCDD/F	-3.0%	-28%	-25%	---	---	---

Recalculations were as well performed in Sector 5C2 Bonfires as it was previously assumed that no bonfires occurred due to COVID-19 gathering strictions. However, the assumption was wrong as the Twelfth Night bonfires did in fact occurred in 2020, right before the pandemic.

Table 6.15 Recalculations in Sector 5C2 Bonfires due to an update in activity data.

5C2 Open Burning – Bonfires	2020
2022 Submission NO_x [kt]	NO
2023 Submission NO_x [kt]	6.5E-4
2022 Submission NMVOC [kt]	NO
2023 Submission NMVOC [kt]	2.5E-4
2022 Submission SO_2 [kt]	NO
2023 Submission SO_2 [kt]	2.2E-5
2022 Submission NH_3 [kt]	NO
2023 Submission NH_3 [kt]	2.7E-4
2022 Submission $PM_{2.5}$ [kt]	NO
2023 Submission $PM_{2.5}$ [kt]	8.5E-4
2022 Submission PM_{10} [kt]	NO
2023 Submission PM_{10} [kt]	9.2E-4
2022 Submission TSP [kt]	NO
2023 Submission TSP [kt]	9.5E-4
2022 Submission BC [kt]	NO
2023 Submission BC [kt]	3.6E-4
2022 Submission CO [kt]	NO
2023 Submission CO [kt]	1.1E-2
2022 Submission PCDD/F [g]	NO
2023 Submission PCDD/F [g]	1.2E-2
2022 Submission BaP [t]	NO
2023 Submission BaP [t]	4.8E-4
2022 Submission BbF [t]	NO
2023 Submission BbF [t]	9.4E-4
2022 Submission BkF [t]	NO
2023 Submission BkF [t]	1.2E-3
2022 Submission IPy [t]	NO
2023 Submission IPy[t]	2.6E-4
2022 Submission PAH4 [t]	NO
2023 Submission PAH4 [t]	2.8E-3
2022 Submission HCB [kg]	NO
2023 Submission HCB [kg]	1.8E-5

5C2 Open Burning – Bonfires	2020
2022 Submission PCB [kg]	NO
2023 Submission PCB [kg]	2.2E-7
2022 Submission Pb [t]	NO
2023 Submission Pb [t]	1.0E-4
2022 Submission Cd [t]	NO
2023 Submission Cd [t]	2.0E-5
2022 Submission Hg [t]	NO
2023 Submission Hg [t]	2.1E-6
2022 Submission As [t]	NO
2023 Submission As [t]	8.4E-5
2022 Submission Cr [t]	NO
2023 Submission Cr [t]	2.0E-6
2022 Submission Cu [t]	NO
2023 Submission Cu [t]	4.1E-5
2022 Submission Ni [t]	NO
2023 Submission Ni [t]	7.3E-6
2022 Submission Se [t]	NO
2023 Submission Se [t]	1.4E-5
2022 Submission Zn [t]	NO
2023 Submission Zn [t]	3.6E-3

6.6.7.5 Planned Improvements

There are no planned improvements for this sector.

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, emissions have not been estimated from wastewater handling.

6.7.1.1 Methodology

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

6.7.1.2 Activity Data

No relevant activity data.

6.7.1.3 Emission Factors

No emission factors used.

6.7.1.4 Recalculations and Improvements

No recalculations were done for this submission.

6.7.1.5 *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.

6.8.1.1 *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 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 most recent Danish IIR. The weight of different types of vehicles is used in the calculations and taken from Table 6-26 of the most recent Danish IIR. The assumption is made that 70% of the total mass is burned.

6.8.1.2 *Activity Data*

Activity data for vehicle and building fires were obtained from the Capital District Fire and Rescue Service (CDFRS) for the years 2003 onward. Building fires are classified by duration of response into small (<60 min.), medium (60-120 min.) and large fires (>120 min.) The data is presented in Table 6.16. As two thirds of the Icelandic population lives in the capital area, it is assumed that the CDFRS serves two thirds of the incidents in Iceland. In

Year	Vehicle Fires	Building Fires			
		<60 min	60-120 min	>120 min	Total Scaled
2005	43	141	24	11	30
2010	34	118	17	9	23
2015	37	88	14	3	14
2020	27	69	13	13	23
2021	26	85	18	10	23

Table 6.17, 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 small and medium fire leads to 5% and 50% of a large fire respectively, and that a large fire is a full-scale fire. Table 6.16 and Table 6.17 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 building had a thick layer of asphalt roll roofing with an estimated weight of around 80 t.

For 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 6.16 Vehicle and building fires, Icelandic Capital Area.

Year	Vehicle Fires	Building Fires			
		<60 min	60-120 min	>120 min	Total Scaled
2005	43	141	24	11	30
2010	34	118	17	9	23
2015	37	88	14	3	14
2020	27	69	13	13	23
2021	26	85	18	10	23

Table 6.17 Vehicle and building fires scaled for all of Iceland (scaled using data from the Capital Area).

Year	Vehicle Fires	Building Fires			
		<60 min	60-120 min	>120 min	Total Scaled
2005	67	220	37	17	47
2010	53	184	27	14	36
2015	58	137	22	5	22
2020	42	108	20	20	36
2021	41	133	28	16	36

6.8.1.3 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 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 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 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 five industrial buildings. Thus, the emission from this particular fire corresponds to five industrial building fires plus the special assessment of the asphalt roll roofing, in total around nine 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.

6.8.1.4 Recalculations and Improvements

In Sector 5E, the notation key for is changed from NE to NA. As the 2019 EMEP/EEA Guidebook does not estimate the emissions from these pollutants in 5E. Furthermore, recalculations were performed on sector 5Eii through the whole timeline for all pollutants. This is due to changes in input values for mass of vehicles burned. The results of these recalculations are shown in

Table 6.19 to Table 6.20.

Table 6.18 Recalculations in Sector 5Ei due to changes in methodology.

5Ei Other Waste – Building Fires	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission BC	NE	NE	NE	NE	NE	NE	NE	NE
2023 Submission BC	NA	NA	NA	NA	NA	NA	NA	NA
2022 Submission Ni	NE	NE	NE	NE	NE	NE	NE	NE
2023 Submission Ni	NA	NA	NA	NA	NA	NA	NA	NA
2022 Submission Se	NE	NE	NE	NE	NE	NE	NE	NE
2023 Submission Se	NA	NA	NA	NA	NA	NA	NA	NA
2022 Submission Zn	NE	NE	NE	NE	NE	NE	NE	NE
2023 Submission Zn	NA	NA	NA	NA	NA	NA	NA	NA
2022 Submission HCB	NE	NE	NE	NE	NE	NE	NE	NE

5Ei Other Waste – Building Fires	1990	1995	2000	2005	2010	2015	2019	2020
2023 Submission HCB	NA	NA	NA	NA	NA	NA	NA	NA
2022 Submission PCB	NE	NE	NE	NE	NE	NE	NE	NE
2023 Submission PCB	NA	NA	NA	NA	NA	NA	NA	NA

Table 6.19 Recalculations in Sector 5Eii due to changes in activity data.

5Eii Other Waste – Vehicle Fires	1990	1995	2000	2005	2010	2015	2020
2022 Submission NO_x [kt]	6.1E-04	6.1E-04	6.0E-04	9.3E-04	7.1E-04	5.0E-04	6.7E-04
2023 Submission NO_x [kt]	6.1E-04	6.1E-04	6.0E-04	9.0E-04	7.1E-04	4.9E-04	6.5E-04
Change relative to the 2022 Submission NO_x	0.2%	0.5%	0.0%	-2.5%	0.0%	-0.8%	-3.4%
2022 Submission CO [kt]	1.1E-02	1.1E-02	1.1E-02	1.6E-02	1.2E-02	9.0E-03	1.1E-02
2023 Submission CO [kt]	1.1E-02	1.1E-02	1.1E-02	1.5E-02	1.2E-02	8.8E-03	1.0E-02
Change relative to the 2022 Submission CO	0.3%	0.9%	0.0%	-4.7%	0.1%	-1.4%	-6.5%
2022 Submission NMVOC [kt]	2.9E-03	2.9E-03	2.9E-03	4.5E-03	3.5E-03	2.4E-03	3.3E-03
2023 Submission NMVOC [kt]	2.9E-03	3.0E-03	2.9E-03	4.4E-03	3.5E-03	2.4E-03	3.2E-03
Change relative to the 2022 Submission NMVOC	0.2%	0.5%	0.0%	-2.2%	0.0%	-0.7%	-2.9%
2022 Submission SO_x [kt]	8.1E-03	8.1E-03	8.1E-03	1.3E-02	1.0E-02	6.4E-03	9.5E-03
2023 Submission SO_x [kt]	8.1E-03	8.1E-03	8.1E-03	1.3E-02	1.0E-02	6.4E-03	9.4E-03
Change relative to the 2022 Submission SO_x	0.0%	0.1%	0.0%	-0.4%	0.0%	-0.2%	-0.6%
2022 Submission $PM_{2.5}$ [kt]	4.2E-03	4.2E-03	4.0E-03	5.5E-03	4.0E-03	3.5E-03	3.7E-03
2023 Submission $PM_{2.5}$ [kt]	4.2E-03	4.3E-03	4.0E-03	5.1E-03	4.0E-03	3.4E-03	3.3E-03
Change relative to the 2022 Submission $PM_{2.5}$	0.5%	1.5%	0.1%	-8.0%	0.1%	-2.2%	-11.6%
2022 Submission PM_{10} [kt]	4.2E-03	4.2E-03	4.0E-03	5.5E-03	4.0E-03	3.5E-03	3.7E-03
2023 Submission PM_{10} [kt]	4.2E-03	4.3E-03	4.0E-03	5.1E-03	4.0E-03	3.4E-03	3.3E-03
Change relative to the 2022 Submission PM_{10}	0.5%	1.5%	0.1%	-8.0%	0.1%	-2.2%	-11.6%
2022 Submission TSP [kt]	4.2E-03	4.2E-03	4.0E-03	5.5E-03	4.0E-03	3.5E-03	3.7E-03
2023 Submission TSP [kt]	4.2E-03	4.3E-03	4.0E-03	5.1E-03	4.0E-03	3.4E-03	3.3E-03
Change relative to the 2022 Submission TSP	0.5%	1.5%	0.1%	-8.0%	0.1%	-2.2%	-11.6%
2022 Submission BC	NE	NE	NE	NE	NE	NE	NE
2023 Submission BC	NA	NA	NA	NA	NA	NA	NA
2022 Submission Pb [t]	5.6E-02	5.6E-02	5.1E-02	6.2E-02	4.1E-02	4.7E-02	3.6E-02
2023 Submission Pb [t]	5.6E-02	5.8E-02	5.1E-02	5.3E-02	4.1E-02	4.5E-02	2.6E-02
Change relative to the 2022 Submission Pb	0.9%	2.4%	0.1%	-15.3%	0.2%	-3.6%	-26.1%
2022 Submission Hg	NE	NE	NE	NE	NE	NE	NE
2023 Submission Hg	NA	NA	NA	NA	NA	NA	NA
2022 Submission Cd [t]	1.2E-04	1.3E-04	1.1E-04	1.4E-04	9.6E-05	1.0E-04	8.6E-05
2023 Submission Cd [t]	1.3E-04	1.3E-04	1.1E-04	1.2E-04	9.6E-05	1.0E-04	6.6E-05
Change relative to the 2022 Submission Cd	0.8%	2.2%	0.1%	-13.7%	0.2%	-3.3%	-22.5%
2022 Submission As [t]	3.3E-05	3.3E-05	3.1E-05	4.5E-05	3.2E-05	2.7E-05	3.1E-05
2023 Submission As [t]	3.3E-05	3.3E-05	3.1E-05	4.2E-05	3.2E-05	2.7E-05	2.8E-05
Change relative to the 2022 Submission As	0.5%	1.3%	0.1%	-6.8%	0.1%	-1.9%	-9.6%
2022 Submission Cr [t]	2.7E-04	2.7E-04	2.5E-04	3.1E-04	2.1E-04	2.3E-04	1.8E-04
2023 Submission Cr [t]	2.7E-04	2.8E-04	2.5E-04	2.7E-04	2.1E-04	2.2E-04	1.4E-04
Change relative to the 2022 Submission Cr	0.8%	2.3%	0.1%	-14.2%	0.2%	-3.4%	-23.5%
2022 Submission Cu [t]	1.9E-03	1.9E-03	1.7E-03	2.1E-03	1.4E-03	1.6E-03	1.2E-03
2023 Submission Cu [t]	1.9E-03	1.9E-03	1.7E-03	1.8E-03	1.4E-03	1.5E-03	9.1E-04
Change relative to the 2022 Submission Cu	0.9%	2.3%	0.1%	-14.9%	0.2%	-3.5%	-25.2%

5Eii Other Waste – Vehicle Fires	1990	1995	2000	2005	2010	2015	2020
2022 Submission Ni [t]	1.9E-04	1.9E-04	1.7E-04	2.1E-04	1.4E-04	1.6E-04	1.2E-04
2023 Submission Ni [t]	1.9E-04	2.0E-04	1.7E-04	1.8E-04	1.4E-04	1.5E-04	9.0E-05
Change relative to the 2022 Submission Ni	0.9%	2.4%	0.1%	-15.3%	0.2%	-3.6%	-26.1%
2022 Submission Se	NE	NE	NE	NE	NE	NE	NE
2023 Submission Se	NA	NA	NA	NA	NA	NA	NA
2022 Submission Zn [t]	2.2E-01	2.2E-01	2.0E-01	2.4E-01	1.6E-01	1.8E-01	1.4E-01
2023 Submission Zn [t]	2.2E-01	2.2E-01	2.0E-01	2.1E-01	1.6E-01	1.8E-01	1.0E-01
Change relative to the 2022 Submission Zn	0.9%	2.4%	0.1%	-15.3%	0.2%	-3.6%	-26.1%
2022 Submission PCDD/F [g]	8.5E-02	8.5E-02	8.5E-02	1.4E-01	1.1E-01	6.9E-02	1.0E-01
2023 Submission PCDD/F [g]	8.5E-02	8.5E-02	8.5E-02	1.4E-01	1.1E-01	6.9E-02	1.0E-01
Change relative to the 2022 Submission PCDD/F	0.0%	0.1%	0.0%	-0.3%	0.0%	-0.1%	-0.4%
2022 Submission BaP [t]	1.2E-03	1.2E-03	1.1E-03	1.4E-03	9.7E-04	9.9E-04	8.7E-04
2023 Submission BaP [t]	1.2E-03	1.2E-03	1.1E-03	1.3E-03	9.7E-04	9.6E-04	7.0E-04
Change relative to the 2022 Submission BaP	0.7%	2.0%	0.1%	-12.0%	0.1%	-3.0%	-19.1%
2022 Submission BbF [t]	2.5E-03	2.5E-03	2.3E-03	2.9E-03	2.0E-03	2.1E-03	1.8E-03
2023 Submission BbF [t]	2.5E-03	2.6E-03	2.3E-03	2.6E-03	2.0E-03	2.0E-03	1.4E-03
Change relative to the 2022 Submission BbF	0.8%	2.1%	0.1%	-12.8%	0.2%	-3.2%	-20.7%
2022 Submission BkF [t]	2.3E-03	2.3E-03	2.1E-03	2.6E-03	1.7E-03	1.9E-03	1.5E-03
2023 Submission BkF [t]	2.3E-03	2.4E-03	2.1E-03	2.2E-03	1.7E-03	1.9E-03	1.2E-03
Change relative to the 2022 Submission BkF	0.8%	2.3%	0.1%	-14.3%	0.2%	-3.4%	-23.9%
2022 Submission IPy [t]	1.8E-03	1.8E-03	1.6E-03	2.1E-03	1.4E-03	1.5E-03	1.3E-03
2023 Submission IPy [t]	1.8E-03	1.8E-03	1.6E-03	1.8E-03	1.4E-03	1.4E-03	1.0E-03
Change relative to the 2022 Submission Ipy	0.8%	2.1%	0.1%	-12.9%	0.2%	-3.2%	-20.9%
2022 Submission HCB	NE	NE	NE	NE	NE	NE	NE
2023 Submission HCB	NA	NA	NA	NA	NA	NA	NA
2022 Submission PCB	NE	NE	NE	NE	NE	NE	NE
2023 Submission PCB	NA	NA	NA	NA	NA	NA	NA
2022 Submission PAH4 [t]	7.8E-03	7.8E-03	7.1E-03	9.1E-03	6.1E-03	6.5E-03	5.4E-03
2023 Submission PAH4 [t]	7.8E-03	8.0E-03	7.2E-03	7.9E-03	6.1E-03	6.3E-03	4.3E-03
Change relative to the 2022 Submission PAH4	0.8%	2.1%	0.1%	-13.1%	0.2%	-3.2%	-21.4%

Table 6.20 Recalculations in Sector 5Eiii due to changes in methodology.

5Eiii Other Waste – Large Fires	1990	1995	2000	2005	2010	2015	2019	2020
2022 Submission BC	NE	NE	NE	NE	NE	NE	NE	NE
2023 Submission BC	NA	NA	NA	NA	NA	NA	NA	NA
2022 Submission Ni	NE	NE	NE	NE	NE	NE	NE	NE
2023 Submission Ni	NA	NA	NA	NA	NA	NA	NA	NA
2022 Submission Se	NE	NE	NE	NE	NE	NE	NE	NE
2023 Submission Se	NA	NA	NA	NA	NA	NA	NA	NA
2022 Submission Zn	NE	NE	NE	NE	NE	NE	NE	NE
2023 Submission Zn	NA	NA	NA	NA	NA	NA	NA	NA
2022 Submission HCB	NE	NE	NE	NE	NE	NE	NE	NE
2023 Submission HCB	NA	NA	NA	NA	NA	NA	NA	NA
2022 Submission PCB	NE	NE	NE	NE	NE	NE	NE	NE
2023 Submission PCB	NA	NA	NA	NA	NA	NA	NA	NA

6.8.1.5 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 EAI 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 Sector 11)

7.1 Volcanoes (NFR 11A)

Volcanic emissions are frequent in Iceland and both remote and in-situ analytical techniques allow for a good estimation of associated emissions. While the following chapters describe the four 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
2021	Fagradalsfjall	967	N/A	N/A	See Section 7.1.4

The last four volcanic eruptions (Eyjafjallajökull, April-May 2010; Grímsvötn, May 2011; Holuhraun, September 2014-February 2015; and Fagradalsfjall, March-September 2021) are reported in 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 (PM_{10}, $PM_{2.5}$) were estimated and reported. The emissions estimates are based on satellite observations on a daily basis during the eruption[15] and amounted to approximately 127 kt of SO_2, 6,000 kt of PM_{10}, and 1,700 kt. of $PM_{2.5}$. These 6,000 kt of PM_{10} were around 3,500 times more than the total estimated anthropogenic PM_{10} emissions in Iceland in 2010.

[15] 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

Grímsvötn volcano lays below the biggest glacier in Iceland, Vatnajökull, in the southeast of the country, and reaches 1,725 m above sea level. It is one of Iceland's most active volcanoes, and has erupted frequently in the past century (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 entirety Eyjafjallajökull eruption. SO_2 emissions from Grímsvötn have been estimated to be around 1,000 kt. The total mass of particulates emitted has not been estimated, but the Environment Agency of Iceland (*Umhverfisstofnun*) (EAI) has scaled the emissions of particulates using the ratio of sulphur emissions from the two eruptions (1,000/127). 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.

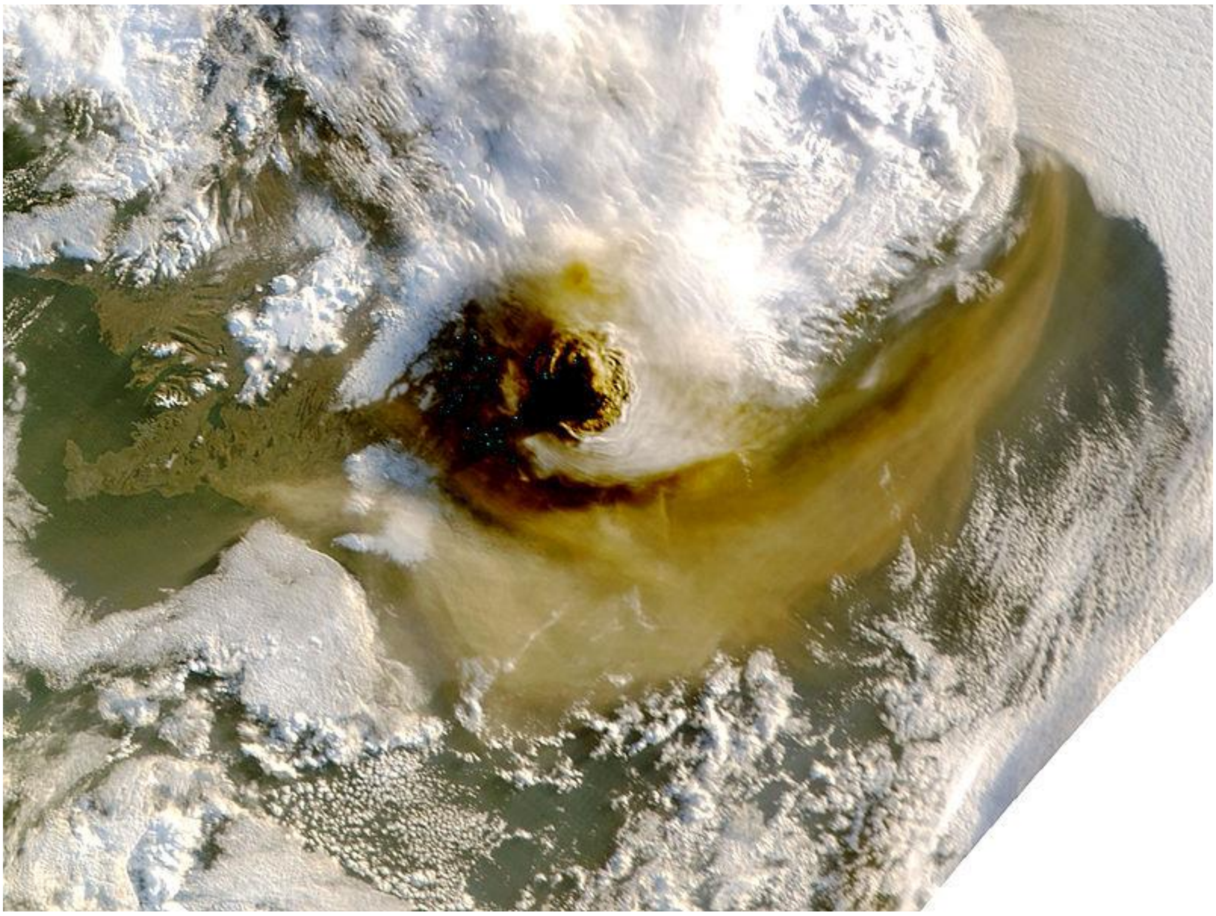


Figure 7.2 Grímsvötn eruption in May 2011. (Photo NASA/GSFC/Jeff Schmaltz/MODIS Land Rapid Response Team).

7.1.3 Holuhraun Eruption: 2014-2015

Holuhraun is located to the north of Vatnajökull glacier and is associated with the volcano Bárðabunga situated beneath Vatnajökull. Prior to the eruption, seismic measurements showed the emplacement of a dike, originating from the Bárðabunga caldera and migrating to the northeast 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 Meteorological Office (*Veðurstofa Íslands*) (IMO). According to information from Sara Barsotti and Melissa Anne Pfeffer, specialists at the IMO, the estimates were conducted 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; 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, good quality measurements were used to calculate daily averages of the 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 2014 and 1,126 kt of SO_2 in 2015. To put these numbers in in perspective, it can be said that the total SO_2 emissions from all the European Union (EU) countries for 2012 was 4,576 kt. This means that the emissions from the eruption in 2014 (i.e., from 29 August 2014 to 31 December 2014) were more than twice the total SO_2 emissions from all the EU for the whole year. For September alone, during the most intensive period of the eruption, the SO_2 emissions from the eruption were similar to the annual SO_2 emissions of the EU.

Because the eruption occurred 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 (IMO), 2016, email communication).

	Average monthly emission rates [kg/s]	**SO_2 per month [kt]**
August 2014	124	332
September 2014	1,708	4,427
October 2014	1,051	2,815
November 2014	1,143	2,963
December 2014	128	343
January 2015	304	814
February 2015	129	312

Figure 7.3 Holuhraun eruption in September 2014. The height of the lava fountains was around 100 m (Photo: Ólafur F. Gíslason).

7.1.4 Fagradalsfjall Eruption: 2021

A basaltic effusive eruption started at Mt. Fagradalsfjall along a fissure on 19 March and lasted until 18 September 2021 (Figure 7.4). This eruption ended a 781-year dormancy on the Reykjanes peninsula in the southwest of Iceland. This peninsula is an onshore continuation of the Mid-Atlantic plate boundary and has volcanic systems consisting of 10-40 km long NE-SW-trending fissure swarms and geothermal areas. However, Fagradalsfjall is the least active volcanic system of the peninsula. The March-September mean bulk effusion rate was 9.5 ±0.2 m^3/s, ranging between 1 and 8 m^3/s in March-April and increasing to 9-13 m^3/s in May-September. This is uncommon for recent Icelandic eruptions, where the highest discharge usually occurs in the opening phase (Pedersen, 2022).

Measurements of SO_2 emissions were done by the IMO in the following way: the flux of SO_2 was measured with ground-based UV spectrometers. A three-instrument network of DOAS instruments (10 km NNW of the eruption site, 6 km to the NW, and 4.5 km to the SW) was augmented by traverses directly under the eruption cloud which were primarily car-borne, but a few measurements were also made by foot and by aircraft. These measurements are used together with plume height and meteorological conditions to calculate the emission rate of SO_2. The scanning instruments measured the SO_2 flux 4,900 times over the duration of the eruption. These measurements include only those where the plume was within ±15 degrees of line of site from the eruption to the instrument and the measurements were not obviously impacted by the low solar angle during sunrise and sunset. Additionally, 148 traverse measurements were made. The traverse calculations attempt to include the uncertainty related to wind properties to have the true measurement uncertainty represented in the results. The total SO_2 emissions are 967 ±538 kt.

Figure 7.4 Fagradalsfjall eruption on 1 May 2021. Photo: Nicole Keller.

8 Spatially Distributed Emissions on a Grid

[last updated for 2022 submission]

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. It should be noted that no updates were made between the 2022 Submission and this one, as gridded data only needs to be submitted every four years. Iceland intends to include updates to this section in the 2025 Submission.

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 (2,273 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 (*Landmælingar Íslands*) (NLSI)[16]. Population density maps and the locations of major ports and airports were extracted from these datasets with the help of 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 (*Hagstofa Íslands*) (SI)[17]. Flight statistics for international and domestic flights were collected from Isavia[18], 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.

[16] https://www.lmi.is/
[17] https://statice.is/
[18] 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	National Energy Authority (*Orkustofnun*) (NEA), 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, NEA – NIR/IIR, EPRTR registry
B_Industry	1A2b	Stationary Combustion in Manufacturing Industries and Construction: Non-ferrous Metals	Fuel consumption of Aluminium producers known, NEA – 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, NEA – NIR/IIR, EPRTR registry
I_Offroad	1A2gvii	Mobile Combustion in Manufacturing Industries and Construction	Population density used as proxy spatial dataset, dataset from NLSI.
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 NEA, 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 NLSI.
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 NLSI.
F_RoadTransport	1A3bi	Road Transport: Passenger Cars	Population density used as proxy, dataset from NLSI
F_RoadTransport	1A3bii	Road transport: Light-duty Vehicles	Population density used as proxy, dataset from NLSI
F_RoadTransport	1A3biii	Road Transport: Heavy-duty Vehicles and Buses	Population density used as proxy, dataset from NLSI
F_RoadTransport	1A3biv	Road transport: Mopeds and Motorcycles	Population density used as proxy, dataset from NLSI
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.
C_OtherStationaryComb	1A4ai	Commercial/Institutional: Stationary	This category comprises pools heated by fossil fuels; according to the NEA, there is only one public pool left heated with fossil fuels (Grundarfjörður and the school building as well).

GNFR Code	NFR Code	Long Name	Source and Proxy Spatial Dataset Used
C_OtherStationaryComb	1A4bi	Residential: Stationary	Population density used as proxy, dataset from NLSI
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 fewer 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 NLSI.
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 NLSI.
I_Offroad	1A4ciii	Agriculture/Forestry/Fishing: National Fishing	Main ports defined from the tonnage landed, dataset from SI and emissions split accordingly.
C_OtherStationaryComb	1A5a	Other Stationary (including Military)	Population density used as proxy, dataset from NLSI
B_Industry	2A6	Other Mineral Products (please specify in the IIR)	Fuel consumption from the mineral wool producers are known, NEA – NIR/IIR
B_Industry	2C2	Ferroalloys Production	Fuel consumption from the ferroalloys producers are known, NEA – NIR/IIR
B_Industry	2C3	Aluminium Production	Fuel consumption from the aluminium producers are known, NEA – 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 NLSI
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 Reykjavík.
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 NLSI

8.3 Emissions 2019

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

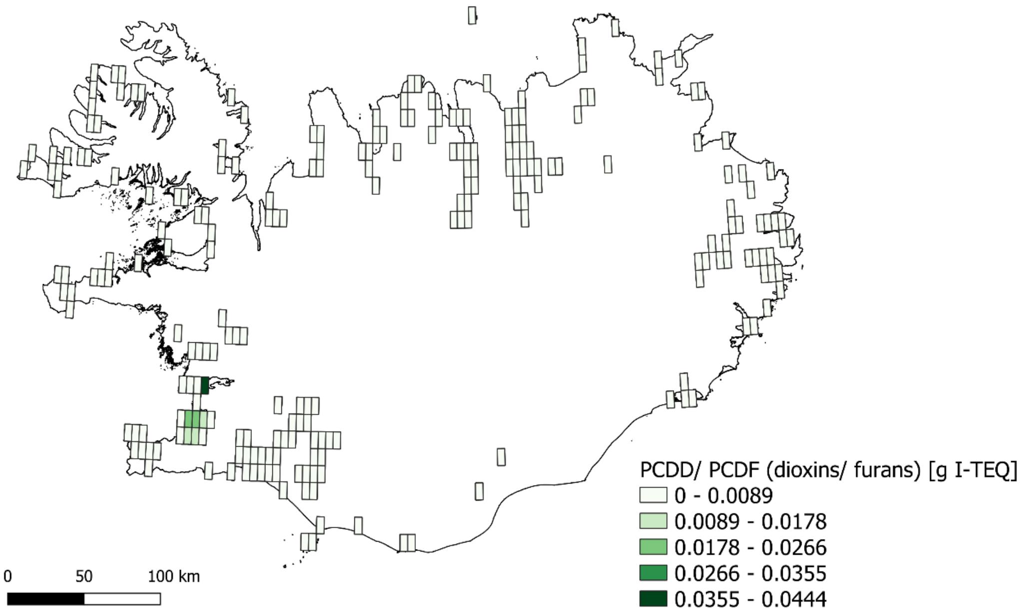


Figure 8.1 Emissions of dioxin/furans 2019 [g I-TEQ].

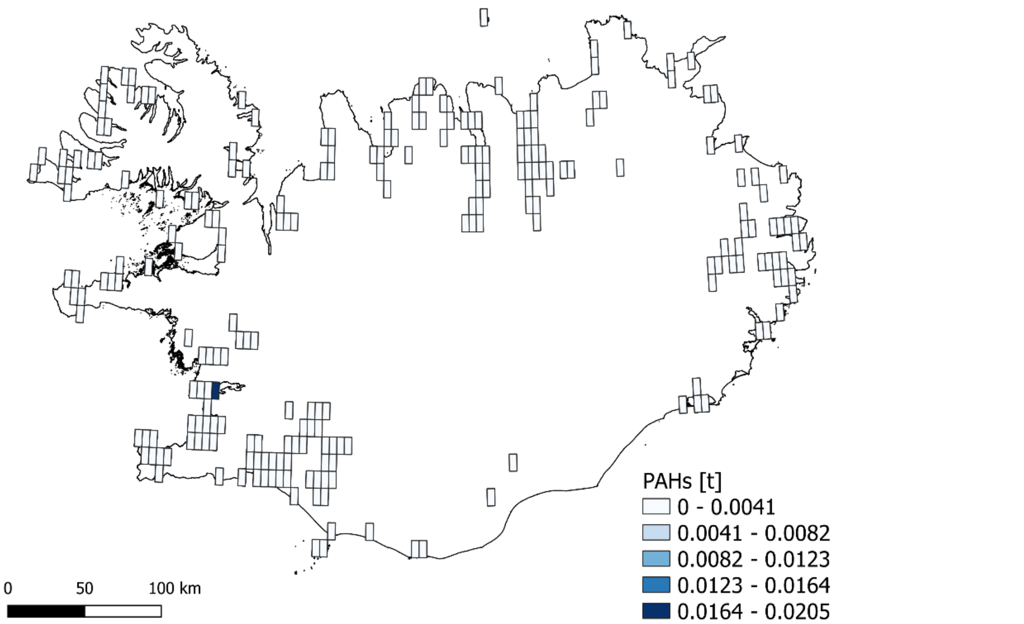


Figure 8.2 Emissions of PAHs [t] in 2019.

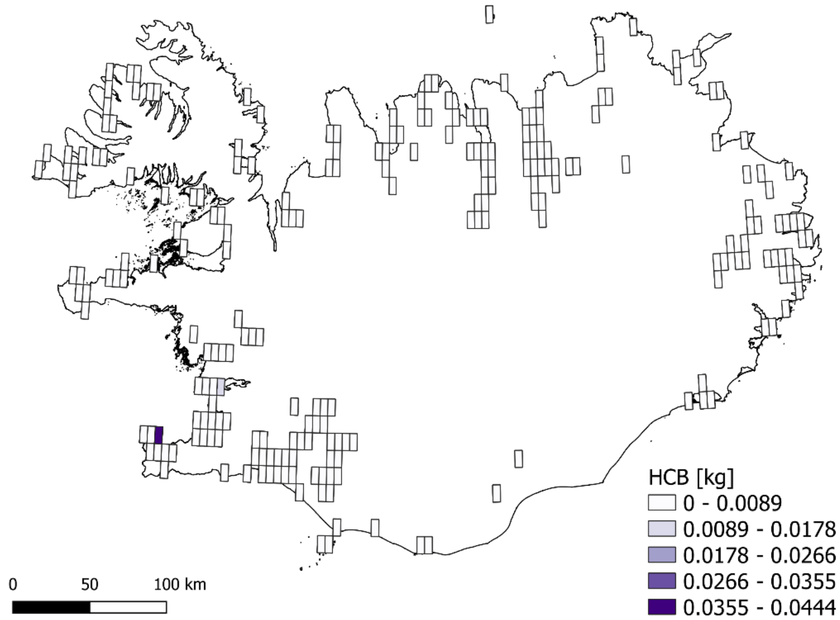


Figure 8.3 Emissions of HCB [kg] in 2019.

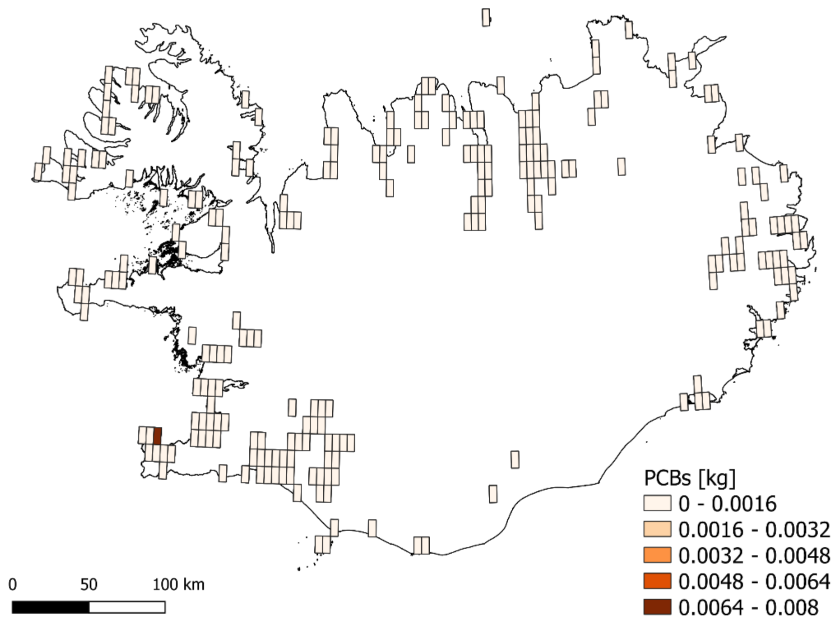


Figure 8.4 Emissions of PCBs [kg] in 2019.

8.4 Emissions 2015

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

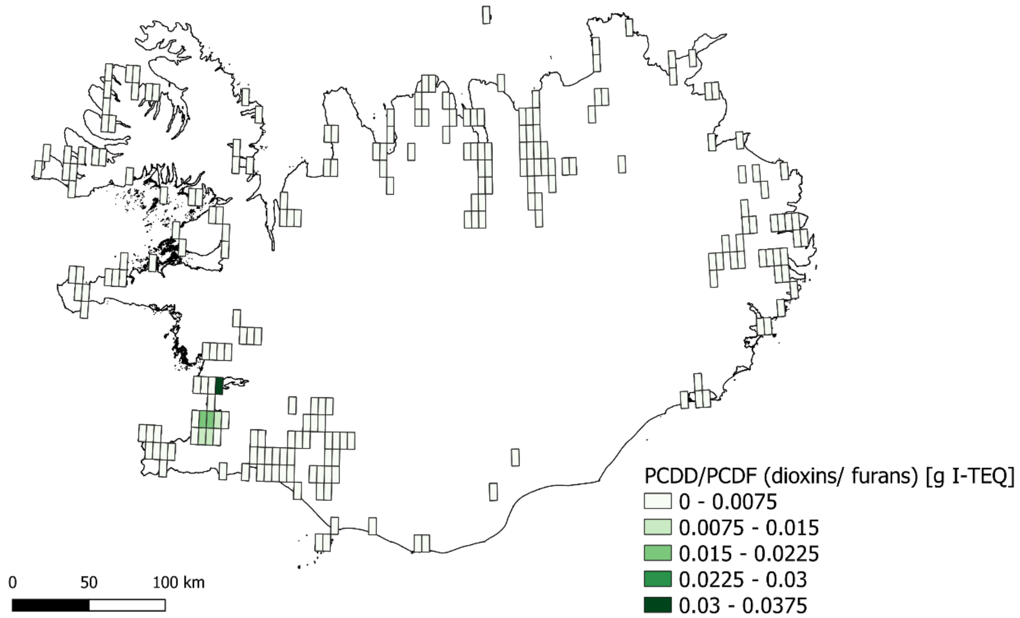


Figure 8.5 Emissions of Dioxin/furans 2015 in [g I-TEQ].

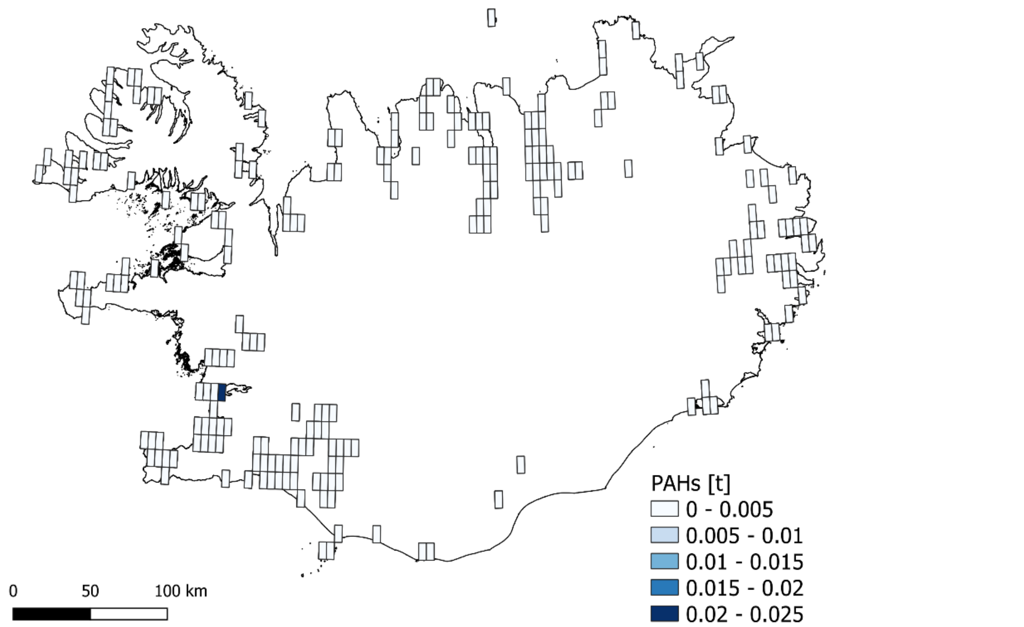


Figure 8.6 Emissions of PAHs [t] in 2015.

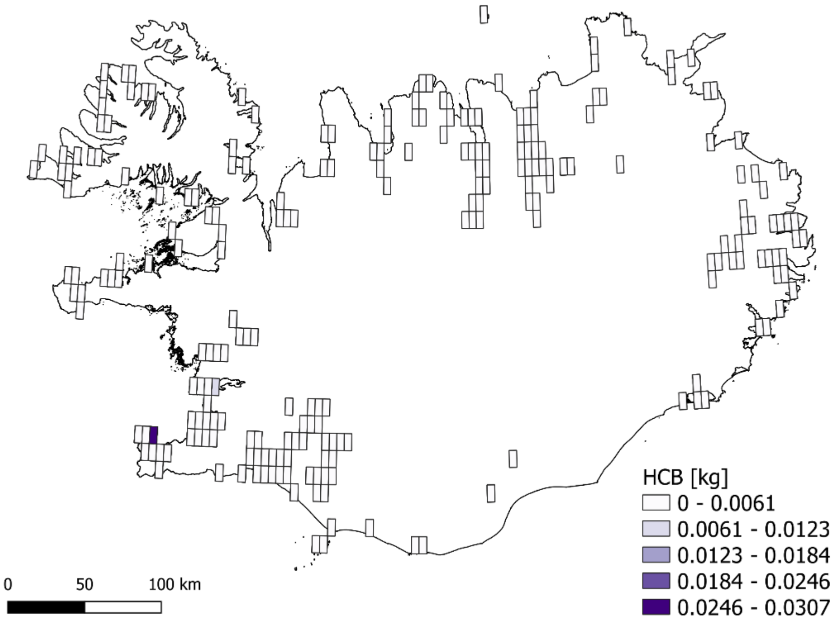


Figure 8.7 Emissions of HCB [kg] in 2015.

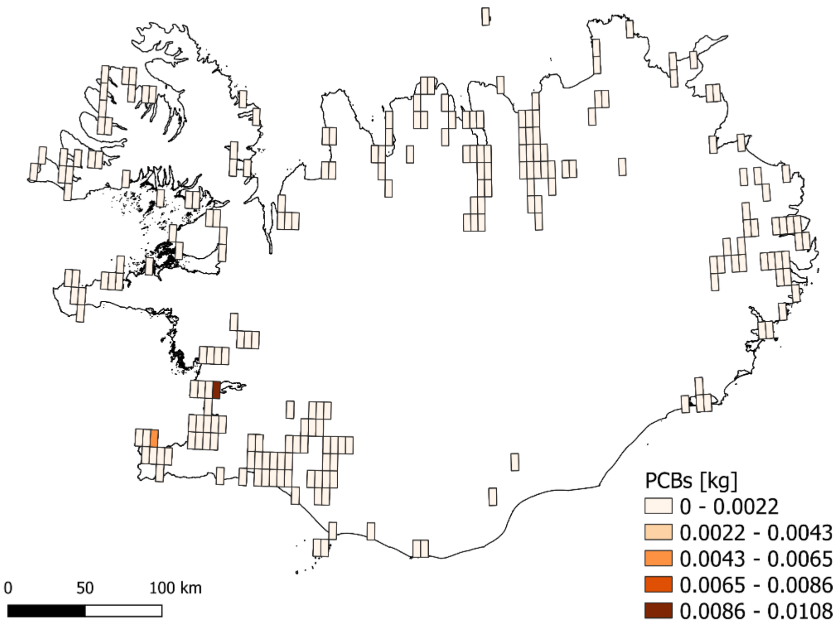


Figure 8.8 Emissions of PCBs [kg] in 2015.

9 Projections

Emissions of NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, BC, CO, dioxin, PAHs, HCB, PCB, and heavy metals are projected until 2050. 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 **W**ith **E**xisting **M**easures (WEM) 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 2. The methodology and underlying assumptions for the projections are presented for each sector in the following subchapters.

Table 9.1: Emissions of all air pollutants. Historical data for 2005 and 2021 and projected emissions for 2030, 2040, and 2050.

Pollutant	Unit	2005	2021	2030	2040	2050	Change 2021-2050	Change 2005-2050
NO_x	[kt NO_2]	26.7	19.6	17.0	14.9	13.5	-31%	-50%
NMVOC	[kt]	7.44	5.79	6.35	6.04	6.00	+3.7%	-19%
SO_x	[kt SO_2]	40.4	60.5	47.9	53.3	58.3	-3.7%	+44%
NH_3	[kt]	4.37	4.37	4.39	4.29	4.20	-4.0%	-3.9%
$PM_{2.5}$	[kt]	1.52	1.04	1.10	1.08	1.06	+1.5%	-30%
BC	[kt]	0.23	0.085	0.088	0.084	0.084	-1.1%	-64%
CO	[kt]	50.4	104	109	108	108	+3.1%	+114%
Dioxin	[g I-TEQ]	0.94	0.98	1.21	1.20	1.19	+21%	+27%
PAH4	[t]	0.15	0.065	0.084	0.077	0.072	+11%	-53%
HCB	[kg]	0.098	0.10	0.098	0.099	0.10	-1.7%	+2.4%
PCB	[kg]	0.15	0.015	0.013	0.013	0.012	-22%	-92%
Pb	[t]	1.27	0.49	0.51	0.41	0.35	-28%	-72%
Cd	[t]	0.029	0.005	0.009	0.008	0.008	+44%	-73%
Hg	[t]	0.034	0.010	0.009	0.008	0.007	-32%	-80%
As	[t]	0.054	0.015	0.015	0.013	0.012	-22%	-78%
Cr	[t]	0.15	0.15	0.15	0.11	0.085	-43%	-45%
Cu	[t]	2.71	3.12	3.15	2.32	1.78	-43%	-34%
Ni	[t]	1.33	0.22	0.20	0.17	0.15	-34%	-89%
Se	[t]	0.032	0.021	0.019	0.016	0.014	-34%	-55%
Zn	[t]	1.63	1.57	1.79	1.66	1.56	-0.54%	-4.0%

9.1 Projected Trends 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 from 2005-2021 and projected emissions from 2021-2050.

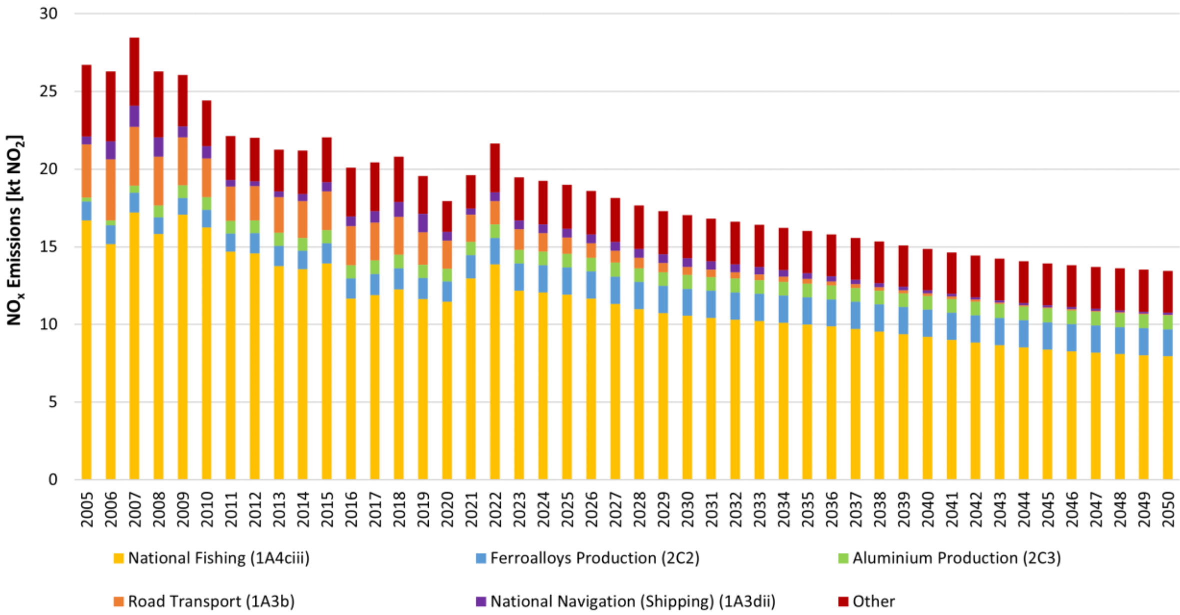


Figure 9.1: NO_x emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.2 Non-methane Volatile Organic Compounds (NMVOCs)

The decrease in emissions since 2005 is mainly due to less fuel use within 1A3b Road Transport and due to the renewal of the car fleet. This trend is projected to continue from 2021-2050. 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 2H2 Food and Beverages Industry is due to increased production and export of spirits. Figure 9.2 shows the historical NMVOC emissions from 2005-2021 and the projected emissions from 2022-2050.[19]

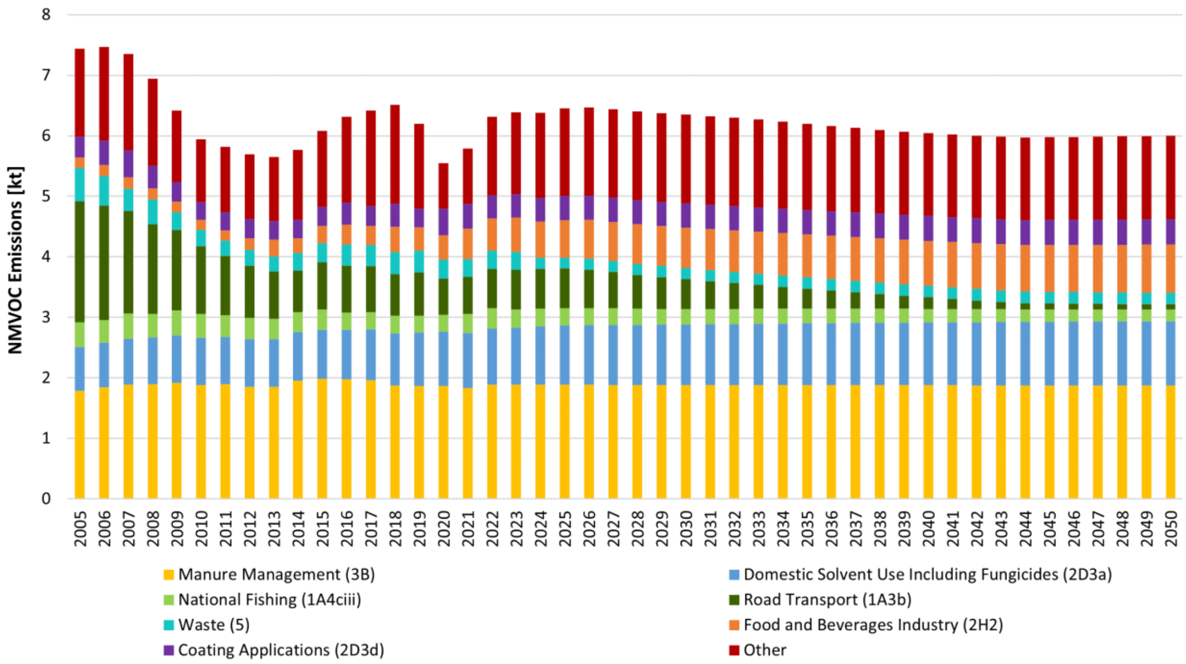


Figure 9.2: NMVOC emissions by main sources. Historical data until 2021 and projections until 2050.

[19] The figure includes emissions from 3B Manure Management and 3D Agricultural Soils, 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 this 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 in Figure 9.3 as 1B2d Other Fugitive Emissions from Energy Production) have increased substantially since 2005 due to an increase in electricity production at geothermal power plants. However, in recent years, 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 *Hellisheiði* and another geothermal plant (*Nesjavellir Power Plant*). This explains the projected decrease in emissions over the next decade and the steep decrease between 2029 and 2030. Figure 9.3 shows the historical SO_x emissions from 2005 and the projected emissions from 2021.

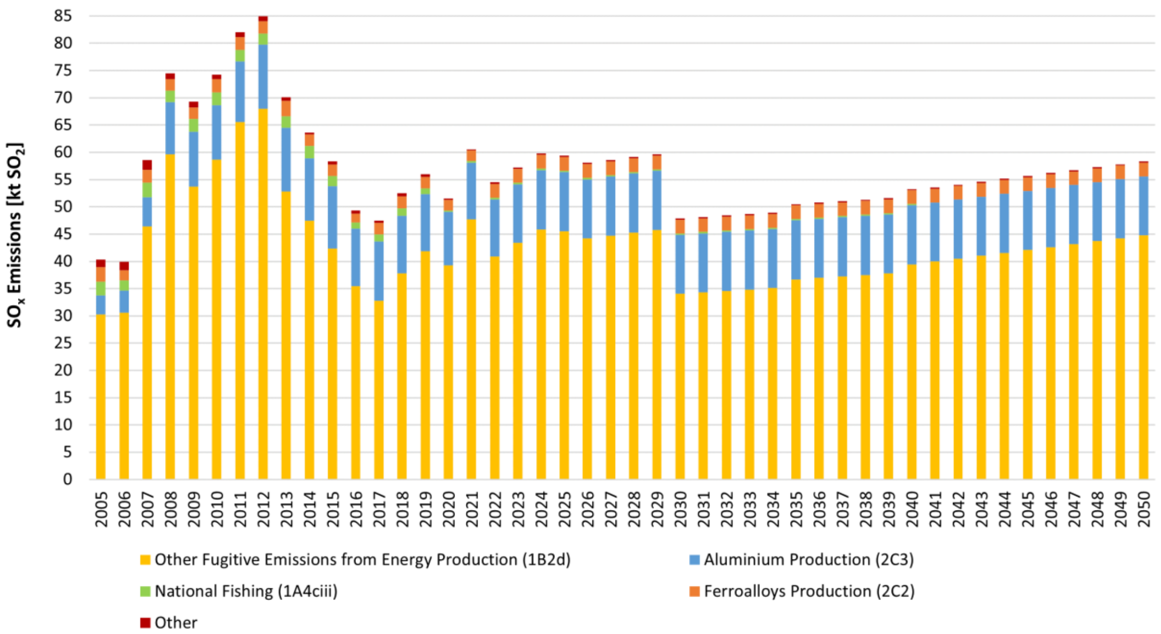


Figure 9.3: SO_x emissions by main sources. Historical data until 2021 and projections until 2050.

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 2005-2021 and the projected emissions from 2022-2050.

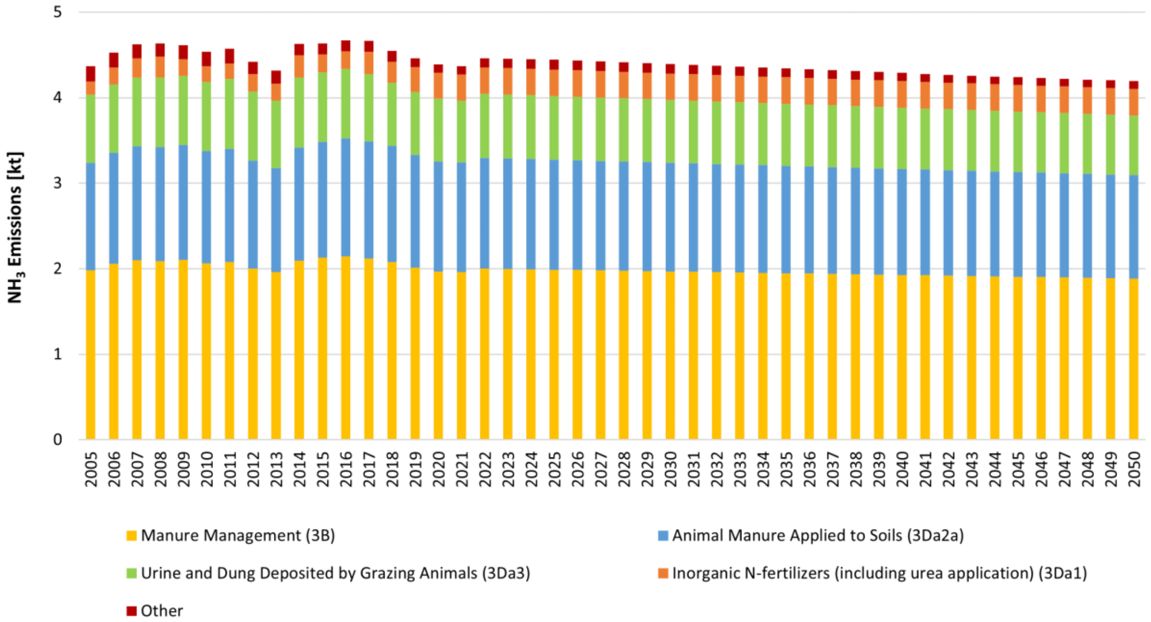


Figure 9.4: NH_3 emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.5 Particulate Matter ($PM_{2.5}$)

Particulate matter emissions are projected to remain relatively constant until 2050. Figure 9.5 shows the historical $PM_{2.5}$ emissions from 2005-2021 and the projected emissions from 2022-2050.

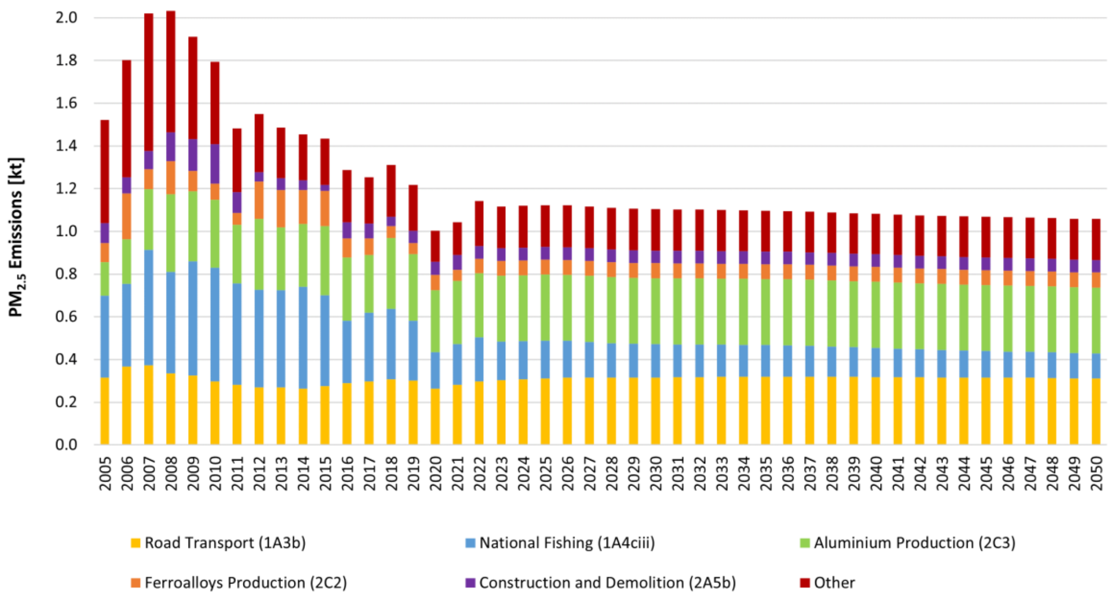


Figure 9.5: $PM_{2.5}$ emissions by main sources. Historical data until 2021 and projections until 2050.

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 2005-2021 and the projected emissions from 2022-2050.

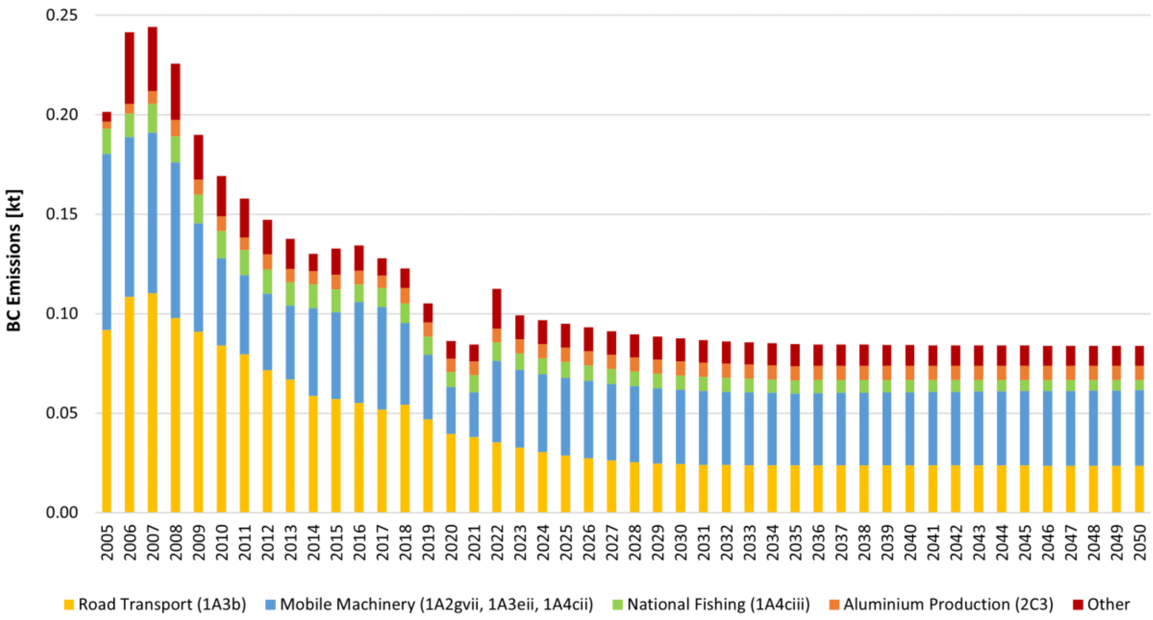


Figure 9.6: BC emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.7 Carbon Monoxide (CO)

Carbon monoxide emissions are dominated by 2C3 Aluminium Production and are expected to remain relatively stable. Figure 9.7: CO emissions by main sources. Historical data until 2021 and projections until 2050. shows the historical CO emissions from 2005-2021 and the projected emissions from 2022-2050.

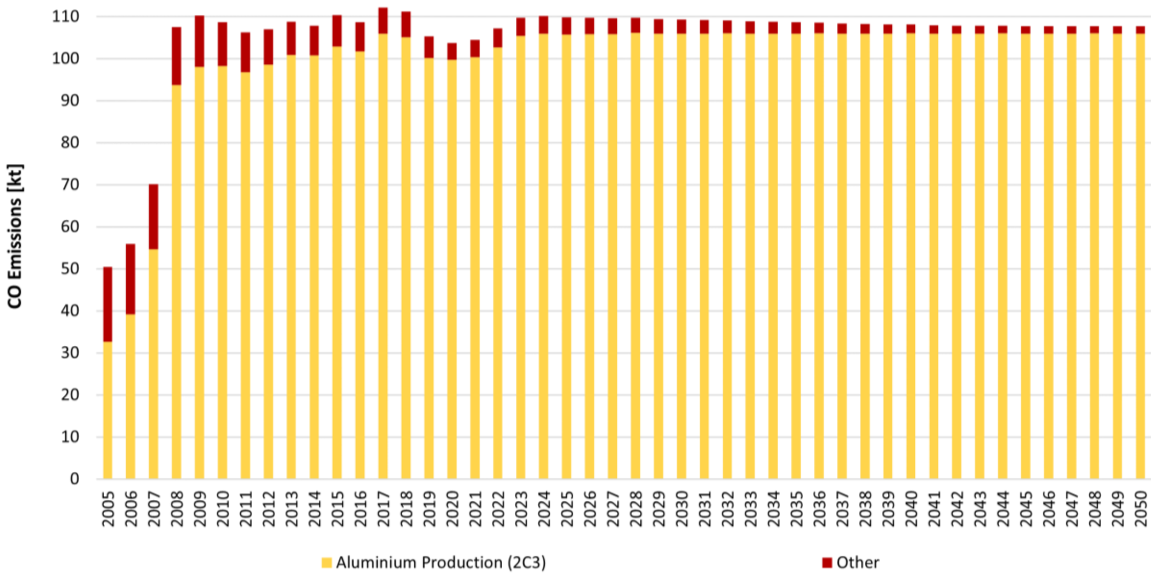


Figure 9.7: CO emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.8 Dioxin

Dioxin emissions are projected to remain relatively stable from the present to 2050. Figure 9.8 shows the historical dioxin emissions from 2005-2021 and the projected emissions from 2022-2050.

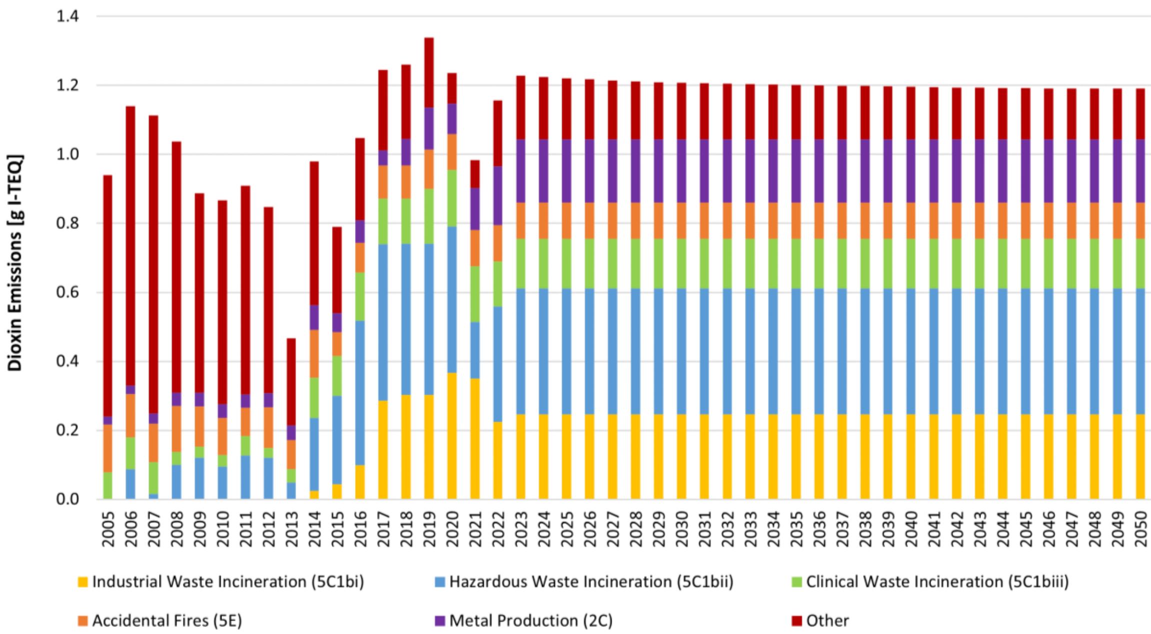


Figure 9.8: Dioxin emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.9 Polycyclic Aromatic Hydrocarbons (PAHs)

PAH emissions are projected to remain relatively stable from the present to 2050. Figure 9.9 shows the historical PAH emissions from 2005-2021 and the projected emissions from 2022-2050. PAH4 emissions are expected to trend slightly downwards until 2050, highlighted by projected reductions in 1A3b Road Transport, which should trend from approximately 29% of Iceland's PAH4 emissions in 2021 to almost 0% by 2050.

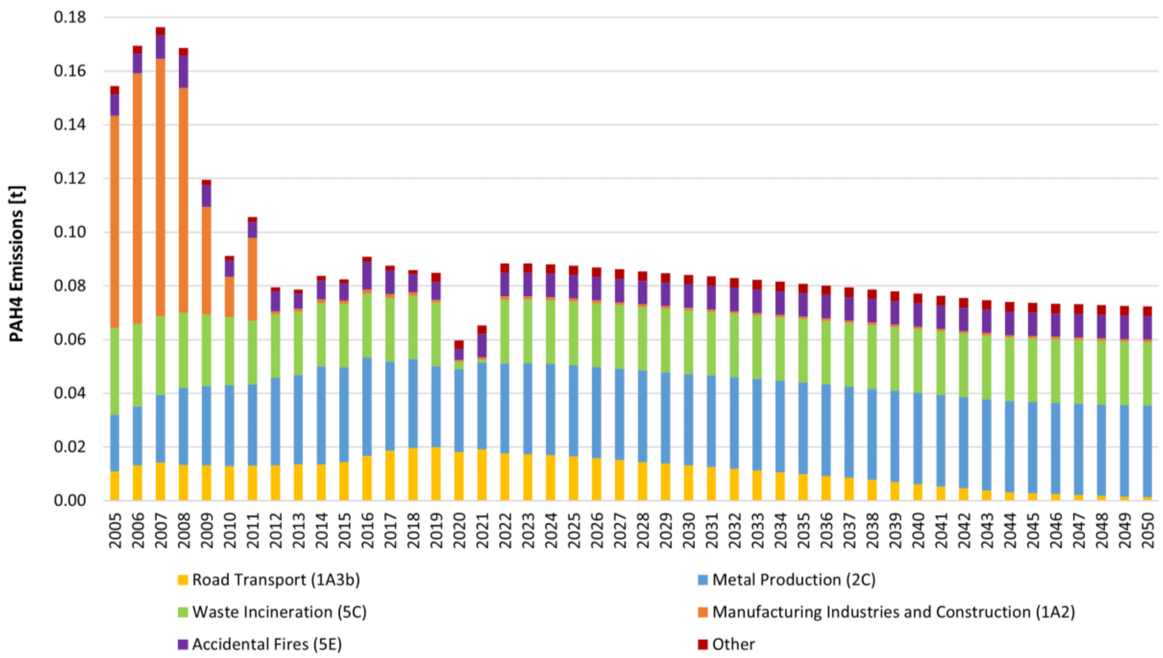


Figure 9.9: PAH4 emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.10 Hexachlorobenzene (HCB)

HCB emissions are projected to remain relatively stable from the present to 2050. Figure 9.10Figure 9.7: CO emissions by main sources. Historical data until 2021 and projections until 2050. shows the historical HCB emissions from 2005-2021 and the projected emissions from 2022-2050.

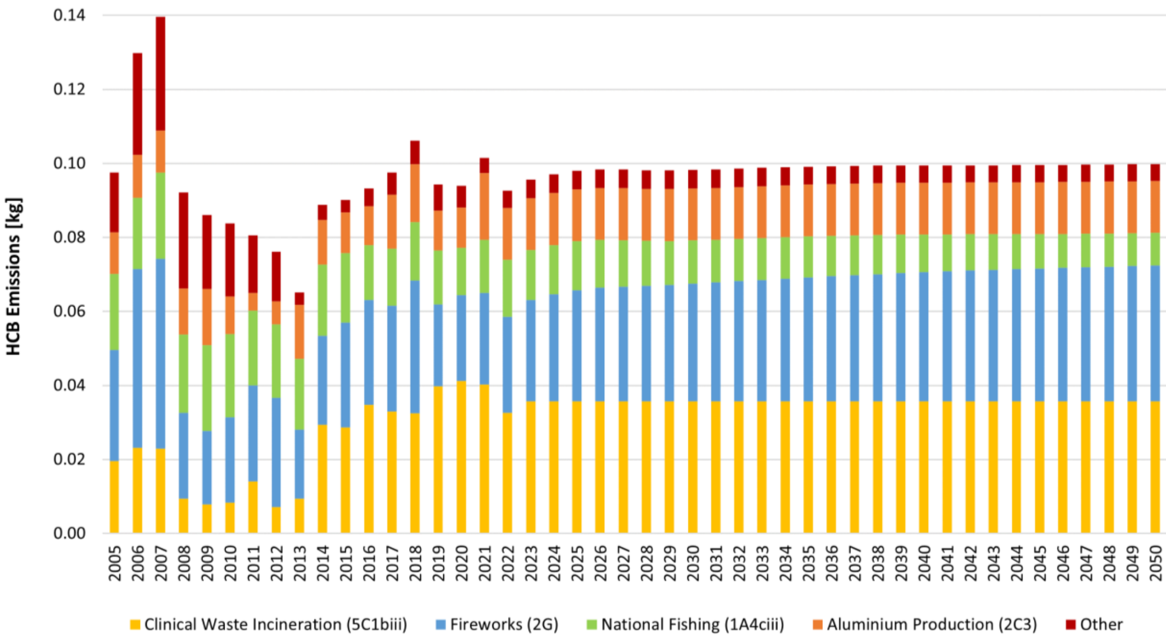


Figure 9.10: HCB emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.11 Polychlorinated Biphenyl (PCB)

PCB emissions are projected to remain relatively stable from the present to 2050. Figure 9.11Figure 9.7: CO emissions by main sources. Historical data until 2021 and projections until 2050. shows the historical PCB emissions from 2005-2021 and the projected emissions from 2022-2050.

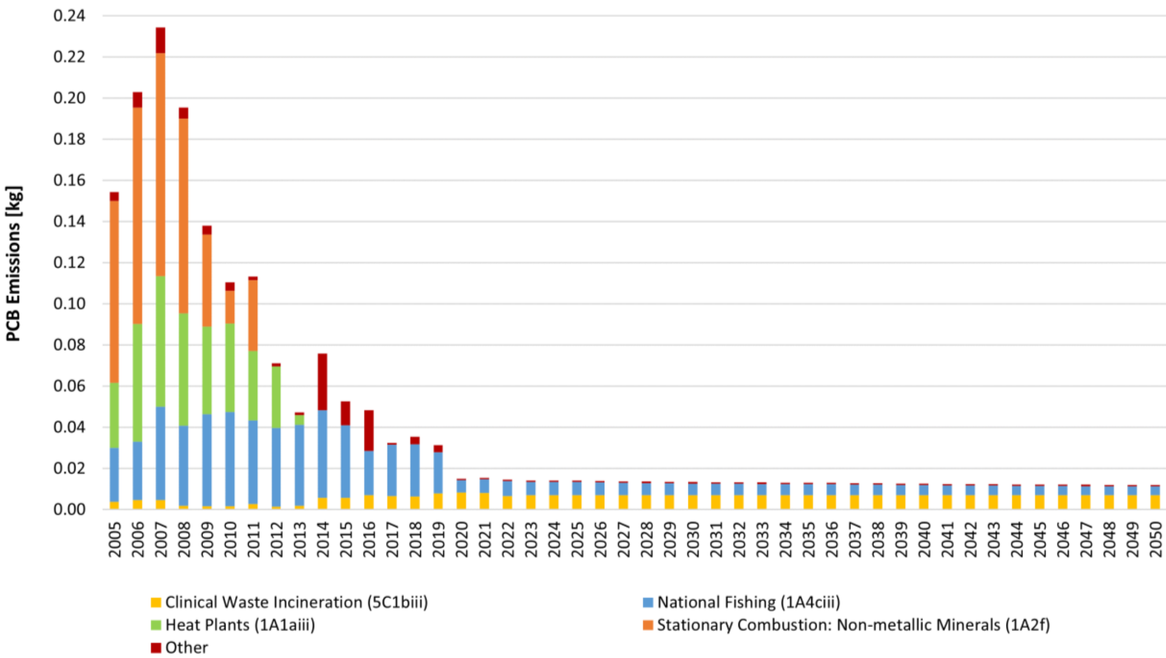


Figure 9.11: PCB emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.12 Priority Heavy Metals (Pb, Cd, Hg)

Projections for the main heavy metals (lead, cadmium, and mercury) are displayed here in Figures Figure 9.12, Figure 9.13, and Figure 9.14, respectively. These figures include historical data from 2005-2021, and projected emissions from 2022-2050.

9.1.12.1 *Lead (Pb)*

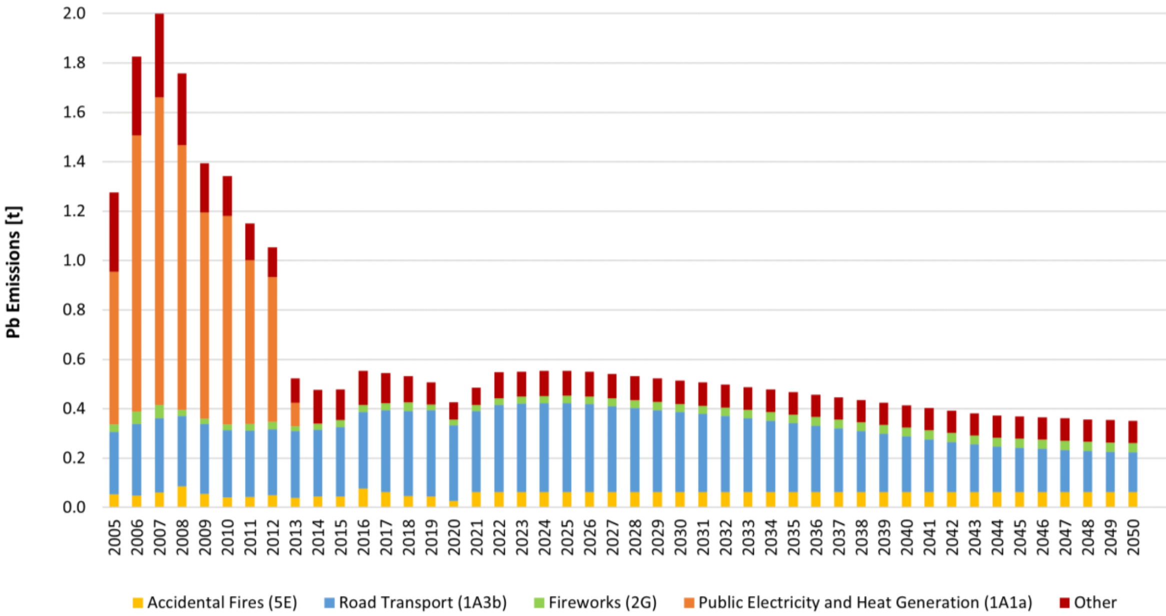


Figure 9.12: Pb emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.12.2 *Cadmium (Cd)*

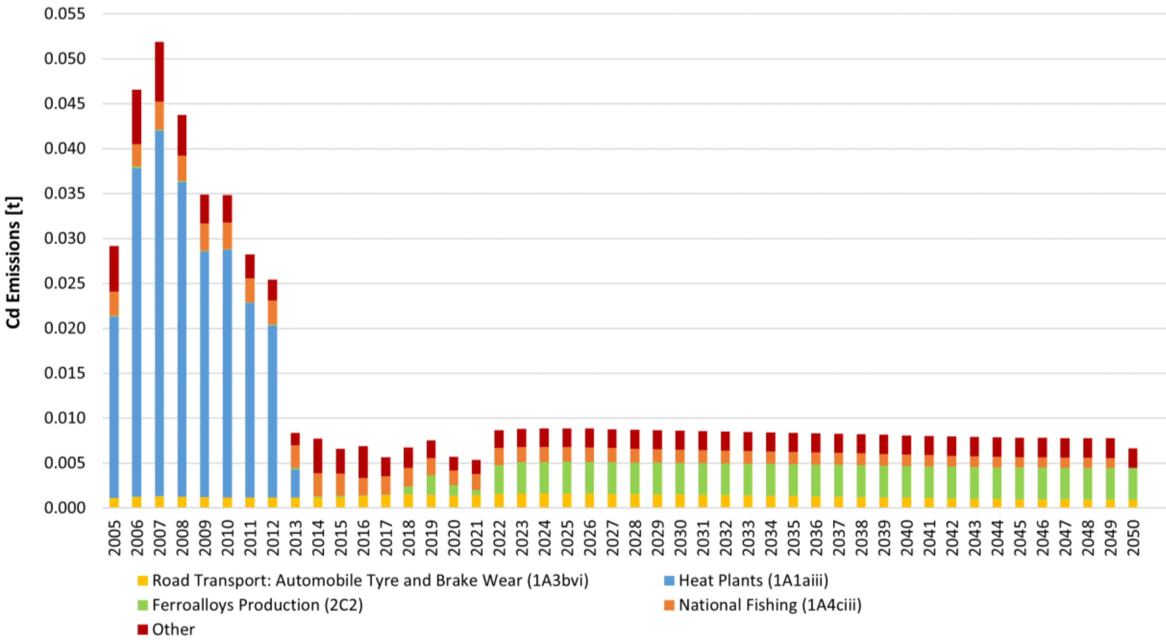


Figure 9.13: Cd emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.12.3 Mercury (Hg)

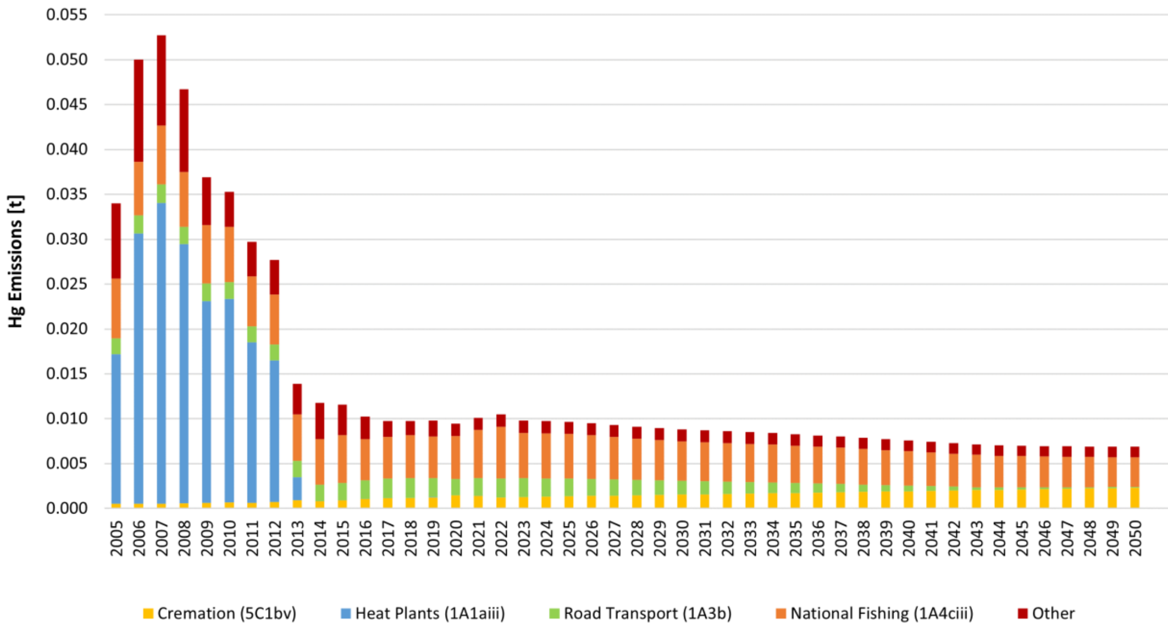


Figure 9.14: Hg emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.13 Additional Heavy Metals (As, Cr, Cu, Ni, Se, Zn)

Projections for additional heavy metals (arsenic, chromium, copper, nickel, selenium, and zinc) are displayed here in Figures Figure 9.15, Figure 9.16, Figure 9.17, Figure 9.18, Figure 9.19, and Figure 9.20, respectively. These figures include historical data from 2005-2021, and projected emissions from 2022-2050.

9.1.13.1 Arsenic (As)

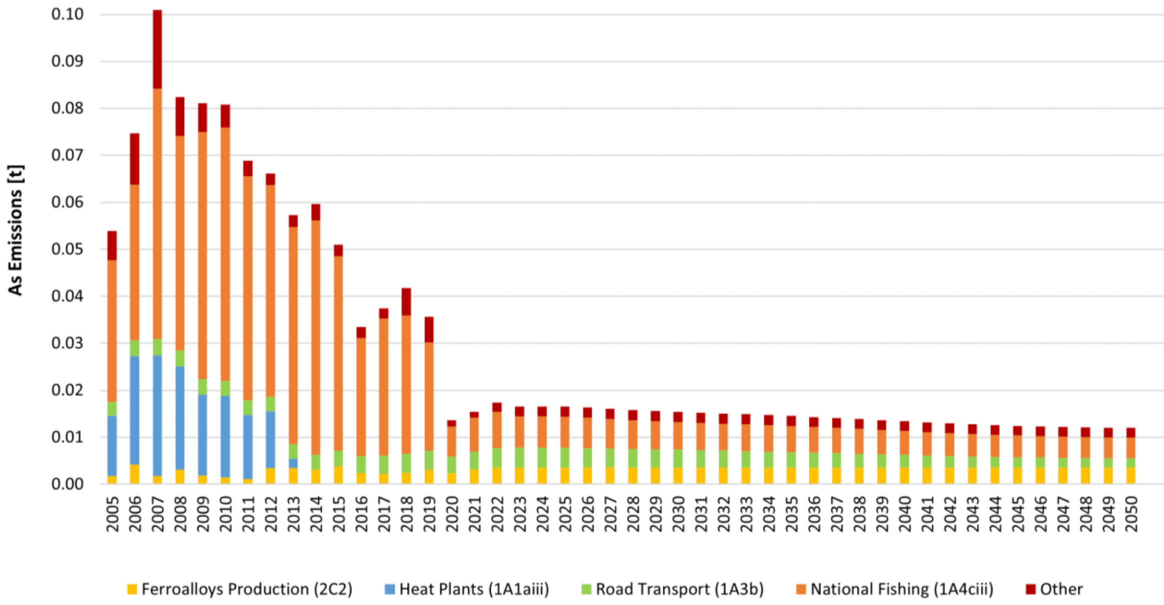


Figure 9.15: As emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.13.2 Chromium (Cr)

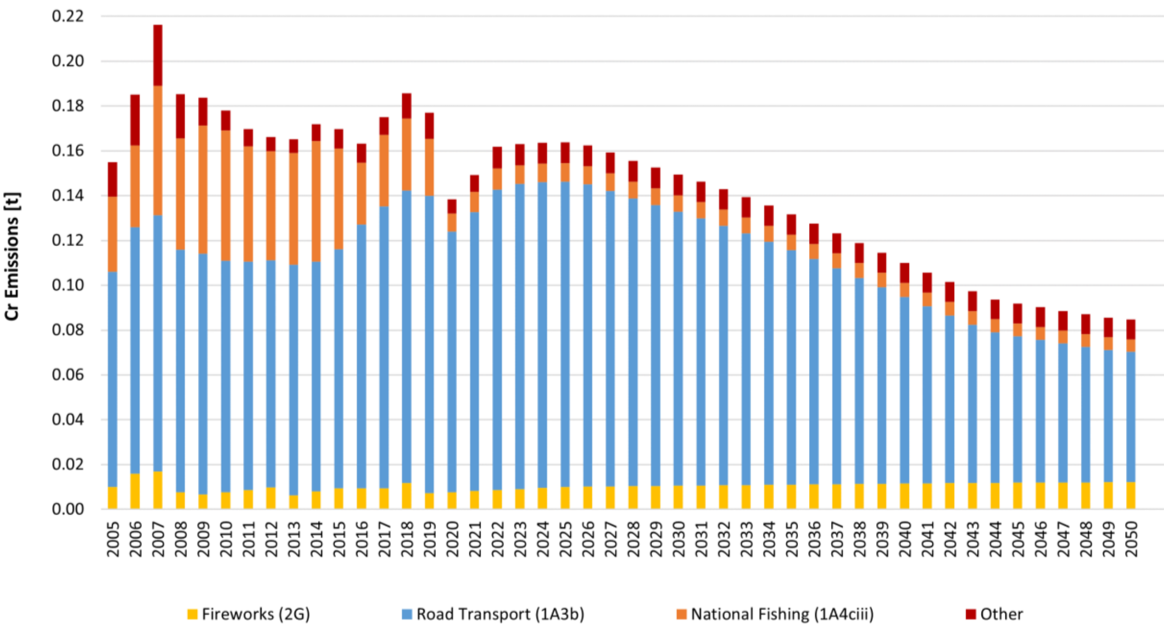


Figure 9.16: Cr emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.13.3 Copper (Cu)

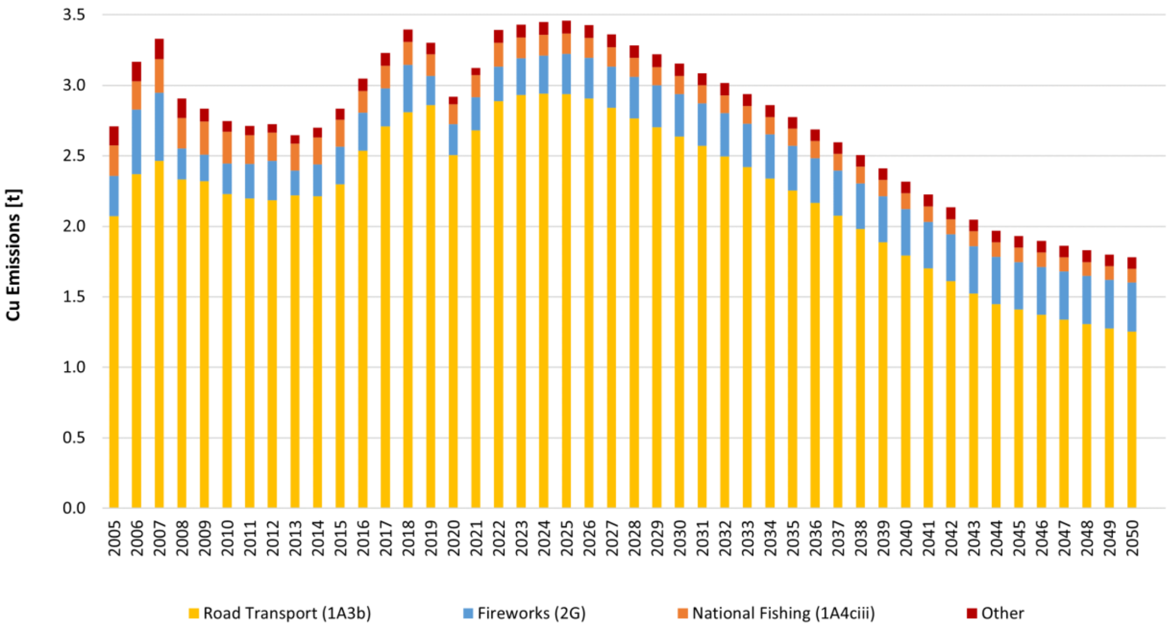


Figure 9.17: Cu emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.13.4 Nickel (Ni)

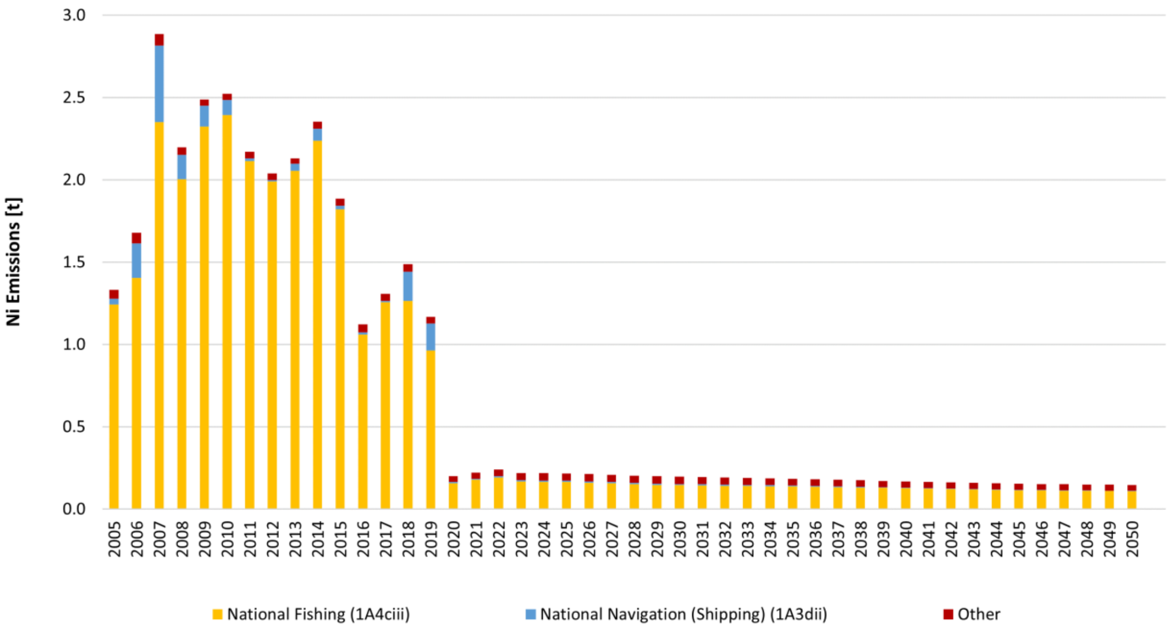


Figure 9.18: Ni emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.13.5 Selenium (Se)

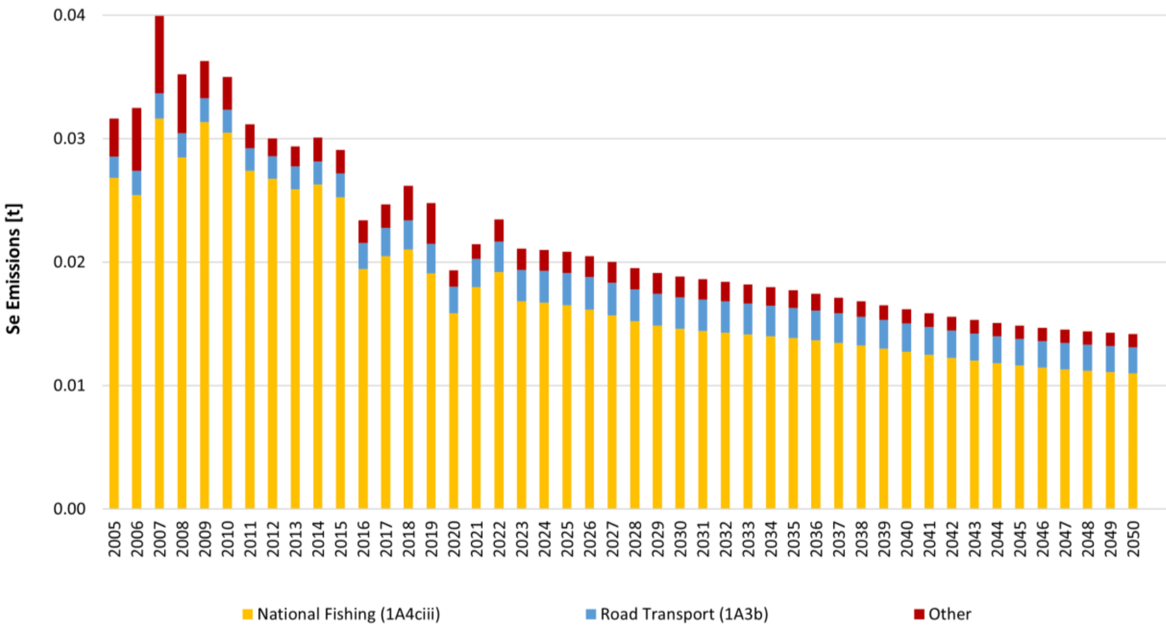


Figure 9.19: Se emissions by main sources. Historical data until 2021 and projections until 2050.

9.1.13.6 Zinc (Zn)

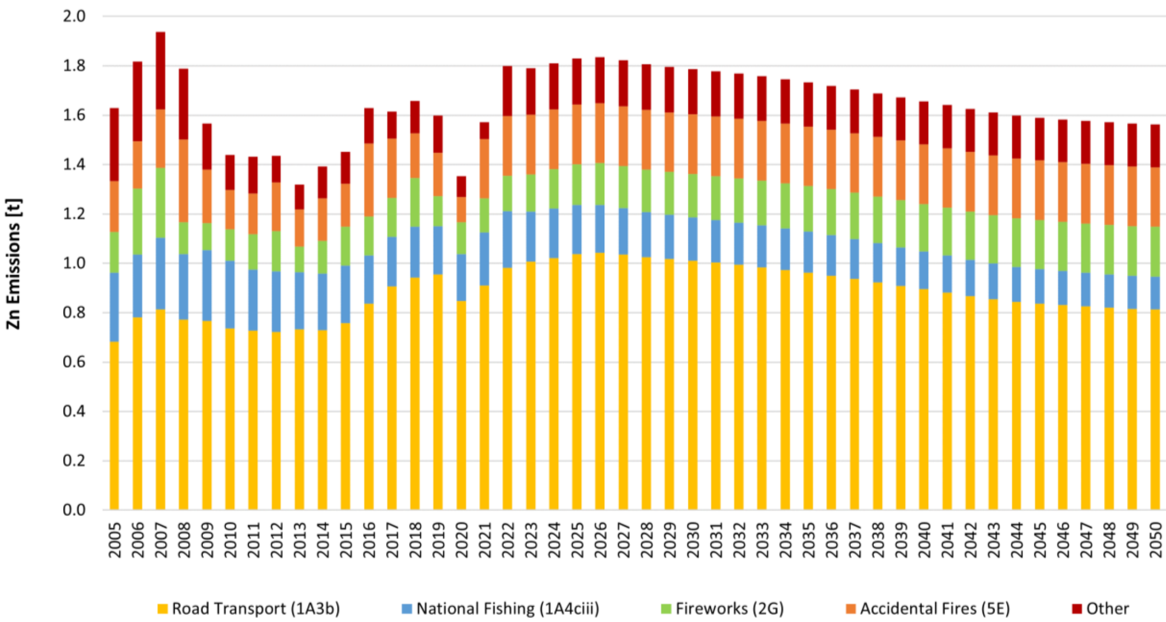


Figure 9.20: Zn emissions by main sources. Historical data until 2021 and projections until 2050.

9.2 Energy

9.2.1 Methodology

The methods used in the emission projections follow the methodologies for the emission inventory as described in Chapter 3.

9.2.2 Activity Data

Projections for the Energy sector are based on fuel projections generated by the National Energy Authority (*Orkustofnun*) (NEA) in the Fuel Use Projection 2022-2060 (Orkustofnun, 2022). 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, 2022). Fuel projections were available by fuel type and activity.

Activity data for the 1B2d Geothermal Energy is based on a geothermal energy consumption projections by the NEA.[20] The main assumptions of the projection are population growth, economic development, development of the total size of apartments, offices, and other heated spaces, 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 1A3b Road Transport are estimated using COPERT 5.6.1 which follows the methodology presented in 2019 EEA/EMEP Guidebook. Projected fuel use was obtained from the Fuel Use Projection 2022-2060 while activity data on vehicle stock numbers by vehicle type and other road transport activity data for COPERT was obtained from the SIBYL baseline.[21]

9.2.3 Emission Factors

The emission factors used in the emissions projections are the same as are used for the emission inventory as described in Chapter 3 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 the emission inventory as described in Chapter 4.

9.3.2 Activity Data

For the 2C2 Ferroalloys Production and 2C3 Primary Aluminium Production, the projected production amount is communicated from the individual companies. For activity within other subsectors (2A, 2D, 2G, 2H, and 2C3 Secondary Aluminium), the projected activity data is in some cases assumed to be the same as the average of the activity data in the past (appropriate range is chosen on a case-by-case basis). 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

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

and GDP. The projected population is from Statistics Iceland (*Hagstofa Íslands*) (SI) (Hagstofa Íslands, 2022) and the GDP projection used by the NEA in the Fuel Use Projection 2022-2060 (Orkustofnun, 2022). 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 emissions projections are the same as are used for the emission inventory as described in Chapter 4 for the last historical year of the inventory. Communication between the EAI 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.

9.4 Agriculture

9.4.1 Methodology

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

9.4.2 Activity Data

The projections on how the 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 2050 based on the historical available data. The historical data is collected from the Ministry of Food, Agriculture, and Fisheries (*Matvælaráðuneytið*) (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 and RML, 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 characterisation (such as pregnancy rates, days on pastures/in housing, feed digestibility, weight, and 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 projected based on the linear historical trend.

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 emissions projections are the same as are used for the emission inventory as described in Chapter 5.

9.5 Waste

9.5.1 Methodology

The methods used in the emission projections follow the methodologies for the emission inventory as described in Chapter 6.

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 each estimated based on the annual amount of waste produced in each sector, projected in correlation with population projections made available by the NEA, taking into account the existing policies and operating permits of waste handling companies. Historical waste generation data from 2012 (as reported in the NIR) was correlated with population data to calculate the overall waste generation until 2050.

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 6.

10 References

Aasestad, K. (2013). *Emissions of Black carbon and Organic carbon in Norway 1990-2011.* Statistics Norway.

Alþingi. (2019). *Lög um skóga og skógrækt.* Alþingi. Alþingi. Retrieved January 10, 2020, from https://www.althingi.is/lagas/149c/2019033.html

Aradóttir, Ó., Svavarsdóttir, K., Jónsson, T., & Guðbergsson, G. (2000). Carbon accumulation in vegetation and soils by reclamation of degraded areas. *Icelandic Agricultural Science, 13*, 99-113.

Arnalds, O., Orradottir, B., & Aradottir, A. (2013). Carbon accumulation in Icelandic desert Andosols during early stages of restoration. *Geodema*, 172-179.

Arnalds, Ó. (2010). Dust sources and deposition of aeolian materials in Iceland. *Icelandic Agricultural Science, 23*, 3-21.

Arnalds, Ó., & Óskarsson, H. (2009). Íslenskt Jarðvegskort. *Náttúrufræðingurinn, 78*(3-4), 107-121.

Arnalds, Ó., Óskarsson, H., Gísladóttir, F., & Grétarsson, E. (2009). Íslenskt Jarðvegskort. Landbúnaðarháskóli Íslands.

Baldvinsson, Í. Þ. (2011). *Gaslosun jarðvarmavirkjana á Íslandi.* National Energy Authority.

BiPRO . (2006). *Identification, assessment and prioritisation of EU measures to reduce releases of unintentionally produced/released Persistent Organic Pollutants.* . Retrieved from http://ec.europa.eu/environment/dioxin: The European Comission.

BiPRO. (2006). *Identification, assessment and prioritisation of EU measures to reduce releases of unintentionally produced/released Persistent Organic Pollutants.* Retrieved from https://ec.europa.eu/environment/archives/dioxin/pdf/report.pdf: The European Comission.

Bjarnadóttir, B. (2009). Carbon stocks and fluxes in a young Siberian larch (Larix sibirica) plantation in Iceland. 62. Lund, Sweden: Lunds Universitet.

Carbon Recycling International. (2018). *Carbon Recycling International*. Retrieved from carbonrecycling.is/

Cusano, G., Gonzalo, M. R., Farrell, F., Remus, R., Roudier, S., & Delgado Sancho, L. (2017). *Best Available Techniques (BAT) Reference Document dor the Non-Ferrous Metals Industries.* Luxembourg: European Comission. doi:doi:10.2760/8224

Dalsgaard, L., Astrup, R., Antón-Fernández, C., Kynding Borgen, S., Breidenbach, J., Lange, H., . . . Liski, J. (2016). Modeling Soil Carbon Dynamics in Northern Forests: Effects of Spatial and Temporal Aggregation of Climatic Input Data. *PLoS ONE, 11*(2), 22. Retrieved from https://doi.org/10.1371/journal.pone.0149902

Dämmgen, U., Amon, B., Gyldenkærne, S., Hutchings, N., Kleine Klausing, H., Haenel, H.-D., & Rösemann, C. (2011). Reassessment of the calculation procedure for the volatile solids excretion rates of cattle and pigs in the Austrian, Danish and German agricultural emission inventories. *Agriculture and Forestry Research 2, 61*, 115-126.

Danish Centre for Environment and Energy. (2018). *Denmark's National Inventory Report 2018. Emission Inventories 1990-2016.* Aarhus University, Danish Centre for Environment and Energy. Danish Centre for Environment and Energy. Retrieved from https://dce2.au.dk/pub/SR272.pdf

EAI. (2018). *National Inventory Report 2018. Emissions of greenhouse gases in Iceland from 1990 to 2016.* Reykjavík: EAI. Retrieved from https://ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/NIR%202018%2015%20April%20submission.pdf

EEA. (2007). *EMEP/CORINAIR Emission Inventory Guidebook 2007.* European Environment Agency.

EEA. (2009). *EMEP/EEA air pollutant emission inventory guidebook - 2009.* European Environment Agency.

EEA. (2013). *EMEP/EEA air pollutant emission inventory guidebook - 2013.* European Environment Agency.

EEA. (2016). *EMEP/EEA air pollutant emission inventory guidebook - 2016.* European Environment Agency.

EEA. (2019). *EMEP/EEA air pollutant emission inventory guidebook.* European Environment Agency.

Embætti Landlæknis. (1990). *Könnun á mataræði Íslendinga.* Rannsóknir manneldisráðs Íslands III.

Embætti Landlæknis. (2002). *Hvað borða Íslendingar? Könnun á mataræði Íslendinga 2002.* Rannsóknir Manneldisráðs Íslands.

Embætti Landlæknis. (2011). *Hvað borða Íslendingar? Könnun á mataræði Íslendinga 2010-2011.* Embætti Landlæknis, Matvælastofnun og Rannsóknarstofa í næringarfræði.

Embætti Landlæknis. (2022). *Könnun á mataræði Íslendinga 2019–2021.* Reykjavík: Embætti landlæknis. Retrieved from https://www.landlaeknir.is/servlet/file/store93/item49171/Hvadbordaislendingar_vefur_lok.pdf

Environment Agency of Iceland. (2017). *Samantekt um stöðu fráveitumála á Íslandi árið 2014 (Summary of the status of sewage disposal in Iceland in 2014).* Reykjavík, Iceland: Environment Agency of Iceland. Retrieved from https://www.ust.is/library/Skrar/utgefid-efni/Annad/Sto%CC%88%C3%B0usky%CC%81rsla%202017%20um%20fr%C3%A1rennslism%C3%A1l%20%C3%9Atg%202.pdf

Environment Agency of Iceland. (2018). *National Inventory Report. Emissions of Greengouse Gases in Iceland from 1990-2016.* Reykjavík: Environment Agency of Iceland.

European Commission. (2001). *Integrated Polltion Prevention and Control (IPCC). Reference Document on Best Available Techniques in the Non Ferrous Metals Industries.*

European Environment Agency. (2016). *EMEP/EEA air pollutant emission inventory guidebook.* Retrieved from EMEP/EEA air pollutant emission inventory guidebook - 2013: https://www.eea.europa.eu/publications/emep-eea-guidebook-2016

European Environment Agency. (2019). *EMEP/EEA air pollutant emission inventory guidebook 2019.* Retrieved from https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

FAO. (2011). *Global Food Losses and Food Waste - Extent, causes and prevention.* Rome: Food and Agriculture Organization of the United Nations. Retrieved from https://www.fao.org/3/i2697e/i2697e.pdf

Fridriksson Th, M. A. (2016). *Greenhouse gases from geothermal power production.* Energy Sector Managment Assistance Program, The World Bank.

Galle, B., Johansson, M., Rivera, C., Zhang, Y., Kihlman, M., Kern, C., . . . Hidalgo, S. (2010). Network for Observation of Volcanic and Atmospheric Change (NOVAC)—A global network for volcanic gas monitoring: Network layout and instrument description. *JOURNAL OF GEOPHYSICAL RESEARCH, 115*(D05304). doi:https://doi.org/10.1029/2009JD011823

Gísladóttir, F. Ó., Metúsalemsson, S., & Óskarsson, H. (2007). Áhrifasvæði skurða: Greining með fjarkönnunaraðferðum. *Fræðaþing landbúnaðarins.* Reykjavík.

Gíslason, S. S. (2015). Environmental pressure from the 2014–15 eruption of Bárðarbunga volcano, Iceland. *Geochemical perspective letters*.

Guðmundsson, J. (2009). *Vísinda og tæknilega lokaskýrsla: Verkefni: Losun hláturgass og annarra gróðurhúsalofttegunda úr lífrænum jarðvegi við msimunandi landnotkun.* Hvanneyri: Landbúnaðarháskóli Ísland.

Guðmundsson, J. (2016). *Greining á losun gróðurhúsalofttegunda frá íslenskum landbúnaði.* Ministry for the Environment and Natural Resources. Retrieved from https://www.umhverfisraduneyti.is/media/PDF_skrar/Greining-a-losun-grodurhusa-vegna-landbunadar_161012JG_okt.pdf

Guðmundsson, J., & Óskarsson, H. (2014). Carbon dioxide emission from drained organic soils in West-Iceland. *Soil carbon sequestration for climate food security and ecosystem services* (pp. 155-159). Reykjavík: JRC Science and Policy Report.

Guðmundsson, J., Brink, S. H., & Gísladóttir, F. (2013). Preparation of a LULUCF land-use map for Iceland: Developement of the Grassland layer and subcategories. *Grassland Science in Europe*, 105-108.

Guðmundsson, J., Gísladóttir, F. Ó., Brink, S. H., & Óskarsson, H. (2010). The Icelandic Geographic Land Use Database (IGLUD). *Mapping and monitoring of Nordic Vegetation and landscapes.* Hveragerði: Norsk Insitute for Skog og landskap.

Guðmundsson, Ó., & Eiríksson, T. (1995). Breyting á orkumatskerfi fyrir jórturdýr. *Ráðunautafundur*, (pp. 39-45).

Gunnarsdóttir, I., Eysteindsdóttir, T., & Þórsdóttir, I. (2008). *Hvað borða íslensk börn á leikskólaaldri? Könnun á mataræði 3ja og 5ára barna 2007.* Research institute on nutrition - Rannsóknastofa í næringafræði. Retrieved from www.landlaeknir.is: http://www.landlaeknir.is/servlet/file/store93/item14897/version2/3ja_og_5_ara_skyrsla_181208.pdf

Gunnarsson, E. (2010). Skógræktarárið 2009. *Skógræktarritið 2010, 2*, 90-95.

Gunnarsson, E. (2011). Skógræktarárið 2010. *Skógræktaráritið 2011, 2*, 96-101.

Gunnarsson, E. (2012). Skógræktarárið 2011. *Skógræktaráritið 2012, 2*, 90-95.

Gunnarsson, E. (2013). Skógræktarárið 2012. *Skógræktaráritið 2013, 2*, 84-89.

Gunnarsson, E. (2014). Skógræktarárið 2013. *Skógræktaráritið 2014*, 88-91.

Gunnarsson, E. (2016). Skógræktarárið 2015. *Skógræktararritið, 2*, 91-99.

Gunnarsson, E., & Brynleifsdóttir, S. (2017). Skógræktarárið 2016. *Skógræktarritið*(2), 86-96.

Gunnarsson, E., & Brynleifsdóttir, S. (2019). Skógræktarárið 2017. *Skógræktarritið*, 113-122.

Gunnarsson, E., & Brynleifsdóttir, S. (2019). Skógræktarárið 2017. *Skógræktarritið*(1), 113-122.

Gustafsson, M., Blomqvist, G., Dahl, A., Gudmundsson, A., Ljungman, A., Lindbom, J., . . . Swietlicki, E. (2005). *Inandningsbara partiklar från interaktion mellan däck, vägbana och friktionsmaterial. Slutrapport av WearTox-projektet.* Linköping: VTI (Statens väg- och transportforskningsinstitut). Retrieved from http://vti.diva-portal.org/smash/record.jsf?pid=diva2%3A675259&dswid=-2958

Hagstofa Íslands (Statistics Iceland). (1997). *Hagskinna.* Reykjavík: Hagstofa Íslands.

Hagstofa Íslands. (2021). *Mannfjöldaspá.* Retrieved from https://hagstofa.is/talnaefni/ibuar/mannfjoldaspa/mannfjoldaspa/

Hagstofa Íslands. (2022). *Mannfjöldaspá.* Retrieved from https://hagstofa.is/talnaefni/ibuar/mannfjoldaspa/mannfjoldaspa/

Helgason, B. (1975). Breytingar á jarðvegi af völdum ólíkra tegunda köfnunarefnisáburðar. Samanburður þriggja tegunda köfnunarefnisáburðar. *Íslenskar landbúnaðarrannsóknir, 7*(1-2), 11.

Icelandic Recycling Fund - Úrvinnslusjóður. (2018). *Annual report - Ársskýrsla 2016*. Retrieved from http://www.urvinnslusjodur.is/media/arsskyrslur/Arsskyrsla-2016.pdf

Icelandic Recycling Fund. (2019). *Annual Reports - 'Arsskýrsla 1998-2016.* Reykjavík: Icelandic Recycling Fund. Retrieved from www.urvinnslusjodur.is/um-urvinsslusjod/utgafa/arsskyrslur

IPCC. (1996). *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: The Reference Manueal (Volume 3).* Intergovernmental Panel on Climate Change.

IPCC. (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* (H. Eggleston, L. Buendia, K. Miwa, T. Ngara, & K. Tanabe, Eds.) IGES, Japan. Retrieved from 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

IPCC. (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* Intergovernmental Panel on Climate Change. Retrieved from 2006 IPCC Guidelines for National Greenhouse Gas Inventories: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol3.html

IPCC. (2006). *IPCC Guidelines for National Greehouse Gas Inventories. Volume 4: Agriculture, Forestry and Other Land Use (AFOLU).* Hayama: Institute for Global Environmental Strategies.

IPCC. (2014). *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.* (T. Hiraishi, T. Krug, K. Tanabe, N. Srivastava, J. Baasansuren, M. Fukuda, & T. Troxler, Eds.) IPCC, Switzerland.

IPCC. (2014). *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands.* (T. Hiraishi, T. Krug, K. Tanabe, N. Srivastava, J. Baasansuren, M. Fukuda, & T. Troxler, Eds.) IPCC, Switzerland.

IPCC. (2014). *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands.* (T. Hiraishi, T. Krug, K. Tanabe, N. Srivastava, J. Baasansuren, M. Fukuda, & T. Troxler, Eds.) IPCC, Switzerland.

Join Research Center. (2014). *Best Available Techniques (BAT) Reference Document dor the Non-Ferrous Metals Industries.* European Comission.

Jónsdóttir, S., & Jóhannsson, M. H. (2016). *Seyra til uppgræðslu á Hrunamannaafrét.* Hella: Landgræðsla ríkisins.

Jónsson, T. H. (2004). Stature of Sub-arctic Birch in Relation to Growth Rate, Lifespan and Tree Form. *Annals of Botany, 94*, 753-762.

Jónsson, T. H., & Snorrason, A. (2018). Single tree aboveground biomass models for native birch in Iceland. *Icelandic Agricultural Sciences*, 65-80.

Júlíusson, A. G. (2011). *Hauggasrannsóknir á urðunarstöðum á Íslandi.* M.Sc. Thesis, Umhverfis- og byggingarverkfræðideild, University of Iceland.

Kamsma, R., & Meyles, C. (2003). *Landfill Gas Formation in Iceland.* Environmental and Food Agency.

Ketilsdóttir, S. Ó., & Sveinsson, Þ. (2010). Efnainnihald kúamykju og mælingar in situ á þurrefni, NH-4 og P með Agros Nova mælibúnaði. *Fræðaþing landbúnaðarins*, 207-215.

Kolka-Jónsson. (2011). *CarbBirch (Kolbjörk): Carbon sequestration and soil development under mountain birch (Betula pubescens) in rehabilitated areas in southern Iceland.* Ohio State University.

Lillesand, T., Kiefer, R., & Chipmann, J. (2004). *Remote Sensing and Image Interpretation.* Wiley.

Magnússon, B., Barkarson, B., Guðleifsson, B., Maronsson, B., Heiðmarsson, S., Guðmundsson, G., . . . Jónsdóttir, S. (2006). Vöktun á ástandi og líffræðilegri fjölbreytni úthaga 2005. *Fræðaþing Landbúnaðarins.* Reykjavík.

Matter, J., Stute, M., Snæbjörnsdottir, S., Oelkers, E., Gislason, S., Aradottir, E., . . . Broecker, W. (2016). Rapid carbon mineralization for permanent disposal of anthropogenic carbon dioxide emissions. *Science, 352*(6291), 1312-1314.

McFarland, M. (2000). *Biosolids Engineering.* New York: McGrawHill.

Ministry for the Environment (Umhverfisráðuneytið). (2007). *Vernd og endurheimt íslenskra birkiskóga. Skýrsla og tillögur nefndar.* Reykjavík: Umhverfisráðuneytið.

NEA. (2014). *Natinal Energy Authority, Hydro, Electricity*.

NERI. (2016). *Annual Danish Infomative Inventory Report to UNECE - Emission Inventories from the base year of the protocols to year 2015.* Aarhus University - Denmark: National Environmental Research Institute. Retrieved from http://www.neri.dk

Nielsen, O.-K., Plejdrup, M. S., Winther, M., Mikkelsen, M. H., Nielsen, M., Gyldenkærne, S., . . . Thomsen, M. (2016). *Annual Danish Informative Inventory Report To UNECE.* Aarhus University, DCE- Danish Centre for Environment and Energy. Retrieved from http://dce2.au.dk/pub/SR183.pdf

Nielsen, O.-K., Plejdrup, M. S., Winther, M., Mikkelsen, M. H., Nielsen, M., Gyldenkærne, S., . . . Thomsen, M. (2021). *Annual Danish Informative Inventory Report To UNECE.* Aarhus University, DCE- Danish Centre for Environment and Energy. Retrieved from http://dce2.au.dk/pub/SR183.pdf

Norwegian Environment Agency. (2016). *Informative Inventory Report (IIR) 2016 Norway.* The Norwegian Environment Agency.

Norwegian Environment Agency. (2020). *Informative Inventory Report (IIR).*

Orkustofnun. (2019). *Gas Emissions of Geothermal Power Plants and Utilities 1969-2018.* Reykjavík: Orkustofnun. Retrieved from https://orkustofnun.is/gogn/Talnaefni/OS-2018-T003-02.pdf

Orkustofnun. (2019). *Primary Energy Use in Iceland 1940-2018.* Reykjavík: Orkustofnun. Retrieved from https://orkustofnun.is/gogn/Talnaefni/OS-2018-T009-01.pdf

Orkustofnun. (2022). *Eldsneytisspá 2022-2060.* Retrieved from https://orkustofnun.is/gogn/Skyrslur/OS-2021/OS-2021-02.pdf

Ottósson, J. S. (2016). Vistgerðir í Íslandi. *Fjölrit Náttúrufræðistofnunar, 54*, 299.

Ottósson, J., Sveinsdóttir, A., & Harðardóttir, M. (2016). Vistgerðir í Íslandi. *Fjölrit Náttúrufræðistofnunar, 54*, 299.

Owona, J. C. (2019). Changes in carbon-stock and soil properties following afforestation in SW Iceland. 97. Agricultural University of Iceland. Retrieved from https://skemman.is/bitstream/1946/34470/1/Joel%27s%20thesis_%20AUI_final.pdf

Óskarsson, H. (1998). Wetland draining in Western Iceland. In J. Ólafsson (Ed.), *Icelandic Wetlands: exploitation and conservation* (pp. 121-129). University of Iceland Press.

Óskarsson, H., & Guðmundsson, J. (2001). *Mat á gróðurhúsaáhrifum fyrirhugaðs Hálslóns.* RALA. Reykjavík: Landsvirkjun.

Óskarsson, H., & Guðmundsson, J. (2008). *Gróðurhúsaáhrif uppistöðulóna; Rannsóknir við Gilsárlón 2003-2006.* Reykjavík: Landsvirkjun.

Pedersen, G. B. (2022). Volume, effusion rate, and lava transport during the 2021 Fagradalsfjall eruption: Results from near real-time photogrammetric monitoring. *Geophysical Research Letters*.

Pfeffer, M. A., Bergsson, B., Barsotti, S., Stefánsdóttir, G., Galle, B., Arellano, S., . . . Keller, N. S. (2018). Ground-Based Measurements of the 2014–2015 Holuhraun Volcanic Cloud (Iceland). *Geosciences*.

Schmidt, A. W. (2015). *Long range transport and air quality impacts of SO2 emissions from Holuhraun (Bárdarbunga, Iceland).* . Geophysical Research Abstracts 17, EGU 2015–14866–1.

Schwarz, W., Gschrey, B., Leisewitz, A., Herold, A., Gores, S., Papst, I., . . . Lindborg, A. (2012). *Preparatory study for a review of Regulation (EC) No 842/2006 on certain fluorinated greenhouse gases.* European Union.

Sempos, I. (2018). *Note on Fossil Carbon Content in Biofuels.*

Sigurdsson, B., & Snorrason, A. (2000). Carbon sequestration by afforestation and revegetation as a means of limiting net-CO2 emissions in Iceland. *Biotechnologie, Agronomie Société et Environnement, 4*(4), 303-307.

Sigurðsson, B., Elmarsdóttir, Á., Bjarnadóttir, B., & Magnússon, B. (2008). Mælingar á kolefnisbindingu mismunandi skógargerða. *Fræðaþing Landbúnaðarins*, (pp. 301-308). Reykjavík.

Sigurðsson, B., Magnússon, B., Elmarsdóttir, A., & Bjarnadóttir, B. (2005). Biomass and composition of understory vegetation and the forest floor carbon stock across Siberian larch and mountain birch chronosequences in Iceland. *Annals of Forest Sciences, 62*(8), 881-888.

Skógræktin, & Skipulagsstofnun. (2017). *Skógrækt í skipulagsáætlunum sveitarfélaga II útgáfa. 2017.* Retrieved from http://www.skogur.is/media/ymislegt/Skograektogskipurlag_2017_lores.pdf

Snorrason, A. (2010). National Forest Inventories reports: Iceland. In E. G. Tomppo, *National Forest Inventories - Pathways for common reporting.* Springer.

Snorrason, A. (2011). *Prediction of Reference Level for the Period 2013-2020 for Forest Management in Iceland.* Reykjavík: Icelandic Forest Research. Retrieved from https://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_iceland_2011.pdf

Snorrason, A., & Einarsson, S. (2006). Single-tree biomass and stem volume functions for eleven tree species used in Icelandic forestry. *Icelandic Agricultural Sciences*, 15-24.

Snorrason, A., & Kjartansson, B. (2004). Towards a general woodland and forestry inventory for Iceland.

Snorrason, A., Jónsson, Þ., Svavarsdóttir, K., Guðbergsson, G., & Traustason, T. (2000). Rannsóknir á kolefnisbindingu ræktaðra skóga á Íslandi. *Ársrit Skógræktarfélags Íslands*(1), 71-89.

Snorrason, A., Sigurðsson, B., Guðbergsson, G., Svavarsdóttir, K., & Jónsson, Þ. (2002). Carbon sequestration in forest plantations in Iceland. *Icelandic Agricultural Sciences, 15*, 81-93.

Snorrason, A., Traustason, B., Kjartansson, B., Heiðarsson, L., Ísleifsson, R., & Eggertsson, Ó. (2016). Náttúrulegt birki á Íslandi - ný úttekt á útbreiðslu þess og ástandi. *Náttúrufræðingurinn, 86*(3-4), 37-51.

Snæbjörnsson, A., Hjartardóttir, D., Blöndal, E., Pétursson, J., Eggertsson, Ó., & Halldórsson, Þ. (2010). *Skýrsla nefndar um landnotkun. Athugun á notkun og varðveislu ræktanlegs lands.* Reykjavík: Sjávarútvegs- og landbúnaðarráðuneytið.

Statistics Iceland. (2018). *Hagstofa Íslands*. Retrieved from http://px.hagstofa.is/pxis/pxweb/is

Statistics Iceland. (2019). *Hagstofa Íslands*. Retrieved from http://px.hagstofa.is/pxis/pxweb/is

Statistics Iceland. (2020). *Hagstofa Íslands*. Retrieved from https://hagstofa.is/talnaefni/atvinnuvegir/landbunadur/bufe-og-uppskera/

Statistics Norway. (2001). *Utslipp til luft av noen miljogifter i Norge - Dokumentasjon av metode og resultater.* Oslo: Statistics Norway. Retrieved from https://www.ssb.no/a/publikasjoner/pdf/rapp_200117/rapp_200117.pdf

Statistics Norway. (2002). *Utslipp til luft av dioksiner i Norge - Dokumentasjon av metoder og tesultater.* Oslo-Kongsvinger: Statistic Norway. Retrieved from https://www.ssb.no/a/publikasjoner/pdf/rapp_200207/rapp_200207.pdf

Steingrímsdóttir, L., Þorgeirsdóttir, H., & Ólafsdóttir, A. (2002). *Hvað borða Íslandingar? Könnun á mataræði Íslendinga.* Icelandic Director of healt report. Retrieved from https://www.landlaeknir.is/servlet/file/store93/item11603/skyrsla.pdf

Sveinbjörnsson, J., Eyþórsdóttir, E., & Örnóflsson, E. K. (2018). "Misjafn er sauður í mörgu fé" greining á áhrifaþáttum haustþunga lamba í gagnasafni Hestbúsins 2002-2013. *Rit LbhÍ*.

Traustason, B., & Snorrason, A. (2008). Spatial distribution of forests and woodlands in Iceland in accordance with the CORINE land cover classification. *Icelandic Agricultural Sciences, 21*, 39-47.

UNEP. (2005). *Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases.* Geneva, Switzerland: United Nations Environment Programme.

UNEP. (2013). *Standardized Toolkit for Identification and Quantification of Releases of Dioxin, Furans and Other Unintentional POPs.* Geneva, Switzerland: United Nations Environment Programme.

Þorgeirsdóttir, H., Valgeirsdóttir, H., Gunnarsdóttir, I., Gísladóttir, E., Gunnarsdóttir, B. E., Þórsdóttir, I., . . . Steingrímsdóttir, L. (2012). *Hvað borða Íslendingar? Könnun á mataræði Íslendinga 2010-2011.* Icelandic directorate of Health. Retrieved from https://www.landlaeknir.is/servlet/file/store93/item14901/Hva

Þorvaldsson, G. (1994). Gróðurfar og nýting túna. *Fjölrit RALA*, 3-28.

Þórsdóttir, I., & Gunnarsdóttir, I. (2006). *Hvað borða íslensk börn og unglingar? Könnun á mataræði og 15 ára barna og unglinga 2003-2004. [The Diet of Icelandic 9- and 15-year-old children and adolescents].* Rannsóknastofa í næringarfræði við Háskóla Íslands og Landspítla-Háskólasjúkrahús & Lýðheilsustöð.

Annexes to the National Inventory Report

10.1 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 2022 submission. This QA/QC file compares the emissions between the current and previous submissions, for 2020 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 $\geq PM_{10} \geq PM_{2.5}$. 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.

10.2 Annex 2: KCA Results for 1990 and Trends 1990-2021

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	Road Transport: Heavy Duty Vehicles and Buses	Stationary Combustion in Manufacturing Industries and Construction: Food Processing, Beverages, and Tobacco		81.7%
	NFR 1A4ciii	NFR 1A3bi	NFR 1A3biii	NFR 1A2e		
	59.2%	15.8%	3.7%	2.9%		
NMVOC	Road Transport: Passenger Cars	Domestic Solvent Use Including Fungicides	Manure Management - Horses	Manure Management - Dairy Cattle	Biological Treatment of Waste - Solid Waste Disposal on Land	82.1%
	NFR 1A3bi	NFR 2D3a	NFR 3B4e	NFR 3B1a	NFR 5A	
	38.4%	6.4%	5.9%	5.8%	5.4%	
	Coating Applications	Road Transport: Gasoline Evaporation	National Fishing	Manure Management - Non-dairy Cattle	Manure Management - Sheep	
	NFR 2D3d	NFR 1A3bv	NFR 1A4ciii	NFR 3B1b	NFR 3B2	
	5.2%	4.4%	4.2%	3.9%	2.4%	
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	Manure Management - Non-dairy Cattle	85.9%
	NFR 3Da2a	NFR 3B2	NFR 3Da3	NFR 3B1a	NFR 3B1b	
	31.0%	15.4%	15.4%	14.3%	9.8%	
$PM_{2.5}$	National Fishing	Open Burning of Waste	Construction and Demolition	Quarrying and Mining of Minerals other than Coal	Road Transport: Automobile Road Abrasion	80.0%
	NFR 1A4ciii	NFR 5C2	NFR 2A5b	NFR 2A5a	NFR 1A3bvii	
	28.0%	11.1%	8.1%	7.6%	6.7%	
	Ferroalloy Production	Aluminium Production	Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals	Road Transport: Heavy Duty Vehicles and Buses	Road Transport: Passenger Cars	
	NFR 2C2	NFR 2C3	NFR 1A2f	NFR 1A3biii	NFR 1A3bi	
	4.2%	4.1%	3.6%	3.3%	3.3%	

Component	Key Categories (Sorted from high to low from left to right and top to bottom)					Total (%)
PM_{10}	Construction and Demolition	National Fishing	Quarrying and Mining of Minerals other than Coal	Road Transport: Automobile Road abrasion	Open Burning of Waste	81.4%
	NFR 2A5b	NFR 1A4ciii	NFR 2A5a	NFR 1A3bvii	NFR 5C2	
	38.8%	13.4%	10.2%	5.9%	5.7%	
	Ferroalloy Production	Aluminium Production	Farm-level Agricultural Operations Including Storage, Handling, and Transport of Agricultural Products			
	NFR 2C2	NFR 2C3	NFR 3Dc			
	2.8%	2.4%	2.1%			
TSP	Construction and Demolition	Quarrying and Mining of Minerals Other than Coal	National Fishing	Road Transport: Automobile Road Abrasion		83.2%
	NFR 2A5b	NFR 2A5a	NFR 1A4ciii	NFR 1A3bvii		
	61.2%	10.2%	6.3%	5.6%		
BC	Open Burning of Waste	Road Transport: Passenger Cars	Road Transport: Heavy-duty Vehicles and Buses	Mobile Combustion in Manufacturing Industries and Construction	Stationary Combustion in Manufacturing Industries and Construction: Food Processing, Beverages, and Tobacco	80.6%
	NFR 5C2	NFR 1A3bi	NFR 1A3biii	NFR 1A2gvii	NFR 1A2e	
	28.8%	10.4%	10.2%	10.2%	8.0%	
	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	National Fishing				
	NFR 1A4cii	NFR 1A4ciii				
	7.3%	5.6%				
CO	Road Transport: Passenger Cars	Aluminium Production				87.9%
	NFR 1A3bi	NFR 2C3				
	69.2%	18.7%				

Table A2.2 Key categories for NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC and CO, Trend 1990-2021

Component	Key Categories (Sorted from high to low from left to right and top to bottom)					Total (%)
NO_x	Road Transport: Passenger Cars	National Fishing	Ferroalloy Production	Aluminium Production	Stationary Combustion in Manufacturing Industries and Construction: Food Processing, Beverages, and Tobacco	80.8%
	NFR 1A3bi	NFR 1A4ciii	NFR 2C2	NFR 2C3	NFR 1A2e	
	31.8%	18.6%	14.0%	10.6%	5.8%	
NMVOC	Road Transport: Passenger Cars	Domestic Solvent Use Including Fungicides	Food and Beverages Industry	Manure Management - Non-dairy Cattle	Manure Management - Horses	81.2%
	NFR 1A3bi	NFR 2D3a	NFR 2H2	NFR 3B1b	NFR 3B4e	
	39.9%	11.8%	9.1%	5.7%	4.6%	
	International Aviation LTO (Civil)	Road Transport: Gasoline Evaporation	Manure Management - Dairy Cattle			
	NFR 1A3ai(i)	NFR 1A3bv	NFR 3B1a			
	4.5%	2.8%	2.8%			
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		85.3%
	NFR 1B2d	NFR 1A4ciii	NFR 2C3	NFR 1 A2e		
	32.7%	25.4%	17.6%	9.7%		
NH_3	Manure Management - Sheep	Inorganic N-fertilisers (Includes also Urea Application)	Manure Management - Laying Hens	Animal Manure Applied to Soils	Urine and Dung Deposited by Grazing Animals	81.5%
	NFR 3B2	NFR 3Da1	NFR 3B4gi	NFR 3Da2a	NFR 3Da3	
	23.9%	10.2%	9.7%	9.7%	6.5%	
	Manure Management - Dairy Cattle	Manure Management - Other Animals	Manure Management - Non-dairy Cattle	Manure Management - Broilers		
	NFR 3B1a	NFR 3B4h	NFR 3B1b	NFR 3B4gii		
	6.2%	5.6%	5.0%	4.7%		
$PM_{2.5}$	Aluminium production	Road transport: Automobile road abrasion	Open burning of waste	National fishing	Quarrying and mining of minerals other than coal	82.8%
	NFR 2C3	NFR 1A3bvii	NFR 5C2	NFR 1A4ciii	NFR 2A5a	
	27.3%	14.9%	12.3%	10.5%	7.7%	

Component	Key Categories (Sorted from high to low from left to right and top to bottom)					Total (%)
	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	Road transport: Automobile tyre and brake wear	Road transport: Heavy duty vehicles and buses			
	NFR 1A2f	NFR 1A3bvi	NFR 1A3biii			
	4.0%	3.2%	2.8%			
PM_{10}	Aluminium production	Road transport: Automobile road abrasion	Quarrying and mining of minerals other than coal	Construction and demolition	Open burning of waste	80.1%
	NFR 2C3	NFR 1A3bvii	NFR 2A5a	NFR 2A5b	NFR 5C2	
	21.2%	17.3%	13.3%	10.2%	8.1%	
	National fishing	Road transport: Automobile tyre and brake wear				
	NFR 1A4ciii	NFR 1A3bvi				
	6.2%	3.8%				
TSP	Road transport: Automobile road abrasion	Quarrying and mining of minerals other than coal	Aluminium production	Construction and demolition	Open burning of waste	82.6%
	NFR 1A3bvii	NFR 2A5a	NFR 2C3	NFR 2A5b	NFR 5C2	
	23.2%	17.4%	16.8%	16.4%	5.2%	
	National fishing					
	NFR 1A4ciii					
	3.5%					
BC	Open Burning of Waste	Road Transport: Automobile Tyre and Brake Wear	Road Transport: Automobile Road Abrasion	Aluminium Production	Mobile Combustion in Manufacturing Industries and Construction	84.5%
	NFR 5C2	NFR 1A3bvi	NFR 1A3bvii	NFR 2C3	NFR 1A2gvii	
	33.5%	12.1%	9.4%	8.7%	5.8%	
	National Fishing	Road Transport: Heavy-duty Vehicles and Buses	Stationary Combustion in Manufacturing Industries and Construction: Food Processing, Beverages, and Tobacco			
	NFR 1A4ciii	NFR 1A3biii	NFR 1A2e			
	5.4%	4.9%	4.7%			
CO	Aluminium Production	Road Transport: Passenger Cars				93.4%
	NFR 2C3	NFR 1A3bi				
	50.0%	43.4%				

Persistent 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		82.9%
	NFR 5C2		
	82.9%		
HCB	Open Burning of Waste		81.5%
	NFR 5C2		
	81.5%		
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 1990-2021.

Component	Key Categories (Sorted from high to low from left to right)					Total (%)
DIOX	Open Burning of Waste	Industrial Waste Incineration	Hazardous Waste Incineration	Clinical Waste Incineration		85.2%
	NFR 5C2	NFR 5C1bi	NFR 5C1bii	NFR 5C1biii		
	50.0%	18.3%	8.5%	8.4%		
PAH4	Open Burning of Waste	Aluminium Production	Ferroalloys Production	Road Transport: Passenger Cars	Accidental Fires	84.8%
	NFR 5C2	NFR 2C3	NFR 2C2	NFR 1A3bi	NFR 5E	
	43.6%	12.9%	12.7%	9.2%	6.5%	
HCB	Open Burning of Waste	Clinical Waste Incineration	Other Product Use (Fireworks, Tobacco)			86.5%
	NFR 5C2	NFR 5C1biii	NFR 2G			
	49.6%	24.1%	12.8%			
PCB	Open Burning of Waste	Clinical Waste Incineration	National Fishing			98.0%
	NFR 5C2	NFR 5C1biii	NFR 1A4ciii			
	41.1%	34.1%	22.8%			

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	Road Transport: Automobile Tyre and Brake Wear	Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals	Accidental Fires	Mobile Combustion in Manufacturing Industries and Construction	National Fishing	82.9%
	NFR 1A3bvi	NFR 1A2f	NFR 5E	NFR 1A2gvii	NFR 1A4ciii	
	37.7%	15.0%	13.1%	9.5%	7.6%	
Cd	Open Burning of Waste	National Fishing	Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals	Road Transport: Automobile Tyre and Brake Wear		87.6%
	NFR 5C2	NFR 1A4ciii	NFR 1A2f	NFR 1A3bvi		
	41.1%	29.6%	9.3%	7.7%		
Hg	Open Burning of Waste					90.2%
	NFR 5C2					
	90.2%					
As	National Fishing	Open Burning of Waste				84.3%
	NFR 1A4ciii	NFR 5C2				
	56.9%	27.4%				
Cr	Road Transport: Automobile Tyre and Brake Wear	National Fishing				84.4%
	NFR 1A3bvi	NFR 1A4ciii				
	53.0%	31.4%				
Cu	Road Transport: Automobile Tyre and Brake Wear	National Fishing				91.3%
	NFR 1A3bvi	NFR 1A4ciii				
	78.2%	13.1%				
Ni	National Fishing					87.1%
	NFR 1A4ciii					
	87.1%					
Se	National Fishing	Open Burning of Waste				86.5%
	NFR 1A4ciii	NFR 5C2				
	78.9%	7.6%				
Zn	Open Burning of Waste	Road Transport: Automobile Tyre and Brake Wear	National Fishing	Accidental Fires		85.7%
	NFR 5C2	NFR 1A3bvi	NFR 1A4ciii	NFR 5E		
	35.6%	23.1%	15.3%	11.7%		

Table A2. 6 Key categories for heavy metals, trend 1990-2021.

Component	Key Categories (Sorted from high to low from left to right and top to bottom)					Total (%)
Pb	Road Transport: Automobile Tyre and Brake Wear	Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals	Mobile Combustion in Manufacturing Industries and Construction	Open Burning of Waste	Other Product Use (Fireworks, Tobacco)	83.1%
	NFR 1A3bvi	NFR 1A2f	NFR 1A2gvii	NFR 5C2	NFR 2G	
	42.8%	21.4%	7.1%	6.21%	5.61%	
Cd	Open Burning of Waste	Road Transport: Automobile Tyre and Brake Wear	Other Product Use (Fireworks, Tobacco)	Ferroalloy Production	Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals	86.1%
	NFR 5C2	NFR 1A3bvi	NFR 2G	NFR 2C2	NFR 1A2f	
	38.3%	18.2%	11.8%	9.0%	8.7%	
Hg	Open Burning of Waste	National Fishing	Cremation			81.6%
	NFR 5C2	NFR 1A4ciii	NFR 5C1bv			
	48.2%	26.0%	7.3%			
As	Open Burning of Waste	Road Transport: Automobile Tyre and Brake Wear	Ferroalloys Production	National Fishing		85.2%
	NFR 5C2	NFR 1A3bvi	NRF 2C2	NFR 1A4ciii		
	30.2%	23.4%	20.4%	11.2%		
Cr	Road Transport: Automobile Tyre and Brake wear	National Fishing	Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals			82.3%
	NFR 1A3bvi	NFR 1A4ciii	NFR 1A2f			
	39.7%	34.8%	7.8%			
Cu	National Fishing	Road Transport: Automobile Tyre and Brake Wear	Other Product Use (Fireworks, Tobacco)			80.8%
	NFR 1A4ciii	NFR 1A3bvi	NFR 2G			
	32.3%	30.5%	17.9%			
Ni	Road Transport: Automobile Tyre and Brake Wear	Other Product Use (Fireworks, Tobacco)	National Fishing	National Navigation (Shipping)		86.8%
	NFR 1A3bvi	NFR 2G	NFR 1A4ciii	NFR 1A3dii		
	24.7%	21.6%	21.1%	19.4%		

Component	Key Categories (Sorted from high to low from left to right and top to bottom)				Total (%)
Se	Open Burning of Waste	Road Transport: Automobile Tyre and Brake Wear	National Fishing	Stationary Combustion in Manufacturing Industries and Construction: Non-metallic Minerals	85.0%
	NFR 5C2	NFR 1A3bvi	NFR 1A4ciii	NFR 1A2f	
	28.8%	28.4%	18.4%	9.4%	
Zn	Open Burning of Waste	Road Transport: Automobile Tyre and Brake Wear	Other Product Use (Fireworks, Tobacco)		82.4%
	NFR 5C2	NFR 1A3bvi	NFR 2G		
	38.0%	36.8%	7.6%		