ENVIRONMENT AGENCY OF ICELAND

2023

National Inventory Report

Emissions of Greenhouse Gases in Iceland from 1990 to 2021

Submitted under the United Nations Framework Convention on Climate Change

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Preface

The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol to the Convention requires the parties to develop and to submit annually to the UNFCCC national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol.

To comply with this requirement, Iceland has prepared a National Inventory Report (NIR) for 1990-2021. The NIR together with the associated Common Reporting Format tables (CRF) and the Standard Electronic format (SEF) is Iceland's contribution to this round of reporting under the Convention, following the guidelines given in Decision 24/CP.19, and under its obligations towards the EU for the period 2021-2030.

The NIR is written by the Environment Agency of Iceland (EAI - *Umhverfisstofnun*), the Soil Conservation Service of Iceland (SCSI – *Landgræðslan*) and the Icelandic Forest Service (IFS - *Skógræktin*). The EAI is responsible for all chapters apart from those concerning Land Use, Land-Use Change and Forestry (LULUCF), which are written by the Soil Conservation Service and the Icelandic Forest Service, with major contributions by the Agricultural University of Iceland (AUI – *Landbúnaðarháskóli Íslands*). Jón Guðmundsson from the AUI is acknowledged for his extensive contribution to the LULUCF chapters.

This NIR, together with the associated CRF tables and the Annexes to Commission Implementing Regulation 2020/1208, is submitted in accordance with Art. 26 and Parts 1 and 2 of Annex 5 of Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action.

Environment Agency of Iceland, Reykjavík, 14 April 2023

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List of Abbreviations

2006 GL	2006 IPCC Guidelines for Greenhouse Gas Inventories
AAU	Assigned Amount Units
AUI	Agricultural University of Iceland (*Landbúnaðarháskóli Íslands*)
BAT	Best Available Technology
BEP	Best Environmental Practice
BOD	Biological Oxygen Demand
C_2F_6	Hexafluoroethane
C_3F_8	Octafluoropropane
CER	Certified Emission Unit
CF_4	Tetrafluoromethane
CFC	Chlorofluorocarbon
CH_4	Methane
CITL	Community Independent Transaction Log
CKD	Cement Kiln Dust
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
COD	Chemical Oxygen Demand
COP	Conference of the Parties
COPERT	Computer Programme to calculate Emissions from Road Transport
CP2	Second Commitment Period to the Kyoto Protocol
CRF	Common Reporting Format
DOC	Degradable Organic Carbon
EAI	The Environment Agency of Iceland (*Umhverfisstofnun*)
EF	Emission Factor
ERT	Expert Review Team
ERU	Emission Reduction Unit
EU	European Union
EU ETS	European Union Greenhouse Gas Emission Trading System
FeSi	Ferrosilicon
FRL	Farmers Revegetate the Land
GDP	Gross Domestic Product
Gg	Gigagrams
GHG	Greenhouse Gases
GIS	Geographic Information System
GPS	Global Positioning System
GRETA	Greenhouse Gases Registry for Emissions Trading Arrangements
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbon
HMI	Habitat Map of Iceland
IAAC	Icelandic Agricultural Advisory Centre (*Ráðgjafamiðstöð landbúnaðarins*)
IEF	Implied Emission Factor
IFR	Icelandic Forest Research
IFS	Icelandic Forest Service (*Skógræktin*)
IFVA	Icelandic Food and Veterinary Association (*Matvælastofnun*)

IINH	Icelandic Institute of Natural History (*Náttúrufræðistofnun Íslands*)
IPCC	Intergovernmental Panel on Climate Change
ITA	Icelandic Transport Authority (*Samgöngustofa*)
ITL	International Transaction Log
IW	Industrial Waste
Kha	Kilohectare
KP	Kyoto Protocol
LULUCF	Land Use, Land-use Change, and Forestry
MAC	Mobile Air Conditioning
MACS	Mobile Air-Conditioning Systems
MCF	Methane Correction Factor
MEEC	Ministry of the Environment, Energy, and Climate (*Umhverfis-, orku- og loftslagsráðuneytið*)
MFAF	Ministry of Food, Agriculture, and Fisheries (*Matvælaráðuneytið*)
MMR	Monitoring Mechanism Regulation
MSW	Municipal Solid Waste
N_2O	Nitrous Oxide
NEA	National Energy Authority (*Orkustofnun*)
NF_3	Nitrogen Trifluoride
NFI	National Forest Inventory
NIR	National Inventory Report
NIRA	The National Inventory on Revegetation Area
NLSI	National Land Survey of Iceland (*Landmælingar Íslands*)
NMVOC	Non-Methane Volatile Organic Compounds
NO_x	Nitrogen Oxides
NPCI	National Power Company of Iceland (*Landsvirkjun*)
ODS	Ozone Depleting Substances
OECD	Organisation for Economic Co-operation and Development
OX	Oxidation Factor
PFC	Perfluorocarbons
POP	Persistent Organic Pollutant
QA/QC	Quality Assurance/Quality Control
RI	Registers Iceland (*Þjóðskrá Íslands*)
RMU	Removal Unit
SCSI	Soil Conservation Service of Iceland (*Landgræðslan*)
SEF	Standard Electronic Format
SF_6	Sulphur Hexafluoride
Si	Silicon
SI	Statistics Iceland (*Hagstofa Íslands*)
SiO	Silicon Monoxide
SiO_2	Quartz
SO_2	Sulphur Dioxide
SO_2e	Sulphur Dioxide Equivalents
SOC	Soil Organic Carbon
SSPP	Systematic Sampling of Permanent Plots
SWD	Solid Waste Disposal
SWDS	Solid Waste Disposal Sites
t/t	Tonne per Tonne
TJ	Terajoule
TOW	Total Organics in Wastewater
UNFCCC	United Nations Framework Convention on Climate Changes

Global Warming Potentials (GWP) of Greenhouse Gases

Greenhouse gas	Chemical formula	GWP – AR5
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265
Sulphur hexafluoride	SF_6	23,500
Perfluorocarbons (PFCs):		
Tetrafluoromethane (PFC 14)	CF_4	6,630
Hexafluoroethane (PFC 116)	C_2F_6	11,100
Octafluoropropane (PFC 218)	C_3F_8	8,900
Hydrofluorocarbons (HFCs):		
HFC-23	CHF_3	12,400
HFC-32	CH_2F_2	677
HFC-125	C_2HF_5	3,170
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1,300
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	4,800
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	138
HFC-227ea	C_3HF_7	3,350

Source: Table 8.A.1 of Chapter 8 of the Contribution of WG1 to the Fifth Assessment report (AR5 - WGI), 100-yr time horizon.

The Global Warming Potentials (GWPs) used in this submission are based on the 100-year time horizon GWPs presented in the Fifth Assessment Report (AR5) of the IPCC. The emissions in the 2022 Submission’s NIR were based on the 100-year time horizon GWPs presented in the Forth Assessment Report (AR4) of the IPCC. Emissions of greenhouse gases other than CO_2, represented in CO_2e, are therefore not directly comparable between the 2022 and 2023 submissions. This also applies to aggregate emissions of different greenhouse gases in CO_2e.

The use of AR5 GWPs is consistent with Recital 2 and Art. 2 of Commission Delegated Regulation (EU) 2020/1044.

Definitions of Prefixes and Symbols Used in the Inventory

Prefix	Symbol	Power of 10
kilo-	k	10^3
mega-	M	10^6
giga-	G	10^9
tera-	T	10^{12}

Executive Summary

ES.1 Background

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) requires that the Parties report annually on their greenhouse gas (GHG) emissions by sources and removals by sinks. In response to this requirement, Iceland has prepared the present National Inventory Report (NIR), following the guidelines given by Decision 24/CP.19.

This NIR, together with the associated CRF tables and the Annexes to Commission Implementing Regulation 2020/1208, is also submitted to the EU in accordance with Art. 26 and Parts 1 and 2 of Annex 5 of Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action.

The responsibility of producing the emissions data lies with the Environment Agency of Iceland (EAI), which compiles and maintains the GHG inventory. Emissions and removals calculations from the Land Use, Land Use Change and Forestry (LULUCF) sector are currently managed by the Soil Conservation Service of Iceland (SCSI) and the Icelandic Forest Service (IFS). The national inventory and reporting system are continually being developed and improved.

Iceland is a party to the UNFCCC and acceded to the Kyoto Protocol on 23 May 2002. Earlier that year, the government adopted a climate change policy that was formulated in close cooperation between several ministries. The aim of the policy was to curb emissions of GHGs, so they would not exceed the limits of Iceland's obligations under the Kyoto Protocol. A second objective was to increase the level of carbon sequestration through afforestation and revegetation programs. In February 2007, a new climate change strategy was adopted by the Icelandic government. The strategy set forth a long-term vision for the reduction of net emissions of GHGs by 50-75% by 2050 compared to 1990 levels. An Action Plan for climate change mitigation was adopted in 2010. The Action Plan built on an expert study on mitigation potential and cost from 2009 and took account of the 2007 climate change strategy and likely international commitments. In 2012, the first yearly progress report was published, where the emissions and removals are compared with the goals put forward in the Action Plan.

In September 2018, the Icelandic government published a new Climate Change Action Plan[1], containing a collection of 34 actions and associated funding of 49 million Euros for the period 2019-2023. The action plan focuses on two major parts: firstly, the electrification of the Transport sector; secondly, an increased effort in afforestation, revegetation, and wetland restoration. An update of the 2018 action plan was published in June 2020[2], with an associated budget of 46 billion Icelandic kr. (300 million Euros) for the period 2020-2024.

Iceland's international obligations on climate change are listed here below:

- For the first commitment period of the Kyoto Protocol, from 2008 to 2012, the GHG gas emissions were not to increase by more than 10% from the level of emissions in 1990.
- Decision 14/CP.7 on the "Impact of single project on emissions in the commitment period" allowed Iceland to report certain industrial process carbon dioxide (CO_2) emissions separately and not include them in national totals; to the extent they caused Iceland to exceed its assigned amount. For the first

[1] Aðgerðaáætlun í loftslagsmálum 2018-2030: Climate Action plan 2018-2030, in Icelandic

[2] Aðgerðaáætlun í loftslagsmálum til 2030: Climate Action plan, updated second edition, in Icelandic

commitment period, from 2008 to 2012, the CO_2 emissions falling under decision 14/CP.7 were not to exceed 8,000,000 tonnes. Iceland complied with its obligations under the first commitment period.

- The second commitment period of the Kyoto Protocol ran for eight years, from 2013 to 2020. In 2015, it was agreed[3] between the European Union (EU), its Member States and Iceland that Iceland would participate in the joint fulfilment of commitments of the Union for the second commitment period of the Kyoto Protocol. Therein the Parties agree to fulfil their quantified emission limitation and reduction commitments for the second commitment period inscribed in the third column of Annex B to the Kyoto Protocol jointly. According to this agreement, Iceland was allocated 15,327,217 t CO_2e for the second commitment period, and Iceland needs to surrender 3,404,217 units in order to comply.
- Under the Paris Agreement, Iceland will be part of a collective delivery by European countries to reach a target of 55% reduction of greenhouse gas emissions by 2030 compared to 1990 levels. Iceland will ensure fulfilment of its fair share of the collective delivery of the 55% target by: a) continuing participation in the EU Emissions Trading Scheme and b) reducing emissions falling under the scope of the EU's Effort Sharing Regulation (Regulation (EU) 2018/842) relative to the 2005 emission level[4]. The current Effort Sharing target for 2030 is 29% reduction relative to 2005, but at the time of this writing work is in progress to determine a new target in line with the updates of the EU's "Fit for 55" legislation package.

ES.2 Summary of National Emission and Removal Related Trends

Greenhouse gases that, according to Annex A of the Kyoto Protocol as modified by the Doha Amendment, have to be considered in national GHG inventories, are:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_20)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6)
- Nitrogen fluoride (NF_3)

Iceland reports emissions of CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6. NF_3 is not used in Iceland and has not been imported as such. In addition, no industry potentially using NF_3 (e.g., semiconductors, LCD manufacture, solar panels, and chemical lasers) is present in Iceland.

For the first time this year, emissions that are reported in CO_2 equivalents are calculated using Global Warming Potentials (GWPs) based on the 100-year time horizon GWPs presented in the Fifth Assessment Report (AR5) of the IPCC. The use of AR5 GWPs is consistent with Recital 2 and Art. 2 of Commission Delegated Regulation (EU) 2020/1044.

The distribution of reported greenhouse gas emissions over the UNFCCC sectors (excluding LULUCF) since 1990 is shown in Figure ES. 1. Emissions from the Energy sector and Industrial Processes

[3] http://register.consilium.europa.eu/doc/srv?l=EN&f=ST%2010941%202014%20INIT
[4] EU Regulation 2018/842 was taken up into the EEA Agreement with the Joint Committee Decision nr. 269/2019 (https://www.efta.int/media/documents/legal-texts/eea/other-legal-documents/adopted-joint-committee-decisions/2019%20-%20English/269-2019.pdf)

contribute approximately with 80% to the national total (excluding LULUCF). The emissions from the Agriculture and Waste sectors are considerably smaller.

A summary of Iceland's national emissions for selected years since 1990 is presented in Table ES. 1. LULUCF is the largest sector, with emissions of more than double the combined emissions from the other sectors across the time series. Total GHG emissions (excluding LULUCF) increased by 27% from 1990 to 2021. LULUCF emissions have remained relatively constant since 1990. The greatest change in the trend over the time series is the increase in the contribution of Industrial Processes to total emissions. This is primarily due to the increased production of aluminium in Iceland, which is a highly energy-intensive process.

A more detailed consideration of emissions trends can be found in Chapter 2.

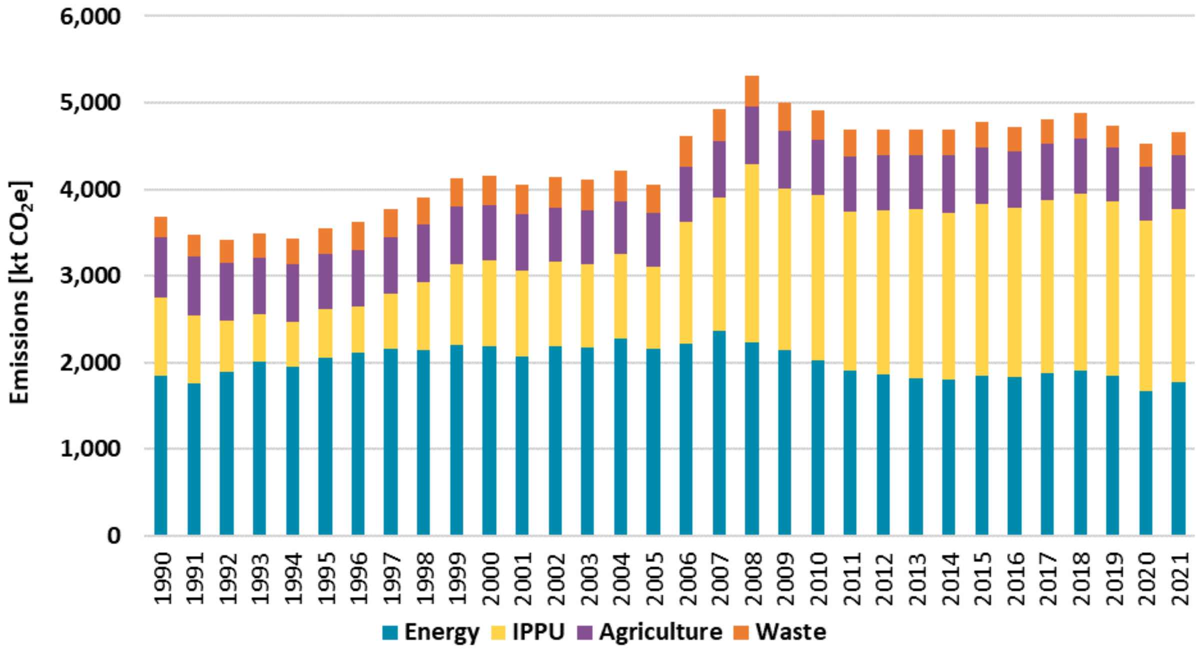


Figure ES.1 Emissions of GHG by sector, without LULUCF, since 1990, [kt CO_2e, calculated using GWP from AR5]

Table ES. 1 Emissions of GHG by sector, since 1990, [kt CO_2e, calculated using GWP from AR5]

	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '20-'21
1 Energy	1,841	2,057	2,185	2,158	2,027	1,854	1,664	1,767	-4.0%	+6.2%
2 Industrial Processes	903	553	992	950	1,899	1,970	1,975	2,007	+122%	+1.6%
3 Agriculture	695	643	641	611	646	659	617	620	-10.8%	+0.5%
4 Land Use, Land-use Change, and Forestry	9,610	9,587	9,604	9,635	9,596	9,506	9,421	9,398	-2.2%	-0.2%
5 Waste	244	301	336	340	334	289	266	268	+10%	+1.3%
Total without LULUCF	**3,682**	**3,555**	**4,154**	**4,059**	**4,906**	**4,773**	**4,521**	**4,662**	**+27%**	**+3.1%**
Total with LULUCF	**13,292**	**13,142**	**13,758**	**13,695**	**14,503**	**14,279**	**13,942**	**14,060**	**+5.8%**	**+0.8%**

The GHG emissions profile for Iceland is unusual in many respects:

- Emissions from generation of electricity and from space heating are very low owing to the use of renewable energy sources (geothermal and hydropower).
- Approximately 90% of emissions from the Energy sector stem from mobile sources (Transport, Mobile Machinery, and commercial fishing vessels; excluding emissions from International Aviation and Navigation).
- Emissions from the Land Use, Land-use Change, and Forestry (LULUCF) sector are high in comparison to other sectors and to other parties. Recent research has indicated that there are significant emissions of CO_2 from drained wetlands. These emissions can be attributed to drainage of wetlands in the latter half of the 20th Century, which had largely ceased by 1990. These emissions of CO_2 continue for a long time after drainage.
- Individual sources of industrial process emissions have a significant proportional impact on emissions at the national level. Expansion in existing metal production capacity as well as start of new operations is reflected in the country's emission profile, as for instance the start of two new aluminium smelters in 1998 and 2007, respectively. This last aspect of Iceland's emission profile made it difficult to set meaningful targets for Iceland during the Kyoto Protocol negotiations. This fact was acknowledged in Decision 1/CP.3 paragraph 5(d), which established a process for considering the issue and taking appropriate action. This process was completed with Decision 14/CP.7 on the Impact of single projects on emissions in the first commitment period.

ES.3 Other Information – Kyoto Accounting

First Commitment Period (2008-2012)

Under the Kyoto Protocol, Parties set targets which are expressed as Assigned Amount Units (AAUs). Iceland's initial AAUs for the first commitment period amounted to 18,523,847 tonnes of CO_2 equivalents (CO_2e) for the period or 3,704,769 tonnes per year on average. Added to that are a total of 1,541,960 removal units (RMUs) from Art. 3.3 and Art. 3.4 activities and total of 33,125 AAUs, CERs and ERUs from Joint Implementation projects, resulting in an available assigned amount of 20,098,931 AAUs.

Emissions from Annex A sources during CP1 were 23,356,071 tonnes CO_2e. This means that Annex A emissions were 3,257,140 tonnes CO_2 in excess of Iceland's available assigned amount.

Total CO_2e emissions falling under Decision 14/CP.7 during CP1 were 5,912,964 tonnes CO_2e. Therefore, in order to comply with its goal for CP1, Iceland reported 3,257,140 tonnes of the CO_2e emissions falling under decision 14/CP.7 separately, without including them in national totals.

The CRF tables accompanying the current NIR, however, still contain Iceland's Annex A emissions in their entirety.

Second Commitment Period (2013-2020)

The second Commitment Period started 1 January 2013 and ended 31 December 2020. The EU, its Member States and Iceland have agreed to the immediate implementation of the Doha Amendment as of 1 January 2013, and to fulfil the commitments under the second commitment period of the Kyoto Protocol, jointly. Iceland's individual assigned amount was established at 15,327,217 AAUs.

As part of its submission to UNFCCC, Iceland submits Standard Electronic Format (SEF) tables for the Kyoto Protocol units issued in 2022 for the second commitment period (CP2). There were no annual external transactions made and at the end of the reported year. At the end of the year there were 15,327,217 AAUs in Iceland's party holding account.

1 Introduction

1.1 Background Information

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) was ratified by Iceland in 1993 and entered into force in 1994. One of the requirements under the Convention is that Parties are to report their national anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, using methodologies agreed upon by the Conference of the Parties to the Convention (COP). This National Inventory Report (NIR) is one of the elements of the annual GHG inventory that is required to be submitted to the UNFCCC, following the guidelines outlined in Decision 24/CP.19. It is also submitted to the EU in accordance with Art. 26 and Parts 1 and 2 of Annex 5 of Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action, including the Annexes to Commission Implementing Regulation (EU) 2020/1208 as listed in the Decision of the EEA Joint Committee No223/2021

1.1.1 First Commitment Period of the Kyoto Protocol (2008-2012)

For the first commitment period of the Kyoto Protocol, the GHG emissions were not to increase by more than 10% from the level of emissions in 1990. Iceland Assigned Amount Units (AAUs) for the first commitment period were decided in Iceland's Initial Report under the Kyoto Protocol and amounted to 18,523,847 tonnes of carbon dioxide equivalents (CO_2e). Decision 14/CP.7 on the "Impact of single project on emissions in the commitment period" allowed Iceland to report certain industrial process carbon dioxide (CO_2) emissions separately and not include them in national totals; to the extent they caused Iceland to exceed its assigned amount. For the first commitment period, from 2008 to 2012, the CO_2 emissions falling under decision 14/CP.7 were not to exceed 8,000,000 tonnes.

At the end of the commitment period, a total of 1,542,761 RMUs were available from Art. 3.3 and Art. 3.4 activities and 33,125 AAUs, CERs and ERUs from Joint Implementation Projects, resulting in an available assigned amount of 20,098,931 AAUs. Emissions from Annex A sources (including those falling under the scope of Decision 14/CP.7) for the entire CP1 were 23,356,066 tonnes CO_2e, corresponding to 3,257,140 tonnes CO_2e in excess of Iceland's available assigned amount. Two projects fulfilled the provisions of Decision 14/CP.7, with a total of 5,912,964 tonnes CO_2e. Of these emissions, 2,655,824 tonnes were reported under the national totals, to match the total available amount of AAUs, and 3,257,140 tonnes were reported separately under decision 14/CP.7. Iceland was thus in compliance with its commitments.

1.1.2 Second Commitment Period of the Kyoto Protocol (Doha Amendment – 2013-2020)

In 2015 a Joint Fulfilment Agreement[5] was concluded between the European Union (EU), its Member States and Iceland. This Agreement concerned Iceland's participation in these parties' joint fulfilment of commitments in the second commitment period of the Kyoto Protocol. Therein the Parties agree to fulfil jointly their quantified emission limitation and reduction commitments for the second commitment period inscribed in the third column of Annex B to the Kyoto Protocol. Iceland's individual assigned amount was established at 15,327,217 AAUs.

According to Article 4, cf. Annex I, of the Joint Fulfilment Agreement, Regulation (EU) No 525/2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other

[5] http://register.consilium.europa.eu/doc/srv?l=EN&f=ST%2010941%202014%20INIT

information at national and Union level relevant to climate change ("MMR") as well as all Delegated and Implementing Acts based on Regulation (EU) No 525/2013 were to be binding upon Iceland. This included for instance Commission Implementing Regulation (EU) No 749/2014, which further detailed the content and format required for the various reporting requirements under Regulation (EU) No 525/2013. The legal acts were rendered applicable in Iceland in 2015 with an amendment to Act No 70/2012, cf. Act No 62/2015.

The accounting for the second commitment period of the Kyoto Protocol will take part in 2023, and includes both settlement of Iceland's obligations towards the EU, and the reporting obligations towards the UNFCCC. More details on the accounting for the second commitment period can be found in Chapter 11.6.2.

1.1.3 Paris Agreement Period (2021-2030)

Under the Paris Agreement, Iceland is part of a collective delivery by EU member states, Iceland and Norway to reach a target of 55% reduction of greenhouse gas emissions by 2030 compared to 1990 levels. Iceland will ensure fulfilment of its fair share of the collective delivery of the 55% target by

a) continuing participation in the EU Emissions Trading Scheme (**EU ETS**) according to Directive 2003/87/EC,

b) reducing emissions falling under the scope of the EU's Effort Sharing Regulation (Regulation (EU) 2018/842 - **ESR**) relative to the 2005 emission level. The current Effort Sharing target for 2030 is 29% reduction relative to 2005, but at the time of this writing work is in progress to determine a new target in line with the updates of the EU's "Fit for 55" legislation package.

c) implementing the reporting and accounting rules pertaining to emissions and removals from the Land Use, Land-use Change, and Forestry (**LULUCF**) as prescribed by the LULUCF regulation (Regulation (EU) 2018/841).

Iceland's and Norway's joint fulfilment with the EU Member States for the Paris Agreement was agreed upon with the uptake in October 2019 of relevant EU legislation into the European Economic Area (EEA) Agreement[6]. This includes the LULUCF Regulation (Regulation (EU) 2018/841), the Effort Sharing Regulation (Regulation (EU) 2018/842), as well as parts of the Governance of the Energy Union Regulation (Regulation (EU) 2918/1999) replacing the MMR Regulation (Regulation (EU) No 525/2013). Furthermore, in 2021 two additional acts were added to the EEA Agreement[7], including Commission Implementing Regulation (EU) 2020/1208 on structure, format, submission processes and review of information to be reported, as well as Commission Delegated Regulation (EU) 2020/1044 on GWP, reporting guidelines and union inventory system.

Work is underway to finalise the legal implementation of Iceland's joint commitment with the EU Member States and Norway under the Paris Agreement. Iceland has implemented the LULUCF Regulation and the ESR through the Climate Act No 70/2012 (*lög um loftslagsmál nr. 70/2012*). Commission Implementing Regulation (EU) 2020/1208 and Commission Delegated Regulation (EU) 2020/1044, are now incorporated into the EEA Agreement through the EEA Joint Committee Decision no 223/2021. At the time of this writing, work is underway to write a new regulation aiming at implementing the JCD No 223/2021 into Icelandic legislation. The same regulation will also serve as a

[6] Decision of the EEA Joint Committee No 269/2019
[7] Decision of the EEA Joint Committee No 223/2021

recast of Regulation No 520/2017, on data collection and information from institutions related to Iceland's inventory of greenhouse gas emissions and carbon removal, that implemented Regulation (EU) No 525/2013. Further discussion on this regulation can be found below in Chapter 1.2.3.

1.1.4 Climate Strategies

A climate strategy was adopted by the Icelandic government in 2007. The long-term strategy was to reduce net GHG emissions in Iceland by 50-75% by 2050, compared to 1990 levels. In the shorter term, Iceland aimed to ensure that emissions of GHGs would not exceed Iceland's obligations under the Kyoto Protocol in the first commitment period. In November 2010, the Icelandic government adopted a Climate Action Plan in order to execute the strategy.

In September 2018, the Icelandic government published a Climate Change Action Plan[8] for 2018-2030; an updated version of the action plan was released in June 2020[9] and is the plan that is currently being put in action. The action plan has two main goals: achieving the emission reductions of the Paris Agreement for 2030 and reaching carbon-neutrality in 2040. To reach these goals the revised action plan set forth 48 actions which mostly focus on electrification of the transport sector and increased efforts in afforestation, revegetation, and wetland restoration. The revision of the plan also contained significantly improved analysis to estimate the individual and collective mitigation gains of the measures presented. According to the Climate Act, the government shall, in consultation with stakeholders, review and update the Climate Action Plan every fourth year based on international commitments and the government's goals. Climate measures shall be developed and put in motion by an inter-ministerial committee. The committee shall also prepare an annual progress report on the status of implementation of the climate plan and its measures, emissions development and whether or not the development is in accordance with the Climate Plan. The first such progress report was published in September 2021 (Ministry of the Environment and Natural Resources[10]) to follow up on the progress of the 2020 Climate Action Plan. Besides the 48 PaMs put forth in the 2020 Climate Action Plan, two new GHG mitigation measures are introduced in the progress report: 1) energy change in the production sector; 2) increased knowledge and research to improve the LULUCF sector of the GHG inventory. According to the progress report, thirty PaMs (out of fifty in total) have currently been implemented, seventeen are in progress and three are in preparation stages.

A minimum of ISK 46 billion (approx. 310 million EUR) is expected to be spent on key climate measures in the period 2020-2024.

In November 2021, the newly formed Government published an agreement on the platform for the coalition government[11], which includes among other topics, the goal to decrease emissions falling under the scope of the Effort Sharing Regulation by 55% in 2030 relative to the emissions in 2005.

1.2 National System for Estimation of Greenhouse Gases

1.2.1 Institutional Arrangements

The Climate Change Act No 70/2012 establishes the national system for the estimation of GHG emissions. In accordance with this Act, the Environment Agency of Iceland (*Umhverfisstofnun*) (EAI), an agency under the auspices of the Ministry of the Environment, Energy, and Climate (*Umhverfis-,*

[8] Aðgerðaáætlun í loftslagsmálum 2018-2030: Climate Action plan 2018-2030, in Icelandic
[9] Aðgerðaáætlun í loftslagsmálum til 2030: Climate Action plan, updated second edition, in Icelandic
[10] 2021 Progress report on the Climate Action Plan, published September 2021 (in icelandic)
[11] https://www.stjornarradid.is/library/05-Rikisstjorn/Agreement2021.pdf

orku- og loftslagsráðuneytið) (MEEC), carries the overall responsibility for the national inventory. The EAI compiles and maintains the GHG emission inventory, except for the LULUCF sector which is compiled by the Soil Conservation Service of Iceland (*Landgræðslan*) (SCSI) and the Icelandic Forest Service (*Skógræktin*) (IFS) in collaboration with the Agricultural University of Iceland (*Landbúnaðarháskóli Íslands*) (AUI). The EAI reports to the Convention and to the EU, as well as to the EFTA (European Free Trade Association). The Act specifies that the EAI is allowed to request all data needed for the inventory from relevant authorities, agencies, companies, and individuals; the obligations are further elaborated in Regulation No 520/2017 on data collection and information from institutions related to Iceland's inventory. The regulation is currently being recast, amongst other things to reflected changes in responsibilities of various data providers.

The UNFCCC national focal point is within the MEEC (Mrs. Helga Barðadóttir) and is responsible for approving the final inventory before its submission to the UNFCCC.

Figure 1.1 illustrates the flow of information and allocation of responsibilities. The main data providing institutions are also listed, including information on which sector they are contributing data to.

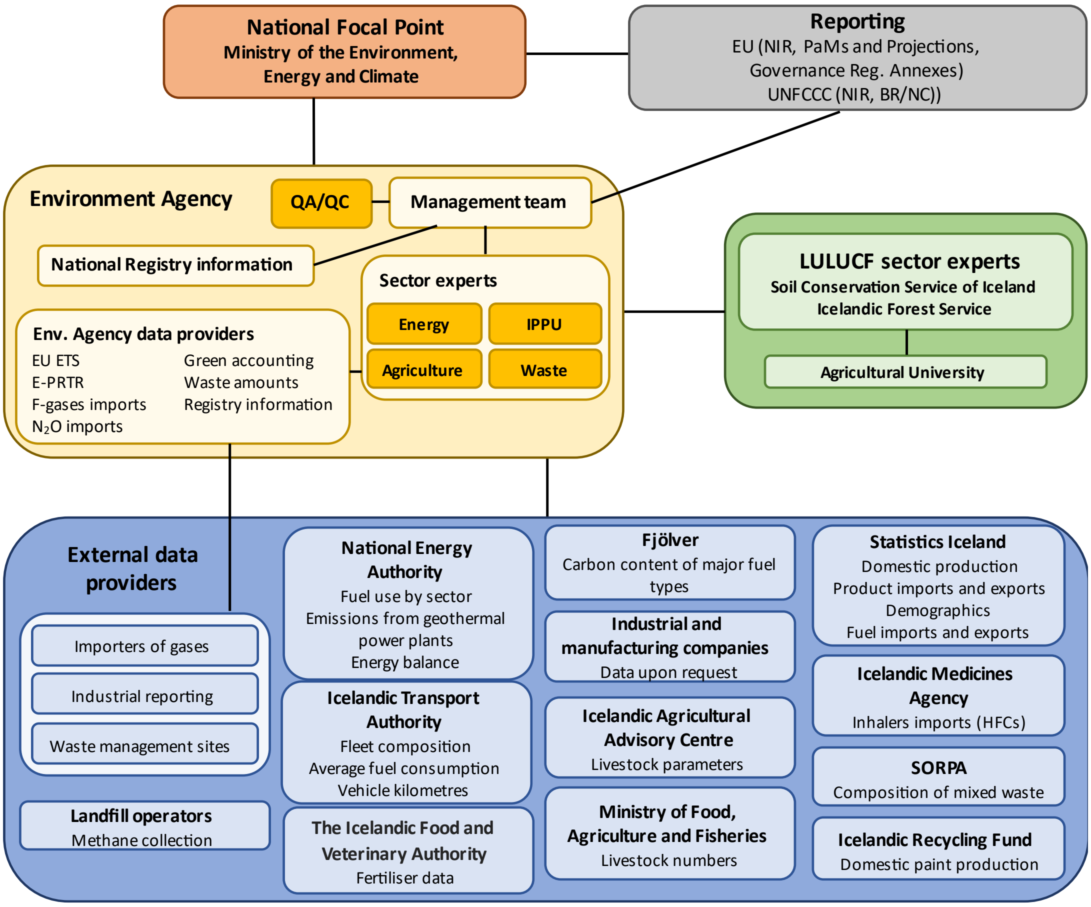


Figure 1.1 Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the UNFCCC.

1.2.2 National Legislation

1.2.2.1 *The Climate Change Act No 70/2012*

In June 2012 the Icelandic Parliament passed a law on climate change (Act No 70/2012). The objectives of the Climate Change Act are the following:

- Reducing GHG emissions efficiently and effectively;
- To increase carbon sequestration from the atmosphere;
- Promoting climate change mitigation;
- To create a framework for the government to fulfil its international obligations regarding climate change; and
- To reach carbon neutrality no later than 2040.

Act No 70/2012 supersedes Act No 65/2007 on which basis the EAI made formal agreements with the necessary collaborating agencies involved in the preparation of the inventory to cover responsibilities such as data collection and methodologies, data delivery timelines and uncertainty estimates. The data collection for the first commitment period of the Kyoto protocol was based on these agreements.

Act No 70/2012 establishes the national system for the estimation of GHG emissions by sources and removals by sinks, the national registry, emission permits and establishes the legal basis for installations and aviation operators participating in the EU ETS. The Act specifies that the EAI is the responsible entity for the national accounting for greenhouse gases as well as for the inventory of emissions and removals of GHGs according to Iceland's international obligations.

Article 6 of Act No 70/2012 addresses Iceland’s GHG inventory. It states that the Environment Agency (EAI) compiles Iceland’s GHG inventory in accordance with Iceland’s international obligations. Act No 70/2012 established the form of relations between the EAI and other bodies concerning data handling. Responsibilities from the various bodies are further specified in Regulation No 520/2017, as described below; Article 6a and 6b serve to implement the Effort Sharing Regulation (EU) 2018/842 and the LULUCF Regulation (EU) 2018/841 into Icelandic law.

1.2.3 Regulation No 520/2017

The Regulation on data collection and information from institutions related to Iceland’s inventory on GHG emissions and removal of carbon from the atmosphere No 520/2017[12] was adopted in June 2017. This regulation establishes formally the data provision modalities, such as content, format and deadlines for data submission to the EAI; furthermore, it implemented EU Regulation No (EU) 525/2013 on a mechanism for monitoring and reporting GHG emissions and for reporting other information at national and Union level relevant to climate change (“MMR”) and delegated Acts; Regulation (EU) 525/2013 and delegated acts are no longer in force, as they pertained to the second commitment under the Kyoto Protocol, and have been replaced by new acts, as mentioned below.

Regulation No 520/2017 is currently under revision. Revisions include clearer definitions and deadlines to improve timeliness of delivery by data providers, as well as clauses on the role of data providers in providing explanations relating to their datasets in reviews for instance. The revision will also serve to implement relevant articles from Regulation (EU) 2018/1999 (Governance Regulation) relating to the

[12] https://www.reglugerd.is/reglugerdir/eftir-raduneytum/umhverfis--og-audlindaraduneyti/nr/0520-2017

inventory preparation[13], as well as relevant articles from Regulation (EU) 2020/1208 and (EU) 2020/1044[14] on structure, format, and submission process of information to be submitted pursuant to the Governance Regulation and on requirements about Global Warming Potential values and IPCC guidelines to be used. In addition to this, several government agencies are being restructured after a change in the configuration of the various ministries, which will likely lead to significant changes such as merging of some agencies. It is expected that these changes will affect several agencies involved in the compilation of Iceland's GHG inventory, including the EAI, National Energy Authority (*Orkustofnun*) (NEA), SCSI, and IFS.

The updated regulation is expected to be published in 2023, and the changes will be highlighted in next year's NIR.

1.2.4 Planned Improvements to the National System

In order to better implement the requirements of Articles 26 to 29 of Commission Implementing Regulation (EU) 2020/1208, there are plans to set up a steering committee for the inventory, as a part of the national system. The exact roles and modalities of functioning of such a committee are yet to be defined; it is thought that such a committee will be coordinated by the EAI and be composed of representatives from the SCSI, IFS, MEEC, and possibly other ministries, as well as major data providers and stakeholders. The aim of such a committee will be, amongst other things, enhanced QA of the inventory as well as prioritisation of improvements needed. Furthermore, it is planned to establish separate working groups for various key subsectors of the inventory, to enhance collaboration between experts in the inventory team, various ministries as well as experts from other institutions, companies, universities, and research centres.

1.3 Inventory Preparation: Data Collection, Processing, and Storage

1.3.1 Data Collection

The data collection for individual sectors or subsectors is described in the corresponding sections of the sectoral chapters. Below is an overview of the main data collection process:

- The EAI collects the bulk of data necessary to run the general emission model,e.g., activity data and emission factors, for all sectors apart from LULUCF. Activity data is collected from various institutions and companies, as well as by EAI directly as listed and illustrated above in Section 1.2.1.
- Information on fuel use reported by all companies under the EU ETS (as per Directive 2003/87/EC) is used directly in the inventory calculations.
- According to Icelandic Regulation No 851/2002 on green accounting, industry is required to hold, and to publish annually, information on how environmental issues are handled, the amount of raw material and energy consumed, the amount of discharged pollutants, including GHG emissions, and waste generated. Emissions reported by installations have to be verified by independent auditors, who need to sign the reports before their submission to the Environment Agency. The green accounts are then made publicly available on the website of the EAI.
- The NEA collects fuel sales data by sector; however, the sectoral split of the NEA does not entirely match that of the IPCC, thus the EAI processes the data in order to ensure correct attribution to the IPCC codes as per the CRF.

[13] As per Decision of the EEA Joint Committee No. 269/2019
[14] As per Decision of the EEA Joint Committee No. 223/2021

- The SCSI provides information on revegetated areas and assesses other land-use categories on the basis of its own geographical database and other available supplementary land-use information. The IFS provides information on forest land, natural birch shrubland, and harvested wood products.

Emission factors are taken mainly from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC, 2014) and the 2013 Revised supplementary methods and good practice guidance arising from the Kyoto Protocol (IPCC, 2014). When available, country specific emission factors are used. This year's submission also includes the use of a factor for N content of Domestic Sewage Sludge (CRF category 5D) from the 2019 Refinements to the 2006 IPCC Guidelines,

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

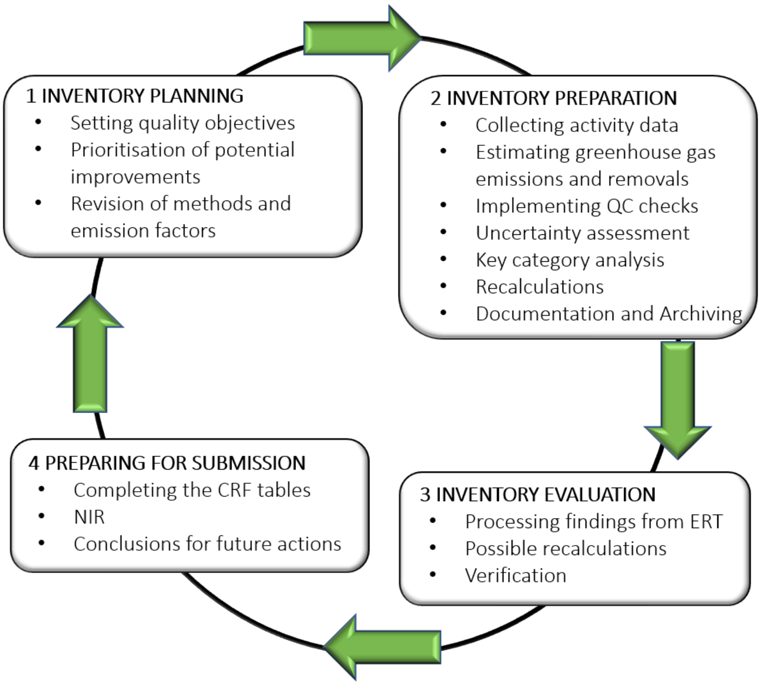


Figure 1.2 Iceland's annual inventory cycle.

1.3.2 Processing

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 as well as the recommendations from the UNFCCC and EU reviews. The initial planning is followed by a period assigned for compilation of the national inventory and improvement of the National System. The estimation methods of all GHGs are harmonised with the IPCC Guidelines for National Greenhouse Gas Inventories. Methodologies and data sources for each sector are described in Chapters 3-7.

After compilation of activity data, emission estimates and uncertainties are calculated, and quality checks performed to validate results. All emission estimates are imported into the CRF Reporter software. The sectoral experts for LULUCF import the LULUCF data separately.

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 emissions from industrial plants falling under the EU ETS, other key categories and for those categories where data and methodological changes have recently occurred.

The GHG inventory is submitted to the EU and the EFTA on 15 January and 15 March as per Art. 26 og Regulation (EU) 2018/1999, and on 15 April, after approval by the Ministry of the Environment, Energy and Climate, the GHG inventory is submitted to the UNFCCC by the EAI, with a copy submitted to the EU and EFTA.

1.3.3 Storage

A document management system (Gopro.net), is used to store email communications concerning the GHG inventory. Digital copies of paper documents, e.g., written letters, are also stored on the document management system. The system runs on its own virtual server and uses a MS SQL server 2019 running on a separate server. Both servers are running Windows Server 2019.

Each staff member at Environmental Agency has a subscription to Microsoft Office 365 and emails are sent and received using Microsoft Office 365 servers hosted in Ireland.

Numerical data, calculations and other related documents are stored on a file server running Windows Server 2019. EA's virtual servers are running on IBM BladeCenter.

Premis (formerly known as *Fjölnet*), a local IT company, hosts the EAI's servers. Their hosting is fully ISO-9001 and ISO-27001 certified. The server and backup rooms are in two locations, the primary server room for EAI is in Sauðárkrókur (a town in northern Iceland) and the disaster recovery room storing off-site backups is in Reykjavík city (located in southwestern Iceland). The rooms are separated by roughly a 200 km straight line.

Backups are taken daily, a subset of those is regularly set for at least 15 months storage.

The land-use database IGLUD is stored on a server of the SCSI, as well as spreadsheets containing calculations regarding land-use classes other than forest land. Data regarding forest land, forestry, and harvested wood products are stored on servers of the IFS.

1.3.4 Training and Capacity-building Activities for Inventory Compilers

The Icelandic inventory team has proactively sought and engaged in training and capacity building activities. These training and capacity building activities aim to support individuals within the inventory team, and include both courses and workshops on generally applicable skills (including, for example, enhanced knowledge in data-processing software, project management, and effective communication) as well as sector-specific training (including visits to companies and sector-specific courses and workshops). The main recent capacity-building activities are outlined below.

- Training by the consulting company which has been helping staff at the EAI for several years (Aether ltd.). Examples from the last few years include:
    - **Energy:** During the review of the Energy files in 2018, a staff member from Aether came to Iceland and worked with the EAI staff to redo all the calculation files. This served both to ascertain that all calculations were done using EFs and methodologies consistent with the 2006 IPCC guidelines and provided an opportunity for new staff members to familiarise themselves with the Energy sector.

- **IPPU:** Almost 90% of the IPPU emissions come from metal production, where the data is obtained from EU ETS verified reports and the data quality is considered to be very good. The rest of the IPPU emissions are mostly from the use of refrigerants and other F gases. During the review of the F gases inventory, started in 2019, a staff member from Aether came to Iceland and worked with the main IPPU sectoral expert of the agency, provided training in the methodologies to be used, and assisted the EAI in generating new calculations files. QC of the files by the Aether staff provided further training opportunities, with numerous Skype meetings between Aether and the EAI to discuss the files.
- **Agriculture**: in 2018 and 2020, training sessions were organised with the consultant, on the basics of estimating emissions from Agriculture, including practicalities of the excel files, imports into CRF, as well as specific aspects particular to the Icelandic conditions. Furthermore, updates of the Agriculture sector that took place for this submission were done in collaboration with consultants at Aether.
- **Waste:** During an in-country visit of Aether staff members in 2019, Aether presented an overview of the waste calculations files. Furthermore, a Skype meeting was held to explain the scientific background of GHG emissions from waste management.
- **Uncertainties** (all sectors, including LULUCF): General, as well as sector-specific training sessions were organised in late 2020/early 2021 with Aether to provide an overview of uncertainty analyses, as well as to go over the uncertainty analysis of each sector with sectoral experts at Aether.

- Participation in capacity building activities proposed by the EU, yearly sector-specific capacity-building webinars, among them:
    - **LULUCF:** LULUCF Virtual Workshop 2021 - Present challenges for LULUCF reporting and accounting. Organised by Joint Research Centre's European Commission. Participation to Support to the assessment of implications of the 2019 Refinement to the 2006 IPCC Guidelines for National and EU Greenhouse Gas Inventories organised by Aether for European Commission.
    - **All sectors:** Capacity-building webinars organised by DG Climate action on ESD review 2021 and LULUCF trial review
    - **Energy, IPPU, Agriculture, and Waste:** Capacity-building webinars organised as a result of the 2022 ESD review.
- Participation in a Nordic inventory experts' working group, where inventory compilers from Norway, Sweden, Finland, Denmark, and Iceland meet once a year with separate sector-specific sessions, including general/QA/QC)) and discuss various aspects of the inventory compilation, ranging from technical aspects of emission estimates to logistical issues with submission to EU and/or UNFCCC.
- Participation in a Nordic expert group on F gases funded by the Nordic Council of Ministers, discussing and comparing methods and parameters used by the various Nordic countries.
- Participation in the annual training session for the COPERT model, organised by the European Environment Agency and carried out by EMISIA, the developer of the software. The training includes an overview of the software, information on the latest updates, a Q&A session with the participants. This one and a half day training is attended by the members of the inventory team every year.

1.3.5 Capacity and Staffing

At the time of this writing, the capacity of the inventory team for the sectors covered by the EAI (all except LULUCF) and for the overall project management amounts to a total of 7.5 positions; in addition to this, the EAI inventory team also includes a 50% lawyer position, and a position specialising in communication. It is worth noting that the same inventory team is also responsible for producing the data and report on policies, measures and projections of greenhouse gases as submitted to the EU, as well as on the annual air pollutant inventory reported to the Convention on Long-range Transport of Atmospheric Pollutants (CLRTAP).

The LULUCF inventory team at the SCSI consists of 13 people, some working part time on the project, but four are full-time members. Two new members were added to the current six members of the summer field campaign staff. The main source of data used to estimate removals and emission regarding forest land and forestry are sampled annually in the Icelandic national forest inventory. Six fulltime employees and two summer workers yielded 3.5 person years in NFI/LULUCF projects in 2022.

1.4 Key Category Analysis

According to the IPCC definition, a key category is one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct GHGs in terms of the absolute level of emissions, the trend in emissions, or both. Total emissions from the key categories amount to 95% of the total emissions included in the inventory. Key Categories are determined with Approach 1 described in Volume 1, Chapter 4 of the 2006 IPCC Guidelines.

The results of the key category analysis including LULUCF are shown in Table 1.1, and the key category analysis excluding LULUCF is shown in Table 1.2 below. More detailed Key Category Analysis tables can be found in Annex 1, including the percentage contribution of each category to the total emissions.

Iceland's key categories may highlight a broader scope of activities than many Parties due to the relatively small anthropogenic emissions from power generation in Iceland. The results highlight the importance of Iceland's industrial sectors, as well as domestic navigation, where the fishing sector plays a strong role in the national economy.

Table 1.1 Key categories of Iceland's GHG inventory (including LULUCF). ✓= Key source category.

IPCC Source Category		Gas	Level 1990	Level 2021	Trend
Energy (CRF sector 1)					
1A2	Fuel combustion - Manufacturing Industries and Construction	CO_2	✓		✓
1A3b	Road Transportation	CO_2	✓	✓	✓
1A4c	Agriculture/Forestry/Fishing	CO_2	✓	✓	✓
1B2d	Fugitive Emissions from Fuels - Other (Geothermal)	CO_2		✓	✓
IPPU (CRF sector 2)					
2C2	Ferroalloys Production	CO_2	✓	✓	✓
2C3	Aluminium Production	CO_2	✓	✓	✓
2C3	Aluminium Production	PFCs	✓		✓
2F1	Refrigeration and Air Conditioning	Aggregate F-gases		✓	✓
Agriculture (CRF sector 3)					
3A1	Enteric Fermentation - Cattle	CH_4	✓	✓	
3A2	Enteric Fermentation - Sheep	CH_4	✓	✓	✓
3D1	Direct N_2O Emissions from Managed Soils	N_2O	✓	✓	
Land use, Land use change and Forestry (CRF sector 4)					
4A1	Forest Land Remaining Forest Land	CO_2		✓	✓
4A2	Land Converted to Forest land	CO_2		✓	✓
4B1	Cropland Remaining Cropland	CO_2	✓	✓	✓
4B2	Land Converted to Cropland	CO_2	✓		✓
4C1	Grassland Remaining Grassland	CO_2	✓	✓	✓
4C2	Land Converted to Grassland	CO_2	✓	✓	✓
4D1	Wetlands Remaining Wetlands	CO_2	✓	✓	✓
4(II) Grassland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	✓	✓	
4(II) Grassland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	✓		
4(II) Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	✓	✓	✓
4(II) Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	✓	✓	
Waste (CRF sector 5)					
5A1	Managed Waste Disposal Sites	CH_4		✓	✓
5A2	Unmanaged Waste Disposal Sites	CH_4	✓		✓

Table 1.2 Key categories of Iceland's GHG inventory (excluding LULUCF). ✓= Key source category.

IPCC source category		Gas	Level 1990	Level 2021	Trend
Energy (CRF sector 1)					
1A2	Fuel combustion - Manufacturing Industries and Construction	CO_2	✓	✓	✓
1A3a	Domestic Aviation	CO_2	✓		
1A3b	Road Transportation	CO_2	✓	✓	✓
1A3d	Domestic Navigation	CO_2	✓		✓
1A3e	Other Mobile Machinery	CO_2	✓		✓
1A4b	Residential Combustion	CO_2	✓		✓
1A4c	Agriculture/Forestry/Fishing	CO_2	✓	✓	✓
1B2d	Fugitive Emissions from Fuels - Other (Geothermal)	CO_2	✓	✓	✓
IPPU (CRF sector 2)					
2A1	Cement Production	CO_2	✓		✓
2B10	Fertiliser Production	N_2O	✓		✓
2C2	Ferroalloys Production	CO_2	✓	✓	✓
2C3	Aluminium Production	CO_2	✓	✓	✓
2C3	Aluminium Production	PFCs	✓	✓	✓
2F1	Refrigeration and Air Conditioning	Aggregate F-gases		✓	✓
Agriculture (CRF sector 3)					
3A1	Enteric Fermentation - Cattle	CH_4	✓	✓	✓
3A2	Enteric Fermentation - Sheep	CH_4	✓	✓	✓
3A4	Enteric Fermentation - Other	CH_4	✓	✓	
3B1	Manure Management - Cattle	CH_4	✓	✓	
3D1	Direct N_2O Emissions from Managed Soils	N_2O	✓	✓	✓
3D2	Indirect N_2O Emissions from Managed Soils	N_2O	✓	✓	
Waste (CRF sector 5)					
5A1	Managed Waste Disposal Sites	CH_4		✓	✓
5A2	Unmanaged Waste Disposal Sites	CH_4	✓		✓
5D2	Industrial Wastewater Treatment	CH_4	✓		✓

1.5 Quality Assurance & Quality Control (QA/AC)

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

1.5.1 Background Information on Iceland's QA/QC Activities

For this submission the QA/QC plan was revised and updated to better reflect the activities of the 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 listedThe 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
- CRF Upload

All steps are time-bound and assigned to one or more team members who are responsible for completing the task and signing it as complete.

1.5.2 Roles and Responsibilities Overview

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

- Inventory team leader – overall responsibility for the accurate and timely production and submission of the inventories, according to the rules and deadlines specified in relevant domestic and international legislation; The team leader is responsible for the communication with the Icelandic ministries, as well as communication with EU and UNFCCC experts/expert review teams.
- 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 NIR chapter is proof-read by one of the experts not involved in the writing of the chapter. Sectoral experts are responsible for communication with relevant data providers.

- 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.

The LULUCF part of the inventory is overseen by the Soil Conservation Service of Iceland (SCSI) and the calculations relating to forestry are covered by the Icelandic Forest Service (IFS).

1.5.3 Quality Assurance (QA)

Iceland's GHG inventory is subjected yearly to reviews by experts mandated by the European Commission and almost yearly by experts mandated by the UNFCCC. Results from these reviews are considered annually and decisions are taken on how the recommendations will be taken forward in the development and improvement of the inventory and the national system.

The most recent review took place in the autumn of 2022, with a centralised UNFCCC review in September 2022. The review lead to a resubmission of the inventory, and Iceland's official 2022 Submission was version v.4. At the time of this writing, the inventory team has not yet received the final review report from the ERT.

Further Quality Assurance is provided by Iceland's collaboration with consultants at Aether Ltd., who assist with and review sector-specific methodological choices and calculations. As part of this collaboration, the calculations for the Agriculture and Waste sectors were revised and improved in recent years, whereas the calculations for the Energy sector were revised in 2018. In 2019, F gases and the Agriculture sector were largely reviewed and improved. Aether also assists Iceland in the development of QA/QC activities and provided Iceland with a tool running several quality assurance checks on the latest GHG inventory. Those checks include:

- Recalculations in comparison to the previous inventory (numerical and notation keys);
- Inter-annual variation within the time series;
- Identifying flat trends in the data;

Furthermore, Iceland participates in various international experts' groups which aim at discussing and enhancing the overall quality of the inventory, as described in chapter 1.3.4 on training and capacity building.

1.5.4 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," developed by Aether), 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). When the QC checks are performed, the QC reviewer follows the QC guidance document and corresponding checklist. 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 if needed QC activities are performed.

QC activities include 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 CRF outputs?
- Are there recalculations since the last submission, and if so, are they properly documented?
- Documentation of performed checks within the emission estimation files and on separate document to track progress and enhance transparency.
- Linking the yearly improvement plan to the outcomes of the QA/QC activities per sector.

The NIR coordinator makes sure to allocate time for all inventory compilers during the inventory preparation cycle for performing the above-mentioned quality checks and assists the compilers regarding the tasks to be carried out and/ or implemented.

The general QC procedures in the guidance document are not set in stone and may change, especially as the sectors continue to improve some sector- and subsector specific guidelines will change and/or be added, current sector specific QC check are given in Table 1.4. An example of a general checklist all sectors have to complete is given in Table 1.3, details of how to perform the checks and in what order are given in the guidance document. As staff changes and general time restrictions could affect QC procedures, the checklist is divided into three sections: minimum requirements, which have to be carried out each year and do not necessarily require a deep knowledge of the sector and then further controls and checks which require a certain experience within the sector and take also longer time to be performed.

Table 1.3 QC checks performed during the inventory cycle.

Check	Description
1 – Activity data	
Activity data source	Is the appropriate data source being used for activity data and is it up to date?
Correct units	Check that the correct units are being used
Consistency	Is the data consistent with previous years?
Documentation	Has the data source been documented and archived correctly?
Colour Coding	Has colour coding been used in a consistent and accurate manner? Are there any significant data gaps of weaknesses?
Notation keys	Review the use of notation keys and the associated assumption to ensure they are correct.
Recalculation	Check values against previous submission. Give reasons where the two values do not match.
Time series consistency	Use recalculations to check for outliers in the data and if the data is time-series consistent.
2 – Emission Factors	
Correct units	Check that the correct units and conversion factors are being used. Check unit carry through in calculations.
Emission factor applicability	Where default emission factors are used, are they correct? Is source information provided?
Documentation	Are all emissions factors and conversion factors documented and referenced correctly?
Colour Coding	Has colour coding been used in a consistent and accurate manner? Are there any significant data gaps of weaknesses?
Recalculation	Check values against previous submission. Give reasons where the two values do not match.

Check	Description
Time series consistency	Are the emission factors time series consistent? Use recalculations to check for outliers and make sure any changes between years are explained and documented correctly.
3 – Emission Calculations	
Method validity	Are the calculation methods used valid and appropriate?
Correct units	Check that the correct units are being used
Documentation	Is there sufficient documentation?
Notation keys	Review the use of notation keys and the associated assumption to ensure they are correct.
Colour coding	Has colour coding been used in a consistent and accurate manner? Are there any significant data gaps of weaknesses?
Recalculation	Check values against previous submission. Give reasons where the two values do not match.
Time series consistency	Are the emission factors time series consistent? Use recalculations to check for outliers and make sure any changes between years are explained and documented correctly.
Uncertainty	Check all uncertainty calculation. Make sure appropriate equations are being used and check if all uncertainty estimations are sufficiently documented.
4 – CRF	
Completeness	Make sure all emissions are reported in the CRF file
Notation keys	Review the use of notation keys and the associated assumption to ensure they are correct.
Accuracy	Cross check emissions in CRF reporting tables with calculation files.

Table 1.4 Sector-specific QC procedures.

Sector	QC Checks
Energy	• Identification and documentation discrepancies between the sectoral approach and the reference approach. • Cross-checks with data from the National Energy Authority (*Orkustofnun*) (NEA) with total input data in calculations files to ensure that all fuels are accounted for. • Monthly meetings with the NEA are held in order to address discrepancies between energy statistics and data used in the inventory. Activity data for the whole time series is checked and the attribution between IPCC subsectors is discussed.
IPPU	• Calculations of CO_2 and PFC emissions from activities falling under the EU ETS Directive (2003/87/EC) are cross-checked with the annual emission reports verified by accredited EU ETS verifiers (according to Article 67 of Directive 2003/87/EC) since 2013. This applies to activities within CRF categories 2.A.4.d, 2.C.2 and 2.C.3. • Participation in a Nordic expert group on F gases, funded by the Nordic Council of Ministers, discussing, and comparing methods and parameters used by the various Nordic countries. • Regular visits with the inspection team of the EAI to factories/companies to increase transparency, knowledge, and accuracy through active dialogue with the field. • Review of the IPPU chapter in this NIR by external stakeholders.
Agriculture	• Work with the livestock data provider to crosscheck the consistency and quality of the data; communicate with agricultural experts to obtain expert judgement on the quality of data used. • For the category mature dairy cows, check the correlation between the following three pairs of inherently connected parameters: milk yield and nitrogen excretion rate (hereafter called Nex rate), gross energy intake and Nex rate, milk yield and feed digestibility. • Data reported under CRF 3B and 3D is checked to assure consistency between N deposited on pasture, range and paddock and urine and dung deposited by grazing animals. • A comparison between the Icelandic country-specific (CS) data on synthetic fertiliser consumption and fertiliser usage data from the International Fertiliser Association (IFA) and synthetic fertiliser consumption estimates from the Food and Agriculture Organization of the United Nations (FAO).
Waste	• Review of the Waste chapter by waste experts from the Circular Economy team and the team of Sea and Water, within the EAI.

Additional checks are done according to the reporting requirements listed in Part 1 of Annex V to Regulation (EU) 2018/1999:

Checks performed on the consistency of the emissions reported in the GHG inventories, for the year X-2, with the verified emissions reported under Directive 2003/87/EC

Data and emissions pertaining to EU ETS under Directive 2003/87/EC ("The ETS Directive"), as calculated in the inventory, are systematically cross-checked against the EU ETS annual emission reports; such a comparison is via Annex XII to Commission Implementing Regulation (EU) 2020/1208. The comparison can also be found in Annex 4: ETS vs. Non-ETS of this report. 40% of the emissions reported by Iceland (without LULUCF) are covered by the EU ETS and therefore are of the highest quality.

Checks performed on the consistency of the emissions reported in the GHG inventory, for the year x-2, with the data used to prepare inventories of air pollutants pursuant to Directive (EU) 2016/2284

As per Article 15 of Regulation (EU) 1020/1208, EU member states, Iceland and Norway are to perform checks on the consistency of the data used to estimate emissions in preparation of the GHG inventories with the data used to prepare inventories of air pollutants pursuant to Directive (EU) 2016/2284, for the year X-2 and for the air pollutants CO, SO_2, NO_x, and NMVOCs. Directive (EU) 2016/2284 has not yet been incorporated into the EEA Agreement, and thus Iceland is not reporting according to that directive. However, as these checks are useful in terms of QA/QC, Iceland performed similar checks with the data reported under the CLRTAP.

Reported data on air pollutants was generally consistent with data reported under CLRTAP for SO_2 and NO_x, and each of these pollutants was under the required reported threshold of ±5% required by Article 15 of Regulation (EU) 2020/1208. However, CO and NMVOCs were above this threshold, and since two of these four pollutants exceeded the threshold, Iceland decided to report information of all four air pollutants in accordance with the format set out in Annex XIII to Regulation (EU) 2020/1208. CO had an absolute difference of 7.5 kt of CO (or 6.7%) with more CO being reported in the GHG inventory than in the inventory submitted to CLRTAP. NMVOCs had an absolute difference of 0.29 kt of NMVOCs (or 5.3%), with more NMVOCs being reported under CLRTAP than in the GHG inventory. The reason for these differences is that different methodologies are used for calculating emissions from the Domestic Aviation and International Aviation sectors. Emissions for the GHG inventory are calculated by using fuel sales, while emissions for CLRTAP are calculated using country-specific landing and take-off data.

Checks performed on the consistency of the emissions reported in the GHG inventory, for the year x-2, with the energy data reported pursuant to Regulation (EC) 1099/2008

In these checks, apparent consumption reported in the GHG inventory under the Reference Approach of the Energy sector, are compared with apparent consumption as reported under Regulation (EC) 1099/2008. Since the only data available to the inventory team for the Reference Approach is the dataset reported under Regulation (EC) 1099/2008, there is no difference between the two. The relevant annexes are reported separately to the ESA and to the EU.

1.5.5 Planned Improvements for QA/QC Activities

The configuration of roles and responsibilities mentioned in Section 1.5.2 above is still being developed, as well as the QC procedures mentioned above.

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

1.6 Uncertainty Analysis

The uncertainty analysis is based on the Approach 1 – error propagation of the 2006 IPCC Guidelines (Vol.1, Chapter 3, Table 3.2). The uncertainties of activity data are collected from data providers or evaluated based on expert judgements. The uncertainties of default emission factors are derived from the values proposed in the 2006 IPCC Guidelines or the 2019 EMEP/EEA Guidebook. The error propagation is used to estimate the uncertainty for each category, the inventory as a whole and the latest inventory year compared to the base year.

The complete uncertainty analysis is reported in Annex 2: Assessment of Uncertainty, with Table A2.1 reporting the uncertainties including LULUCF and Table A2.2 excluding LULUCF.

The results of the uncertainty estimation are summarised here below:

Table 1.5 Uncertainties 2021

	With LULUCF		Without LULUCF	
	Uncertainty 2021 [%]	Trend [%]	Uncertainty 2021 [%]	Trend [%]
CO_2	21.1%	15.0%	1.6%	2.5%
CH_4	58.6%	9.6%	3.3%	4.8%
N_2O	1.7%	0.6%	5.3%	2.7%
HFCs	0.6%	0.0%	1.9%	0.0%
PFCs	0.10%	0.43%	0.29%	1.93%
SF_6	0.009%	0.010%	0.027%	0.037%
Total GHG	**62.4%**	**17.8%**	**6.7%**	**6.4%**

The total inventory uncertainty is 62.4% and the trend uncertainty estimate for this submission is 17.8%. When excluding LULUCF the total inventory uncertainty is 6.7% and the trend uncertainty is 6.4% as can be seen in Table 1.5.

1.7 General Assessment of Completeness

The emissions reported in this inventory cover all activities within Iceland's jurisdiction. In the case of temporal coverage, CRF tables are reported for the whole time series from 1990 to 2020. Regarding sectoral coverage, all sources considered to be above the threshold of significance[15] are reported.

[15] As per paragraph 37(b) of annex I ("Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories") to Decisions 24/CP.19, an emission is considered insignificant if the likely level of emissions is below 0.05 per cent of the national total GHG emissions (without LULUCF).

2 Trends in Greenhouse Gases

This chapter presents the trends in GHG emissions and removals. GHG are compiled under five main sectors. Emissions which are calculated but excluded from the national totals are included as memo items. These sectors are defined as:

- ***Energy***: Emissions from fuel combustion dominated by carbon dioxide (CO_2) released from the conversion of carbon in fuel to CO_2 and generation of heat. The Energy sector also includes emissions of methane (CH_4) and other carbon rich volatile organic compounds associated with fugitive emissions from fuel production and storage. In many countries, this sector is dominated by big fossil fuel users including Electricity Generation and Road Transport. This is, however, somewhat different in Iceland due to most electricity being produced by hydroelectric and geothermal sources, and the Energy sector is dominated by Road Transport and the fishing industry.

- ***Industrial Processes and Product Use (IPPU)***: Non-fuel related emissions from industrial processes and use of products with global warming impacts. This is dominated by CO_2 and sometimes nitrous oxide (N_2O) emissions from large industrial process biproducts (such as converting limestone and dolomite to cement (CO_2), or hydrocarbons to base chemicals (CO_2, CH_4 and N_2O)). Emissions also occur as a result of the consumption of the use of fluorinated substitutes for Ozone Depleting Substances (ODS), otherwise referred to as "F-gases," from air conditioning and refrigeration, and sulphur hexafluoride (SF_6) from electrical equipment.

- ***Agriculture***: Non-energy use emissions from livestock and crop production. This category can be broadly split into emissions from livestock and emissions from agricultural soils. The main sources of emissions from livestock are from gases released from animals (enteric fermentation), a digestive process in herbivores which emits CH_4, and from the management of animal manure which contains and emits CH_4 and N_2O. The methods of storage and treatment of manure impacts the quantity of CH_4 and N_2O emitted. The application of organic manure and synthetic fertiliser to land results in both direct and indirect N_2O from soils. Finally, liming and the application of carbon-containing fertilisers releases CO_2. It is worth mentioning that emissions from fuel consumption in machinery used in agriculture, such as tractors for instance, are not reported in this chapter; they are reported in the Energy sector.

- ***Land Use, Land-Use Change, and Forestry (LULUCF)***: Emissions and removals from land use. This sector focuses on the different carbon pools; living biomass, dead organic matter divided into litter and deadwood, soil organic matter, and harvested wood products. Removals occur through carbon sequestration driven mostly by revegetation and afforestation activities, whereas emissions are dominated by land-management practices such as the drainage of mineral and organic soils. Land is categorised into one of six land uses; Forest Land, Cropland, Grassland, Wetland, Settlements, and Other Land.

- ***Waste***: Non-energy use emissions associated with the management of solid and liquid waste. Emissions from waste are split into four main categories; Solid Waste Disposal, Biological Treatment of Solid Waste, Incineration and Open Burning of Waste, and Wastewater Treatment and Discharge. The main gases emitted are CH_4 through the anaerobic (absence of oxygen) decomposition of solid or liquid waste, N_2O from the oxygenation of protein rich compounds (e.g., foods) in the waste streams and CO_2 from incineration of fossil-based waste materials (e.g., plastic). CH_4 is emitted in solid waste disposal sites where organic matter decays over a period of many years, at a declining rate. Anaerobic conditions in wastewater treatment also produce CH_4. The biological treatment of waste, such as composting, also results in CH_4 emissions (from anaerobic decomposition) and N_2O emissions from oxidation of nitrogen rich materials (e.g., protein). Incineration and open burning of fossil-based wastes (e.g., increasingly plastics) are the most important sources of CO_2 emissions from waste incineration activities.

- ***Memo:*** Emissions which are not included in the national totals in accordance with international reporting agreements, include International Navigation, International Aviation, and CO_2 from biomass (bio-CO_2).

2.1 Emission Trends Overview

GHGs that, according to Annex A of the Kyoto Protocol as modified by the Doha Amendment[16], have to be considered in national GHG inventories, are:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6)
- Nitrogen fluoride (NF_3)

Iceland reports emissions of CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6. No emissions of NF_3 occur in Iceland; there are no imports and no industries potentially using NF_3 (e.g., semiconductors, LCD manufacture, solar panels, and chemical lasers) present.

Total amounts of GHGs emitted in Iceland during the period from 1990 to the most recent inventory year are presented in the following figures and tables, expressed in terms of contribution by gas and sector in kt CO_2 equivalents (CO_2e).

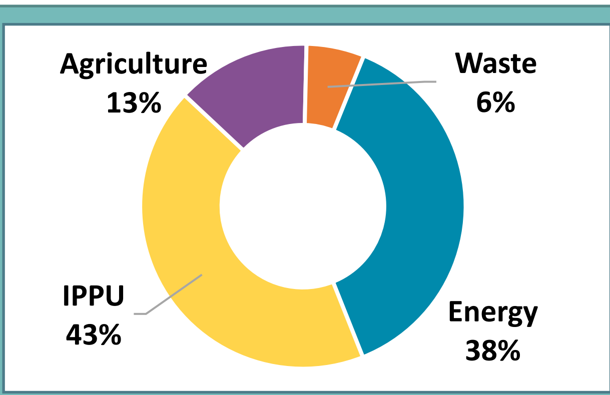
Iceland also reports precursor and indirect GHG emissions; this includes:

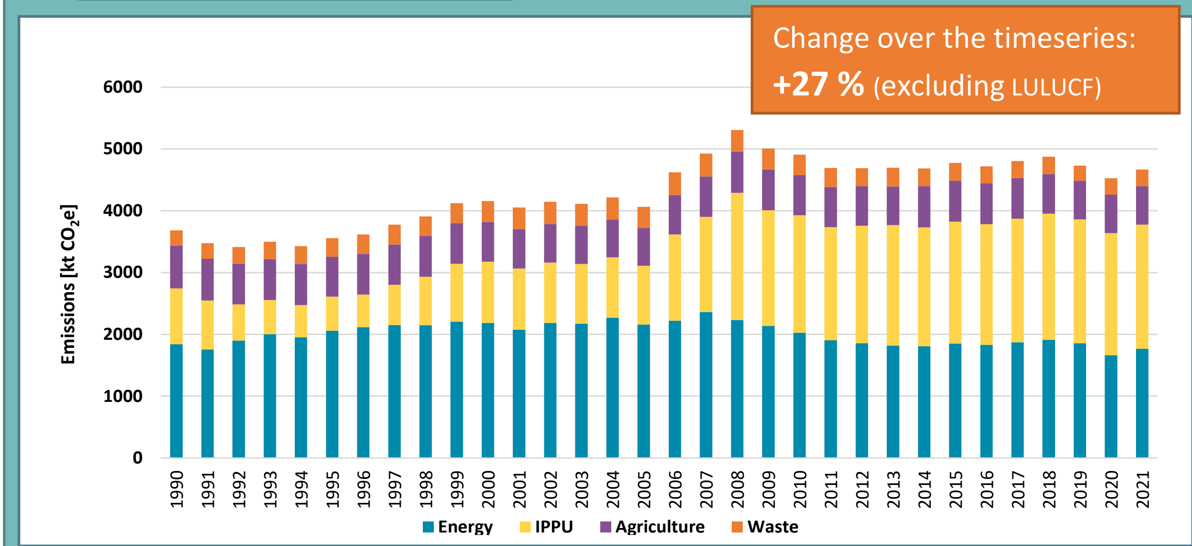
- Nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) which contribute to the formation of the GHG ozone; and
- Sulphur dioxide (SO_2) and Ammonia (NH_3) which affects climate by increasing the level of aerosols that in turn have a cooling effect on the atmosphere.

The emission trends for precursors and indirect GHGs are presented separately in Section 2.2.

[16] https://unfccc.int/process/the-kyoto-protocol/the-doha-amendment

In the most recent inventory year, the Industrial Processes sector was the largest contributor of GHG emissions in Iceland (without LULUCF), followed by Energy, Agriculture, and Waste.

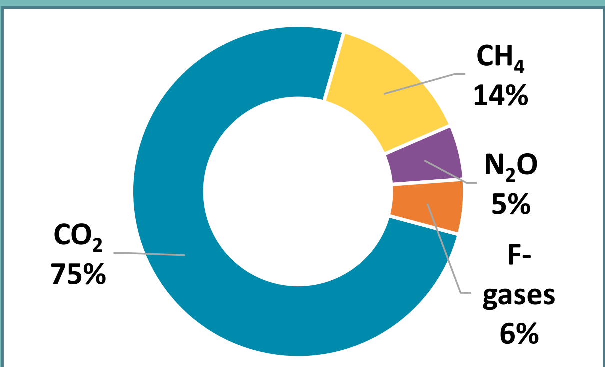




By the middle of the 1990s, economic growth started to gain momentum in Iceland. The main driver behind increased emissions since 1990 is the expansion of the metal production sector:

- There was one aluminium plant in 1990
- Second aluminium plant opened in 1998
- Third aluminium plant opened in 2007

The contribution of IPPU to total emissions (without LULUCF) has more than doubled over the time series, overtaking emissions from the Energy sector in 2012.



Total GHG emissions (excluding LULUCF) increased by approximately a third since 1990, mostly due to the expansion of the metal production industry. Emissions from the energy sector are dominated by fuel combustion in road transport and fishing, whereas the emissions due to electricity production and district heating are relatively small and almost exclusively linked to CO_2 emissions from geothermal power plants.

Figure 2.1 Overview of GHG emissions (without LULUCF), from top to bottom: (1) emission by sector for the latest year (2) emission by sector over the time series and (3) emissions by gas for the latest year. CO_2e values calculated using GWP from AR5.

Overall Trend

Since 1990, Iceland's total GHG emissions have increased by more than a quarter (excluding LULUCF). This trend of increasing emissions is dominated by:

- The expansion of the metal production sector, in particular the aluminium sector;
- Increases in emissions from geothermal energy utilisation due to an increase in electricity production, which increased 18-fold between 1990 and 2019; and
- The Road Transport sector CO_2 emissions almost doubling since 1990 due to increases in population, number of cars per capita, more mileage driven, and an increase in the share of larger vehicles; these changes can partly be attributed to a significant increase in the number of tourists in Iceland in the last 10 years.

In contrast, annual emissions have seen an overall decline since 1990 from commercial fishing, with GHG emissions reducing by approximately a quarter over the time series. Emissions from both domestic flights and navigation have also declined since 1990.

Emissions During 1990-1999

Total emissions show a slight decrease between 1990 and 1994, except for 1993. From 1995-1999, total emissions increased slightly.

By the middle of the 1990s, economic growth started to gain momentum in Iceland. The main driver behind increased emissions since 1990 is the expansion of the metal production sector. In 1990, 87,839 tonnes of aluminium were produced in one aluminium plant in Iceland. A second aluminium plant was established in 1998 and a third one in 2007.

Emissions during 2000-2007

Emissions plateaued from 2000 to 2005, but increased more rapidly between 2005 and 2007.

The overall increasing trend of GHG emissions until 2005 was counteracted to some extent by decreased emissions of PFCs, which was caused by improved technology and process control in the aluminium industry. Increased emissions due to an increase in production capacity of the aluminium industry (since 2006) led to a trend of overall increase in GHG emissions between 2006 and 2008, when emissions from the aluminium sector peaked.

Until 2007, Iceland experienced one of the highest GDP growth rates among OECD countries. A knock-off effect of the increased levels of economic growth until 2007 was an increase in construction, especially residential building in the capital area. The construction of a large hydropower plant (*Kárahnjúkar*, built from 2002 to 2007) led to a further increase in emissions in Iceland.

Emissions During 2008-2011

Between 2008 and 2011, annual emissions steadily decreased.

In the autumn of 2008, Iceland was hit by an economic crisis when three of the largest banks collapsed. The blow was particularly hard owing to the large size of the banking sector in relation to the overall economy as the sector's worth was about ten times the annual GDP of Iceland. The crisis resulted in a serious contraction of the economy followed by an increase in unemployment, a depreciation of the currency, the Icelandic Króna (ISK), and a drastic increase in external debt. Private consumption contracted by 20% between 2007 and 2010. Emissions of GHGs decreased from most sectors between 2008 and 2011.

Emissions from fuel combustion in the transport and construction sectors decreased each year between 2008 and 2011 because of the economic crisis. In 2015, the emissions were slightly higher than in 2011, yet still approximately 20% below the peak in 2007.

Emissions Since 2011

Emissions have been increasing steadily since 2011, with the exception of 2016 which saw a slight decrease.

By 2021, Aluminium Production was almost tenfold compared to 1990. Parallel investments in increased power capacity were needed to accommodate for this increase. The size of these investments is large compared to the size of Iceland's economy. In 2021, total emissions from the aluminium sector were 13% lower than in 2008 due to improved technology and process control.

Table 2.1 Emissions of GHG by sector in Iceland for the reported time series [kt CO_2e, calculated using GWP from AR5]

Sector	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '20-'21
1 Energy	1,841	2,057	2,185	2,158	2,027	1,854	1,664	1,767	-4.0%	+6.2%
2 Industrial Processes	903	553	992	950	1,899	1,970	1,975	2,007	+122%	+1.6%
3 Agriculture	695	643	641	611	646	659	617	620	-10.8%	+0.5%
4 Land Use, Land-Use Change, and Forestry	9,610	9,587	9,604	9,635	9,596	9,506	9,421	9,398	-2.2%	-0.2%
5 Waste	244	301	336	340	334	289	266	268	+10.2%	+1.3%
Total without LULUCF	**3,682**	**3,555**	**4,154**	**4,059**	**4,906**	**4,773**	**4,521**	**4,662**	**+27%**	**+3.1%**
Total with LULUCF	**13,292**	**13,142**	**13,758**	**13,695**	**14,503**	**14,279**	**13,942**	**14,060**	**+5.8%**	**+0.8%**
International bunkers (memo items)	249	241	465	426	380	828	341	539	+116%	+58%

As shown in Table 2.2, the largest contributor by far to total GHG emissions without LULUCF is CO_2, followed by CH_4, N_2O, and fluorinated gases (PFCs, HFCs, and SF_6). Over the time series, emissions of CO_2 have increased the most, and PFCs and N_2O emissions have decreased significantly.

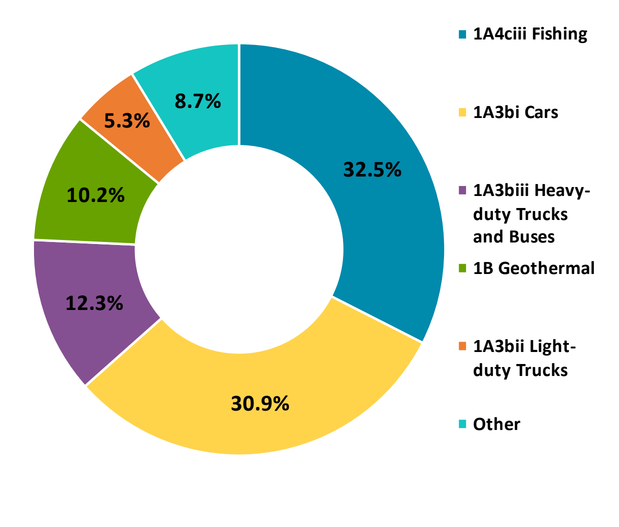
Table 2.2 Emissions of GHG gases by gas for the reported time series (without LULUCF) [kt CO_2e, calculated using GWP from AR5]

GHG	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '20-'21	% Total in latest year
CO_2	2,223	2,469	2,933	2,978	3,627	3,544	3,340	3,510	+58%	+5.1%	+75%
CH_4	718	732	755	735	755	715	652	654	-8.9%	+0.3%	+14%
N_2O	295	287	287	259	254	258	245	249	-16%	+1.7%	+5.3%
PFCs	445	62	135	28	154	93	86	89	-80%	+3.5%	+1.9%
HFCs	0.3	3.1	43	57	110	161	196	157	+50,036%	-20%	+3.4%
SF_6	1.1	1.3	1.4	2.6	4.8	1.6	3.3	3.0	+163%	-8.5%	+0.1%
Total	**3,682**	**3,555**	**4,154**	**4,059**	**4,906**	**4,773**	**4,521**	**4,662**	**+27%**	**+3.1%**	**+100%**

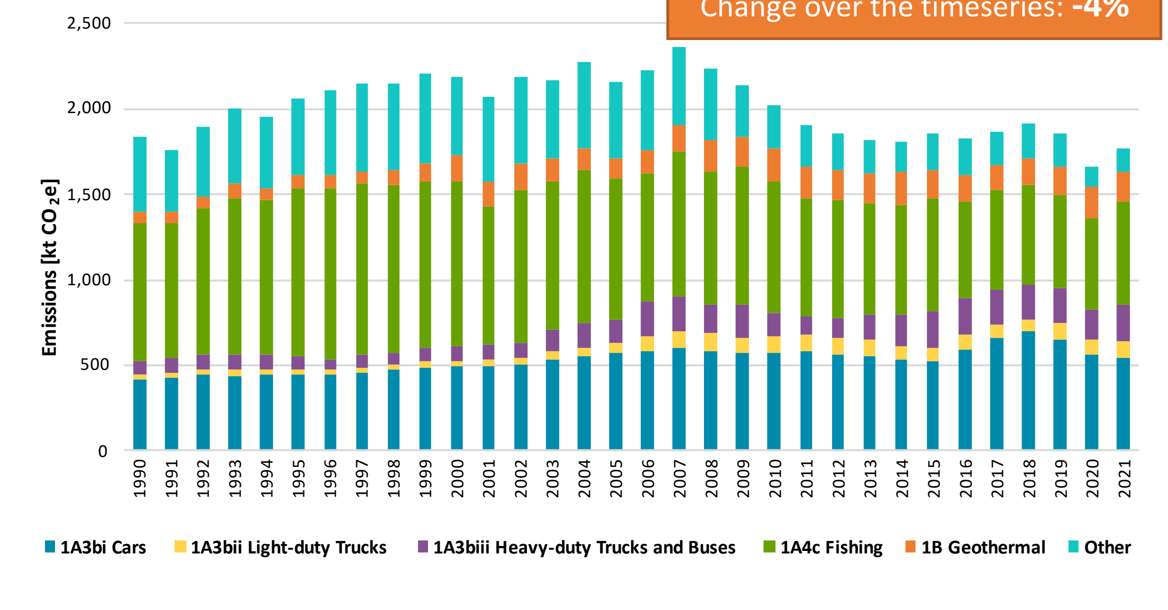
2.1.1 Energy (CRF Sector 1)

Iceland ranks first among OECD countries in the per capita consumption of primary energy. However, the proportion of domestic renewable energy in the total energy budget is approx. 85%, which is a much higher share than in most other countries, with close to 100% of the energy demand covered by hydro-, geothermal, and wind power. The cool climate and sparse population have high energy and transportation needs. Together with Road Transport, fishing industry dominate emissions of the Energy sector.

38% of total emissions (excluding LULUCF)



Change over the timeseries: **-4%**



The Energy sector is dominated by CO_2 emissions from Road Transport and the fishing industry. CO_2 emissions from geothermal energy exploitation have increased since 1990 with the opening of new geothermal power plants. CO_2 sequestration projects are ongoing to capture CO_2 emissions from geothermal plants and mineralise it underground for permanent storage.

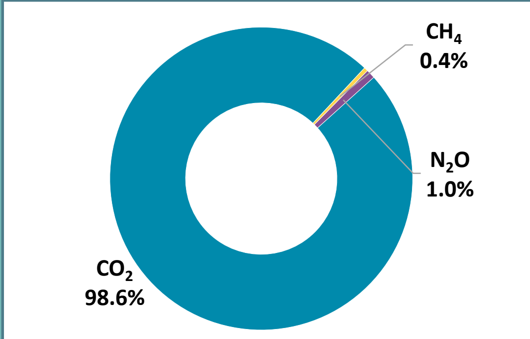


Figure 2.2 Overview of emissions from the Energy sector, from top to bottom: (1) emission by subsector for the latest year, (2) emission by subsector over the time series and (3) emissions by gas for the latest year. CO_2e values calculated using GWP from AR5.

Key export industries such as Fisheries and Metal Production are energy intensive. The metal 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 (30% of electricity) and on hydropower for electricity production (70% of the electricity).

The development of the energy sources in Iceland can be divided into three phases:

1) The electrification of the country and harnessing the most accessible geothermal fields, mainly for space heating.
2) Harnessing the resources for power-intensive industry. This began in 1966 with agreements on the building of an aluminium plant, and in 1979 a ferrosilicon plant began production.
3) Following the oil crisis of 1973-1974, efforts were made to use domestic sources of energy to replace oil, particularly for space heating and fishmeal production. Oil has almost disappeared as a source of energy for space heating in Iceland, and domestic energy has replaced oil in industry and in other fields where such replacement is feasible and economically viable.

The emission trends are discussed in more detail below by subsector. These are categorised into fuel combustion, which covers all direct emissions from oxidation of fuel for generating heat or mechanical work to a process, and geothermal and fugitive emissions, which covers emissions from the extraction, transformation, and transportation of primary energy carriers. Emissions from Transport have significantly increased since 1990, whilst emissions from Energy Industries, Fishing and Manufacturing Industries, and Construction have decreased, as can be seen in Table 2.3. The causes of these emission trends are discussed below.

Electricity and Heat Production

The Energy sector includes emissions from electricity and heat production. Iceland relies heavily on renewable energy sources for electricity and heat production, thus emissions from this sector are very low (accounting for just >1% of the sector's total emissions for the whole timeseries). The sources of emissions from electricity and heat production are:

- ***Electricity produced with fuel combustion*** occurs at two locations (two islands, Flatey and Grímsey), which are located far from the distribution system.
- ***Backup systems*** in some electricity facilities using fuel combustion to be used if problems occur in the distribution system.
- ***Electric boilers*** to produce heat from electricity are used at some district heating facilities which lack access to geothermal energy sources. They depend on curtailable energy. These heat plants have back-up fuel combustion in case of an electricity shortage or problems in the distribution system.

Emissions from the Energy Industry sector have generally decreased since 1990. In 1995, there were issues in the electricity distribution system (snow avalanches in the Westfjords region (*Vestfirðir*) and icing in the northern part of the country) that resulted in higher emissions that year. Unusual weather conditions during the winter of 1997/1998 led to unfavourable water conditions for the hydropower plants. This created a shortage of electricity which was met by burning oil for electricity and heat production. In 2007, a new aluminium plant was established. Due to the delay of the *Kárahnjúkar* hydropower project, the aluminium plant was initially supplied with electricity from the distribution system. This led to electricity shortages for the district heating systems and industry depending on curtailable energy, leading to increased fuel combustion and emissions.

Manufacturing Industries and Construction

Increased emissions from the Manufacturing Industries and Construction source categories over the period 1990-2007 are explained by the increased activity in the Construction sector during the period. The knock-off effect of the increased levels of economic growth was increased activity in the Construction sector. Emissions rose until 2007, where the rise, particularly in the years prior to 2007, was related to the construction of Iceland's largest hydropower plant (*Kárahnjúkar*, built 2002-2007). The Construction sector collapsed in autumn of 2008 due to an unprecedented national economic crisis, and thus the emissions from the sector decreased by over half between 2007 and 2011. Emissions from fuel combustion at the cement plant decreased rapidly due to the collapse of the Construction sector, and in 2011 the plant closed. The Fishmeal industry is the second most important source within Manufacturing Industries and Construction. Emissions from Fishmeal Production decreased over the period due to replacement of oil with electricity, as well as a drop in production.

Transport

Emissions from the Transport sector have increased by over half across the time series. The largest increase in emissions is from Road Transport, owing to substantial increases the national population, the number of cars per capita, total mileage driven, the number of larger vehicles (at least until 2007), and tourism, all of which have increased the vehicle fleet significantly since 1990. Emissions from Road Transport peaked in 2018 after a decreasing trend from the previous 2007 peak, which has been followed by a rise in road emissions since 2012. In recent years, there has been a significant increase in the number of fuel-efficient and electric vehicles; a reversal of the trend from 2002-2007 when large, fuel-inefficient vehicles were imported. New registrations of electric vehicles and plug-in hybrids have been increasing rapidly since 2014. Emissions from both Domestic Aviation and Navigation have declined since 1990. This decrease in Navigation and Aviation has compensated for rising emissions in the Transport sector to some extent.

Fishing

Fisheries dominate the Other sector (1A4). Emissions from fisheries rose from 1990-1996 because a substantial portion of the fishing fleet was operating in unusually distant fishing grounds. From 1996, the emissions have generally been decreasing and reached levels below those of 1990 in 2011. Emissions remain below 1990 levels, however there are large annual variations due to the inherent nature of fisheries.

Geothermal Energy

Emissions from geothermal energy have accounted for 3-8% of the total annual GHG emissions (excluding LULUCF) in Iceland since 2015. Iceland relies heavily on geothermal energy for space heating (over 90% of the homes) and electricity production (approximately 30% of the total electricity production in recent years). Table 2.3 shows the emissions from geothermal energy from 1990-2021. Electricity production using geothermal power increased approximately 20-fold during this period resulting in an increase in emissions. Emissions from geothermal utilisation are site- and time-specific and exhibit significant variations between different wells and well sites, as well as by the time of extraction.

Distribution of Oil Products

Emissions from distribution of oil products are a minor source in Iceland (>1 kt CO_2e). There are no other transportation emissions in Iceland and no coal, oil, or gas production emissions.

Memo Items

Emissions from International Aviation and marine bunker fuels are excluded from national totals as outlined in the IPCC Guidelines. These emissions are presented separately for information purposes, but are included in Table 2.3. GHG emissions from marine and aviation bunkers have more than quadrupled since 1990, mostly due to increased tourism in recent years.

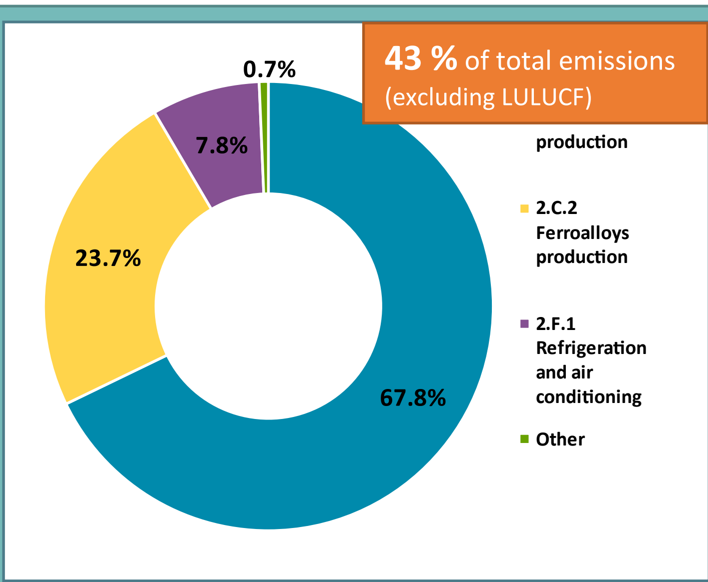
CO_2 emissions from biomass are also reported as Memo Items and are excluded from national totals. These emissions have been reported since 2003 and have been rapidly increasing over recent years due to increase in the use of biofuels.

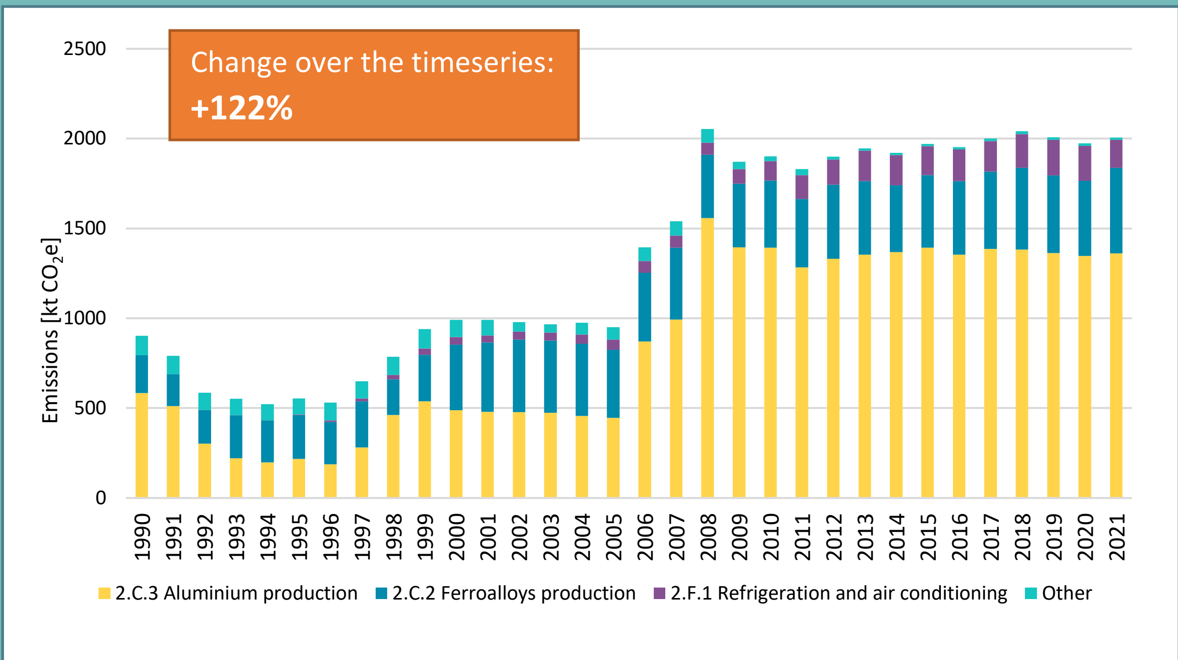
Table 2.3 Total GHG emissions from the Energy sector for the reported time series [kt CO_2e]. CO_2e values calculated using GWP from AR5.

Energy Sector	1990	1995	2000	2005	2010	2015	2020	2021	Change '90-'21	Change '20-'21
1A1 Energy Industries	14	15	6.5	3.4	8.6	4.2	1.8	2.6	-81%	+44%
1A2 Manufacturing Industries	302	295	330	298	138	117	54	77	-75%	+41%
1A3 Transport	621	655	696	866	895	895	883	901	+45%	+2.0%
1A3a Domestic Aviation	34	30	28	26	21	21	13	21	-38%	+58%
1A3b Road Transport	531	558	616	775	814	827	831	860	+62%	+3.5%
1A3d Domestic Navigation	33	38	13	23	35	27	25	18	-47%	-30%
1A4 Other Sectors (Fishing)	842	1,007	993	841	775	669	544	604	-28%	+11%
1A4a Commercial/ Institutional	8.1	7.8	6.7	4.9	1.7	2.1	1.6	1.7	-78%	+6.5%
1A4b Residential Stationary	28	22	21	13	8.5	5.9	6.7	5.2	-81%	-22%
1A4c Fishing	806	977	965	823	765	661	536	597	-26%	+11%
1A5 Other	0.1	1.6	4.6	29	14	0.2	0.4	2.5	+1,978%	+599%
1B2 Fugitive Emissions from Fuels (incl. Geothermal Energy	62	83	155	120	195	168	180	180	+190%	+0.3%
1B2d Geothermal	62	82	154	119	195	168	179	180	+192%	+0.3%
Total Emissions	**1,841**	**2,057**	**2,185**	**2,158**	**2,027**	**1,854**	**1,664**	**1,767**	**-4.0%**	**+6.2%**
International Aviation (Memo)	221	238	410	424	380	679	263	415	+88%	+58%
International Navigation (Memo)	28	3.4	54	1.8	0.3	149	78	124	+341%	+59%
CO_2 from Biomass (memo)	NO	3.9	5.1	5.9	7.3	43	64	89	-	+39%

2.1.2 Industrial Processes and Product Use (CRF sector 2)

The emissions in this sector fall mostly under the EU emission trading system (EU ETS), where the main sub-sectors in Iceland are Aluminium and Ferroalloy production. The availability of renewable energy in Iceland like hydropower leads to lower GHG emissions per ton of metal produced compared to the use of fossil fuels for energy generation.





Large part of the GHG emissions is in the form of CO_2 as a result of the oxidation of carbon-based reductants (coal, coke) used in metal production. F-gases in the form of PFCs are also formed during aluminium production, explaining part of the total F-gas emissions, while the rest can be assigned to Refrigeration and Air Conditioning, Electrical Equipment, and Metered Dose Inhalers.

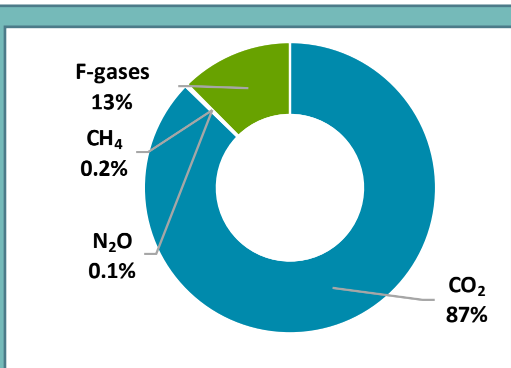


Figure 2.3 Overview of emissions from the IPPU sector, from top to bottom: (1) emission by subsector for the latest year, (2) emission by subsector over the time series and (3) emissions by gas for the latest year. CO_2e values calculated using GWP from AR5.

The Industrial Processes and Product Use (IPPU) sector is the sector largest contributor to national GHG emissions after LULUCF (when removals are included). The emissions from this sector are dominated by CO_2, hydrofluorocarbons (HFCs) and perfluorocarbon (PFC). HFCs are used as substitutes for ozone depleting substances (ODS) in refrigeration systems. Perfluorocarbon emissions in Iceland come mostly from the aluminium industry (tetrafluoromethane, CF_4, and hexafluoroethane, C_2F_6), and to a small extent from refrigeration equipment (hexafluoroethane (C_2F_6) commercially known as PFC116, and octafluoropropane (C_3F_8), commercially known as PFC-218.

Emissions from IPPU have increased over the time series primarily due to the expansion of energy-intensive industry, primarily from metal production (aluminium smelting and ferroalloy production), see Table 2.4. Metal production accounts for approximately 90% of the IPPU sector emissions in recent years:

Aluminium Production is the main source within the metal production category, accounting for the majority of total Industrial Processes emissions across the time series. Aluminium is produced at three plants. The production technology in all aluminium plants is based on using centre worked prebaked anode cells. The main energy source is electricity, and industrial process CO_2 emissions are mainly due to the anodes that are consumed during electrolysis. In addition, the production of aluminium gives rise to emissions of PFCs. Due to the expansion of the existing aluminium plant in 1997 and the establishment of a second aluminium plant in 1998, emissions increased from 1997 to 1999. From 2000, the emissions showed a steady downward trend until 2005. The PFC reduction was achieved through improved technology and process control and led to a 98% decrease in the amount of PFC emitted per tonne of aluminium produced during the period of 1990 to 2005. In 2006, the PFC emissions rose significantly due to an expansion of one smelter, but PFC emissions per tonne of aluminium decreased from 2007 to 2011 through improved process technology. The third aluminium plant was established in 2007 and reached full production capacity in 2008. PFC emissions per tonne of aluminium are generally high during start up and usually rise during expansion. PFC emission declined in 2009 and 2010 through improved process technology until December 2010 at the third smelter, when a rectifier was damaged in fire. This led to increased PFC emissions leading to higher emissions at the plant in 2010 than in 2009. Since 2010 the average PFC emissions for all three aluminium smelters is around 0.1 t CO_2e/t Al produced.

Ferroalloy Production accounts for approximately a fifth of Industrial Processes emissions. CO_2 is emitted due to the use of coal and coke as reducing agents and from the consumption of electrodes and other carbon-containing additives (carbon blocks, electrode casings and limestone). In 1998 a power shortage caused a temporary closure of the ferrosilicon plant, resulting in exceptionally low emissions that year. In 1999, however, the plant was expanded (addition of the third furnace) and emissions have therefore increased considerably since 1990. In late 2016, a silicon metal plant opened, which contributed slightly to the increase in emissions from this subsector for 2017. The new plant ceased operations in mid-2017, but another silicon plant started its operations in May 2018.

Mineral Production emissions have significantly decreased since 1990. Cement production was the dominant contributor until 2011 when the sole cement plant shut down. CO_2 derived from carbon in the shellsand used as raw material is the source of CO_2 emissions from cement production. Emissions from the cement industry reached a peak in 2000 but declined until 2003, partly because of cement imports. In 2004 to 2007 emissions increased again because of increased activity related to the construction of the *Kárahnjúkar* hydropower plant (built 2002 to 2007) although most of the cement used for the project was imported.

Emissions from the ***chemical industry*** ceased in 2005. The production of fertilisers, which used to be the main contributor to process emissions from the chemical industry was closed in 2001. No chemical industry has been in operation in Iceland after the closure of a diatomite (silica) production facility in 2004.

Imports of HFCs (***F-gases***) started in 1993 and have increased steadily until 2018. In 2019 a tax scheme was established, putting a tax on the import of F-gases according to their global warming potential. Since 2019 the import has been decreasing. No HFC/PFCs were routinely used for refrigeration before 1993 and the only HFCs reported before then is HFC-134 in Metered Dose Inhalers, therefore the increase since 1990 is very large. Refrigeration and air conditioning are the main uses of HFCs in Iceland, and the fishing industry plays a preeminent role. HFCs stored in refrigeration units constitute banks of refrigerants which emit HFCs during use due to leakage. Very minor amounts of PFCs are used in certain refrigerant blends, and the PFC emissions from refrigeration and air conditioning is on the order of a few tens of tons of CO_2e.

The sole source of SF_6 emissions is leakage from electrical equipment such as gas insulated switchgear. Emissions have been increasing since 1990 due to the expansion of the Icelandic electricity distribution. The peak in leakage in 2010 was caused by two unrelated accidents during which the SF_6 contained in equipment leaked into the atmosphere. The peak in 2018 was due to equipment breakdown that caused leakage.

The use of ***solvents*** and products containing solvents (CRF sector 2D3) leads to emissions of non-methane volatile organic compounds (NMVOC), which are regarded as indirect GHGs as the NMVOC compounds are oxidised to CO_2 in the atmosphere over time. These CO_2 emissions are also included in this inventory.

Also included in the IPPU sector are emissions of N_2O from medical and other uses and emissions of CO_2 from lubricants and paraffin wax use. ***Other sources*** of emissions included in the Icelandic inventory are CH_4 and N_2O emissions from tobacco, as well as GHG and precursor emissions from firework use. Historically, Industrial Processes has been an important source of N_2O, but emissions have been significantly reduced since the shutdown of the fertiliser plant in 2001.

Table 2.4 GHG emissions from Industrial Processes and Product Use for the reported time series [kt CO_2e, calculated using GWP from AR5].

Industry Sector	1990	1995	2000	2005	2010	2015	2020	2021	Change '90- '21	Change '20- '21
2A Mineral Products	52	38	65	55	10	0.7	0.9	0.9	-98%	+4.0%
2B Chemical Industry	42	36	16	-	-	-	-	-	NA	NA
2C Metal Production	795	462	853	825	1,764	1,797	1,766	1,837	131%	+4.0%
2D Non-energy Products from Fuels and Solvent Use	7.2	7.9	7.8	7.4	5.7	6.2	6.3	6.5	-9.2%	+3.7%
2F Product Uses as Substitutes for Ozone Depleting Substances	0.3	3.1	43	57	110	161	196	157	+50,056%	-20%
2G Other Product Manufacture and Use	6.6	5.3	5.8	6.1	8.3	4.6	5.8	4.9	-26%	+16%
Total Emissions	**903**	**553**	**992**	**950**	**1,899**	**1,970**	**1,975**	**2,007**	**+122%**	**+1.6%**

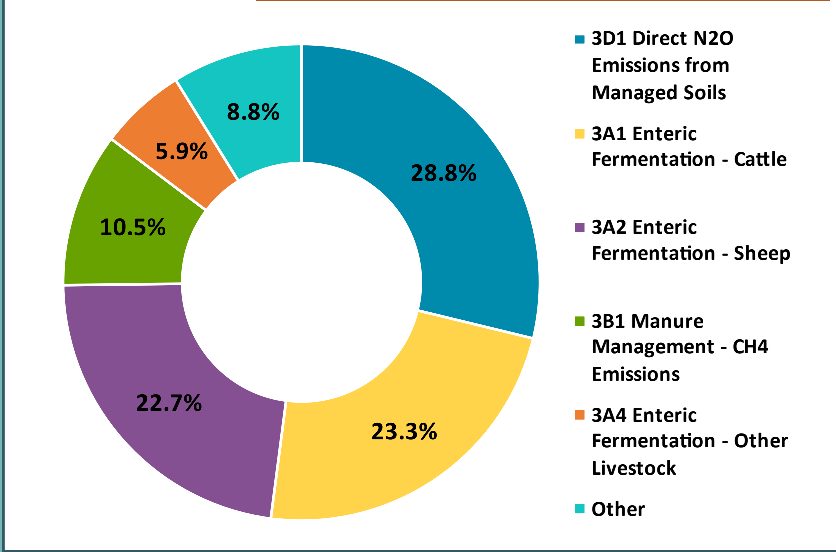
Table 2.5 Total HFC, PFC and SF_6 emissions from F-gas consumption [kt CO_2e, calculated using GWP from AR5].

GHG	1990	1995	2000	2005	2010	2015	2020	2021	Change '90- '21	Change '20- '21
HFCs	0.31	3.2	43	57	110	161	196	157	50,036%	-20%
PFCs	445	62	135	28	154	93	86	89	-80%	+3.5%
SF_6	1.1	1.3	1.4	2.6	4.8	1.6	3.3	3.0	163%	-8.5%

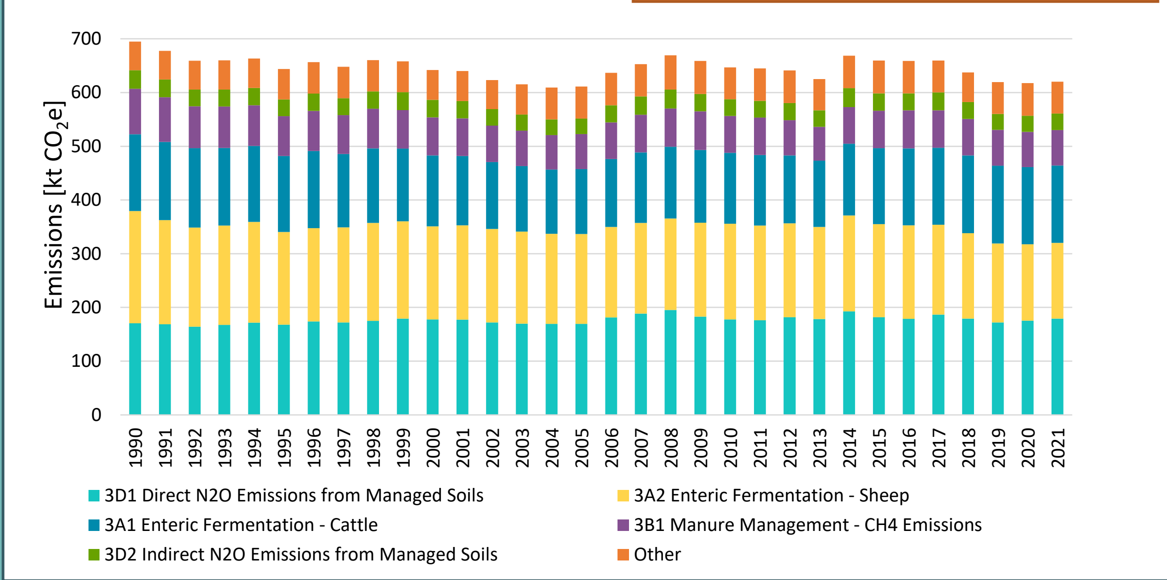
2.1.3 Agriculture (CRF sector 3)

13% of total emissions (excluding LULUCF)

Emissions are dominated by agricultural soils and enteric fermentation across the time series. Approximately 90% of emissions from enteric fermentation are caused by the two biggest livestock categories: Sheep and Cattle



Change over the timeseries: **-11%**



Enteric fermentation is the main source of CH_4. Agriculture is the main source of N_2O emissions which are generated from agricultural soils and manure management.

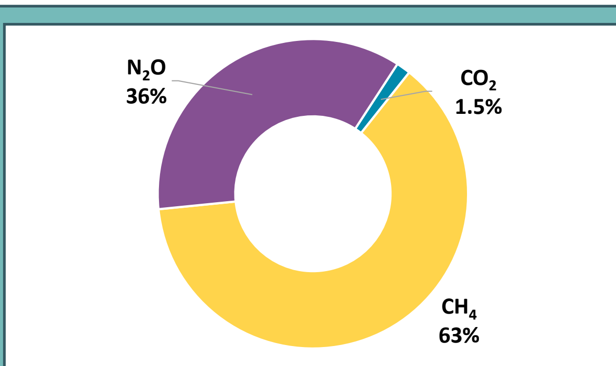


Figure 2.4 Overview of emissions from the Agriculture sector, from top to bottom: (1) emission by subsector for the latest year, (2) emission by subsector over the time series and (3) emissions by gas for the latest year. CO_2e values calculated using GWP from AR5.

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, e.g., dairy cattle, sheep, horses, and goats, which are of an ancient Nordic origin, one breed for each species. These animals are generally smaller than the breeds common elsewhere in Europe. Beef production, however, is partly through imported breeds, as is most poultry and all pork production. There is not much arable crop production in Iceland, due to a cold climate and short growing season. Cropland in Iceland consists mainly of cultivated hayfields, but potatoes, barley, beets, and carrots are grown on limited acreage. Emissions from agriculture are closely coupled with livestock population sizes, especially cattle and sheep. Another factor that has a considerable impact on emission estimates is the amount of nitrogen in fertiliser applied annually to agricultural soils. A decrease in livestock population size of sheep between 1990 and 2005 was partly counteracted by increases of livestock population sizes of horses, swine, and poultry, but led to overall emission decreases and resulted in a decrease of total agriculture emissions during the same period (Figure 2.4 and Table 2.6).

In 2005-2018 increased fertiliser use lead to higher emissions from agriculture. However, sharp decrease in sheep livestock numbers since 2016 and slight decrease in fertiliser use since 2018 have led to decreased emissions again. The emissions from Agriculture have though stayed relatively stable since 1992, hence, it is difficult to state whether the resent decrease in emissions will continue or not.

Table 2.6 GHG emissions from Agriculture sector for the reported time series [kt CO_2e, calculated using GWP from AR5].

Agriculture Sector	1990	1995	2000	2005	2010	2015	2020	2021	Change '90- '21	Change '20- '21
3A Enteric Fermentation	391	356	345	329	352	357	325	323	-17%	-0.6%
3B Manure Management	99	86	83	77	81	83	77	77	-22%	+0.5%
3D Agricultural Soils	205	199	210	198	209	214	206	210	+2.8%	+2.0%
3G Liming	0.5	0.0001	0.04	4.1	1.9	3.3	5.3	5.8	1,149%	+9.6%
3H Urea Application	-	-	-	-	-	0.01	1.67	1.48	NA	-11%
3I Other Carbon-containing Fertilisers	-	2.4	2.8	2.1	2.3	2.1	1.9	1.9	NA	+3.0%
Total Emissions	**695**	**643**	**641**	**611**	**646**	**659**	**617**	**620**	**-10.8%**	**+0.5%**

2.1.4 Land Use, Land-use Change, and Forestry (LULUCF, CRF sector 4)

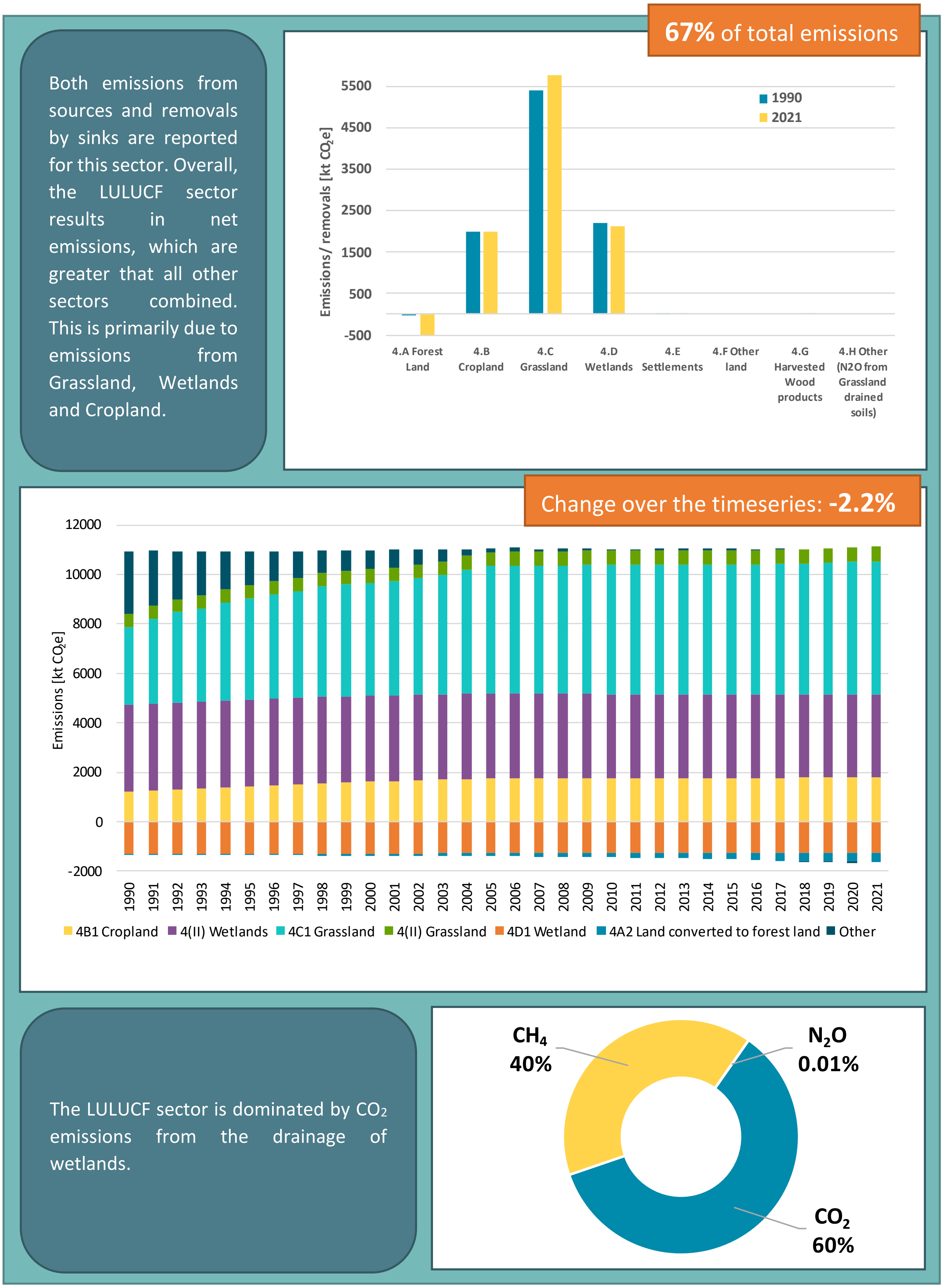


Figure 2.5 Overview of emissions and removals from the LULUCF sector, from top to bottom: (1) absolute emission and removals by subsector for the latest year, (2) emission and removals by subsector over the time series and (3) absolute emissions and removals by gas for the latest year. CO_2e values calculated using GWP from AR5.

Net emissions (emissions – removals) in the LULUCF sector have slightly decreased over the time period. Emission increase from Grassland is explained by drainage of wetland, converting Wetlands to Grassland, which is somewhat counterbalanced within the category by increased removals through revegetation. Increase in wetland drainage decreases the area of wetland and consequently the emissions. The increased removals through afforestation are explained by increased activity in the category and changes in forest growth with stand age. The area of Cropland organic soils is estimated through the time series available. The time series and conversion period applied to these new subcategories are constructed on ratio calculations between the total area of Cropland, Cropland Active, and Cropland Inactive (Fallow) areas emerged from the new map layers through the IGLUD process and then subtracting the ratio of Land Converted to Cropland areas also emerged from the new map layers through the IGLUD process (see chapter 6.6 Cropland (CRF 4B)). Therefore, despite the slight reduction in the total area of cultivated areas, the areas related to organic soils have an increasing trend which, consequently, also explains the small increasing trend of emissions from the Cropland category detected in 2023 Submission.

Analyses of trends in emissions of the LULUCF sector must be interpreted with care as some potential sinks and sources are not included. Uncertainty estimates for reported emissions are considerable and observed changes in reported emissions therefore not necessarily significantly different from zero.

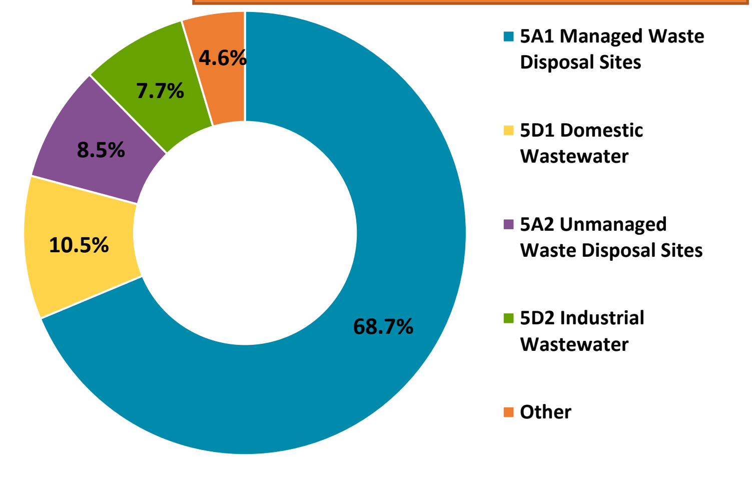
Table 2.7 GHG emissions and removals from the LULUCF sector for the reported time series [kt CO_2e, calculated using GWP from AR5].

LULUCF Sector	1990	1995	2000	2005	2010	2015	2020	2021	Change '90- '21	Change '20- '21
4.A Forest Land	-29	-53	-89	-140	-293	-398	-493	-509	+1,639%	+3.3%
4.B Cropland	1,991	1,993	1,994	1,996	1,998	2,001	2,003	2,003	+0.6%	+0.02%
4.C Grassland	5,420	5,415	5,486	5,589	5,747	5,769	5,776	5,774	+6.5%	-0.04%
4.D Wetlands	2,206	2,211	2,195	2,172	2,140	2,131	2,121	2,121	-3.8%	+0.01%
4.E Settlements	22	22	18	18	3.7	3.7	14	8.8	-60%	-37%
4.F Other Land	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4.G Harvested Wood Products	NO,NA	NO,NA	0.003	0.003	-0.033	-0.038	-0.041	-0.014	NA	-65.3%
Total Emissions	**9,610**	**9,587**	**9,604**	**9,635**	**9,596**	**9,506**	**9,421**	**9,398**	**-2.2%**	**-0.2%**

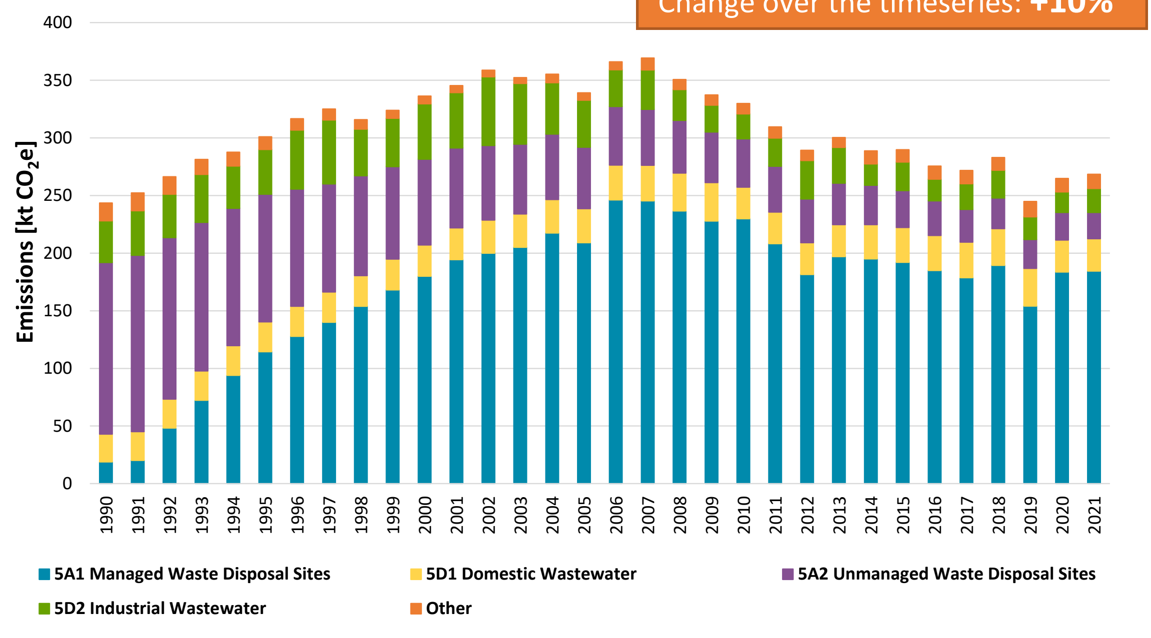
2.1.5 Waste (CRF sector 5)

Emissions from the Waste sector show a parabolic shape increasing from 1990 to 2007 and then decreasing to reach similar levels as were in 1990. Emissions are dominated by Solid Waste Disposal and Wastewater Treatment.

6% of total emissions (excluding LULUCF)



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



Emissions from the Waste sector are dominated by CH_4 emissions from Solid Waste Disposal and Wastewater Treatment and Discharge.

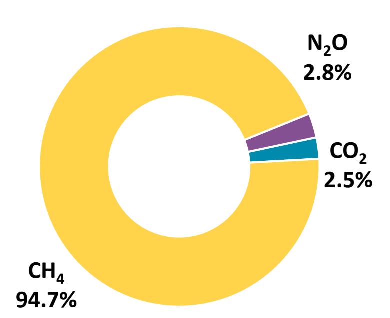


Figure 2.6 Overview of emissions from the Waste sector, from top to bottom: (1) emission by subsector for the latest year, (2) emission by subsector over the time series and (3) emissions by gas for the latest year. CO_2e values calculated using GWP from AR5.

The majority of emissions from the Waste sector are CH_4 emissions from Solid Waste Disposal. The remaining emissions arose from Wastewater Treatment and Discharge, Waste Incineration, and Biological Treatment of Waste, e.g., Composting. The trend in Waste emissions is dominated by:

An increase in ***Solid Waste Disposal (SWD)*** emissions between 1990 and 2006 was caused by the accumulation of degradable organic carbon in recently established managed, anaerobic solid waste disposal sites which are characterised by higher methane production potential than the unmanaged SWDS they succeeded. The decrease in emissions from the waste sector since 2006 is caused by a decrease in SWD emissions which is due to a rapidly decreasing share of waste landfilled since 2004 and by an increase in methane recovery at SWDS.

Emissions from ***Composting*** have been steadily increasing from 1995 when composting started. Improved collection of organic waste leads to a rapid increase of the emissions in recent years.

The significant decrease in emissions from ***Incineration and Open Burning of Waste*** from 1990 is due to a decrease in the amount of waste incinerated and a change in waste incineration technology. During the early 1990s waste was either burned in open pits or in waste incinerators at low or varying temperatures. Since the mid-1990s increasing amounts of waste are incinerated in proper waste incinerators that control combustion temperatures which lead to lower emissions per waste amount incinerated. From 2011 only one incineration plant has been in operation in Iceland.

Wastewater Treatment and Discharge emissions have decreased slightly since 1990. Emissions from Domestic Wastewater have increased due to an increase in population. Industrial Wastewater emissions are based on amount of fish processed in Iceland, and there are some annual fluctuations which cause changes in emissions.

Table 2.8 GHG emissions from the Waste sector for the reported time series [kt CO_2e, calculated using GWP from AR5].

Waste Sector	1990	1995	2000	2005	2010	2015	2020	2021	Changes '90-'21	Changes '20-'21
5A Solid Waste Disposal	168	225	254	263	272	224	208	207	+24%	-0.2%
5B Biological Treatment of Solid Waste	NO	0.4	0.4	0.9	2.7	3.7	5.6	5.5	NA	-1.9%
5C Incineration and Open Burning of Waste	15.6	10.7	6.3	5.6	6.7	7.6	7.0	6.9	-55%	-0.5%
5D Wastewater Treatment and Discharge	60	65	75	71	53	54	46	49	-19%	+7.3%
Total Emissions	**244**	**301**	**336**	**340**	**334**	**289**	**266**	**268**	**+10.2%**	**+1.1%**

2.2 Emission Trends for Ozone Precursors and Indirect Greenhouse Gases

Nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) in the atmosphere can lead to the formation of the greenhouse gas Ozone (O_3). Sulphur dioxide (SO_2) and Ammonia (NH_3) affect climate by increasing the level of aerosols that have in turn a cooling effect on the atmosphere. Data presented here, and submitted to the UNFCCC, is in accordance with guidelines for reporting air pollutants under the CLRTAP[17]. The emissions presented in this section are from the energy, IPPU, agriculture and waste sectors as no indirect emissions from the LULUCF sector have been compiled to date.

2.2.1 Nitrogen Oxides (NO_x)

The main source of NO_x in Iceland is the Energy sector, as can be seen in Figure 2.7. The main contributors to this sector are commercial fishing and transport, followed by manufacturing industries and construction. In industrial processes, the main NO_x source is ferroalloys production.

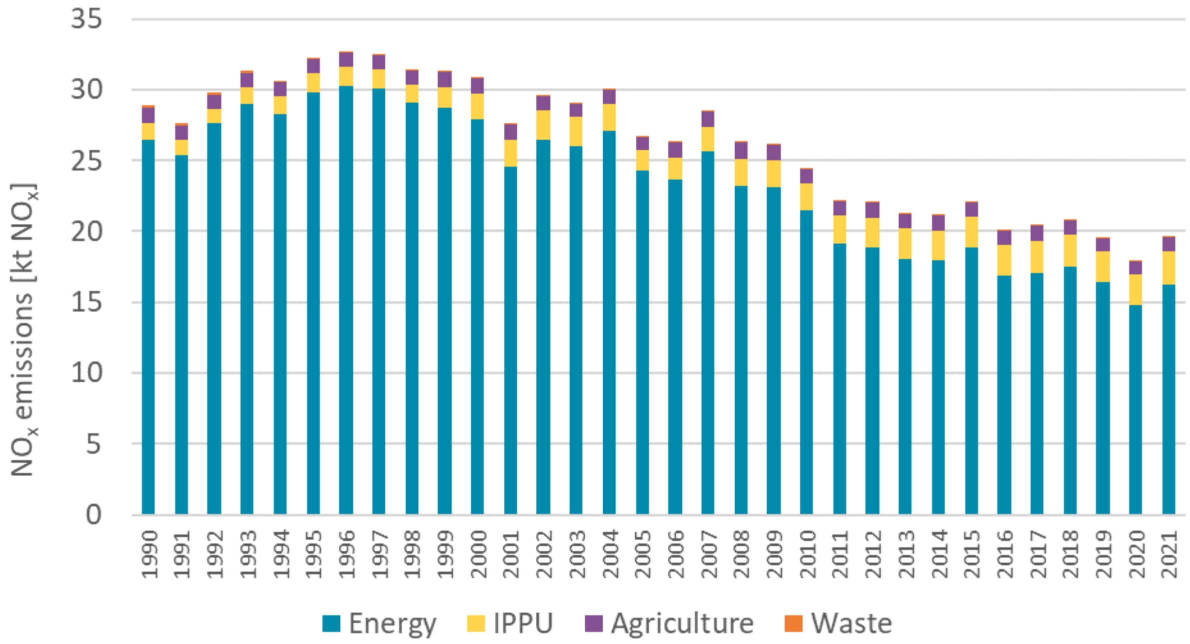


Figure 2.7 Emissions of NOx by sector for the reported time series [kt].

2.2.2 Non-Methane Volatile Organic Compounds (NMVOC)

The main sources of NMVOCs are the Industrial processes, followed by Agriculture and the Energy sector, as can be seen in Figure 2.8. In the energy sector, NMVOC emissions are dominated by road transport. These emissions decreased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995. In Industrial processes, NMVOC are mostly emitted in various solvent uses, as well as in food and beverage production. In the Agriculture sector, manure management is the greatest source of NMVOC. The total emissions have been showing a general downward trend since 1990.

[17] Convention on Long-Range Transboundary Air Pollution, find out more at: https://www.ceip.at/

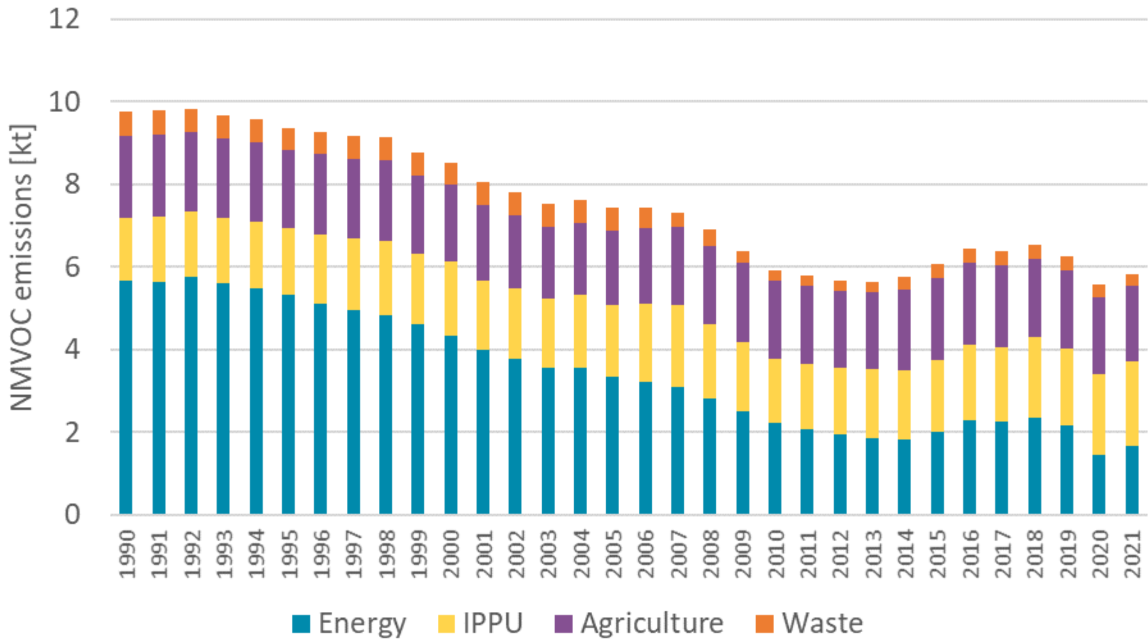


Figure 2.8 Emissions of NMVOC by sector for the reported time series [kt].

2.2.3 Carbon Monoxide (CO)

Industrial Processes are the most prominent contributors to CO emissions in Iceland, as can be seen in Figure 2.9. Within industrial processes, almost all the CO emissions are due to primary Aluminium production. It is worth mentioning that emissions from road transport have decreased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995. Total CO emissions have almost doubled since 1990.

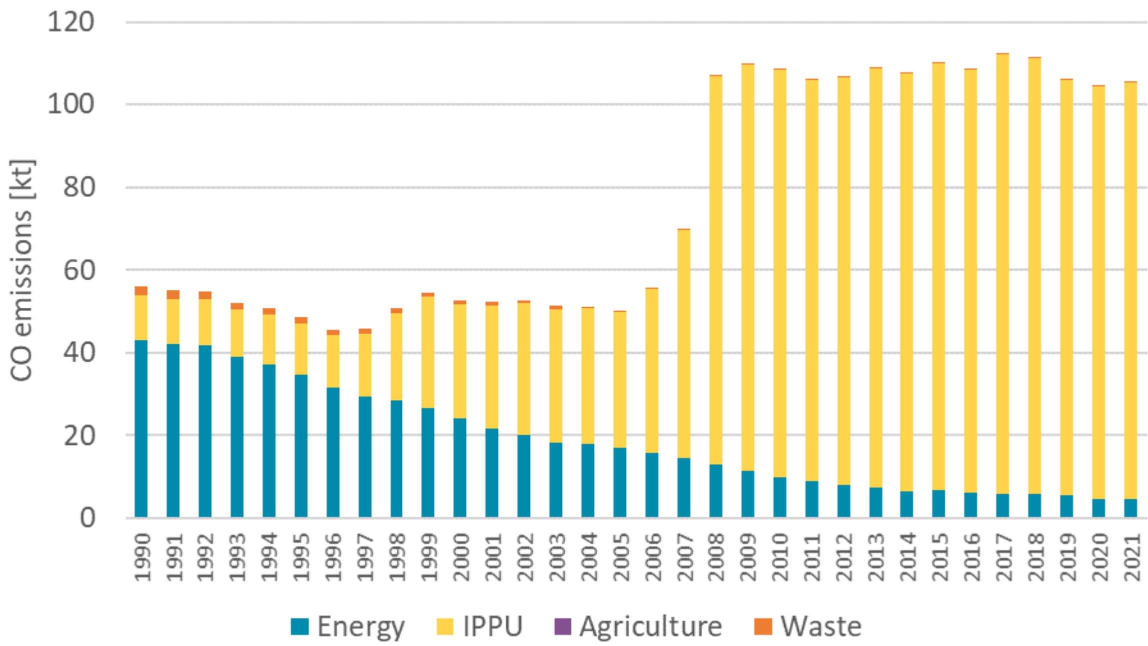


Figure 2.9 Emissions of CO by sector for the reported time series [kt].

2.2.4 Sulphur Dioxide (SO_2)

Geothermal energy exploitation is by far the largest source of SO_2 emissions in Iceland. Sulphur emitted from geothermal power plants is in the form of hydrogen sulphide and is reported here in kt SO_2-equivalents. Emissions have doubled since 1990 due to an increase in electricity production at geothermal power plants. Other significant sources of SO_2 in Iceland are industrial processes, as can be seen in Figure 2.10.

Emissions from industrial processes are dominated by metal production. Until 1996 industrial process sulphur dioxide emissions were relatively stable. Since then, the metal industry has expanded, leading to an increase in SO_2 emissions. The fishmeal industry is the main contributor to SO_2 emissions from fuel combustion in the sector Manufacturing Industries and Construction. Emissions from the fishmeal industry increased from 1990 to 1997 but have declined since as fuel has been replaced with electricity and production has decreased.

SO_2 from the fishing fleet depend upon the use of residual fuel oil. When fuel prices rise, the use of residual fuel oil rises and the use of gas oil drops. This leads to higher sulphur emissions as the sulphur content of residual fuel oil is significantly higher than in gas oil. The rising fuel prices since 2008 have led to higher SO_2 emissions from the commercial fishing fleet in recent years. As a result of this, emissions have decreased at a lower rate compared to fuel consumption.

Across the time series, annual SO_2 emissions in Iceland have more than doubled.

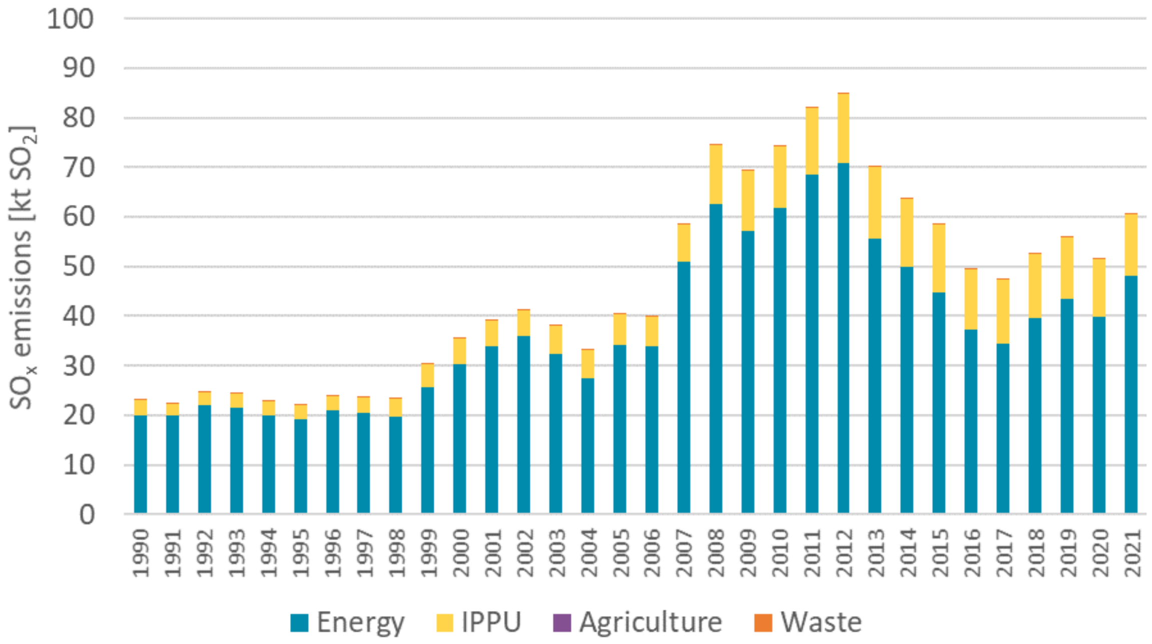


Figure 2.10 Emissions of SO_2 by sector for the reported time series [kt SO_2].

2.2.5 Ammonia (NH_3)

The main source of NH_3 is the agriculture sector. Most emissions come from manure - animal manure applied to soils, manure management and manure deposition of grazing animals on pastures. Emissions have been fluctuating between 4 and 5 kt NH_3 since 1990, see Figure 2.11. The trend in NH_3 emissions is relatively steady which is driven by relatively little overall variability in livestock numbers.

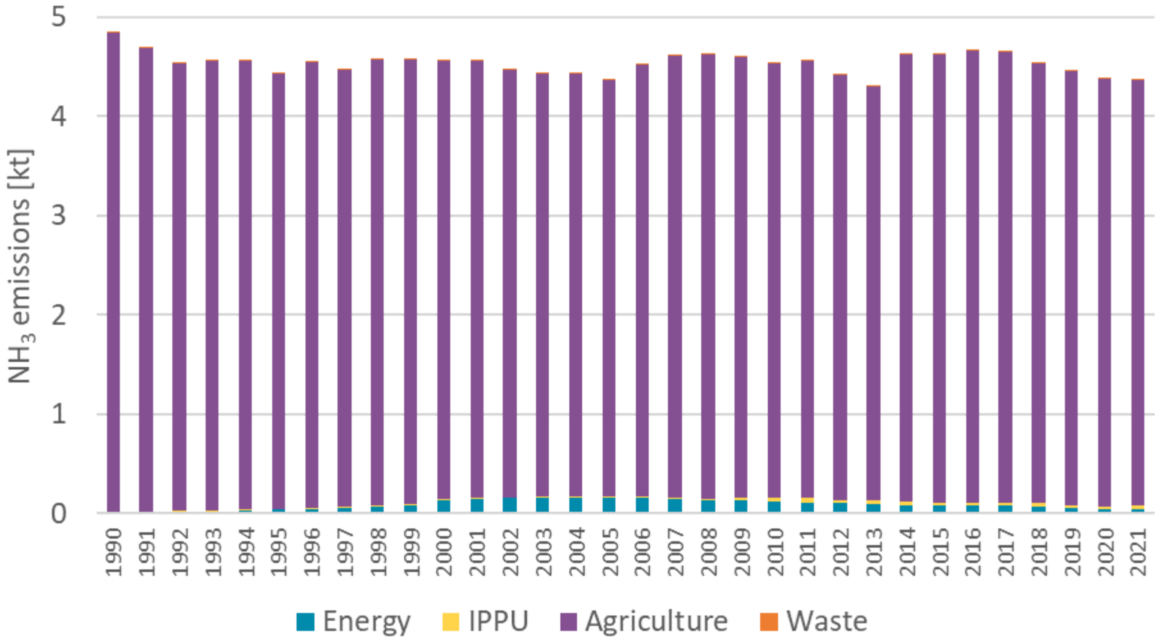


Figure 2.11 Emissions of NH_3 by sector for the reported time series [kt].

3 Energy (CRF sector 1)

3.1 Overview

The Energy sector contains all emissions from fuel combustion, energy production, and distribution of fuels.

The Energy sector is reported under four main chapters:

- Stationary Combustion (CRF 1A1, 1A2, 1A4 and 1A5)
- Transport and Other Mobile Sources (CRF 1A2, 1A3, and 1A4)
- Fugitive Emissions Including Geothermal Energy Production (CRF 1B)
- Reference Approach, Feedstocks, and Non-energy Use of Fuels (CRF 1AB, 1AC, and 1AD)

3.1.1 Methodology

Emissions from fuel combustion activities are estimated at the sector level based on methodologies suggested by the 2006 IPCC Guidelines. They are calculated by multiplying energy use by source and sector with pollutant-specific emission factors. In all calculations, the oxidation factor was set to the default value of 1. Emissions from Road Transport are estimated using COPERT 5.6.1. which uses a Tier 3 methodology to estimate N_2O and CH_4 emissions, and a Tier 2 methodology to estimate CO_2 emissions. A more detailed description can be found in Chapter 3.3.3 Road Transport (CRF 1A3b). Information of tier methodology for each subsector can be seen in Table 3.1.

Table 3.1 Methodological information for all estimated subsectors in Energy.

Sources	Methodology		
1A Fuel Combustion Activities	CO_2	CH_4	N_2O
1. Energy Industries			
a. Public Electricity and Heat Production	T2, T1	T1	T1
2. Manufacturing Industries and Construction			
a. Iron and Steel	T2, T1	T1	T1
b. Non-Ferrous Metals	T2, T1	T1	T1
c. Chemicals	T1	T1	T1
e. Food Processing, Beverages, and Tobacco	T2, T1	T1	T1
f. Non-Metallic Minerals	T2, T1	T1	T1
g. Transport Equipment	T2	T1	T1
3. Transport			
a. Domestic Aviation	T1	T1	T1
b.i. Cars	T2	T3	T3
b.ii. Light-duty Trucks	T2	T3	T3
b.iii. Heavy-duty Trucks and Buses	T2	T3	T3
b.iv. Motorcycles	T2	T3	T3
d. Water-borne Navigation	T2, T1	T1	T1
e. Other Transportation	T2, T1	T1	T1
4. Other Sectors			
a. Commercial/Institutional	T2, T1	T1	T1
b. Residential	T2, T1	T1	T1
ci. Agriculture/Forestry/Fishing - Stationary	T1	T1	T1
cii. Agriculture/Forestry/Fishing - Off-road vehicles	T2	T1	T1

Sources 1A Fuel Combustion Activities	Methodology CO_2	CH_4	N_2O
ci. Agriculture/Forestry/Fishing - Fishing	T2, T1	T1	T1
5. Non-specified Elsewhere			
a. Stationary	T2, T1	T1	T1
1B Fugitive Emissions			
2. Oil and Natural Gas and Other Emissions from Energy Production			
a5. Oil – Distribution of Oil Products	T1	T1	NA
d. Other – Geothermal Energy	T2	T2	NA
1D Memo Items			
1. International Bunkers			
a. International Aviation	T1	T1	T1
b. International Navigation	T2, T1	T1	T1
3. CO_2 Emissions from Biomass	T1	T1	T1

3.1.2 Key Category Analysis

The key categories for 1990, 2021, and the 1990-2021 trend in the Energy sector are shown in Table 3.2 (compared to total emissions without LULUCF):

Table 3.2 Key category analysis for the Energy sector.

IPCC Source Category		Gas	Level 1990	Level 2021	Trend
Energy (CRF sector 1)					
1A2	Fuel combustion - Manufacturing Industries and Construction	CO_2	✓	✓	✓
1A3a	Domestic Aviation	CO_2	✓		
1A3b	Road Transportation	CO_2	✓	✓	✓
1A3d	Domestic Navigation	CO_2	✓		✓
1A3e	Other Mobile Machinery	CO_2	✓		✓
1A4b	Residential Combustion	CO_2	✓		✓
1A4c	Agriculture/Forestry/Fishing	CO_2	✓	✓	✓
1B2d	Fugitive Emissions from Fuels - Other (Geothermal)	CO_2	✓	✓	✓

3.1.3 Completeness

Table 3.3 gives an overview of the IPCC source categories included in this chapter and presents the status of emission estimates from all sub-sources in the Energy sector.

Table 3.3 Energy - Completeness (E: estimated, NA: not applicable, NO: not occurring)

Sources 1A Fuel Combustion Activities	CO_2	CH_4	N_2O	Notes
1. Energy Industries				
a. Public Electricity and Heat Production	E	E	E	
b. Petroleum Refining	NO	NO	NO	
c. Manufacture of Solid Fuels and Other Energy Industries	NO	NO	NO	
2. Manufacturing Industries and Construction				
a. Iron and Steel	E	E	E	
b. Non-Ferrous Metals	E	E	E	
c. Chemicals	E	E	E	NO since 2004
d. Pulp, Paper, and Print	NO	NO	NO	
e. Food Processing, Beverages, and Tobacco	E	E	E	

Sources 1A Fuel Combustion Activities	CO_2	CH_4	N_2O	Notes
f. Non-Metallic Minerals	E	E	E	
g. Transport Equipment	E	E	E	
3. Transport				
a. Domestic Aviation	E	E	E	
b.i. Cars	E	E	E	
b.ii. Light Duty Trucks	E	E	E	
b.iii. Heavy Duty Trucks and Buses	E	E	E	
b.iv. Motorcycles	E	E	E	
b.v. Other	NO	NO	NO	
c. Railways	NO	NO	NO	
d. Water-borne Navigation	E	E	E	
e. Other Transportation	E	E	E	
4. Other Sectors				
a. Commercial/Institutional	E	E	E	
b. Residential	E	E	E	
ci. Agriculture/Forestry/Fishing - Stationary	E	E	E	
cii. Agriculture/Forestry/Fishing - Off-road vehicles	E	E	E	
ci. Agriculture/Forestry/Fishing - Fishing	E	E	E	
5. Non-specified Elsewhere				
a. Stationary	E	E	E	
b. Mobile	NO	NO	NO	
1B Fugitive Emissions				
1. Solid Fuels				
a. Coal Mining and Handling	NO	NO	NO	
b. Solid Fuels Transformation	NO	NO	NO	
c. Other	NO	NO	NO	

Sources	CO_2	CH_4	N_2O	Notes
2. Oil and Natural Gas and Other Emissions from Energy Production				
a5. Oil – Distribution of Oil Products	E	E	NA	All other subsectors of 1B2a are NO
b. Natural Gas	NO	NO	NO	
c. Venting and Flaring	NO	NO	NO	
d. Other – Geothermal Energy	E	E	NO	
1C CO_2 Transport and Storage				
1. Transport of CO_2	NO	NO	NO	
2. Injections and Storage	NO	NO	NO	
3. Other	NO	NO	NO	
1D Memo Items				
1. International Bunkers				
a. International Aviation	E	E	E	
b. International Navigation	E	E	E	
2. Multilateral Operations	NO	NO	NO	
3. CO_2 Emissions from Biomass	E	E	E	
4. CO_2 Captured	NO	NO	NO	

3.1.4 Source Specific QA/QC Procedures

General QA/QC activities performed for the Energy sector are listed in Chapter 1.5. Further sector-specific activities include:

- Identification and documentation discrepancies between the sectoral approach and the reference approach.
- Cross-checks with data from the National Energy Authority (*Orkustofnun*) (NEA) with total input data in calculations files to ensure that all fuels are accounted for.
- Monthly meetings with the NEA are held in order to address discrepancies between energy statistics and data used in the inventory. Activity data for the whole time series is checked and the attribution between IPCC subsectors is discussed.

3.1.5 Planned Improvements

Several improvements are planned for the next submission:

- Increased collaboration with the Icelandic Transport Authority (*Samgöngustofa*) (ITA) to streamline data transfer to the Environment Agency of Iceland (*Umhverfisstofnun*) (EAI).
- It is planned to investigate the availability of more refined data on fleet composition/engine types in order to move to a higher tier for estimating emissions from the navigation and fishing subsectors.
- It is planned to send the Energy chapter for review by national stakeholders.

3.1.6 Activity Data

Activity data is provided by the NEA, which collects data from the oil companies on fuel sales by sector. For the 2020 submission, a comprehensive review was performed on how the fuel sales data from the NEA is attributed to IPCC sectors. For that submission, the review only included 2003-2018 because the methodology used to collect the data by the NEA changed between 2002 and 2003. In the 2021 Submission, the same attribution of fuels to IPCC categories for 1990-2002 was performed with a review of the sales statistics. Consequently, the whole time series has been reviewed and methodologies harmonised from 1990 and onwards.

The aim of the review of the fuel sales data from the NEA was to make the adjustments from the sales statistics to the IPCC categories more transparent. This is what was done for each IPCC 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 IPCC 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. 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 results 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.

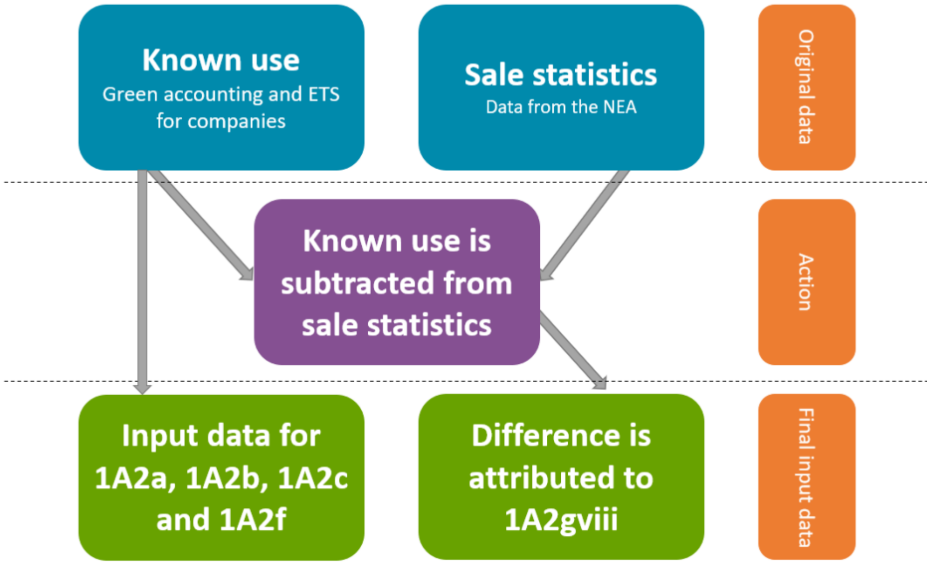


Figure 3.1 Description of adjustments in input data for IPCC category 1A2.

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

3.1.7 Emissions Factors

For most categories in the Energy sector, default emission factors from the 2006 IPCC guidelines are used for emission calculations, except for gas/diesel oil where country-specific emission factors are used. These emission factors for stationary combustion can be seen in Table 3.4. Emission factors for mobile combustion are shown in the chapters for each subsector as they vary.

Table 3.4 Emission factors used for calculations emissions from Stationary Combustion.

Fuel / Factor	Value	Unit	Reference
			Gas/Diesel Oil
NCV	42.9	TJ/kt	Country Specific from 2017, based on annual measurements
C-content	20.1	t/TJ	Country Specific from 2017, based on annual measurements
CH_4 emission factor	3.0	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2
N_2O emission factor	0.60	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2
			Residual Fuel Oil
NCV	40.4	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	21.1	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	3.0	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2
N_2O emission factor	0.60	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2
			Biomethane
NCV	50.4	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	14.9	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	1.0	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2
N_2O emission factor	0.10	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2
			Biodiesel
NCV	27.0	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	19.3	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	3.0	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2

Fuel / Factor	Value	Unit	Reference
N_2O emission factor	0.60	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2
Waste			
NCV	10.0	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1 (Municipal Wastes (non-biomass fraction))
C-content	-	-	Annual fluctuations between years based on composition of waste
CH_4 emission factor	237.0	kg/kt MSW	Table 5.3 p.5.20, Chapter 5 in Volume 5 of the 2006 IPCC Guidelines
N_2O emission factor	60.0	g/t MSW waste	Table 5.6 p.5.22, Chapter 5 in Volume 5 of the 2006 IPCC Guidelines
LPG			
NCV	47.3	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	17.2	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	1.0	kg/TJ	Table 2.3 2006 IPCC Guidelines, V2, Ch2
N_2O emission factor	0.10	kg/TJ	Table 2.3 2006 IPCC Guidelines, V2, Ch2
Waste Oil			
NCV	40.2	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	20.0	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	30.0	kg/TJ	Table 2.3 2006 IPCC Guidelines, V2, Ch2
N_2O emission factor	4.0	kg/TJ	Table 2.3 2006 IPCC Guidelines, V2, Ch2
Petroleum Coke			
NCV	32.5	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	26.6	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	3.0	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2
N_2O emission factor	0.60	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2
Other Bituminous Coal			
NCV	25.8	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	25.8	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	10.0	kg/TJ	Table 2.3 2006 IPCC Guidelines, V2, Ch2
N_2O emission factor	1.5	kg/TJ	Table 2.3 2006 IPCC Guidelines, V2, Ch2
Charcoal			
NCV	29.5	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	112	t/TJ	Table 2.5 2006 IPCC Guidelines, V2, Ch2
CH_4 emission factor	200	kg/TJ	Table 2.5 2006 IPCC Guidelines, V2, Ch2
N_2O emission factor	1.0	kg/TJ	Table 2.5 2006 IPCC Guidelines, V2, Ch2

3.2 Stationary Combustion (CRF 1A1, 1A2, 1A4, and 1A5)

3.2.1 Energy Industries (CRF 1A1ai and 1A1aiii)

Iceland has used renewable energy sources extensively for electricity and heat production for decades, and the emissions from energy industries are therefore lower than those of most other countries, which utilise a higher share of fossil fuels. It should be noted that only approximately 0.01% of the electricity in Iceland is produced with fuel combustion and less than 5% of buildings in Iceland are heated with fossil fuels.

1A1ai: Electricity Generation: Electricity is produced from hydropower, geothermal energy, fuel combustion, and wind power in Iceland (Table 3.5), with hydropower as the main source of electricity (Orkustofnun, 2019). Electricity was produced with fuel combustion at two localities that are located far from the distribution network (two islands, Grímsey and Flatey). Some public electricity facilities have emergency backup fuel combustion power plants which they can use when problems occur in the distribution system. Those plants are, however, seldom used, apart from testing and during maintenance. In 2013, the first wind turbines were connected and used for public electricity production.

Table 3.5 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	**4,446**	**4,976**	**7,678**	**8,681**	**17,059**	**18,799**	**19,127**	**19,614**

Emissions from hydropower reservoirs are included in the LULUCF sector and emissions from geothermal power plants are reported in sector 1B2d.

1A1aiii: Heat Plants: Geothermal energy was the main source of heat production in 2019. Some district heating facilities, which lack access to geothermal energy sources, use electric boilers to produce heat from electricity. They depend on curtailable energy. These heat plants have back-up fuel combustion systems in case of electricity shortages or problems in the distribution system. Three district heating stations burned waste to produce heat and were connected to the local distribution system. They stopped production in 2012. Emissions from these waste incineration plants are reported here.

3.2.1.1 *Activity Data*

1A1ai: Electricity Generation: Activity data for whole timeseries is sales numbers for fuel sold for electricity production from the NEA. In the past decade, 0.01-0.02% of the annual electricity production in Iceland was via fuel combustion. Activity data for fuel combustion is given in Table 3.6. During 2003-2007, biomethane was used for electricity production and 2017-2018 biodiesel was used. These fuels are both reported as biomass in CRF.

Table 3.6 Fuel use [kt] from Electricity Production.

	1990	1995	2000	2005	2010	2015	2020	2021
Gas/Diesel Oil	1.30	1.09	1.07	0.02	1.01	1.19	0.56	0.75
Residual Fuel Oil	NO	NO	NO	NO	NO	NO	NO	NO
Biomethane	NO	NO	NO	0.29	NO	NO	NO	NO
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO

1A1aiii: Heat Plants: Activity data for heat production with fuel combustion and waste incineration are given in Table 3.7. According to Annex II in the waste framework Directive 2008/98/EC incineration facilities dedicated to the processing of municipal solid waste need to have their energy efficiency equal or above 60%-65% in order to qualify as recovery operations. Since 2013, there has been only one incineration facility in Iceland, *Kalka*, and it does not qualify as a recovery operation. From 2013, no solid waste was used for the production of heat.

Table 3.7 Fuel use [kt] from Heat Production.

	1990	1995	2000	2005	2010	2015	2020	2021
Gas/Diesel Oil	NO	NO	NO	NO	NO	NO	NO	0.06
Residual Fuel Oil	2.99	3.08	0.12	0.20	NO	0.14	NO	NO
Biodiesel	NO	NO	NO	NO	NO	NO	NO	NO
Waste - fossil	NO	1.49	1.94	1.91	3.42	NO	NO	NO
Waste - biogenic	NO	3.16	4.11	4.04	4.69	NO	NO	NO

3.2.1.2 *Emission Factors*

All emission factors for this sector can be seen in Table 3.4. The IEF for energy industries is affected by the different consumption of waste and fossil fuels, as waste, gas/diesel oil, and residual fuel oil have different EFs. In years where more waste oil is used, the IEF is considerably higher than in other years.

CO_2 emission factors reflect the average carbon content of fossil fuels and are taken from the 2006 IPCC Guidelines for National GHG Inventories. For diesel, country-specific NCV values are used for 2017 and onwards and country-specific carbon content, which is reflected in the CO_2 emission factor. For other fuels and other years in the timeline, default IPCC values are used.

Emission factors for energy recovery from waste incineration are described in the Waste sector, Chapter 7.4. The emission factors are based on the fossil content of the waste incinerated and varies due to the varying waste composition each year.

3.2.1.3 *Emissions*

Emissions from 1A1ai and 1A1aii have generally been decreasing over the timeline due to less dependence on fossil fuels for energy production in Iceland. In 2007, there were unusually high emissions from electricity production. That year, a new aluminium plant was established in Iceland. Because the *Kárahnjúkar Hydropower Project* (hydropower plant built for this aluminium plant) was delayed, the aluminium plant was supplied with electricity for a while from the distribution system. This led to electricity shortages for the district heating system and industry depending on curtailable energy leading to increased fuel combustion.

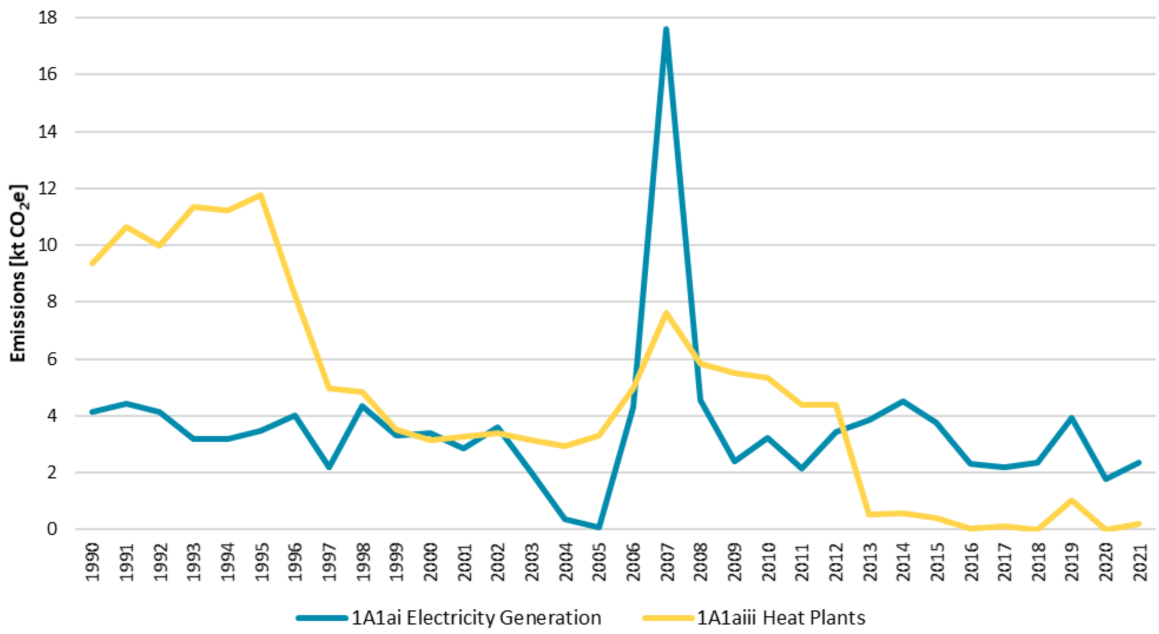


Figure 3.2 Emissions from 1A1 Energy industries.

Table 3.8 Emissions [kt CO_2e, calculated using GWP from AR5] from 1A1 Energy industries.

	1990	1995	2000	2005	2010	2015	2020	2021
1A1ai Electricity Generation	4.13	3.47	3.38	0.07	3.22	3.76	1.79	2.37
1A1aii Heat Plants	9.37	11.78	3.14	3.33	5.34	0.43	NO	0.19
Total Emissions [kt CO_2e]	**13.5**	**15.2**	**6.53**	**3.40**	**8.55**	**4.19**	**1.79**	**2.57**

3.2.1.4 *Recalculations*

1A1ai: Electricity Generation

The measurement for country-specific carbon content for gas/diesel oil from 2019 was applied to all previous years, 1990-2018. This caused a 0.6% decrease in emissions for those years. The measurement for carbon content that was performed in 2020 was applied which caused an increase in emissions by 0.3% for that year.

Table 3.9 Recalculations of CO_2 in 1A1ai.

	1990	1995	2000	2005	2010	2015	2019	2020
2022 v4 Submission [kt CO_2]	4.140	3.475	3.392	0.067	3.223	3.774	3.950	1.775
2023 Submission [kt CO_2]	4.117	3.455	3.372	0.066	3.205	3.752	3.919	1.781
Change relative to the 2022 Submission [kt CO_2]	-0.024	-0.020	-0.019	0.000	-0.018	-0.022	-0.032	0.005
Change relative to 2022 the Submission [%]	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%	-0.8%	0.3%

1A1aiii: Heat Plants

The measurement for country-specific carbon content for gas/diesel oil from 2019 was applied. This caused recalculations for 2019, as that is the only year where gas/diesel oil was used in 1A1aiii Heat Plants.

Table 3.10 Recalculations CO_2 in 1A1aiii.

	2019
2022 v4 Submission [kt CO_2]	1.041
2023 Submission [kt CO_2]	1.032
Change relative to the 2022 Submission [kt CO_2]	-0.008
Change relative to the 2022 Submission [%]	-0.8%

Recalculations from the 2022 Submission:

1A1ai: Electricity Generation

A minor recalculation was done for biodiesel emissions for Electricity Generation 1A1ai. This was due to an error in the NCV for biodiesel which has been corrected according to IPCC guidebook and now utilises the default NCV for biodiesel. This has affected emissions of bio-CO_2, CH_4, and N_2O for 2017 and 2018. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.11 Recalculations of CH_4 and N_2O in 1A1ai.

Electricity Generation	2017	2018
2021 v1 Submission [CO_2e kt]	2.2266	2.3825
2022 Submission [CO_2e kt]	2.2265	2.3824
Change relative to the 2021 Submission	-0.006%	-0.003%

1A1aiii: Heat Plants

Recalculations were made for heat plants. Recalculations apply only to CO_2 and from 1993-2013. Recalculations were made on the basis that a significant part of the waste used for heat plants was of biomass origin. Therefore, the biomass CO_2 emissions are subtracted from other fossil fuels and reported as biomass instead of fossil. Consequently, CO_2 emissions, of fossil origin from heat plants are reduced by 0.5-9.6 kt CO_2 or by 20-63% during 1993-2013 (see Table 3.12) and these emissions are not reported as biomass. Moreover, emissions in 2019 are affected to a small degree due to a correction in the NCV for biodiesel. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.12 Recalculations, fossil, in 1A1aiii due to waste and biodiesel.

Heat Plants - Fossil emissions	1993	1995	2000	2005	2010	2013	2019
2021 v1 Submission [CO_2 kt]	14.0	15.2	7.6	7.7	10.6	1.1	1.044
2022 Submission [CO_2 kt]	11.3	11.6	3.0	3.2	5.2	0.5	1.041
Change relative to the 2021 Submission	-20%	-23%	-61%	-59%	-51%	-50%	-0.4%

3.2.1.5 *Planned Improvements*

No improvements are planned for this sector.

3.2.1.6 *Uncertainties*

Uncertainty for the activity data (fuel sales) is estimated by the data provider (NEA) to be 5%. Emission factor uncertainties are 5% for CO_2 (2006 IPCC Guidelines default), 100% for CH_4 (central value for the default range given in the 2006 IPCC Guidelines) and 100% for N_2O (expert judgement, Aether Ltd, based on a comparison with other countries' NIRs (for instance UK NIR)). When combining the AD and EF uncertainties, the total uncertainty is 7% for CO_2, 100.1% for CH_4, and 100.1% for N_2O. The complete uncertainty analysis is shown in Annex 2.

3.2.2 Manufacturing Industries and Construction (CRF 1A2, Excluding Mobile Sources)

Table 3.13 shows the structure of the stationary combustion part of CRF sector 1A2, and the industries included under each subcategory. The mobile sources under CRF 1A2 can be seen in Section 3.3.1.

Table 3.13 Overview of stationary manufacturing industries reported in sector 1A2.

CRF code	IPCC name	Included
1A2a	Iron and Steel	Ferroalloy Production, Silicon Production, and Secondary Steel Recycling
1A2b	Non-ferrous Metals	Primary Aluminum Production
1A2c	Chemicals	Fertiliser Production (1990-2001), Diatomite Production (1990-2004)
1A2d	Pulp, Paper, and Print	NO
1A2e	Food Processing	Fishmeal Production and Other Food Processing
1A2f	Non-metallic Minerals	Cement (1990-2011), Mineral Wool
1A2gviii	Other Industries	All production that is not attributed to any of the other 1A2 subcategories.

3.2.2.1 *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).

Table 3.14 shows the fuel sales statistics for the various fuel types used for stationary combustion in CRF sector 1A2:

Table 3.14 Fuel use [kt] from stationary combustion from subsectors in the Manufacturing Industry (1A2).

	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	0.05	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	41.0	48.5	36.4	21.4	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	18.6	8.65	13.3	9.91	3.65	NO	NO	NO
1A2f - Non-metallic Minerals (Mineral Wool)								
Gas/Diesel Oil	NO	0.15	0.17	0.16	0.07	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	0.05	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

3.2.2.2 *Emission Factors*

All emission factors used for Stationary Combustion from CRF 1A2 can be seen in Table 3.4.

3.2.2.3 *Emissions*

Emissions from Stationary Combustion from CRF 1A2 have historically been dominated by emissions from Fishmeal Production (CRF 1A2e). Over the past few years, more fishmeal factories have been using electricity instead of fossil fuels and therefore the emissions have decreased.

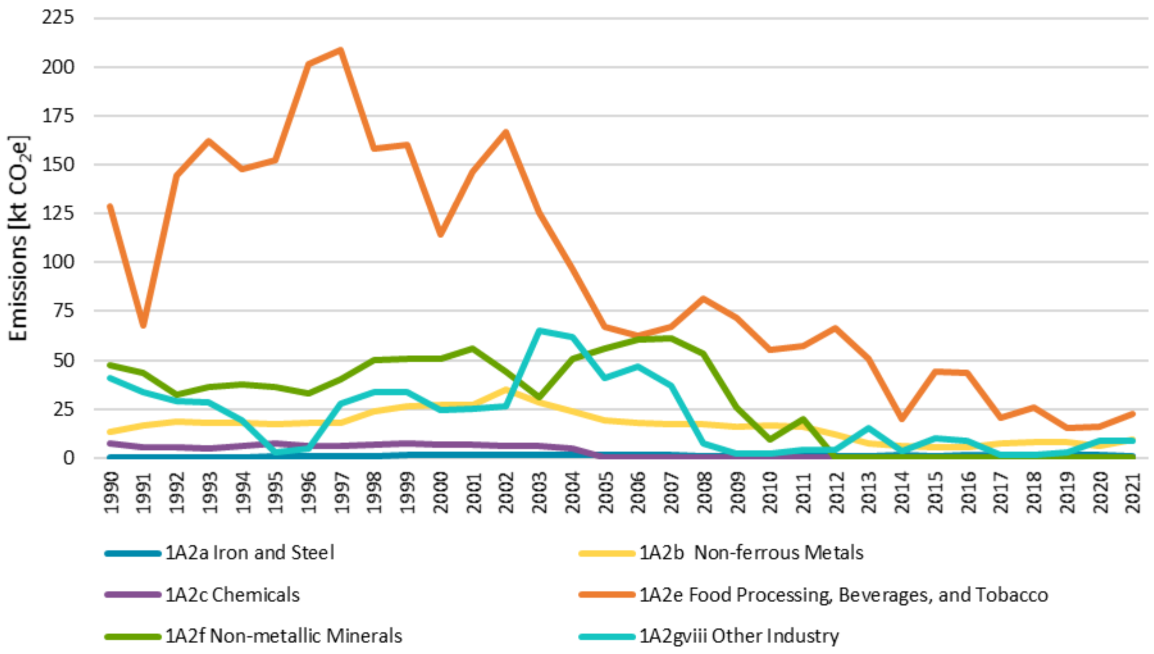


Figure 3.3 Emissions from stationary combustion of subcategories of CRF 1A2.

Table 3.15 Emissions [kt CO_2e, calculated using GWP from AR5] from stationary combustion of subcategories of CRF 1A2.

	1990	1995	2000	2005	2010	2015	2020	2021
1A2a - Iron and Steel	0.35	0.71	1.76	1.45	1.46	1.22	1.28	1.18
1A2b - Non-ferrous Metals	13.54	17.10	27.29	19.02	16.46	5.69	6.16	9.20
1A2c - Chemicals	7.45	7.25	7.11	NO	NO	NO	NO	NO
1A2e - Food Processing, Beverages, and Tobacco	128.6	152.2	114.0	67.23	55.04	44.11	15.72	22.47
1A2f - Non-metallic Minerals	47.75	36.46	51.00	56.16	9.21	0.34	0.41	0.41
1A2gviii - Other Industry	40.56	2.92	24.82	41.18	2.24	10.38	8.47	8.80
Total Emissions [kt CO_2e]	**238.3**	**216.6**	**226.0**	**185.0**	**84.4**	**61.7**	**32.0**	**42.1**

3.2.2.4 *Recalculations*

1A2a: Iron and Steel

Country-specific carbon content for diesel was applied to the years that this sector is reported. This caused a very minor decrease in CO_2 emissions, except in 2020 when it caused a slight increase.

Table 3.16 Recalculations in 1A2a due to the use of country-specific carbon content for diesel.

Iron and Steel	1990	1995	2000	2005	2010	2015	2018	2019	2020
2022 v4 Submission [kt CO_2e]	0.355	0.715	1.769	1.449	1.459	1.220	1.498	1.762	1.280
2023 Submission [kt CO_2e]	0.353	0.711	1.759	1.441	1.450	1.215	1.490	1.757	1.282
Change relative to the 2022 v4 Submission [kt CO_2e]	-0.002	-0.004	-0.010	-0.008	-0.008	-0.005	-0.008	-0.005	0.002
Change relative to the 2022 v4 Submission [%]	-0.57%	-0.57%	-0.57%	-0.57%	-0.57%	-0.44%	-0.52%	-0.30%	+0.16%

1A2b: Non-ferrous Metals

Country-specific carbon content for diesel was applied to the years that this sector is reported. This caused a very minor decrease in CO_2 emissions. Diesel was not used before 2000 and thus 1990 and 1995 were not included in Table 3.17 below.

Table 3.17 Recalculations in 1A2b due to the use of country-specific carbon content for diesel.

Non-ferrous Metals	2000	2005	2010	2015	2018	2019	2020
2022 v4 Submission [kt CO_2e]	27.216	19.063	16.434	5.676	8.110	8.402	6.146
2023 Submission [kt CO_2e]	27.206	18.965	16.410	5.675	8.101	8.360	6.143
Change relative to 2022 v4 Submission [kt CO_2e]	-0.010	-0.098	-0.025	-0.001	-0.008	-0.042	-0.003
Change relative to 2022 v4 Submission [%]	-0.04%	-0.51%	-0.15%	-0.01%	-0.10%	-0.50%	-0.04%

1A2c: Chemicals

No recalculations were necessary for this subsector for the current submission.

1A2e: Food Processing, Beverages, and Tobacco

Country-specific carbon content for diesel was applied to the years that this sector is reported. This caused a very minor decrease in CO_2 emissions, except in 2020 when a very minor increase in CO_2 emissions was observed. Diesel was reported as used in this subsector in 1996, and was not reported again until 2007. It has been reported in this subsector every year since then. The years shown in Table 3.18 were chosen to reflect this.

Table 3.18 Recalculations in 1A2e due to the use of country-specific carbon content for diesel.

Food Processing, Beverages, and Tobacco	1996	2010	2015	2016	2017	2018	2019	2020
2022 v4 Submission [kt CO_2e]	200.5	54.87	43.94	43.59	20.31	26.05	15.24	15.61
2023 Submission [kt CO_2e]	200.5	54.78	43.87	43.44	20.23	25.94	15.16	15.64
Change relative to the 2022 v4 Submission [kt CO_2e]	-0.023	-0.089	-0.068	-0.145	-0.084	-0.112	-0.084	0.033
Change relative to the 2022 v4 Submission [%]	-0.01%	-0.16%	-0.16%	-0.33%	-0.41%	-0.43%	-0.55%	+0.21%

1A2f: Non-metallic Metals

Country-specific carbon content for diesel was applied to the years that this sector is reported. This caused a very minor decrease in CO_2 emissions, except in 2020 when a very minor increase in CO2 emissions was observed. Diesel began being reported in this subsector in 1994 and has been reported in this subsector every year since then. The years shown in Table 3.19 were chosen to reflect this.

Table 3.19 Recalculations in 1A2f due to the use of country-specific carbon content for diesel.

Non-metallic Metals	1995	2000	2005	2010	2015	2018	2019	2020
2022 v4 Submission [kt CO_2e]	36.263	50.713	55.901	9.150	0.339	0.382	0.415	0.406
2023 Submission [kt CO_2e]	36.260	50.709	55.898	9.148	0.337	0.378	0.411	0.407
Change relative to the 2022 v4 Submission [kt CO_2e]	-0.003	-0.003	-0.003	-0.001	-0.002	-0.004	-0.003	0.001
Change relative to the 2022 v4 Submission [%]	-0.01%	-0.01%	-0.01%	-0.02%	-0.57%	-1.03%	-0.80%	+0.31%

1A2gviii: Other Industry

Country-specific carbon content for diesel was applied to the years that this sector is reported. This caused a very minor decrease in CO_2 emissions, except in 2020 when a very minor increase in CO_2 emissions was observed. Diesel usage in this sector has been sporadic since 1990, and in the past 12 years there are various years in which no diesel usage was observed for this subsector. As the changes seen in the recalculations are diesel-usage dependent, and no diesel was used from 2017-2019, these years were skipped in Table 3.20. Only five-year intervals in which diesel was used are shown in the table.

Table 3.20 Recalculations in 1A2g due to the use of country-specific carbon content for diesel.

Other Industry	1990	1995	2000	2005	2015	2020
2022 v4 Submission [kt CO_2e]	40.525	2.922	24.884	41.219	10.403	8.430
2023 Submission [kt CO_2e]	40.435	2.908	24.745	41.051	10.349	8.450
Change relative to the 2022 v4 Submission [kt CO_2e]	-0.091	-0.014	-0.139	-0.168	-0.053	0.021
Change relative to the 2022 v4 Submission [%]	-0.22%	-0.47%	-0.56%	-0.41%	-0.51%	+0.25%

Recalculations from the 2022 Submission:

1A2f: Non-metallic Minerals

Recalculations were made in 1A2f due to an issue with double counting petroleum coke. Total emissions in the sub-sector were reduced by 0.07-0.13 kt CO_2e in the time period 2013-2019, see Table 3.21. Petroleum coke was reported under 1A2f because it was reported as energy use in the AER. However, after review with ETS experts it was removed from the energy sector and is now only reported under the IPPU sector. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.21 Recalculations in 1A2f due to double counting of petroleum coke.

Non-metallic minerals	2013	2014	2015	2016	2017	2018	2019
2021 v1 Submission [CO_2e kt]	0.35	0.32	0.43	0.44	0.51	0.50	0.54
2022 Submission [CO_2e kt]	0.28	0.24	0.34	0.33	0.39	0.38	0.42
Change relative to the 2021 Submission [CO_2e kt]	-0.07	-0.08	-0.09	-0.11	-0.11	-0.12	-0.13

1A2e: Food processing, Beverages, and Tobacco

Three different recalculations were done in this subsector. Note that figures from the 2022 Submission are based on GWP in AR4.

1. A recalculation was made for CH_4 and N_2O emissions from waste oil utilisation in food processing due to the application of IPCC default EF for waste oil. In previous years the emission factor for diesel had been applied which is substantially lower. This caused and nine-fold and almost six-fold increase in CH_4 and N_2O emissions, respectively, in the time period 2007-2019 (see Table 3.22 and Table 3.23). Consequently, total emissions increased by 0.05-0.16 kt CO_2e in the time period 2007-2019.

Table 3.22 Recalculations in 1A2e due to waste oil CH_4.

Food processing, Beverages, and Tobacco – Waste Oil	2007	2010	2015	2018	2019
2021 v1 Submission [CH_4 kt]	0.000272	0.000164	0.000192	0.000151	0.000085
2022 Submission [CH_4 kt]	0.00272	0.00164	0.00192	0.00151	0.00085
Change relative to 2021 Submission	+900%	+900%	+900%	+900%	+900%

Table 3.23 Recalculations in 1A2e due to waste oil N_2O.

Food processing, Beverages, and Tobacco – Waste Oil	2007	2010	2015	2018	2019
2021 v1 Submission [N_2O kt]	0.00005	0.00003	0.00004	0.00003	0.00002
2022 Submission [N_2O kt]	0.00036	0.00022	0.00026	0.00020	0.00011
Change relative to 2021 Submission	+567%	+567%	+567%	+567%	+567%

2. A recalculation was made for 1A2e in 2019 due to reallocation of gas/diesel oil, by the NEA, between sub-categories within 1A2e. The previously mentioned factors combined caused a recalculation of 0.047 kt CO_2e, where emissions increased by 0.3% in 2019.

3. During a review of the activity data for fishmeal factories, significant outliers were noted in 2003-2006. This was investigated with the Association for fishmeal factories as well as the data provider, NEA. The

data set for stationary energy fuel use showed that unallocated fuel for non-specified industry in the same years, increased significantly. By allocating non-specified fuel to the 1A2e category, the dataset became aligned with the dataset from the Association for fishmeal factories. This was further analysed with respect to fish processed and electricity utilised. The reallocation of fuels was therefore executed by the NEA. This does not change total emissions from Energy, only the allocation between subcategories.

Table 3.24 Recalculations in 1A2e due to reallocation of fuels.

Food processing, Beverages, and Tobacco	2003	2004	2005	2006
2021 v1 submission CO_2e [kt]	30.9	4.5	5.4	12.8
2022 Submission CO_2e [kt]	39.9	30.7	21.4	20.0
Change relative to 2021 Submission CO_2e [kt]	9.0	26.2	16.1	7.2

3.2.2.5 *Planned Improvements*

The drop in emissions from 1A2e and subsequent increase in emissions from 1A2gvii in 2004 is most likely due to an error in allocation of fuels. This is being looked into and will be corrected for the next submission.

3.2.2.6 *Uncertainties*

For subsectors 1A2a and 1A2b (Iron and Steel and Non-ferrous Metals, respectively), the activity data uncertainty is small, or 1.5%, due to the uncertainty constraints imposed on companies participating in the EU ETS trading scheme. The combined uncertainty for those two sectors is 5.2 % for CO_2 emissions (with an activity data uncertainty of 1.5% and emission factor uncertainty of 5% (Default 2006 IPCC Guidelines), 100% for CH_4 emissions (with an activity data uncertainty of 1.5% and emission factor uncertainty of 100% (central value of default range, 2006 IPCC Guidelines) and 100% for N_2O emissions (with an activity data uncertainty of 1.5% and emission factor uncertainty of 100% (expert judgement, Aether ltd, based on the comparison with other countries NIR (for instance UK NIR)).

The uncertainty of CO_2 emissions from the other subsectors (1A2c, e, f and g) and 1A5a is 7% (with an activity data uncertainty of 5%, as given by the data provider (NEA), and emission factor uncertainty of 5%), 100.1% for CH_4 emissions (with an activity data uncertainty of 5% and emission factor uncertainty of 100% (central value of default range, 2006 IPCC Guidelines)), and 100.1% for N_2O emissions (with an activity data uncertainty of 5% and emission factor uncertainty of 100% (expert judgement, Aether ltd, based on the comparison with other countries NIR (for instance UK NIR)). This can be seen in the quantitative uncertainty table in Annex 2.

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

Since Iceland relies largely on renewable energy sources, fuel use for residential, commercial, and institutional heating is low and GHG emissions from stationary subsectors 1A4a and 1A4b are very low. Residential heating with electricity is subsidised and occurs in areas far from public heat plants. Commercial fuel combustion includes the heating of swimming pools, but only a few swimming pools in the country are heated with oil. Mobile combustion under CRF 1A4 is reported in Sections 3.3.1 and 3.3.4.

3.2.3.1 *Activity Data*

The NEA collects data on fuel sales by sector. Activity data for residential use of charcoal for grilling is obtained from import numbers from Statistics Iceland (*Hagstofa Íslands*) (SI). Activity data for fuel combustion from the Commercial/Institutional sector and in the Residential sector are given in Table 3.25.

Table 3.25 Fuel use [in kt] from stationary combustion from subsectors of CRF 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
Charcoal	NE	NE	NE	NE	NE	NE	0.18	0.23
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

3.2.3.2 *Emission Factors*

All emission factors for this subsector can be seen in Table 3.4.

The IEF for the 1A4ai Commercial/Institutional shows fluctuations over the time series. From 1993 to 2012, waste was incinerated to produce heat at two locations (swimming pools, a school building). The IEF for waste is considerably higher than for liquid fuel, and therefore this influences the IEF for this sector.

3.2.3.3 *Emissions*

Emissions from Stationary Combustion under CRF 1A4 have generally been decreasing over the past years, with some annual fluctuations. These emissions can be seen in Table 3.26 and Figure 3.4.

Table 3.26 Emissions from Stationary Combustion of subsectors under CRF 1A4 [kt CO_2e, calculated using GWP from AR5.

	1990	1995	2000	2005	2010	2015	2020	2021
1A4ai - Commercial/Institutional	8.06	7.80	6.74	4.93	1.71	2.07	1.64	1.74
1A4bi - Residential	28.1	22.1	21.3	13.1	8.50	5.94	6.72	5.22
1A4ci - Agriculture	NO	NO	NO	NO	NO	0.012	0.024	0.021
Total Emissions [kt CO_2e]	**36.2**	**29.9**	**28.1**	**18.0**	**10.2**	**8.02**	**8.38**	**6.98**

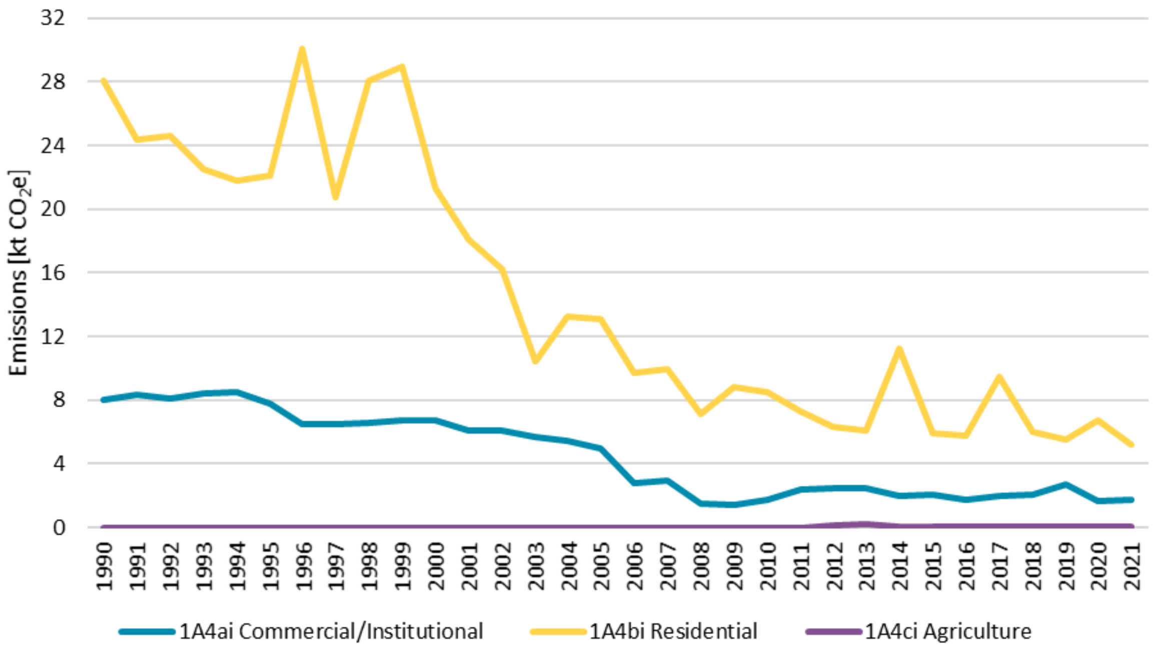


Figure 3.4 Emissions from stationary combustion of subsectors under CRF 1A4.

3.2.3.4 *Recalculations*

1A4ai Commercial/Institutional Stationary

Recalculations in 1A4ai are due to two separate issues. Firstly, country-specific carbon content for diesel was applied to the years that this sector is reported. This generally caused very minor decreases in CO_2 emissions. Secondly, there was an error in the fuel sales submissions from one of the fuel companies. The error resulted in wrong diesel oil sales numbers being reported under this subcategory that should have been reported under 1A4bi in 2019 and 2020. This caused a significant decrease in the activity data, and thus, the emissions. Recalculations for this subsector can be viewed in Table 3.27. It should be noted that the recalculations pertaining to the error in the fuel sales reporting apply only to the last two years in the timeseries in this table, but the change regarding country-specific carbon content for diesel affects all years in the timeseries. Thus, the absolute change and percentage change in emissions are much greater in 2019 and 2020 when compared to the rest of the timeseries.

Table 3.27 Recalculations in 1A4ai due the use of country-specific carbon content for diesel and an error in fuel sales reported.

Commercial/Institutional	1990	1995	2000	2005	2010	2015	2018	2019	2020
2022 v4 Submission [kt CO_2e]	8.05	7.78	6.72	4.92	1.70	2.06	2.07	3.82	2.91
2023 Submission [kt CO_2e]	8.02	7.75	6.69	4.90	1.69	2.06	2.06	2.67	1.63
Change relative to the 2022 v4 Submission [kt CO_2e]	-0.03	-0.03	-0.03	-0.02	-0.01	-0.01	0.00	-1.15	-1.28
Change relative to the 2022 v4 Submission [%]	-0.41%	-0.38%	-0.43%	-0.37%	-0.32%	-0.27%	-0.24%	-30.1%	-43.9%

1A4bi Residential Stationary

Recalculations in 1A4bi are due to two separate issues. Firstly, country-specific carbon content for diesel was applied to the years that this sector is reported. This generally caused very minor decreases in CO_2 emissions. Secondly, there was an error in the fuel sales submissions from one of the fuel companies. The error resulted in wrong diesel oil sales numbers being reported under 1A4ai that should have been reported under this subsector in 2019 and 2020. This caused a significant increase in the activity data, and thus, the emissions. Recalculations for this subsector can be viewed in Table 3.28. It should be noted that the recalculations pertaining to the error in the fuel sales reporting apply only to the last two years in the timeseries in this table, but the change regarding country-specific carbon content for diesel affects all years in the timeseries. Thus, the absolute change and percentage change in emissions are much greater in 2019 and 2020 when compared to the rest of the timeseries.

Table 3.28 Recalculations in 1A4bi due the use of country-specific carbon content for diesel and an error in fuel sales reported.

Commercial/Institutional	1990	1995	2000	2005	2010	2015	2018	2019	2020
2022 v4 Submission [kt CO_2e]	28.10	22.09	21.33	13.09	8.49	5.93	5.97	4.35	5.37
2023 Submission [kt CO_2e]	27.94	21.96	21.22	13.03	8.46	5.91	5.95	5.48	6.66
Change relative to 2022 v4 Submission [kt CO_2e]	-0.16	-0.13	-0.11	-0.06	-0.02	-0.02	-0.03	1.12	1.29
Change relative to 2022 v4 Submission [%]	-0.57%	-0.57%	-0.52%	-0.45%	-0.29%	-0.31%	-0.47%	+25.79%	+23.99%

1A4ci Agricultural Stationary

No recalculations were necessary for this subsector for the current submission.

Recalculation for the 2022 Submission:

1A4ai Commercial/Institutional

Recalculations in 1A4ai are due to three separate issues. Firstly, the CH_4 and N_2O emissions in previous submission of the NIR had been interchanged for waste burning. Therefore, the figure for CH_4 was reported as N_2O and N_2O as CH_4. Waste was used in the time period 1993-2012. Recalculations due to this amounted to between 0.01-0.03 kt CO_2e in the previously mentioned. Consequently, total emissions were reduced by approximately 0.26-0.97% (see Table 3.29). Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.29 Recalculations in 1A4ai due to error in EF.

Commercial/Institutional	1993	1995	2000	2005	2010	2012
2021 v1 Submission [CO_2e kt]	8.45	7.85	6.79	4.98	1.73	2.51
2022 Submission [CO_2e kt]	8.43	7.83	6.77	4.95	1.71	2.50
Change relative to the 2021 Submission	-0.26%	-0.28%	-0.41%	-0.56%	-0.97%	-0.35%

Secondly, recalculations in 1A4ai are due to a change in the NEA data on fuel allocation. Gas/Diesel oil was increased between submissions by 123% in 2019 and LPG was increased 333%, 556%, and 517% in 2017-2019, respectively. This increased emissions from 1A4ai by 1.17-2.61 kt CO_2e in the respective years, see Table 3.30. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.30 Recalculations in 1A4ai due to reallocation of fuels.

Commercial/Institutional	2017	2018	2019
2021 v1 Submission [CO_2e kt]	0.83	0.72	1.22
2022 Submission [CO_2e kt]	2.00	2.07	3.83
Change relative to the 2021 Submission [CO_2e kt]	1.17	1.35	2.61

Thirdly, the biomass fraction of waste had not been reported in CRF. Therefore, biomass emissions from 1A4ai are now reported correctly and occur between 1993-2012, see Table 3.31. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.31 Recalculations in 1A4ai due to biomass in waste.

Commercial/Institutional	1993	1995	2000	2005	2010	2012
2021 v1 submission Biomass [CO_2 kt]	NO	NO	NO	NO	NO	NO
2022 Submission Biomass [CO_2 kt]	0.34	0.34	0.44	0.44	0.23	0.12

1A4bi Residential Stationary

Recalculations in 1A4bi 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 reduced total emissions from 1A4bi by 1.38, 1.47, and 2.74 kt CO_2e in 2017-2019, respectively, see Table 3.32. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.32 Recalculations in 1A4bi due to fuel reallocation.

Residential Stationary	2017	2018	2019
2021 v1 Submission [CO_2e kt]	10.91	7.47	7.11
2022 Submission [CO_2e kt]	9.53	6.00	4.37
Change relative to the 2021 Submission [CO_2e kt]	-1.38	-1.47	-2.74

3.2.3.5 *Planned Improvements*

There are no planned improvements for this sector.

3.2.3.6 *Uncertainties*

Uncertainty for the activity data (fuel sales) is estimated by the data provider (NEA) to be 5%. Emission factor uncertainties are 5% for CO_2 (2006 IPCC Guidelines default), 100% for CH_4 (central value for the default range given in the 2006 IPCC Guidelines), and 100% for N_2O (expert judgement, Aether ltd, based on comparison with other countries NIR (for instance UK NIR)). When combining the AD and EF uncertainties, total uncertainty is 7% for CO_2, 100% for CH_4, and 100% for N_2O. The complete uncertainty analysis is shown in Annex 2.

3.2.4 Other (CRF 1A5)

All fuels categorised as “Other” in sales statistics without any explanation of type of use, are 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.

3.2.4.1 *Activity Data*

Activity data for 1A5 Other can be seen in Table 3.33.

Table 3.33 Fuel use [in 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

3.2.4.2 *Emission Factors*

All emission factors for this sector can be seen in Table 3.4.

3.2.4.3 *Emissions*

Emissions from unallocated fuels from CRF 1A5 have been decreasing over the past years. There was a sharp increase in emissions in 2004-2006 and it is likely that this is fuel that should have been allocated to CRF 1A2e. This is being investigated and will be resolved for future submissions.

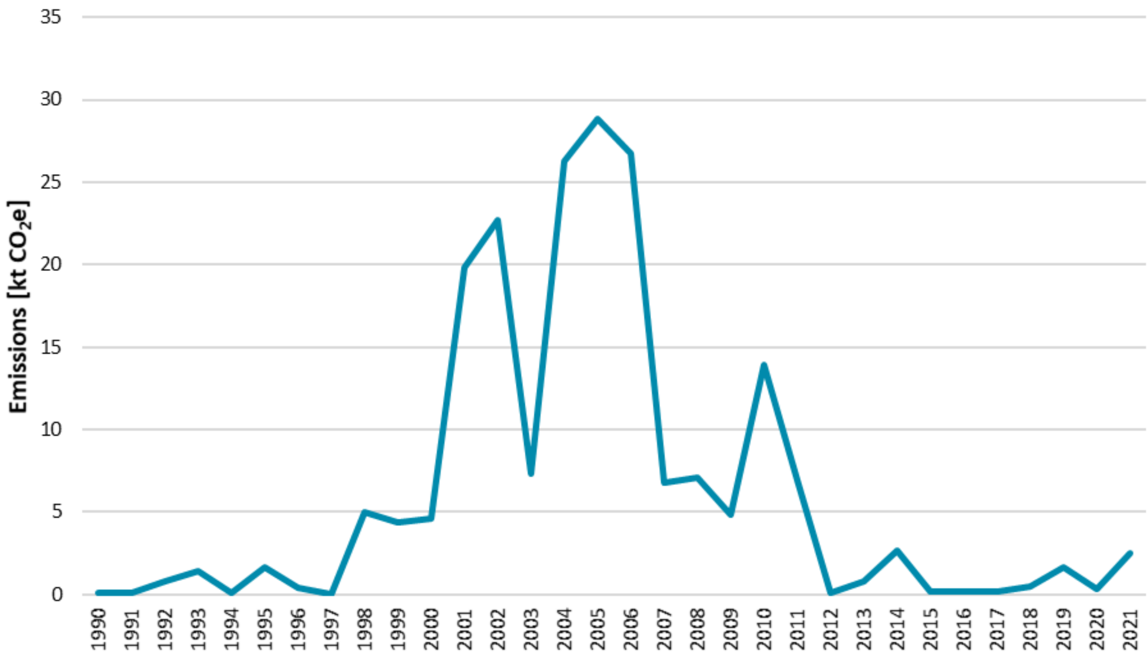


Figure 3.5 Emissions from Stationary Combustion from CRF 1A5.

Table 3.34 Emissions from Stationary Combustion from CRF 1A5 [kt CO_2e, calculated using GWP from AR5].

	1990	1995	2000	2005	2010	2015	2020	2021
1A5 - Total emissions [kt CO_2e]	0.122	1.62	4.61	28.8	13.9	0.187	0.364	2.54

3.2.4.4 *Recalculations*

Country-specific carbon content for diesel was applied to the years that this sector is reported. This caused a very minor decrease in CO_2 emissions, except in 2020 where a small increase was observed. There are a number of years in the timeseries where diesel use was not observed, and thus, these years (at five-year intervals) were omitted from Table 3.35.

Table 3.35 Recalculations in 1A5 due to country-specific carbon content.

Other Stationary	1995	2000	2005	2010	2019	2020
2022 v4 Submission [kt CO_2e]	1.624	4.624	28.91	13.93	1.686	0.361
2023 Submission [kt CO_2e]	1.613	4.598	28.75	13.88	1.676	0.362
Change relative to 2022 v4 Submission [kt CO_2e]	-0.01	-0.03	-0.16	-0.05	-0.01	0.00
Change relative to 2022 v4 Submission [%]	-0.52%	-0.55%	-0.56%	-0.36%	-0.60%	+0.23%

Recalculations from the 2022 Submission:

Recalculations in 1A5 are twofold. Firstly, recalculations are due to a correction in the applied NCV for bio-gasoline. In previous submissions the wrong NCV was applied to bio gasoline which caused an overestimation of emissions. Biomass CO_2 emissions from bio gasoline have been reduced by between

0.03-0.34 kt CO_2 in the time periods 2012-2013 and 2016-2019, see Table 3.36. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.36 Recalculations in 1A5 due to bio gasoline NCV.

Other – Liquid biofuel	2012	2013	2016	2017	2018	2019
2021 v1 submission [bio-CO_2 kt]	0.26	0.93	0.09	0.18	0.14	0.07
2022 Submission [bio-CO_2 kt]	0.16	0.59	0.06	0.11	0.08	0.04
Change relative to 2021 Submission [CO_2 kt]	-0.10	-0.34	-0.03	-0.07	-0.05	-0.03

Secondly, bio methane has now been allocated to 2019 in the current submission of activity data from the NEA. This had been reported as NO in the previous submission. Therefore, biomethane emissions in 2019 have been increased by 0.25 kt CO_2, see Table 3.37. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.37 Recalculations in 1A5 due to change in activity data of bio methane.

Other - Biomethane	2019
2021 v1 Submission biomethane [kt]	NO
2022 Submission biomethane [kt]	0.25

3.2.4.5 *Uncertainties*

The uncertainty of CO_2 emissions from 1A5 is 7% (with an activity data uncertainty of 5%, as given by the data provider (NEA), and emission factor uncertainty of 5%), 100.1% for CH_4 emissions (with an activity data uncertainty of 5% and emission factor uncertainty of 100% (central value of default range, 2006 IPCC Guidelines)), and 100.1% for N_2O emissions (with an activity data uncertainty of 5% and emission factor uncertainty of 100% (expert judgement, Aether ltd, based on the comparison with other countries NIR (for instance UK NIR)). This can be seen in the quantitative uncertainty table in Annex 2.

3.2.4.6 *Planned Improvements*

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.

3.3 Transport and Other Mobile Sources (CRF 1A2, 1A3, and 1A4)

3.3.1 Mobile Machinery (CRF 1A2gvii, 1A3eii, and 1A4cii)

This section includes all mobile sources that are included under CRF 1A2, 1A3, and 1A4. Information on the specific subsectors can be seen in Table 3.38.

Table 3.38 Information on subsectors reported as Mobile Machinery.

CRF code	IPCC name	Included
1A2gvii	Off-road Vehicles and Other Machinery in Construction	Extrapolation for 1990-2018, data for Mobile Machinery in Construction from 2019.
1A3eii	Off-road Vehicles and Other Machinery	Extrapolation for 1990-2018, all Other Machinery after 2019.
1A4cii	Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	Extrapolation for 1990-2018, data for Mobile Machinery in Agriculture from 2019.

3.3.1.1 *Activity Data*

Activity data for Mobile Combustion in these sectors is provided by the NEA. The fuel used can be seen in Table 3.40. Activity data and information available from the NEA for 1990-2018 do not allow the distinction between fuels sold to machinery in construction, agriculture, or other uses, but provides data on fuel sold from fuel delivery trucks (as opposed to fuel sold at petrol stations). However, improvements were made in the data gathering by the NEA and it was possible to distinguish between off-road vehicles in agriculture and construction from the inventory years 2019 and onwards.

For 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 ***Mobile Machinery in Construction (1A2gvii)*** and ***Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery (1A4cii)*** as well as transport activities not reported under road transport such as ground activities in airports and harbours (1A3eii). Categories 1A2gvii and 1A4cii 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 diesel fuel previously reported under 1A3eii to the other categories for Mobile Machinery. An average proportion of each category was calculated based on the split in 2019-2021. These proportions can be seen in Table 3.39.

Table 3.39 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%

For 2019 and onwards, Mobile Machinery in Construction (1A2gvii) and Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery (1A4cii) 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.

Table 3.40 Fuel use (in kt) from Mobile Combustion in the Construction Industry (1A2gv), Agriculture (1A4cii), and Other (1A2gvii).

	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
1A3eii - Other Mobile Machinery								
Gas/Diesel Oil	6.8	8.4	11.1	12.2	5.8	6.0	3.7	0.7
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

3.3.1.2 *Emission Factors*

All emission factors used to calculate emissions from fuel combustion from Mobile Machinery can be seen in Table 3.41. All factors, except NCV and carbon content for diesel, are from 2006 IPCC guidelines. The values in Table 3.41 represent the values used in the most recent inventory year.

Table 3.41 Emission factors for CO_2, CH_4, and N_2O from Mobile Combustion reported under 1A2gvii, 1A3eii, and 1A4cii.

Fuel / Factor	Value	Unit	Reference
Diesel Oil			
NCV	42.89	TJ/kt	Country Specific from 2017, based on annual measurements
C-content	20.17	t/TJ	Country Specific, based on measurements
CH_4 emission factor	4.2	kg/TJ	Table 3.3.1 2006 IPCC Guidelines, "Industry" defaults
N_2O emission factor	28.6	kg/TJ	Table 3.3.1 2006 IPCC Guidelines, "Industry" defaults
Other Kerosene			

Fuel / Factor	Value	Unit	Reference
NCV	43.8	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	19.6	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	4.2	kg/TJ	Table 3.3.1 2006 IPCC Guidelines, "Industry" defaults*
N_2O emission factor	28.6	kg/TJ	Table 3.3.1 2006 IPCC Guidelines, "Industry" defaults*
Biodiesel			
NCV	27.0	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	19.3	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	3.0	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2
N_2O emission factor	0.6	kg/TJ	Table 2.2 2006 IPCC Guidelines, V2, Ch2

* These values are the EFs for diesel oil, as no specific EFs exist for other kerosene for mobile machinery, and kerosene would be used in diesel engines rather than petrol engines.

3.3.1.3 *Emissions*

As can be seen in Figure 3.6 and Table 3.42, emissions from Mobile Machinery increased in the beginning of the timeseries, but they have generally been decreasing from 2008, albeit with some fluctuations.

Table 3.42 Emissions [kt CO_2e] from mobile machinery (1A2gvii, 1A3eii, and 1A4cii)

	1990	1995	2000	2005	2010	2015	2020	2021
1A2gvii - Mobile Machinery in Construction	63.5	78.2	103.5	113.4	53.9	55.3	22.4	34.6
1A3eii - Other Mobile Machinery	23.9	29.4	38.9	42.7	24.3	21.3	14.1	3.1
1A4cii - Mobile Machinery in Agriculture	45.3	55.7	73.8	80.8	38.4	39.4	26.5	22.6
Total	**132.7**	**163.3**	**216.2**	**236.9**	**116.7**	**116.1**	**63.1**	**60.3**

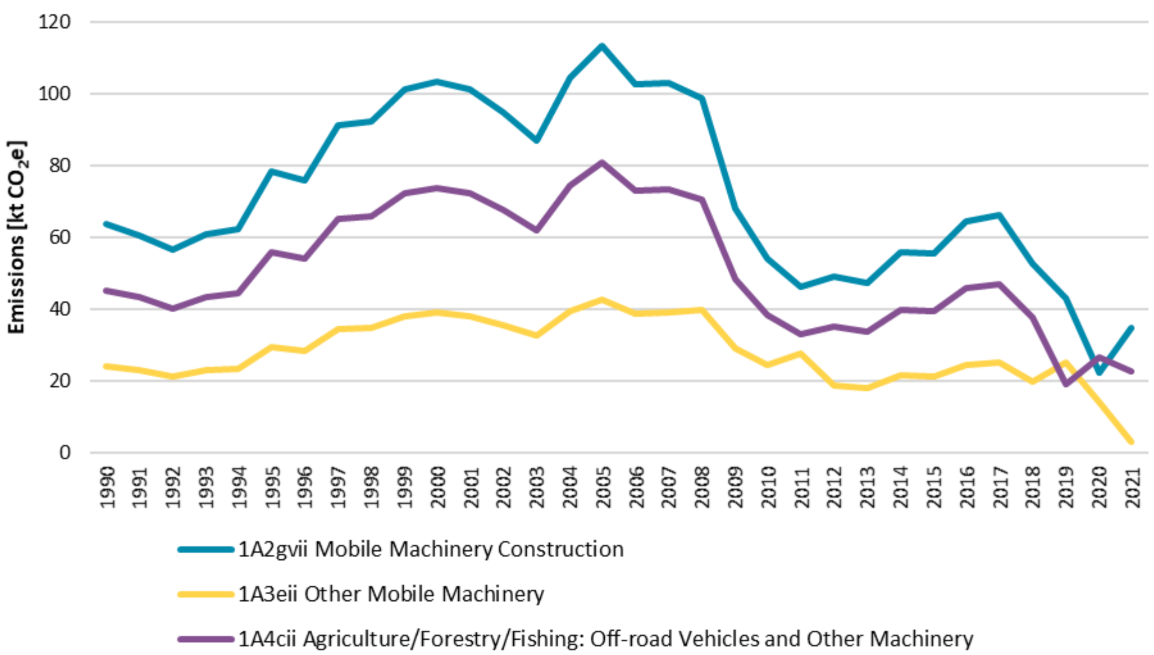


Figure 3.6 Emissions [kt CO_2e, calculated using GWP from AR5] from Mobile Machinery (1A2gvii, 1A3eii, and 1A4cii). Emission split for 1990-2018 is based on extrapolation.

3.3.1.4 *Recalculations*

Recalculations for all three subcategories were performed for 1990-2018 due to the extrapolation of allocation of diesel fuels between the categories. This does not affect total emissions from mobile machinery as the same emission factors are used and all fuel is allocated, this recalculation was done for increased transparency of the inventory. Information on how this reallocation of fuels was done can be seen in Section 3.3.1.1.

1A2gvii Off-road Vehicles and Other Machinery in Construction

There are two reasons, other than the extrapolation for 1990-2018, for recalculations in this subsector. Firstly, country-specific carbon content for diesel was applied to the years that this sector is reported. This caused a minor decrease in CO_2 emissions.

Secondly, there was an error in an input data sheet where data for Construction and Other Mobile Machinery was swapped. This error does not affect the inventory's total emissions, but does affect all gases reported under this subsector. The changes in activity data and emissions in this subsector can be seen in Table 3.43.

Table 3.43 Recalculations for 1A2gvii Off-road Vehicles and Other Machinery in Construction.

1A2gvii Off-road Vehicles and Other Machinery in Construction	2019	2020
Activity Data		
2022 v4 Submission [TJ Gas/Diesel Oil]	307.1	159.2
2023 Submission [TJ Gas/Diesel Oil]	530.6	274.2
Emissions		
2022 v4 Submission [kt CO_2e]	25.1	13.0
2023 Submission [kt CO_2e]	43.0	22.4
Change relative to the 2022 Submission [kt CO_2e]	17.9	9.4
Change relative to the 2022 Submission [%]	71.3%	72.3%

1A3eii Off-road Vehicles and Other Machinery

The same reasons exist for recalculations in this subsector as for 1A2gvii; country-specific carbon content for gas/diesel oil affects CO_2 emissions. As with the previous subsector, an error in an input data sheet which swapped the activity data for these two sectors caused the need for recalculations for 2019-2020. The effect of these recalculations on this subsector can be seen in Table 3.44.

Table 3.44 Recalculations in 1A3eii Off-road Vehicles and Other Machinery.

1A3eii Off-road Vehicles and Other Machinery	2019	2020
Activity Data		
2022 v4 Submission [TJ Gas/Diesel Oil]	530.6	274.2
2023 Submission [TJ Gas/Diesel Oil]	307.1	159.2
Emissions		
2022 v4 Submission [kt CO_2e]	43.5	23.6
2023 Submission [kt CO_2e]	25.0	14.1
Change relative to the 2022 Submission [kt CO_2e]	-18.5	-9.4
Change relative to the 2022 Submission [%]	-43%	-40%

1A4cii Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery

Country-specific carbon content for diesel was applied to the years for which this subsector is reported. This caused a minor decrease in CO_2 emissions. These recalculations for this subsector can be seen in Table 3.45.

Table 3.45 Recalculations in 1A4cii Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery.

1A4cii Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery	2019	2020
2021 v1 Submission [kt CO_2e]	19.05	26.49
2022 Submission [kt CO_2e]	18.89	26.49
Change relative to the 2022 Submission [kt CO_2e]	-0.1584	-0.0039
Change relative to the 2022 Submission [%]	-0.83%	-0.01%

Recalculations from the 2022 Submission:

During the 2021 UNFCCC review it was pointed out that Iceland should be allocating fuels used for mobile machinery differently that it was. Therefore, allocations of fuels for the whole timeseries for two subsectors was changed (see Table 3.46). This did not affect total emissions from the energy sectors, but it did affect emissions from subcategories 1A2 and 1A3e. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.46 Changes in allocation of fuels to CRF categories from this submission.

2021 Submission		2022 Submission
1A2gv – Construction	→	1A2gvii – Mobile Machinery in Construction
1A2gvii – Mobile Machinery	→	1A3eii – Other Mobile Machinery

Category 1A3eii (previously reported under the category 1A2gvii) has recalculations due to two aspects. Firstly, the NEA has reallocated gas/diesel oil in the category's activity data for 2014 and 2019, by -7 kt and 5.2 kt, respectively. This caused a recalculation of -24.9 kt CO_2e in 2014 and 18.5 kt CO_2e in 2019, see Table 3.45.

Secondly, changes in years where biodiesel is in the activity data affect total emissions due to changes in the NCV for biodiesel and are visible in the table below in 2013, 2016, and 2017. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.47 Recalculations in 1A3eii due to activity data change in 2014 and 2019 and due to biodiesel NCV.

Other Mobile Machinery	2013	2014	2016	2017	2018	2019
2021 v1 submission [CO_2e kt]	100.59	144.33	137.27	140.76	112.34	25.49
2022 Submission [CO_2e kt]	100.60	119.45	137.28	140.79	112.40	43.98
Change relative to the 2021 Submission [CO_2e kt]	0.01%	-17.24%	0.01%	0.03%	0.05%	72.53%

Mobile Machinery in Construction 1A2gv, is affected by a change in activity data reported by the NEA. This caused a decrease in emissions by approximately 31% due to a decrease in activity data for 2019 by 3 kt of gas/diesel oil. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.48 Recalculations in 1A2gv due to activity data change.

Mobile Machinery in Construction	2019
2021 v1 Submission [CO_2e kt]	36.68
2022 Submission [CO_2e kt]	25.39
Change relative to the 2021 Submission [CO_2e kt]	-30.78%

Agricultural Machinery 1A4cii, is affected by a change in activity data reported by the NEA. This caused a decrease in emissions by approximately 27% due to a decrease in activity data for 2019 by 2 kt of gas/diesel oil. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.49 Recalculations in 1A4cii due to activity data change.

Agricultural Machinery	2019
2021 v1 Submission [CO_2e kt]	26.43
2022 Submission [CO_2e kt]	19.26
Change relative to the 2021 Submission [CO_2e kt]	-27.12%

NCV for biodiesel has been corrected in this submission to the IPCC default and was in previous submission incorrectly reported. Effective change in total emissions due to this correction is under 0.05 kt CO_2e.

3.3.1.5 *Planned Improvements*

No improvements are planned for this sector.

3.3.1.6 *Uncertainties*

The uncertainty of CO_2 emissions from the other subsectors (1A2c, e, f, and g) and 1A5a is 7% (with an activity data uncertainty of 5%, as given by the data provider (NEA), and emission factor uncertainty of 5%), 100.1% for CH_4 emissions (with an activity data uncertainty of 5% and emission factor uncertainty of 100% (central value of default range, 2006 IPCC Guidelines)), and 100.1% for N_2O emissions (with an activity data uncertainty of 5% and emission factor uncertainty of 100% (expert judgement, Aether ltd, based on the comparison with other countries NIR (for instance UK NIR)). This can be seen in the quantitative uncertainty table in Annex 2.

3.3.2 Domestic Aviation (CRF 1A3a)

3.3.2.1 *Activity Data*

Domestic aviation (1A3a) includes flights departing from and subsequently landing in Iceland. Flights, that would be accounted under military operations in 1A5b are not occurring in Iceland as there is no Icelandic military.

Total use of jet kerosene and aviation gasoline is based on the NEA's annual sales statistics for fossil fuels sold for flights in all airports that service domestic flights. These are all airports in Iceland except one, which services international flights. Activity data for fuel sales are given in Table 3.50.

Table 3.50 Fuel use [kt] for Domestic Aviation.

	1990	1995	2000	2005	2010	2015	2020	2021
Aviation Gasoline	1.7	1.1	1.1	0.87	0.65	0.50	0.20	0.24
Jet Kerosene	8.9	8.4	7.9	7.4	6.1	6.0	4.0	6.3

3.3.2.2 *Emission Factors*

The emission factors for greenhouse gases are taken from the 2006 IPCC Guidelines and are presented in Table 3.51. Emission factors for NO_x, NMVOC, and CO are taken from 2019 EMEP/EEA Guidebook, Table 3.3.

Table 3.51 Emission factors for greenhouse gases for Aviation.

Fuel / Factor	Value	Unit	Reference
Aviation Gasoline			
NCV	44.3	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	19.1	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	0.5	kg/TJ	Table 3.6.5 2006 IPCC Guidelines, V2, Ch3
N_2O emission factor	2.0	kg/TJ	Table 3.6.5 2006 IPCC Guidelines, V2, Ch4
Jet Kerosene			
NCV	44.1	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	19.5	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	0.5	kg/TJ	Table 3.6.5 2006 IPCC Guidelines, V2, Ch3
N_2O emission factor	2.0	kg/TJ	Table 3.6.5 2006 IPCC Guidelines, V2, Ch4

3.3.2.3 *Emissions*

Emissions from 1A3a Domestic Aviation had generally been decreasing over the time period, but they increased during 2015-2019, most likely due to increase in tourism in Iceland. There was a drop in emissions in 2020 due to the COVID pandemic. These emissions can be seen in Table 3.52.

Table 3.52 Emissions [kt CO_2e, calculated using GWP from AR5] from 1A3a Domestic aviation.

	1990	1995	2000	2005	2010	2015	2020	2021
Total Emissions [kt CO_2e]	33.6	30.2	28.5	26.2	21.3	20.6	13.2	20.9

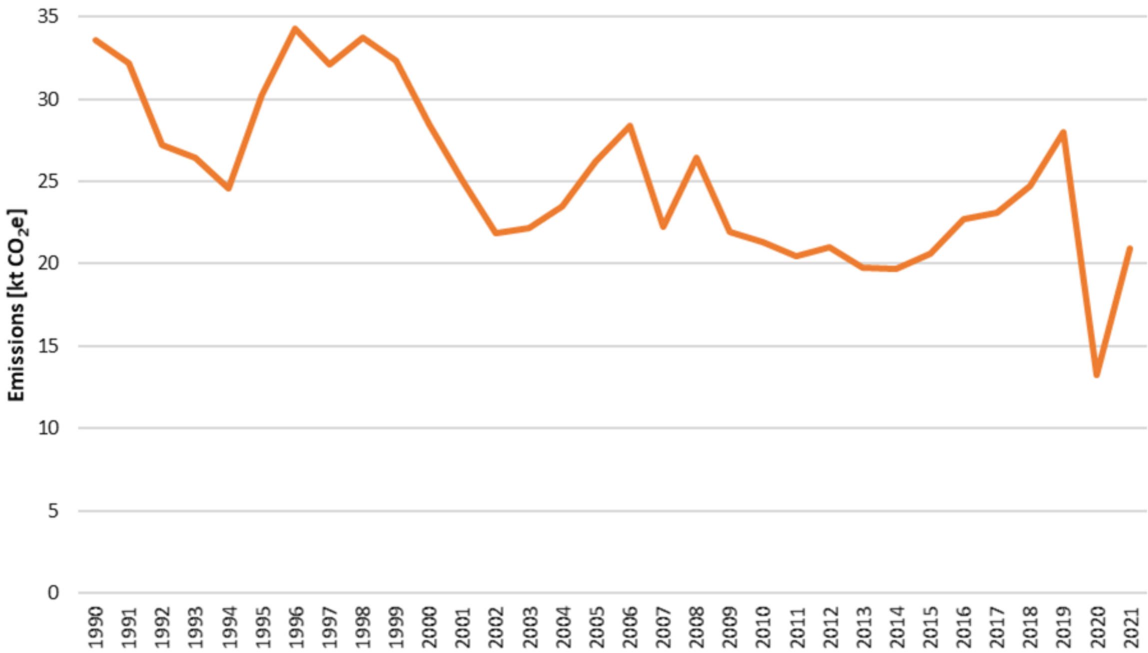


Figure 3.7 Emissions [kt CO_2e, calculated using GWP from AR5] from 1A3a Domestic Aviation.

3.3.2.4 *Recalculations*

No recalculations were performed for this sector.

Recalculations from the 2022 Submission:

Recalculations for Domestic Aviation only occur in 2014 where the activity data for jet kerosene was changed by the NEA. The fuel is reduced by approximately 7 kt which affected emissions by 52% in 2014, see Table 3.53. During the 2021 UNFCCC review, the ERT asked about an outlier in 2014 for Domestic Aviation. This was brought up with the NEA which inquired the data provider about this specific sub-sector. The NEA and the data provider reached a conclusion that an over allocation of fuel was done for Domestic Aviation in 2014 and an under allocation in International Aviation. Therefore, the amount of jet kerosene in 2014 was reduced for Domestic Aviation and added the same amount to International Aviation. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.53 Recalculations in 1A3a due to activity data change

Domestic Aviation	2014
2021 v1 Submission [CO_2e kt]	40.68
2022 Submission [CO_2e kt]	19.37
Change relative to the 2021 Submission [CO_2e kt]	-52.38%

3.3.2.5 *Planned Improvements*

No improvements are planned for this sector.

3.3.2.6 *Uncertainties*

Fuel sales uncertainties are reported by the data provider (NEA) to be within 5%. The uncertainty of CO_2 emissions from domestic aviation is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5% (2006 IPCC Guidelines)), whilst the CH_4 emissions uncertainty is 100% (with an activity data uncertainty of 5% and emission factor uncertainty of 100% (highest value in the range given by the IPCC guidelines) and the N_2O emissions uncertainty is 150% (with an activity data uncertainty of 5% and EF uncertainty of 150%). The complete uncertainty analysis is shown in Annex 2.

3.3.3 Road Transport (CRF 1A3b)

Emissions from the Road Transport category is split into four subcategories:

- 1A3bi Cars
- 1A3bii Light-duty Trucks
- 1A3biii Heavy-duty Trucks and Buses
- 1A3biv Motorcycles

Emissions from Road Transport are estimated using COPERT 5.6.1. which uses a Tier 3 methodology to estimate N_2O and CH_4 emissions, and a Tier 2 methodology to estimate CO_2 emissions. All emission factors in COPERT are from the 2006 IPCC guidelines and 2019 EMEP/EEA guidebook. These factors are default in COPERT if country-specific data is not available.

3.3.3.1 *Activity Data*

Total use of diesel oil, gasoline, and biofuels in Road Transport are based on the NEA's annual sales statistics and can be found in Table 3.54.

Table 3.54 Fuel use [kt] in 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
Gas/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	NO	NO	NO	NO	NO	1.93	11.0	25.6
Hydrogen	NO	NO	NO	0.00001	0.002	NO	0.0004	0.0002

All of the biogasoline in Iceland is bioethanol and does therefore not include any fossil carbon. The team for pollution monitoring at the EAI, which is responsible for monitoring and reporting under the Fuel Quality Directive (Directive 2009/30/EC of the European Parliament and of the Council), has confirmed that before 2021, no FAME biodiesel has been imported to Iceland, only HVO. In 2021, FAME was used for this first time in Iceland and 6.8% of biodiesel was FAME, which has a fossil component. The emissions from the fossil component of biodiesel is reported as Other Fossil Fuels.

Activity Data for COPERT

A comprehensive dataset was purchased from Emisia[18], the company that develops COPERT. That data was used where country-specific data was not available.

The country-specific data that was available and used for input into COPERT was:

- Average temperature values were obtained from the Icelandic Met Office (*Veðurstofa Íslands*).
- Vehicle stock numbers for 2017-2021 were obtained from the ITA. For other years, vehicle numbers from the Emisia dataset were used.
- Measurements collected by the EAI for energy content, density, and sulphur content for fuels were used where available.
- Total fuel sales for all fuels 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.

3.3.3.2 *Emission Factors*

Emissions from Road Transportation are estimated using COPERT 5.6.1, which uses a Tier 3 methodology to estimate N_2O and CH_4 emissions, and a Tier 2 methodology to estimate CO_2 emissions. An energy balance feature in COPERT was used to ensure that emissions from all fuel sold was accounted. The emission factors can be seen in Table 3.55.

Table 3.55 Emission factors used for calculations emissions from Road Transport.

Fuel / Factor	1990-2016	2017	2018	2019	2020	2021	Note/Reference
Gasoline							
NCV [TJ/kt]	43.99	44.00	43.70	43.90	43.90	43.99	Table 1.2 2006 IPCC Guidelines, V2, Ch1 for 1990-2016, country-specific measurements from 2017.
C-content [t/TJ]	19.42	19.28	19.41	19.32	19.38	19.42	The country-specific measurement of carbon content performed in 2019 was applied to the whole timeseries. A new measurement exists for 2020.
Diesel							
NCV [TJ/kt]	42.89	43.10	43.20	43.10	42.80	42.89	Table 1.2 2006 IPCC Guidelines, V2, Ch1 for 1990-2016, country-specific measurements from 2017.
C-content [t/TJ]	20.17	20.01	19.97	20.01	20.20	20.17	The country-specific measurement of carbon content performed in 2019 was applied to the whole timeseries. A new measurement exists for 2020.

Emission factors in COPERT for CH_4 and N_2O are from Chapter *1.A.3.b.i-iv Road Transport 2019* in the 2019 EMEP/EEA Guidebook. There it can be seen that with improved technology in vehicles, the emission factor decreases, which explains the decrease in IEFs for CH_4 and N_2O over the timeseries.

Inter-annual changes are observed in the IEFs for biomass, most prominently in 2012-2015. This is due to the introduction of new biofuels into the biomass category. Before 2012, biomethane was the only

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

fuel reported as biomass. In 2012, biodiesel was introduced and has increased rapidly since then, and in 2015 bioethanol was introduced as biofuel in Iceland. These additions to the mix of biofuels used for Road Transport in Iceland affect the IEF reported for biomass, as their emission factors are different from emission factors for biomethane.

3.3.3.3 *Emissions*

Emissions from Road Transport have been steadily increasing from 1990-2007. In 2008, emissions started decreasing due to the Icelandic national financial crisis and they remained steady until 2015. Due to increased tourism, emissions started increasing again in 2016, but a drop in emissions were observed in 2020 due to the COVID pandemic. In 2021, there is a slight increase observed due to the post-pandemic economic recovery. The emissions can be seen in Table 3.56 and Figure 3.8.

Only CH_4 and N_2O emissions from biofuels are included in the national totals, whereas CO_2 emissions are reported as a memo item under CRF category 1D3.

Table 3.56 Emissions from subcategories and total emissions [kt CO_2e, calculated using GWP from AR5] from 1A3b Road Transport.

Sector	1990	1995	2000	2005	2010	2015	2020	2021
1A3bi - Passenger Cars	412.9	444.4	490.3	576.8	577.1	527.1	560.0	546.7
1A3bii - Light-duty Trucks	29.4	30.8	35.2	52.8	93.9	74.7	87.5	94.5
1A3bii - Heavy-duty Trucks and Buses	86.0	80.3	87.5	141.9	134.1	215.3	181.8	217.3
1A3biv - Motorcycles	2.38	2.55	2.69	3.45	9.40	9.66	1.29	1.14
Total [kt CO_2e]	**530.7**	**558.1**	**615.7**	**775.0**	**814.5**	**826.8**	**830.6**	**859.6**

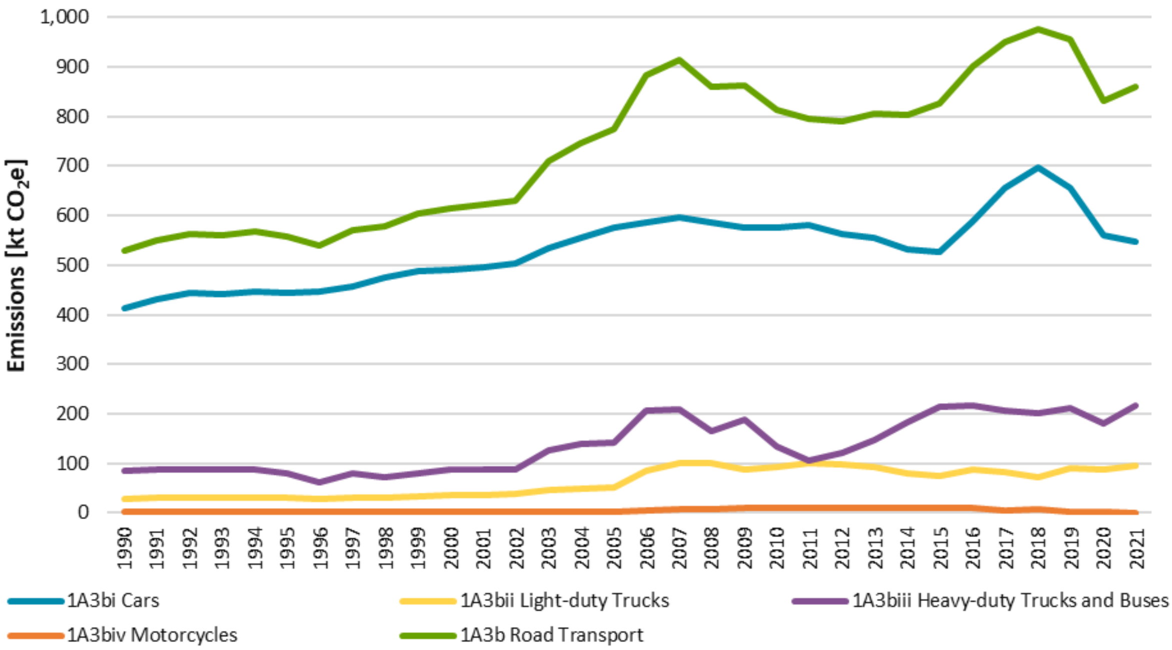


Figure 3.8 Emissions from subcategories and total emissions [kt CO_2e, calculated using GWP from AR5] from 1A3b Road Transport.

3.3.3.4 *Recalculations*

Several recalculations were done for the Road Transport sector for this submission.

The recalculation that had the most effect on emissions was because of recalculated carbon content for gasoline for the whole timeseries. Measurements have been done for carbon content in gasoline for 2019-2021. In the 2021 UNFCCC review, the ERT commented that these measurements were most likely done on blended fuel, gasoline, and biofuel. This was correct and Iceland has now calculated the carbon content in pure gasoline based on the assumption that the biofuel part has default factors of NCV and carbon content from 2006 IPPC guidelines. The fuel was a blend of 5% biofuel. As can be seen in Table 3.57, this caused an increase in carbon content in gasoline and therefore an increase in CO_2 emissions. The changes in CO_2 emissions can be seen in Table 3.58.

Table 3.57 Changes in carbon content of gasoline because of correction for biofuel blended.

% Carbon in gasoline	1990-2019	2020
2022 v4 Submission	84.89 %	85.15 %
2023 Submission	86.62 %	86.89 %

Another recalculation was due to an error found in the categorisation of L7 vehicles, which are a part of the motorcycle category. In the last submission, L7 vehicles were reported as using diesel, and missing from the inventory, which was incorrect. Now they are included and correctly reported using gasoline. That means the diesel is allocated elsewhere and now included and for motorcycles there is an increase in use of gasoline and emissions from that. For other sectors there is an increase in use of diesel which was allocated to motorcycles for last submission. This is only applicable for 2019-2020. However, a part of these recalculations were also due to the change of carbon content in gasoline, and changes in other factors which cannot be distinguished from the recalculation due to the error of L7 categorisation.

An error was also found in the km numbers for light duty vehicles for 2016-2020, where the numbers were extremely high. This was corrected which cause the km to be lower. This did not affect total emissions from 1A3b Road Transport, but it did change the allocation between vehicle categories where less fuel is now allocated to light duty vehicles and more fuel to other vehicle categories, especially passenger cars.

Several other 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 last can be seen on Emisia website[19], the company that develops COPERT.

The summary of all recalculations, separated by gases, can be seen in the table below:

Table 3.58 Summary of Road Transport recalculations done for this submission [kt CO_2e, calculated using GWP from AR5].

1A3b Road Transport	1990	1995	2000	2005	2010	2015	2018	2019	2020
CO_2 [kt CO_2e]									
2022 v4 Submission	511.7	537.1	592.7	750.8	797.1	811.2	960.8	940.5	817.0
2023 Submission	519.8	545.7	601.7	760.7	806.4	819.6	968.8	948.5	823.3
Change	8.05	8.54	8.99	9.88	9.34	8.36	8.01	8.04	6.31
CH_4 [kt CO_2e]									
2022 v4 Submission	6.25	5.65	4.22	3.32	2.40	1.87	1.71	1.41	1.14
2023 Submission	6.24	5.65	4.23	3.32	2.34	1.92	1.60	1.36	1.09
Change	-0.013	0.000	0.002	-0.007	-0.059	0.045	-0.111	-0.056	-0.048
N_2O [kt CO_2e]									
2022 v4 Submission	4.67	6.94	9.96	11.00	5.37	5.23	6.84	6.97	6.23
2023 Submission	4.65	6.83	9.81	10.92	5.69	5.31	6.68	6.88	6.20

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

1A3b Road Transport	1990	1995	2000	2005	2010	2015	2018	2019	2020
Change	-0.022	-0.107	-0.158	-0.087	0.320	0.077	-0.156	-0.095	-0.027
Total [kt CO_2e]									
2022 v4 Submission	522.7	549.7	606.9	765.2	804.8	818.3	969.3	948.8	824.4
2023 Submission	530.7	558.1	615.7	775.0	814.5	826.8	977.1	956.7	830.6
Total change [kt CO_2e]	8.02	8.44	8.83	9.79	9.61	8.48	7.74	7.89	6.23
Total change (%)	**+1.5%**	**+1.5%**	**+1.5%**	**+1.3%**	**+1.2%**	**+1.0%**	**+0.8%**	**+0.8%**	**+0.8%**

Recalculation from the 2022 Submission:

The most extensive recalculation in Road Transport between the 2021 Submission and 2022 Submission is due to a reallocation of diesel oil in Road Transport in 2014. Review by the NEA of allocation of diesel between sub-sectors of mobile combustion revealed outliers which the NEA corrected for this submission. Diesel oil utilised in mobile machinery was re-allocated to Road Transport for 2014, which caused an increase of 301 TJ which increased total emissions by 2.7% or 21 kt CO_2e. Note that figures from the 2022 Submission are based on GWP in AR4.

Emissions of N_2O from heavy duty trucks and buses due to diesel consumption has decreased total emissions by 0.0015-0.0060 kt N_2O or 0.5-2.2 kt CO_2e over the timeline (see Table 3.58). The reason for this is a change of emission factors for N_2O in COPERT for diesel in heavy duty trucks and buses. According to patch notes released by Emisia for version 5.4.52, in May 2021, there was a correction of N_2O calculations for urban buses CNG. Note that figures from the 2022 Submission are based on GWP in AR4.

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.

Table 3.59 Summary of road transport recalculations done for this submission.

Road Transport	1990	1995	2000	2005	2010	2014	2015	2018	2019
CO_2 [kt CO_2e]									
2021 v1 submission	512	537	593	751	797	767	811	961	940
2022 Submission	512	537	593	751	797	789	811	961	940
Change	-	-	-	-	-	22.14	0.00	0.00	-0.03
CH_4 [kt CO_2e]									
2021 v1 submission	5.58	5.04	3.77	2.97	2.14	1.65	1.68	1.54	1.27
2022 Submission	5.58	5.04	3.77	2.97	2.14	1.66	1.68	1.54	1.26
Change	-	-	-	-	-	0.01	0.00	0.00	0.00
N_2O [kt CO_2e]									
2021 v1 submission	5.78	8.27	11.75	13.30	7.25	6.57	7.50	9.13	10.25
2022 Submission	5.26	7.80	11.20	12.38	6.04	5.57	6.01	7.88	8.03
Change	-0.52	-0.47	-0.55	-0.93	-1.22	-1.00	-1.50	-1.25	-2.21
Total [kt CO_2e]									
2021 v1 submission	523	550	608	767	806	775	820	971	952
2022 Submission	523	550	608	766	805	796	819	970	950
Total change [kt CO_2e]	-0.52	-0.47	-0.55	-0.93	-1.22	21.15	-1.50	-1.25	-2.24
Total change (%)	**-0.10%**	**-0.09%**	**-0.09%**	**-0.12%**	**-0.15%**	**+2.73%**	**-0.18%**	**-0.13%**	**-0.24%**

3.3.3.5 *Planned Improvements*

For future submissions, further collaboration with the ITA will be needed to obtain more detailed information on vehicle stock numbers. This data would go further back in time and be split by Euro standards and driven kilometres for each vehicle category.

3.3.3.6 *Uncertainties*

Fuel sales uncertainties are reported by the data provider (NEA) to be within 5%. The CO_2 emission factor uncertainty is 2.8% which is based in the uncertainty of the carbon content measurements performed in 2020 on fuels used in road transport in Iceland. The emission factor uncertainties for CH_4 and N_2O are estimated to be 219% and 188%, respectively. The emission factor uncertainties for CH_4 and N_2O are found using Combined Uncertainty (for diesel, gasoline, and biomass) as per Equation 3.2 from 2006 IPCC GL, Vol 3 Chap 5 using uncertainty ranges in IPCC Volume 2 Chapter 3 Table 3.2.2.

The combined uncertainty of CO_2 emissions from road vehicles is 5.7%, CH_4 emissions it is 219% and for N_2O emissions from road vehicles is 188%. The complete uncertainty analysis is shown in Annex 2.

3.3.4 Domestic Navigation and Fishing (CRF 1A3d and 1A4ciii)

The Domestic Navigation sector (CRF 1A3d) includes all vessels of all flags which purchase fuel in Iceland and sail between two Icelandic harbours. The Fishing Ship sector (1A4ciii) includes all fishing ships of all flags which purchase fuel in Iceland.

3.3.4.1 *Activity Data*

1A3d Domestic Navigation: Total use of fuel for national navigation is based on NEA's annual sales statistics. Activity data for fuel combustion in Domestic Navigation are given in Table 3.60.

Table 3.60 Fuel use [in kt] in 1A3d 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

1A4ciii: Fishing: Total use of fuel for fishing is based on the NEA’s annual sales statistics to fishing vessels of all flags and all destinations (domestic and international). Activity data for fuel combustion in the Fishing sector are given in Table 3.61.

Table 3.61 Fuel use [in kt] in 1A4ciii Fishing.

	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

Fuel sales data provided by the NEA allows the correct attribution of fuel sold to fishing vessels vs. international ships for the time period 1995 to the current year. During 1990-1994 fuel sales statistics were recorded differently and fuel sold for international use was recorded without information on whether it was used for a fishing vessel or another ship. Therefore, the share of fuel use by fishing vessels had to be approximated. This was done by averaging the percentage of fuel sold to fishing vessels relative to total fuel sales over 1995 to 1999, for diesel oil and fuel oil; this percentage was then applied to the fuel sales for 1990 to 1994.

3.3.4.2 *Emission Factors*

Default C contents and oxidation factor are used, as well as default emission factors for CH_4 and N_2O (taken from the 2006 IPCC guidelines, Table 3.5.3, Volume 2, Chapter 3 for ocean-going ships). A country-specific NCV for gas/diesel oil is used from 2017 and onwards based on annual measurements, for other fuels and years a default NCV is used. These factors are presented in Table 3.62.

Table 3.62 Emission factors for CO_2, CH_4 and N_2O for ocean-going ships.

Fuel / Factor	Value	Unit	Reference
Marine Diesel Oil			
NCV	42.89*	TJ/kt	Country-specific measurements from 2012
C-content	20.11*	t/TJ	Country-specific measurements from 2012
CH_4 emission factor	7.0	kg/TJ	Table 3.5.3 2006 IPCC Guidelines, V2, Ch3
N_2O emission factor	2.0	kg/TJ	Table 3.5.3 2006 IPCC Guidelines, V2, Ch3
Residual Fuel Oil			
NCV	40.4	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	21.1	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	7.0	kg/TJ	Table 3.5.3 2006 IPCC Guidelines, V2, Ch3
N_2O emission factor	2.0	kg/TJ	Table 3.5.3 2006 IPCC Guidelines, V2, Ch3
Biodiesel			
NCV	27.0	TJ/kt	Table 1.2 2006 IPCC Guidelines, V2, Ch1
C-content	19.3	t/TJ	Table 1.3 2006 IPCC Guidelines, V2, Ch1
CH_4 emission factor	10.0	kg/TJ	Table 2.5 2006 IPCC Guidelines, V2, Ch2
N_2O emission factor	0.6	kg/TJ	Table 2.5 2006 IPCC Guidelines, V2, Ch2

*A country-specific value for 2021

3.3.4.3 *Emissions*

Emissions from ocean-going ships in Iceland is dominated by the Fishing sector. Emissions from the fishing sector has decreased by approximately a third over the time series. These emissions can be seen in Table 3.63:

Table 3.63 Emissions [kt CO_2e, calculated using GWP from AR5] from ocean-going ships.

	1990	1995	2000	2005	2010	2015	2020	2021
1A3d - Domestic Navigation	32.9	37.5	12.7	22.6	35.3	26.6	25.2	17.5
1A4ciii - Fishing	760.4	921.6	891.6	742.3	726.6	621.2	509.5	574.2
Total	**793.3**	**959.1**	**904.3**	**764.9**	**761.9**	**647.9**	**534.6**	**591.7**

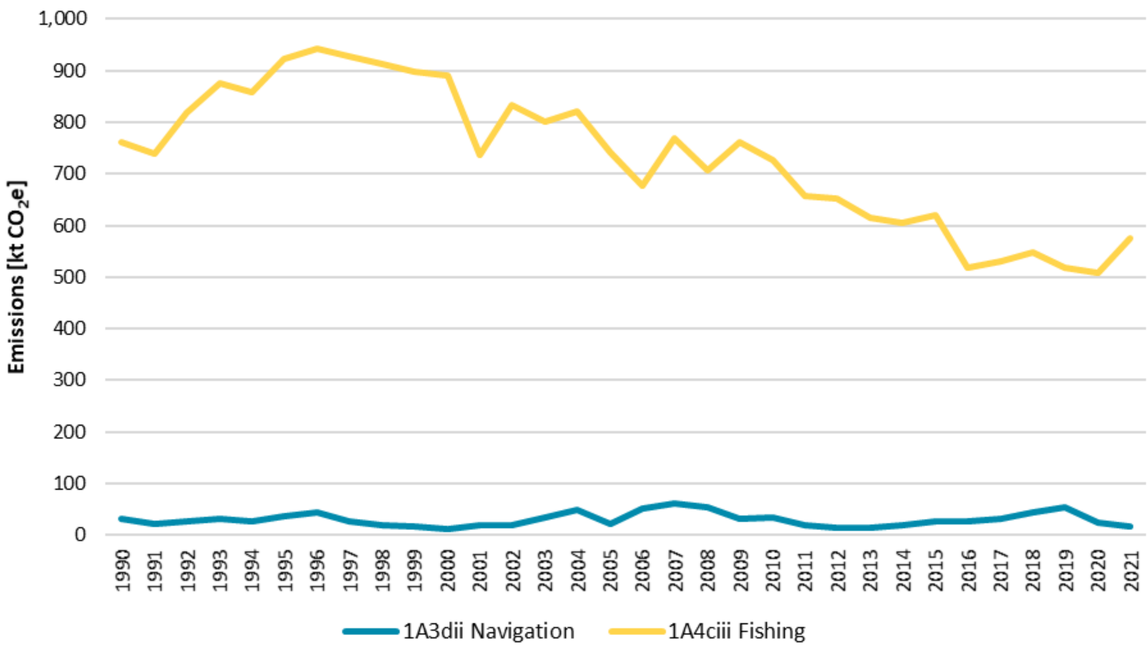


Figure 3.9 Emissions [kt CO_2e] from ocean-going ships for the whole timeseries.

3.3.4.4 *Recalculations*

1A3d Domestic Navigation

No recalculations were performed for this sector.

1A4ciii: Fishing

No recalculations were performed for this sector.

Recalculation from the 2022 Submission:

1A3d Domestic Navigation

Recalculations for domestic navigation are linked to recalculations in 1A4ciii Fishing and 1D1b International Navigation (memo). During review of the activity data and allocation of fuels in 1990-1994 for the abovementioned categories outliers were revealed. This prompted research into the allocation of fuels between these three categories by the NEA which led to reallocation of fuels between the categories. Therefore, between 27-32 kt CO_2e were withdrawn, by the NEA, from Domestic Navigation and allocated to Fishing (15-25 kt CO_2e) and International Navigation (7-16 kt CO_2e), through reallocation of gas/diesel oil and residual fuel oil, see Table 3.64. Moreover, emissions from domestic navigation were reduced by 0.000007 kt CO_2e in 2017 and 2019 due to an error correction of the NCV of biodiesel, and by 0.06-0.30 kt CO_2e throughout the timeline due to country specific measurements of carbon content in marine gasoil, see Table 3.65. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.64 Recalculations for Domestic Navigation due to reallocation of fuels.

Domestic Navigation	1990	1991	1992	1993	1994
2021 v1 Submission [CO_2e kt]	60.44	55.27	56.75	61.29	58.43
2022 Submission [CO_2e kt]	32.93	23.13	26.23	32.04	26.97
Change relative to the 2021 Submission [%]	-46%	-58%	-54%	-48%	-54%

Table 3.65 Recalculations for domestic navigation due to country-specific carbon content in marine gasoil.

Domestic Navigation	1995	2000	2005	2010	2015	2019
2021 v1 submission [CO_2e kt]	37.67	12.73	22.73	35.48	26.80	53.54
2022 Submission [CO_2e kt]	37.55	12.67	22.62	35.33	26.65	53.23
Change relative to 2021 Submission [%]	-0.3%	-0.5%	-0.5%	-0.4%	-0.5%	-0.6%

1A4ciii: Fishing

Recalculations for Fishing are linked to recalculations in 1A3d Domestic Navigation and 1D1b International Navigation (memo). During review of the activity data and allocation of fuels in 1990-1994 for the abovementioned categories outliers were revealed. This prompted research into the allocation of fuels between these three categories by the NEA which led to reallocation of fuels between the categories. Therefore, between 11-22 kt CO_2e were added to fishing, see Table 3.66. Moreover, emissions from Fishing were reduced by 0.0002-0.0006 kt CO_2e in 2013-2017 and 2019 due to an error correction of the NCV of biodiesel, and by 2-5 kt CO_2e throughout the timeline due to country-specific measurements of carbon content in marine gasoil, see Table 3.67. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.66 Recalculations for Fishing due to reallocation of fuels.

Fishing	1990	1991	1992	1993	1994
2021 v1 Submission [CO_2e kt]	746.4	717.0	800.5	862.1	848.0
2022 Submission [CO_2e kt]	760.9	739.0	818.2	875.9	859.1
Change relative to the 2021 Submission [%]	+1.9%	+3.1%	+2.2%	+1.6%	+1.3%

Table 3.67 Recalculations for Fishing due to new biodiesel NCV and country specific carbon content of marine gasoil.

Fishing	1995	2000	2005	2010	2015	2019
2021 v1 Submission [CO_2e kt]	926.4	896.9	746.4	729.9	624.2	522.2
2022 Submission [CO_2e kt]	922.1	892.2	742.7	727.0	621.6	518.7
Change relative to the 2021 Submission [%]	-0.5%	-0.5%	-0.5%	-0.4%	-0.4%	-0.7%

3.3.4.5 *Planned Improvements*

It is planned to investigate the availability of more refined data on fleet composition/engine types in order to move to a higher tier for CH_4 and N_2O this subcategory.

3.3.4.6 *Uncertainties*

Fuel sales uncertainties are reported by the data provider (NEA) to be within 5%. The uncertainty of CO_2 emissions from domestic navigation is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%), whilst the CH_4 emissions uncertainty is 50% (with an activity data uncertainty of 5% and emission factor uncertainty of 50%) and the N_2O emissions uncertainty is 140% (with an activity data uncertainty of 5% and emission factor uncertainty of 140%). The complete uncertainty analysis is shown in Annex 2.

3.3.5 International Bunkers (CRF 1D1a and 1D1b)

1D1a International Aviation (memo): This sector includes all flights to or from destinations other than Iceland which purchase fuel in Iceland.

1D1b International Navigation (memo): This sector includes all vessels of all flags which purchase fuel in Iceland and sail internationally from an Icelandic harbour.

3.3.5.1 *Activity Data and Emissions*

1D1a: International Aviation: Activity data is provided by the NEA, which collects data on fuel sales by sector. This dataset distinguishes between national and international usage. In Iceland there is one main airport for international flights, Keflavík International Airport (KEF). Under normal circumstances almost all international flights depart and arrive from KEF, except for most flights to Greenland, the Faroe Islands, and some flights by private airplanes which depart and arrive from Reykjavík Airport. Domestic flights sometimes depart from KEF in case of special weather conditions. Oil products sold to KEF are reported as international usage. The deviations between national and international usage are believed to level out. Fuel use attributed to International Aviation, and associated GHG emissions, are shown in Table 3.68.

Table 3.68 Fuel use [in kt] and resulting emissions [GHG, in kt CO_2e] from International Aviation.

	1990	1995	2000	2005	2010	2015	2020	2021
Jet Kerosene	69.4	74.6	129.2	133.2	119.5	213.7	82.9	130.7
Gasoline	0.20	0.18	0.03	0.40	0.01	0.01	NO	NO
Emissions [kt CO_2e]	221.1	237.7	410.4	424.4	379.8	679.1	263.3	415.4

1D1b: International Navigation: The reported fuel-use numbers are based on fuel sales data from the retail suppliers. Fuel data and associated emissions are shown in Table 3.69. Fuel sales data provided by the NEA allows the correct attribution of fuel sold to fishing vessels vs. international ships for the time period 1995 to the current year. However, during 1990 to 1994 fuel sales statistics were recorded differently and fuel sold for international use was recorded without information on whether it was used for a fishing vessel or another type of ship. Therefore, the share of fuel use by fishing vessels had to be approximated for 1990-1994. This was done by averaging the percentage of fuel sold to fishing vessels relative to total fuel sales over 1995 to 1999, for diesel oil and fuel oil; this percentage was then applied to the fuel sales for 1990 to 1994.

Table 3.69 Fuel use [in kt] and resulting emissions [GHG, in kt CO_2e] from International Navigation.

	1990	1995	2000	2005	2010	2015	2020	2021
Residual Fuel Oil	0.25	NO	2.00	0.44	0.08	13.25	NO	3.48
Gas/Diesel Oil	8.53	1.05	15.0	0.12	NO	33.6	24.3	35.3
Emissions [kt CO_2e]	28.1	3.37	54.4	1.75	0.25	149.1	77.9	123.7

3.3.5.2 *Emission Factors*

Emission factors for International Aviation are reported in Table 3.51 and those for International Navigation are reported in Table 3.62.

3.3.5.3 *Recalculations*

1D1a International Aviation

No recalculations were performed for this sector.

1D1b: International Navigation

No recalculations were performed for this sector.

Recalculation from the 2022 Submission:

1D1a International Aviation

Recalculations occur in international aviation in 2014. This is due to a change in activity data during a review of data by the NEA. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.70 Recalculations for 1D1a International Aviation.

International Aviation	2014
2021 v1 submission [CO_2e kt]	564.3
2022 Submission [CO_2e kt]	585.7
Change relative to 2021 Submission [%]	3.8%

1D1b: International Navigation

Recalculations for fishing are linked to recalculations in 1A3d Domestic Navigation and 1A4ciii Fishing. During review of the activity data and allocation of fuels in the 1990-1994 for the above-mentioned categories outliers were revealed. This prompted research into the allocation of fuels between these three categories by the NEA which led to reallocation of fuels between the categories. Therefore, between 7-16 kt CO_2e were added to international navigation, see Table 3.71. Moreover, emissions from international navigation were reduced by 0.02-1.2 kt CO_2e throughout the timeline due to country specific measurements of carbon content in marine gasoil which is now applied instead of the IPCC default value, see Table 3.72. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.71 Recalculations for 1D1b International Navigation due to reallocation of fuels.

International navigation	1990	1991	1992	1993	1994
2021 v1 Submission [CO_2e kt]	19.0	7.2	11.5	18.7	17.9
2022 Submission [CO_2e kt]	28.1	14.0	20.5	29.9	34.0
Change relative to the 2021 Submission [%]	48%	93%	78%	60%	90%

Table 3.72 Recalculation for International Navigation due country-specific carbon content in marine gasoil

International Navigation	1995	2000	2005	2015	2019
2021 v1 Submission [CO_2e kt]	3.4	54.7	1.8	149.8	206.8
2022 Submission [CO_2e kt]	3.4	54.4	1.8	149.2	205.6
Change relative to the 2021 Submission [%]	-1.9%	-27%	-0.2%	-61%	-116%

3.3.5.4 *Planned Improvements*

No improvements are planned for these sectors.

3.3.5.5 *Uncertainties*

Fuel sales uncertainties are reported by the data provider (NEA) to be within 5%. The uncertainty of CO_2 emissions from domestic aviation is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5% (2006 IPCC Guidelines)), whilst the CH_4 emissions uncertainty is 100% (with an activity data uncertainty of 5% and emission factor uncertainty of 100% (highest value in the range given by the IPCC guidelines) and the N_2O emissions uncertainty is 200% (with an activity data uncertainty of 5% and emission factor uncertainty of 200%). The complete uncertainty analysis is shown in Annex 2.

3.4 Fugitive Emissions and Geothermal Energy (CRF 1B)

3.4.1 Fugitive Emissions from Fuels (CRF 1B2a5)

This sector includes emissions from distribution of oil products, which in Iceland includes distribution of gasoline, jet kerosene, gas/diesel oil, residual fuel oil, and LPG.

3.4.1.1 *Emission Factors*

The emission factors are taken from Table 4.2.4 in the 2006 IPCC GL. These emission factors can be seen in Table 3.73.

Table 3.73 Emission factors for 1B2a5 Fugitive Emissions from Fuels.

Fuel / Factor	Value	Unit	Reference
Liquid Fuels			
CO_2 emission factor	2.3E-6	Gg per 1,000 m^3 total oil transported	Table 4.2.4 2006 IPCC Guidelines Tanker Trucks and Rail Cards
CH_4 emission factor	2.5E-5	Gg per 1,000 m^3 total oil transported	Table 4.2.4 2006 IPCC Guidelines Tanker Trucks and Rail Cards
N_2O emission factor	NA	Gg per 1,000 m^3 total oil transported	Table 4.2.4 2006 IPCC Guidelines Tanker Trucks and Rail Cards
LPG			
CO_2 emission factor	4.3E-4	Gg per 1,000 m^3 total LPG	Table 4.2.4 2006 IPCC Guidelines Liquefied Petroleum Gas
CH_4 emission factor	NA	Gg per 1,000 m^3 total LPG	Table 4.2.4 2006 IPCC Guidelines Liquefied Petroleum Gas
N_2O emission factor	2.2E-9	Gg per 1,000 m^3 total LPG	Table 4.2.4 2006 IPCC Guidelines Liquefied Petroleum Gas

3.4.1.2 *Activity Data and Emissions*

Emissions from distribution of oil products are estimated by multiplying the total imported fuel with emission factors. Activity data and resulting emissions are provided in Table 3.74Table 3.74 Fuel use [in kt] and resulting GHG emissions [in kt CO2e, calculated using GWP from AR5] from distribution of oil products

Table 3.74 Fuel use [in kt] and resulting GHG emissions [in kt CO_2e, calculated using GWP from AR5] from distribution of oil products.

	1990	1995	2000	2005	2010	2015	2020	2021
Gasoline	129.4	132.2	153.4	164.2	144.5	139.6	101.5	103.7
Jet Kerosene	78.7	72.3	146.5	139.4	120.4	218.3	96.0	101.6
Gas/Diesel oil	335.8	309.3	427.9	418.2	292.3	342.1	387.3	427.2
Residual Fuel Oil	106.0	151.9	64.1	62.9	93.1	105.3	0.1	3.6
LPG	1.29	1.32	1.68	2.46	2.62	2.56	2.61	2.46
Emissions [kt CO_2e]	**0.55**	**0.56**	**0.67**	**0.67**	**0.55**	**0.68**	**0.50**	**0.54**

3.4.1.3 *Recalculations*

No recalculations were performed for this sector.

3.4.1.4 *Uncertainties*

Uncertainty for the activity data (fuel sales) is estimated by the data provider (NEA) to be 5%. Emission factor uncertainties are 5% for CO_2 (2006 IPCC Guidelines default) and 100% for CH_4 (central value for the default range given in the 2006 IPCC Guidelines). When combining the AD and EF uncertainties, total uncertainty is 7% for CO_2 and 100.1% for CH_4. The complete uncertainty analysis is shown in Annex 2.

3.4.1.5 *Planned Improvements*

No improvements are planned for this sector.

3.4.2 Geothermal Energy (CRF 1B2d)

This category includes emissions from all geothermal power plants in Iceland, including (as of 2020) two power plants, one heat plant and five combined heat and power plants (CHP plants). Currently there is no disaggregation between emissions associated with district heating and those associated with electricity production. All reported emissions are from geothermal systems classified as high temperature. Emissions from direct hot water use from low-temperature geothermal resources are not thought to result in significant GHG emissions (Fridriksson Th, 2016) and are not included in the inventory.

Iceland relies heavily on geothermal energy for space heating (90%) and to a significant extent for electricity production (around 30% in the past few years). Small amounts of methane and considerable quantities of sulphur in the form of hydrogen sulphide (H_2S) are emitted from geothermal power plants.

3.4.2.1 *Activity Data*

The NEA is the agency responsible for gathering information from power companies regarding emissions of CO_2 from power plants. This information is published annually in the data repository on the NEA’s website. The values for 1969-2020 were published on 7 May 2021[20] and include data for CO_2, CH_4, and H_2S emissions from CHP plants, electric power plants, one power plant that is under construction and one heat plant.

Table 3.75 shows the electricity production with geothermal energy and the total CO_2, CH_4 (in CO_2e), and H_2S emissions (in SO_2e).

Table 3.75 Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2010	2015	2020	2021
Electricity Productions [GWh]	283	290	1,323	1,658	4,465	5,003	5,961	5,802
CO_2 emissions [kt]	61.4	82.2	153.1	118.2	189.6	163.1	174.9	175.8
CH_4 emissions [kt CO_2e]	0.22	0.22	1.02	1.28	5.12	4.42	4.32	3.95
H_2S emissions [kt SO_2e]	13.3	11.0	26.0	30.3	58.7	42.4	39.3	47.7

3.4.2.2 *Method Approach*

Degassing of mantle-derived magma is the sole source of CO_2 in geothermal systems in Iceland. CO_2 sinks include calcite precipitation, CO_2 discharge to the atmosphere, and release of CO_2 to enveloping groundwater systems. The CO_2 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 methodology used for estimating the emissions from geothermal power plants is described in the report “*Gaslosun jarðvarmavirkjana á Íslandi 1970-2009*” (e. Gas emissions of geothermal power plants in Iceland 1970-2009) (Baldvinsson, Þórisdóttir, & Ketilsson, 2011). The report describes the methodologies that the operating power companies (*Orkuveita Reykjavíkur*, *HS Orka*, and *Landsvirkjun*) use when estimating the gas emissions. The power companies use similar methodologies, e.g., calculations based on measurements of the flow of steam through the plants and analyses of the steam. All gas is assumed to go into the gas-phase upon separation of steam and liquid by the well-head and that all the gas is released into the atmosphere. *HS Orka* and *Landsvirkjun* collect

[20] https://orkustofnun.is/orkustofnun/gagnasofn/talnaefni/

samples at the well-head and at the separator-station, whereas *Orkuveita Reykjavíkur* gathers samples in the power plant. In the case of power plants that are under construction, prior to generation of electricity, the estimated emissions are based on gas release from the individual holes that are allowed to blow steam into the atmosphere prior to their harnessing into the turbines of the prospective power plant.

The NEA refers to the text of the report for further information on the methodology.

Emissions of CH_4 and H_2S are also calculated in a similar way that CO_2 is calculated, e.g., based on direct measurements. H_2S has been measured for the whole time series. Methane has been measured consistently from 2008. Based on the measurements from 2008-2016 an average methane emission factor was calculated and used for the years where no information has been provided. The emission factors used for 1990-2007 is 27.6 kg/GWh.

3.4.2.3 *Emissions*

Greenhouse gas emissions from geothermal energy production are subject to large fluctuations over the time series, reflecting geological and hydrological changes occurring during exploitation of the geothermal resource. The drivers for the trends in greenhouse gas emissions are complex and vary from one geothermal field to the next. Processes such as steam cap formation can lead to increased GHG concentrations if geothermal production taps from the steam cap, whereas concentrations are lower in the deeper part of the reservoir; furthermore, reinjection of fluids after heat extraction (fluids now poorer in dissolved gases) can lead to generally gas-poorer systems (see also Chapter 2.1 of Fridriksson et al., 2016: Greenhouse gases from geothermal power production, Technical Report 009/16 of the Energy Sector Management Assistance Program (The World Bank)).

In Figure 3.10, emissions from 1B2d Geothermal power can be seen for the whole timeline. The sharp increases in emissions in 1998 and 2006 are due to new power plants. In 1998, *Nesjavellir* started operation and in 2006 two power plants started operations, *Hellisheiði* and *Reykjanes*.

Two power plants, *Hellisheiði* and *Svartsengi*, have capturing mechanisms attached to their outgoing gas streams. The *CarbFix* project, located at the *Hellisheiði Power Station*, has been pioneering CO_2 capture and reinjection on site into the basaltic subsurface, and has proven rapid and complete reaction to calcium carbonate precipitate (Matter, et al., 2016). Reported emissions from the *Hellisheiði Power Station* have been adjusted to reflect the amount of injected CO_2. The CO_2 captured and injected can be seen in Table 3.76.

A sister project, *SulFix*, consists of separating H_2S from the stream and also reinjecting the gas into the subsurface and mineralizing on contact with the basalt host rock.

Table 3.76 Amount of CO_2 captured and injected using the Carbfix method.

	2012	2014	2015	2016	2017	2018	2019	2020	2021
CarbFix – Mineralised [kt CO_2]	0.06	2.38	3.91	6.64	10.17	12.20	9.70	11.70	7.54

At the George Olah Renewable Methanol Plant in *Svartsengi*, on the Reykjanes peninsula in southwest Iceland, Carbon Recycling International recycles part of the CO_2 emitted by *Svartsengi* and converts it to methanol, which is mostly exported (Carbon Recycling International, 2018). Emissions utilised at the George Olah Plant are not subtracted from the total emissions of the geothermal power plant in *Svartsengi*.

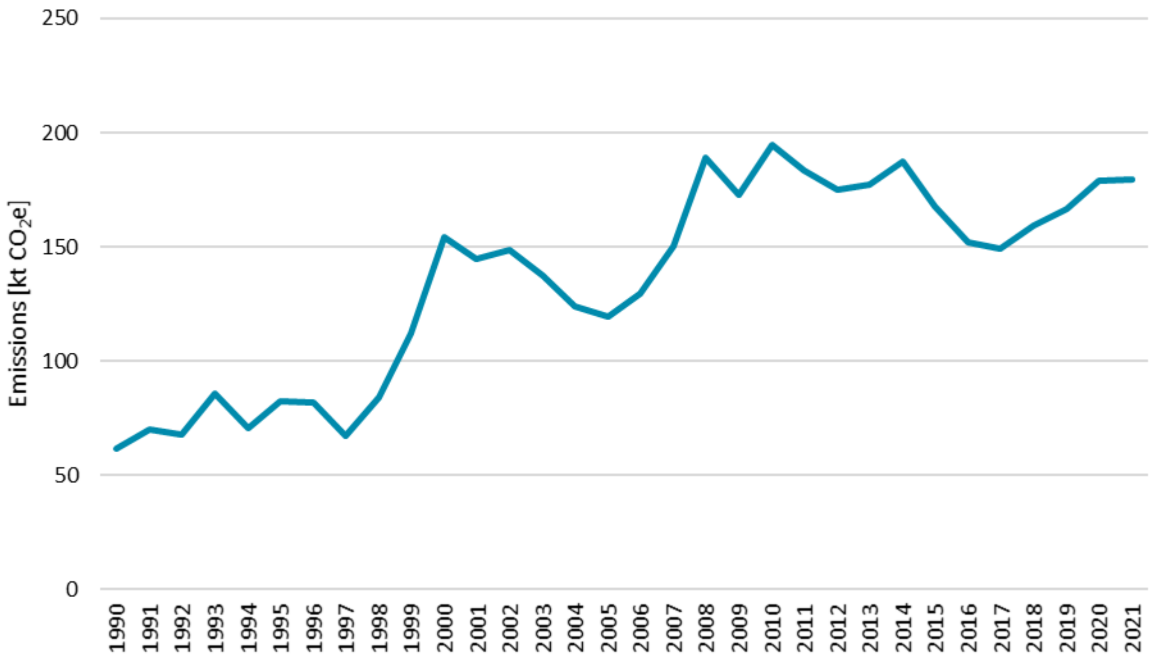


Figure 3.10 Emissions from 1B2d Geothermal Power.

3.4.2.4 *Recalculations*

Minor recalculations were performed for CH_4 emission in this sector. For 1990-2007, a calculated emission factor for CH_4 is being used because of lack of measurements. This calculated emission factor is based partly on GWh produced, and for this submission the numbers for GWh produced were updated by the NEA. This caused a minor change in the calculated emission factor for CH_4 and therefore the emissions for 1990-2007.

Table 3.77 Summary of recalculations done for this submission [kt CO_2e, calculated using GWP from AR5].

	1990	1995	2000	2005	2006	2007
2022 v4 Submission [kt CH_4]	0.0078182	0.0079638	0.0365518	0.0457367	0.0726965	0.0988931
2023 Submission [kt CH_4]	0.0078180	0.0080205	0.0365589	0.0458177	0.0727135	0.0988909
Change relative to 2022 Submission [kt CH_4]	-1.7E-7	5.7E-5	7.1E-6	8.1E-5	1.7E-5	-2.2E-6
Change relative to 2022 Submission [%]	-0.002%	+0.713%	+0.019%	+0.177%	+0.023%	-0.002%

Recalculations from the 2022 Submission:

Recalculations were performed for CH_4 emissions from geothermal power plants in 2017. This is due to a minor error in the amount of numbers after decimal for CH_4. This caused a decrease in total CO_2e emissions by 0.02 kt in 2017, see Table 3.78. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 3.78 Recalculations from geothermal due to a decimal issue

Geothermal	2017
2021 v1 submission [CO_2e kt]	149.10
2022 Submission [CO_2e kt]	149.08
Change relative to 2021 Submission [%]	-0.01%

3.4.2.5 *Uncertainties*

CO_2 and CH_4 emissions figures are provided by the NEA, who reports an uncertainty of 10% for the CO_2 values, and of 25% for the CH_4 values. The complete uncertainty analysis is shown in Annex 2.

3.4.2.6 *Planned Improvements*

The disaggregation between the emissions related to electricity production vs. district heating will be investigated in the future in collaboration with the geothermal power plant operators.

3.5 Reference Approach, Feedstocks, and Non-Energy Use of Fuels (CRF 1AB, 1AC, and 1AD)

3.5.1 Reference Approach

Emissions calculations are conducted using the Sectoral Approach (SA), which is a “bottom-up” method that relies on fuel sales statistics as gathered and provided by NEA. However, there is also the Reference Approach (RA), which uses a “top-down” method that relies national energy statistics that are collected and provided to Eurostat by the NEA. The RA is not used for reporting of emissions, but rather serves as a means to check the values obtained through the SA. According to Volume 2, Chapter 6 of the IPCC guidelines, the RA and SA should be within ±5% of each other for each fuel type.

Information regarding the acquisition of subsector-specific activity data (upon which the SA relies) can be found throughout Chapter 3, but the majority of it is provided to the EAI by the NEA. The RA relies on fuel imports, stock changes, and international navigation and aviation to calculate emissions. This data is also provided to the EAI by the NEA.

Calculations for the RA are conducted according to the 2006 IPCC guidelines and a comparison is made with the SA for each fuel type, as well as an overall aggregated comparison for all fuel types. Currently, large discrepancies exist between the two approaches for some of the reporting years, while for other years the difference between the two approaches is less than ±5% (Table 3.79).

The EAI has been, and will continue to, work with the NEA to identify the possible causes of discrepancies that are larger than ±5%. It may not be possible to identify the exact causes of discrepancies for earlier years in the timeseries, however, according to NEA, in recent years the most likely causes of discrepancies are incorrect reporting in imports by the fuel companies that provide data to the NEA; this incorrect reporting is likely due to the allocation of certain fuels to the wrong import category. It should be noted that this is not definitive and there may in fact be other causes for the discrepancies.

Table 3.79 Apparent consumption for the Reference and Sectoral Approaches.

		1990	1995	2000	2005	2010	2015	2020	2021
Liquid Fuels	Reference Approach (TJ)	23,090	25,926	26,555	26,458	24,289	22,555	19,859	21,209
	Sectoral Approach (TJ)	23,624	23,669	24,121	24,724	21,777	22,548	20,295	21,222
	Difference (%)	+2.31%	-8.71%	-9.17%	-6.55%	-10.34%	-0.03%	+2.19%	+0.06%
Solid Fuels	Reference Approach (TJ)	479.8	223.1	342.1	520.0	94.1	NO	NO	NO
	Sectoral Approach (TJ)	335.4	180.6	361.2	361.2	103.2	NO	NO	NO
	Difference (%)	-30.09%	-19.04%	+5.59%	-30.54%	+9.71%	NO	NO	NO

The aggregated discrepancy between the RA and SA for liquid fuels has exceeded the IPCC guideline of ±5% three times in the past five years, and 21 times since 1990. In 2017 and 2018, the emissions calculated using the SA were 5.8% and 8.1% higher than those calculated using the RA, respectively. In the current submission, emissions calculated using the SA were 6.7% lower than those calculated using the RA. For specific fuels, the biggest single-year differences are generally observed in jet kerosene, RFO, and LPG and these fuels are the most likely to be contributing to the aggregated discrepancies. As of this submission, the reason for the discrepancies between the RA and SA for these specific fuels is unclear, but the EAI will continue to work with the NEA to investigate.

3.5.2 Feedstock and Non-Energy Use of Fuels

Emissions from the Use of Feedstock are estimated according to 2006 IPCC Guidelines and are accounted for in the Industrial Processes sector in the Icelandic inventory. This includes all use of anthracite, coking coal, other-bituminous coal, coke-oven coke, petroleum coke, and lubricants. Previously, electrodes were reported under IPPU as well, however this has since changed to address a recommendation by the ERT that the correct consumption be reported under this sector to allow for an appropriate comparison between the RA and SA. Electrodes are now reported under 1AB Solid Fuels.

4 Industrial Processes and Product Use (CRF Sector 2)

4.1 Overview

The production of raw materials is the main source of greenhouse gas emissions related to Industrial Processes. Another significant source is the use of HFCs as substitutes for ozone depleting substances in refrigeration and air-conditioning. The dominant category within the IPPU sector is metal production where almost all of the emissions are reported under the EU ETS (Directive 2003/87/EC).

4.1.1 Methodology

GHG emissions from industrial processes are calculated according to methodologies described in the 2006 IPCC Guidelines, using the highest possible tier. For the activities reported under the EU ETS, activity data and emission factors are taken from verified EU ETS annual emissions reports. For other activities, activity data is taken from Green Accounting (according to Icelandic regulation No 851/2002) reports, sales statistics and/or import/export statistics, or directly from the operators. Detailed methodological approaches are described for each source stream individually. As specified in the 2006 IPCC guidelines, emissions reported in this chapter include all emissions resulting from the production processes themselves. All emissions resulting from the burning of fuel as a source of energy are included in the Energy sector. Table 4.1 gives an overview of the reported emissions, calculation methods and type of emissions factors. The methodologies are described under each of the CRF categories in the respective chapters.

NF_3 is reported in the Icelandic Inventory as "NO" or "NA." The Chemical Team of the EAI has confirmed that NF_3 is not used in Iceland and has not been imported as such (the Directorate of Customs registers all imported goods to Iceland). In addition, no industry potentially using NF_3 (e.g., semiconductors, LCD manufacture, solar panels and chemical lasers) is present.

Table 4.1 Reported emissions, calculation methods and type of emission factors used in the Icelandic inventory. PS: Plant specific, CS: Country specific, D: Default, OTH: Other.

CRF	Sector name	Reported emissions	Method	Emission factor
2A	**Mineral Industry**			
2A1	Cement Production (until 2011)	CO_2	Tier 2	PS
2A4d	Mineral Wool	CO_2	Tier 3	PS
2B	**Chemical Industry**			
2B10	Diatomite Production (until 2004)	CO_2	Tier 3	PS
2B10	Fertiliser Production (until 2001)	N_2O	OTH	PS
2C	**Metal Industry**			
2C1	Iron and Steel Production (2014-2016)	CO_2	Tier 1	D
2C2	Ferroalloys Production	CO_2	Tier 3/Tier 1	PS
2C2	Ferroalloys Production	CH_4	Tier 2	D
2C3	Aluminium Production	CO_2	Tier 3	PS
2C3	Aluminium Production	PFC	Tier 2	D
2D	**Non-Energy Products from Fuels and Solvent Use**			
2D1	Lubricant Use	CO_2	Tier 1	D
2D2	Paraffin Wax Use	CO_2	Tier 1	D
2D3a	Domestic Solvent Use	CO_2	Tier 2b	D
2D3b	Road paving w. asphalt	CO_2	Tier 1	D
2D3d	Coating applications	CO_2	Tier 2	D

CRF	Sector name	Reported emissions	Method	Emission factor
2D3e	Degreasing	CO_2	Tier 1	D
2D3f	Dry cleaning	CO_2	Tier 2	D
2D3g	Paint manufacturing	CO_2	Tier 2	D
2D3h	Printing	CO_2	Tier 1	D
2D3i	Other: Creosote	CO_2	Tier 2	D
2D3i	Other: Organic preservatives	CO_2	Tier 2	D
2D3i	Other: De-icing	CO_2	Tier 2	D
2D3	Urea based catalytic converters	CO_2	Tier 1	D
2F	**Product Uses as Substitutes for ODS**			
2F1a	Commercial Refrigeration	HFCs	Tier 2a	D
2F1a	Commercial Refrigeration	PFCs	Tier 2a	D
2F1b	Domestic refrigeration	HFCs	Tier 2a	D
2F1c	Industrial Refrigeration	HFCs	Tier 2a	D
2F1c	Industrial Refrigeration	PFCs	Tier 2a	D
2F1d	Transport Refrigeration	HFCs	Tier 2a	D
2F1d	Transport Refrigeration	PFCs	Tier 2a	D
2F1e	Mobile Air-Conditioning	HFCs	Tier 2a	D
2F1f	Stationary Air-Conditioning	HFCs	Tier 2a	D
2F4	Aerosols	HFCs	Tier 1a	D
2G	**Other Product Manufacture and Use**			
2G1	Use of Electric Equipment	SF_6	Tier 2	CS
2G3	N_2O from Product Use	N_2O	D	D
2G4	Other: Tobacco consumption	CH_4	Tier 2	OTH
2G4	Other: Tobacco consumption	N_2O	Tier 2	OTH
2G4	Other: Fireworks use	CO_2	Tier 2	OTH
2G4	Other: Fireworks use	CH_4	Tier 2	OTH
2G4	Other: Fireworks use	N_2O	Tier 2	OTH

4.1.2 Key Category Analysis

The key categories for 1990, 2021 and 1990-2021 trend in the Industrial processes sector are as follows (compared to total emissions without LULUCF) (Table 4.2).

Table 4.2 Key category analysis for Industrial Processes, 1990, 2021 and trend (excluding LULUCF).

IPCC source category		Gas	Level 1990	Level 2021	Trend
IPPU (CRF sector 2)					
2A1	Cement Production	CO_2	✓		✓
2B10	Fertiliser Production	N_2O	✓		✓
2C2	Ferroalloys Production	CO_2	✓	✓	✓
2C3	Aluminium Production	CO_2	✓	✓	✓
2C3	Aluminium Production	PFCs	✓	✓	✓
2F1	Refrigeration and Air Conditioning	Aggregate F-gases		✓	✓

4.1.3 Completeness

Table 4.3 gives an overview of the 2006 IPCC source categories included in this chapter and presents the status of emission estimates from all subcategories in the Industrial Process and Product Use sector. The emissions marked “Not Estimated” are possibly occurring, but no default methodology is available to calculated them.

Table 4.3 Industrial Processes - Completeness (E: estimated, NE: not estimated, NA: not applicable, IE: included elsewhere).

Sector	Greenhouse gases						Indirect Greenhouse Gases			
	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NO_x	CO	NMVOC	SO_2
2A Mineral Industry										
2A1 Cement Production (until 2011)	E	NA	NA	NA	NA	NA	NA	NA	NA	IE[5]
2A2 Lime Production	NOT OCCURRING									
2A3 Glass Production	NOT OCCURRING									
2A4a Ceramics	NOT OCCURRING									
2A4b Other Uses of Soda Ash	IE[1]	NA	NA	NA	NA	NA	IE	NA	NA	NA
2A4c Non-metallurgical Magnesium Production	NOT OCCURRING									
2A4d Mineral Wool, Ferrosilicon production	E, IE[2]	NA	NA	NA	NA	NA	NA	E	NA	E
2B Chemical Industry										
2B1 Ammonia Production (until 2001)	NA	NA	IE[3]	NA	NA	NA	IE[3]	NA	NA	NA
2B2 Nitric Acid Production	NOT OCCURRING									
2B3 Adipic Acid Production	NOT OCCURRING									
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	NOT OCCURRING									
2B5 Carbide Production	NOT OCCURRING									
2B6 Titanium Dioxide Production	NOT OCCURRING									
2B7 Soda Ash Production	NOT OCCURRING									
2B8a Methanol production (from 2012)	NA[4]	NA[4]	NA	NA	NA	NA	NA	NA	NA	NA
2B9 Fluorochemical Production	NOT OCCURRING									
2B10 Other: Diatomite Production (until 2004)	E	NA	NA	NA	NA	NA	E	NA	NA	NA
2B10 Other: Fertiliser Production (until 2001)	NA	NA	E	NA	NA	NA	E	NA	NA	NA
2C Metal Industry										
2C1 Iron and Steel Production (2014-2016)	E	NA	NA	NA	NA	NA	E	E	E	E
2C2 Ferroalloys Production	E	E	NA	NA	NA	NA	E	E	E	E
2C3 Aluminium Production	E	NA	NA	NA	E	NA	E	E	NA	E
2C4 Magnesium Production	NOT OCCURRING									
2C5 Lead Production	NOT OCCURRING									
2C6 Zinc Production	NOT OCCURRING									
2C7 Other	NOT OCCURRING									
2D Non-Energy Products from Fuels and Solvent Use										
2D1 Lubricant Use	E	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D2 Paraffin Wax Use	E	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3a Domestic solvent use	E	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3b Road paving w. asphalt	E	NA	NA	NA	NA	NA	NA	NA	E	NA

Sector	Greenhouse gases						Indirect Greenhouse Gases			
	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NO_x	CO	NMVOC	SO_2
2D3d Coating Applications	E	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3e Degreasing	E	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3f Dry cleaning	E	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3g Paint Manufacturing	E	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3h Printing	E	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3i Other: Creosote	E	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3i Other: Organic preservatives	E	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3i Other: De-icing	E	NA	NA	NA	NA	NA	NA	NA	E	NA
2D3 Urea based catalytic converters	E	NA	NA	NA	NA	NA	NA	NA	NA	NA
2E Electronics Industry	**NOT OCCURRING**									
2F Product Uses as Substitutes for Ozone Depleting Substances										
2F1a Commercial Refrigeration	NA	NA	NA	E	E	NA	NA	NA	NA	NA
2F1b Domestic refrigeration	NA	NA	NA	E	NA	NA	NA	NA	NA	NA
2F1c Industrial Refrigeration	NA	NA	NA	E	E	NA	NA	NA	NA	NA
2F1d Transport Refrigeration	NA	NA	NA	E	E	NA	NA	NA	NA	NA
2F1e Mobile Air-Conditioning	NA	NA	NA	E	NA	NA	NA	NA	NA	NA
2F1f Stationary Air-Conditioning	NA	NA	NA	E	NA	NA	NA	NA	NA	NA
2F2 Foam Blowing Agents	NOT OCCURING									
2F3 Fire Protection	NOT OCCURING									
2F4 Aerosols	NA	NA	NA	E	NA	NA	NA	NA	NA	NA
2F5 Solvents	NOT OCCURING									
2F6 Other Applications	NOT OCCURING									
2G Other Product Manufacture and Use										
2G1 Use of Electric Equipment	NA	NA	NA	NA	NA	E	NA	NA	NA	NA
2G2 SF_6 and PFCs from Other Product Uses	NOT OCCURING									
2G3 N_2O from Product Use	NA	NA	E	NA	NA	NA	NA	NA	NA	NA
2G4 Other: Tobacco consumption	NA	E	E	NA	NA	NA	E	E	E	NA
2G4 Other: Fireworks use	E	E	E	NA	NA	NA	E	E	NA	E
2H Other										
2H1 Pulp and Paper Industry	NOT OCCURING									
2H2 Food and Beverage Industry	NA	NA	NA	NA	NA	NA	NA	NA	E	NA
2H3 Other	NOT OCCURING									

[1] CO_2 emissions linked to process use of soda ash are included in 2B10 Diatomite production (Diatomite production stopped in 2004)

[2] CO_2 emissions from other process use of carbonates occur both from Mineral wool production and from carbonates used in the ferroalloy industry. Mineral wool emissions are reported under 2A4d, whereas CO_2 emissions from limestone in ferroalloy production are included in 2C2 Ferroalloy production.

[3] Ammonia was produced at the fertiliser production plant that closed down in 2001. Resulting emissions of N_2O and NO_x are reported under 2B10 Fertiliser production.

[4] Methanol production uses geothermal fluids from a near-by geothermal power plants, therefore emissions linked to this activity are reported under 1B2 Geothermal Energy.
[5] SO2 emissions were reported by the plant and included both process-related and combustion-related SO2 emissions, and these emissions are all reported under 1A2.

4.1.4 Source-Specific QA/QC Procedures

General QA/QC activities, as listed in Chapter 1.5, are performed for the IPPU sector. Further sector-specific activities include the following:

- Calculations of CO_2 and PFC emissions from activities falling under the EU ETS Directive (2003/87/EC) are cross-checked with the annual emission reports verified by accredited EU ETS verifiers (according to Article 67 of Directive 2003/87/EC) since 2013. This applies to activities within CRF categories 2.A.4.d, 2.C.2 and 2.C.3.
- Participation in a Nordic expert group on F gases, funded by the Nordic Council of Ministers, discussing, and comparing methods and parameters used by the various Nordic countries.
- Regular visits with the inspection team of the EAI to factories/companies to increase transparency, knowledge, and accuracy through active dialogue with the field.
- Review of the IPPU chapter in this NIR by external stakeholders.

4.2 Mineral Products (CRF 2A)

4.2.1 Cement Production (CRF 2A1)

4.2.1.1 *Category Description*

The single operating cement plant in Iceland was closed down in 2011. The plant produced cement from shell sand and rhyolite in a rotary kiln using a wet process. Emissions of CO_2 originate from the calcination of the raw material, calcium carbonate, which comes from shell sand in the production process. The resulting calcium oxide is heated to form clinker and then crushed to form cement.

4.2.1.2 *Methodology*

Emissions are calculated according to the Tier 2 method of the 2006 IPCC Guidelines (Equation 2.2, Volume 3, Chapter 2), based on clinker production data and data on the CaO content of the clinker. Cement Kiln Dust (CKD) is non-calcined to fully calcined dust produced in the kiln. CKD may be partly or completely recycled in the kiln. Any CKD that is not recycled can be considered lost to the system in terms of CO_2 emissions. Emissions are thus corrected with plant specific cement kiln dust correction factor.

Equation 2.2

$$CO_2 Emissions = M_{cl} * EF_{cl} * CF_{ckd}$$

Where:

- CO_2 Emissions = emissions of CO_2 from cement production, tonnes
- M_{cl} = weight (mass) of clinker production, tonnes
- EF_{cl} = clinker emission factor, tonnes CO_2/tonnes clinker; $EF_{cl} = 0.785 \times$ CaO content
- CF_{ckd} = emissions correction factor for non-recycled cement kiln dust, dimensionless

Process-specific data on clinker production, the CaO content of the clinker and the amount of non-recycled CKD are collected by the EAI directly from the cement production plant. Data on clinker production is only available from 2003 onwards. Historical clinker production data has been calculated as 85% of cement production, which was the average proportion for 2003 and 2004.

The production at the cement plant decreased slowly between 2000 and 2004. 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 significantly less than in 2007, due to the collapse of the construction sector. Late 2011 the plant ceased operation.

Table 4.4 Clinker production and CO_2 emissions from cement production from 1990-2011. The cement factory ceased its activities in 2011.

Year	Cement Production [t]	Clinker Production [t]	CaO Content of Clinker	EF_{cl}	CF_{ckd}	CO_2 Emissions [kt]
1990	114,100	96,985	63.0%	0.495	108%	51.6
1995	81,514	69,287	63.0%	0.495	108%	36.8
2000	142,604	121,213	63.0%	0.495	108%	64.4
2005	126,123	99,170	63.0%	0.495	110%	53.9
2010	33,489	18,492	63.3%	0.497	108%	9.9
2011	38,048	35,441	64.2%	0.504	110%	19.6
2012	-	-	-	-	-	-

It has been estimated by an expert at the cement production plant that the CaO content of the clinker was 63% for all years from 1990 to 2006. From 2007 the CaO content is based on chemical analysis at the plant, as presented in Table 4.4. The cement factory was undergoing rough operating conditions, leading to the closing of the factory in 2011. The cement kiln was only running for 8 weeks in 2010, while the cement grinder was active longer. This is the reason for the significant inter-annual change in the CO_2 IEF between 2010 and 2011.

4.2.1.3 *Category-specific Recalculations*

No category-specific recalculations were done for this submission.

4.2.1.4 *Category-specific Planned Improvements*

No improvements are currently planned for this category.

Uncertainties

The uncertainty on activity data is assumed 2.0% which is the higher value of range given for plant reported production data (Table 2.3, Volume 3, Chapter 2, IPCC Guidelines). The uncertainty of emission factor is 30% which is the median value of the default uncertainty for CKD (Table 2.3, Volume 3, Chapter 2, IPCC Guidelines). The combined uncertainty is 30%. The complete uncertainty analysis is shown in Annex 2.

4.2.2 Lime Production (CRF 2A2)

This activity does not occur in Iceland.

4.2.3 Glass Production (CRF 2A3)

This activity does not occur in Iceland.

4.2.4 Other Process Uses of Carbonates (CRF 2A4)

4.2.4.1 *Ceramics (CRF 2A4a)*

This activity does not occur in Iceland.

4.2.4.2 *Other Uses of Soda Ash (CRF 2A4b)*

Other use of soda ash was in diatomite production for the period 1990-2004. The emissions associated with the use of soda ash are marked as Included Elsewhere under 2A4b Other uses of soda ash and are included in the emissions reported under 2B10 Diatomite Production. Methodological description of calculations of emissions related to soda ash use can be found under 4.3.10.1 Diatomite Production (CRF 2B10a).

4.2.4.3 *Non-Metallurgical Magnesium Production (CRF 2A4c)*

This activity does not occur in Iceland.

4.2.4.4 *Other (CRF 2A4d) Mineral Wool Production, Limestone Use in Ferrosilicon Production*

Category Description

Two emission sources fall under this category, on one hand a mineral wool production plant and on the other hand limestone used in a ferroalloy production plant. Emissions from mineral wool production are reported here, whereas the emissions associated with limestone use in ferroalloy production are reported under 2C2 Ferroalloys Production, as noted as “node comment” in CRF reporter. Methodology for mineral wool production is described here, whereas the methodology used for determining GHG emissions from limestone use in ferroalloy production are described under Ferroalloys Production (CRF 2C2).

All imported goods are registered by the Directorate of Customs and subsequently by Statistics Iceland (*Hagstofa*) (SI), which indicates that there is no other recorded use of carbonates. If carbonates are imported for manufacturing artistic ceramics, for example, the quantity is negligible.

Methodology

The mineral wool production plant has a production capacity requiring it to be a part of the EU Emission Trading Scheme (EU ETS - described in Directive 2003/87/EC (“The ETS Directive”)). However, since its annual GHG emissions are low (typically ≤1 kt CO_2e/year), the plant is excluded from the EU scheme as per Article 27 of the ETS Directive (which applies to operations producing less than 25 kt CO_2e/year). According to Article 27 of the ETS Directive and Article 14a of the Icelandic climate law (Lög um loftslagsmál No 70/2012), the plant is obligated to report annual emissions to the Environment Agency in a format similar to the EU ETS operators and pays annual emission fee to the Icelandic State.

Activity data are provided by the plant (application for free allowances under the EU ETS for 2005-2010 and reporting under the EU ETS, or exemption thereof, after that). In particular, the plant provides data on electrode consumption, EF and NCV, as well as C content of shell sand. Emissions of CO_2 are calculated from the carbon content and the amount of shell sand and electrodes used in the production process. Emissions of SO_2 are calculated from the S-content of electrodes and amount (in unit of mass) of electrodes used. Emissions of CO are based on measurements performed at the plant in 2009 and Mineral Wool Production.

Emissions from the mineral wool plant were 0.93 kt CO_2e in 2021. Fluctuations in GHG emissions reflect fluctuations in annual production.

Category-specific Recalculations

No category-specific recalculations were done for this submission.

Category-specific Planned Improvements

No improvements are currently planned for this category.

Uncertainties

The uncertainty on activity data was calculated to be 2.25% based on the combined uncertainty for two source stream types as reported in the ETS 2019 annual emission reports. CO_2 emission factor uncertainty was estimated to be 1.5% according to Chapter 2, subchapter 2.5.2.1, in 2006 IPCC guidelines. The combined uncertainty is 2.7%. The complete uncertainty analysis is shown in Annex 2.

4.3 Chemical Industry (CRF 2B)

The Chemical Industry Sector is insignificant in the Icelandic inventory, with no GHG emissions reported under this sector since 2005. In the past, there were two large contributors to this sector, a fertiliser production plant, which stopped production in 2001, and a diatomite production plant, which stopped production in 2004.

4.3.1 Ammonia Production (CRF 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 2B10 Fertiliser Production. The methodology associated with ammonia Production is also described under Fertiliser Production (CRF 2B10b).

4.3.2 Nitric Acid Production (CRF 2B2)

This activity does not occur in Iceland.

4.3.3 Adipic Acid Production (CRF 2B3)

This activity does not occur in Iceland.

4.3.4 Caprolactam, Glyoxal and Glyoxalic Acid Production (CRF 2B4)

This activity does not occur in Iceland.

4.3.5 Carbide Production (CRF 2B5)

This activity does not occur in Iceland.

4.3.6 Titanium Dioxide Production (CRF 2B6)

This activity does not occur in Iceland.

4.3.7 Soda Ash Production (CRF 2B7)

This activity does not occur in Iceland.

4.3.8 Petrochemical and Carbon Black Production (CRF 2B8)

The only activity mentioned under this subsector is 2B8a Methanol Production which in Iceland started in 2012. However, methanol production in this case does not produce any GHG, since the plant is recycling CO_2 emitted from a geothermal power plant to convert it to methanol. All energy used in the plant comes from the Icelandic grid, which is generated from hydro and geothermal energy. The plant uses electricity to make hydrogen which is converted to methanol in a catalytic reaction with CO_2. The CO_2 is captured from gas released by a geothermal power plant located next to the facility (Carbon Recycling International, 2018); see also section 3.4.2 Geothermal Energy (CRF 1B2d).

4.3.9 Fluorochemical Production (CRF 2B9)

This activity does not occur in Iceland.

4.3.10 Other (CRF 2B10)

4.3.10.1 *Diatomite Production*

Category Description

One company was producing diatomite (diatomaceous earth) by dredging diatom sand from the bottom of Lake Mývatn in the north of Iceland. The silica-rich sludge was burned to remove organic material, and soda ash was used as a fluxing agent. Production ceased in 2004.

Methodology

Emissions of CO_2 and NO_x were estimated on the basis of the C-content and N-content of the sludge, and of the stoichiometric carbonate content of the soda ash. All activity data was obtained from the plant directly. CO_2 emissions from the silicic sludge derive from organic carbon and therefore are not included in the totals. CO_2 emissions that occurred from the use of soda ash in the production process are reported here (in the CRF tables, EAI uses the notation key “Included Elsewhere” (IE) under sector 2A4b Other use of soda ash). The annual CO_2 emissions ranged from 0.24 to 0.49 kt CO_2, and the annual NO_x emissions ranged from 0.31 to 0.48 kt NO_x.

Category-specific Recalculations

No category-specific recalculations were done for this submission.

Category-specific Planned Improvements

No improvements are currently planned for this category.

Uncertainties

The uncertainty on activity data was estimated to be 5% (higher end of the range suggested as general default AD uncertainty values suggested in vol. 3 chap 3 of the IPCC guidelines), and the CO_2 emission factor uncertainty was estimated to be 10%, leading to a combined uncertainty of 11%. The complete uncertainty analysis is shown in Annex 2.

4.3.10.2 *Fertiliser Production*

Category Description

A fertiliser production plant was operational until 2001 when there was an explosion at the plant. 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.

Category-specific Recalculations

No category-specific recalculations were done for this submission.

Category-specific Planned Improvements

No improvements are currently planned for this category.

Uncertainties

The uncertainty on activity data was estimated to be 5% (higher end of the range suggested as general default AD uncertainty values suggested in vol. 3 chap 3 of the IPCC guidelines), and the N_2O emission factor uncertainty was estimated to be 40%, leading to a combined uncertainty of 40.3% The complete uncertainty analysis is shown in Annex 2.

4.4 Metal Production (CRF 2C)

4.4.1 Iron and Steel Production (CRF 2C1)

The only activity under Iron and Steel Production occurring in Iceland was Steel production (2C1a).

4.4.1.1 *Steel (CRF 2C1a)*

Category Description

A secondary steelmaking facility was operating in the industrial area in Grundartangi, West-Iceland next to one ferroalloy plant and one aluminium smelter from 2014 to February 2017. Production stopped at the end of 2016 and no production is reported for 2017. The company produced steel from scrap iron and steel from the aluminium smelters, using an electric arc furnace. Carbonates and slags were added during the smelting process. The CO_2 emissions amounted between 0.34 and 0.83 kt CO_2 during the years of operation (2014-2016).

Methodology

CO_2 emissions are calculated using production data provided by the plant in their annual Green Accounting reports, and the default Tier 1 emission factor for steel production in electric arc furnaces (Volume 3, Chapter 4, Table 4.1, 2006 IPCC Guidelines). Pollutants are calculated using the Tiers 2 EFs for Electric Arc Furnaces in the 2019 EMEP/EEA Guidebook (EEA, 2019).

Category-specific Recalculations

No category-specific recalculations were done for this submission.

Category-specific Planned Improvements

No improvements are currently planned for this category.

Uncertainties

The uncertainty on activity data was estimated to be 10% (Default 2006 IPCC Guidelines), and the CO_2 emission factor uncertainty was estimated to be 25% (Default 2006 IPCC Guidelines), leading to a combined uncertainty of 27%. The complete uncertainty analysis is shown in Annex 2.

4.4.2 Ferroalloys Production (CRF 2C2)

Category description

Two factories were producing metals falling under the CRF category 2C2 Ferroalloys. 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. 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.

One company is using a submerged, three phase electrical arc furnace with self-baking Söderberg electrodes. The furnaces are semi-covered. The other is using submerged arc furnaces using pre-baked graphite electrodes.

Methodology

CO_2 emissions are calculated according to the Tier 3 method from the 2006 IPCC Guidelines (Equation 4.17 Vol. 3) based on the consumption of fossil reducing agents and electrodes (Electrodes, electrode paste, carbon blocks, coal and coke) and plant specific carbon content. Information on the carbon content of electrodes and reducing agents is provided by the plants through annual emission reports submitted within the EU ETS. Emissions from limestone calcination are calculated based on the consumption of limestone, also reported through the EU ETS, and emission factors from the IPCC Guidelines for one operating factory while the other performs laboratory analysis. The emissions are included in this sector (marked as “included elsewhere” under CRF sector 2A4d: Other process use of carbonate). The emission factor is 440 kg CO_2 per tonne limestone, assuming the fractional purity of the limestone is 1.

CH_4 emissions are calculated using the Tiers 2 defaults from the 2006 IPCC guidelines (Volume 3, Chapter 4, Table 4.8, 2006 IPCC Guidelines) using the appropriate emission factor for the different technologies used by the operators (batch-charging, sprinkle charging).

Activity data for raw materials, products and the resulting emissions are given in Table 4.5.

Table 4.5 Raw materials [kt], production [kt] and resulting GHG emissions [kt CO_2e, calculated using GWP from AR5] from the production of ferroalloys.

	1990	1995	2000	2005	2010	2015	2020	2021
Electrodes, Casings, and Paste	3.8	3.9	5.7	6.0	4.8	4.9	4.8	5.2
Carbon Blocks								
Anthracite/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								
Wood	16.7	7.7	16.2	15.6	11.3	27.2	59.9	77.9
Limestone	0.00	0.00	0.47	1.62	0.50	2.19	0.95	2.09
FeSi, Silicon Metal Production	62.8	71.4	109	111	102	118	116	133
Total Emissions [kt CO_2e]	**211**	**246**	**366**	**380**	**373**	**404**	**419**	**476**

Plant- and year-specific emission factors for CO_2 are based on the carbon content of the reducing agents, the electrodes. For the FeSi75 plant, this information was taken from the company’s application for free allowances under the EU ETS for 2005-2010. Upon request by the EAI, the company provided this information for 2000-2004 and 2011. Since 2013, this data has been obtained from the electronic reports submitted under the EU ETS and Green Accounting for both factories.

Carbon content of electrode paste, graphite electrodes, coal, coke, charcoal, limestone, and wood have been obtained from the reports submitted under the EU ETS. Earlier in the timeline carbon content of coal (anthracite), coke-oven coke and charcoal are based on routine measurements of each lot at the FeSi75 plant. These measurements are available for the years 2000 to 2013. For the years 1990 to 1999 the average values for the years 2005 to 2010 were used. Carbon content of wood is taken from a Norwegian report (*SINTEF. Data og informasjon om skogbruk og virke, Report OR 54.88*). The carbon content of the electrodes is measured by the producer of the electrodes.

The emission factors for the major source streams coal and coke are plant and year specific. The implied emission factor differs from year to year based on different carbon content of inputs and outputs as well as different composition of the reducing agents used, from 3.2 tonne CO_2 per tonne Ferrosilicon in 1998, to 3.7 tonne CO_2 per tonne Ferrosilicon in 2018. The CH_4 emission factor is the default value for FeSi75 production in furnaces operating in sprinkle-charging mode (1 kg CH_4/t product - Volume 3, Chapter 4, Table 4.8, 2006 IPCC Guidelines) and for the silicon metal plant the default value for Si-metal production in furnaces operating in Batch-charging mode (1.5 kg CH_4/t product - Volume 3, Chapter 4, Table 4.8, 2006 IPCC Guidelines).

Figure 4.1 shows the evolution of total GHG emissions from Ferroalloy production since 1990. Since 2000 the production and associated emissions have been on somewhat steady level, with a clear dip in 2008 which is due to the major financial collapse Iceland experienced that year.

The main contributor to GHG emissions is CO_2, with CH_4 only contributing to less than 1% of the emissions from ferroalloy production.

The IEF fluctuates over the time series depending on the consumption of different reducing agents and electrodes (3.2-3.7 t CO_2/t FeSi), as well as expansions and changes in production capacity in existing facilities (1996-1999) and establishments of new facilities (2017, 2018).

Category-specific QA/QC and Verification

CO_2 emissions reported in this inventory are cross-checked with the annual emission reports verified by accredited EU ETS verifiers (according to Article 67 of Directive 2003/87/EC) since 2013.

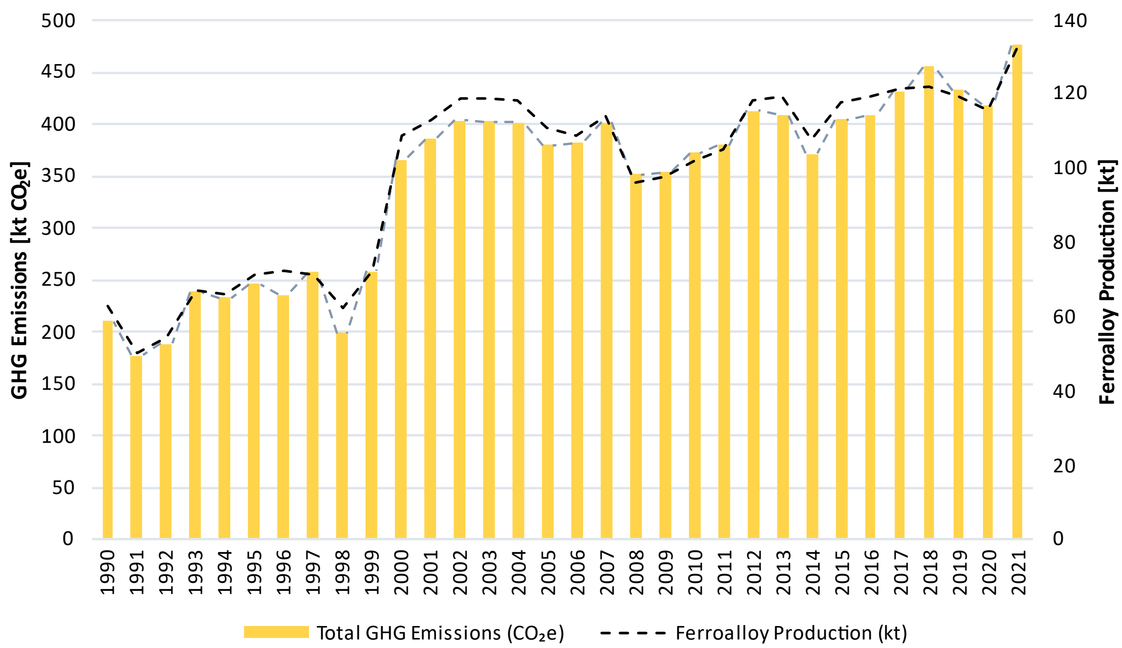


Figure 4.1 Total GHG emissions (CO_2 and CH_4) from the Ferroalloy production [kt CO_2e, calculated using GWP from AR5], and annual production [kt]

Category-specific Recalculations

Recalculations were done for 2013, 2014, and 2015. Data on C-content of coke and amount of limestone was rounded before it was used in the emission calculations. Now more significant figures are used for this data before doing the emission calculations. Also, the production amount used for methane calculations for 2015 was updated for consistency within the inventory (also rounding issue).

Table 4.6 Comparison between the 2022 v4 Submission and the 2023 Submission for CO_2 and CH_4 emissions from Ferroalloys Production (2C2) for 2013-2015.

2C2, Ferroalloys Production	2013	2014	2015
2022 v4 Submission CO_2 [kt]	406.158739	368.423	400.916
2023 Submission CO_2 [kt]	406.158740	368.428	400.918
Change relative to the 2022 Submission CO_2	+0.00000032%	+0.0012%	+0.00038%
2022 v4 Submission CH_4 [t]	0.12	0.11	0.1179487
2023 Submission CH_4 [t]	0.12	0.11	0.1179490
Change relative to the 2022 Submission CH_4	0%	0%	+0.00022%

Recalculation for the 2022 Submission:

There were two recalculations for 2019. The first recalculation is due to the industry starting to use microsilica to reduce CO_2 emissions (Table 4.7). That was not accounted for in the last submission and it only effects emissions in 2019.

Table 4.7 Comparison between the 2021 v1 Submission and the 2022 Submission for CO_2 emissions from Ferroalloys Production (2C2) for 2019.

Ferroalloys Production	2019
2021 v1 Submission CO_2 [kt]	429.8
2022 Submission CO_2 [kt]	428.8
Change relative to the 2021 Submission	-0.24%

The second recalculation concerns methane emissions and is due to human error in the emission estimation files (Table 4.8). Note that figures from the 2022 Submission are based on GWP in AR4.

Table 4.8 Comparison between the 2021 v1 Submission and the 2022 Submission for methane emissions from Ferroalloy Production (2C2) for 2019.

Ferroalloys Production	2019
2021 v1 submission CH_4 [kt CO_2e]	2.80
2022 Submission CH_4 [kt CO_2e]	3.23
Change relative to 2021 Submission	15%

Category-specific Planned Improvements

No improvements are currently planned for this category.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from ferroalloys production is 2.1% (with an activity data uncertainty of 1.5% (as given in the ETS Annual Emission Report) and emission factor uncertainty of 1.5%). It is estimated that the uncertainty of the CH_4 emission factor is 10% as suggested in the 2006 IPCC Guidelines, uncertainties for Tier 2 emission factors. In combination with above mentioned activity data uncertainty this leads to a combined uncertainty of 10.1% for CH_4. The complete uncertainty analysis is shown in Annex 2.

4.4.3 Aluminium Production (CRF 2C3)

There are four aluminium factories in Iceland, three primary aluminium producers and one secondary aluminium producer. Primary aluminium production results in emissions of CO_2 and PFCs, whereas secondary aluminium production does not generate any significant amounts of GHG in the process itself. However, in both primary and secondary aluminium production there are GHG emissions associated with the combustion of fossil fuels used as energy source, and these emissions are accounted for in the Energy chapter under sector 1A2.

4.4.3.1 *Primary Aluminium Production*

Category Description

Primary aluminium production occurs in three smelters. All three primary aluminium producers use the Centre Worked Prebaked Technology. The emissions of CO_2 originate from the consumption of electrodes during the electrolysis process, whereas PFCs (CF_4 and C_2F_6) are produced during anode effects (AE) in the prebake cells, when the voltage of the cells increases from the normal 4 - 5 V to 25 - 40 V.

All three primary aluminium operators are under the EU-Emission Trading Scheme (as per Directive 2003/87/EC) and submit annual emission reports verified by accredited EU ETS verifiers (according to Article 67 of Directive 2003/87/EC).

Activity data

The EAI collects annual process specific data from the aluminium plants, through electronic reporting forms in accordance with the EU ETS. Activity data and the resulting emissions can be found in Table 4.9 and are displayed in Figure 4.2.

Table 4.9 Aluminium Production, CO_2 and PFC emissions, IEF for CO_2 and PFC since 1990.

	1990	1995	2000	2005	2010	2015	2020	2021
Primary Aluminium Production [kt]	87.8	100	226	272	819	857	831	836
CO_2 emissions [kt]	139	154	353	417	1,238	1,300	1,261	1,272
PFC emissions [kt CO_2e]	445	62	140	29.8	160.9	95.5	85.9	88.9
CO_2 [t/t Al]	1.58	1.54	1.56	1.53	1.51	1.52	1.52	1.52
PFC [t CO_2e/t Al]	5.06	0.62	0.62	0.11	0.20	0.11	0.10	0.11
Total emissions [kt CO_2e]	**584**	**216**	**493**	**447**	**1,398**	**1,395**	**1,347**	**1,361**

CO_2 Emissions:

Emissions are calculated according to the Tier 3 method from the 2006 IPCC Guidelines, based on the quantity of electrodes used in the process and the plant and year specific carbon content of the electrodes. This information was taken from the aluminium plants' applications for free allowances under the EU ETS for 2005-2010. Upon request by the EAI, the aluminium plants also provided information on carbon content of the electrodes for all other years in which the corresponding aluminium plant was operating in the time period 1990-2012. Since 2013, the information comes from submitted data from the operators under the EU ETS. The weighted average carbon content of the electrodes ranges from 98%-99%.

PFC Emissions:

PFCs (CF_4 and C_2F_6) are produced during anode effects (AE) in the prebake cells, when the voltage of the cells increases from the normal 4 - 5 V to 25 - 40 V. Emissions of PFCs are dependent on the number of anode effects and their intensity and duration. Anode effect characteristics vary from plant to plant.

The PFCs emissions are either calculated according to the Tier 2 Slope Method, using equation 4.26 from the 2006 IPCC Guidelines (see below) with default coefficients taken from table 4.16 in the 2006 IPCC Guideline for Centre Worked Prebaked Technology, or using plant-specific emission factors for some of the operators in recent years (depending on the EU ETS requirements in this matter).

Equation 4.26

$$E_{CF4} = S_{CF4} * AEM * MP$$

and

$$E_{C2F6} = E_{CF4} * F_{C2F6/CF4}$$

Where:

- E_{CF4} = emissions of CF_4 from aluminium production, kg CF_4
- E_{C2F6} = emissions of C_2F_6 from aluminium production, kg C_2F_6
- S_{CF4} = slope coefficient for CF_4, (kg CF_4/tonne Al)/(AE-Mins/cell-day)
- AEM = anode effects per dell-day, AE-Mins/cell-day
- MP = metal production, tonnes Al
- $F_{C2F6}/_{CF4}$ = weight fraction of C_2F_6/ CF_4, kg C_2F_6/kg CF_4

GHG emissions from primary Al production have been relatively stable since 2008 (Figure 4.2). The main contributor to GHG emissions gas is CO_2, with various contributions from PFC. The PFC emissions rose significantly in 2006 due to an expansion of one facility and in 2008 which was the first full year of operations at a new facility. Total GHG emissions from the primary Aluminium sector have more than doubled since 1990 although a slight decrease in emissions has occurred in the last few years.

Category-specific QA/QC and Verification

CO_2 and PFC emissions reported in this inventory are cross-checked with the annual emission reports verified by accredited EU ETS verifiers (according to Article 67 of Directive 2003/87/EC).

Category-specific Recalculations

Recalculations were done for 2013, 2014, and 2015. Activity data (anode consumption, C-content of anodes and emissions of CF_4 and C_2F_6) was rounded when used from the aluminium plants, through electronic reporting forms in accordance with the EU ETS. Now the data with more significant figures is used.

Table 4.10 Comparison between the 2022 v4 Submissions and the 2023 Submission for CO_2, CF_4 and C_2F_6 emission from Aluminium production (2C3) for 2013-2015.

2C3, Aluminium Production	2013	2014	2015
2022 v4 Submission CO_2 [kt]	1,274.190536	1,279.505	1,299.55850
2023 Submission CO_2 [kt]	1,274.190538	1,279.504	1,299.55848
Change relative to 2022 Submission CO_2	+0.00000014%	-0.000097%	-0.0000017%
2022 v4 Submission CF_4 [t]	9.943546	11.1689631	11.69460
2023 Submission CF_4 [t]	9.943547	11.1689628	11.69463
Change relative to 2022 Submission CF_4	+0.000012%	-0.0000024%	+0.00029%
2022 v4 Submission C_2F_6 [t]	1.203169	1.3514445	1.415051
2023 Submission C_2F_6 [t]	1.203168	1.3514447	1.415054
Change relative to 2022 Submission C_2F_6	-0.00010%	+0.00001160%	+0.00026%

Category-specific Planned Improvements

No improvements are currently planned for this category.

Uncertainties

The uncertainty of CO_2 emissions is based on the ETS Annual Emission Reports and is 1.5% for activity data and 1.5% for the emission factors giving a combined uncertainty of 2.1%. For PFC the activity data has also 1.5% uncertainty and the emission factor uncertainty is 15%, following the suggestion of the 2006 IPCC Guidelines for Tier 3. This leads to a combined uncertainty of 15,1%. The complete uncertainty analysis is shown in Annex 2.

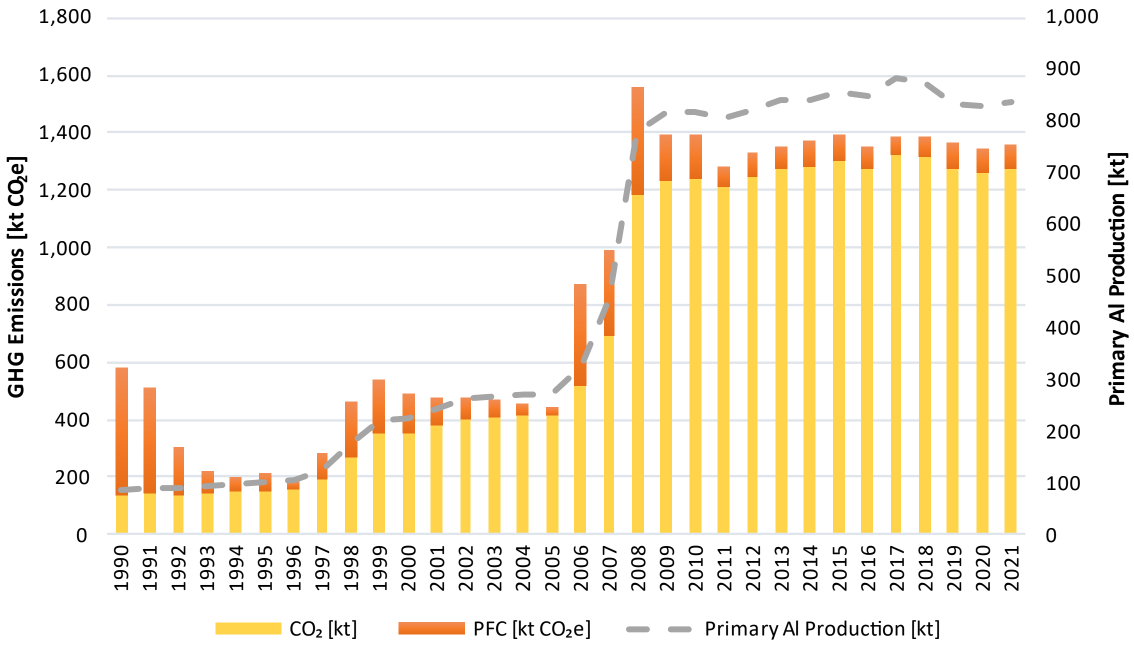


Figure 4.2 GHG emissions (CO_2 and PFC) from primary Al production [kt CO_2e, calculated using GWP from AR5], and annual production [kt].

4.4.3.2 *Secondary Aluminium Production*

Secondary aluminium production started in 2004. In 2012, another facility opened in the industrial area of Grundartangi. At the end of 2014, the first company was acquired by the second moving the production to Grundartangi. Secondary aluminium production does not lead to GHG emissions; however, it does lead to emissions of certain atmospheric pollutants which are reported under CLRTAP. Upon request during the 2019 UNFCCC desk review, the company was contacted for a clarification about the oxidation process. It is possible to affirm that the secondary aluminium industries work with two processes to prevent oxidation: one is salt-flux and in the other the slag acts as a cover for oxidation when the raw material melts. No cover gases are used for either process.

4.5 Non-Energy Products from Fuels and Solvent Use (CRF 2D)

4.5.1 Lubricant Use (CRF 2D1)

Category Description

Lubricants are mostly used in industrial and transportation applications. Lubricants are produced either at refineries through separation from crude oil or at petrochemical facilities. They can be subdivided into (a) motor oils and industrial oils, and (b) greases, which differ in terms of physical characteristics (e.g., viscosity), commercial applications, and environmental fate (IPCC, 2006).

Only CO_2 emissions are reported here. There is no default methodology currently available to estimate NMVOC emissions. Currently available activity data does not allow to separate lubricants mixed in with other fuel in 2-stroke engines from lubricants used for their lubricating properties, however the amount of lubricant used as 2-stroke engine fuel is likely to be very small. Thus, we attribute all emissions from lubricants to this category (2D1), and none to combustion in the energy sector.

Methodology

Lubricant emissions are calculated using the Tier 1 method (Equation 5.2, 2006 IPCC Guidelines) and the IPCC default Oxidised During Use (ODU) factor used when the activity data does not allow to discriminate between lubricant oils and greases. Default NCV and C contents are used (from Table 1.2 and 1.3, respectively, Chapter 1 Volume 2 of the 2006 IPCC Guidelines).

Activity data for import and export of lubricants is obtained from Statistics Iceland. Lubricant use of a given year is assumed to be the difference between imports and exports of that year.

CO_2 emissions from lubricant use have generally been following a decreasing trend since 1990: From 4.06 kt CO_2e in 1990, the emissions decreased to 1.87 kt CO_2e in 2009. Since 2010, the emissions have been rather stable between 2.1 kt and 2.5 kt CO_2e.

Category-specific Recalculations

There was recalculation for the years 2002, 2004, 2005, 2006, 2011, 2012, and 2019. The recalculation is due to updated import/export data from Statistics Iceland, see Table 4.11.

Table 4.11: Recalculations in 2D1 Lubricant Use due to updated activity data between submissions.

2D1, Lubricant Use	2002	2004	2005	2006	2011	2012	2019
2022 v4 Submission CO_2 [kt]	3.540	3.820	3.593	4.099	2.532	2.403	2.070
2023 Submission CO_2 [kt]	3.539	3.819	3.591	4.099	2.532	2.399	2.070
Change relative to 2022 Submission	-0.017%	-0.028%	-0.039%	0.008%	-0.0004%	-0.166%	0.029%

Category-specific Planned Improvements

There are no improvements planned in this category.

Uncertainties

The activity data uncertainty is 5% (Volume 3, Chapter 5.2.3.2, 2006 IPCC Guidelines) and the emission factor uncertainty is 50.1% deriving from the combined uncertainty of the C-content (3%) and the ODU-content (50%); both uncertainty values are taken from the 2006 IPCC Guidelines, vol 3, chapter 5.2.3.1. The combined uncertainty for activity data and emission factors is 50.3%. The complete uncertainty analysis is shown in Annex 2.

4.5.2 Paraffin Wax Use (CRF 2D2)

Category Description

Paraffin waxes are used in applications such as candles, corrugated boxes, paper coating, board sizing, food production, wax polishes, surfactants (as used in detergents) and many others. Emissions from the use of waxes derive primarily when the waxes or derivatives of paraffin are combusted during use (e.g., candles), and when they are incinerated with or without heat recovery or in wastewater treatment (for surfactants). In the cases of incineration and wastewater treatment the emissions should be reported in the Energy or Waste Sectors, respectively (IPCC, 2006).

According to 2006 IPCC guidelines, CH_4 and N_2O emissions are possible but no default methodology for estimating those is provided, therefore those emissions are marked as “NA“ in the CRF tables.

The emissions from Paraffin Wax Use are estimated to be 0.17 kt CO_2 in 1990 and 0.34 kt CO_2 in 2021.

Methodology

CO_2 emissions from paraffin wax use are calculated using equation 5.4 (Tier 1), Volume 3, in the IPCC 2006 guidelines.

Equation 5.4

$$\mathrm{CO_2\ Emissions} = \mathrm{PW} * \mathrm{CC_{wax}} * \mathrm{ODU_{wax}} * 44/12$$

Where:

- CO_2 emissions = emissions of CO_2 from paraffin waxes, kt CO_2
- PW = Total paraffin wax consumption, TJ
- CC_{Wax} = Carbon content of paraffin wax, tonne C/TJ
- ODU_{Wax} = “Oxidised during use”-factor for paraffin wax, fraction
- 44/12 = mass ratio of CO_2/C

For calculating the total paraffin wax consumption, PW, in energy units, the activity data given in tons are multiplied by the Net Calorific Value of 40.2 TJ/kt given in table 1.2, Vol. 2 of the IPCC 2006 guidelines. The default CCWax factor of 20.0 kg C/GJ (on a Lower Heating Value basis) and the default ODUWax factor of 0.2 (Tier 1) given in the IPCC 2006 guidelines is applied.

Since the activity data is twofold, we have the emissions both from candles and other paraffin:

1. Emissions from paraffin from candles based on net consumption of candles (import - export + production where production is zero).

2. Emissions from paraffin (without candles) based on net consumption of paraffin (without candles) (import – export + production where production is zero).

To be able to add the two, the net consumption of candles is multiplied by the factor 0.66 since not all of the candle activity data is made of paraffin:

$$PW = \left(m_{\mathrm{candles}} * 0.66 + m_{\mathrm{paraffin}}\right) * NCV$$

where $m_{candles}$ and $m_{paraffin}$ is the mass (net consumption) of candles and paraffin (without candles), respectively. The proportion of paraffin candles used is assumed to be 66%, taken from the Norwegian Inventory Report for 2021 as the activity data available in Iceland does not distinguish between paraffin candles and others.

There is no available data for the production of candles. Considering that most candles used in Iceland are imported (and therefore accounted for) only candles produced by very small local craft workshops might be missing from the estimates. According to expert judgement the amount of candles produced within the country is insignificant. Activity data for paraffin production is missing but is considered insignificant based on expert judgement.

Category-specific recalculations

There was recalculation for the years 2012 and 2019. The recalculation was due to updated import/export data of candles from Statistics Iceland, see Table 4.12.

Table 4.12: Comparison between the 2022 v4 Submissions and the 2023 Submission for CO_2 emission from Paraffin wax use (2D2) for the year 2012 and 2019.

2D2, Paraffin Wax Use	2012	2019
2022 v4 Submission CO_2 [t]	276.66	285.9320
2023 Submission CO_2 [t]	276.58	285.9324
Change relative to 2021 Submission	-0.0281%	+0.00014%

Recalculations from the 2022 Submission:

Emissions in 2019 were recalculated since the export number of candles was updated from 719 kg to 720 kg within the data from Statistics Iceland. The emissions from this subsector (2D2) was updated, see Table 4.13.

Table 4.13: Comparison between the 2021 v1 submissions and the 2022 Submission for CO_2 emission from Paraffin wax use (2D2) for the year 2019.

2D2, Paraffin Wax Use	2019
2021 v1 submission CO_2 [t]	285.9324
2022 Submission CO_2 [t]	285.9320
Change relative to 2021 Submission	-0.00014%

Category-specific Planned Improvements

There are no improvements planned in this category.

Uncertainties

The activity data uncertainty is 5% (Volume 3, Chapter 5.3.3.2, 2006 IPCC Guidelines,) and the emission factor uncertainty is combined 100.1%, deriving from a 5% uncertainty for the C-content and 100% uncertainty for the ODU-factor (Volume 3, Chapter 5.3.3.1, 2006 IPCC Guidelines). The combined uncertainty for both activity data and emission factors is therefore 100.2%. The complete uncertainty analysis is shown in Annex 2.

4.5.3 Other Non-Energy Products from Fuels and Solvent Use (CRF 2D3)

Category Description

This section describes non-methane volatile organic compounds (NMVOC) emissions from asphalt production, fossil fuel-derived solvents use and urea-based additives for catalytic converters. The various subgroups within 2D3 are taken from the 2019 EMEP/EEA Guidebook.

NMVOCs are not considered direct greenhouse gases but once they are emitted, they will oxidise to CO_2 in the atmosphere over a period of time, and the associated CO_2 emissions are considered indirect. However, in order for these emissions to count towards national totals in the CRF reporter, we are including these CO_2 inputs from the atmospheric oxidation of NMVOC in CRF Tables 2(I)s2 and 2(I).A-Hs2, following recommendations from the Working Group 1 under the European Union Climate Change Committee.

An overview of the NMVOC emissions from the individual 2D3 subcategories is given in Table 4.14 and is shown in Figure 4.3.

Methodology

NMVOC emissions are estimated according to the 2019 EMEP/EEA Guidebook (EEA, 2019), using activity data provided by Statistics Iceland unless otherwise noted in the specific subcategories below. The source category "Other non-energy Product and Solvent Use" is divided into subcategories in accordance with the EMEP/EEA Guidebook classification, as the nature of this source requires somewhat different approaches to calculate emissions than other emissions categories.

The conversion of NMVOC to CO_2 was done using the general formula provided in Box 7.2, Vol. 1 Chapter 7 of the 2006 IPCC Guidelines:

$$Inputs\ (CO_2) = Emissions_{NMVOC} * C * 44/12$$

where C is the fraction carbon in NMVOC by mass. For the subcategory "Road paving with Asphalt," C was set to 0.5, the upper range given in the 2006 IPCC guidelines for asphalt production and use for road paving (Volume 3, Chapter 5.4.4, 2006 IPCC Guidelines). For all other subcategories of 2D3, the default value of 0.6 was given (Volume 3, Chapter 5.5.4, 2006 IPCC Guidelines).

4.5.3.1 *Domestic Solvent Use Including Fungicides (2D3a)*

NMVOC emissions from domestic solvent use including fungicides (2D3a) is calculated using tier 2b methodology according to Table 3.5 in the 2019 EMEP/EEA Guidebook (EEA, 2019). Since product statistics in terms of the product types are not complete, the emission factors used for different product types that release NMVOC are in the units of g/person/year.

4.5.3.2 *Road Paving with Asphalt (2D3b)*

Asphalt road surfaces are composed of compacted aggregate and asphalt binder. Gases are emitted from the asphalt plant itself, the road surfacing operations and subsequently from the road surface. Information on the amount of asphalt produced comes from Statistics Iceland for the time period 1990 to 2011, and directly from the producers since 2012. The emission factors for NMVOC (0.016 kg/t asphalt) are taken from Table 3.1, in chapter 2D3b in the 2019 EMEP/EEA emission inventory Guidebook (EEA, 2019). 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 1A2.

4.5.3.3 *Coating Applications (2D3d)*

The EMEP/EEA Guidebook (EEA, 2019) provides emission factors based on amounts of paint applied. Data exists on imported paint since 1990 (Statistics Iceland, 2019) and on domestic production of paint since 1998 (Icelandic Recycling Fund - Úrvinnslusjóður, 2018) or written communication for the most recent reporting year. 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. The Tier 1 emission factor refers to all paints applied, e.g., waterborne, powder, high solid, and solvent based paints. The existing activity data on production and imported paints, however, makes it possible to narrow the activity data down to conventional solvent-based paints. Subsequently, Tier 2 emission factors for conventional solvent-based paints could be applied. The activity data does not permit 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.

4.5.3.4 *Degreasing (2D3e)*

The 2019 EMEP/EEA Guidebook provides a Tier 1 emission factor for degreasing based on amounts of cleaning products used. Data on the amount of cleaning products imported is provided by Statistics Iceland. Activity data consisted of the chemicals listed by the EMEP/EEA Guidebook methylene chloride (MC), tetrachloroethylene (PER), trichloroethylene (TRI) and xylenes (XYL). In Iceland, though, PER is mainly used for dry cleaning (expert judgement). In order to estimate emissions from degreasing more correctly without underestimating them, only half of the imported PER was allocated to degreasing. Emissions from dry cleaning are estimated without using data on solvents used (see below). The use of PER in dry cleaning, though, is implicitly contained in the method. In Iceland, Xylenes are mainly used in paint production (expert judgement). In order to estimate emissions from degreasing more correctly without underestimating them, 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-trichloroethane (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 as well as other composite organic solvents. The amount of imported solvents for degreasing was multiplied with the NMVOC Tier 1 emission factor for degreasing: 460 g/kg cleaning product.

4.5.3.5 *Dry Cleaning (2D3f)*

Emissions from dry cleaning were calculated using the Tier 2 emission factor for conventional closed-circuit PER machines with abatement efficiency of $\eta_{\mathrm{abatement}} = 89\%$ provided by the EMEP/EEA 2019 Guidebook. Activity data for calculation of NMVOC emissions is the amount of textile treated annually, which is assumed to be 0.3 kg/head (EEA, 2019) and calculated using demographic data. The unabated NMVOC emission factor is 177 g/kg textile treated.

4.5.3.6 *Chemical Products, Manufacturing, and Processing (2D3g)*

The only activity identified for the subcategory chemical products, manufacture and processing is manufacture of paints. NMVOC emissions from the manufacture of paints were calculated using the EMEP/EEA 2019 Guidebook Tier 2 emission factor of 11 g/kg product. The activity data consists of the amount of paint produced domestically, with data from the Icelandic Recycling Fund (2020), from yearly reports or written communication for the most recent reporting year. Data only exist from the year 1998, thus for the time before 1998 the domestically produced paint amount of 1998, which happens to be the highest of the time period for which data exists, is used for the period from 1990-1997.

4.5.3.7 *Printing (2D3h)*

NMVOC emissions for printing (2D3h) were calculated using the 2019 EMEP/EEA Guidebook Tier 1 emission factor of 500 g/kg ink used. Import data on ink was received from Statistics Iceland (Statistics Iceland, 2019).

4.5.3.8 *Other Solvent and Product Use (2D3i)*

Emissions from wood preservation (2D3i) 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). Import data on both wood preservatives was received from Statistics Iceland. In Iceland, creosotes were used from 1990 to 2010, and have been banned since 2011. Emissions from Aircraft de-icing (2D3i) were calculated using the 2019 EMEP/EEA Guidebook

Tier 2 emission factors for de-icing (53 kg/ton deicing fluid used). Data on de-icing fluid used was sent by e-mail from Icelandair/Jet Center and Airport Associates Keflavík.

4.5.3.9 *Urea-based Catalytic Converters*

Emissions deriving from the use of urea-based additives for diesel vehicles are allocated to the subcategory 2D3. Urea imports are registered at Customs Iceland and data are provided by Statistics Iceland. However, urea used as fertiliser was registered in the same category until January 2020 (see also Agriculture sector, chapter 5.11.2.2 and Figure 5.9). Customs Iceland has been contacted to correct the error in the registration which took place 2020. In order to gather the data of urea-based additives for SCR (selective catalytic reduction), the oil distributor companies in Iceland were contacted and the amount of urea-additives sold was requested. The so obtained activity data refers to the years 2008-2019. The emissions are then calculated following the 2006 IPCC guidelines, Volume 2, Chapter 3, Equation 3.2.2 as amount of urea-based additives used in catalytic converters multiplied by the purity (in this case 32.5%) and multiplied by 12/60 (stochiometric conversion from urea ($CO(NH_2)_2$) to carbon) and 44/12 (conversion from carbon to CO_2). The obtained emissions are 0.75 kt CO_2e for the year 2021 and were 0.012 kt CO_2e in 2008, the first year in which this activity is reported.

Emissions of Sector 2D3

Table 4.14 and Figure 4.3 show the NMVOC emissions from the sector 2D3 from 1990.

Table 4.14 NMVOC emissions [kt] from all sub-categories, and total emissions from subsector 2D3 [kt CO_2e] due to NMVOC.

	1990	1995	2000	2005	2010	2015	2020	2021
2D3a Domestic Solvent Use	0.625	0.657	0.687	0.723	0.782	0.810	0.896	0.908
2D3b Road Paving with Asphalt	0.003	0.003	0.005	0.005	0.004	0.003	0.004	0.004
2D3d Coating Applications	0.509	0.547	0.560	0.342	0.289	0.318	0.442	0.410
2D3e Degreasing	0.076	0.057	0.085	0.058	0.038	0.046	0.043	0.052
2D3f Dry Cleaning	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002
2D3g Paint Manufacturing	0.016	0.016	0.012	0.005	0.003	0.003	0.008	0.004
2D3h Printing	0.077	0.109	0.198	0.305	0.189	0.207	0.078	0.086
2D3i Wood Preservation	0.009	0.019	0.025	0.086	0.031	0.026	0.038	0.041
2D3i Aircraft De-icing	0.037	0.037	0.037	0.037	0.037	0.031	0.038	0.023
Total NMVOC [kt]	1.35	1.45	1.61	1.56	1.37	1.45	1.55	1.53
Total NMVOC [kt CO_2e]	**2.97**	**3.18**	**3.54**	**3.44**	**3.02**	**3.18**	**3.41**	**3.36**

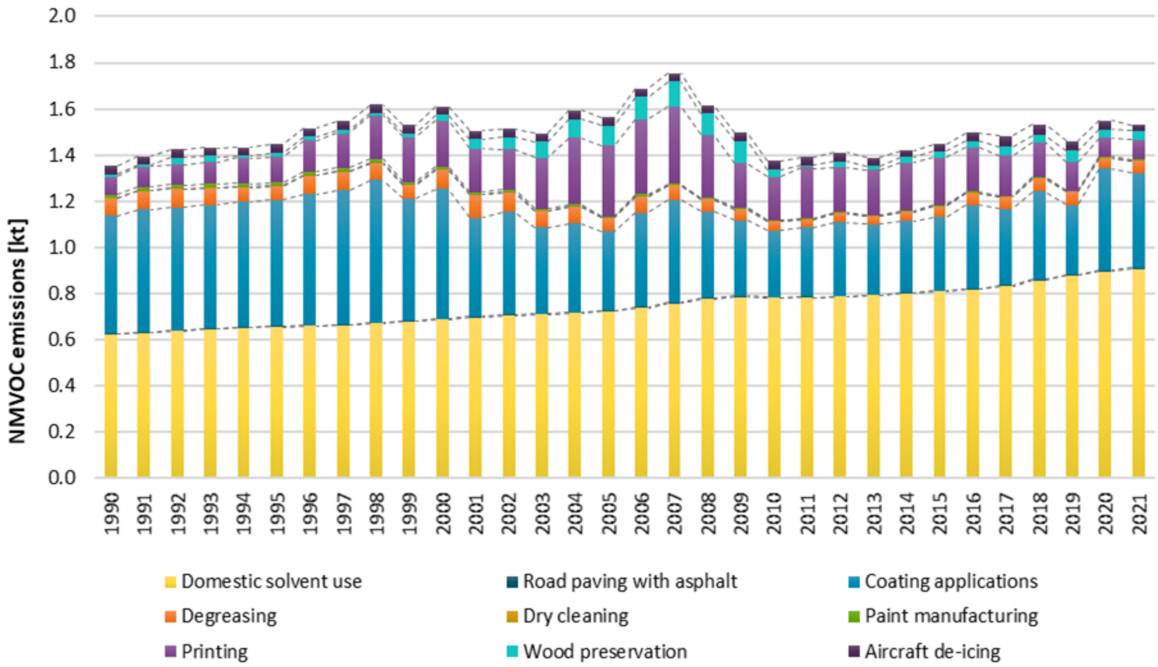


Figure 4.3 NMVOC emissions from all subgroups of Sector 2D3, other non-energy products from fuels and solvent use.

Category-specific Recalculations

Recalculation within the 2D3 subsector is due to updated data from Statistics Iceland, see Table 4.15, Table 4.16, Table 4.17, and Table 4.18. Recalculation for 2D3i, Total Wood Preservation, is only due to change in data for Organic solvent borne preservative. Aircraft de-icing was added for the first time for the 2022 Submission, see above 4.5.3.8.

Table 4.15 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 v4 Submission [t CO_2e]	1,161.402	718.36	704.56	700.19	644.00
2023 Submission [t CO_2e]	1,161.398	718.35	704.55	700.18	661.95
Change relative to 2022 Submission	-0.0003%	-0.0016%	-0.0011%	-0.0005%	+2.79%

Table 4.16 Recalculations of emissions within 2D3e (Degreasing) for 2010, 2014, and 2019 between the 2022 and 2023 Submissions.

2D3e, Degreasing	2010	2014	2019
2022 v4 Submission [t CO_2e]	83.491	81.375	128.0
2023 Submission [t CO_2e]	83.490	81.369	127.2
Change relative to 2022 Submission	-0.001%	-0.007%	-0.6%

Table 4.17 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 v4 Submission [t CO_2e]	426.37	436.00	431.25	459.59	276.94
2023 Submission [t CO_2e]	426.35	435.92	431.18	459.66	278.81
Change relative to 2022 Submission	-0.01%	-0.02%	-0.02%	+0.01%	+0.68%

Table 4.18 Recalculations of emissions within 2D3i Total Wood Preservation for 2019 between the 2022 and 2023 Submissions.

2D3i, Total Wood Preservation	2019
2022 v4 Submission [t CO_2e]	105.02
2023 Submission [t CO_2e]	104.92
Change relative to 2022 Submission	-0.10%

Recalculations from the 2022 Submission:

Recalculation within the 2D3 subsector for this submission is due to two reasons. First, the population number was updated to ensure consistency within the inventory. Since NMVOC emissions within Dry cleaning (2D3f) is calculated based on population data, there were recalculations for the whole timeline within the subsector. Second, NMVOC emissions within Domestic solvent use including fungicides (2D3a), is now calculated based on tier 2b methodology instead of tier 1 (according to the 2019 EMEP/EEA Guidebook (EEA, 2019). Table 4.19 and

Table 4.20 show the emission change due to these recalculations.

Table 4.19 Recalculations of emissions within 2D3a Domestic Solvent Use Including Fungicides between the 2021 and 2022 Submissions.

2D3a, Domestic Solvent Use Including Fungicides	1990	1995	2000	2005	2010	2015	2018	2019
2021 v1 submission [t CO_2e]	1.01	1.06	1.12	1.19	1.26	1.32	1.41	1.44
2022 Submission [t CO_2e]	1.37	1.45	1.51	1.59	1.72	1.78	1.89	1.93
Change relative to 2021 Submission	+36%	+36%	+35%	+34%	+36%	+35%	+34%	+34%

Table 4.20 Recalculations of emissions within 2D3f Dry Cleaning between the 2021 and 2022 Submissions.

2D3f, Dry Cleaning	1990	1995	2000	2005	2010	2015	2018	2019
2021 v1 submission [kg CO_2e]	3.29	3.44	3.64	3.85	4.09	4.27	4.59	4.68
2022 Submission [kg CO_2e]	3.26	3.43	3.59	3.77	4.08	4.23	4.48	4.59
Change relative to 2021 Submission	-0.8%	-0.4%	-1.5%	-2.1%	-0.3%	-1.0%	-2.4%	-2.0%

Category-specific Planned Improvements

There are no improvements planned in this category.

Uncertainties

The uncertainties for this subcategory (2D3) were calculated for each subgroup and then aggregated. The activity data is retrieved from national statistics and the uncertainty is therefore for each group 2% (except 30% for aircraft de-icing where data is retrieved from service companies) as proposed in table 2-1, chapter 5 of the General Guidance of the 2019 EMEP/EEA Guidebook. The emission factor uncertainties are derived from the upper and lower range of emission factors proposed in the 2019 EMEP/EEA Guidebook (except for urea based catalytic converters where the EF uncertainty is 5% based on 2006 IPCC Guidelines default value for CO_2). The complete uncertainty analysis is shown in Annex 2.

4.6 Electronic Industry (CRF 2E)

This CRF sector is not occurring in Iceland and therefore subcategories 2E1-2E5 are reported as NO.

4.7 Product Uses as Substitutes for Ozone Depleting Substances (CRF 2F)

4.7.1 Overview

This chapter covers HFC and PFC emissions from product use in refrigeration and air conditioning as substitutes for Ozone Depleting Substances. In Iceland hydrofluorocarbons (HFCs) are also used in refrigerants and in metered dose inhalers. HFCs substitute ozone depleting substances like the chlorofluorocarbon (CFC) R-12 and the hydrochlorofluorocarbons (HCFCs) R-22 and R-502, which are being phased out by the Montreal Protocol. PFCs are also used in some refrigeration applications, as part of HFC-containing blends, however emissions from PFCs in refrigeration applications are typically < 0.01% of the total emissions from refrigeration.

The structure of the source category 2F “Product uses as substitutes for ozone depleting substances” is shown in Table 4.21 Use of HFCs and PFCs in other sub-source categories of sector 2F is not occurring. SF_6 is used only in electric switchgear and is reported under 2G1 Electrical Equipment (see chapter 4.8.1) while NF_3 has never been used or imported to Iceland.

In this chapter the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 34 is used to label HCFCs and HFCs (ASHRAE, 1992). It consists of the letter R and additional numbers and letters. HFC and PFC notations are used later on when the R-blends have been disaggregated into their components. In the written text, HFCs and PFCs are referred to as F-gases.

Table 4.21 Source category structure of product uses as substitutes for ozone depleting substances.

GHG Source Category	GHG Sub-source Category		Further Specification	HFCs	PFCs
2F1 Refrigeration and Air Conditioning	Refrigeration	2F1a Commercial Refrigeration	Combination of stand-alone and medium & large commercial refrigeration	✓	✓
		2F1b Domestic Refrigeration	Household fridges and freezers	✓	
		2F1c Industrial Refrigeration	Food industries (fish farming, meat processing, vegetable production, etc.)	✓	✓
		2F1d Transport Refrigeration	Reefers	✓	✓
			Fishing vessels		
	2F1e Mobile Air-Conditioning (MAC)		Passenger cars	✓	
			Trucks		
			Coaches		
	2F1f Stationary Air-Conditioning		Residential and Commercial AC, including heat pumps	✓	
2F4 Aerosols	2F4a Metered Dose Inhalers (MDI)			✓	

4.7.1.1 *Legislation*

HFCs in bulk were first imported to Iceland in 1993. The use of fluorinated gases was regulated in 1998 with the implementation of Icelandic regulation No 230/1998 (Regulation on substances contributing to greenhouse effect) banning the import, production, and sale of HFCs for other uses than in refrigeration systems, air conditioning and in drugs (metered dose inhalers). This regulation was later repealed by Icelandic regulation No 834/2010 (Regulation on fluorinated greenhouse gases). Regulation No 834/2010 is to a large extent an implementation of regulation (EC) No 842/2006 as dictated by the EEA agreement. However, in accordance with article 9 in the EU regulation, states that had adopted stricter national measures were allowed to maintain those measures until 31 December 2012. In light of this, Regulation No 834/2010 banned production, import and sale of HFCs or products containing HFCs with the exception of HFCs used in refrigerants, air conditioning equipment and in metered dose inhalers (MDIs). The regulation thus implied a ban of HFC use as foam blowing agent and HFC contained in hard cell foams imported (2F2), its use in fire protection (2F3), as aerosols (2F4) (with the exception of metered dose inhalers), and as solvents (2F5).

As per the transitional provisions described above the bans of production, import and sale of HFCs were only allowed to reach to the year 2013 and have not been re-established. From 2013, article 9 (and Annex II) of regulation (EC) 842/2006 states which products and equipment are prohibited. Instead of import and sale ban with exceptions, there was now a list of those products and equipment prohibited. Icelandic regulation 1279/2018 amends 834/2010 by implementing import quotas according to the Kigali amendment for the phasing out of the use of F-gases, taking effect in 2019.

All previous regulations were repealed with regulation 1066/2019 (Regulation about fluorinated greenhouse gases) which combines regulations 834/2010, 1279/2018 and institutes the European F-gas regulation (EU) No 517/2014 into the Icelandic system. Article 11 (and Annex III) of regulation (EU) 517/2014 states which products and equipment are prohibited to place on the market (incl. foams with HFC with high GWP, use in fire protection, aerosols for entertainment and decorative purposes). In 2019 a tax scheme was established with act No. 135 from 18 December 2019 (Act on amendments to various laws regarding the budget for 2020), chapter 18, putting a tax on the import of F-gases (blends and species) according to their global warming potential.

4.7.2 Refrigeration and Air Conditioning (CRF 2F1)

HFCs are used either as single compounds, or in blends. The most used HFCs are HFC-125, HFC-134a, and HFC-143a. They are imported in bulk, as part of blends and in equipment such as domestic refrigerators, vehicle air conditionings and reefers. All other HFCs are imported in bulk only, either as single compounds or as parts of blends. In the case where HFC blends are used, the individual components are calculated using the blend ratios shown in Table 7.8, Volume 3, Chapter 7 of the 2006 IPCC guidelines. Since 2001, two blends containing PFCs (R412A and R508B) have been used in Iceland.

Refrigeration and Air Conditioning is a significant sector in Iceland, as it is by far the largest source of emissions in the IPPU sector when considering the sources outside of the EU ETS.

Methodology

Emissions for the refrigeration and air conditioning sector are estimated using the Tier 2a methodology from the 2006 IPCC Guidelines, using Emission Factors (EF) and other calculation factors from the default range (Volume 3, Chapter 7, Table 7.9, 2006 IPCC Guidelines). For the 2020 submission the Icelandic estimation model was reworked completely based on the information provided in the 2019 IPCC Refinements of the guidelines.

The calculation method applies a mixed model between defined amount of imported F-gases which are yearly reported and registered by EAI and other data from which the use of F-gases is only inferred, that is (a) number of cars with MACs, b) number of imported domestic refrigeration appliances, c) units of reefers charged with a defined amount. This leads to imbalances between the actual imported amount and the calculated use which requires some data modelling to even out imported and used amounts. The total imported amounts of R134a over the whole timeline is also compared to what is calculated to be filled due to emissions from MAC and reefers. If the total timeseries import is lower, then the data is adjusted in a way that the usage is capped at the total import. See below. That could lead to a change in the IEF (Product life factor) within 2F1d and 2F1e.

The main equations used in the Icelandic estimation model are the following:

Equation 7.4

$$Total\ Emissions = Assembly/Manufacture\ Emissions + Operation\ Emissions + Disposal\ Emissions$$

Where:

- Assembly or Manufacture emissions include the emissions associated with product manufacturing or when new equipment is filled with chemical for the first time.
- Operation emissions include annual leakage or diffusion from equipment stock in use as well as servicing emissions.
- Disposal emissions occur when the product or equipment reaches its end-of-life and is decommissioned and disposed of.

Equation 7.12

Sources of Emissions when charging new equipment

$$E_{\mathrm{charge},t} = M_t * \frac{k}{100}$$

Where:

- $E_{charge,t}$= emissions during system manufacture/assembly, in year t, kg
- M_t= amount of HFC charged into new equipment per year t, kg
- k= emission factor of assembly losses of HFC charged into new equipment, percent

Equation 7.13

Sources of Emissions during equipment lifetime

$$E_{\mathrm{lifetime},t} = B_t * \frac{x}{100}$$

Where:

- $E_{lifetime,t}$= emissions during system operation, in year t, kg
- B_t= amount of HFC banked in existing systems in year t, kg
- x= emission factor of each bank during operation, percent

Equation 7.14

Emissions at end-of-life

$$E_{\mathrm{end-of-life},t} = M_{t-d} * \frac{p}{100} * \left(1 - \frac{\eta_{\mathrm{rec,d}}}{100}\right)$$

Where:

- $E_{end\text{-}of\text{-}life,t}$= emissions at system disposal, in year t, kg
- M_{t-d}= amount of HFC initially charged into new system installed in year (t-d), kg
- p= residual charge of HFC in equipment being disposed, percentage of full charge
- $\eta_{rec,d}$= recovery efficiency at disposal, ratio of recovered HFC referred to the HFC contained in the system, percent

The annual refrigeration bank of year y is calculated following the example from the 2019 IPCC Refinements (Box 7.2B) as $Bank_y = Bank_{y-1} + Addition_y - Removal_y$. These equations are applied for each subcategory with exception of the Mobile Air Conditioning, which follows the calculation procedure from Chapter 7.5.2.4 of the 2019 IPCC Refinements (Vol. 3, Chapter 7).

Recovery is calculated as the difference between the amount remaining in products at decommissioning minus disposal emissions. In the case of mobile A/C no recovery is calculated as there is no data on recovery upon disposal of cars, coaches, and trucks.

Activity Data

Input data comes from different sources:

- Environment Agency (EAI), Team Chemicals, providing yearly bulk import data of F-gases as declared by the industry
- Two logistic companies using reefers, providing the yearly amount of reefers using F-gases (for 2F1d Transport).
- The Transport Authority (Samgöngustofa) which provides numbers of first registrations of cars (for 2F1e Mobile ACs) and country of previous registration for used cars imported.
- Statistics Iceland provides the amounts of imported domestic appliances (fridges, freezers) registered at the Directorate of Customs (2F1b Domestic Refrigeration).

In order to allocate the blends/species to the subcategories the following assumptions are made:

- All R-407C and R-410A goes to 2F1f Stationary AC as suggested by the 2006 IPCC Guidelines
- HFC-134a and R404A from reefers (2F1d Transport) are calculated from the information provided from the logistics company (either data about yearly refill or number of reefers in their use with refill rate)
- HFC-134a from MAC (2F1e) is calculated (applying the calculation procedure from the 2006/2019 IPCC Guidelines, Chapter 7, Vol. 3)
- A comparison is made between (A) the sum of assumed emissions from stock of R134a from MAC and reefers within a specific year and (B) the sum of the assumed stock available at the beginning of the year and the import of the year. If (A) is larger than (B) than (A) is reduced in a way that the stock at the end of the year is zero. The reduction of emissions from stock is proportionally the same for MAC and reefers. This way the total amount of emissions does not exceed the total amount of import.
- The calculated amounts of HFC-134a and R404A from Reefers and MACs are subtracted from the total imported amount of that species/blends. If the import of R404A is none, the calculated amount is manually adjusted to zero for consistency.
- Using all assumptions above and the bulk import amount as communicated from the Environment Agency, Team Chemicals, the remaining blends are distributed over the categories by applying the following percentages of use for the years 1990-2012:
    - 15% Commercial Refrigeration
    - 20% Industrial Refrigeration
    - 65% Transport minus Reefers

  After 2012 the percentages are species specific. For the year 2020 they are presented in Table 4.22. For the years between 2012 and 2020 they change linearly from the 2012 to the 2020 values.

Table 4.22 Distribution of unallocated blends, the share in 2020.

Distribution of Unallocated Blends, 2020 share	2F1a	2F1c	2F1d
HFC-125	32%	52%	16%
HFC-143a	40%	44%	16%
HFC-134a	23%	55%	22%
HFC-32	6%	77%	17%
HFC-23	0%	100%	0%
HFC-227ea	0%	100%	0%
C_2F_6	0%	100%	0%

The percentages of use derive from surveys carried out among service providers and importers of F-gases. For the newest survey (2021) all importers returned a spreadsheet to the EAI with information about the distribution of each blend between these sectors. The distribution is based on sale numbers. Since parts of the sales were to service providers of F-gases, the EAI has also managed to get information from some of the service providers. After analysing the data, the EAI now has a distribution of the F-gas usage for by each blend and therefore species. There were no sales of blends with HFC-152a and C_3F_8 in 2020 which is consistent with import data that show that the last import took place in 2009.

Figure 4.4 gives an overview of the imported bulk amounts of F-gases since 1990 as registered by the Chemical Team of the Environment Agency. The drop in import between 2019 and 2021 can partly be explained by stricter measures to decrease the use of F-gases (tax and import quota) and partly due to the possibility that companies did stock up in 2018 before the new import quota took place. Pre-charged equipment is not included in this data, but separate surveys about the type and number of equipment sold were carried out by contacting the biggest service providers in Iceland. Pre-charged equipment is included in Commercial refrigeration (2F1a) and consists of commercially used refrigeration and freezing units used in industrial kitchens and supermarkets for example. The sharp peak in the import amounts of 2018 can be explained by the onset of the import quota from the year 2019 (see 4.7.1.1 Legislation).

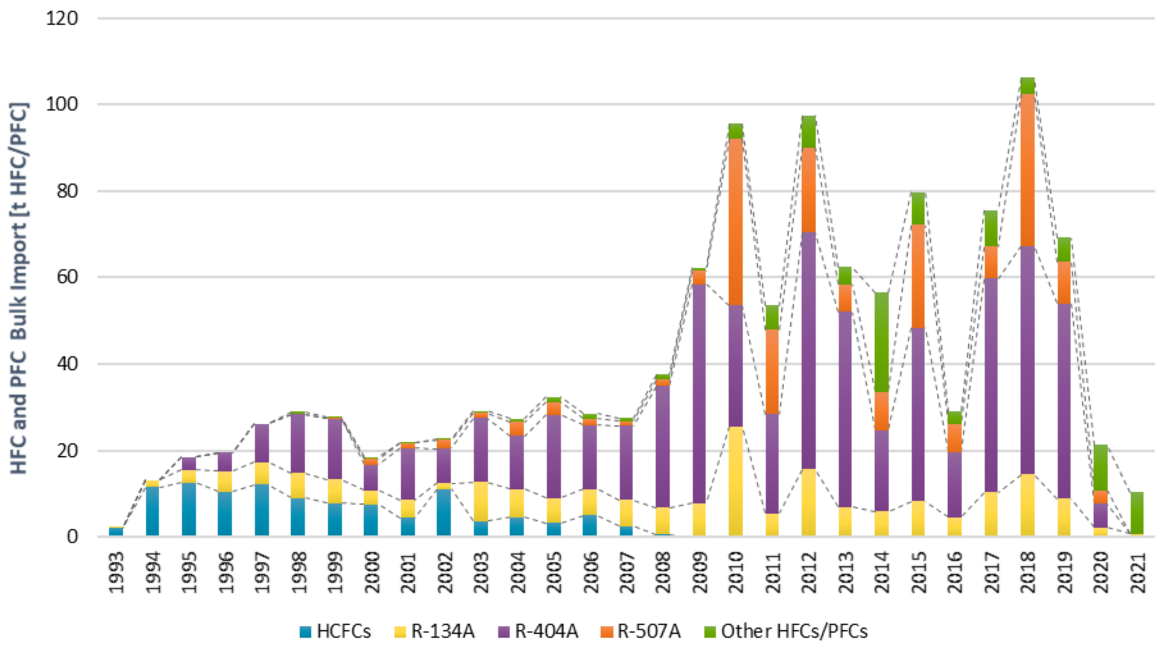


Figure 4.4 Quantity of F-gases imported in bulk to Iceland since 1993

Domestic Refrigeration 2F1b

Based on expert judgement it is assumed that all domestic refrigerators imported to Iceland from the US since 1993 contain R-134A as refrigerant whereas refrigerators from elsewhere contain non-HFC refrigerants. Data about the import amounts are collected from Statistics Iceland based on the imports registered by the Directorate of Customs. The average charge per refrigerator is estimated at 0.25 kg. This estimation is in line with the range given by the 2006 IPCC Guidelines, or 0.05-0.5 kg (Volume 3, Chapter 7, Table 7.9, 2006 IPCC Guidelines). It is also assumed that all equipment is coming pre-charged to the country, resulting in “NO” for assembly emissions.

Transport Refrigeration 2F1d

Transport refrigeration is calculated on a disaggregated level. On the one side, the emissions from the use of reefers, which are only using R-134A and R-404A are accounted for. Reefers come to Iceland already prefilled, therefore emissions arise only from the yearly servicing operations and assembly/first filling emissions are “NO.” Information on the number of reefers in stock along with information on the sort of refrigerants contained in them was obtained from major stakeholders. During the 1990s R-12 in reefers was replaced by R-134A. Today reefers contain either R-134A or R-404A. The average refrigerant charge per reefer is 6 kg for R134A and 4 kg for R404A refrigerant. No information about recovery or disposal emissions are available, therefore these emissions are “NE.”

Refrigeration systems on-board fishing ships are fundamentally different from systems on land regarding their susceptibility to leakage. Therefore, they are allocated to transport refrigeration. The lifetime of systems on-board fishing ships does, however, resemble the equipment in industry and is therefore longer than for usual transport refrigeration. Two experts from the fishing industry were contacted and confirmed that the lifetime of refrigeration systems on-board fishing ships is more similar to equipment in industry. The commercial fishing industry is one of Iceland’s most important industry sectors, yielding total annual catches between one and two million tonnes since 1990. Directly after catch and processing, fish is either cooled or frozen and shipped to the market. A substantial part of the Icelandic fleet replaced refrigeration systems that used CFCs and HCFCs as refrigerants with systems that use ammonia. Some ships, especially smaller ones, retrofitted their systems with HFCs because the additional space requirements of ammonia-based systems exceeded available space. The phase of retrofitting and replacing refrigerant systems in the fishing industry is still on-going. A ban of importing new R-22 became effective in 2010 and a total ban on R-22 import has been in effect since 1 January 2015. Therefore, R-22 refrigerant systems are obsolete as the refrigerant is no longer available and its use for repairs and servicing is prohibited.

Mobile Air Conditioning 2F1e

To derive activity data pertaining to mobile air-conditioning (MAC), information on the first registration of vehicles was obtained from the Iceland Transport Authority. This data consisted of annual information dating back to 1995 on the number of registered vehicles subdivided by vehicle classes and their first registration year. Vehicle classes were aggregated based on estimated refrigerant charges:

- EU classes M1, M2, and N1: default value of 0.8 kg for passenger cars
- EU classes N2 and N3 (trucks): default value of 1.2 kg for trucks
- EU class M3 (coaches): country specific value of 10 kg (expert judgement)

The information on vehicles' first registration years was used to estimate the number of vehicles equipped with (R-134A containing) MACs. Based on a study by the EU (Schwarz, et al., 2012) it is assumed that 80% of all vehicles manufactured (since 2010) contain MACs. This value was reduced linearly to 5% in 1995, the first year in which the automobile industry used R-134A in new vehicles.

According to data obtained from the largest car importers in Iceland in 2020, all vehicles imported by them in 2019 had R-1234yf as a coolant. This development started in 2016 in response to the European Directive on MACs (Directive 2006/40/EC) which introduces a gradual ban of F-gases in passenger cars. Data from the Transport Authority shows that 3% of newly registered vehicles in Iceland in 2019 were imported from outside of Europe by individuals, mostly from North America, where R134a is still in use. Therefore, we assume a linear decrease of newly registered vehicles containing R134a from 80% in 2015 to 3% to 2019. The same percentage is used onwards after 2019.

Vehicles come to Iceland already pre-charged and therefore no emissions occur from manufacturing/assembly.

At decommissioning of vehicles, the remaining F-gases in the system are not collected, therefore recovery is reported as “NO.”

Emission Factors

All emission factors applied in the different subcategories are shown in Table 4.23. They are taken from the 2006 IPCC Guidelines (Volume 3, Chapter 7, Table 7.9, 2006 IPCC Guidelines), taking into consideration Icelandic conditions and variations over the time series (such as the operation emission factor in transport refrigeration-fishing vessels).

Table 4.23 Values used for charge, lifetime and emission factors for stationary and transport refrigeration equipment and mobile air conditioning.

Application	HFC Charge [kg/unit]	Lifetime n [years]	Initial EF - k [% of initial charge]	EF Equipment in Use - x	End-of-life EF z [% recovery efficiency]
Domestic Refrigeration	0.25	12	NO	0.3%	70%
Commercial Refrigeration1	NE	8	2%	10%	70%
Transport ref.: Reefers	4 (404a) & 6 (134a)	NE	NO	15% until 2015 and 10% since 2016	NE
Transport ref.: Fishing Vessels	NE	15[2]	2%[2]	Linear decrease from 50% in 1993 to 20% in 2012; 20% since 2012	70%
Industrial Refrigeration	NE	15	2%	10%	85%
Residential AC	NE	12	1%	3%	75%
MAC: Passenger Cars	0.8	14	NO	10%	0%
MAC: Trucks	1.2	14	NO	10%	0%
MAC: Coaches	10	14	NO	10%	0%

[1] Stand-alone and medium & large commercial refrigeration are combined in Commercial Refrigeration.

[2] The lifetime and initial EF of transport refrigeration equipment on fishing vessels is outside the range in the guidelines for transport. Expert judgements from some of the major fishing companies led to revaluation of the lifetime. The lifetime is the lower value of the range in the 2019 Refinements for Industrial Refrigeration (for developed countries). The main reason is that the nature of the equipment on fishing vessels resembles the equipment in industry.

The lifetime for domestic refrigerators is at the lower end of the range given by the 2006 IPCC Guidelines, the lifetime EF and the efficiency of recovery at end of life are also 2006 IPCC Guidelines default values. Initial emissions are not occurring as domestic refrigeration equipment's are assembled prior to import. The same applies for MACs and reefers until 2015. Since data logistics companies imply a lower leakage proportion for recent years, it is assumed to be 10% since 2016. and MACs. The lifetime of transport refrigeration equipment on fishing vessels is 15 years which is outside the range in the guidelines for transport. Expert judgements from some of the major fishing companies led to revaluation of the lifetime. That is the lower value of the range in the 2019 Refinements for Industrial Refrigeration (for developed countries). The lifetime of equipment on fishing vessels is now the same as the lifetime of industrial refrigeration in the inventory. The main reason is that the nature of the equipment on fishing vessels resembles the equipment in industry.

Transport refrigeration equipment on fishing vessels, commercial and industrial refrigeration equipment as well as residential ACs are assembled on site and are therefore attributed with initial EFs. These initial EFs as well as lifetimes for other sub-source categories are taken from the ranges given in the 2006 IPCC Guidelines default values (Volume 3, Chapter 7, Table 7.9, 2006 IPCC Guidelines). Stand-alone and medium & large commercial refrigeration are combined into one sub-source. Both commercial and industrial refrigeration lifetime EFs are estimated at 10%. Thus, they are in the lower half of the ranges given by the 2006 IPCC Guidelines (both commercial applications together have a lifetime EF range from 1-35%). The value was chosen based on information from the poll of the Icelandic refrigeration sector mentioned above.

Leakage on shipping vessels has decreased considerably in the last decades. This is mainly a consequence of the higher prices of HFC refrigerants compared to the prices of their predecessors. Higher refrigerant prices make leakage detection and reduction more feasible. The employments of leak detectors and routine leakage searches have become common practice on fishing vessels. Therefore, it can be assumed that the lifetime EF of shipping vessels has decreased since the introduction of HFCs. The lifetime EF of shipping vessels for the beginning of the period is assumed to be at the upper end of the range for transport refrigeration (50%). This EF is lowered linearly to 20% in 2012, which equals 1.6% decrease each year. The latter value was determined after evaluation of information from the above-mentioned poll and has been kept constant for all years since 2012.

Values for residential AC in the subcategory Stationary AC are default values given by the 2006 IPCC Guidelines as are the recovery efficiencies for all applications.

No HFC charge amounts are given for commercial refrigeration, fishing vessels, industrial refrigeration, and residential AC. No information is available on the average charge and the number of units for these sub-source categories. Therefore, the bottom-up approach was modified. Instead of estimating sub-source specific HFC amounts by multiplying units with their average charge, imported HFC bulk amounts were divided between sub-sources using fractions (cf. explanations above). The bulk import is then treated as the equipment in which it is contained so it is attributed with a sub-source specific lifetime n. After n years the part of initially imported HFC not yet emitted is disposed of or recovered.

The lifetime of vehicles is based on information collected by the Icelandic recycling fund. The average age of vehicles at end-of-life is 14 years. The lifetime EF is at the lower end of the range given in the 2006 IPCC Guideline. This is justified by the prevailing cold temperate climate which limits AC use. The recovery efficiency is set to zero since no refrigerant recovery takes place when vehicles are prepared for destruction.

For MACs the residual charge being disposed (%) (p value from Eq. 7.14) is estimated in the following way: assuming that the MAC is serviced the year before it is disposed and that the annual emission rate is estimated, p is calculated as $p = 1 - x$. x is 10%, hence $p = 90\%$. In the case of MACs, there is no recovery at disposal, therefore the recovery efficiency at disposal (%), or the $\eta_{\mathrm{rec,d}}$ value from Eq 7.14 is 0%. Calculating the recovery as charge contained at disposal multiplied with recovery efficiency, we obtain 0 and therefore “NO.”

Emissions

Emitted refrigerants are separated into constituent HFCs and PFCs (information on blend compositions from Volume 3, Chapter 7, Table 7.8, 2006 IPCC guidelines). HFC and PFC emissions are aggregated by multiplying individual compounds with respective GWPs leading to totals in kt CO_2e. All values and fractions below relating to aggregated emissions are expressed in CO_2e.

Total HFC and PFC emissions from all refrigeration and air conditioning equipment disaggregated to constituents are shown in Table 4.24.

Table 4.24 HFC and PFC emissions [kt CO_2e, calculated using GWP from AR5] for all individual compounds, calculated into kt CO_2e using AR5 GWPs.

	1990	1995	2000	2005	2010	2015	2020	2021
HFC-23	NO	NO	NO	0.035	0.014	0.014	0.052	0.057
HFC-32	NO	NO	0.005	0.016	0.061	0.11	0.42	0.53
HFC-125	NO	0.80	19	22	41	60	73	58
HFC-134a	NO	1.7	5.6	10	16	23	26	23
HFC-143a	NO	0.2	19	25	54	79	97	76
HFC-152a	NO	0.008	0.067	0.047	0.041	0.0020	NO	NO
HFC-227ea	NO	NO	NO	0.11	0.023	0.31	0.19	0.25
Total HFC [kt CO_2e]	**NO**	**2.5**	**42.3**	**56.5**	**109**	**161**	**195**	**156**
C_2F_6 (PFC-116)	NO	NO	NO	0.0032	0.0012	0.0080	0.067	0.069

	1990	1995	2000	2005	2010	2015	2020	2021
C_2F_8 (PFC-218) [	NO	NO	NO	NO	0.0006	0.0002	0.00007	0.00006
Total PFC [kt CO_2e]	**NO**	**NO**	**NO**	**0.0029**	**0.0018**	**0.0075**	**0.061**	**0.063**
Total HFC+PFC [kt CO_2e]	**NO**	**2.5**	**42.3**	**56.5**	**109**	**161**	**195**	**156**

Figure 4.5 shows the total emissions (assembly emissions, lifetime emissions and disposal emissions) expressed as kt CO_2e from Refrigeration and Air Conditioning (2F1). The largest emissions arise from the transport refrigeration which is explained by the importance of the Icelandic fishing fleet and the high emission factors applied due to the nature of this category. Stationary AC and domestic refrigeration are minor emission sources considering the cold climate of Iceland and the fact that most domestic appliances are imported from mainland Europe and do not use F-gases for refrigeration but rather natural refrigerants.

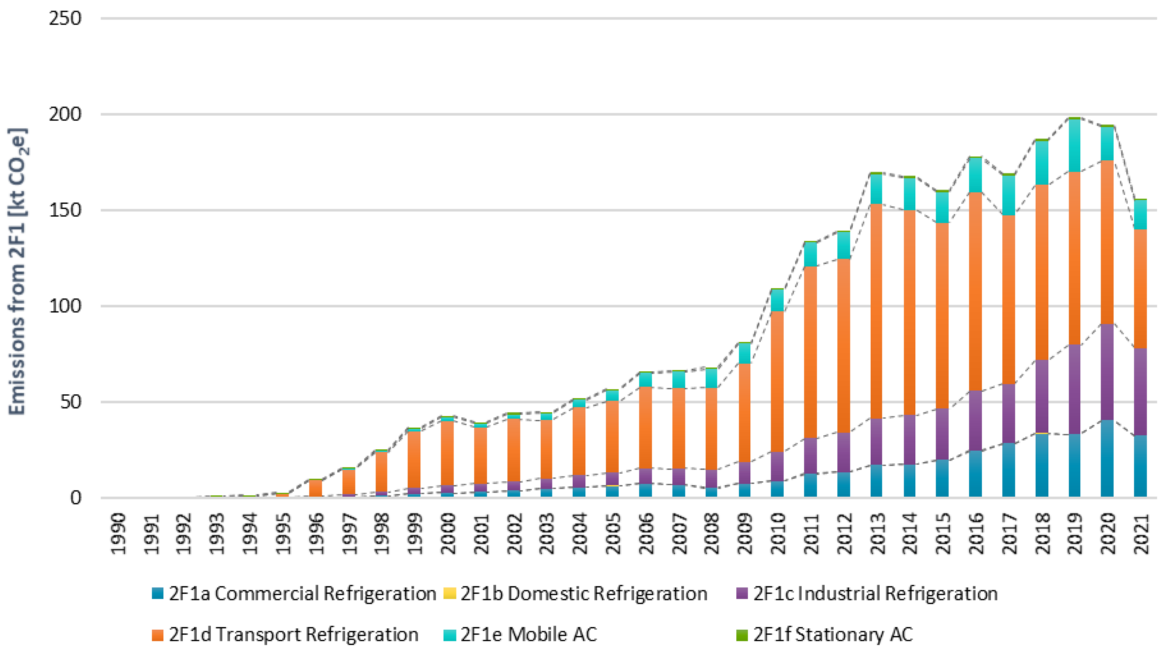


Figure 4.5 Total F-gas emissions from Refrigeration and Air Conditioning, split by subcategories [kt CO_2e].

Category-specific Recalculations

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

Recalculations from the 2022 Submission:

There were three recalculations within the 2F1 subsector. One is a minor one due to updated activity data about number of reefers from one logistics company in the year 2019. That led to recalculations for 2F1d (Transport) for 2019. The other two are substantial and concern the lifetime of fishing ships (part of 2F1d Transport) and the distribution of the remaining unallocated blends over the categories (see above about the input data).

The lifetime of transport refrigeration equipment on fishing vessels was 7 years in previous submissions. Expert judgements from some of the major fishing companies led to revaluation of the lifetime. It is now 15 years for the whole timeline. That is the lower value of the range in the 2019 Refinements for Industrial Refrigeration (for developed countries). The lifetime of equipment on fishing vessels is now the same as the lifetime of industrial refrigeration in the inventory. The main reason is that the nature of the equipment on fishing vessels resembles the equipment in industry.

The remaining blends of the import (after R407C and R410A is allocated to 2F1f and after HFC134a and R404A from Reefers and MACS are subtracted from the total import) was distributed over the whole timeline with the following percentages for the last submission:

- 15% Commercial Refrigeration
- 20% Industrial Refrigeration
- 65% Transport minus Reefers

The percentages used were derived from surveys among service providers and importers of F-gases. The last survey was completed in 2012. For this submission, a new thorough survey was made. All importers returned a spreadsheet to the EAI with information about the distribution of each blend between these sectors. The distribution is based on 2020 sales numbers. Since parts of the sales were to service providers of F-gases, the EAI has also managed to get information from some of the service providers. After analysing the data, the EAI now has a distribution of the F-gas usage for 2020 by each blend and therefore species.

There were no sales of blends with HFC-152a and C_3F_8 in 2020 which is consistent with import data that show that the last import took place in 2009. The new distribution was applied for 2020. For 1990-2012, the distribution from the 2012 survey is applied, just as in the last submission. From 2012 until 2020, the share of each blend and subsector changed linearly from the 2012 value to the 2020 value. Table 4.25, Table 4.26, and Table 4.27 show the shares of the subsectors Commercial Refrigeration (2F1a), Industrial Refrigeration (2F1c), and Transport and after the recalculation.

Table 4.25 Distribution of Unallocated Blends to Commercial Refrigeration (2F1a), changes from the last submission.

Distribution of Unallocated Blends, Commercial Refrigeration (2F1a) share	2012	2013	2014	2015	2016	2017	2018	2019	2020
2021 v1 submission: 2F1a, all species	15%	15%	15%	15%	15%	15%	15%	15%	NA
2022 Submission: 2F1a, HFC-125	15%	17%	19%	21%	24%	26%	28%	30%	32%
2022 Submission: 2F1a, HFC-143a	15%	18%	21%	24%	28%	31%	34%	37%	40%
2022 Submission: 2F1a, HFC-134a	15%	16%	17%	18%	19%	20%	21%	22%	23%
2022 Submission: 2F1a, HFC-32	15%	14%	13%	12%	11%	10%	9%	7%	6%
2022 Submission: 2F1a, HFC-23	15%	13%	11%	9%	8%	6%	4%	2%	0%
2022 Submission: 2F1a, HFC-227ea	15%	13%	11%	9%	8%	6%	4%	2%	0%
2022 Submission: 2F1a, C2F6	15%	13%	11%	9%	8%	6%	4%	2%	0%

Table 4.26 Distribution of Unallocated Blends to Industrial Refrigeration (2F1b), changes from the last submission.

Distribution of Unallocated Blends, Industrial Refrigeration (2F1c) share	2012	2013	2014	2015	2016	2017	2018	2019	2020
2021 v1 submission: 2F1c, all species	20%	20%	20%	20%	20%	20%	20%	20%	NA
2022 Submission: 2F1c, HFC-125	20%	24%	28%	32%	36%	40%	44%	48%	52%
2022 Submission: 2F1c, HFC-143a	20%	23%	26%	29%	32%	35%	38%	41%	44%
2022 Submission: 2F1c, HFC-134a	20%	24%	29%	33%	37%	42%	46%	50%	55%
2022 Submission: 2F1c, HFC-32	20%	27%	34%	41%	48%	55%	63%	70%	77%
2022 Submission: 2F1c, HFC-23	20%	30%	40%	50%	60%	70%	80%	90%	100%
2022 Submission: 2F1c, HFC-227ea	20%	30%	40%	50%	60%	70%	80%	90%	100%
2022 Submission: 2F1c, C2F6	20%	30%	40%	50%	60%	70%	80%	90%	100%

Table 4.27 Distribution of unallocated blends to Transport excluding Reefers (2F1d), changes from the last submission.

Distribution of unallocated blends, Transport minus reefers (2F1d) share	2012	2013	2014	2015	2016	2017	2018	2019	2020
2021 v1 submission: 2F1d, all species	65%	65%	65%	65%	65%	65%	65%	65%	NA
2022 Submission: 2F1d, HFC-125	65%	59%	53%	47%	41%	35%	28%	22%	16%
2022 Submission: 2F1d, HFC-143a	65%	59%	53%	47%	40%	34%	28%	22%	16%
2022 Submission: 2F1d, HFC-134a	65%	60%	54%	49%	44%	38%	33%	28%	22%
2022 Submission: 2F1d, HFC-32	65%	59%	53%	47%	41%	35%	29%	23%	17%
2022 Submission: 2F1d, HFC-23	65%	57%	49%	41%	33%	24%	16%	8%	0%
2022 Submission: 2F1d, HFC-227ea	65%	57%	49%	41%	33%	24%	16%	8%	0%
2022 Submission: 2F1d, C2F6	65%	57%	49%	41%	33%	24%	16%	8%	0%

These three changes led to recalculations within Commercial Refrigeration (2F1a), see Table 4.28, Industrial Refrigeration (2F1c), see Table 4.29 and Transport excluding Reefers (2F1d), see Table 4.30. Within Transport the recalculations start earlier than within the other subsectors since the lifetime change of equipment in fishing vessels led to changes to years before 2012. Note that figures from the 2022 Submission are based on GWP in AR4.

Table 4.28: Recalculations within 2F1a Commercial Refrigeration between submissions.

2F1a Commercial Refrigeration	2012	2013	2014	2015	2016	2017	2018	2019
2021 v1 submission [kt CO_2e]	14	17	17	18	21	24	26	21
2022 Submission [kt CO_2e]	14	17	18	20	25	29	34	33
Change relative to 2021 Submission	0.0%	0.6%	4.4%	10%	16%	19%	30%	58%

Table 4.29: Recalculations within 2F1c Industrial Refrigeration between submissions.

2F1c Industrial Refrigeration	2012	2013	2014	2015	2016	2017	2018	2019
2021 v1 submission [kt CO_2e]	21	24	25	24	27	25	28	31
2022 Submission [kt CO_2e]	21	24	26	27	31	31	38	47
Change relative to 2021 Submission	0.0%	0.6%	3.9%	10%	17%	24%	36%	51%

Table 4.30: Recalculations within 2F1d Transport excluding Reefers between submissions.

2F1d Transport	2001	2005	2010	2015	2016	2017	2018	2019
2021 v1 submission [kt CO_2e]	30	35	67	118	134	115	82	123
2022 Submission [kt CO_2e]	30	38	73	97	104	88	92	90
Change relative to 2021 Submission	-1.0%	8.4%	9.3%	-18%	-23%	-23%	12%	-27%

The total recalculations within the subsector Refrigeration and Air Conditioning (2F1) can be seen in Table 4.31 and Figure 4.6.

Table 4.31: Recalculations within 2F1 Refrigeration and Air conditioning between submissions.

2F1 Refrigeration and Air conditioning	2001	2005	2010	2015	2016	2017	2018	2019
2021 v1 submission [kt CO_2e]	40	55	104	179	203	188	163	206
2022 Submission [kt CO_2e]	40	58	110	162	180	172	190	202
Change relative to 2021 Submission	-0.7%	5.3%	6.0%	-9.1%	-11%	-8.6%	17%	-2.3%

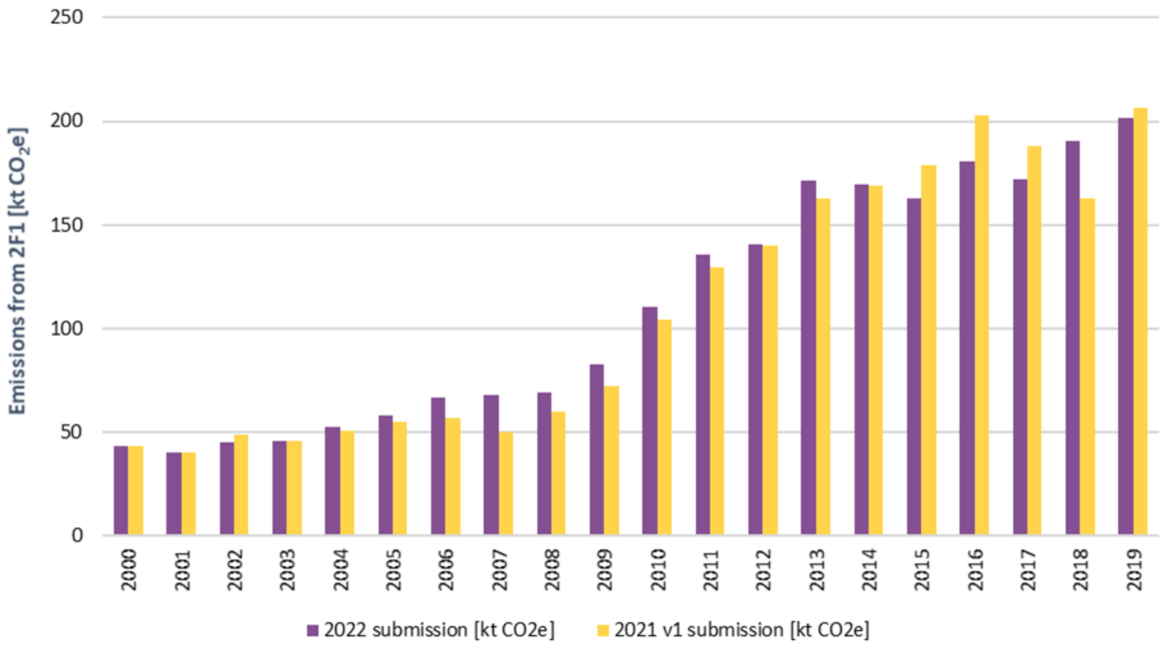


Figure 4.6 Recalculation within the subsector Refrigeration and Air Conditioning (2F1) between 2021 and 2022 Submission.

Category-specific Planned Improvements

It is planned to investigate recovery and disposal emissions further and to repeat the survey among end users and importers of F-gases for future submissions. It is also planned to investigate the usage of R134a in MAC in response to significant reduction of import for the next submission.

Uncertainties

The emission factor uncertainty of each subsector was calculated for the lifetime emission factor ranges, initial emission ranges, operation emission ranges, and recovery efficiency ranges given in the 2006 IPCC Guidelines to the respective values used. Using equation 3.1 (Volume 1, Chapter 3, 2006 IPCC guidelines) the emission uncertainty was calculated for each application in every subsector by combining the emission factor uncertainty and the activity data uncertainty. The emission uncertainty for all subsectors of sector 2F1 was derived by combining the uncertainty of each subsector to one value using equation 3.2 (Volume 1, Chapter 3, 2006 IPCC guidelines). The combined emission uncertainty for the sector was calculated as per equation 3.2 (Volume 1, Chapter 3, 2006 IPCC guidelines). The combined emission uncertainty was calculated to be 57.3%.

Details about the retrieval of the uncertainty factors are summarised in Table 4.32. Overview of the uncertainties can be found in Annex 2.

Table 4.32 EFs used along with EF ranges given in the 2006 IPCC Guidelines; calculated combined EF uncertainties and estimated AD uncertainties.

Sector		EF Used	Lower Bound	Upper Bound	EF Uncertainty	AD uncertainty
2F1a Commercial ref.	Lifetime EF	8	7	15	50%	100%
	Initial Em.	2	0.5	3	63%	100%
	Operation Em.	10	10	35	125%	100%
	Recovery Effic.	70	0	70	50%	100%

Sector		EF Used	Lower Bound	Upper Bound	EF Uncertainty	AD uncertainty
2F1b Domestic ref.	Lifetime EF	12	12	20	33%	50%
	Initial Em.			No first fills in Iceland		
	Operation Em.	0.3	0.1	0.5	67%	50%
	Recovery Effic.	70	0	70	50%	50%
2F1c Industrial ref.	Lifetime EF	15	15	30	50%	100%
	Initial Em.	2	0.5	3	63%	100%
	Operation Em.	10	7	25	90%	100%
	Recovery Effic.	85	0	90	53%	100%
2F1d Transport fishing	Lifetime EF	15	15	30	50%	100%
	Initial Em.	2	0.5	3	63%	100%
	Operation Em.	20	15	50	88%	100%
	Recovery Effic.	70	0	70	50%	100%
2F1d Transport reefers	Lifetime EF			NA		
	Initial Em.			No first fills in Iceland		
	Operation Em.	20	15	50	88%	100%
	Recovery Effic.			NA		
2F1e Mobile air-con.	Lifetime EF	14	9	16	25%	70%
	Initial Em.			No first fills in Iceland		
	Operation Em.	10	10	20	50%	70%
	Recovery Effic.			NA		
2F1f Stationary air-con.	Lifetime EF	12	10	20	42%	50%
	Initial Em.	1.0	0.2	1.0	40%	50%
	Operation Em.	3.0	1.0	10	150%	50%
	Recovery Effic.	75	0	80	53%	50%

4.7.3 Foam Blowing Agents (CRF 2F2)

This activity does not occur in Iceland. During the in-country review of the 2011 submission the expert review team remarked that emissions from foam blowing were declared as not occurring although Iceland reported the import of hard foams in containers for fish export since 2001. During the preparation of the 2012 submission information on the nature of imported fish containers were gathered in order to estimate emissions more exactly. The Icelandic Directorate of Customs supplied the EAI with a list of all companies importing goods under the customs number denoting fish boxes to Iceland. The five biggest importers, which comprise more than 99% of fish container imports, were contacted. The biggest importer buys foam boxes from a manufacturer in the UK. The manufacturer produces the boxes from HFC free polypropylene. Another company buys its boxes from a manufacturer in Slovakia. The manufacturer was contacted and explained that it does not use HFC in the production of foam boxes. One company buys HFC free containers in Spain. The same company also imports polyurethane boards from The Netherlands to insulate fish tanks they manufacture. The manufacturer of the polyurethane boards was contacted and declared that it did not use HFC in the production of its boards. The remaining two companies importing fish containers import exclusively cardboard containers. Therefore, emissions from foam blowing in Iceland are reported as not occurring.

4.7.4 Fire Protection (CRF 2F3)

This activity does not occur in Iceland.

4.7.5 Aerosols (CRF 2F4)

Emissions from metered dose inhalers (MDI) use are reported under CRF 2F4a. R-134A and R-227ea are used in MDI's imported to Iceland. No other emissions are attributed to CRF sector 2F4.

Methodology

Emissions from MDIs are assumed to be 50% from year of import plus 50% of import from the previous year.

Activity Data

The Icelandic Medicines Agency records import of MDIs containing R-134A since 2002 and R-227ea since 2014. The amount of HFCs in MDIs imported has been oscillating between 500 and 660 kg since 2002. No import data is available for the time period 1990-2001. Therefore, the activity data was extrapolated by determining the average MDI import per capita for the period 2002 to 2015, and by using this average to calculate MDI imports as a function of population for the period 1990-2001.

Emissions

Emissions from MDIs in 2021 were approx. 0.82 kt CO_2e.

Category-specific Recalculations

Recalculation within the 2F4a subsector is due to an update in population data. For the years 1990-2001 the emissions are based on population data, this data has been updated to ensure consistency within the inventory. The emissions from 2002 are also affected due to methodology used in the calculations.

2F4a, Metered Dose Inhalers	1990	1995	2000	2001	2002
2022 v4 Submission HFC-134a [t]	0.2407	0.5031	0.5290	0.5361	0.5573
2023 Submission HFC-134a [t]	0.2413	0.5058	0.5274	0.5347	0.5571
Change relative to 2022 Submission	0.250%	0.526%	-0.302%	-0.262%	-0.030%

Category-specific Planned Improvements

There are no category-specific improvements planned for future submissions.

Uncertainties

The combined uncertainty of HFC emissions from MDIs are assumed to be 7.1%, with an activity data uncertainty of 5% and an emission factor uncertainty of 5%. The complete uncertainty analysis is shown in Annex 2.

4.8 Other Product Manufacture and Use (CRF 2G)

This sector covers emissions from other product manufacture and use. In Iceland the relevant subsectors are 2G1 (SF_6 emissions from use of electrical equipment), 2G3 (N_2O from product use, mostly in medical applications) and 2G4 where we report CH_4, N_2O, NO_x, CO and NMVOC emissions from tobacco consumption and CO_2, CH_4, N_2O, NO_x, CO and SO_2 emissions from fireworks use.

4.8.1 Electrical Equipment (CRF 2G1)

4.8.1.1 *Use of Electrical Equipment (2G1b)*

Sulphur hexafluoride (SF_6) is used as insulation gas in gas insulated switchgear (GIS) and circuit breakers. The number of SF_6 users in Iceland is small. The bulk of SF_6 used in Iceland is used by Landsnet

LLC which operates Iceland's electricity transmission system. Additionally, a number of energy intensive plants, like aluminium smelters and an aluminium foil producer have their own high voltage gear using SF_6.

Methodology

SF_6 nameplate capacity development data as well as SF_6 quantities lost due to leakage were obtained from the above-mentioned stakeholders. The data regarding leakage consisted of measured quantities as well as calculated ones. Measurements consisted mainly of weighing amounts used to refill or replace equipment after incidents. Quantities were calculated either by allocating periodical refilling amounts to the number of years since the last refilling or by assuming leakage percentages. The Icelandic calculating method takes into account that when circuit breakers (CB) are imported to Iceland they have normally been filled with SF_6 at the factory. Combined CB cabinets come also to Iceland already prefilled. Nevertheless, this equipment could need a top up upon installations, as well as GIS (gas insulated switchgear) substations. In absence of detailed data about the installation of new equipment per year which is assembled or topped up with SF_6 in Iceland, the approach is based on the yearly amount of SF_6 which has been refilled by each power distribution/generation company and industry with its own gas insulated switchgear. Therefore "Filled into new manufactured products" is reported as "NO" in the Icelandic Inventory and no emissions are occurring from manufacturing. The emissions from stocks on the other hand comprises the total refill or use of SF_6 carried out in one year and reported by the stakeholders; it is comprised of the first top-up, the first filling, and the refill in case of annual servicing. The amount refilled reflects the amount leaked obtaining therefore the yearly emissions (as reported "from stocks"). Stakeholders also report the total amount of SF_6 within the electrical equipment in order to obtain the yearly stock of SF_6 in the country.

Iceland acquired its first SF_6 equipment (220 V) in 1981, used at one power station. At the same time some 66 kV equipment was imported. These installations are still in use which explains why there are no disposal emissions. The lifetime reported in the IPCC 2006 guidelines is > 35 years (vol. 3, table 8.2). In addition, circuit breakers (CB) have an expected lifetime of 40-50 years, which is supported by the fact that none of the early installed equipment has been decommissioned yet. This information was obtained from an expert at a consulting company working amongst other things on assisting in design of power plants, transmission, and distribution[21]. Based on this information the amount "Remaining in products at decommissioning" and the resulting emissions "from disposal" and the "recovery" is reported as "NO."

Emissions

Figure 4.7 shows the evolution of SF_6 in switchgear and the associated emissions due to leakage. The increase in emissions is less than proportional compared to the net increase in SF_6 nameplate capacity since 1990. The spike in 2010 is caused by two unrelated incidents during which switchgear was destroyed and SF_6 emitted. The spike in 2012 is caused by an increase of emissions from Landsnet LLC.

[21] https://www.lota.is/power-and-energy/?lang=en

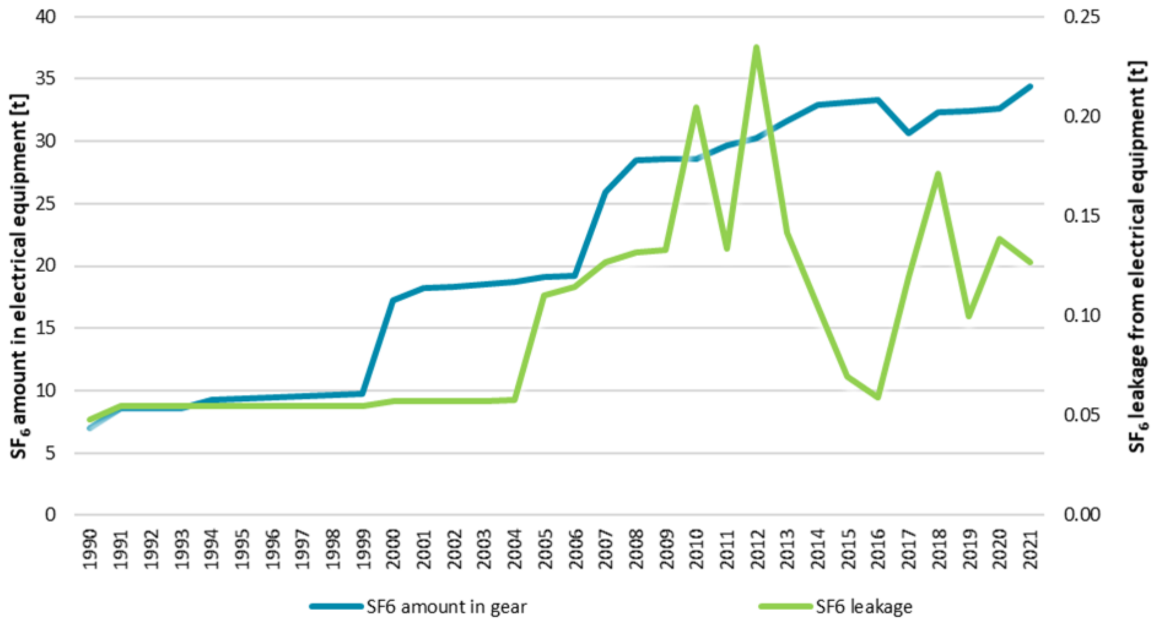


Figure 4.7 Total SF_6 amounts contained in and SF_6 leakage from electrical equipment [t].

Recalculations

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

Recalculations from the 2022 Submission:

Activity data was updated due to new information from the stakeholders for 2009 and 2012-2019. Table 4.33 shows the emission change of SF_6 due to these recalculations.

Table 4.33 Recalculations for SF_6 emission within 2G1 between 2021 and 2022 Submissions.

Electrical equipment	2009	2012	2013	2014	2015	2016	2017	2018	2019
2021 v1 submission SF_6 [t]	0.133	0.233	0.140	0.102	0.068	0.059	0.101	0.143	0.087
2022 Submission SF_6 [t]	0.133	0.234	0.141	0.105	0.070	0.059	0.120	0.171	0.100
Change relative to 2021 Submission	0.38%	0.44%	0.73%	3.02%	1.76%	0.00%	18.2%	19.8%	14.1%

Planned Improvements

It is planned to further investigate the extent of the usage of SF_6 in this category and if it occurs in other categories for future submissions.

Uncertainty

The uncertainty of the activity data is assumed to be 30% following expert judgement while the emission factor uncertainty is derived from Table 8.5, chapter 8, volume 3 of the 2006 IPCC Guidelines and is 30%. The combined uncertainty is therefore 42.4%. The complete uncertainty analysis is shown in Annex 2.

4.8.2 SF_6 and PFCs from Other Product Use (CRF 2G2)

This activity does not occur in Iceland.

4.8.3 N_2O from Product Use (CRF 2G3)

Overview

N_2O in Iceland is almost exclusively used as anaesthetic and analgesic in medical applications (CRF subsector 2G3a). Minor uses of N_2O in Iceland comprise its use as fuel oxidant in auto racing, in fire extinguishers and from the use of aerosol cans of cream (CRF subsector 2G3b).

Methodology

N_2O emissions from product uses (2G3a and 2G3b) were calculated using the 2006 guidelines. Activity data stems from import and sales statistics from the main importers of N_2O to Iceland and is therefore confidential. It is assumed that all N_2O is used within 12 months from import/sale. Therefore, emissions were calculated using equation 8.24 of the 2006 IPCC guideline, which assumes that half of the N_2O sold in year t is emitted in the same year and half of it in the year afterwards. The available activity data since 2015 does not allow to determine whether the end use of the imported N_2O is for medical applications or other applications. The average distribution ratio (medical vs. other uses) of the years 2010-2014 was used for the years since 2015, and the ratio used (95% vs 5%) was confirmed by expert judgment.

The Directorate of Customs does not register the number of aerosol cans of cream or whipped cream cartridges imported to Iceland. In order to estimate the amount of N_2O that could be emitted from whipped cream containers, Iceland follows the Finnish example of applying an average of the EFs used in Central Europe, that is, 3.3 g N_2O/inhabitant/year.

Equation 8.24

$$E_{\mathrm{N_2O}}(t) = \sum_i \{[0.5 * A_i(t) + 0.5 * A_i(t-1)] + EF_i\}$$

Where:

- $E_{N2O}(t)$ = emissions of N_2O in year t, tonnes
- A_i (t) = total quantity of N_2O supplied in year t for application type i, tonnes
- A_i (t-1) = total quantity of N_2O supplied in year t-1 for application type i, tonnes
- EF_i = emission factor for application type i, fraction

4.8.3.1 *Emissions from Medical Applications (2G3a)*

The 2006 IPCC Guideline recommends an emission factor of 1 for medical use of N_2O. This emission factor is also used for other N_2O uses. Total emissions from medical use of N_2O decreased from 17.8 t N_2O in 1990 (4.7 kt CO_2e) to 4.6 t in 2021 (1.2 kt CO_2e). Because the Icelandic market is relatively small there can be large fluctuations in imports year-to-year, and sometimes whether a shipment is recorded at the end of a calendar year or at the begin of the next one can have a large impact on the yearly totals. The significant interannual change in the IEF between 2016 and 2017 arises from the amount of N_2O imported in those years, especially the imported amount in 2016 which is half of the year 2015 and a third less than in 2017. Combining half of the emissions of the current year with the previous year leads to the deviation of the IEF from 1.

4.8.3.2 *Emissions from Other Product Use (2G3b)*

Emissions from other use of N_2O comprise the emissions from aerosol cans of cream and whipped cream cartridges for the whole time series. In 1990, emissions from the use of N_2O from other product use including fuel oxidants for motorsport, fire extinguishers and whipped cream applications were 2.4 t N_2O (639 t CO_2e) and 1.46 t N_2O (387 t CO_2e) in 2021.

Recalculations

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

Recalculations from the 2022 Submission:

The population number was updated to ensure consistency within the inventory. Since N_2O emissions from whipped cream is calculated based on population data, there were recalculations on the N_2O emissions for the whole timeline. Table 4.34 shows the emission change of N_2O due to these recalculations.

Table 4.34 Recalculations for N_2O emission within 2G3b (Fire extinguishers and other uses) between 2021 and 2022 Submissions.

Fire Extinguishers and Other Uses	1990	1995	2000	2005	2010	2015	2018	2019
2021 v1 submission N_2O [t]	2.417	2.010	2.142	1.313	1.691	1.693	1.538	1.567
2022 Submission N_2O [t]	2.410	2.007	2.128	1.292	1.688	1.682	1.510	1.544
Change relative to 2021 Submission	-0.3%	-0.2%	-0.7%	-1.6%	-0.2%	-0.7%	-1.8%	-1.5%

Planned Improvements

There are no category-specific improvements planned for future submissions.

Uncertainties

The activity data uncertainty was calculated to be 6% as the data is based on national statistics but some uncertainty lies in the completeness and allocation of the data. The emission factor uncertainty is 5% giving a combined uncertainty factor of 7.8%. The complete uncertainty analysis is shown in Annex 2.

4.8.4 Other: Tobacco Combustion and Fireworks Use (CRF 2G4)

4.8.4.1 *Tobacco*

All tobacco used in Iceland is imported. Emissions for CH_4, N_2O, NO_x, CO, and NMVOC are reported here.

Methodology

Activity data for tobacco consumption is based on import data collected by Statistics Iceland and includes all imports of tobacco (including loose tobacco, cigarettes, cigars, and all other tobacco products). CH_4 and N_2O emissions are calculated using the Danish country-specific approach (Danish Centre for Environment and Energy, 2018) with emission factors of 3.187 t CH_4/kt tobacco used and 0.064 t N_2O/kt tobacco used. These emission factors are based on calorific data and energy content for wood. NO_x, CO and NMVOC emissions are calculated using the Tier 2 emission factors in the EMEP/EEA 2019 Guidebook. CO_2 emissions from tobacco are biogenic and therefore not applicable.

Emissions

As can be seen in Figure 4.8, Tobacco consumption in Iceland has been steadily decreasing since 1990, with the imports in the most recent inventory year less than half of the 1990 imports. Accordingly, the GHG emissions have decreased significantly, as shown in the same figure.

Recalculations

There were recalculations for 2003, 2005, 2013, and 2019 due to updated import/export data from SI, see Table 4.35.

Table 4.35 Recalculation in 2G4, Tobacco due to updated activity data between submissions.

2G4, Tobacco	2003	2005	2013	2019
2022 v4 Submission CH_4 [kg]	1,282.66	1,225.91	1,404.2	681.8
2023 Submission CH_4 [kg]	1,282.68	1,225.90	949.9	682.2
Change relative to 2022 Submission CH_4	+0.001%	-0.001%	-32%	0.06%
2022 v4 Submission N_2O [kg]	25.7578	24.6182	28.2	13.69
2023 Submission N_2O [kg]	25.7581	24.6180	19.1	13.70
Change relative to 2022 Submission N_2O	+0.001%	-0.001%	-32%	+0.06%

Planned Improvements

There are no category-specific improvements planned for future submissions.

Uncertainties

The activity data uncertainty is 2% as proposed in table 2-1, chapter 5 of the General Guidance of the 2019 EMEP/EEA Guidebook. The emission factor uncertainties are 50% for CH_4 and 50% for N_2O and are chosen in analogy to the Danish NIR 2021. The combined uncertainty for each greenhouse gas is 50.04%. The complete uncertainty analysis is shown in Annex 2.

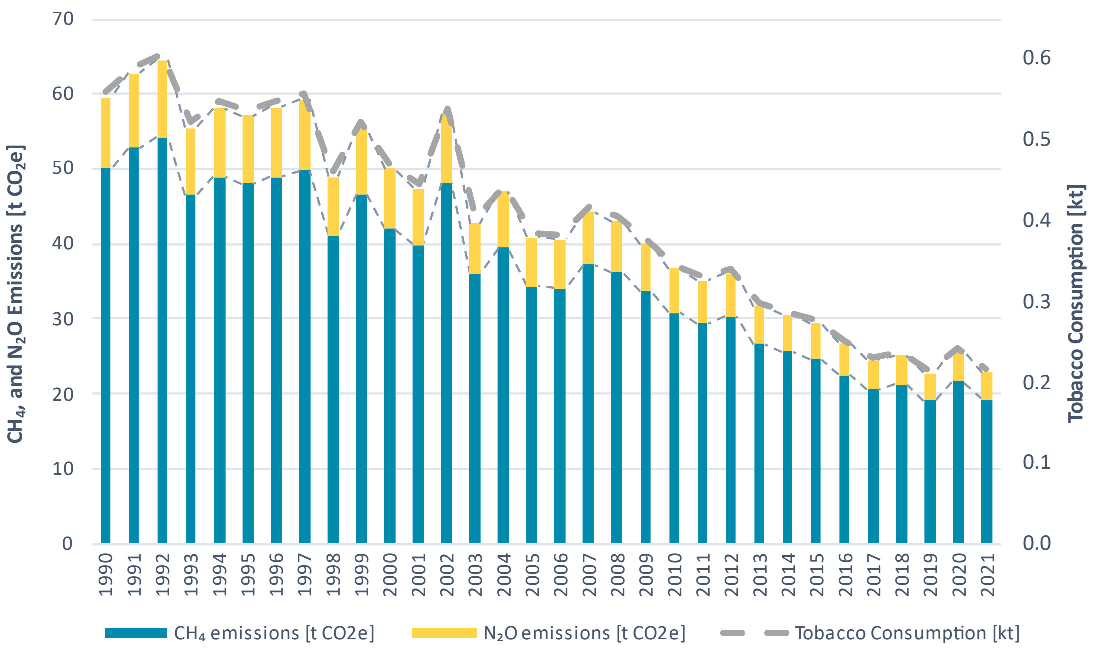


Figure 4.8 Tobacco imports and GHG emissions [kt CO_2e, calculated using GWP from AR5] from tobacco use.

4.8.4.2 *Fireworks*

All fireworks used in Iceland are imported. Here we are reporting emission data for CO_2, CH_4, N_2O, NO_x, CO and SO_2 emissions.

Methodology

Activity data for fireworks use was collected from Statistics Iceland and is based on yearly imports. CO_2, CH_4 and N_2O emissions were calculated using emission factors from the Netherland National

Water Board (2008). Emissions of SO_2, CO and NO_x were calculated using default Tier 2 emission factors from the 2019 EMEP/EEA Guidebook.

Emissions

Total fireworks use has been gradually increasing since the early 1990's, with associated increase in emissions (Figure 4.9). The large spike in fireworks import in 2007 was due to a strong economic upturn, which was then followed by a financial collapse in 2008 which is reflected in the fireworks activity data and associated emissions. Total GHG emissions is estimated to have been less than 0.1 kt CO_2e in 1990 and amounted to 0.30 kt CO_2e in 2021. The main contributor to GHG emissions from fireworks is N_2O, with about 90% of total emissions (when calculated in CO_2e).

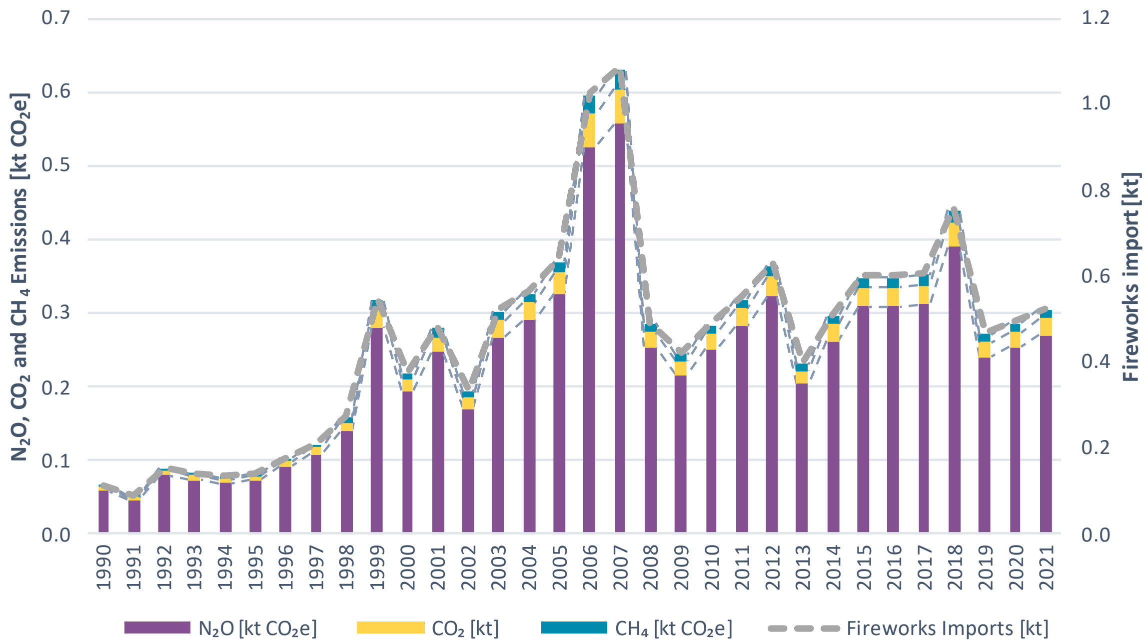


Figure 4.9 Fireworks import and GHG emissions [kt CO_2e, calculated using GWP from AR5] from firework use.

Recalculations and planned improvements

There was recalculation for the years 2012, 2013, and 2019 due to updated import/export data from Statistics Iceland, see Table 4.36.

Table 4.36 Recalculation in 2G4, Fireworks due to updated activity data between submissions.

2G4, Fireworks	2012	2013	2019
2022 v4 Submission CO_2 [t]	27.1623	17.19	20.2950
2023 Submission CO_2 [t]	27.1618	17.20	20.2949
Change relative to 2022 Submission	-0.002%	+0.07%	-0.0002%
2022 v4 Submission N_2O [t]	1.21524	0.769	0.907995
2023 Submission N_2O [t]	1.21522	0.770	0.907993
Change relative to 2022 Submission N_2O	-0.002%	+0.07%	-0.0002%
2022 v4 Submission CH_4 [t]	0.518125	0.3279	0.387130
2023 Submission CH_4 [t]	0.518116	0.3281	0.387129
Change relative to 2022 Submission CH_4	-0.002%	+0.07%	-0.0002%

Planned Improvements

There are no category-specific improvements planned for future submissions.

Uncertainties

The activity data uncertainty is 2% as proposed in table 2-1, chapter 5 of the General Guidance of the 2019 EMEP/EEA Guidebook. The emission factor uncertainties are 50% for CO_2, 50% for CH_4 and 50% for N_2O and are chosen in analogy to the Danish NIR 2021. The combined uncertainty for each greenhouse gas is 50.04%. The complete uncertainty analysis is shown in Annex 2.

4.9 Other (CRF 2H)

In this sector emissions are reported from the Food and Beverages industry (CRF sector 2H2).

4.9.1 Food and Beverages Industry (CRF 2H2)

The only pollutant emitted in this industry is NMVOC. The emission calculations include production of fish, meat, poultry, animal feed, coffee, bread and other breadstuff, beer and other malted beverages and spirits.

Methodology

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 are exports of fish and meat, but they are 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 SI. 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.

Emission factors for NMVOC were taken from the 2019 EMEP/EEA Guidebook (EEA, 2019) and are presented in Table 4.37.

Table 4.37 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

Emissions

NMVOC emissions have increased since 1990. Figure 4.10 shows the various subcategories contributing to the emissions from the food and beverage production industry. Production of spirit has increased in recent years leading to NMVOC emissions. Iceland's inventory does not include CO_2 emission from NMVOC emission oxidation from this subsector.

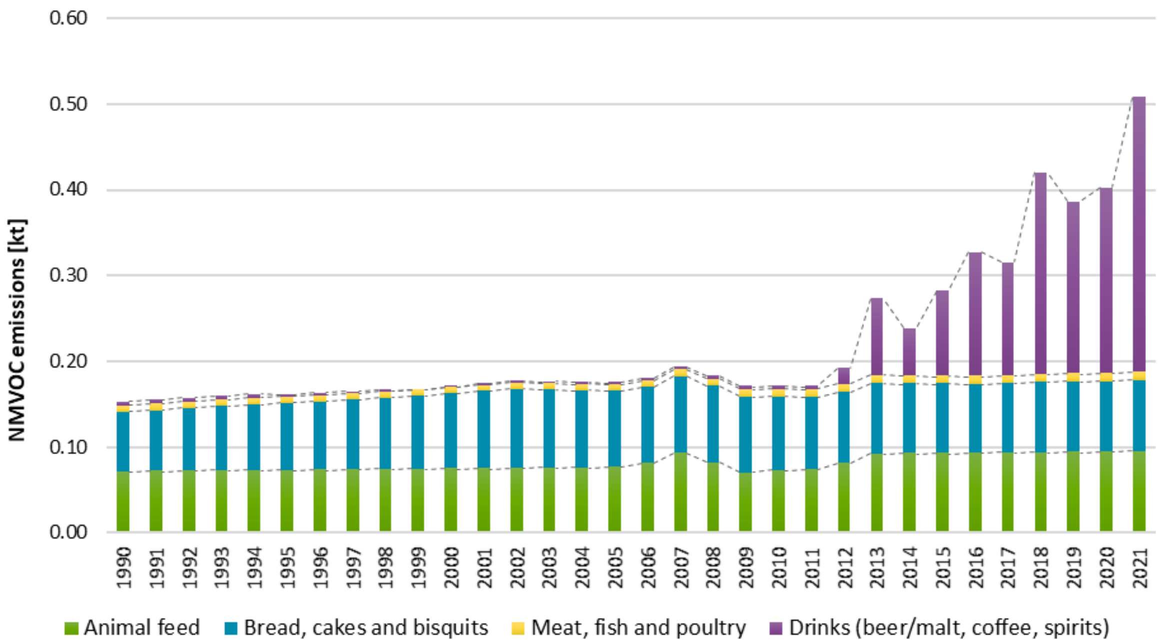


Figure 4.10 NMVOC emissions [kt NMVOC] for various food and beverage processing.

Recalculations

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 4.38.

Table 4.38 Recalculations of emissions within 2H2 (Food and beverages industry) between submissions.

2H2, Food and Beverages Industry	2013	2014	2015	2016	2017	2018	2019	2020
2022 v4 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
Change relative to the 2022 Submission	-2%	-5%	-6%	-7%	-10%	-9%	-11%	-13%

Recalculations from the 2022 Submission:

This subsector was revised for this submission. The emission factors remain the same, but the activity data has been changed. Since production data was only available for part of the time series, now most of the emissions are estimated the same way, based on consumption figures. In some cases, also corrected for import and export figures (see above). Table 4.39 shows the recalculation of the subsector due to these changes.

Table 4.39 Recalculations of emissions within 2H2 (Food and beverages industry) between submissions.

2H2, Food and beverages industry	1990	1995	2000	2005	2010	2015	2018	2019
2021 v1 submission NMVOC [kt]	0.33	0.31	0.33	0.37	0.38	0.38	0.40	0.41
2022 Submission NMVOC [kt]	0.15	0.16	0.17	0.18	0.17	0.30	0.46	0.44
Change relative to 2021 Submission	-53%	-47%	-49%	-53%	-54%	-20%	+16%	+7%

Planned Improvements

No improvements are currently planned for this subsector.

5 Agriculture (CRF 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, e.g., dairy cattle, sheep, horses, and goats, which are all of an ancient Nordic origin, one breed for each species. These animals are generally smaller than the breeds common elsewhere in Europe. Beef production, however, is partly through imported breeds, as is most poultry and all pork production. There is not much arable crop production in Iceland, due to the cold climate and short growing season. Cropland in Iceland consists mainly of cultivated hayfields, although potatoes, barley, beets, and carrots are grown on limited acreage.

The total GHG emissions from Agriculture amounted to 620 kt CO_2e in the year 2021 and were 11% below the 1990 level (Table 5.1). Emissions of CH_4 account for 63%, N_2O for 36% of the total emissions from agriculture - CO_2 for the rest (1%). The decrease of GHG emissions since 1990 is mainly due to a decrease in sheep livestock population, reducing methane emissions from enteric fermentation. 83% of CH_4 emissions were caused by enteric fermentation, the rest by manure management. 94% of N_2O emissions were caused by agricultural soils, the rest by manure management, e.g., storage of manure.

For the 2023 Submission improvement efforts for this sector were continued. Calculations of emissions were reviewed and updated for some subsectors, the quality of activity data has been improved, transparency has been improved throughout the calculation process and comments received by Iceland during the 2022 UNFCCC centralised review have been implemented.

Table 5.1 Emission of GHG in the agricultural sector in Iceland 1990-2021, [kt CO_2e, calculated using GWP from AR5].

	1990	1995	2000	2005	2010	2015	2020	2021
CH_4	476	430	415	394	420	426	390	388
N_2O	219	212	224	211	222	228	219	223
CO_2	0.46	2.44	2.80	6.22	4.22	5.35	8.82	9.19
Total	**695**	**643**	**641**	**611**	**646**	**659**	**617**	**620**
Emission reduction (year-base year)/base year		-7.5%	-7.7%	-12.1%	-7.0%	-5.2%	-11.3%	-10.8%

5.1.1 Methodology

Livestock characterisation follows the Tier 2 methodology of the 2006 IPCC Guidelines, Volume 4 (AFOLU) for the main animal categories: cattle and sheep. CH_4 emissions from enteric fermentation and manure management build upon this livestock characterisation and are calculated by applying the 2006 IPCC Guidelines using, when available, country specific emission factors. N_2O emissions from manure management and agricultural soils are however estimated using a comprehensive nitrogen flow model as described in the 2019 EMEP/EEA Guidebook (EEA, 2019). Applying the nitrogen flow methodology allows for full consistency with the methodologies presented in the 2006 IPCC Guidelines and allows for a more detailed assessment of N_2O emissions and other N species and consistency with the reporting under CLTRAP.

CO_2 from liming, urea application and other carbon containing fertilisers are calculated by applying the default emission factors and methodology as presented in the 2006 IPCC Guidelines.

The following Table 5.2 gives an overview of the reported emissions, calculation methods and type of EFs for the sector agriculture. The methodologies are described in more detail under each of the CRF categories in the respective chapters.

Table 5.2 Reported emissions, calculated methods and type of emission factors used in the Icelandic inventory. CS=Country specific, D=Default.

CRF Source		Reported Emissions	Method	Emission Factor
3A	Enteric Fermentation	CH_4	T1, T2	CS, D
3B	**Manure Management**			
3B1	Manure Management	CH_4	T1, T2	CS, D
3B2	Manure Management	N_2O	T1, T2	CS, D
3C	Rice Cultivation	CH_4	NA	NA
3D	**Agricultural Soils**			
3D1	Agricultural Soils	N_2O	T1, T1b, T2	CS, D
3D2	Agricultural Soils	N_2O	T1b	D
3E	Prescribed Burning of Savannas	CH_4, N_2O	NA	NA
3F	Field Burning of Agricultural Residues	CH_4, N_2O	NA	NA
3G	Liming	CO_2	T1	D
3H	Urea	CO_2	T1	D
3I	Other Carbon-containing Fertilisers	CO_2	T1	D

5.1.2 Key Category Analysis

The key sources for 1990, 2021, and 1990-2021 trend in the Agriculture sector are shown in Table 5.3 (compared to total emissions without LULUCF):

Table 5.3 Key source analysis for Agriculture, 1990, 2021 and trend (excluding LULUCF).

IPCC Source Category		Gas	Level 1990	Level 2021	Trend
Agriculture (CRF Sector 3)					
3A1	Enteric Fermentation - Cattle	CH_4	✓	✓	✓
3A2	Enteric Fermentation - Sheep	CH_4	✓	✓	✓
3A4	Enteric Fermentation - Other	CH_4	✓	✓	
3B1	Manure Management - Cattle	CH_4	✓	✓	
3D1	Direct N_2O Emissions from Managed Soils	N_2O	✓	✓	✓
3D2	Indirect N_2O Emissions from Managed Soils	N_2O	✓	✓	

5.1.3 Completeness

Table 5.4 gives an overview of the IPCC source categories included in this chapter and presents the status of emission estimates from all sub-sources in the Agricultural sector.

Table 5.4 Agriculture – completeness (E: estimated, NA: not applicable, NE: not estimated, NO: not occurring).

Sources		CO_2	CH_4	N_2O
3A	Enteric Fermentation	NA	E	NA
3B	Manure Management	NA	E	E
3C	Rice Cultivation		NOT OCCURRING	
3D	Agricultural Soils			
	Direct Emissions	NA	NA	E
	Indirect Emissions	NA	NA	E
3E	Prescribed burning of Savannas		NOT OCCURRING	
3F	Field burning of Agricultural Residues		NOT OCCURRING	

Sources		CO_2	CH_4	N_2O
3G	Liming	E	NA	NA
3H	Urea application	E	NA	NA
3I	Other Carbon-containing fertilisers	E	NA	NA

5.1.4 Source Specific QA/QC Procedures

General QA/QC activities, as listed in Chapter 1.5, are performed for the Agriculture sector. Further sector-specific activities include the following:

- Work with the livestock data provider to crosscheck the consistency and quality of the data; communicate with agricultural experts to obtain expert judgement on the quality of data used.
- For the category mature dairy cows, check the correlation between the following three pairs of inherently connected parameters: milk yield and nitrogen excretion rate (hereafter called Nex rate), gross energy intake and Nex rate, milk yield and feed digestibility.
- Data reported under CRF 3B and 3D is checked to assure consistency between N deposited on pasture, range and paddock and urine and dung deposited by grazing animals.
- A comparison between the Icelandic country-specific (CS) data on synthetic fertiliser consumption and fertiliser usage data from the International Fertiliser Association (IFA) and synthetic fertiliser consumption estimates from the Food and Agriculture Organization of the United Nations (FAO).

These checks are performed after completion of the emission estimates. More details on some of the sector-specific activities are provided in the following sections.

5.1.4.1 *Mature Dairy Cows: Correlation Between Milk Yield, Nex Rate, and Feed Digestibility*

This check for the livestock category mature dairy cows is conducted because the parameters milk yield, Nitrogen excretion (Nex) rate and feed digestibility are all inherently connected:

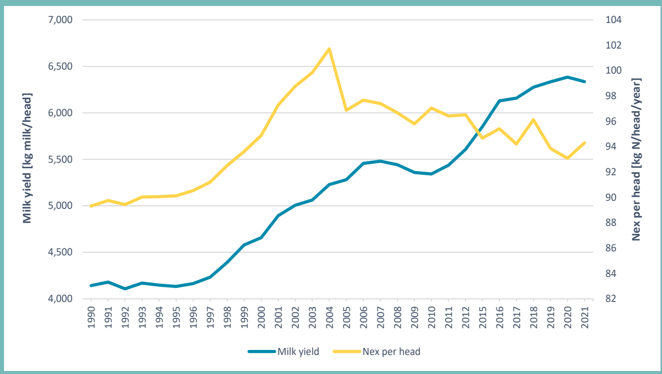
- Increasing milk production requires a higher protein intake, resulting in a higher Nex rate;
- A higher protein intake, which results in a higher Nex rate, means a higher energy intake;
- Higher productivity, resulting in increased milk production, requires a higher feed intake and higher quality feed with a higher digestibility.

This check is threefold. The following correlations are checked:

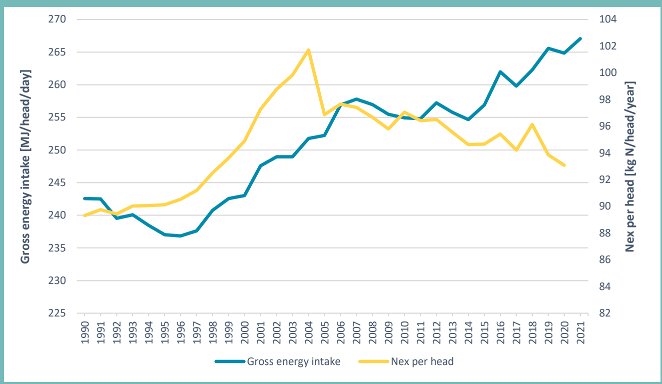
1. Consistency between milk yield and Nex rate
2. Consistency between gross energy intake (GE) and Nex rate
3. Consistency between milk yield and feed digestibility (DE)

This is described in more detail in the textbox on the next page.

The average nitrogen excretion rate per animal (Nex) is calculated based on Equation 10.31 (Tier 2) from the 2006 IPCC Guidelines. Nex is proportional to the **N intake rate for cattle**, which is calculated based in part on gross energy intake (GE) (Eq. 10.32), and inversely proportional to **N retention rates for cattle**, which for dairy cattle is based entirely on milk production (Eq. 10.33). The N retention rates for dairy cattle have increased by 30% from 1990 to 2021. Therefore, the correlation between milk yield and Nex rate on one hand and gross energy intake and Nex rate on the other hand, has decreased, although it is still moderately high, or 0.54 in both cases.

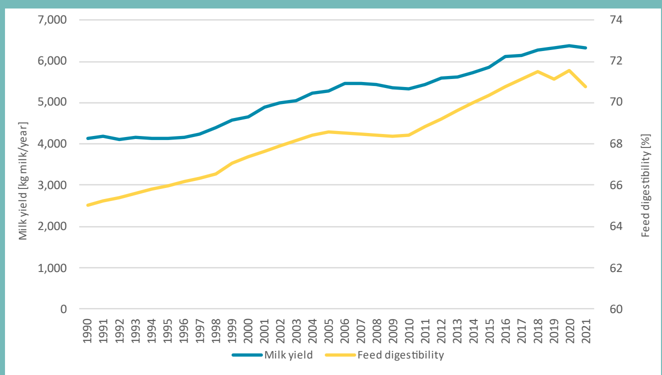


Decreased consistency between milk yield and Nex rate, because of increased N retention rates.



Decreased consistency between gross energy intake and Nex rate, because of increased N retention rates.

The correlation between milk yield and feed digestibility is the strongest out of the three, or 0.98



Consistency between milk yield and feed digestibility

5.1.4.2 *CRF 3B2 Pasture, Range, and Paddock Consistent with CRF 3D13 Urine and Dung Deposited by Grazing Animals*

This check is implemented to ensure that the total manure excreted by animals equals the total manure excreted over the manure management systems (MMS), by calculating livestock population multiplied by the Nex rate, e.g., that for each livestock category:

$$Population \times Nex\ rate = \sum MMS\ Nex$$

That is to say, the sum of all manure “managed” in *Pasture, range, and paddock* in CRF 3B2 should be consistent with *Urine and Dung Deposited by Grazing Animals* in CRF 3D13.

Table 5.5 Sector specific QC - check on reporting tables - 3B2 Pasture Range and Paddock consistent with 3D13 Urine and Dung Deposited by Grazing Animals.

CRF Code	Activity	Source	Unit	1990	1995	2000	2005	2010	2005	2020	2021
3B	Pasture, Range and Paddock	Reporting Tables	kt N/yr	7.732	7.133	7.074	6.979	7.283	7.245	6.304	6.267
3D	Urine and Dung Deposited by Grazing Animals	Reporting Tables	kt N/yr	7.732	7.133	7.074	6.979	7.283	7.245	6.304	6.267
	Check			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3B	Pasture, Range and Paddock	Emission calculation files	kt N/yr	7.732	7.133	7.074	6.979	7.283	7.245	6.304	6.267
3D	Urine and Dung Deposited by Grazing Animals	Emission calculation files	kt N/yr	7.732	7.133	7.074	6.979	7.283	7.245	6.304	6.267
	Check			TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

5.1.4.3 *Data Comparison on Synthetic Fertiliser Consumption*

During the 2019 UNFCCC desk review it was noted (Question 2019ISLQA216) that there were sharp peaks in N fertilisers use in 2009 and 2014. It was recommended that Iceland conducts a comparison between the Icelandic CS data on synthetic fertiliser consumption and fertiliser usage data from the IFA and synthetic fertiliser consumption estimates from the FAO. This has now been completed.

As can be seen in Figure 5.1 there are various peaks and dips in all three datasets. The CS dataset appears to coincide better with the FAO dataset. The overall trend of the country-specific dataset is higher, however. The main conclusions are that:

- All datasets correspond well in the first decade (1990-2000), after which they diverge further.
- The CS dataset and the FAO dataset continue to correspond quite well until 2009. For the years 2009-2014 the FAO dataset is on average 26% lower than the CS data. After that the datasets come together again and correspond nearly perfectly.
- There are bigger differences when the CS dataset is compared with the IFA dataset. The IFA data is up to 43% higher than the CS data in 2005, then grows up to 54% lower than the CS data in 2018.

Synthetic fertiliser data for the inventory is either obtained directly from the IFVA or from Statistics Iceland (*Hagstofa Íslands*) (SI), which receive the information from the IFVA. IFVA must be notified about every import or manufacture of fertilisers in the country according to Icelandic laws 22/1994, 630/2007, 398/1995, 499/1996, 25/1993, 87/1995 and regulation 479/1995 regarding the inspection of food, fertilisers and seeds, animal diseases and prevention of them and relative changes.

According to information provided by IFVA, the peak in import of fertilisers occurred during the financial boom in Iceland, after which the financial crisis and fall of the currency is expected to have caused the drop in imports, in line with a sharp increase in the price of imported goods. The numbers refer to import data in a calendar year; in November 2014 a company imported more than 2,000 tonnes of fertilisers which were then sold over the following spring 2015; this can distort the overall picture and lead to these kinds of "artificial" peaks.

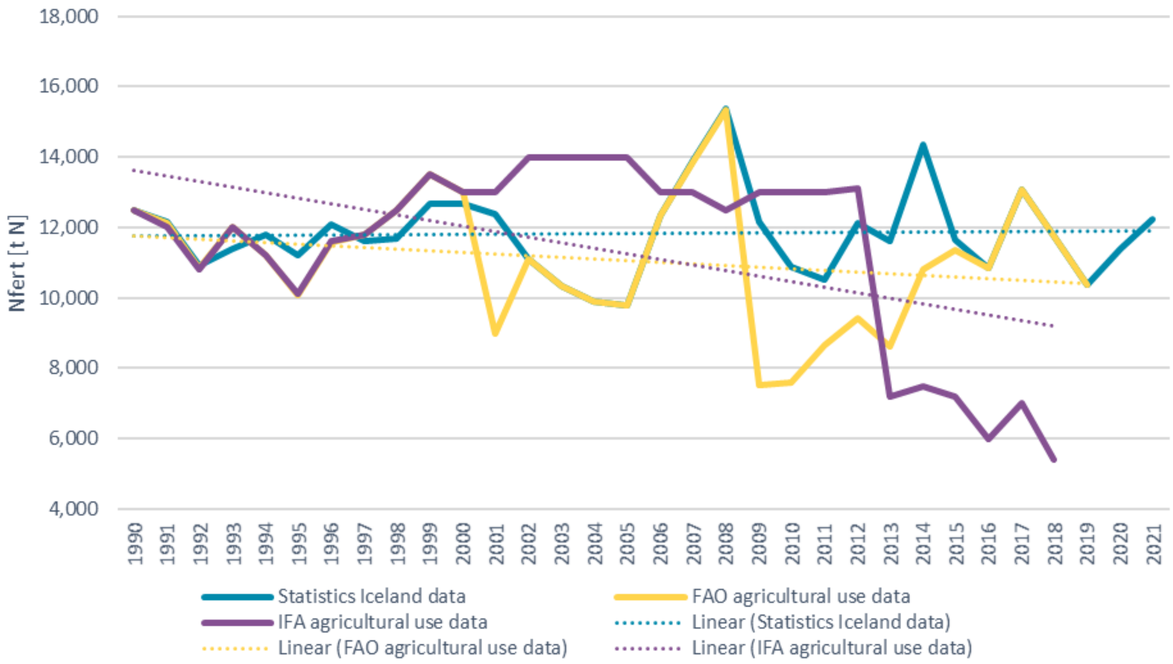


Figure 5.1 Comparison of different datasets on synthetic fertiliser use in Agriculture.

Based on this comparison, the conclusion is that the CS data is currently the best available data. This is supported by the relative soundness of the domestic data flow and the big inconsistencies between the FAO and IFA datasets. They diverge too much, both from each other and from the domestic data, for either of them to be the better choice conclusively.

5.1.5 Planned Improvements

The 2006 IPCC Guidelines, used as a basis for the estimation of the emissions, have been updated in 2019. It is planned to adapt and check the Icelandic inventory against the 2019 IPCC Refinements to be fully consistent with emission factors and methodologies.

Transparency of the inventory compilation has been improved over the past years, nevertheless, some parts still need improvement.

Sector specific QA/QC will be further improved, and specific improvements are described under each subsector.

5.2 Data Sources

Activity data and emission factors are collected from different institutions and processed at the EAI. The main data providers are listed in Table 5.6. In addition, data can be requested from private companies and farmers or breeding associations if needed. When published data is lacking information that is needed for the compilation of the emission inventory, expert judgement is requested.

Table 5.6 Main data providers for the Agricultural sector.

Data Provider	Icelandic Name	Website	Data/Information
Ministry of Food, Agriculture and Fisheries (MFAF)	Matvælaráðuneytið	government.is/ministries/ministry-of-food-agriculture-and-fisheries/	Annual livestock census (bustofn.is) (formerly reported by IFVA)
Icelandic Food and Veterinary Authority (IFVA)	Matvælastofnun	mast.is	Slaughtering data Inorganic fertiliser import data
Icelandic Agricultural Advisory Centre (IAAC)	Ráðgjafarmiðstöð landbúnaðarins (RML)	rml.is	Milk yield Fat content of milk Data required for the Tier 2 methodology for cattle and sheep Expert judgements
Soil Conservation Service (SCS)	Landgræðslan	land.is	Areas of drained organic soils Use of sewage sludge for land reclamation purposes Use of other organic fertilisers for land reclamation
Statistics Iceland	Hagstofa	hagstofa.is	Crop production Inorganic fertiliser import data Livestock numbers for comparison
Agricultural University of Iceland (AUI)	Landbúnaðarháskóli Íslands	lbhi.is	Specific studies about Icelandic agricultural practices Emission factor for drained organic soils Expert judgements
Food and Agriculture Organization of the United Nations (FAO)		fao.org	Annual area of crops harvested

In addition to the data collection from the abovementioned data providers, an extensive effort to update livestock parameters for cattle and sheep, which are both key categories in the Icelandic Agriculture sector, was undertaken for this submission. The EAI collaborated with The Agricultural Advisory Centre (*Ráðgjafamiðstöð landbúnaðarins*) (IAAC) on updating various livestock parameters, including feed digestibility, animal weights, pregnancy rates, time spent in various feeding situations, fractions of manure going to different manure storage pathways, and the ratios for how many lambs each ewe and animal for replacement carried with her in pasture over the summer (IAAC, 2022). A similar collaboration was undertaken for the 2020 submission, where some livestock parameters were updated for the sub-categories Mature Dairy Cattle and Lambs for the year 2018. For the collaboration for the 2023 Submission, more livestock parameters have been updated for all cattle (e.g., Mature Dairy Cattle, Other Mature Cattle, Heifers, Steers and Calves) and sheep (e.g., Ewes, Rams, Animals for Replacement, and Lambs) subcategories for the three most recent years (2019-2021) and for 1990, 1999, 2005, and 2010. The parameters and recalculations are discussed in more detailed in the relevant subchapters of this chapter.

5.2.1 Animal Population Data

The Ministry of Food, Agriculture, and Fisheries (*Matvælaráðuneytið*) (MFAF) conducts an annual livestock census, formerly conducted by the IFVA. Farmers count their livestock once a year in November and send the numbers to MFAF through the online application bustofn.is. Consultants from local municipalities visit each farm during March of the following year and correct the numbers from the farmers in case of discrepancies. The EAI has access to the online application bustofn.is and downloads the livestock numbers directly from there.

The livestock data collection method leads to one issue, namely that young animals that live less than one year and have been slaughtered at the time of the census are not accounted for (lambs, piglets, kids, a portion of foals, and poultry). Consequently, the number of animals with a lifespan shorter than one year is calculated based on the parameters and methods listed in the section on *animals with a lifespan shorter than one year* below. As a result, the numbers of several animal species are higher in the NIR than they are in the national census as reported by SI, as can be seen in Table 5.7. While differences are small for most species, they are significant for livestock categories of which a big share of the population has a life span of less than one year, such as lambs and piglets. Lambs and piglets are not reported in SI or in the MFAF autumn reports, because at the time of the national census they have already been slaughtered. This explains the notable differences between the two counts as shown in Table 5.7.

Animal categorisations have, furthermore, changed and improved over time. In the SI data, cattle for meat production or Other Mature Cattle were not reported until 1998. The discrepancy between Mature Dairy Cattle as reported in SI and the NIR derives from the fact that Other Mature Cattle was included in the Mature Dairy Cattle numbers in the SI data and were therefore disaggregated in the NIR for the years 1990 and 1991 from the total Mature Dairy Cattle number. From 1993 Other Mature Cattle numbers are available through MFAF, even though they are not reported on the website of SI. The annual livestock census is the basis for government subsidies in the raising of cattle and sheep and can be considered very accurate. For Swine, the data can be considered accurate as well because of the nature of the industry.

Table 5.7 Comparison between animal numbers as used for the calculation of GHG emissions and as reported on the website of SI.

Animal Category	Source	1990	1995	2000	2005	2010	2015	2020	2021
Mature Dairy Cattle	SI	32,246	30,428	27,066	24,538	25,711	27,386	25,763	25,772
	NIR	31,604	30,428	27,066	24,488	25,379	27,441	25,896	25,772
Other Mature Cattle	SI	...	...	949	1,355	1,672	2,049	3,295	3,572
	NIR	645	737	953	1,355	1,608	2,049	3,295	3,572
Ewes	SI	445,513	372,202	373,340	360,375	374,266	374,863	315,122	300,822
	NIR	445,185	372,222	373,240	360,119	372,672	373,278	315,613	300,860
Lambs	SI	...	...	...	...	...	...	...	...
	NIR	309,821	260,177	264,540	258,693	275,845	278,962	234,045	227,346
Swine	SI	3,116	3,726	3,862	3,982	3,615	3,550	3,063	2,994
	NIR	3,148	3,726	3,862	4,017	3,399	3,518	3,063	2,994
Piglets	SI	...	...	...	...	...	...	...	...
	NIR	26,620	27,020	28,380	35,333	34,633	39,024	36,190	35,387
Laying Hens	SI	214,936	164,402	193,097	166,119	173,419	238,000	203,643	187,565
	NIR	506,165	186,295	284,612	212,795	164,374	171,161	240,853	230,383

Horses

Since changing the yearly livestock count methodology in 2013, there have been issues with the number of horses which could result in an under- or overestimation (double counting). MFAF is in the process of setting up a better system by linking Worldfengur, the studbook of origin for the Icelandic horse[22] with the annual autumn census. When numbers are submitted through the studbook, the fate of a single horse can be followed through the birth number which is assigned to each individual. In this way, double counting is avoided. This new system has been implemented since 2019 and it will take some time to be fully reliable. However, there is no legal obligation for horse owners to report the number of horses, as they do not receive any support payments as for cattle and sheep. This could still lead to an underestimation of the actual number of horses present in the country (Lorange, written communication, 2019).

For this submission it was decided to maintain the estimation method established for the past submissions by modelling the total number of horses as the sum of two thirds of animals registered at MFAF (bustofn.is) and one third registered in the studbook after consulting with Jón Baldur Lorange, advisor at the office for agricultural affairs at MFAF and manager of the studbook Worldfengur (Table 5.8). The calculated total number of horses is assumed to include all horses, mares, young horses, and live foals, but excludes the number of foals that are slaughtered annually. This methodology has been re-confirmed by expert judgment (Lorange, written communication, 2021) for the 2021 Submission. At a certain point, no calculations should be necessary, and the horse numbers should derive directly from the studbook, linked to the autumnal census of livestock. Until then, the abovementioned expert judgment is used to have the most realistic livestock population numbers as possible.

Table 5.8 Comparison of registered horses in the autumn census of IFVA and the studbook Worldfengur for 2015-2021 and calculated horse numbers to be used in this submission.[23]

Source	2015	2016	2017	2018	2019	2020	2021
MFAF (bustofn.is)	67,417	67,239	64,816	53,453	55,230	58,456	54,069
Studbook (worldfengur.com)	97,941	97,955	96,840	96,689	93,733	91,648	91,166
Calculated for NIR	77,592	77,478	75,491	67,865	70,631	71,733	68,908

5.2.1.1 *Animals with a Lifespan Shorter than One Year*

The fact that young animals that live less than one year and have been slaughtered by autumn, means that they are unaccounted for in the annual census data. This issue has been resolved by calculating these animal populations based on the parameters and methods listed below.

To adjust for the fact that the animals have a lifespan shorter than one year, annual average populations (AAP) were calculated, according to equation 10.1 in the 2006 IPCC Guidelines, using estimates of total production of animals and average lifespan.

Equation 10.1
Annual average population

$$AAP = Days_{\text{alive}} * \left(\frac{NAPA}{365}\right)$$

[22] https://www.worldfengur.com/

[23] This table contains the number of horses which are alive for more than one year (horses, mares, young horses, and live foals). The AAP of foals which are slaughtered is not included in this number, because they have never been a part of the census. Therefore, the total number of horses calculated for NIR in this table is a little lower than the total number of horses reported in CRF.

Where:

- AAP= annual average population
- NAPA= number of animals produced annually

More details on how the numbers of each relevant animal category are calculated can be found in the sections below.

Lambs

The population of lambs was calculated with information on birth rates, derived from data on infertility rates, single, double, and triple birth fractions for both mature ewes and animals for replacement, e.g., one-year-old ewes, early mortality rate and average age at slaughter, as shown in Table 5.9 (IAAC, 2022). The number of lambs produced annually (NLPA) is consequently estimated with the following equation:

Equation

Number of lambs produced annually

$$NLPA = \left(1 - Rate_{\mathrm{Mortality}}\right) * \left(Frac_{\mathrm{ewes}} * \mathrm{N}_{\mathrm{ewes}} + Frac_{\mathrm{afr}} * N_{\mathrm{afr}}\right)$$

Where:

- NLPA = Number of lambs produced annually
- $\mathrm{Rate}_{\mathrm{Mortality}}$ = Early mortality rate
- $\mathrm{Frac}_{\mathrm{ewes}}$ = Birth rate fraction for ewes
- $\mathrm{Frac}_{\mathrm{afr}}$ = Birth rate fraction for animals for replacement
- $\mathrm{N}_{\mathrm{ewes}}$ = Number of ewes
- $\mathrm{N}_{\mathrm{afr}}$ = Number of animals for replacement

When the NLPA has been established, the AAP of lambs is calculated based on data on the age of lambs at slaughter. The parameters and resulting calculated AAP of lambs can be seen in Table 5.9.

Table 5.9 Parameters used to calculate the AAP of lambs and the resulting calculated AAP of lambs.

Lambs	Unit	1990	2000	2010	2020	2021
Mature ewes	Number/Year	445,185	373,240	372,672	315,613	300,860
Lambs born per mature ewe	Number/Year	1.81	1.81	1.81	1.83	1.84
Female animals for replacement	Number/Year	79,655	71,122	83,257	67,063	65,947
Lambs born per female animal for replacement	Number/Year	0.83	0.83	0.83	0.94	0.97
Lambs born	Number/Year	869,673	739,148	755,473	641,739	618,886
Early mortality	%	5.0%	4.6%	4.1%	3.5%	3.5%
Number of lambs produced annually (NLPA)	Number/Year	826,189	705,440	724,341	619,033	596,989
Age at slaughter	Months	4.5	4.5	4.6	4.5	4.6
AAP of lambs	Number/Year	309,821	264,540	275,845	234,045	227,346

Piglets

The number of piglets was calculated with data on the number of piglets born to each sow per year (Farmer's Association of Iceland[24], written information, 2012, 2021). The parameters and resulting calculated AAP of piglets can be seen in Table 5.10.

[24] The Farmer's Association of Iceland, sections for each livestock category: https://www.bondi.is/bugreinadeildir

Table 5.10 Parameters used to calculate the AAP of piglets and the resulting calculated AAP of piglets.

Piglets	Unit	1990	2000	2010	2020	2021
Sows	Number/Year	3,013	3,693	3,331	3,021	2,954
Piglets born per sow	Number/Year	15.0	17.0	23.0	26.5	26.5
Piglets born (NAPA)	Number/Year	45,192	62,781	76,613	80,057	78,281
Age at slaughter	Days	215	165	165	165	165
AAP of piglets	Number/Year	26,620	28,380	34,633	36,190	35,387

Kids

The number of kids was calculated with information on the fraction of female goats of the total mature goat population, birth fractions and the age at slaughter received from Iceland's biggest goat farmer (Þorvaldsdóttir, oral information, 2012). The parameters and resulting calculated AAP of kids can be seen in Table 5.11.

Table 5.11 Parameters used to calculate the AAP of kids and the resulting calculated AAP of kids.

Kids	Unit	1990	2000	2010	2020	2021
Goats	Number/Year	332	375	695	1,621	1,672
Fraction female	%	85%	85%	85%	85%	85%
Goats (female)	Number/Year	282	319	591	1,378	1,421
Single birth rate	Fraction	0.7	0.7	0.7	0.7	0.7
Double birth rate	Fraction	0.3	0.3	0.3	0.3	0.3
Kids born (NAPA)	Number/Year	367	414	768	1,791	1,848
Age at slaughter	Months	5.0	5.0	5.0	5.0	5.0
AAP of kids	Number/Year	153	173	320	746	770

Foals

Due to a lack of registration of foals, their number is estimated as a share of the total calculated number of horses. These numbers are based on data received from the IFVA and on expert judgment from the MFAF. Data on the number of foals, both live and slaughtered, was received from the IFVA between 1990-2012. From then on, the average share of live- and slaughtered foals between 2007-2011 of the total number of horses in Iceland was used to calculate the number of live- and slaughtered foals for the years 2013-2021.

A key difference between live and slaughtered foals, is that the live foals are calculated as a share of the total calculated horse population, because they are alive for more than one year, while the slaughtered foals are added to the total; i.e., it is assumed that horses, mares, young horses, and live foals add up to 100% of the total calculated number of horses. The 6% of slaughtered foals is added on top of that. The parameters and resulting calculated AAP of foals can be seen in Table 5.12.

Table 5.12 Parameters used to calculate the AAP of foals and the resulting calculated AAP of foals.

Foals	Unit	1990	2000	2010	2020	2021
Total horses	Number/Year	72,030	73,669	77,196	71,733	68,908
Live foals, share of total horses	%	8.6%	8.6%	8.6%	8.6%	8.6%
Slaughtered foals, share of total horses	%	5.6%	5.6%	5.6%	5.6%	5.6%
Live foals	Number/Year	6,763	4,828	6,906	6,199	5,955
Slaughtered foals	Number/Year	4,409	4,706	3,968	3,994	3,837
Age at slaughter	Months	5.0	5.0	5.0	5.0	5.0
AAP of foals	Number/Year	8,600	6,789	8,559	7,863	7,553

Poultry

Animal numbers for mature poultry are derived from the yearly census data on bustofn.is. This is used for the more mature animals, including hens and pullets. The number of pullets (chicken) is however adjusted to derive the AAP, since pullets, as defined in the census, are less than five months old. To avoid underestimations of emission, it is estimated that all pullets are alive for five months out of the year. For 1990-1991, data on the number of mature turkeys was missing. This was gap filled by estimating the number of mature turkeys to be the average of the first five known years (1992-1996).

The number of younger poultry is derived from data on slaughtered poultry. Information on age at slaughter was reviewed in collaboration with a poultry expert at the IFVA in 2021.

For some of the poultry categories, data on slaughtered animals was missing for the early years, between 1990-1995. For the chicks categories of chicken, ducks, and turkeys, the same AAP was assumed for 1990-1994 as there were estimated to be in 1995 – the earliest year for which real data on the number of slaughtered chicks is available.

The parameters used for these calculations and resulting annual average and total populations of chicken, ducks and turkeys can be seen in Table 5.13.

Table 5.13 Parameters used to calculate the AAP of poultry (chicken, ducks, and turkeys) and the resulting calculated AAP of poultry.

Poultry Category	Description	Unit	1990	2000	2010	2020	2021
Chicken	Total hens	Number/Year	506,165	284,612	164,374	240,853	145,383
Chicken	Total pullets	Count	24,020	63,039	73,195	66,048	63,621
Chicken	Age of pullet at slaughter	Months	5	5	5	5	5
Chicken	AAP of pullets	Number/Year	10,008	26,266	30,498	27,520	26,509
Chicken	Total chicks	Count	1,517,395	2,009,471	4,283,876	5,401,052	5,465,656
Chicken	Age of chicks at slaughter	Months	1.10	1.10	1.10	1.16	1.16
Chicken	AAP of chicks	Number/Year	139,095	184,202	392,689	520,601	526,829
Chicken	**Total population**	**Number/Year**	**655,268**	**495,080**	**587,561**	**788,974**	**698,720**
Ducks	Total hens	Number/Year	3,618	884	1,079	519	525
Ducks	Total chicks	Count	11,944	8,936	0	0	0
Ducks	Age of chicks at slaughter	Months	1.67	1.67	1.67	1.67	1.67
Ducks	AAP of chicks	Number/Year	1,659	1,241	0	0	0
Ducks	**Total population**	**Number/Year**	**5,277**	**2,125**	**1,079**	**519**	**525**
Turkeys	Total hens	Number/Year	845	4,505	957	1,200	1,200
Turkeys	Total chicks	Count	12,571	29,938	38,295	48,838	44,518
Turkeys	Age of turkeys at slaughter	Months	2.57	2.57	2.57	2.75	2.75
Turkeys	AAP of chicks	Number/Year	2,689	6,403	8,191	11,206	10,214
Turkeys	**Total population**	**Number/Year**	**3,534**	**10,908**	**9,148**	**12,406**	**11,414**

5.2.2 Livestock Population Characterisation

The livestock categories reported in the annual autumn census differ from the categories used for the calculations of the methane emissions from enteric fermentation and manure management. The enhanced livestock population characterisation, applied for the first time in the 2018 submission, was maintained for all subsequent submissions. The category Cattle is subdivided into Mature Dairy Cattle, Other Mature Cattle and Growing Cattle. The category Other Mature Cattle comprises cows used for meat production, while the category Growing Cattle summarises the three categories of the autumn census: 1) Pregnant heifers 2) Steers and non-inseminated heifers (12-25-month-old bullocks and 12-

18-month-old heifers) and 3) Calves (males and females up to 12 months of age). The emissions are calculated separately for each of these subcategories and then summed together in the category Growing Cattle in CRF. An overview of the NIR categories is provided in Table 5.14.

Table 5.14 Clarification of cattle categories, English translations of Icelandic categories.

Icelandic	English Translation	Category in NIR
Mjólkurkýr	Dairy cattle	Mature Dairy Cattle
Holdakýr til undaneldis	Beef cattle for reproduction	Other Mature Cattle
Kelfdar kvígur	Pregnant heifer. Heifers when inseminated at the age of 18 months until they are calving.	Pregnant Heifers
Geldneyti og ungar kvígur	12-25 months old intact males and 12-18 months old females	Steers and Non-inseminated Heifers
Kvígkálfar yngri en 1 árs	Female calves younger than 12 months	Calves
Nautkálfar yngri en 1 árs	Male calves younger than 12 months	Calves

The livestock category Sheep comprises Mature Ewes, Animals for Replacement, Other Mature Sheep and Lambs. Animals for Replacement match the category of female and male yearlings in the autumn census, while Other Mature Sheep are rams. The category Lambs is calculated from the number of mature ewes, their pregnancy rate, and the early mortality rate of lambs. Livestock characterisation is carried out applying the Tier 2 method from Chapter 10, Volume 4, of the 2006 IPCC Guidelines for cattle and sheep.

Table 5.15 shows the equations used in calculating net energy needed for maintenance, activity, growth, lactation, wool production and pregnancy for cattle and sheep subcategories. The ratio of net energy available in diet for maintenance to digestible energy consumed (REM) is calculated by applying Eq. 10.14 in the 2006 IPCC Guidelines, the ratio of net energy available for growth in a diet to digestible energy consumed (REG) is calculated by applying Eq. 10.15 and the gross energy (GE) is calculated applying Eq. 10.16 in the 2006 IPCC Guidelines.

Table 5.15. Overview of equations used to calculate gross energy intake in enhanced livestock population characterisation for cattle and sheep (NA: not applicable).

Subcategory	Equations from Chapter 10, vol. 4 of the 2006 IPCC Guidelines. Net Energy for Maintenance, Activity, Growth, Lactation, Wool, and Pregnancy					
	Maintenance NEm	Activity NEa	Growth NEg	Lactation NEl	Wool NEwool	Pregnancy NEp
Mature Dairy Cows	10.3	10.4	NA	10.8	NA	10.13
Other Mature Cattle	10.3	10.4	NA	10.8	NA	10.13
Pregnant Heifers[1]	10.3	10.4	10.6	NA	NA	4.8
Steers and non-inseminated Heifers	10.3	10.4	10.6	NA	NA	NA
Young Cattle	10.3	10.4	10.6	NA	NA	NA
Mature Ewes	10.3	10.4	NA	10.1	10.12	10.13
Other Mature Sheep	10.3	10.4	NA	NA	10.12	NA
Animals for Replacement	10.3	10.4	10.7	10.1	10.12	10.13
Lambs	10.3	10.4	10.7	NA	10.12	NA

[1] Animals for replacement are considered from 4.5 months (when lambs are slaughtered) to 16.5 months, i.e., one year later, when they will be categories as mature in the autumn census.

Table 5.16 shows national parameters that were used to calculate gross energy intake for cattle in 2021. Not all parameters have been constant over the last three decades. The ones that have changed over that time period are days on stall, days on pasture, kg milk per day, CF_i — a coefficient used for calculating the net energy for maintenance. For cattle, the number of calves is taken directly from the autumn census of the IFVA because calves have a lifespan longer than one year.

Icelandic Sheep

The Icelandic sheep breed has been a part of the Icelandic landscape since the age of settlement (874-930). The breed was brought over from Norway and belongs to the Northern European short-tailed sheep.

Selective breeding of the Icelandic sheep began in the 19th century, but it led to diseases that the Icelandic sheep was very sensitive to and therefore it was stopped. Today it is forbidden to import sheep to Iceland. The size of the sheep is average. The ewes weigh around 65kg and the rams around 93kg. The sheep are generally short legged with face and legs free of wool. Both ewe and ram can be horned or polled, but most sheep are horned.

There are around 400,000 sheep in Iceland during the winter and 1,000,000 during the summer. That means that there are usually more sheep in Iceland than humans. After lambing in May, Icelandic farmers turn their flocks loose into the hills, valleys, and highlands, where they graze freely on grass, berries, and herbs over the summer. The sheep roundup takes place in the autumn, where the sheep are brought in, sorted, and go back to their respective owners. This method has been used ever since settlement. Every summer, the sheep roam around the highlands.

Pictures are from icelandiclamb.is, gettyimages.com and funiceland.is, information from icelandiclamb.is, fao-dadis-breed-detail.firebaseapp.com and rml.is.

Table 5.16. Animal performance data used in calculation of gross energy intake for cattle in 2021. (NA: Not applicable, NO: Not occurring).

	Mature Dairy Cattle	Other Mature Cattle	Pregnant Heifers	Steers and non-inseminated Heifers[1]	Calves
Weight [kg]	471	470	372	361	137
Days in stall	309	30	245	307	365
Days on pasture	56	335	120	58	0
Mature body weight [kg]	471	470	505	523	517
Daily weight gain [kg]	NO	NO	0.50	0.57	0.50
Milk per day [kg]	17.4	5.5	NA	NA	NA
Fat content of milk [%]	4.2	5.2	NA	NA	NA
CF_i[2]	0.365	0.343	0.322	0.356	0.322

[1] The category Steers and non-inseminated Heifers consists of both bullocks older than 1 year and young cows between the age of 12 and 18 months. While the latter are allowed outside for approximately 120 days a year, the male animals remain indoors throughout. Therefore, the calculated average time on pasture for the total category Steers and non-inseminated Heifers is 58 days.

[2] The parameter CF_i is taken from Table 10.4 in the 2006 IPCC Guidelines. For Mature Dairy Cattle and Other Mature Cattle, the default value is adjusted to the lactating period (305 days for Mature Dairy Cattle and 120 days for Other Mature Cattle) and for Steers and non-inseminated Heifers the gender fractions are used to calculate the factor for the category, since intact males require 15% more energy for maintenance.

Table 5.17 shows national parameters that were used to calculate gross energy intake for sheep in 2021.

Table 5.17 Animal performance data used in calculation of gross energy intake for sheep for 2020. NA: Not applicable, NO: Not occurring.

	Mature Ewes	Other Mature Sheep	Animals for Replacement	Lambs
Weight [kg]	65	93	50	22
Days in stall	200	200	200	0
Days on flat pasture	60	60	60	32
Days on hilly pasture	105	105	105	105
Body weight at weaning [kg]	NA	NA	NA	20
Body weight at one year old or at slaughter [kg][1]	NA	NA	60	17
Birth weight [kg]	3.9	3.9	3.9	3.9
Single birth fraction[2]	0.16	NA	0.50	NA
Double birth fraction	0.70	NA	0.24	NA
Triple birth fraction	0.09	NA	NO	NA
Annual wool production [kg]	2.0	2.5	1.5	1.5
Digestible energy [%]	65.86	65.86	65.86	70.43
CF_i[3]	0.217	0.250	0.232	0.254

[1] Weight at 16.5 months for AFR and 4.5 months for lambs (slaughter).

[2] Difference between sum of birth fractions and one is due to infertility rates of mature ewes and animals for replacement.

[3] The parameter CFi is taken from Table 10.4 in the 2006 IPCC Guidelines. For lambs and animals for replacement the gender ratio is used for calculations, since CFi of males is 15% higher than that of females.

Icelandic Cattle

The Icelandic cow breed is probably one of the very few breeds in the world that has remained little or not mixed with other breeds since the age of settlement in Iceland (874-930 AD). Research shows that the Icelandic breed is very similar to old breeds still found in Norway nowadays. While all the dairy cattle is of the old Icelandic breed, the beef cattle are Aberdeen Angus, Galloway, and Limousin, all imported from Great Britain and France. The import of these breeds started in the early 20th century and is fairly limited.

The Icelandic dairy cattle is small, and adults weigh only about 470 kg. The cows are multicoloured and show more diverse colours than any other cattle breed in Europe. Average milk yield reported in 2020 per cow is 6,336 kg with 4.2% fat and 3.39% protein.

The table below shows a comparison in weight between the Icelandic breed (ISL), one Norwegian Cattle (NRF), two Swedish breeds (SRB, SLB) and one breed from New Zealand (NZF).

	NRF	SRB	SLB	NZF	ISL
Weight at birth [kg]	40	40	41	40	32
Weight at first calf [kg]	500	510	570	410	405
Mature body weight [kg]	550	550	670	530	470
Age at first calf [months]	25	28	28	24	26

NFR: Norwegian Red, SRB: Swedish Red and White, SLB Swedish Friesian, NZF: New Zealand Friesian, ISL: Icelandic breed

Information and pictures from naut.is (Icelandic), Comparison between breeds from (Kristofersson, Eythorsdottir, Harðarson, & Jonsson, 2007)

5.2.3 Feed Characteristics and Gross Energy Intake

Feed composition, daily feed amounts, their dry matter digestibility and feed ash content were collected by the Agricultural University of Iceland (*Landbúnaðarháskóli Íslands*) (AUI) (Sveinbjörnsson, written communication) and this information is based on feeding plans and research. In 2020, feed digestibility parameters and body weight for mature dairy cattle were updated for 2018, in collaboration with the IAAC (IAAC, written communication, 2020). For the 2023 Submission, the EAI made an agreement with the IAAC to gather data on the feed digestibility of cattle and sheep fodder for all subcategories, as well as body weight, body weight gain, mature body weight, fat content of milk, pregnancy rates, days in stall and on pasture and hilly pasture, age of animals slaughtered, early mortality rates of lambs, fraction of ewes and yearling with 0, 1, 2, and 3 or more lambs in hilly pasture, annual wool production (IAAC, 2022).

All these parameters were updated before the 2023 Submission for all cattle and sheep subcategories for 1990, 1999, 2005, 2010, and 2019-2021, in collaboration with the IAAC. The parameters were extrapolated linearly between those years to complete the timeline, with advice from the IAAC. In the future it is planned to update feed digestibility data every three to four years. Data about milk yield is collected annually and published by the Icelandic Agricultural Advisory Centre (and other entities in the past).

Feed ash content (instead of manure ash content) was used in all calculations in accordance with Dämmgen et al. (2011). Dry matter digestibility and feed ash content were weighted with the respective daily feed amounts in order to calculate average annual values. This method included seasonal variations in feed, e.g., stall feeding versus grazing on pasture, lactation versus non-lactation period etc. Dry matter digestibility was transformed into digestible energy content using a formula from Guðmundsson and Eiríksson (1995). Table 5.18 shows dry matter digestibility, digestible energy, and ash content of feed in 2021, for all cattle and sheep categories. All values used as well as calculations and formulas for all cattle and sheep categories are reported in Annex 5.

Equation 10.16

Gross energy for cattle and sheep

$$GE = \left[\frac{\left(\frac{NE_m + NE_a + NE_l + NE_{\mathrm{work}} + NE_p}{REM}\right) + \left(\frac{NE_g + NE_{\mathrm{wool}}}{REG}\right)}{\frac{DE\%}{100}} \right]$$

Where:

- GE = gross energy intake, MJ/head/day
- NE_m, NE_a, NE_l, NE_{work}, NE_p, NE_g, NE_{wool} = net energy required for different activities as calculated by equations 10.3- 10.13, MJ/day
- REM = ratio of net energy available in a diet for maintenance to digestible energy consumed
- REG = ratio of net energy available for growth in a diet to digestible energy consumed
- DE% = digestible energy expressed as a percentage of gross energy

Table 5.18 Dry matter digestibility, digestible energy and ash content of cattle and sheep feed in 2021.

	DMD [%]	DE [%]	Ash in feed [%]
Mature Dairy Cattle	74.70	68.48	7.71
Other Mature Cattle	75.54	69.30	7.02

	DMD [%]	DE [%]	Ash in feed [%]
Pregnant Heifers	74.90	68.67	7.44
Steers used principally for producing meat	75.36	69.12	7.07
Calves	78.44	72.14	7.90
Mature Ewes	72.03	65.86	7.48
Other Mature Sheep	72.03	65.86	7.48
Animals for Replacement	72.03	65.86	7.48
Lambs	76.69	70.43	6.71

Figure 5.2 shows the gross energy intake (GE) in MJ per animal per day for all cattle and sheep subcategories. Starting in the 2023 Submission, all subcategories have time dependent values for GE (see paragraph 5.2.4). Feed digestibility has been increasing over the timeline which has led to slightly lowered gross energy intake for all categories except Mature Dairy Cattle and Lambs. Mature dairy cattle have been producing increasingly much milk over the timeline and lambs have been growing in average body weight over this time period. These elements mainly explain their increased gross energy intake.

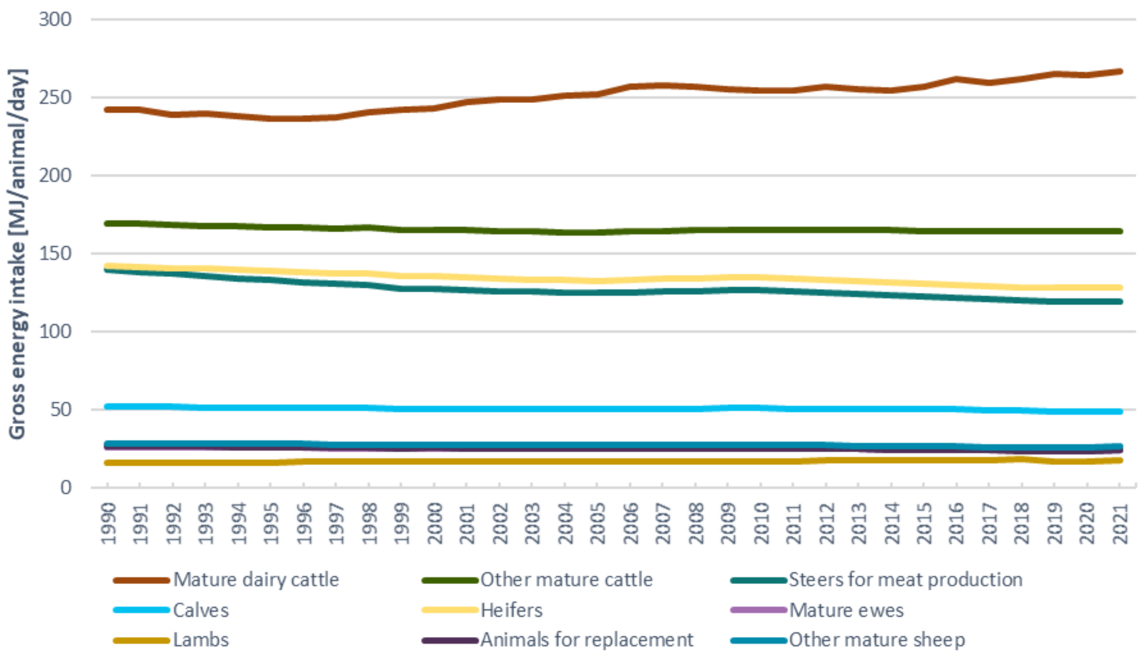


Figure 5.2 Gross energy intake [MJ/animal/day] for cattle and sheep subcategories from 1990-2021.

5.2.4 Recalculations

There have been a number of recalculations due to, both updated livestock population numbers and updated livestock parameters for cattle and sheep. The recalculations, which impacted livestock population numbers, are described below. The impacts of these changes on emissions can be found under the recalculation chapters of each relevant CRF chapter.

The lamb population activity data was updated for 1990-2020, as shown in Table 5.19. A thorough review was undertaken for the Cattle and Sheep categories in the inventory, and it was discovered that there were some inconsistencies and errors in the Sheep category which affected the lamb population numbers.

Previously, the lamb population was calculated based on the ratios for how many lambs each ewe and animal for replacement carried with her in pasture over the summer, which does not represent the number of lambs born but the number of lambs the ewe or animal for replacement lactates for. This has been corrected and now, the lamb population is calculated based on the pregnancy ratios of mature ewes and animals for replacement instead. In Iceland, almost no sheep is sent out to pasture with more than two lambs, even though it might have carried three. The third lamb is given to a sheep with one lamb. Hence, even though the percentage of ewes carrying three lambs has increased from 6-9%, the ewes in pasture with three lambs has decreased from 2.0-0.6% in 1990-2020. Since the lactation ratios were incorrectly used as pregnancy ratios the lamb population was underestimated by 8-14% over the timeline.

In addition, the pregnancy ratios for Animals for Replacement were corrected. Previously the pregnancy rates were applied to the whole category population, even though on average only 89% of the population is female. Hence, the population of lambs for the earliest years in the timeline is lower, after the correction was made, as can be seen in Table 5.19.

Table 5.19 Recalculations of lamb population numbers for the years 1990-2020.

Total Lamb Population (AD) [number]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	312,801	261,163	263,750	256,227	271,156	272,279	207,823
2023 Submission	309,821	260,177	264,540	258,693	275,845	278,962	234,045
Change relative to the 2022 Submission	-0.95%	-0.38%	0.30%	0.96%	1.73%	2.45%	12.62%

Total horse population activity data (AD) was updated for the years 2012-2020, as is shown in Table 5.20. The previous method to estimate this number was untransparent and was, therefore, simplified. Now, the total horse population number used in CRF should match the sum of the horse population calculation in Table 5.8 and the AAP of slaughtered foals in Table 5.12.

Table 5.20 Recalculations of horse population numbers for the years 2012-2020.

Total Horse Population (AD) [number]	2012	2013	2014	2015	2016	2017	2018	2019	2020
2022 v4 Submission	79,217	76,837	79,733	79,429	79,315	77,328	69,702	72,449	73,584
2023 Submission	79,175	76,740	79,703	79,392	79,275	77,242	69,440	72,270	73,397
Change relative to the 2022 Submission	-0.05%	-0.13%	-0.04%	-0.05%	-0.05%	-0.11%	-0.38%	-0.25%	-0.25%

Poultry population activity data was updated for the years 1990-2020, as show in Table 5.1. The number of pullets was adjusted according to their AAP, since chickens are only categorised as pullets until they are 5 months old. The number of turkey chickens was gap filled for 1990-1991, as they were previously reported to be zero for those years. The number of turkey hens was also corrected for 2010-2011 and 2017-2020, where activity data had been lacking.

Table 5.21 Recalculations of poultry population numbers for 1990-2020

Total Poultry Population (AD) [number]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	678,710	361,527	545,259	775,777	639,801	718,935	839,296
2023 Submission	664,608	345,297	508,486	655,950	598,055	674,698	801,961
Change relative to the 2022 Submission	-2.08%	-4.49%	-6.74%	-15.45%	-6.52%	-6.15%	-4.45%

5.2.4.1 *Animal Characterisation Update for the 2022 Submission*

During a review of livestock parameters for the 2022 Submission, an error in the categorisation of poultry was discovered. Poultry previously categorised as Broilers should, in fact, be categorised as Laying Hens for the whole timeseries according to the poultry expert veterinarian at the IFVA. Table 5.22 shows the change in the livestock categorisation. The total number of Laying Hens and Broilers remained the same. This updated livestock categorisation resulted in some changes in the emissions from manure management, as the emission factors used for Broilers and Laying hens are different. In detail, the following CRF categories 3B14 Other livestock – poultry, 3B24 Other livestock – poultry, 3B25 Indirect N_2O Emissions, 3D12a Animal Manure Applied to Soils, and 3D2 Indirect N_2O Emissions from Managed Soils are affected and the emission changes are shown in the recalculations section in the respective chapters. The sum of change in emissions due to this reclassification, over the timeseries ranges from 0.3% to 4.5%.

Table 5.22 Activity data change: Updated livestock categorisation of laying hens and broilers for the whole timeseries 1990-2019 in number of animals.

	Livestock Category	1990	1995	2000	2005	2010	2015	2019
2021 v1 Submission	Laying hens	214,975	164,402	193,097	152,217	144,429	119,811	205,091
	Broilers	291,190	21,893	91,515	60,578	19,945	51,350	61,974
2022 Submission	Laying hens	506,165	186,295	284,612	212,795	164,374	171,161	267,065
	Broilers	0	0	0	0	0	0	0

5.2.5 Planned Improvements

For this submission a collaboration was undertaken with the IAAC to update the feed digestibility parameters for cattle and sheep. Furthermore, feed digestibility for the historical timeline has been estimated, in line with Iceland's response to the 2021 UNFCCC centralised review question 2021ISLQA194.

Iceland is continuing to work on improving the quality of the animal characterisation data by working with the MFAF and the IAAC with the aim of updating productivity data, such as the digestible energy content of feed and gross energy intake, approximately every three years for the Tier 2 livestock categories. In addition, it is planned to continue to update animal characterisation parameters regularly for all livestock categories, as was done for Tier 1 livestock categories in the previous submission, and Tier 2 livestock categories in this submission.

A closer cooperation is planned with the MFAF to streamline data acquisition. The MFAF collects agricultural data, some of which corresponds to activity data required for the inventory, in relation to grants given out to farmers annually. There is potential to restructure the MFAF database to correspond better with activity data required for the inventory and to collaborate on data acquisition in the future.

Activity data regarding manure management systems for sheep is lacking. However, research is needed to improve the data. The plan is to improve this for future submissions.

5.3 CH_4 Emissions from Enteric Fermentation (CRF 3A)

The amount of enteric methane emitted by livestock is driven primarily by the number of animals, the type of digestive system and the type and amount of feed consumed. Cattle and Sheep are the largest sources of enteric methane emissions in Iceland and therefore the Tier 2 methodology proposed by the 2006 IPCC Guidelines is applied. For all other livestock categories Tier 1 is applied.

5.3.1 Emission Factors

Tier 1

Methane emission factors for pseudo-ruminant and mono-gastric animal species were taken from the 2006 IPCC Guidelines (Table 5.23). For Poultry and Fur-bearing animals, emission factors reported in the Norwegian Emission Inventory are used, as agricultural practices and the climate in the two countries are similar. Further information can be found in the Norwegian NIR (Statistics Norway, 2019).

Table 5.23 Default emission factors [kg CH_4/head/year] used for Tier 1 calculations.

Livestock Category	Source	2020
Swine	Table 10.10 2006 IPCC	1.5
Horses	Table 10.10 2006 IPCC	18
Goats	Table 10.10 2006 IPCC	5
Minks, Foxes, Rabbits	Norwegian NIR	0.1
Poultry	Norwegian NIR	0.02

Tier 2

Livestock population characterisation was used to calculate gross energy intake of Cattle and Sheep as shown in paragraph 5.2.3. These values, together with the default values of the methane conversion rate from the 2006 IPCC Guidelines and reported in

Table 5.24, was used to calculate emission factors for methane emissions from enteric fermentation by applying Equation 10.21.

Table 5.25 shows the country specific emission factors for Cattle and Sheep and the respective subcategories. Starting with the 2023 Submission all Sheep and Cattle subcategories have a gross energy intake that varies over time and as a result a fluctuating emission factor (IAAC, 2022). For all subcategories other than Mature Dairy Cattle and Lambs the emission factor has been decreasing due to increased feed digestibility. The increase for Mature Dairy Cattle is mainly due to the increase in milk production during the last two decades. For Lambs it is the increased average body weight that has driven the emission factor increase.

Equation 10.21

CH_4 emission factors for enteric fermentation for a livestock category

$$EF = \frac{GE * \frac{Y_m}{100} * 365}{55.65}$$

Where:

- EF = emission factor, kg CH_4/head/yr
- GE = gross energy intake, MJ/head/day
- Y_m = methane conversion rate which is the fraction of gross energy in feed converted to methane
- 55.65 = energy content of methane, MJ/kg CH_4

Table 5.24 Methane conversion rates for cattle and sheep (from tables 10.12 and 10.13 IPCC, 2006). The value for the Animals for Replacement is a weighted average between the Y_m for Mature Sheep and Lambs.

Category/Subcategory	Cattle	Mature Ewes	Animals for Replacement	Lambs (<1-year-old)
Y_m	6.5%	6.5%	5.3%	4.5%

Table 5.25 Country-specific emission factors [kg CH_4/head/year] for cattle and sheep, calculated based on Equation 10.21 (IPCC, 2006).

Livestock Category	2021	Relative Change 1990-2021
Mature Dairy Cattle	113.8	10%
Other Mature Cattle	70.1	-3%
Pregnant Heifers	54.9	-10%

Livestock Category	2021	Relative Change 1990-2021
Steers and Non-inseminated Heifers	51.0	-14%
Calves	20.9	-6%
Mature Ewes	10.3	-8%
Other Mature Sheep	11.3	-8%
Animals for Replacement	8.4	-10%
Lambs	5.3	10%

5.3.2 Emissions

Methane emissions from enteric fermentation in domestic livestock are calculated by multiplying the emission factors from paragraph 5.3.1 with the respective population sizes of each livestock category and subsequent aggregation of emissions of all categories. The results are shown in Table 5.26.

The livestock category Growing Cattle comprises the categories Pregnant Heifers, Steers and non-inseminated Heifers and Calves. The methane emissions are calculated separately for each category, as shown in Table 5.26 and Table 5.27, but uploaded in CRF as a sum. In CRF all relevant parameters are expressed as a weighted average leading to shifts in the IEF in case of population composition changes in this category.

The livestock category emitting most methane from enteric fermentation is Mature Ewes. Due to a proportionate decrease in population size, emissions from Mature Ewes decreased by 38% between 1990 and 2021. Similar decreases can be seen for other Sheep subcategories. The only non-ruminant livestock category with substantial methane emissions is Horses. The population size of Horses has been rather stable from 1990, and therefore, the methane emissions are fairly constant.

The decrease in methane emissions from Mature Dairy Cattle and Sheep caused total methane emissions from enteric fermentation to drop by 17% over the time period 1990-2021.

Table 5.26 Methane emissions from enteric fermentation [t CH_4].

Livestock Category	1990	1995	2000	2005	2010	2015	2020	2021
Mature Dairy Cattle	3,268	3,075	2,804	2,633	2,758	3,005	2,924	2,934
Other Mature Cattle	47	53	67	95	113	144	231	251
Pregnant Heifers	279	756	368	381	381	399	338	361
Steers and non-inseminated Heifers	1,069	873	1,081	812	1,020	1,032	1,170	1,144
Calves	449	304	387	388	435	479	474	464
Mature Ewes	4,981	4,077	4,022	3,821	4,006	3,874	3,150	3,100
Other Mature Sheep	163	148	143	130	142	134	121	121
Animals for Replacement	831	665	709	722	813	746	615	616
Lambs	1,483	1,268	1,312	1,305	1,404	1,437	1,179	1,201
Swine	45	46	48	59	57	64	59	58
Horses	1,330	1,444	1,361	1,379	1,419	1,429	1,321	1,269
Goats	2.4	2.6	2.7	3.3	5.1	7.4	11.8	12.2
Fur Animals	5.0	3.8	4.1	3.7	4.0	4.8	1.6	1.7
Poultry	13.3	6.9	10.2	13.1	12.0	13.5	16.0	15.9
Total Methane Emissions [t]	**13,964**	**12,723**	**12,320**	**11,746**	**12,570**	**12,768**	**11,612**	**11,548**
Emission change 1990-2021		-8.9%	-11.8%	-15.9%	-10.0%	-8.6%	-16.8%	-17.3%

Table 5.27 Livestock category Growing Cattle: weighted averages of parameters necessary to calculate the methane emissions as reported in CRF.

Growing Cattle	1990	1995	2000	2005	2010	2015	2020	2021
Population Pregnant Heifers	4,579	12,781	6,361	6,728	6,620	7,157	6,167	6,580
Population Steers and non-inseminated Heifers	17,957	15,379	19,848	15,250	18,873	19,757	22,928	22,416
Population Calves	20,118	13,874	17,916	18,149	20,029	22,372	22,744	22,223
Weighted average Body weight (BW) [kg]	256.4	289.8	271.4	261.2	263.8	260.7	264.2	265.4
Weighted average digestible energy (DE) [%]	66.0	66.6	68.1	69.0	68.3	69.3	70.4	70.4
Weighted average gross energy (GE) [MJ/day]	98.8	107.9	97.6	92.5	94.6	90.9	89.7	90.2
Weighted average Volatile solid excretion (VS) [kg VS/day]	2.0	2.1	1.8	1.7	1.7	1.6	1.5	1.6
Sum Emissions [kt CH_4]	**1.80**	**1.93**	**1.84**	**1.58**	**1.84**	**1.91**	**1.98**	**1.97**
IEF	42.12	46.00	41.61	39.42	40.33	38.74	38.24	38.44

5.3.3 Recalculations

Several recalculations, that have an impact on CH_4 emissions from enteric fermentation, have been performed for this submission. The main updates are due to the updated livestock parameters for the Tier 2 categories Cattle and Sheep for the whole timeseries, from 1990-2020, see Table 5.28 and Table 5.29 as well as some human errors found when updating those parameters, as discussed in Section 5.2.4. Smaller recalculations in emissions from horses (Table 5.30) and poultry (Table 5.31) are the result of updated livestock population numbers.

Table 5.28 Recalculations of CRF 3A1 Cattle due to updated livestock parameters for 1990-2020.

CRF 3A1 - Cattle [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	122.6	127.1	120.9	114.5	124.1	135.8	137.5
2023 Submission	143.1	141.7	131.8	120.7	131.8	141.7	143.8
Change relative to the 2022 Submission	16.7%	11.5%	9.0%	5.4%	6.2%	4.3%	4.6%

Table 5.29 Recalculations of CRF 3A2 Sheep due to updated livestock parameters for 1990-2020.

CRF 3A2 - Sheep [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	203.8	170.4	172.7	168.3	173.4	173.1	149.2
2023 Submission	208.8	172.4	173.2	167.4	178.2	173.3	141.8
Change relative to the 2022 Submission	2.5%	1.2%	0.3%	-0.5%	2.8%	0.1%	-4.9%

Table 5.30 Recalculations of CRF 3A4 Poultry due to updated livestock population numbers for 1990-2020.

CRF 3A4 - Poultry [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	0.380	0.202	0.305	0.434	0.358	0.403	0.470
2023 Submission	0.372	0.193	0.285	0.367	0.335	0.378	0.449
Change relative to the 2022 Submission	-2.1%	-4.5%	-6.7%	-15.4%	-6.5%	-6.2%	-4.4%

Table 5.31 Recalculations of CRF 3A4 Horses due to updated livestock population numbers for 2012-2020.

CRF 3A4 - Horses [kt CO_2e]	2012	2013	2014	2015	2016	2017	2018	2019	2020
2022 v4 Submission	39.93	38.73	40.19	40.03	39.97	38.97	35.13	36.51	37.09
2023 Submission	39.90	38.68	40.17	40.01	39.95	38.93	35.00	36.42	36.99

CRF 3A4 - Horses [kt CO_2e]	2012	2013	2014	2015	2016	2017	2018	2019	2020
Change relative to the 2022 Submission	-0.05%	-0.13%	-0.04%	-0.05%	-0.05%	-0.11%	-0.38%	-0.25%	-0.25%

5.3.3.1 *Recalculations from the 2022 Submission*

During the quality checking of the parameters used in the calculations, a slight error was discovered in the value of the parameter Maximum methane producing capacity (Bo) of Cattle. The wrong value 0.17 had been used for Other Mature Cattle, Heifers, Steers, and Young Cattle instead of the correct number 0.18 from Table 10A-5 (Western Europe) in the 2006 IPCC GL. This resulted in slight recalculations over the whole timeseries, showing a decrease of less than 0.0001%

5.3.4 Uncertainties

Annual livestock data are based on a national census, and it is possible to assign an activity data uncertainty of 5.0% for all animal categories except Horses, which are assigned 10% due to the shifting in the registration system over the past few years. These uncertainties were assigned based on expert judgement. The uncertainty of the CH_4 emissions is estimated to be 40% based on the indications of the 2006 IPCC Guidelines for Tier 1 calculations. It was decided to also apply this uncertainty to the animal classes for which a Tier 2 calculation is performed. The combined activity data and emission factor uncertainty for CRF categories 3A1 (Cattle), 3A2 (Sheep), 3A4 (Swine), and for 3A4 (Other livestock) is 40%. The complete uncertainty analysis is shown in Annex 2.

5.3.5 Planned improvements

No improvements are currently planned for this category; however, updated livestock characterisation will also impact this sector.

5.4 CH_4 Emissions from Manure Management (CRF 3B1)

Livestock manure is principally composed of organic material. When this organic material decomposes in an anaerobic environment, methanogenic bacteria produce methane. These conditions often occur when large numbers of animals are managed in confined areas, e.g., in dairy, swine and poultry farms, where manure is typically stored in large piles or disposed of in storage tanks (IPCC, 2006).

5.4.1 Emission Factors

Tier 1

Default methane emission factors are used for all livestock categories except cattle and sheep. The emission factors are taken from Tables 10.14, 10.15 and 10.16 from the 2006 IPCC Guidelines. Table 5.32 summarises the emission factors used for the whole timeline. For the livestock category Poultry, the emissions are calculated in a disaggregated level (laying hens, broilers, pullets, chicken, ducks/ geese, turkeys) to reflect the different emission factors and then summed.

Table 5.32 Tier 1 default emission factors for methane emissions from manure management.

Livestock Category	Source	2021
Swine	Table 10.14 2006 IPCC	6.0
Horses	Table 10.15 2006 IPCC	1.58
Goats	Table 10.15 2006 IPCC	0.13
Minks, Foxes	Table 10.16 2006 IPCC	0.68
Rabbits	Table 10.16 2006 IPCC	0.08

Livestock Category	Source	2021
Laying Hens	Calculated dry/wet from table 10.15 2006 IPCC	0.615
Broilers	Table 10.15 2006 IPCC	0.02
Turkeys	Table 10.15 2006 IPCC	0.09
Ducks	Table 10.15 2006 IPCC	0.02

Tier 2

For the livestock categories Cattle and Sheep, the Tier 2 methodology as reported in the 2006 IPCC guidelines (Volume 4, AFOLU, chapter 10) is applied. Based on the livestock characterisation described in 5.2.2, the volatile solid excretion rate (VS) is calculated following Equation 10.24 of the 2006 IPCC Guidelines.

Equation 10.24

Volatile solid excretion rates

$$VS = \left[GE * \left(1 - \frac{DE\%}{100}\right) + UE * GE\right] * \left[\left(\frac{1 - ASH}{18.45}\right)\right]$$

Where:

- VS = volatile solid excretion per day on a dry-matter weight basis, kg VS/day
- GE = gross energy intake, MJ/day
- DE% = digestibility of the feed, %
- UE*GE = urinary energy expressed as fraction of GE; value of 0.04 GE used
- ASH = ash content of the manure in percent
- 18.45 = conversion factor for dietary GE per kg of dry matter (MJ/day)

Volatile solid excretion per day is then used in equation 10.23 of the 2006 IPCC Guidelines to calculate the CH_4 emission factor from manure management:

Equation 10.23

CH_4 Emission factor from manure management

$$EF_{(T)} = (VS * 365) * [B_O * 0.67\ {}^{\mathrm{kg}}/_{\mathrm{m}^3} * \textstyle\sum_{S,k} \frac{MCF_{S,k}}{100} * MS_{S,k}]$$

Where:

- $EF_{(T)}$ = annual CH_4 emission factor for defined livestock category, kg CH_4/animal/year
- VS = daily VS excreted for livestock category, kg dry matter/animal/day
- 365 = basis for calculating annual VS production, days/year
- B_o = maximum CH_4 producing capacity for manure produced by livestock category, m3 CH_4/kg of VS excreted
- 0.67 = conversion factor of m^3 CH_4 to kg CH_4
- $MCF_{S,k}$ = CH_4 conversion factors for each manure management system S by climate region k, %
- $MS_{S,k}$ = fraction of livestock category manure handled using manure management system S by climate region k

Methane conversion factors (MCF) and maximum methane producing capacity values (B_o) for both livestock categories, Cattle and Sheep, are taken from the 2006 IPCC Guidelines, see Table 5.33.

Table 5.33 MCF and B_o from the 2006 IPCC Guidelines used for the calculations of methane emissions from manure management.

	Source	Cattle	Cattle	Cattle	Sheep
Cool climate		pasture/ range	solid storage	liquid/ slurry	all MM systems
Methane conversion factor - MCF	Table 10.17, 2006 IPCC	1%	2%	10% [1] 17% [2]	same as for cattle
		Mature Dairy Cattle		Other Cattle	Sheep
Maximum methane producing capacity of manure - Bo	Tables 10A-4, 10A-9, 2006 IPCC	0.24		0.18	0.19

[1] With natural crust cover

[2] Without natural crust cover.

5.4.2 Manure Management System Fractions

The fractions of total manure managed in the different manure management systems (MMS) impact not only CH_4 emissions from manure management but also N_2O emissions from manure management and consequently N_2O emissions from agricultural soils. The fractions used for all Cattle subcategories were updated for the whole timeline for the 2023 Submission (IAAC, 2022). The type of manure management systems used, time in each system and amount of straw used as bedding were all updated. The fractions used for other livestock categories are based on expert judgement (Sveinsson, oral communication; Sveinbjörnsson, oral communication; Dýrmundsson, oral communication) and are assumed to be constant since 1990, see Table 5.34.

The average amount of time Mature Dairy Cattle spend on pasture has decreased from 90 to 56 days from 1990-2021. Heifers spend 4 months per year on pasture whereas Other Mature Cattle spend 11 months on grazing pastures. Calves and Steers are housed all year round. Most cattle manure, not deposited outside by grazing animals, is managed as slurry without a natural crust cover. The use of solid storage for Calves increased from 10-74% from 1990-2008 and has been stable since then. Sheep spend 5.5 months on pasture, range, and paddock (PRP); this includes the whole life span of lambs. Around 19% of the manure from adult sheep is assumed to be kept as slurry, which has a much higher methane conversion factor, MCF (17%) than PRP (1%) or solid storage (2%). Therefore, the emission factor from sheep in the Icelandic inventory is much higher than the Tier 1 emission factor from the IPCC Guidelines (0.19 kg CH_4/head/year, cool conditions, Table 10.15 of the 2006 IPCC Guidelines), which assumes that all manure is managed in a solid system.

Table 5.34 Manure management system fractions for all livestock categories.

	Slurry w/ Natural Crust Cover	Slurry w/o Natural Crust Cover	Solid Storage	Pasture/Range/ Paddock
Mature Dairy Cattle	9%	75%		15%
Other Mature Cattle		8%		92%
Pregnant Heifers	7%	60%		33%
Steers and non-inseminated Heifers	10%	84%		16%
Calves		26%	74%	
Mature Ewes		19%	36%	45%
Other Mature Sheep		19%	36%	45%
Animals for Replacement		19%	36%	45%
Lambs			2%	98%
Goats			55%	45%

	Slurry w/ Natural Crust Cover	Slurry w/o Natural Crust Cover	Solid Storage	Pasture/Range/ Paddock
Horses			14%	86%
Young horses			14%	86%
Foals				100%
Sows		100%		
Piglets		100%		
Poultry			100%	

The emission factors are calculated with volatile solid excretion rates, methane conversion factors, and manure management fractions for Cattle and Sheep, and are shown in Table 5.35. Mature Dairy Cows have the highest emission factors for methane from manure management.

Table 5.35 Emission factors values and range for the tier 2 calculations of methane emissions from manure management.

Livestock Category	Emission Factor 2021	Emission Factor Range 1990-2021
	[kg CH_4/head year]	[kg CH_4/head year]
Mature Dairy Cattle	38.69	36.95 - 38.83
Other Mature Cattle	2.93	2.92 - 3.18
Pregnant Heifers	11.27	11.27 - 14.78
Steers and Mon-inseminated Heifers	14.27	14.24 - 19.34
Calves	2.02	2.02 - 6.24
Mature Ewes	0.95	0.90 - 1.13
Other Mature Sheep	1.04	0.99 - 1.24
Animals for Replacement	0.95	0.91 - 1.16
Lambs	0.14	0.13 - 0.15

5.4.3 Emissions

The emission factor variations, which can be seen for Cattle subcategories in Table 5.35, are due to changes in feed digestibility and gross energy intake, as well as changes in feeding situation and manure management systems. For Sheep subcategories there is a lack of activity data for manure management systems and hence, the emission factor variability stems entirely from change in feed digestibility and gross energy intake.

Three livestock subcategories alone are responsible for roughly two thirds of methane emissions from manure management: Mature Dairy Cattle, Steers and non-inseminated Heifers, and Mature Ewes. Other important livestock categories for methane emissions from manure management are Swine, Horses, and Poultry, as seen in Table 5.36.

Table 5.36 Methane emissions from manure management [t].

Livestock Category	1990	1995	2000	2005	2010	2015	2020	2021
Mature Dairy Cattle	1,212	1,128	1,004	923	982	1,024	971	997
Other Mature Cattle	2.0	2.3	2.9	4.0	4.8	6.1	9.7	10.5
Pregnant Heifers	68	177	84	84	85	85	69	74
Steers and Non-inseminated Heifers	315	246	293	214	274	265	292	286
Calves	125	75	73	63	45	48	46	45
Mature Ewes	504	404	391	365	389	360	283	286
Other Mature Sheep	16	15	14	12	14	12	11	11
Animals for Replacement	104	81	85	86	98	86	68	70
Lambs	40	34	35	35	38	39	32	33

Livestock Category	1990	1995	2000	2005	2010	2015	2020	2021
Swine	179	184	193	236	228	255	236	230
Horses	117	127	119	121	125	125	116	111
Goats	0.06	0.07	0.07	0.09	0.13	0.19	0.31	0.32
Fur animals (minks and foxes)	32	26	28	25	27	32	11	11
Rabbits	0.15	0.01	0.06	0.02	0.01	0.03	0.01	0.01
Poultry	315	118	180	140	110	116	160	154
Total CH_4 from manure management	**3,029**	**2,617**	**2,503**	**2,308**	**2,418**	**2,456**	**2,305**	**2,320**
Emission reduction 1990-2021		-14%	-17%	-24%	-20%	-19%	-24%	-23%

5.4.4 Recalculations

Several recalculations, that have an impact on CH_4 emissions from manure management, have been performed for this submission. The main updates are due to the updated livestock parameters for the Tier 2 categories Cattle and Sheep for the whole timeseries, from 1990-2021, see Table 5.28 and Table 5.29.

Some human errors found when updating those parameters, as discussed in Section 5.2.4. Smaller recalculations in emissions from horses (see Table 5.30) and poultry (see Table 5.31) are the result of updated livestock population numbers.

Table 5.37 Recalculations of CRF 3B1.1 Cattle due to updated livestock parameters for 1990-2020.

CRF 3B1.1 - Cattle [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	37.52	37.58	36.10	33.69	36.24	38.31	36.91
2023 Submission	48.22	45.60	40.78	36.06	38.92	40.00	38.86
Change relative to the 2022 Submission	28.5%	21.3%	13.0%	7.0%	7.4%	4.4%	5.3%

Table 5.38 Recalculations of CRF 3B1.2 Sheep due to updated livestock parameters for 1990-2020.

CRF 3B1.2 - Sheep [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	17.11	14.32	14.51	14.17	14.38	14.31	12.38
2023 Submission	18.60	14.94	14.72	13.95	15.06	13.94	11.04
Change relative to the 2022 Submission	8.7%	4.4%	1.4%	-1.6%	4.7%	-2.5%	-10.8%

Table 5.39 Recalculations of CRF 3B14 Poultry due to updated livestock population numbers for 1990-2020.

CRF 3B14 - Poultry [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	8.82	3.31	5.07	4.00	3.11	3.28	4.50
2023 Submission	8.81	3.30	5.05	3.93	3.09	3.25	4.49
Change relative to the 2022 Submission	-0.09%	-0.27%	-0.41%	-1.68%	-0.69%	-0.76%	-0.41%

Table 5.40 Recalculations of CRF 3B14 Horses due to updated livestock population numbers for 2012-2020.

CRF 3B14 - Horses [kt CO_2e]	2012	2013	2014	2015	2016	2017	2018	2019	2020
2022 v4 Submission	2.42	2.35	2.43	2.42	2.42	2.36	2.13	2.21	2.25
2023 Submission	3.50	3.39	3.53	3.51	3.51	3.42	3.07	3.20	3.25
Change relative to the 2022 Submission	45%	45%	45%	45%	45%	45%	44%	45%	45%

5.4.4.1 *Recalculations from the 2022 Submission*

There were no recalculations in this subsector for the 2022 Submission.

5.4.5 Uncertainties

The activity data uncertainties are a combination between the livestock number uncertainty (5.0% for each animal class except Horses, which are assigned an uncertainty of 10% due to the nature of the registration system) and the uncertainty related to the manure management system distribution (50% for Sheep, 10% for all other animal classes). The emission factor uncertainties are chosen on the basis of the indication of the 2006 IPCC Guidelines, that is 20% for Tier 2 calculations (Cattle, Sheep) and 30% for Tier 1 calculations (all other animal categories). The combined uncertainties, activity data and emission factors are the following: 3B1 (Cattle) 23%, 3B2 (Sheep) 54%, 3B3 (Swine) 32%, 3B4 (Other livestock) 22%. The complete uncertainty analysis is shown in Annex 2.

5.4.6 Planned Improvements

For future submissions, it is planned to obtain measurements of emissions from manure storage on sheep farms. However, a cooperation with the AUI or IAAC and the MFAF is needed. The first steps regarding this cooperation have been undertaken and the plan is for these measurements to be available within the next few years.

5.5 N_2O Emissions from Manure Management (CRF 3B2)

This section describes the direct and indirect nitrous oxide emissions occurring during housing and storage of manure before it is applied to land. The emissions occurring due to manure applied to soils or deposited directly during grazing are reported under 3D Agricultural Soils (Chapters 5.7 and 5.8)

A nitrogen mass-flow approach has been used, as presented in the 2019 version of the EMEP/EEA Guidebook. This approach has been designed to be fully consistent with the IPCC 2006 Guidelines on estimating emissions from manure management and provides a methodology that is considered to be a “higher Tier” methodology. For the 2021 Submission, the emission factors for this method were changed from the 2016 edition of the Guidebook to the 2019 edition (EEA, 2019).

The N-flow approach considers the flow of total N and total ammoniacal N (TAN) through the entire manure management system. The N-flow is modelled by a series of equations that consider the amount of N and TAN at each management stage and corresponding losses as different N compounds. The methodology provided in the EMEP/EEA Guidebook (EEA, 2019) was applied to the disaggregated livestock category level described in section 5.2.2 (e.g., for Cattle: Mature Dairy Cattle, Other Mature Cattle and Growing Cattle, including separate calculations for the subcategories Pregnant Heifers, Steers and non-inseminated Heifers and Calves; Mature Ewes, Other Mature Sheep (e.g., rams), Animals for Replacement, and Lambs instead of just Sheep). The resulting emissions were then aggregated to the respective CRF reporting categories. N_2O emissions from grazing animals are part of this N flow approach, as is the calculation of the organic N in management systems that is available for application to land as organic fertiliser. Consequently, the approach provides a methodology that is used for estimating emissions from both 3B Manure management and selected sources that are reported under 3D Managed soils.

5.5.1 Methodology

The calculations are based on the 2006 IPCC Guidelines for calculating the N-content in manure. The same livestock parameters as described previously in this chapter are used to calculate the Nex rate, both applying Tier 1 and Tier 2, depending on animal category.

The N-content is then fed into the N-flow tool following the 2019 EMEP/EEA Guidebook (EEA, 2019). This method uses a mass flow approach based on the concept of Total Ammoniacal Nitrogen (TAN) in contrast to the total amount of N used by IPCC. Based on TAN, a more accurate estimate of gaseous N emissions such as NH_3 and other forms is possible. This calculation method allows consistency of the nitrogen emissions from the Agricultural sector between the GHG inventory and the air pollutant inventory compiled under the LTRAP convention. Further information on the N-flow methodology is reported in the 2019 version of the EMEP/EEA Guidebook and can be retrieved there. A brief outline of the stepwise procedure, in which manure is either managed as slurry/liquid or solid is given here:

- Calculation of the amount of the annual N excreted, which is deposited in different areas (housed, yards, grazing), depending on the time period in which animals are for example housed inside or outside.
- Multiplication with the default proportions of TAN that can be found in table 3.9 of the 2019 EMEP/EEA guidebook.
- Calculation of the amount of TAN and total N deposited in buildings as liquid/slurry or as solid.
- NH_3-N losses from buildings and yards for both liquid and solid are calculated by multiplying with an EF, which is also given in table 3.9 of the 2019 EMEP/EEA Guidebook.
- Addition of straw to the bedding of housed animals.
- Calculation of the total-N and TAN leaving housing (only solid).
- Calculation of the total-N and TAN entering storage (slurry and solid).
- Calculation of TAN from which slurry storage emissions will occur (only slurry).
- Calculation of the storage emissions of all N- species (NH_3-N, N_2O-N, NO-N).
- Calculation of organic N and TAN applied to the field.
- Calculation of emissions during and immediately following application to field.
- Calculation of total-N and TAN returned to soil.

The same tool allows for the calculation of the emissions from N returned to soils in manure and NH_3-N emissions from grazing, which need to be included in 3D Agricultural Soils. It is also possible to deduct the amount of manure as feedstock for anaerobic digestors in biogas facilities, which is not applicable for Iceland as there are no biogas facilities in the country. In order to ensure that no double counting or omissions occur during this calculation procedure, a nitrogen balance is carried out, where the total input of N (animal excretion plus addition through bedding) should match the output of N (total of all emissions, N inputs to soil and N in manures used as anaerobic digestors feedstock).

Indirect emissions from housing are calculated by multiplying the N volatilised as NH_3-N and NO-N, deriving from the above-described N-flow methodology with the default emission factors (EF4 = 0.01 kg N_2O-N) from the 2006 IPCC Guidelines. Figure 5.3 shows the N-flow methodology with the data for 2021 and the relationship in the reporting between the different N-species (NH_3-N, NO_x-N, N_2O-N) and the different chapters, 3B Manure Management and 3D Agricultural Soils. The diagram also includes 5B2 Biological Treatment of waste, but biodigesters are not occurring in Iceland.

5.5.2 Activity Data

The activity data for the N-flow approach is N and TAN that is quantified throughout the manure management process, rather than livestock numbers. However, the nitrogen input into each of the management systems is determined by livestock numbers combined with nitrogen excretion (Nex) rates. Livestock numbers and characteristics, therefore, remain fundamental input datasets to the methodology and are described in sections 5.2.1 and 5.2.2. Manure management systems (MMS) are reported in section 5.4.2. In addition, two thirds of Icelandic horses are on pasture all year round. The remaining third spends around five months in stables, where manure is managed in solid storage. All swine manure is managed as liquid/slurry whereas the manure of fur animals and poultry is managed in solid storage. Manure management system fractions have changed for Cattle subcategories over the timeline. The main changes are that Mature Dairy Cattle spend less time outside now, 56 days in 2021 compared to 90 days in 1990 and 74% of manure from Calves is stored in solid storage in 2021 compared to 10% in 1990. For other livestock categories the manure management system fractions are assumed to be stable over the past thirty years and are summarised in Table 5.34.

The Nex rate is calculated applying Tier 2 methodology from the 2006 IPCC Guidelines for Cattle and Sheep (Eq. 10.31), and Tier 1 methodology for all other livestock categories.

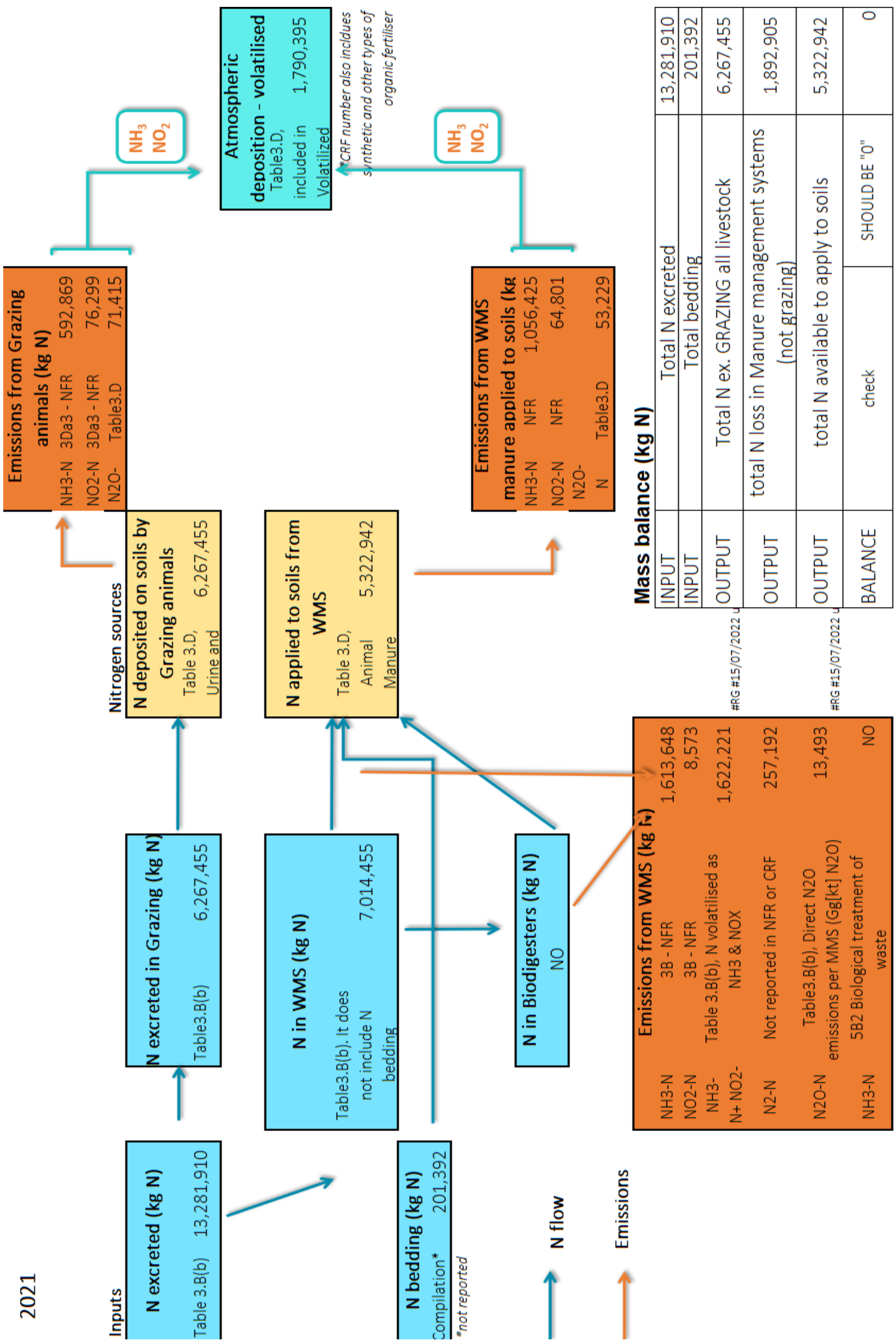


Figure 5.3 Complete Nitrogen flow applied to the categories 3B Manure Management and 3D Agricultural soils for 2021. Biodigesters are not occurring in Iceland. In Atmospheric Deposition – volatilised CRF includes also synthetic and other types of organic fertilisers. NFR refers to the reporting of air pollutants under CLTRAP (NH_3 and NO_x).

Table 5.41 shows the Nex default values, multiplied by the animal weight. For most livestock categories the animal parameters are not changing over the timeseries and the Nex rate is also constant. Exceptions are Cattle and Sheep categories, calculated using the Tier 2 approach and Horses and Poultry, for which the Nex rate has been calculated on a more disaggregated level and reported as a weighted average in relation to the population data.

The calculation method for the Nex rate for Cattle and Sheep follows the Tier 2 methodology from the 2006 IPCC Guidelines (Volume 4, chapter 10) by applying Equation 10.31, Equation 10.32[25], and Equation 10.33 for Cattle and $N_{retention\_frac}$ of 0.10 from Table 10.20 for Sheep.

Equation 10.31

Annual N excretion rates (Tier 2)

$$Nex = N_{\text{intake}} * \left(1 - N_{\text{retention}_{\text{frac}}}\right) * 365$$

Where:

- Nex= annual N excretions rates, kg N/animal/yr
- N_{intake}= the daily N intake per head of animal category, kg N/animal/day
- $N_{retention\_frac}$= fraction of N intake that is retained by animal category, dimensionless

Equation 10.32

N intake rates for Cattle, Sheep and Goats

$$N_{\text{intake}} = \frac{GE}{18.45} * \left(\frac{\frac{CP\%}{100}}{6.25} \right)$$

Where:

- N_{intake}= the daily N consumed per head of animal category, kg N/animal/day
- GE= gross energy intake, MJ/animal/day
- 18.45= conversion factor for dietary GE per kg of dry matter, MJ/kg
- CP%= percent crude protein in diet, input
- 6.25= conversion factor from kg of dietary protein to kg of dietary N, kg feed protein/ kg N

Equation 10.33

N retained rates for cattle

$$N_{\text{retention}} = \left[\frac{\text{Milk} * \left(\frac{\text{Milk PR\%}}{100}\right)}{6.38} \right] + \left[\frac{WG * \left[268 - \left(\frac{7.03 * NE_g}{WG}\right)\right]}{1000 * 6.25} \right]$$

Where:

- $N_{retention}$= daily N retained per head of animal category, kg N/animal/day
- Milk= milk production, kg/animal/day
- Milk PR%= percent of protein in milk, calculated as [1.9+0.4*%Fat], %Fat assumed to be 4%
- 6.38= conversion from milk protein to milk N, kg Protein/ kg N
- WG= weight gain, kg/day
- 268= constant, g Protein/kg/animal
- 7.03= constant, g Protein/MJ/animal
- NEg= net energy for growth, MJ/day
- 6.25= conversion factor from kg of dietary protein to kg of dietary N, kg feed protein/ kg N

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

Table 5.41 Nitrogen excretion rates defaults, animal weight and Nex for the time series 1990-2021

Livestock Category	Nex Default [kg N/1,000 kg animal mass/day]	Animal Weight [kg]	1990	1995	2000	2005	2010	2015	2020	2021
Mature Dairy Cattle	(1)	471.0	89.3	90.1	94.9	96.9	97.1	94.7	93.1	94.3
Other Mature Cattle	(1)	470.0	71.2	71.6	72.3	73.2	72.8	70.5	68.7	66.4
Pregnant Heifers	(1)	372.0	62.8	62.9	63.5	64.1	63.7	60.9	59.3	59.3
Steers and non-inseminated Heifers	(1)	361.3	57.8	43.5	43.5	43.5	43.5	43.5	43.5	43.5
Calves	(1)	137.0	20.0	20.3	20.9	20.9	21.1	20.4	19.7	19.8
Growing Cattle	Weighted average from heifers, steers, and calves		40.5	41.8	37.2	36.7	36.6	35.5	34.9	35.2
Mature Ewes	(1)	64.9	11.0	11.1	11.2	11.2	11.2	10.7	10.3	10.6
Other Mature Sheep	(1)	93.3	12.0	12.1	12.3	12.2	12.3	11.7	11.4	11.7
Animals for Replacement	(1)	49.7	11.2	11.3	11.4	11.3	11.4	10.8	10.4	10.7
Lambs	(1)	21.6	7.3	7.5	7.6	7.7	7.8	7.9	7.7	8.1
Sows	0.42	150.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Piglets	0.51	40.7	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
Horses	0.26	360.0	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2
Young horses	0.26	175.0	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
Foals	0.26	60.0	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Horses (weighted average)	Weighted average from horses, young horses, and foals		27.1	26.4	27.6	28.1	27.4	27.5	27.5	27.5
Goats	1.28	43.5	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3
Minks	NE	NE	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Foxes	NE	NE	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
Rabbits	NE	NE	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Hens	0.96	4.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Pullets	0.55	3.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Chickens	0.55	1.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ducks/geese	0.83	4.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Turkeys	0.74	5.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Poultry	Weighted average from all poultry subcategories		1.1	0.9	0.9	0.7	0.6	0.5	0.6	0.6

(1) Calculated with Tier 2, Eq. 10.31, 10.32 and 10.33 of the 2006 IPCC Guidelines.

5.5.3 Emission Factors

The parameters and emission factors for the different N-species used in the N-flow methodology are taken from the 2019 EMEP/EEA Guidebook (Tables 3.8, 3.9 and 3.10) (EEA, 2019) and an extract is given in Table 5.42.

Table 5.42 Proportion of TAN, fraction slurry/solid housing periods and EF for N species used in the N-flow methodology, non-exhaustive list.

Livestock Category	Prop. TAN (of N)	Fraction Slurry	Fraction Solid	Housing Period [days]	MMS	EF NH_3-N Housing	EF NH_3-N Storage	EF N_2O-N Storage[1]	EF NO-N Storage
Mature Dairy Cattle	0.6	1	0	309	Slurry	0.24	0.25	0/0.01	0.0001
					Solid	0.08	0.32	0.02	0.01
All Other Cattle[2]	0.6	0.70	0.30	305	Slurry	0.24	0.25	0/0.01	0.0001
					Solid	0.08	0.32	0.02	0.01
Sheep	0.5	0.35	0.65	200	Slurry	0.24[3]	0.25[3]	0.001	0.0001
					Solid	0.22	0.32	0.02	0.01
Swine - piglets	0.7	1	0	365	Slurry	0.27	0.11	0	0.0001
					Solid	0.23	0.29	0.01	0.01
Swine - Sows	0.7	1	0	365	Slurry	0.35	0.11	0	0.0001
					Solid	0.24	0.29	0.01	0.01
Goats	0.5	0	1	200	Solid	0.22	0.28	0.02	0.01
Horses	0.6	0	1	51	Solid	0.22	0.35	0.02	0.01
Laying Hens	0.7	0	1	365	Slurry	0.41	0.14	0	0.0001
					Solid	0.2	0.08	0.002	0.01
Turkeys	0.7	0	1	365	Solid	0.35	0.24	0.002	0.01
1Other Poultry (ducks)	0.7	0	1	365	Solid	0.24	0.24	0.002	0.01
Other (fur animals)	0.6	0	1	365	Solid	0.27	0.09	0.002	0.01

[1] 0/0.01 means "0" for slurry without a natural crust cover and "0.01" for slurry with a natural crust cover. Most cattle manure is stored in slurry without a natural crust cover.

[2] All Other Cattle consists of Other Mature Cattle, Pregnant Heifers, Steers and non-inseminated Heifers and Calves. A weighted average is used for fraction slurry/solid and housing period for these subcategories.

[3] 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 factors used to calculate emissions of N_2O-N during manure storage (Table 5.42) are based on the default 2006 IPCC emission factors. While the IPCC emission factors are expressed as a proportion of total N at excretion, the EMEP EEA emission factors are expressed as proportions of TAN in manure entering storage. In order to convert from the IPCC emission factors to the EMEP EEA emission factors, the IPCC ones are divided by the proportion of TAN in manure-N entering storage. Further information can be found in the annex (Table A1.8) of the EMEP EEA 2019 Guidebook, chapter 3B. The addition of straw is only relevant for Calves, since they are the only Cattle subcategory whose manure is stored in solid storage. In 2022, the IAAC 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 is otherwise only used for calving cows in Iceland and was estimated 3 kg/animal/year. For Sheep, Goats and Horses the default straw values from the 2019 EMEP EEA guidebook, Table 3.7, are adjusted for a different housing period. For example, sheep have a default housing period of 30 days but in Iceland it is 200 days. So, the default straw value of 20 kg/animal/year is multiplied by 200/30 to obtain 133.3 kg/animal/year.

The emission factor for indirect emissions due to volatilised NH_3-N and NO-N is taken from the 2006 IPCC Guidelines (Volume 4, chapter 11), EF_4, and corresponds to 0.01 kg N_2O-N/(kg NH_3–N + NO–N volatilised). Indirect emissions from leaching and runoff from storage are not estimated, further information on this can be found in section 5.5.5.

5.5.4 Emissions

N_2O emissions from the manure management systems slurry and solid storage amounted to 21 tonnes N_2O in 2021 and 24 tonnes in 1990 (-13%).

Emissions from liquid systems make up only a small part of total emissions from managed systems or 15% of total N_2O emissions from manure management systems in 2021. This is because the emission factor is twenty times lower for liquid systems than for solid storage. The majority of emissions from solid and liquid storage in 2021 originated from the solid storage of sheep manure (53%), followed by solid storage of calf manure (19%) and horse manure (9%).

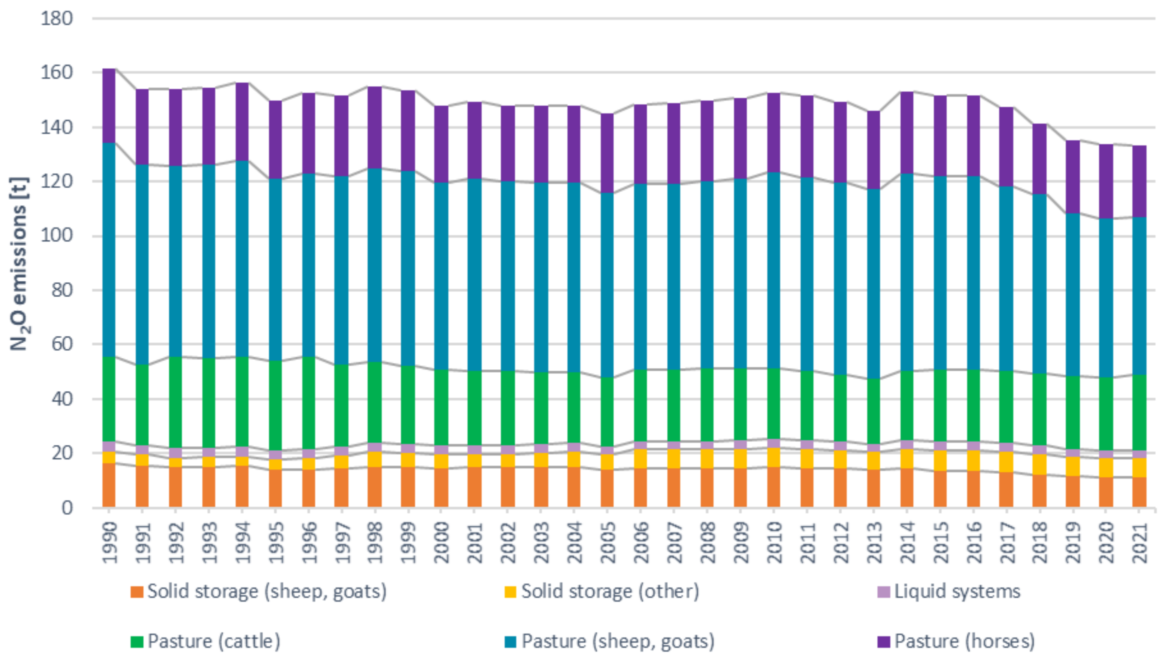


Figure 5.4 N_2O emissions from manure management, [t N_2O].

Figure 5.4 shows N_2O emissions from slurry and solid storage. It also includes emissions from manure deposited directly onto soils from farm animals (Pasture). Although they are reported under emissions from Agricultural Soils in national totals, they are included here to show their magnitude in comparison to other emissions. In 2021 N_2O emissions from manure deposited on pasture by grazing livestock amounted to 112 t N_2O. Emissions from sheep manure were 58 t N_2O, emissions from cattle manure amounted to 27 t, and emissions from horse manure were 26 t N_2O.

Indirect emission from manure management from atmospheric deposition of nitrogen on soils and water surfaces, due to volatilisation of nitrogen, resulted in a total of 25 t N_2O for 2021, decreasing from 30 t in 1990.

5.5.5 Indirect Emissions from Leaching and Run-off from Storage

Whilst detailed information is available regarding the N going into different manure stores, and the losses to air during storage, Iceland does not have country specific data on the fraction of N from manure storage that goes to leaching and run-off. This country specific information is needed to allow emissions from leaching and run-off from storage to be calculated.

Having reviewed the approaches used in several other countries (Denmark, Sweden, Norway, Finland) it is clear that there is a wide variety of approaches and assumptions that are used for estimating this source (and in particular the fraction of stored N going to leaching and run-off). Consequently, it was not considered appropriate to arbitrarily take a value from the 1-20% range that is quoted in the 2006 IPCC Guidelines. Notably no default fraction is given to support a Tier 2 calculation.

The approach that has been used assumes that there is no N loss to leaching and run-off from stored manure. This approach is expected to give rise to a small over-estimate of N_2O emissions from the agriculture sector. This is because instead of assigning N to leaching and run-off, the N is retained in the stored N which is then applied to land – giving rise to emissions of N_2O. The EF for leaching and run-off (0.0075 kg N_2O-N / kg N leaching and run-off) is smaller than that from storage and/or application (0.01 kg N_2O-N / kg N applied).

Leaching and run-off that may arise from N inputs to agricultural soils are considered in 3D Managed soils.

5.5.6 Recalculations

Several recalculations, that have an impact on N_2O emissions from Manure Management, have been performed for this submission. The main updates are due to the updated livestock parameters for the Tier 2 categories Cattle and Sheep for the whole timeseries, from 1990-2021, see Table 5.28 and

Table 5.29, as well as some human errors found when updating those parameters, as discussed in Section 5.2.4. Smaller recalculations in emissions from horses (see Table 5.30) and poultry (see Table 5.31) are the result of updated livestock population numbers.

Table 5.43 Recalculations of CRF 3B2.1 Cattle due to updated livestock parameters for 1990-2020.

CRF 3B2.1 - Cattle [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	0.65	0.65	0.63	0.58	0.62	0.67	0.66
2023 Submission	0.87	0.90	1.17	1.24	1.69	1.80	1.75
Change relative to the 2022 Submission	32%	38%	87%	116%	171%	168%	165%

Table 5.44 Recalculations of CRF 3B2.2 Sheep due to updated livestock parameters for 1990-2020.

CRF 3B2.2 - Sheep [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	9.86	8.27	8.34	8.08	8.43	8.40	7.13
2023 Submission	4.56	3.88	4.01	3.89	4.12	3.78	3.01
Change relative to the 2022 Submission	-54%	-53%	-52%	-52%	-51%	-55%	-58%

Table 5.45 Recalculations of CRF 3B14 Poultry due to updated livestock population numbers for 1990-2020.

CRF 3B14 - Poultry [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	0.36	0.15	0.23	0.23	0.17	0.18	0.23
2023 Submission	0.35	0.14	0.22	0.20	0.16	0.17	0.22
Change relative to the 2022 Submission	-1.1%	-3.1%	-4.5%	-14.2%	-6.7%	-6.7%	-4.4%

Table 5.46 Recalculations of CRF 3B24 Horses due to updated livestock population numbers for 2012-2020.

CRF 3B24 - Horses [kt CO_2e]	2012	2013	2014	2015	2016	2017	2018	2019	2020
2022 v4 Submission	0.64	0.62	0.64	0.64	0.64	0.62	0.56	0.58	0.59
2023 Submission	0.60	0.58	0.60	0.60	0.60	0.58	0.52	0.55	0.55
Change relative to 2022 Submission	-6.5%	-6.5%	-6.5%	-6.5%	-6.5%	-6.5%	-6.5%	-6.5%	-6.5%

5.5.6.1 *Recalculations from the 2022 Submission*

As explained in Paragraph 5.2.4.1. poultry previously categorised as Broilers should, in fact, be categorised as Laying Hens for the whole timeseries according to the poultry expert veterinarian at the IFVA. This led to a decrease of both direct and indirect N_2O emissions in this category.

5.5.7 Uncertainties

The activity data uncertainty is based on the livestock number uncertainties, the manure management system distribution, the amount, and uncertainty of N excreted, and the amount and uncertainty of N volatilised. All these activity data uncertainties are calculated and aggregated using both Equation 3.1 and Equation 3.2 of the 2006 IPCC Guidelines and differ for each animal category ranging from 47% for Fur animals to 68% for Sheep. The emission factor uncertainty is assigned to be 100% for all animal categories as it is based on Table 10.21, chapter 10, vol. 4 of the 2006 IPCC Guidelines. The combination of activity data and emission factor uncertainty produces the following uncertainties for each CRF subcategory: 3B21 (Cattle) 114%, 3B22 (Sheep) 121%, 3B23 (Swine) 116%, and 3B24 (Other livestock) 77%.

Indirect emissions from manure management have a combined uncertainty of 412%, with 100% uncertainty for activity data and 400% uncertainty for the emission factor following the indications of Table 11.3, chapter 11, vol. 4 of the 2006 IPCC Guidelines. The complete uncertainty analysis is shown in Annex 2.

5.5.8 Planned Improvements

During the 2021 UNFCCC review Iceland was encouraged to take steps to define an appropriate $Frac_{leachMS}$ value for Iceland and include estimates for indirect N emissions from leaching and run-off in the inventory, along with a justification of the methodology and assumptions used in the calculations (Question 2021ISLQA73). Such research requires resources and time which are at the moment not available. In the meantime, a temporary solution is described in Section 5.5.5.

For future submissions, it is planned to obtain measurements of emissions from manure storage on sheep farms. However, a cooperation with the AUI or IAAC and the MFAF is needed. The first steps regarding this cooperation have been undertaken and the plan is for these measurements to be available within the next few years.

5.6 Rice Cultivation (CRF 3C)

This activity is not occurring in Iceland.

5.7 Direct N_2O Emissions from Managed Soils (CRF 3D1)

Nitrous oxide (N_2O) is produced naturally in soils through the microbial processes of nitrification and denitrification. The following agricultural activities lead to N_2O emissions and are described in this chapter:

- Application of inorganic N fertiliser
- Application of organic N fertiliser (animal manure, sewage sludge, other organic fertilisers)
- Urine and dung deposited by grazing animals
- Crop residues
- Mineralisation/ immobilisation associated with loss/gain of soil organic matter (not occurring in Iceland)
- Cultivation of organic soils

These activities add nitrogen to soils, increasing the amount of nitrogen available for nitrification and denitrification, and ultimately the amount of N_2O emitted. The emissions of N_2O that result from anthropogenic N inputs occur through both a direct pathway (i.e., directly from the soils to which the N is added), and through two indirect pathways - through volatilisation as NH_3 and NO_x and subsequent redeposition and through leaching and runoff (IPCC, 2006). Direct N_2O emissions from agricultural soils are described in the sections below, and indirect emissions are described in Chapter 5.8.

5.7.1 Methodology

Direct N_2O emissions from agricultural soils are calculated applying the Tier 1 methodology from the 2006 IPCC Guidelines using the equation 11.1:

Equation 11.1

Direct N_2O emissions from agricultural soils (Tier 1a)

$$N_2O_{\text{Direct–N}} = [(F_{SN} + F_{ON} + F_{CR}) * EF_1] + (F_{PRP} * EF_{PRP}) + (F_{OS} * EF_{OS})$$

Where:

- $N_2O_{Direct\text{-}N}$ = Emission of N_2O in units of Nitrogen
- F_{SN} = Annual amount of synthetic fertiliser nitrogen applied to soils, kg N/yr
- F_{ON} = Annual amount of organic N amendments (animal manure, sewage sludge) applied to soils, kg N/yr
- F_{CR} = Amount of nitrogen in crop residues returned to soils annually, kg N/yr
- F_{PRP} = Amount of N deposited by animals at pasture, range, paddock, kg N/yr
- F_{OS} = Area of organic soils cultivated annually, ha
- EF_1 = Emission factor for emissions from mineral fertilisers, organic amendments and crop residues, kg N_2O-N/kg N input
- EF_{PRP} = Emission factor for emissions from grazing animals, split by livestock type, kg N_2O-N/kg N input
- EF_{OS} = Emission factor for emissions from organic soil cultivation (kg N_2O-N/ha-yr)

5.7.2 Activity data

Iceland has implemented a nitrogen-flow approach which better describes emissions of N_2O (and other N species) throughout the agriculture sector. This N-flow approach is based on the methodologies presented in the 2019 EMEP/EEA Guidebook but retains full consistency with the higher tier methodologies in the IPCC 2006 Guidelines. The methodology applied to manure management is described in earlier sections of this chapter and provides the amount of N leaving manure storage (both slurry and solid) that is available for application to land.

5.7.2.1 *Inorganic N Fertiliser (F_{SN})*

All fertilisers imported to Iceland need to be registered by customs and the IFVA has to be notified about every import or manufacture of fertilisers in the country according to Icelandic laws No 22/1994, 630/2007, 398/1995, 499/1996, 25/1993, 87/1995 and regulation 479/1995 regarding the inspection of food, fertilisers and seeds, animal diseases and prevention of them and relative changes. The EAI receives a detailed list of the inorganic fertilisers from the IFVA, and the amount of N applied to soils is calculated from this information which can also be downloaded from the website of Statistics Iceland[26]. Table 5.47 reports the nitrogen content in inorganic fertilisers and the associated N_2O emissions from 1990-2021. Due to the nature of the import system, which registers imports during one solar year, stockpiling of fertilisers can occur, e.g., when one shipment comes late in autumn and won't be used during the same year. This explains the irregular trend of the imports, with periodic peaks (Figure 5.5). In addition, according to the expert at the IFVA, the peak in import of fertilisers occurred during the financial boom in Iceland (2007-2008), after which the financial crisis (2009) and fall of the currency is assumed to have caused the drop in imports in line with a sharp increase in the price of imported goods.

Table 5.47 Nitrogen applied in inorganic fertilisers to soils and the associated emissions, 1990-2021.

	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
N_2O emissions [kt N_2O]	0.20	0.18	0.20	0.15	0.17	0.18	0.18	0.19

5.7.2.2 *Organic N Fertiliser (F_{ON})*

Animal Manure Applied to Soils

Animal manure nitrogen, available from storage for application as a fertiliser, is calculated through the N flow approach detailed in earlier sections of this chapter. The amount of N input deriving from slurry and solid manure management systems taken from the N-flow approach described in section 5.5 is multiplied with the Tier 1 default emission factor from the 2006 IPCC Guidelines. Fluctuations in the emissions are due to fluctuations in yearly livestock numbers (Table 5.48).

Table 5.48 Nitrogen input from animal manure, both slurry and solid, applied to soils and associated N_2O emissions, 1990-2021.

	1990	1995	2000	2005	2010	2015	2020	2021
N input – slurry [kt N]	3.74	3.52	3.41	3.22	3.37	3.50	3.29	3.29
N input – solid [kt N]	2.69	2.12	2.33	2.26	2.39	2.39	2.08	2.04
N_2O emissions [kt N_2O]	0.101	0.089	0.090	0.086	0.091	0.092	0.084	0.084

Sewage Sludge Applied to Soils

The regulations 799/1999 (Regulation about handling of sewage sludge) and 737/2003 (Regulation on waste management) define the type and modalities of the application of sewage sludge, which can occur only after applying for a permit and after treatment of the sewage sludge. Strict rules apply for the use in agriculture, such as for fertiliser for areas to produce feed and forage for animals. Currently in Iceland, a few municipalities are using sewage sludge as an organic fertiliser for land reclamation purposes in collaboration with the Soil Conservation Service of Iceland. A pilot project was carried out between 2012-2014 in the Hrunamanna-district and a report (only in Icelandic) is available (Jónsdóttir & Jóhannsson, 2016). An unpublished report (Magnus H. Johannsson, e-mail May 2020) from the Soil Conservation Service summarises quantities of sewage sludge and N-content (0.8%) used from 2012-2019. This data and data for 2020 (Magnus H. Johannsson, e-mail, August 2021) and 2021 (Magnus H. Johannsson, e-mail, June 2022) has been used in the current submission for calculating the emissions. Before 2012 no application of sewage sludge on agricultural soils or for land reclamation purposes is

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

known. As can be seen from Table 5.49 the emissions from the application of sewage sludge are low, with 0.110 t N_2O in 2021.

Table 5.49 Nitrogen content of sewage sludge 2013-2021 and associated N_2O emissions

	1990	1995	2000	2005	2010	2015	2020	2021
N in sewage sludge [t N]	NO	NO	NO	NO	NO	0.81	6.56	6.98
N_2O emissions [t N_2O]	NO	NO	NO	NO	NO	0.013	0.103	0.110

Other Organic Fertilisers Applied to Soils

Research carried out in 2020 has shown that there are other organic fertilisers applied to soils and emissions from this subcategory were added to the inventory for the first time in 2021. The information derives from an unpublished report by the SCS (Magnus H. Johannsson, e-mail May 2020) and written communication (Magnus H. Johannson, e-mail, August 2021, June 2022) reporting type and quantity of organic fertilisers used from 2009-2021 for land reclamation purposes and related N-contents.

An effort was made for this submission to ensure that no underreporting of organic fertiliser use is taking place in the Icelandic inventory. The IFVA has a list of companies that have obtained a licence to sell organic fertilisers in Iceland since 1990. All of those companies were contacted requesting data on their sales of organic fertilisers before the 2023 Submission. However, no full dataset of sales from all companies was obtained, other than what the SCS had already provided. Furthermore, it would be impossible to separate fertiliser sold by the companies and subsequently used by the SCS from the data the SCS has already provided, as the SCS is the predominant user of organic fertilisers in Iceland. Therefore, the risk of double-counting would be high. Therefore, it was decided not to use any of the obtained fertiliser sales data for this submission.

In this category we report other organic fertilisers used by the SCS for land-reclamation purposes: bone meal and a by-product of slaughterhouses, stomach, and gut contents of sheep. These fertilisers are applied only on land reclamation sites, where grazing of domestic animals is excluded for the next 20-50 years. In addition, compost produced by one company in Iceland with a high N-content has been added to this subcategory. Table 5.50 shows the N-content and associated N_2O emissions from this category, reaching 2.74 t N_2O in 2021.

Table 5.50 Nitrogen content of other organic fertilisers and associated N_2O emissions, 1990-2021.

	1990	1995	2000	2005	2010	2015	2020	2021
N in other organic fertilisers [t N]	NO	NO	NO	NO	103	163	178	175
N_2O emissions [t N_2O]	NO	NO	NO	NO	1.62	2.56	2.79	2.74

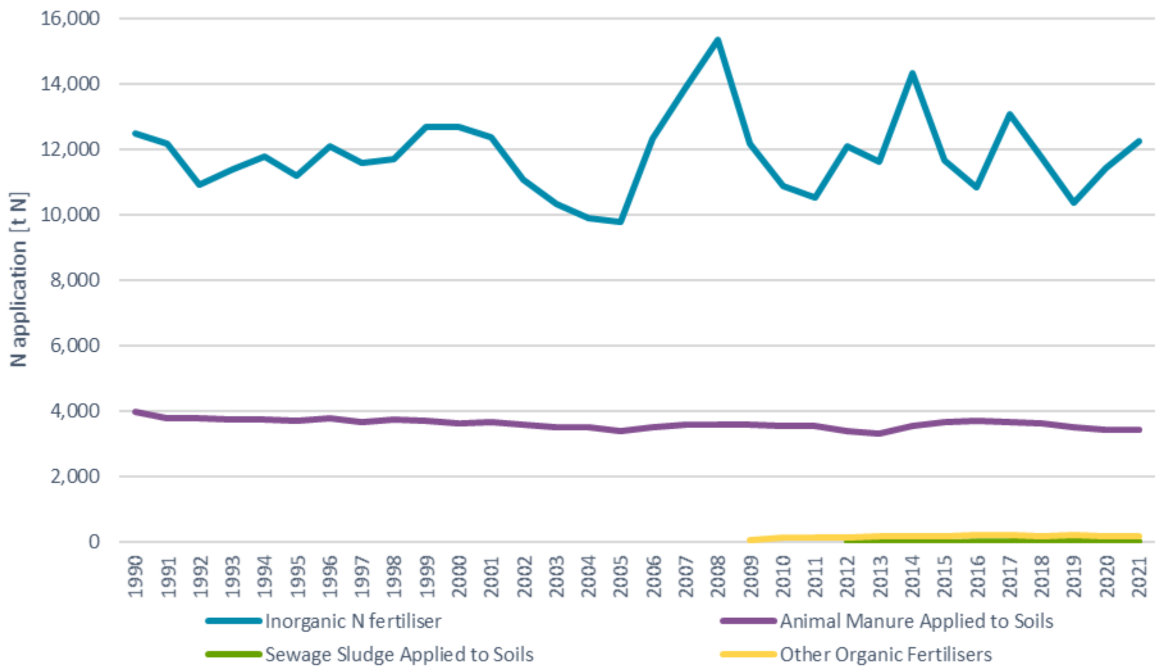


Figure 5.5 Amounts of nitrogen from synthetic (inorganic) and organic fertiliser (animal manure, sewage sludge, and other organic fertilisers) applied to soils[t].

5.7.2.3 *Urine and Dung Deposited by Grazing Animals (F_{PRP})*

N deposited from animals at pasture, range and paddock is also determined by the N-flow approach described in section 5.5. The number of days animals spend outside are collected for the livestock characterisation and are reported in chapter 5.2.2. Default emission factors of 0.02 kg N_2O-N/kg N deposited for cattle, poultry and pigs, and 0.01 kg N_2O-N/kg N deposited for sheep and other animals are applied (Table 5.51) to calculate the N_2O emissions from this category.

Table 5.51 Nitrogen deposited by grazing animals (pasture, range, and paddock) and associated N_2O emissions, 1990-2021

	1990	1995	2000	2005	2010	2015	2020	2021
N excretion, grazing [kt N]	7.73	7.13	7.07	6.98	7.28	7.24	6.30	6.27
N_2O emissions [kt N_2O]	0.137	0.129	0.125	0.122	0.127	0.127	0.113	0.112

5.7.2.4 *Nitrogen in Crop Residues Returned to Soils (FCR)*

There are three types of N-fixing crops cultivated in Iceland: tubers (potatoes), barley and root crops (beets and carrots). After harvest, crop residues are returned to soils. The amount of residue returned to soils is derived from crop production data. The crop yield data, retrieved from Statistics Iceland, is reported in harvested fresh yield and is therefore corrected for dry-weight by using Equation 11.7 from the IPCC 2006 Guidelines. For the residue/crop ratio, dry matter fraction and nitrogen fraction, the IPCC default values from Table 11.2 are used. It is estimated that 80% of barley residue is used as fodder, as well as bedding for calves.

Data on the total annual areas harvested of each crop were exported from the FAO database for the time series available. The years for which data on annual areas harvested was missing were gap filled based the following assumptions:

- The timeseries, from 1990-2020, was available for potatoes and carrots. The ratio between the annual areas harvested with the crop yield for the latest known 6 years (2014-2020) was used to calculate the annual areas harvested in 2021. For potatoes, the ratio was calculated to be 0.070. For carrots, the ratio was calculated to be 0.007.

- The years 2015-2020 were available for barley. The rest of the years were gap filled for barley, using the ratio between the annual areas harvested with the crop yield for 2015-2020. The ratio was calculated to be 0.296. This ratio was then multiplied with the crop yield of barley for 1990-2014.
- No data was available for beets. The annual areas of beets harvested was gap filled for all years by using the ratio for carrots (0.007). This ratio was then multiplied with the crop yield of beets for 1990-2021.

The amount of residue per crop returned to soils is subsequently calculated using Equation 11.6 from the IPCC 2006 Guidelines. Crop produce amounts and associated N_2O emissions are shown in Figure 5.6.

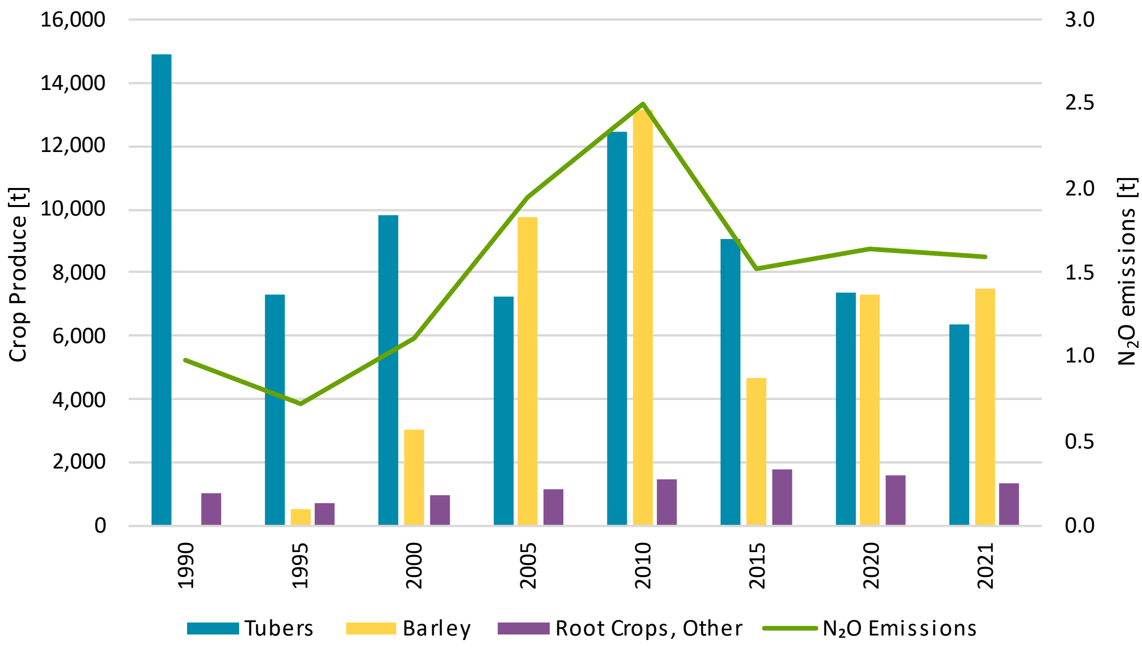


Figure 5.6 Crop produce and associated N_2O [t] emissions for 1990-2021.

The amount of nitrogen in crop residues returned to soils was at its lowest in 1995, when it amounted to roughly 46 tonnes and highest in 2009 when it amounted to roughly 197 tonnes. It must be noted, however, that there is a very large difference in scale between the amounts of nitrogen in crop residues returned to soils and N amounts in synthetic fertiliser and animal manure applied to soils. N inputs to soils from crop residues range between 40 and 200 tonnes per year, N inputs to soils from synthetic fertiliser application ranges from 10,000-15,000 tonnes per year.

5.7.2.5 *Mineralisation/Immobilisation Associated with Loss/Gain of Soil Organic Matter*

This category does not occur (NO) in Iceland. As can be seen in CRF table 4B (LULUCF sector), there is a carbon stock gain (+) reported in land remaining cropland or in land converted to cropland, and therefore there are no associated N_2O emissions.

5.7.2.6 *Cultivation of Organic Soils*

In this category N_2O emissions from cultivated drained histosols, comprising mostly hayfields, and from drained organic soils used for the grazing of animals are calculated. The areas of the organic soils are calculated by the LULUCF team at the Soil Conservation Service and communicated to EAI. The areas and associated N_2O emissions are reported in Table 5.52.

Table 5.52 Area of organic soils [kha] and associated N_2O emissions, 1990-2021.

	1990	1995	2000	2005	2010	2015	2020	2021
Organic soils-histosols	65	65	65	65	65	65	66	66
Drained organic soils-grasslands	150	196	219	247	251	252	258	259
Total area [kha]	215	261	284	312	316	318	323	324
N_2O emissions [kt N_2O]	0.205	0.237	0.253	0.272	0.275	0.276	0.280	0.281

There is a slight difference in the areas reported for cultivated organic soils under CRF category 3Da6 and the sum of the areas of organic soils under cropland and grassland in CRF table 4B and 4C. The reason for the difference in the area reported is that the area of natural birch shrubland (old and recently expanded into other grassland) is not considered in the agriculture sector, as these areas are neither considered as cultivated/managed cropland nor as cultivated/managed grassland.

5.7.3 Emission Factors

The emission factors applied in this category are taken from the 2006 IPCC Guidelines, Vol. 4 AFOLU, chapter 11 and are reported in Table 5.53. For urine and dung deposited by grazing animals two emission factors are used based on the animal category: for cattle, poultry and pigs 0.02 kg N_2O-N per kg N is applied, while for sheep and all other animal categories the emission factor is 0.1 kg N_2O-N per kg N. This has a particularly large impact on the emissions as sheep are a major source in the agriculture sector.

Iceland uses two country specific emission factors; 0.99 kg N_2O-N/ha/yr for the emissions from cultivated drained histosols comprising mostly hay fields and 0.44 kg N_2O-N/ha/yr for drained organic soils used for grazing, for calculating the emissions from organic soils, which are tenfold lower than the default emission factor proposed by the 2006 IPCC Guidelines.

These values derive from the measurements of N_2O fluxes in Iceland, carried out by Jón Guðmundsson from the AUI over a period of three years comprising nine measurement sites with three different land management types of organic soils: undrained land, drained but not cultivated land and drained, cultivated, and fertilised (hayfield land). In addition to these sites, some measurements were performed in freshly tilled drained land. In total, 861 measurements on plots with different land use were carried out (Guðmundsson J. , 2009). The measurements were carried out using a static chamber and a gas chromatograph measuring the gas flux from the gas concentration in the headspace of the chamber with time. Detailed information about this study and the peculiarity of Icelandic soils can be found in Annex 6, which was produced for the 2019 UNFCCC desk review as a response to a potential issue.

In view of the unique composition of Icelandic soils, with active volcanism playing a major role in soil formation, the low emission factors are justified. N_2O emissions are linked to the amount of phosphorus and copper in the peat; if both P and Cu are low, they can limit N_2O production even though there is sufficient N available in the soil. The reason for low P content and intermediate Cu content in Icelandic soils can be found in the mineralogic composition of Icelandic soils strongly influenced by mostly basic volcanic parent material, tephra, which weathers easily, releasing Al, Fe, and Si.

Table 5.53 Emission factors used for the estimation of direct N_2O emissions from agricultural soils (CS: Country specific)

		N_2O emission factor [kg N_2O-N per kg N]	Source
Inorganic N fertilisers	EF_1	0.01	Table 11.1 IPCC 2006
Animal manure applied to soils	EF_1	0.01	Table 11.1 IPCC 2006
Sewage sludge applied to soils	EF_1	0.01	Table 11.1 IPCC 2006
Urine and Dung deposited by grazing animals	EF_{PRP}	0.02 cattle, poultry, pigs	Table 11.1 IPCC 2006
	EF_{PRP}	0.01 sheep and other	
Crop residues	EF_1	0.01	Table 11.1 IPCC 2006
Cultivation of organic soils	EF_{OS}	0.99/0.44 [kg N_2O-N/ha/yr]	CS (Annex 6)

5.7.4 Emissions

The direct emissions from agricultural soils amount to 674 t of N_2O in 2021 and are slightly higher than in 1990 (640 t). The main fluctuations are due to the import and use of synthetic N-fertilisers as can be seen in Figure 5.7.

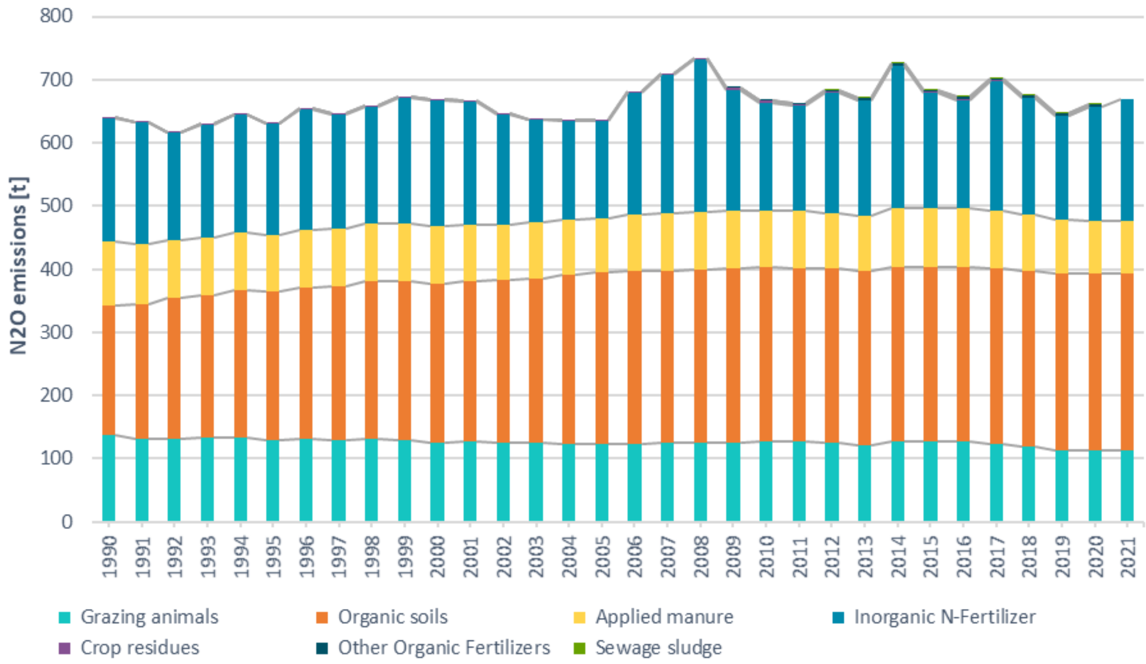


Figure 5.7 Direct N_2O emissions from Agricultural soils [t].

5.7.5 Recalculations

Several recalculations that have an impact on N_2O emissions from 3D12a Animal Manure Applied to Soils and 3D13 Urine and Dung Deposited by Grazing Animals, have been performed for this submission, see Table 5.54 and

Table 5.55. The main updates are due to the updated livestock parameters for the Tier 2 categories Cattle and Sheep for the whole timeseries, from 1990-2021. Smaller recalculations in emissions from horses and poultry are the result of updated livestock population numbers.

Table 5.54 Recalculations of CRF 3D12a Animal Manure Applied to Soils due to updated livestock parameters for 1990-2020.

CRF 3D1.2.a [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	33.89	29.46	29.72	28.55	29.60	30.53	27.58
2023 Submission	26.78	23.52	23.91	22.82	23.98	24.51	22.35
Change relative to the 2022 Submission	-21%	-20%	-20%	-20%	-19%	-20%	-19%

Table 5.55 Recalculations of CRF 3D13 Urine and Dung Deposited by Grazing Animals due to updated livestock parameters for 1990-2020.

CRF 3D1.3 [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	42.56	39.34	38.74	38.22	40.02	40.96	36.64
2023 Submission	36.35	34.08	33.14	32.43	33.77	33.69	29.82
Change relative to the 2022 Submission	-15%	-13%	-14%	-15%	-16%	-18%	-19%

A review of the activity data used to calculate emissions from 3D1.2.b Sewage Sludge Applied to Soils resulted in the discovery of an error: for one municipality AD was registered in 2018 instead of 2019. This issue has been fixed, leading to recalculations for 2018 and 2019, as can be seen in Table 5.56.

Table 5.56 Recalculations of CRF 3D1.2.b Sewage sludge applied to soils due to updated AD for 2018 and 2019.

CRF 3D1.2.b [kt CO_2e]	2018	2019
2022 v4 Submission	0.065	0.020
2023 Submission	0.015	0.065
Change relative to 2022 Submission	-77%	231%

The methodology to calculate emissions from 3D14 Crop Residues was updated for this submission, for the years 1990-2020. Previously, the method from the GPG2000 was still used for this category, due to the unavailability of reliable data on the annual area of crops harvested. The reported crop yields (tubers, barley, beets, and carrots), retrieved from Statistics Iceland, are corrected for dry weight with Equation 11.7. Data on annual areas harvested has now been retrieved from the FAO database for the timeseries available.

- The full timeseries, from 1990-2020, was available for potatoes and carrots.
- The years 2015-2020 were available for barley. The rest of the years were gap filled for barley, using the correlation between the annual areas harvested with the crop yield for 2015-2020. The correlation factor was calculated to be 0.296. This correlation factor was then multiplied with the crop yield of barley for 1990-2014.
- Annual areas of beets harvested was similarly gap filled by using the correlation between the annual areas harvested of carrots and the crop yield of carrots for 1990-2020. The correlation factor was calculated to be 0.007. This correlation factor was then multiplied with the crop yield of beets for 1990-2020.

Subsequently, the 2006 IPCC Guidelines method has been used to calculate emissions from Crop Residues. N from crop residues is now calculated using the Tier 1 method of Equation 11.6 and default parameters from Table 11.2 for the relevant crop types: tubers (incl. potatoes), barley and root crops, other (inc. carrots and beets). The recalculations for the whole timeseries can be seen in Table 5.57.

Table 5.57 Recalculations of CRF 3D1.4 Crop residues due to the updated calculation method for emissions, 1990-2020.

CRF 3D1.4 [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	0.05	0.03	0.05	0.07	0.10	0.06	0.06
2023 Submission	0.26	0.19	0.29	0.52	0.66	0.40	0.44
Change relative to the 2022 Submission	391%	486%	457%	648%	551%	569%	594%

The activity data (land areas) used to calculate emissions from 3D16 Cultivation of organic soils were updated due to updates in the Icelandic Geographic Land-Use Database (IGLUD), discussed further in Section 6.6.1.1. The recalculations for the whole timeseries can be seen in Table 5.58.

Table 5.58 Recalculations of CRF 3D1.6 Cultivation of organic soils due to updated land areas, 1990-2020.

CRF 3D1.6 [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	54.32	62.68	66.86	72.05	72.76	73.03	74.12
2023 Submission	54.32	62.74	66.97	72.16	72.90	73.19	74.21
Change relative to the 2022 Submission	0.00%	0.09%	0.15%	0.16%	0.20%	0.22%	0.13%

5.7.5.1 *Recalculations from the 2022 Submission*

The livestock characterisation change within the poultry category lead to recalculations in nitrous oxide emissions from Animal Manure Applied to soils, CRF category 3D1.2a. As explained in paragraph 5.2.4.1. poultry previously categorised as Broilers should, in fact, be categorised as Laying Hens for the whole timeseries according to the poultry expert veterinarian at the IFVA. As the nitrogen excretion rate for laying hens is higher, moving all animals previously categorised as broilers to laying hens, increased the emissions slightly for the time series 1990-2019, or on average by 0.1.

Recalculations in the subcategory cultivated organic soils were due to changes in the areas of histosols as reported by the LULUCF specialists. This led to minor recalculations over the whole time series 1990-2019 with an average increase in emissions of 0.5%.

5.7.6 Uncertainties

The activity data uncertainties vary according to the used activity data. For 3D11 Inorganic Fertilisers the uncertainty is 5.0% based on expert judgement and based on the fact that the amount of imported N-fertilisers are part of national statistics. The activity data uncertainty for 3D12 Animal Manure Applied to Soils is the maximum uncertainty of the activity data in 3B and is 71%, while for Sewage Sludge and Other Organic Fertilisers this uncertainty is 20% in light of the uncertainty of completeness. For subcategory 3D13, Urine and Dung Deposited by Grazing Animals the activity data uncertainty is derived from the maximum uncertainty values used in 3B (livestock uncertainty, distribution of manure management systems and N excretion) and is 71%. The activity data uncertainty for Crop Residues 3D14 derives mainly from completeness issues and is estimated to be 100%. For the subcategory Cultivation of Organic Soils 3D16, the activity data uncertainty is estimated to be 20%, based on expert judgement.

The emission factor uncertainties for N_2O emissions are calculated using the lower and upper range values of the default emission factors from the 2006 IPCC Guidelines, Volume 4, Chapter 11, Table 11.1, and amount to 233%.

The combined uncertainties of activity data and emission factors are the following: 3D11 Inorganic Fertilisers 233%, 3D12 Organic Fertilisers 236%, 3D13 Urine and Dung Deposited by Grazing Animals 244%, 3D14 Crop Residues 254%, and 3D16 Cultivation of Organic Soils 201%. The complete uncertainty analysis is shown in Annex 2.

5.7.7 Planned improvements

There are no planned improvements in this subsector.

5.8 Indirect N_2O Emissions from Managed Soils (CRF 3D2)

Indirect N_2O emissions originate from three sources:

- Volatilisation of N as NH_3 and NO_x from agricultural fertilisers and manure and subsequent atmospheric deposition.
- Leaching and runoff of applied fertiliser and animal manure, crop residues and urine and dung deposition.
- Discharge of human sewage nitrogen into rivers or estuaries.

The last source is reported under the Waste sector (Chapter 7). The first two sources are covered here.

5.8.1 Methodology

The amounts of NH_3-N and NO_2-N from Inorganic N fertilisers, Animal Manure Applied to Soils, Urine and Dung Deposited by Grazing Animals and from Sewage Sludge Applied to Soils are calculated separately and multiplied with the default IPCC emission factor (EF 4) of 0.01 kg N_2O-N per kg of NH_3-N & NO-N deposited is used. A comparison of this method with the IPCC 2006 Tier 1a (using FracGas) was carried out and the proportion of synthetic N volatilised as NH_3 and NO is only about 0.022 compared to the 0.1 assumed with FracGas. Considering, however, that not much urea is used in Iceland, combined with the cool climate and normal pH soils, this method seems more accurate.

A large proportion of nitrogen applied to agricultural soils can be lost through leaching and runoff. This nitrogen enters groundwater, wetlands, rivers, and eventually the ocean, where it enhances biogenic production of N_2O. To estimate the amount of applied N that is leached or runs off, the methodology in the 2006 IPCC Guidelines is used (Equation 11.10) with default input parameters and EFs.

Equation 11.10

N_2O from N leaching/runoff from managed soils (Tier 1)

$$N_2O_{(L)} - N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR}) * FRAC_{LEACH-(H)} * EF_5$$

Where:

- $N_2O_{(L)}-_N$ = emission of N_2O-N produced from leaching and runoff of N additions to managed soils, kg N_2O-N/yr
- F_{SN} = annual amount of synthetic fertiliser nitrogen applied to soils, kg N/yr
- F_{ON} = annual amount of animal manure, sewage sludge and other organic N additions applied to soils, kg N/yr
- F_{PRP} = amount of nitrogen deposited during pasture, range and paddock, kg N/yr
- F_{CRP}= amount of N in crop residues, kg N/yr
- $Frac_{LEACH-(H)}$ = Fraction of all added N applied that is lost through leaching and runoff, kg N/kg N additions

The total amount of N input into soils is determined by methodologies explained in earlier sections of this Chapter. It is then assumed that 30% is leached or runs-off (the IPCC 2006 default value). Indirect N_2O emissions from leaching and runoff are then calculated by multiplying the resulting nitrogen amount with the emission factor from the 2006 IPCC Guidelines for estimating indirect emissions due to leaching and runoff of N_2O.

5.8.2 Activity Data

5.8.2.1 *Atmospheric Deposition*

The atmospheric deposition includes emissions from livestock manure applied to soils and deposited during grazing, from the use of inorganic and organic N-fertiliser and crop production. This data is calculated in section 5.7. From 1990 to 2021, volatilised nitrogen from agricultural inputs diminished by 10% or from 2,199 t in 1990 to 1,975 t in 2021.

5.8.2.2 *Leaching and Runoff*

The amount of N input (deriving from the application of inorganic and organic N-fertilisers, manure and dung deposited by grazing animals and from crop residues) lost to soils through leaching and runoff is calculated by summing all the agricultural inputs and applying the default 30% ($Frac_{LEACH-(H)}$). This amount has diminished by 10% from 8,053 t in 1990 to 7,242 t in 2021.

5.8.3 Emission Factors

Table 5.59 reports the emission factors and parameters used for the calculation of the indirect emissions. They are all default values from the 2006 IPCC Guidelines, Volume 4, Chapter 11.

Table 5.59 Emission factors used for the estimation of indirect N_2O emissions from agricultural soils

		N_2O Emission Factor	Source
N Volatilisation and redeposition	EF4	0.01 [kg N_2O–N / (kg NH_3–N + NO_x–N volatilised)]	Table 11.3 IPCC 2006
Leaching and runoff	EF5	0.0075 [kg N_2O–N / (kg N leaching/runoff)]	Table 11.3 IPCC 2006
$Frac_{LEACH-(H)}$		0.3 [kg N (kg N additions or deposition by grazing animals)]	Table 11.3 IPCC 2006

5.8.4 Emissions

The development of indirect N_2O emissions from 1990-2021 - after conversion from nitrogen to nitrous oxide - is shown in Figure 5.8. Indirect N_2O emissions amounted to 120 t N_2O in 2021, which is 9% lower than the 1990 emissions of 132 t. However, the emissions fluctuate without showing a clear trend.

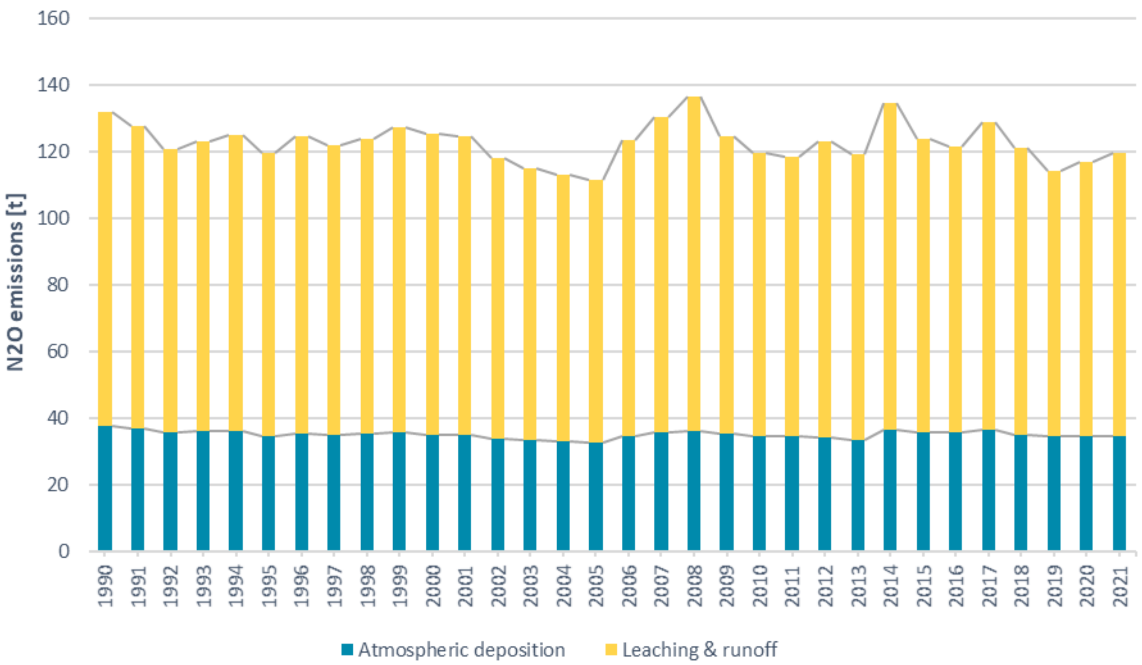


Figure 5.8 Indirect N_2O emissions from agricultural soils [t].

5.8.5 Recalculations

Several recalculations, that have an impact on N_2O emissions from 3D2 Indirect N_2O emissions from managed soils, have been performed for this submission, see Table 5.60. The main updates are due to the updated livestock parameters for the Tier 2 categories Cattle and Sheep for the whole timeseries, from 1990-2020. Smaller recalculations in emissions from horses and poultry are the result of updated livestock population numbers.

Table 5.60 Recalculations of CRF 3D2 Indirect N_2O Emissions from Managed Soils, predominantly due to updated livestock parameters for cattle and sheep, 1990-2020.

CRF 3D2 [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	38.2	34.4	35.9	32.3	34.4	35.9	33.5
2023 Submission	34.9	31.6	33.2	29.5	31.6	32.8	31.0
Change relative to the 2022 Submission	-8.6%	-7.9%	-7.5%	-8.5%	-8.0%	-8.6%	-7.4%

5.8.5.1 *Recalculations from the 2022 Submission*

An issue was raised during the 2021 UNFCCC Review (Question 2021ISLQA197: Consistency of $Frac_{GASF}$ and $Frac_{GASM}$). Consequently, external consultants at Aether performed a quality check of the 3D calculations and discovered an error in the calculation of NO_2-N and NH_3-N from sewage sludge and other organic fertilisers. This issue has now been resolved and resulted in a slight change in the volatilised N from agricultural inputs of N and consequent N_2O emissions reported under CRF category 3D21 Atmospheric Deposition.

5.8.6 Uncertainties

For atmospheric deposition estimated combined uncertainty is 412%, with an activity data uncertainty of 100% and emission factor uncertainty of 400% where the latter one is calculated based on the upper and lower ranges of Table 11.3, Chapter 11, Volume 4 of the 2006 IPCC Guidelines.

For nitrogen leaching and run-off, the estimated combined uncertainty is 510% with an activity data uncertainty of 100% and an emission factor uncertainty of 500% based on expert judgement.

5.8.7 Planned Improvements

There are no planned improvements in this subsector.

5.9 Prescribed Burning of Savannas (CRF 3E)

This activity is not occurring in Iceland.

5.10 Field Burning of Agricultural Residues (CRF 3F)

No field burning is occurring in fields that are in use in Iceland, for reasons that are detailed below. Hence, the notation key for this category was updated from NE to NO for this submission.

Crop residues that are produced in Iceland are considered a valuable resource (Þóroddur Sveinsson, written information, 2022). Straw is used for bedding and hay for feeding, since livestock must be kept inside for a large part of the year in Iceland and many livestock categories (incl. horses and sheep) are fed exclusively on hay, harvested during the summertime, over the winter months.

Old fields that have not been in use for a considerable amount of time often grow a thick vegetation in the form of straws over a few years. In these cases, the old fields have occasionally been burned if the farmer intended to start using the field again for farming. This is not considered burning of agricultural residues. However, this was almost completely banned with strict laws in 1992 with Act No 61/1992 (Law on the burning of straws and use of fire in open areas). Later, the laws were restricted even further with Act No 40/2015 (Law on the treatment of fire and fire prevention) and Regulation No 325/2016 (Regulation on the treatment of fire and fire prevention), which almost closed the possibility to gain a permit from the District Commissioner in Iceland.

If a landowner gains a permit, which can only be gained between the 1 April and 1 May each year, provided the purpose is justified, it is still uncertain whether the field burning will take place. The time frame is very limited, the weather conditions have to be perfect, and the fire marshal has to be contacted at least 6 hours before the burning is to take place and he can cancel the field burning if the weather conditions change. Despite it being difficult to obtain a permit, illegal burning of land is expected to be extremely rare. According to the District Commissioner’s office there are serious consequences for not getting a licence.

To confirm even further that no oversight of this activity has occurred in Iceland’s inventory, a review was performed of countries where field burning is known to occur, which crops are known to be most commonly burned, as well as how the other Scandinavian countries are reporting field burning of agricultural residues. Globally, field burning seems to be most common for cereals, fibres, oilseeds, pulses, and sugarcane. Of these, only cereals are grown in Iceland. In Norway and Denmark, field burning is only reported in very little amounts for cereals and hay. Hay is, as mentioned above, too valuable a resource for bedding and feeding to be burned in Iceland. The main crops grown in Iceland have traditionally been tubers – potatoes - and root crops. The first cereals (barley) were grown in Iceland in 1992 and this crop has been grown steadily more and more since then. Iceland, however, only has 1 short outdoor growing season during the year, which is over the summer months (May-September) and, therefore, farmers have no reason to need to burn crop residue fast in order to be able to get the fields ready for a winter growing season. Residues from barley crops are also considered valuable as bedding for Calves. Farming has been modernised in Iceland for many years and every farm has a tractor and ploughing machinery, which has been the main method for getting fields ready for the next growing season. Hence, it is most appropriate to report this activity as not occurring in Iceland.

5.11 CO_2 Emissions from Liming, Urea Application, Other Carbon Containing Fertilisers and Other (CRF 3G, 3H, 3I, 3J)

Combined CO_2 emissions from liming (3G), urea application (3H) and other carbon containing fertilisers (3I) account for 1.5% of the total GHG emissions from the Agricultural sector.

For this submission, two main changes have been made in sectors 3G and 3I. This includes shellsand being relocated from 3I to 3G1 (more details in Section 5.11.2.1) and CO_2 emissions from calcium ammonium nitrate fertilisers (CAN) being added to sector 3I (more details in Section 5.11.2.3).

5.11.1 Methodology

Tier 1 methodology from the 2006 IPCC Guidelines, Volume 4, Chapter 11 is applied for all three subsectors.

Annual CO_2 emissions from Liming 3G, i.e., emissions from the application of limestone, shellsand (90% $CaCO_3$), and dolomite, are estimated by using Eq. 11.12 from the 2006 IPCC Guidelines. This is because shellsand is 90% limestone the total limestone amount is obtained by adding 90% of the shellsand weight to the other limestone data.

Equation 11.12

Annual CO_2 emissions from lime application (Tier 1)

$$CO_2 - C\ Emission = (M_{\text{Limestone}} * EF_{\text{Limestone}}) + (M_{\text{Dolomite}} * EF_{\text{Dolomite}})$$

Where:

- CO_2-C Emission = emission of C from lime application, t C/yr
- M = annual amount of calcic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$), t/yr
- EF = emission factor, t of C (t of limestone or dolomite)$^{-1}$

Annual CO_2 emissions from urea application (CRF 3H) are estimated using Equation 11.13 from the 2006 IPCC Guidelines.

Equation 11.13

Annual CO_2 emissions from urea application (Tier 1)

$$CO_2 - C\ Emission = M * EF$$

Where:

- CO_2-C Emission = emission of C from urea application, t C/yr
- M = annual amount of urea fertilisation, t/yr
- EF = emission factor, t of C (t of urea)$^{-1}$

CAN exists usually in a fertiliser mixture, where other nutrients, such as phosphorus and potassium, are included in the mixture. In 2020 and 2021 around 78% of the CAN fertilisers imported to Iceland were pure calcium ammonium nitrate. Hence, the fertiliser weight was multiplied by 0.8 to isolate the CAN part. For pure CAN, around 23% is limestone or dolomite. Therefore, 23% of the CAN weight was calculated and CO_2 emissions were subsequently estimated using Eq. 11.12 from the 2006 IPCC Guidelines. This is the same equation as is used to calculate emissions from 3G Liming, with the exception that for CAN, the slightly higher EF for dolomite is used. This process is described in the following equation:

Equation

Annual CO_2 emissions from CAN application (Tier 1)

$$CO_2 - C\ Emission = M_{\mathrm{CANfertiliser}} * 0.8 * 0.23 * EF_{\mathrm{Dolomite}}$$

Where:

- CO_2-C Emission = emission of C from CAN application, t C/yr
- M = annual amount of CAN fertiliser, t/yr
- EF = emission factor, tonne of C (tonne of dolomite)$^{-1}$

5.11.2 Activity Data

5.11.2.1 *Liming*

Data on liming is based on sold $CaCO_3$ and imported synthetic fertilisers containing chalk or dolomite. Although the ratio of calcifying materials is low in these fertilisers, the amount of fertilisers applied make this source relatively large in terms of emissions. Activity data about imported limestone, dolomite and synthetic fertilisers are registered through the customs system and obtained either from Statistics Iceland or from IFVA. Data on the use of shellsand is derived from distributor sales numbers. Shellsand contains 90% of $CaCO_3$ and is naturally available from Icelandic seashores and there is no system in place at the moment registering the amount of shellsand used by single farmers.

The time series 1990-2003 for limestone has been completed by an update in data collection from Statistics Iceland. Data for dolomite and shellsand is not available before 2002. However, based on expert judgement from specialists at the Agricultural University and the Icelandic Agricultural Advisory Centre received in 2021, there was no- or very little dolomite and shellsand used during those years. Therefore, they are now estimated as not occurring for the period 1990-2002. Figure 5.9 shows the imported amounts of limestone, dolomite, Urea and CAN and the sold amounts of shellsand.

It is assumed that all liming occurs on cropland and that the bulk occurs on organic soil as the pH of mineral soils is generally so high that liming is unnecessary.

The peak in imports of dolomite in 2020 is due to a significant increase in imports by one distributor according to information received from IFVA. The distributor intends to encourage a significant calcification effort by Icelandic farmers which is taking place from 2021-2022. Calcification improves the uptake of nutrients from fertilisers in soils significantly and, therefore, soils at the optimum pH level (5.5 pH to 6.0 pH for grassland) require much less fertilisation than soils at sub-optimum pH levels.[27]

[27] https://www.yara.is/kolkun-er-grundvallaratridi-thegar-kemur-ad-godri-upptoku-naeringarefna/

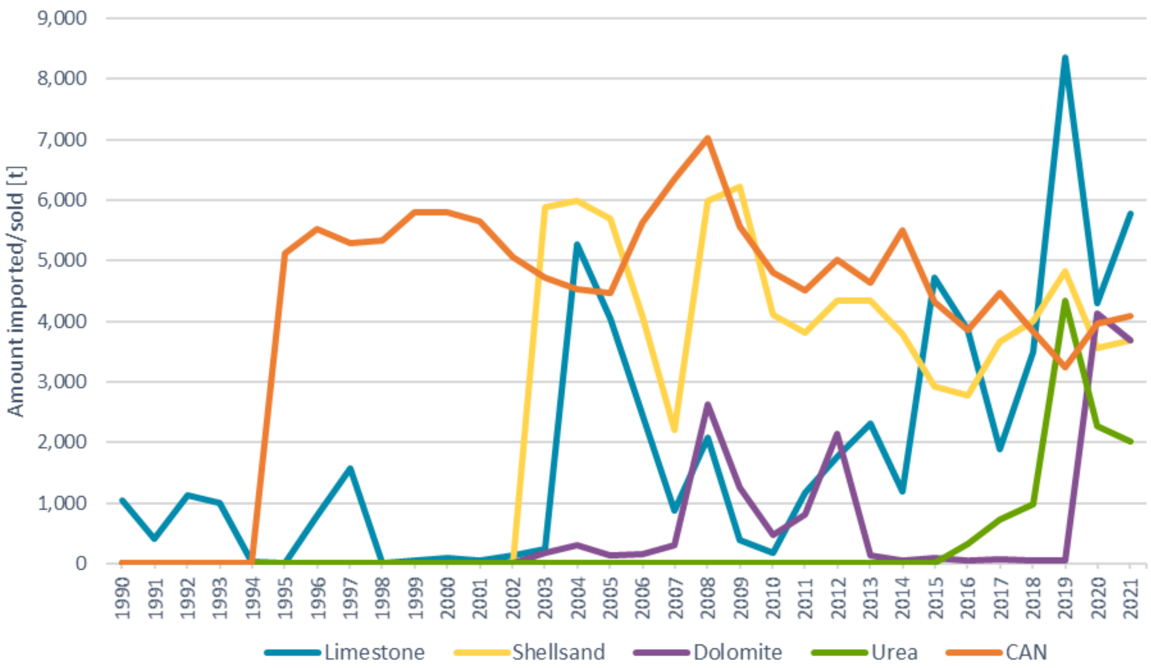


Figure 5.9 The amount of limestone, dolomite, Urea and CAN imported and shellsand sold in 1990-2021.

5.11.2.2 *Urea Application*

Activity data about imported urea fertilisers are registered through the customs system and obtained by the IFVA. Urea data from the IFVA is used from 2012. Based on expert judgment (Valgeir Bjarnason, written communication, 2022) and real data from the IFVA for 2012 and 2013, no urea was used as fertiliser in agriculture in Iceland until 2014. It is, therefore, marked as not occurring for 1990-2013. Urea import data can be seen in Figure 5.9.

5.11.2.3 *Other Carbon-containing Fertilisers*

For the 2023 Submission, the amount of CAN fertilisers imported was only readily available for 2020 and 2021. Before that, only the amount of imported N fertilisers is available. Hence, it was necessary to rely heavily on the expert judgement of the fertiliser expert at the IFVA (Valgeir Bjarnason, meetings and phone calls, 2022). A single fertiliser factory in Iceland had exclusive rights to import and manufacture fertilisers in Iceland until 1995. They manufactured ammonium nitrate-based fertilisers. Hence, it is safe to say that no CAN fertiliser was used in Iceland until 1995 when the factory's exclusive rights were revoked.

According to expert judgement close to 100% of imported N fertilisers in 1995-2010 were CAN except for granular fertilisers, which proportion has been rather steady throughout the timeline. The proportion of granular fertilisers was 33% in 2021 and that proportion is kept for 1995-2021, and the rest is assumed to be CAN. The proportion of CAN of all inorganic N fertilisers in 2020 was 44% and in 2021 it was 42%, the amount of CAN fertilisers imported in 2011-2019 was estimated by interpolating the proportion of CAN of all inorganic N fertilisers from 67% in 2010 to 44% in 2020.

The amount of other nutrients mixed into the fertilisers has also stayed rather stable over the timeline and was around 21-22% in 2020 and 2021, hence, to not underestimate the emissions, a 20% of the weight of the CAN fertiliser was subtracted to obtain the pure CAN weight. Approximately 23% of pure CAN fertilisers is limestone or dolomite. Therefore, the limestone/dolomite weight is obtained by taking 23% of the CAN fertiliser weight.

5.11.3 Emission factors

Default emission factors from the 2006 IPCC Guidelines, Vol. 4, Chapter 11 for limestone, 0.12 and dolomite, 0.13, are used. Since the limestone amount in shellsand has been added to the other limestone data, only the limestone EF is needed for this group. The emission factor for the application of urea fertilisers is 0.2.

The activity data available for CAN in 2020 and 2021 does not fully annotate whether magnesium or calcium or both is used in the fertiliser. The emission factor for dolomite is slightly higher than for limestone. Hence, the dolomite emission factor is used for all CAN fertilisers to not underestimate the emissions.

5.11.4 Emissions

The CO_2 emissions due to liming of cropland, Urea or CAN use are calculated by conversion of carbonated carbon to CO_2 and are shown in Table 5.61 and Figure 5.10.

Table 5.61 CO_2 emissions from liming (limestone and dolomite), urea application and other carbon containing fertilisers (CAN).

	1990	1995	2000	2005	2010	2015	2020	2021
Limestone + shellsand	462	0	44	4,029	1,706	3,238	3,297	4,008
Dolomite	NO	NO	NO	65	225	47	1,969	1,761
Urea	NO	NO	NO	NO	NO	7	1,668	1,476
CAN	NO	2,437	2,760	2,127	2,292	2,055	1,888	1,945
Total CO_2 Emissions [t]	462	2,437	2,804	6,221	4,223	5,346	8,822	9,190
Relative change since 1990		427%	507%	1,247%	814%	1,057%	1,809%	1,889%

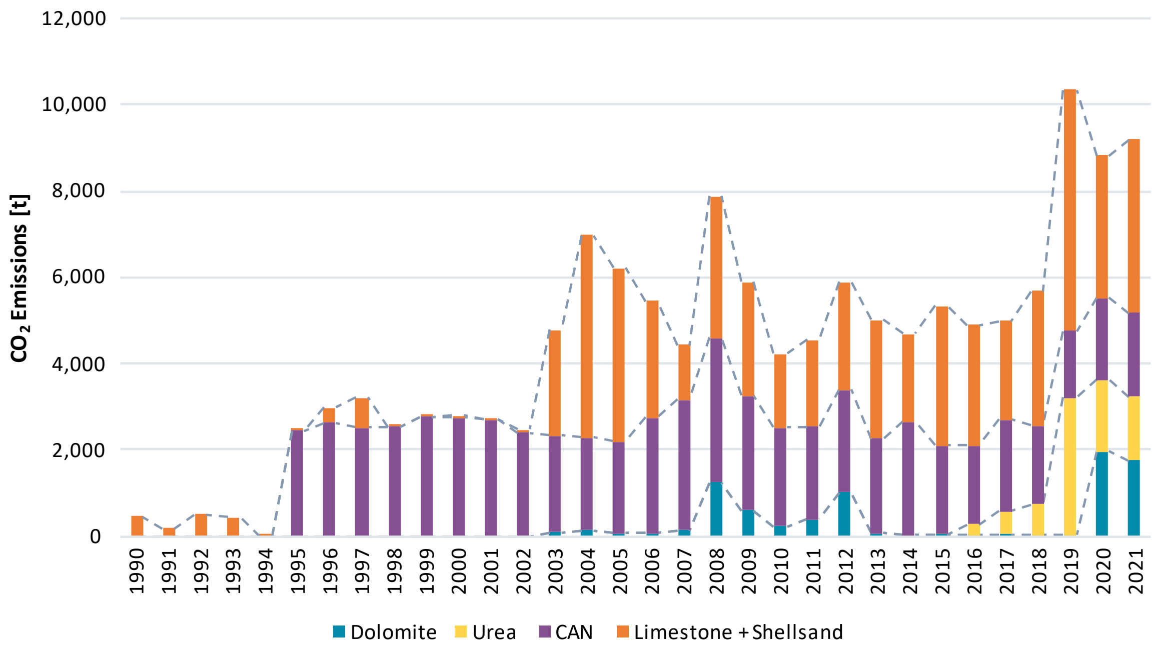


Figure 5.10 CO_2 emissions from liming (limestone and dolomite), urea application and other carbon containing fertilisers (CAN).

5.11.5 Recalculations

Data for dolomite and shellsand is not available before 2002. However, based on expert judgement from specialists at the Agricultural University and the Icelandic Agricultural Advisory Centre, received in 2021, there was no- or very little dolomite and shellsand used during those years. Hence, the notation keys used were changed from NE to NO for 1990-2002.

Emissions from shellsand were previously reported under the CRF category 3I but have been moved to CRF category 3G1. No other changes have been made regarding shellsand and there is no impact on emissions, as can be seen in Table 5.62. Shellsand is used predominantly for liming purposes, rather than as a fertiliser and this categorisation was, therefore, deemed more appropriate.

Table 5.62 Recalculations of 3G1 and 3I due to emissions from shellsand being recategorised, 1990-2020.

CRF 3I, 3G1 [kt CO_2e]	CRF	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	3I (shellsand)	NO	NO	NO	2.29	1.66	1.18	1.43
2023 Submission	3G1 (shellsand)	NO	NO	NO	2.29	1.66	1.18	1.43
Change relative to the 2022 Submission [%]		-	-	-	0.00	0.00	0.00	0.00

Activity data on urea fertiliser was previously retrieved from Statistics Iceland, which in turn received it from the customs authority. Imports, however, had started showing a sharp increase from 2014 onwards and after some research and meetings with the customs authority it was found out that urea used as an additive for selective catalytic reduction for diesel vehicles was registered on the same custom number as the urea used as fertiliser. The figures reported until the 2020 submission (reporting year 2018) were, therefore, updated by deducting the amount of urea sold as SCR-additives which have been directly collected from the oil distributing companies. From 2020 onwards, there were different custom numbers for different urea uses and this issue should not have been of concern anymore.

However, after reviewing the historical inventory numbers with an experienced fertiliser expert from the IFVA, it became clear that that the urea customs data for the earlier years of the timeline was still very unreliable, and included urea used not just as an additive for diesel vehicles and as fertiliser, but many other purposes. Urea was not used as fertiliser in Iceland until 2014 according to the expert at the IFVA, which has been confirmed by checking that the imports of urea as fertiliser registered by the IFVA in 2012 and 2013 were 0. Therefore, there is a recalculation of urea emissions for the whole timeseries, as can be seen in Table 5.63. Urea used as fertiliser is not occurring in Iceland until 2014 and from then on fertiliser import data form the IFVA is used directly.

Table 5.63 Recalculations of 3H due to updated activity data for the whole timeseries, 1990-2020.

CRF 3H [kt CO_2e]	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	0.06	0.06	0.07	0.07	0.13	0.17	0.19
2023 Submission	NO	NO	NO	NO	NO	0.01	1.67
Change relative to the 2022 Submission [%]	-	-	-	-	-	-96%	763%

CO_2 emissions from CAN were included in the Icelandic GHG inventory for the first time for the 2023 Submission, which impacted the emissions as shown in Table 5.64. How the emissions are calculated is described in detail in earlier subsections of Section 5.11.

Table 5.64 Recalculations of 3I due to emissions from CAN fertilisers being added to the inventory, 1990-2020.

CRF 3I [kt CO_2e]	CRF	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission	3I (CAN)	-	-	-	-	-	-	-
2023 Submission	3I (CAN)	NO	2.44	2.76	2.13	2.29	2.05	1.89
Change relative to the 2022 Submission [kt CO_2e]		-	2.44	2.76	2.13	2.29	2.05	1.89

5.11.5.1 *Recalculations from the 2022 Submission*

There were no recalculations in this category for the 2022 Submission.

5.11.6 Uncertainties

For liming, urea application and other carbon containing fertilisers the activity data uncertainty is 50% based on expert judgement in light of completeness and data retrieval issues. The emission factor uncertainty for CO_2 is 0 based on the 2006 IPCC Guidelines in which by using Tier 1 method it is assumed that all C contained for example in lime is emitted as CO_2 to the atmosphere which is a conservative approach and implies that the default emission factors are considered certain given this assumption. The combined uncertainty for each category is therefore 50%. The complete uncertainty analysis is shown in Annex 2.

5.11.7 Planned Improvements

For future emissions it is planned to process more IFVA data back in time to verify the CAN activity data and become less reliant on expert judgement.

6 Land Use, Land-use Change, and Forestry (CRF sector 4)

6.1 Overview

In this sector, emissions and removals related to **L**and **U**se, **L**and-**U**se **C**hange, and **F**orestry (LULUCF) are reported. The categorisation of land use is according to the 2006 IPCC guidelines (IPCC 2006). This defines six mainland-use categories and conversions between them. Emissions and removals of GHGs are reported for all managed land within these categories according to guidelines given in Volume 4: Agriculture, Forestry, and Other Land Use of the 2006 Guidelines (IPCC, 2006), hereafter named 2006 AFOLU Guidelines, and the 2013 Supplement to the 2006 Guidelines: Wetlands (IPCC, 2014), hereafter named 2013 Wetlands Supplement. The Soil Conservation Service of Iceland (*Landgræðslan*) (SCSI) and the research division of the Icelandic Forest Service (*Skógræktin*) (IFS) are responsible for preparing the inventory for this sector.

Almost 90 % of the total area of Iceland is included in two land-use categories; these are Other Land and Grassland. Land categories were changed considerably in the 2021 Submission as part of the Other Land category is now under Grassland. This change was due to new data available for this year's submission. Figure 6.1 shows the relative division of the area of Iceland to the six mainland-use categories reported.

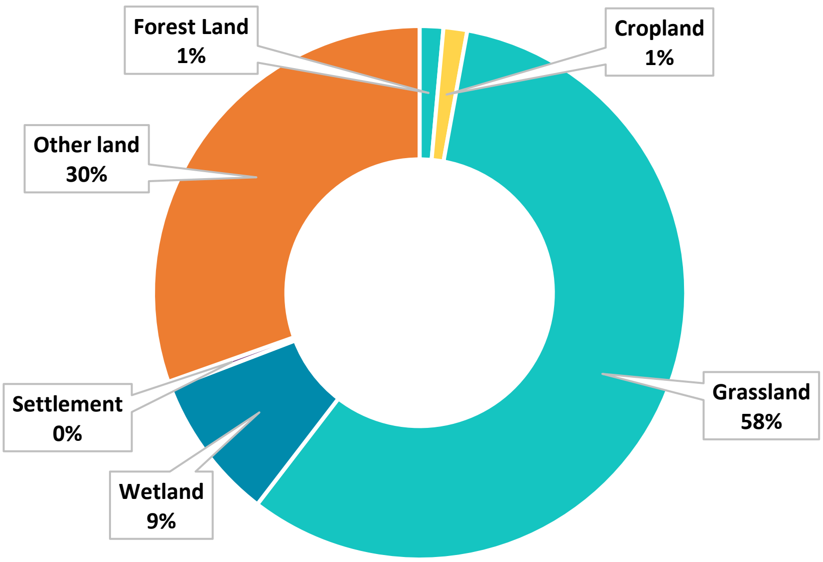


Figure 6.1 Relative size of land-use categories in Iceland according to land use database 2021 and other land-use estimates available for the reporting.

Both emissions from sources and removals by sinks are reported for this sector. The net contribution of the mainland-use categories is summarised in Figure 6.2.

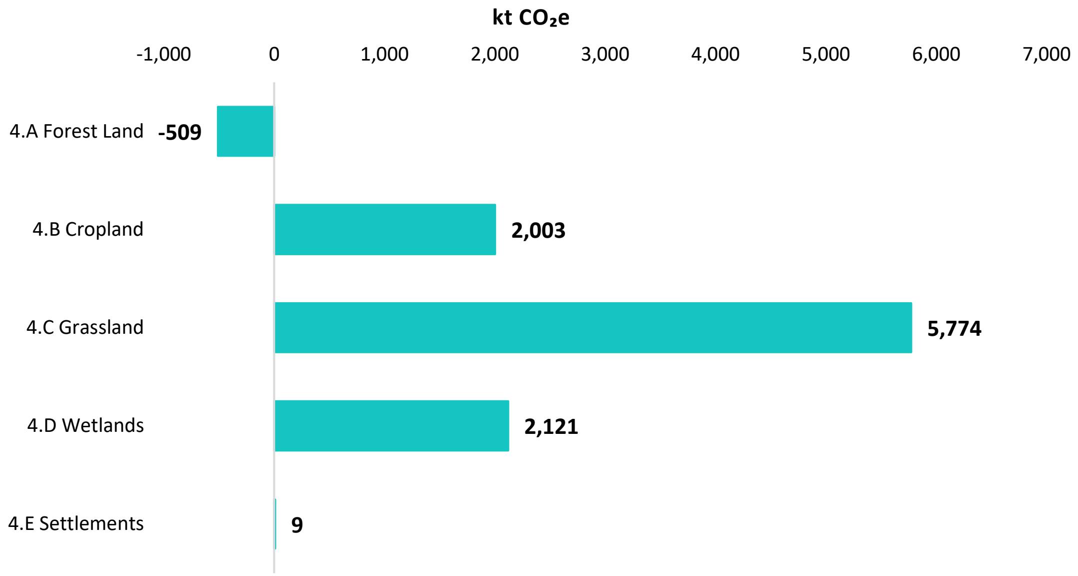


Figure 6.2 The net emissions/removals of land-use categories [kt CO_2e] in 2021 calculated using global warming potentials (GWP) from the IPCC's 5th Assessment Report (AR5). Emissions from Other Land (4F) and Harvested Wood Products (4G) are not included in this graph.

The total gross emissions reported are 11,902.92 kt CO_2e and they are 72.2% dominated by 8,595.29 kt CO_2e emissions related to drainage of organic soils, mostly included under Grassland, Cropland, and to a small extent Forest Land. Another important emission component of 26.7% or 3,178.45 kt CO_2e is the methane emissions from managed wetlands. The remaining reported emissions are assigned to biomass burning, hydropower reservoirs (CO_2), losses of soil organic carbon (SOC) from mineral soils, and loss of biomass due to conversion of land to Settlements. The removal by sinks reported is by sequestration of carbon to wetlands (49.6% or 1,243.00 kt CO_2), to biomass and SOC in revegetation (27.9% or 697.40 kt CO_2), and to biomass and SOC in forests (20.7% or 518.51 kt CO_2). Other components contributing to the total 3.5% removals by sinks reported are an increased SOC of mineral soils in some Croplands, increased biomass and SOC of mineral soils in Natural Birch Shrubland, and increase of biomass of Abandoned Croplands.

Compared to last year, the net emissions reported for the LULUCF sector have increased from 9,009.75 kt CO_2e to 9,397.86 kt CO_2e. The use of new GWP from the IPCC's 5th Assessment Report (AR5) mostly explain the significant increase in emissions for the 2023 Submission. However, when AR5 calculations are also applied for the 2022 Submission, the comparison between the 2022 and 2023 Submissions highlights that the net emissions have decreased by 0.2%, from 9,412.53 kt CO_2e to 9,397.86 kt CO_2e. New area estimate of some land-use categories included in this submission affects emissions increasing. Table 6.1 summarises the GHG emissions in kt CO_2e for the LULUCF sector from 1990 to 2021. Total GHG emissions in 2021 are 2.2% below the total GHG emissions reported for 1990.

The CRF tables are prepared through the new version of the CRF reporter (version 6.0.8). The information on all categories has the same structure as in the 2022 Submission.

Table 6.1 GHG emissions in LULUCF sector 1990-2021, [kt CO_2e].

GHG	1990	1995	2000	2005	2010	2015	2020	2021
CO_2	5,761.4	5,740.2	5,774.7	5,829.3	5,822.1	5,741.3	5,666.2	5,642.1
CH_4	3,848.0	3,846.6	3,828.6	3,805.4	3,773.3	3,763.4	3,753.7	3,754.8
N_2O	0.2	0.4	0.5	0.7	0.8	1.0	0.9	0.9
Total	**9,609.6**	**9,587.2**	**9,603.8**	**9,635.3**	**9,596.2**	**9,505.8**	**9,420.8**	**9,397.8**
Emissions increases/ reductions (year-base year)/base year		-0.2%	-0.1%	0.3%	-0.1%	-1.1%	-2.0%	-2.2%

6.1.1 Methodology

The present CRF reporting is based on land use as recorded in the Icelandic Geographical Land-Use Database (IGLUD). Activity data and mapping on afforestation and deforestation, maps of natural birch forest and shrubland are from the Icelandic Forest Research (IFR). Activity data (incl. active grazing areas), and maps on revegetation are from the SCSI. Time series of Afforestation, Reforestation, and Grassland categories (including revegetation, drainage, cropland abandonment, and reservoirs) are based on data from IFR, the Agricultural University of Iceland (*Landbúnaðarháskóli Íslands*) (AUI), Registers Iceland (*Þjóðskrá Íslands*) (RI), the Icelandic Agricultural Advisory Centre (*Ráðgjafamiðstöð landbúnaðarins*) (IAAC), the National Power Company of Iceland (*Landsvirkjun*) (NPCI), and the National Land Survey of Iceland (*Landmælingar Íslands*) (NLSI). Data on biomass burning is based on area mapping of the Icelandic Institute of Natural History (*Náttúrufræðistofnun Íslands*) (IINH) and biomass estimation for relevant land categories was obtained through IGLUD field sampling (Guðmundsson, Gísladóttir, Brink, & Óskarsson, 2010). The project was designed to provide two types of data: 1) land-use classification data for both geographically identifiable categories and relative dimensions of land use; 2) data on the sizes of different carbon pools inside each land-use category. The project enabled a classification build on available geographical maps and a classification according to field data which, in addition, proposed that field data could be applied to determine relative division size of subcategories.

Considerable changes were made to IGLUD for the 2023 Submission (Table 6.2). The IGLUD map now consists of 102 categories, of which 69 belong to the Habitat Map of Iceland (HMI). The HMI is a comprehensive description and overview of habitat types in Iceland and their distribution, size, and conservation value. The HMI includes a total of 105 habitat types of which 64 are terrestrial, 17 freshwater, and 24 coastal habitat types. IINH submitted its first habitat classification scheme for Iceland, based on the EUNIS habitat classification system (a recognised pan-European system) (Ottósson, Sveinsdóttir, & Harðardóttir, 2016). There is no specific information regarding uncertainties for the habitat type classification. In any case, the process of describing and mapping habitat types in Iceland has been the most extensive project undertaken by the IINH to date. Project findings are the product of wide-ranging field observations and data analysis, and the databases developed in the process will continue to serve well in the future. The project was carried out in collaboration with numerous individuals and natural history institutes. Concise descriptions of each habitat type with their attributes, distribution and conservation values are provided (Ottósson, Sveinsdóttir, & Harðardóttir, 2016). Further investigations regarding HMI is being assessed by GróLind (the National Soil and Vegetation Monitoring Program: https://grolind.is/; an independent research program coordinated by the SCSI). The other 33 categories are from the SCSI, IFR, Ministry of Industry and Innovation, NPCI, RI, NLSI, and AUI. One of the changes made to the IGLUD map is the reintroduction of 13 Icelandic Farmland Database (IFD) classes. This is necessary following the deletion of the HMI layer L14.1 Constructed, industrial, and other artificial habitats from the habitat mapping that left gaps that have since been replaced with IFD data. The IFD data used had comparable IGLUD/LULUCF classifications of the land surface for the IGLUD database/mapping.

In the IFD, the classification method was supervised classification adjusted to ground truth sampling points to reach reasonable certainty, whereas in the HMI the classification is automatic ISODATA (Lillesand, Kiefer, & Chipmann, 2004) and classes correlated to on ground classification.

The HMI adopted in 2019 as the IGLUD base map is a hybrid map applying remote sensing of RapidEye™ satellite imagery from 2011-2013, but also other available imagery such as SPOT-5 from 2002-2010, and LANDSAT 8 from 2013-2016 (Ottósson, Sveinsdóttir, & Harðardóttir, 2016). As for the HMI, the IFD is a hybrid map applying available imagery from SPOT-5, SPOT-4, and Landsat 7. Other data used includes various other available data and direct mapping on aerial photographs as necessary due to current data gaps. The HMI is updated regularly, and this year's submission reflects changes released by the IINH in 2021.

In preparing the IGLUD land-use map, other map layers also included in previous versions are still utilised. This includes a map of Grassland on Drained (organic) Soils, a map of Reservoirs, a map of Revegetated Land (with its subcategories), a map of Forest Land (with subcategories), a map of Cropland (with subcategories), a map of Birch Shrubland, and a map of Settlements. There are still some discrepancies between these layers that will be addressed in future submissions as an effort to improve the overall quality and accuracy and to comply with current guidelines.

Table 6.2 Map layers applied for this year's land-use map and their order of compilation hierarchy. The table also shows to which land-use category the area merging from the compilation process is classified.

Land-use Category	Subcategories	Habitat Type Class	Habitat Type/or Other Map Layer	Compilation Hierarchy
Forest Land	Cultivated Forest 1990-2021	Not HMI category	Not HMI category	3
	Cultivated Forest before 1990	Not HMI category	Not HMI category	4
	Icelandic Farmland Database (IFD) – Cultivated Forest before 1990	Not HMI category	Not HMI category	27
	Natural Birch Forest	Not HMI category	Not HMI category	5
Cropland	Harvested Croplands 2021	Not HMI category	Not HMI category	13
	Harvested Croplands 2020	Not HMI category	Not HMI category	14
	Harvested Croplands 2019	Not HMI category	Not HMI category	15
	Harvested Croplands 2018	Not HMI category	Not HMI category	16
	Harvested Croplands 2017	Not HMI category	Not HMI category	17
	Cropland Other (1) 2021	Not HMI category	Not HMI category	18
	Cropland Other (1) 2020	Not HMI category	Not HMI category	19
	Cropland Inactive (Fallow) (2)	Not HMI category	Not HMI category	20
Grassland	Revegetated Land SCSI before 1990	Not HMI category	Not HMI category	8
	Revegetated Land SCSI 1990-2021	Not HMI category	Not HMI category	9

Land-use Category	Subcategories	Habitat Type Class	Habitat Type/or Other Map Layer	Compilation Hierarchy
	Farmer's revegetation before 1990	Not HMI category	Not HMI category	10
	Farmer's revegetation 1990-2021	Not HMI category	Not HMI category	11
	Natural Birch Shrubland	Not HMI category	Not HMI category	12
	Croplands	Not HMI category	L14.2 *Other Land* types	21
	Icelandic Farmland Database (IFD) – Grassland	Not HMI category	Not HMI category	22
	Icelandic Farmland Database (IFD) – Richly Vegetated Heath Land	Not HMI category	Not HMI category	23
	Icelandic Farmland Database (IFD) – Cultivated Land	Not HMI category	Not HMI category	24
	Icelandic Farmland Database (IFD) – Poorly Vegetated Heath Land	Not HMI category	Not HMI category	25
	Icelandic Farmland Database (IFD) – Birch Shrubland	Not HMI category	Not HMI category	26
	Icelandic Farmland Database (IFD) – Moss Land	Not HMI category	Not HMI category	28
	Icelandic Farmland Database (IFD) – Partially Vegetated Land	Not HMI category	Not HMI category	31
	Grassland on Drained Soils	Not HMI category	Not HMI category	38
	Other Grassland [Grazing Areas / Grassland without Grazing]	Fell Fields, Moraines, and Sands	L1.6 Icelandic Inland Dunes	39
		Exposed Aeolian Soils	L2.1 Icelandic Exposed Andic Soils	40
		River Plains	L4.2 Icelandic Braided River Plains	41
		Moss Lands	L5.3 Moss and Lichen Fjell Fields	42
		Lava Fields	L6.4 Icelandic Lava Field Shrub Heaths	43
		Coastal Lands	L7.1 Icelandic Sand Beach Perennial Communities	44
			L7.4 Northern Fixed Grey Dunes	45
			L7.7 Atlantic Sea-Cliff Communities	46
		Grasslands	L9.1 Icelandic *Carex bigelowii* Grasslands	47
			L9.2 Insular *Nardus – Galium* Grasslands	48
			L9.3 Wavy Hair – Grass Grasslands	49
			L9.4 Boreal Tufted Hairgrass Meadows	50
			L9.5 Icelandic *Festuca* Grasslands	51
			L9.6 Boreo – Subalpine Agrostis Grasslands	52
			L9.7 Northern Boreal *Festuca* Grasslands	53
		Heathlands	*L10.1 Icelandic Racomitrium Grass Heaths*	54
			L10.2 Arctic *Dryas* Heaths	55

Land-use Category	Subcategories	Habitat Type Class	Habitat Type/or Other Map Layer	Compilation Hierarchy
			L10.3 Icelandic *Carex bigelowii* Heaths	56
			L10.4 Icelandic *Empetrum Thymus* Grasslands	57
			L10.5 Icelandic Lichen *Racomitrium* Heaths	58
			L10.6 North Atlantic Boreo – Alpine Heaths	59
			L10.7 Oroboreal Moss – Dwarf Willow Snowbed Communities	60
			L10.8 North Atlantic Vaccinium – *Empetrum-Racomitrium* Heaths	61
			L10.9 Icelandic *Salix lanata/S. phylicifolia* Scrub	62
			L10.10 Oroboreal Willow Scrub	63
		Woodlands	L11.1-3 Subclasses of Birch Wood	64
		Not HMI category	L14.3 Mixed Forestry Plantations	65
		Not HMI category	L14.4 Land Reclamation Forb fields	66
Wetland	Reservoirs	Reservoirs Landsvirkjun & AUI	Not HMI category	1
	Icelandic Farmland Database (IFD) – Semi Wetland	Not HMI category	Not HMI category	29
	Icelandic Farmland Database (IFD) – Wetland	Not HMI category	Not HMI category	30
	Icelandic Farmland Database (IFD) – Lakes and Rivers	Not HMI category	Not HMI category	33
	Lakes	Standing Waters	V1	36
	Rivers	Running Waters	V2	37
	Coastal Wetlands	Coastal Lands	L7.5 Atlantic Lower Shore Communities	67
			L7.6 Icelandic *Carex lyngbyei* Salt Meadows	68
	Mires and Fens	Wetlands	L8.1 *Philonotis-Saxifraga stellaris* Springs	69
			L8.2 Icelandic Stiff Sedge Fens	70
			L8.3 Cottonsedge Marsh Fens	71
			L8.4 *Juncus arcticus* Meadows	72
			L8.5 Boreal Black Sedge-brown Moss Fens (high altitude)	73
			L8.6 Boreal Black Sedge-brown Moss Fens (low altitude)	74
			L8.7 Aapa Mires	75
			L8.8 Palsa Mires	76
			L8.9 Icelandic Black Sedge-brown Moss Fens	77
			L8.10 Icelandic *Carex rariflora* Alpine Fens	78
			L8.11 Common Cotton-grass Fens	79
			L8.12 Icelandic Black Sedge-brown Moss Fens	80
			L8.13 Basicline Bottle Sedge Quaking Mires	81
			L8.14 Icelandic *Carex lyngbyei* Fens	82
	Geothermal Wetland	Geothermal Lands	L12.1 Geothermal wetlands	83
Settlements	Settlements	Not HMI category	Not HMI category	6
	Roads	Not HMI category	Not HMI category	7
	Icelandic Farmland Database (IFD) –	Not HMI category	Not HMI category	32

Land-use Category	Subcategories	Habitat Type Class	Habitat Type/or Other Map Layer	Compilation Hierarchy
	Sparsely Vegetated Land			
	Icelandic Farmland Database (IFD) – Uncategorised, Islands and Reefs	Not HMI category	Not HMI category	35
Other Land	*Other Land*	Fell Fields, Moraines, and Sands	L1.1 Sparsely- or un-vegetated Habitats on Mineral Substrates not Resulting from Recent Ice Activity	84
			L1.2 Sparsely- or un-vegetated Habitats on Mineral Substrates not Resulting from Recent Ice Activity	85
			L1.3 Oroboreal *Carex bigelowii-Racomitrium* Moss Heaths	86
			L1.4 Glacial Moraines with very Sparse or no Vegetation	87
			L1.5 Volcanic Ash and Lapilli Fields	88
		Screes and Cliffs	L3.1 Icelandic Talus Slopes	89
			L3.2 Icelandic *Salix herbacea* Screes	90
			L3.3 Icelandic *Alchemilla* Screes	91
		River Plains	L4.1 Unvegetated or Sparsely Vegetated Shores	92
		Moss Lands	L5.1 Boreal Moss Snowbed Communities	93
			L5.2 Icelandic *Racomitrium ericoides* Heaths	94
		Lava Fields	L6.1 Barren Icelandic Lava Fields	95
			L6.2 Icelandic Lava Field Lichen Heaths	96
			L6.3 Icelandic Lava Field Moss Heaths	97
		Coastal Lands	L7.2 Upper Shingle Beaches with Open Vegetation	98
			L7.3 Atlantic Embryonic Dunes	99
		Geothermal Lands	L12.2 Geothermal Heathlands	100
			L12.3 Geothermal Alpine Habitats	101
			L12.4 Geothermal Bare Grounds	102
	Glaciers, Rock Glaciers, and Unvegetated, Ice-dominated Moraines	Glaciers	L13.1 Glaciers, Rock Glaciers, and Unvegetated, Ice-dominated Moraines	2

(1) Cropland Other: Other Cultivated Fields (horticulture, green fodder, cereals, oilseeds, lack of crops).
(2) Cropland Inactive (fallow): Crops map layers from the Registers Iceland (crops not in use).

6.1.2 Key Category Analysis

Analyses of key categories is performed collectively for all sectors and a list of all key categories is presented in Chapter 1.4. Furthermore, the complete quantitative key category analysis can be found in Annex 1. Key categories within the LULUCF sector are presented in Table 6.3 below.

Table 6.3 Key Categories for LULUCF: 1990, 2021 Level, and 1990-2021 trend.

IPCC Source Category			Level 1990	Level 2021	Trend
LULUCF (CRF sector 4)					
4A1	Forest Land Remaining Forest Land – Carbon Stock change	CO_2		✓	✓
4A2	Land Converted to Forest Land – Carbon Stock Change	CO_2		✓	✓
4B1	Cropland Remaining Cropland – Carbon Stock Change	CO_2	✓	✓	✓
4B2	Land Converted to Cropland – Carbon Stock Change	CO_2	✓		✓

IPCC Source Category			Level 1990	Level 2021	Trend
4C1	Grassland Remaining Grassland – Carbon Stock Change	CO_2	✓	✓	✓
4C2	Land Converted to Grassland – Carbon Stock Change	CO_2	✓	✓	✓
4D1	Wetlands Remaining Wetlands – Carbon Stock Change	CO_2	✓	✓	✓
4(II) Grassland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	✓	✓	
4(II) Grassland	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	✓		
4(II) Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	✓	✓	✓
4(II) Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	✓	✓	

6.1.3 Completeness

The emissions and removal of most sources and sinks are estimated. There are still a few categories or components where sufficient data is not available. Table 6.4 and Table 6.5 give an overview of the IPCC source/sink categories included in this chapter and present the status of emission/removal estimates from all sub-land categories in the LULUCF sector for 2023 Submission.

Table 6.4 LULUCF – Completeness. Notation keys used for changes in carbon stock changes and net CO_2 emissions/removals in soils for Forest Land (e: estimated; NE: not estimated; NA: not applicable; NO: not occurring; IE: included elsewhere).

Land-use Category	Living Biomass		Net carbon stock change in dead wood	Net carbon stock change in litter	Soils	
	Gains	Losses			Mineral	Organic
4.A.1 Forest Land Remaining Forest Land						
Natural Birch Forest older than 50 years	e	IE	NO	NA	NA	e
Afforestation older than 50 years	e	IE	IE	NA	NA	e
Plantations in Natural Birch Forest	e	IE	IE	NA	NA	NO
4.A.2 Land Converted to Forest Land						
Cropland Converted to Forest Land	NO	NO	NO	NO	NO	NO
Grassland Converted to Forest Land						
Afforestation Natural Birch Forest 1-50 years old	e	IE	NO	e	e	e
Afforestation 1-50 years old – Cultivated Forest	e	e	e	e	e	e
Wetlands Converted to Forest Land	NO	NO	NO	NO	NO	NO
Settlements Converted to Forest Land	NO	NO	NO	NO	NO	NO
Other Land Converted to Forest Land						
Afforestation 1-50 years old	e	IE	IE	e	e	NO
Afforestation Natural Birch Forest 1-50 years old	e	IE	NO	e	e	NO

Table 6.5 LULUCF – Completeness. Notation keys used for Carbon Stock Changes and net CO_2 emissions/removals in soils for Cropland, Grassland, Wetlands, Settlements, and Other Land (e: estimated; NE: not estimated; NA: not applicable; NO: not occurring; IE: included elsewhere).

Land-use Category	Living Biomass		Dead Organic Matter	Soils	
	Gains	Losses		Mineral	Organic
4.B.1 Cropland Remaining Cropland					
Cropland Active	NA	NA	NA	e	e
Cropland Inactive (Fallow)	NA	NA	NA	e	e
4.B.2 Land Converted to Cropland					
Forest Land Converted to Cropland	NO	NO	NO	NO	e
Grassland Converted to Cropland	e	e	IE	e	IE
Wetlands Converted to Cropland	e	e	IE	IE	e
Settlements Converted to Cropland	NO	NO	NO	NO	NO
Other Land Converted to Cropland	IE	IE	IE	IE	NO
4.C.1 Grassland Remaining Grassland					
Revegetated Land older than 60 years	NA	NA	NA	NA	NO
Cropland Abandoned for more than 20 years	NA	NA	NA	NA	e
Natural Birch Shrubland – recently expanded into Other Grassland	e	IE	e	e	e
Natural Birch Shrubland – old	e	IE	NA	NA	e
Wetland Drained for more than 20 years	NA	NA	NA	IE	e
Grazing Areas	NA	NA	NA	NA	IE
Grassland without Grazing	NA	NA	NA	NA	IE
Grazing Areas on Other Land	NA	NA	NA	NA	NO
4.C.2 Land Converted to Grassland					
Forest Land Converted to Grassland	NO	NO	NO	NO	NO
Cropland Converted to Grassland	e	IE	IE	e	e
Wetlands Converted to Grassland	NA	NA	NA	NA	e
Settlements Converted to Grassland	NO	NO	NO	NO	NO
Other Land Converted to Grassland					
Revegetation before 1990	e	IE	IE	e	NO
Other Land Converted to Natural Birch Shrubland	e	IE	e	e	NO
Revegetation since 1990 – Protected from Grazing	e	IE	IE	e	NO
Revegetation since 1990 – Limited Grazing Allowed	e	IE	IE	e	NO
4.D.1 Wetlands Remaining Wetlands					
Peat Extraction Remaining Peat Extraction	NO	NO	NO	NO	NO
Flooded Land Remaining Flooded Land					
Mires Converted to Reservoirs	IE	IE	IE	IE	e
Other Wetlands Remaining Other Wetlands					
Lakes and Rivers	NA	NA	NA	NA	NA
Intact Mires	IE	IE	IE	IE	e
Lakes and Rivers Converted to Reservoirs	NA	NA	NA	NA	NO
4.D.2 Land Converted to Wetlands					
Land Converted to Peat Extraction	NO	NO	NO	NO	NO
Land Converted to Flooded Land					
4.D.2.2.3 Grassland Converted to Flooded Land					
Medium SOC to Reservoirs	IE	IE	IE	e	NO
4.D.2.2.5 Other Land Converted to Flooded Land					
Low SOC to Reservoirs	IE	IE	IE	e	NO
Land Converted to Other Wetlands					

Land-use Category	Living Biomass		Dead Organic Matter	Soils	
	Gains	Losses		Mineral	Organic
4.D.2.3.3 Grassland Converted to Other Wetlands					
Rewetted Wetland Soils	NE	NE	NE	e	e
Refilled Lakes and Ponds	NE	NE	NE	NE	IE
4.E.1 Settlements Remaining Settlements	NA	NA	NA	NA	IE
4.E.2 Land Converted to Settlements					
Forest Land Converted to Settlements	NO	e	e	e	NO
Cropland Converted to Settlements	IE	IE	IE	IE	IE
Grassland Converted to Settlements					
All Other Grassland subcategories Converted to Settlements	NE	e	IE	NE	IE
Natural Birch Shrubland Converted to Settlements	NO	e	e	e	NO
Wetlands Converted to Settlements	IE	IE	IE	IE	IE
Other Land Converted to Settlements	IE	IE	IE	IE	IE
4.F.2 Land Converted to Other Land					
Forest Land Converted to Other Land	NO	NO	NO	NO	NO
Cropland Converted to Other Land	NO	NO	NO	NO	NO
Grassland Converted to Other Land	NO	NO	NO	NO	NO
Wetlands Converted to Other Land	NO	NO	NO	NO	NO
Settlements Converted to Other Land	NO	NO	NO	NO	NO

6.2 Land-use Definitions and Classification Systems Used

Definitions of the six mainland-use categories as applied in IGLUD are listed below, along with descriptions of how they were compiled from the existing data.

Forest Land

Includes all land not included under Settlements that is presently covered with trees or woody vegetation that is on average more than 2 m high, with a crown cover minimum of 10%, that covers at least 0.5 ha in continuous area, and has a minimum width of 20 m. Land which currently falls below these thresholds but is expected to reach them in situ at mature state, is also included.

Cropland

Includes all cultivated land not included under Settlements or Forest Land that is at least 0.5 ha in continuous area and has a minimum width of 20 m. This category, besides including fields with annual or bi-annual crops, includes harvested hayfields with perennial grasses.

Grassland

Includes all land where vascular plant cover is >20% and is not included under the Settlements, Forest Land, Cropland, or Wetlands categories, with the exception below. This category includes, as a subcategory, land that is being revegetated and meets the definition of the activity but does not fall into the other categories. Drained wetlands, not falling into other categories, are included in this category. A new subcategory has been added in the 2021 Submission. This is the subcategory Grazing Areas on Other Land and represents managed land with vascular plant cover <20%. This land was previously under the Other Land main category but has been relocated because of the new available land-use data (see also chapter 6.7).

Wetland

Includes all land that is covered or saturated by water for at least part of the year and does not fall into the Settlements, Forest Land, or Cropland categories. It includes intact mires and reservoirs as managed subdivisions, and natural rivers and lakes as unmanaged subdivisions.

Settlements

All areas included within the map layers “Towns and villages” and “Airports” as defined in the IS 50 v2020 geographical database (NLSI). Settlements include roads classified as having a 15 m wide road zone, including primary and secondary roads. Roads within Forest Land are excluded if the actual road zone does not reach 20 m, the minimum width of Forest Land.

Other Land

This category includes bare soil, rock, glaciers, and all land that does not fall into any of the other categories. All land in this category is unmanaged. This category allows the total area of identified land to match the total area of the country.

The land-use map resulting from the preparation of map layers and the compilation process is shown in Figure 6.3 and Figure 6.4 ; they are also available at the AUI website http://www.lbhi.is/vefsja.

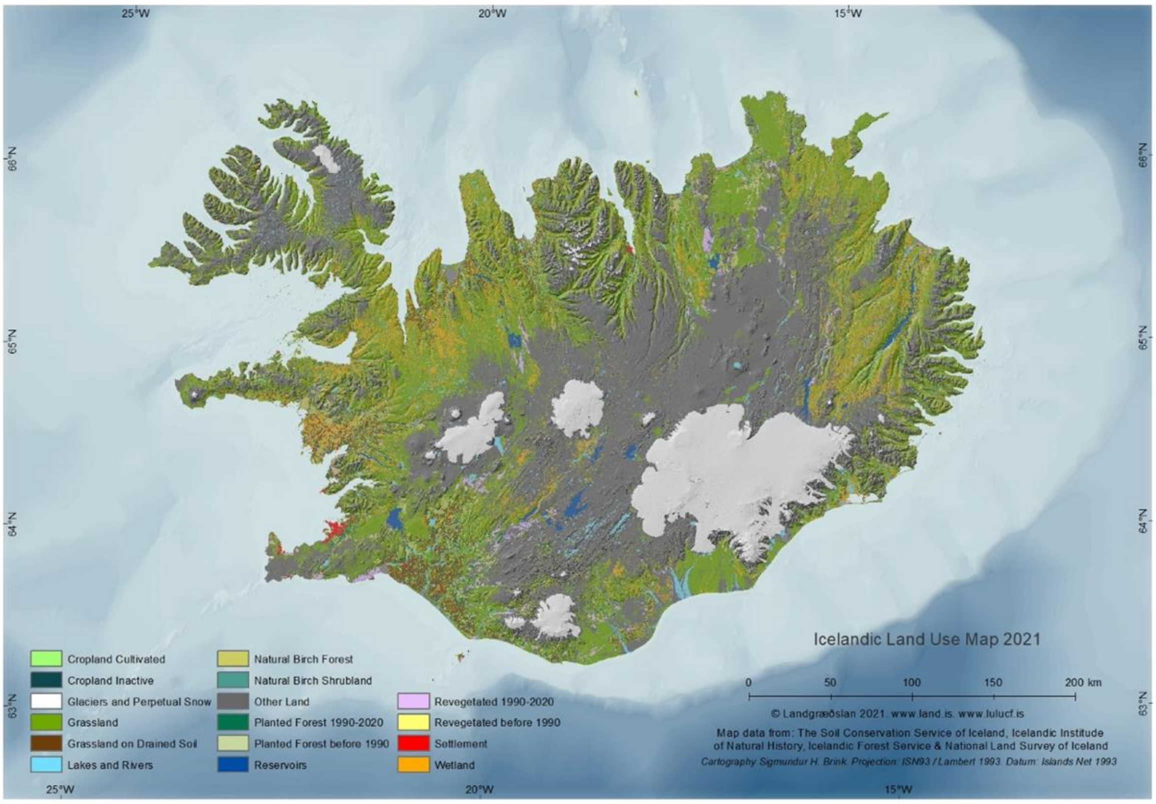


Figure 6.3 The land-use map of IGLUD prepared for 2021.

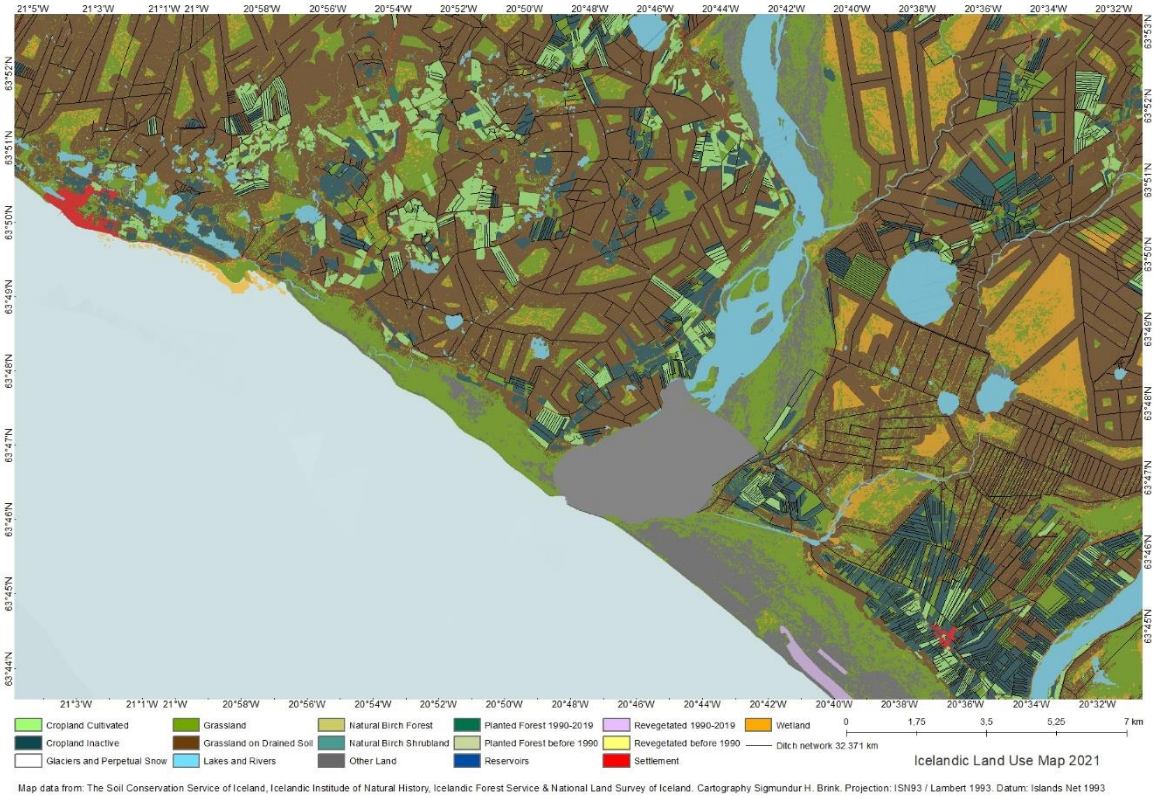


Figure 6.4 Enlargement of land-use map for 2021, emphasizing the subcategory Grassland on drained soils and Cropland inactive.

6.3 Land-use Changes

The reported land-use changes rely on a few independent time series of areas of some land-use categories converted to different land-use categories. There is ongoing development in the qualities of these series, regarding both geographical correctness of new areas and the previous land use of these new areas. Development of the time series for Forest Land (through past submissions) shows this well. Both improvements in mapping accuracy and categorisation of previous land use can be traced through previous submissions.

From 2017, agricultural support was modified with Regulation No.1240/2016 on General Support for Agriculture[28], adding emphasis on land-based support. Due to these modifications in support, farmers applying for support must annually submit maps of harvested land. This new recording of harvested Cropland was not available for the preparation of the present IGLUD land-use map but is expected to be for the next submission. Land-use changes in this submission involving Cropland are estimated through the time series constructed from available data, as in previous submissions.

In 2018, AUI started new digitation of ditches in Iceland. Along with this digitation, the 2008 map is updated through aerial images that were previously not accessible. Preliminary results from this work are ready and used in this submission.

[28] “Reglugerð No. 1240/2016 um almennan stuðning við landbúnað”

Information Concerning CRF Table 4.1 Land Transition Matrix

Small inconsistencies between final areas in CRF Table 4.1 and the corresponding total areas in CRF tables on carbon stocks for 4C Grassland, 4D Wetlands, and 4F Other Land occur. In the case of the land category Grassland the inconsistency is only for 2007, where the final area in Table 4.1 is 0.51 kha larger than the total area in CRF Table 4.C for the same year. In the case of the land category Wetlands the inconsistency appears only for 2021, where the sum of the final areas for Wetlands (managed) and Wetlands (unmanaged) in Table 4.1 is 0.07 kha smaller than the total area in CRF Table 4.D for the same year. For the land category Other Land, the inconsistencies appear in 2007 where the final areas in Table 4.1 are 0.51 smaller than the total area in CRF Table 4.C for the same year, and in 2021 where the final area in Table 4.1 is 0.07 kha larger than the total area in CRF Table 4.F for the same year (Table 6.6). Furthermore, in CRF Table 4.1 Cropland (managed) converted to settlements is reported as IE because no data are available for separation of Cropland from Grassland converted to settlements. AD and CSCs are included as aggregate area and CSCs under the sub-category All other Grassland converted subcategories converted to Settlements. Area of Wetlands managed converted to settlements is reported as IE because reported as aggregate. Other Land converted to Cropland is reported as IE as aggregate in Grassland converted to cropland. Other Land converted to settlements is reported as IE as aggregate values under the sub-category All other Grassland converted to settlements.

Table 6.6 Inconsistencies detected in Table 4.1 between final areas and corresponding total areas in CRF tables for 2023 Submission.

Land Category	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Grassland [managed]	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wetlands (managed - unmanaged)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.07
Other Land	-0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07

6.4 Approaches Used for Representing Land Areas and Land-use Databases

Information on land use is mostly in line with Approach 2 as described in Chapter 3.3.1 of the 2006 AFOLU Guidelines (IPCC, 2006). Some categories follow Approach 3 qualifications with spatially-explicit observations either as systematic sample plot inventory as for Cultivated Forest, or by direct mapping as for land converted to reservoirs and the Settlements category.

IGLUD is the land-use database used in this reporting. That database was constructed by AUI but is now maintained by the SCSI. The compilation of available geographical data into the land-use map is as described in Guðmundsson et al. (2013). Other estimates besides the land-use map exist for several land-use categories. When these estimates are considered more accurate, the area of the category is reported accordingly. The difference in these two area estimates is transferred to/from other categories as summarised in the following Table 6.7.

The IGLUD database contains map layers of diverse origin, geographically referable datasets obtained through IGLUD field work, results of analyses of the samples obtained in the aforesaid field work, photographs taken at sampling points, geographical data related to surveys on specific map layers or topics related to the database, and metadata describing the above data. A description of the fieldwork for collecting land information for the database and some preliminary results can be found in Guðmundsson et al. (2010).

Table 6.7 Land-use map area transfer matrix showing area transfer (ha) between land-use categories to adjust other mapped areas to other estimates available. Lines shows area moved from category and columns area moved to category. Final area estimate reported is shown as Corrected Area.

Land-use Map Units From\to [ha]	Cultivated Forest	Natural Birch Forest	Cropland	Grassland Drained	Natural Birch Shrubland	RV before 1990	RV since 1990	Grazing Areas	Grassland without Grazing	Grazing Areas on OL	Other Wetlands	Lakes and Rivers	Reservoirs	Settlements	OL Except Grazing Areas	Glaciers
Cultivated Forest								7,046	870							
Natural Birch Forest																
Cropland																
Grassland Drained																
Natural Birch Shrubland																
RV before. 1990																
RV since. 1990																
Grazing Areas		2,004			2,153	136,177										
Grassland Without Grazing		247			266	16,810										
Grazing Areas on OL															4,624	
Other Wetlands				19,589												
Lakes and Rivers																
Reservoirs																
Settlements																
OL Except Grazing Areas							21,418									
Glaciers																
Other																
Other Estimate	47,340	99,175	147,137	281,720	56,502	157,166	156,604									
Map Area	55,256	96,924	147,137	262,131	54,083	4,179	135,186	2,794,423	344,152	2,255,712	638,703	217,842	59,358	41,533	2,097,772	1,033,133
Difference	7,916	-2,251		-19,589	-2,419	-152,987	-21,418									
Corrected Area	47,340	99,175	147,137	281,720	56,502	157,166	156,604	2,661,135	327,698	2,251,088	619,114	217,842	59,358	41,782	2,080,729	1,033,133
Total Area [ha]																**10,237,525**

6.5 Forest Land (CRF 4A)

In accordance with the GPG arising from the Kyoto Protocol, a country-specific definition of forest has been adopted. The minimum crown cover and the minimum height of forest at maturity is 10% and 2 m accordingly. The minimum area of forest is 0.5 ha and minimum width 20 m. This definition is also used in the National Forest Inventory (NFI) as a classification definition to distinguish between forest, shrubland, and other land categories. All forests, both naturally regenerated and planted, are defined as managed, as they are all directly affected by human activity. The Natural Birch Woodland has been under continuous usage for many centuries. Until the middle of last century, it was the main source for fuel wood for house heating and cooking in Iceland (Ministry for the Environment (Umhverfisráðuneytið), 2007). Most of the woodland was used for grazing and still is, although some areas have been protected from grazing.

Natural Birch Woodland (NBW) is included in the IFR NFI. In the NFI, Natural Birch Woodland is defined as one of the two predefined strata to be sampled. The other stratum is Cultivated Forest (CF) consisting of tree plantation, direct seeding, or natural regeneration originating from Cultivated Forest. The sampling fraction in the NBW is lower than in the CF. Each 200 m^2 plot is placed on the intersection of 1.5 x 3.0 km grid but in the NFI of CF the grid is 0.5 x 1.0 km (Snorrason A. , 2010). All plots in the NFI are permanent. CF-NFI plots are visited in five-year intervals, and every year one-fifth of the plots are visited. NBW-NFI plots are visited in ten-year intervals. The sample population for NBF is the mapped area of NBW. The sample population of CF is an aggregation of maps of forest management reports from stakeholders in forestry in Iceland. In some cases, the NFI staff does mapping in the field of private CF. To ensure that forest areas are not outside the population area, the population for both strata is increased with buffering of the mapped border. Current buffering is 24 m. The third inventory cycle of CF and the second one of the NBW was ongoing in the period 2015-2019. The fourth inventory cycle of CF started in 2020 and remaining plots of the second cycle of the NBW were measured in 2021. The part of NBW defined as forest (reaching 2 m or greater in height at maturity) is estimated on basis of new map of NBW mapped in 2010-2014 (Snorrason, et al., 2016).

By analysing the age structure in the NBW that does not geographically merge the old map from the survey in 1987-1991, it was possible to re-estimate the area of NBW in 1987-1991 and 2010-2014. The area was estimated to be 137.69 kha at the time of the initial survey in 1987-1991 (Snorrason, et al., 2016). Earlier analyses of the 1987-1991 survey resulted in 115.40 kha (Traustason & Snorrason, 2008). The difference is the area that was missed in the earlier survey. The area of NBW was estimated 150.65 kha in the 2010-2014 mapping survey. The difference of 12.95 kha is an estimate of a natural expansion over the period of 1989 to 2012 (23 years) where the midyears of the two surveys are chosen as reference years. In the new map of 2010-2014, the ratio of NBW that can reach 2 m height in the mature state and is defined as a forest is 64% of the total area. Natural Birch Forest (NBF) is accordingly estimated as 87.72 kha in 1989 and 95.97 kha in 2012, with the former figure categorising NBF classified as Forest Remaining Forest and the difference between the two figures (8.25 kha) as NBF classified as Grassland or Other Land Converted to Forest Land with a mean annual increase of 0.36 kha.

In accordance with the Forest Law (Alþingi, 2019), the IFS and the National Planning Agency hold a register on planned activity that can lead to deforestation (Skógræktin & Skipulagsstofnun, 2017). Planned activities leading to deforestation must be announced by the municipalities to the IFS and the National Planning Agency. IFR samples activity data of the affected areas and data about the forest that will be or has been removed. This data is used to estimate emissions from lost biomass and C-stock in dead wood, litter, and soils. Deforestation in this year's submission is reported for the inventory years 2004-2007, 2011, 2013, 2015, 2017, 2020, and 2021. Three different types of deforestation occurred in these years. The first and most common type is road building, house building, and construction of snow avalanche defences. In these cases, not only were the trees removed, but also the litter together with the uppermost soil layer. The second type of deforestation is two events in 2006 and 2020 in which trees in an afforested area were cut down for new power lines. Bigger trees were removed. In this case, dead wood, litter, and soil were not removed, so only the biomass of the trees was supposed to cause instant emissions in the year of the action taken and reported as such. These two types of deforestation are both reported as Forest Land Converted to Settlements. The third type of deforestation reported was an afforested area on drained organic soil that was converted to cropland and reported as such in 2015. Further description on C-stock changes regarding deforestation can be found in the Cropland and Settlement chapters below.

6.5.1 Forest Land Remaining Forest Land (CRF 4A1)

6.5.1.1 *Category Description*

Three categories are defined as Forest Land Remaining Forest Land:

- Afforestation older than 50 years
- Plantations in Natural Birch Forest
- Natural Birch Forest older than 50 years

The two first categories are extracted from the systematic sample plot (SSP) of the NFI of CF. The conversion period for land-use changes to Forest Land is defined as 50 years and as plantations measured on plots are of known age, they move to Forest Land Remaining Forest Land when they reach an age over 50 years. Accordingly, the area of these categories' changes between reporting years and are updated annually when new plot data are merged into the database.

The third category is extracted from the SSP-NFI of NBW and the new mapping survey of the NBW. All NBFs that existed before the 1987-1991 survey are assumed to be existing more than 50 years ago. The majority are pristine Natural Birch Forests. Area changes reported in the NBF older than 50 years are deforestation and plantations. In the case of plantations, the area is moved from NBF to the category Plantations in Natural Birch Forest.

6.5.1.2 *Methodology*

As already mentioned in Chapter 6.3, the mapping of the CF is done by annually adding the mapping of afforestation to the map activity; this is collected from forest management centres around the country. This map has turned out to be inaccurate and overestimates the area of CF. Accordingly, another approach is used to estimate the area of CF. The land classification results on the SSP-NFI and area is calculated by proportions as described in Annex 3 A.3 in Chapter 3 of the 2006 AFOLU Guidelines (IPCC, 2006). Historical area and time series of CF are estimated by the age distribution of the forest in the sample.

The area of the third category, Natural Birch Forest older than 50 years, is estimated directly from the new mapping survey of the NBW (Snorrason, et al., 2016).

The net C-stock change of the biomass of the NBW is estimated by the "The Stock-Difference Method" described in Chapter 2.3.1.1, with Equation 2.8 in the 2006 AFOLU Guidelines (IPCC, 2006). Biomass losses caused by mortality and harvest are therefore included in the net annual removal and reported as Included Elsewhere (IE) in the CRF reporting table. Net C-stock changes in biomass of the Natural

Birch Woodland for the period 2007-2021 are, for the second time, estimated with new data of the above-ground biomass from the second NFI of NBW conducted in 2015-2021 compared to biomass estimates from the first NFI of NBW conducted in 2005-2011. Paired plot estimates on 196 plots were compared and resulted in average net gain of 0.31 t C $ha^{-1}yr^{-1}$ for the 10-year period from 2007 to 2017 with significant changes in stock in the period (P=<0.001). (Snorrason et al. in prep.). These plots were defined as inside the NBW that existed before the 1987-1991. Increases in the biomass stock in this ten-year period can be partially explained by skewed age distribution as shown in Figure 6.5, for median age class 21-40 years. Biomass stock per hectare is increasing with age, meaning NBW will likely become a sink of carbon as long as mean age increases.

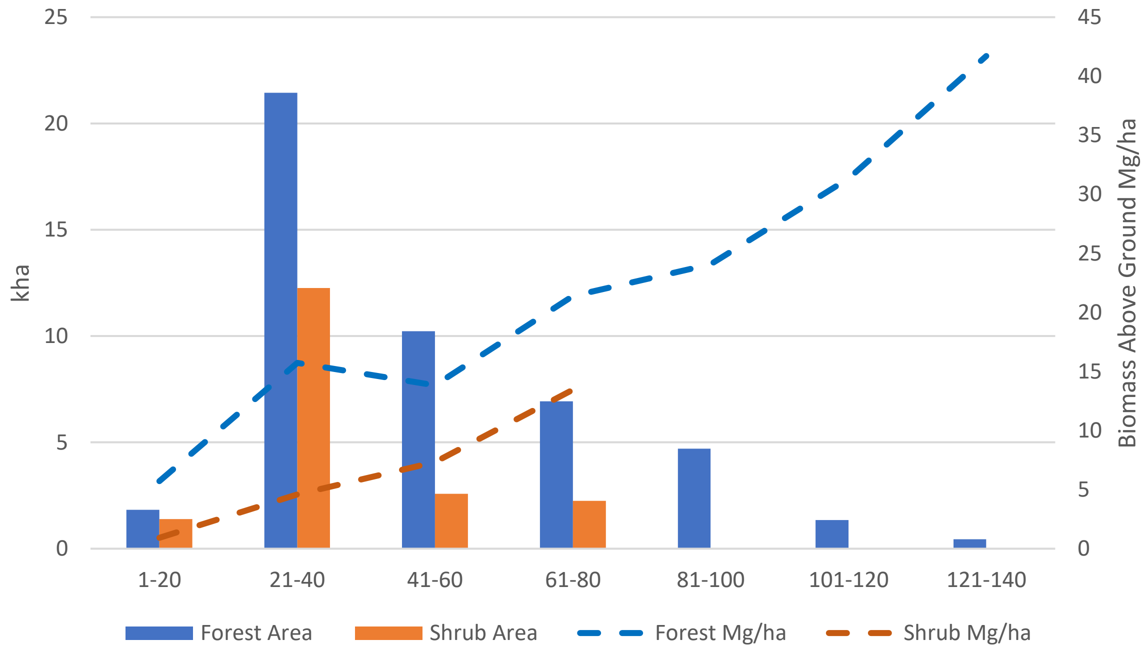


Figure 6.5 Age distribution and the mean stock of biomass aboveground of the Natural Birch Woodland as estimated in the 2015-2021 inventory.

An older analysis of the comparison of the 1987-1988 tree data sampling (Jónsson T. H., 2004) with the data from the 2005-2011 SSPI of NBW was used to estimate the woody above-ground biomass of the NBW in 1987 and 2007, and compare these estimates (Snorrason, Jónsson, & Eggertsson, 2019). These estimates were built on the same newly made biomass equations as used to estimate C-stocks in 2005-2011 (Jónsson & Snorrason, 2018) and the 2015-2021 inventories. C-stocks in above-ground biomass of birch trees and shrubs in NBW was according to this estimate 752 kt C (±88 kt SE, n=272) with an average of 5.45 t C ha^{-1} in 1987. A rough, older estimate of 1,300 kt C from same raw data, with an average of 11 t C ha^{-1} (Sigurdsson & Snorrason, 2000). A new estimate of the C-stocks of the Natural Birch Woodland built on the sample plot inventory of 2005-2011 was 728 kt C (±90 kt SE, n=181), with average of 5.28 t C ha^{-1}. The C-stock in the forest and the shrub part of the Natural Birch Woodland was estimated to 576 kt C with an average of 6.46 t C ha^{-1} and 152 kt C with average of 3.13 t C ha^{-1}, respectively. The net change in the tree biomass C-stock between 1987 and 2007 (the midyear of the 2005-2011 inventory) turned out to be insignificant (Snorrason, Jónsson, & Eggertsson, 2019). Consequently, the net C-stock change in tree biomass is reported as “not occurring” in the period 1990-2006 for the categories of Natural Birch Forest older than 50 years and Natural Birch Shrubland older than 50 years, which is in subcategory of Grassland Remaining Grassland.

Carbon stock gain of the living biomass of trees in CF is based on data from a direct sample plot field measurement of the NFI. The figures provided by IFR are based on the inventory data from 2005-2022. In 2010, the second inventory round of Cultivated Forest started with remeasurement of plots measured in 2005 and of new plots since 2005 on new afforestation areas. Currently the fourth inventory cycle is ongoing, and the oldest plots have been measured four times. In each inventory year, the internal annual growth rate of all living trees is estimated by the differences between current biomass and the biomass five years ago. Trees that died or were cut and removed in the five-year period are not included, so the C-stock gain estimated is not entirely a gross gain.

The biomass stock change estimates of the C-stock of CF are for each year built on five-year sample plot measurements, seen in Table 6.8. The most accurate estimates are for 2007-2020, as they are built on growth measurements of the two nearest years before, the two nearest years after, and of the year of interest (here named mid-value estimates). In these cases, biomass growth rates are equal forward and backward. For 2021, the estimate is forwarded one year respectively, compared to the mid-value for 2020. Estimates for 2005 and 2006 are backward values for two years and one year, respectively, from the mid-value for the field measurements of the period 2005-2009. They are calibrated with the relative difference between the backward value and the mid-value from 2008, which was 1.21. For earlier years (1990-2004), a species-specific growth model that is calibrated towards the inventory results is used to estimate annual stock changes. The forward value for 2021 was calibrated by the average difference between mid-values and forward values of 2008-2020, which was 0.84. In the next submission, a mid-value estimate build on measurement years 2019-2023 will be used instead of the forward calibrated estimate. This is the reason for regular update of the biomass gain CSC of the second last year of the inventory.

Table 6.8 Measurement years used to estimate different annual estimates of biomass stock change in CF.

Mid-value Estimates	Forward Estimates	Backward Estimates	Built on Measurement Years
	2021		2018-2022
2020			2018-2022
2019			2017-2021
2018			2016-2020
2017			2015-2019
2016			2014-2018
2015			2013-2017
2014			2012-2016
2013			2011-2015
2012			2010-2014
2011			2009-2013
2010			2008-2012
2009			2007-2011
2008			2006-2010
2007			2005-2009
		2006	2005-2009
		2005	2005-2009

Estimates of carbon stock losses and dead wood C-stock changes in the Forest land remaining Forest land (FrF) categories of Cultivated Forest are included in the Grassland converted to Forest Land (GcF) category as they are built on annual wood removal statistics and cannot be divided between FrF and Land converted to Forest Land categories. These estimates are further described in Chapter 6.5.2.2 below.

For C-stock changes in litter and mineral soil for Land Converted to Forest Land, country-specific removal factors are used, built on in-country research as explained below. No evidence from research literature exists for Forest Remaining Forest in Iceland, but models and model modifications used in other Nordic countries show an increase in litter and mineral soil pools overall in Forest in general (Dalsgaard, et al., 2016). Changes in the litter C-stock in the categories of Forest Remaining Forest are likely to be sinks rather than sources and are therefore reported as not applicable. As in the Tier 1 approach, they are assumed to be zero as recommended in 2006 AFOLU Guidelines (see page 2.21).

C-stock changes in mineral soil are reported in the same manner as for litter. They are reported as NA and assumed in a Tier 1 approach to be zero, as recommended in AFOLU (see page 2.29).

Direct CO_2-emissions from drained organic soil are estimated by default emission factor of 0.37 t CO_2-C ha^{-1} yr^{-1} for “Forest Land, drained, including shrubland and drained land that may not be classified as forest” (see Table 2.1 in the 2013 Wetlands Supplement (IPCC, 2014)). Newly published research of Eddy Covariance CO_2 estimates on the 23-25-year-old Black Cottonwood plantation on drained peatland in South Iceland unexpectedly resulted in a net sink in DOC of drained organic soil and litter of 0.53 t C ha^{-1} yr^{-1} (Bjarnadóttir B., 2021). This result supports the use of a rather conservative emission factor for drained organic soil on Forest Land as done in this submission.

Areas and emission factors used for carbon stock changes and comparable CO_2 emission/removal calculations for Forest Land Remaining Forest Land subcategories are summarised in Table 6.9.

Table 6.9 Carbon stock changes and related CO_2 emission/removal for Forest Remaining Forest subcategories in 2021.

Land Category	Soil Type/ Biomass	[kha]	EF Type	Tiers	[t C ha^{-1} yr^{-1}]	CSC [kt C]	Emissions/ Removals [kt CO_2]
Natural Birch Forest older than 50 years	Biomass Gain	87.69	OTH	T3	0.31	27.37	-100.34
	Organic Soil	0.08	D	T1	-0.37	-0.03	0.11
Afforestation older than 50 years	Biomass Gain	1.76	OTH	T3	2.89	5.08	-18.63
	Organic Soil	0.10	D	T1	-0.37	-0.04	0.14
Plantations in natural birch forest	Biomass Gain	1.12	OTH	T3	2.28	2.59	-9.50
Total							**-128.22**

6.5.1.3 *Uncertainties and Time-Series Consistency*

As the area estimate of Natural Birch Forest is entirely built on in field mapping, a sample error propagation is not applicable. It can be stated that areal errors of field mapping are lower than systematic sample errors of the SSI NFI of NBW. Half the 95% confidence interval of the area estimate of the Cultivated Forest is in this year submission estimated 5%. The same relative error will be used for the area of NBW in the uncertainty calculation.

The estimate of C-stock in living biomass of the trees is based on results from the field sample plot inventory, which is a major part of the national forest inventory of IFR. The C-stock changes estimated through the forest inventory fit well with earlier measurements in research projects (Snorrason, Sigurðsson, Guðbergsson, Svavarsdóttir, & Jónsson, 2002; Sigurðsson, Elmarsdóttir, Bjarnadóttir, & Magnússon, 2008).

It is possible to estimate uncertainties by calculating statistical error of the sample plot estimates; this is because of the design of the NFI. Currently, error estimates are available for the area of Cultivated Forest as mentioned above (5%), the annual C-stock change in biomass of the Cultivated Forest (10%)

and the Natural Birch Woodland between 2007 and 2017 (32%). Combined uncertainty for Forest Land Remaining Forest Land category is 25.0% in this year's submission.

6.5.1.4 *Category-specific Recalculations*

As described above, the emission/removal estimate for Forest Land has been revised in comparison to previous submissions. Area-dependent sources, such as emissions from drained organic soil, have been changed in relation to changes in the area estimate for each category and each year. The main reason for area changes is inclusion of measurements plots from newly discovered old forest. The C-stock changes in biomass in CF are based on direct stock measurements (Tier 3) as in last year's submission. They were recalculated for 2020 due to new data from NFI measurements in 2022. Estimates of the net gain of biomass of the Natural Birch Forest were totally revised in last year submission; built on new data from the newly conducted NFI (2015-2021) of the Natural Birch Woodland described in Chapter 6.5.1.2 above. The changes in values and relative impact are shown in Table 6.10.

Table 6.10 Comparison between the 2022 Submission and 2023 Submission on CSC in the Forest Remaining Forest category and subcategories for 2020.

Land Category	Soil Type/ Biomass	[kha] 2022 subm.	[kha] 2023 subm.	% Change	[t C ha^{-1}yr^{-1}] 2022 subm.	[t C ha^{-1}yr^{-1}] 2023 subm.	% Change	CSC [kt C] 2022 subm.	CSC [kt C] 2023 subm.	% Change
Natural Birch Forest older than 50 years	Biomass Gain	87.72	87.72	0.0%	0.31	0.31	0.0%	27.37	27.37	0.0%
	Organic Soil	0.08	0.08	0.0%	-0.37	-0.37	0.0%	-0.03	-0.03	0.0%
Afforestation older than 50 years	Biomass Gain	1.68	1.70	1.4%	2.95	3.15	6.7%	4.95	5.36	8.3%
	Organic Soil	0.05	0.10	94%	-0.37	-0.37	0.0%	-0.02	-0.04	94%
Plantations in Natural Birch Forest	Biomass Gain	1.22	1.12	-7.9%	2.12	2.54	19.8%	2.59	2.85	10.2%
Total		**90.62**	**90.55**	**-0.1%**	**0.38**	**0.39**	**2.0%**	**34.86**	**35.52**	**1.9%**

6.5.1.5 *Category-specific Planned Improvements*

Data from NFI are used for the 15th time to estimate main sources of carbon stock changes in the Cultivated Forest where changes in carbon stock are most rapid.

Sampling of soil, litter, and vegetation other than trees, is included as part of NFI. Higher tier estimates of changes in the carbon stock in soil, dead organic matter, and vegetation other than trees are expected in future reporting when data from remeasurement of the permanent sample plot will be available and analysed for C-content.

One can therefore expect gradually improved estimates of carbon stock and carbon stock changes regarding forest and forestry in Iceland. As mentioned before, improvements in forest inventories will also improve uncertainty estimates both on area and stock changes.

6.5.2 Land Converted to Forest Land (CRF 4A2)

6.5.2.1 *Category Description*

Carbon dioxide emissions/removals caused by carbon stock changes in Land Converted to Forest Land are recognised as key source/sink in level (2021) as well as in the 1990-2021 trend.

Four categories are defined as Land Converted to Forest Land:

Grassland Converted to Forest Land (4.A.2.2)

Afforestation 1-50 years old – Cultivated Forest

Afforestation 1-50 years old – Natural Birch Forest

Other Land Converted to Forest Land (4.A.2.5)

Afforestation 1-50 years old – Cultivated Forest

Afforestation 1-50 years old – Natural Birch Forest

In a chronosequence study (named ICEWOODS research project) where afforestation sites of the four most commonly used tree species of different age were compared in eastern and western Iceland, the results showed a significant increase in the soil organic carbon (SOC) on fully vegetated sites with well-developed, deep mineral soil profiles (Bjarnadóttir, 2009). The age of the oldest afforestation sites examined were 50 years so an increase of carbon in mineral soil can be confirmed up to that age. These results did govern the choose of conversion period of 50 years for Land Converted to Forest Land.

Both categories of Cultivated Forest are extracted from the systematic sample plot (SSP) of the NFI of CF. The conversion period for land-use changes to Forest Land is defined as 50 years. As plantations measured on plots are of known age, they move from Land Converted to Forest Land when they reach age over 50 years. Accordingly, the areas of these categories' changes between reporting years. They, too, are updated annually when new plot data are merged into the database.

The categories of Natural Birch Forest are extracted from the new mapping survey of the NBW. All NBF that did not exist before the 1987-1991 survey were afforested in the period 1989-2012. Specifically, they expanded from zero in 1989 to 8.25 kha in 2012. A mean annual area increases of 0.36 kha is interpolated over the 1989-2012 period and extrapolated for 2013-2021.

Conversion from other land-use classes does not occur. Old hayfields are sometimes used for afforestation but are converted from Cropland to Grassland before afforestation.

6.5.2.2 *Methodology*

Area estimation for categories in Land Converted to Forest Land is identical to Forest Land Remaining Forest Land. Former land-use classification is for the CF assessed on the measurement plots in field but for the NBF the mapping ratio between the two former land-use classes (Grassland and Other Land) is used.

Estimation of C-stock changes in biomass for the CF categories are the same as for CF categories in Forest Land Remaining Forest Land. C-stock changes are gradually increasing with annual additions of afforestation area every year and the increasing age of the Cultivated Forest. Skewed age distributions with high ratios of young age classes are accelerating the annual increase of C-stock change in tree biomass, as can be seen in Figure 6.6.

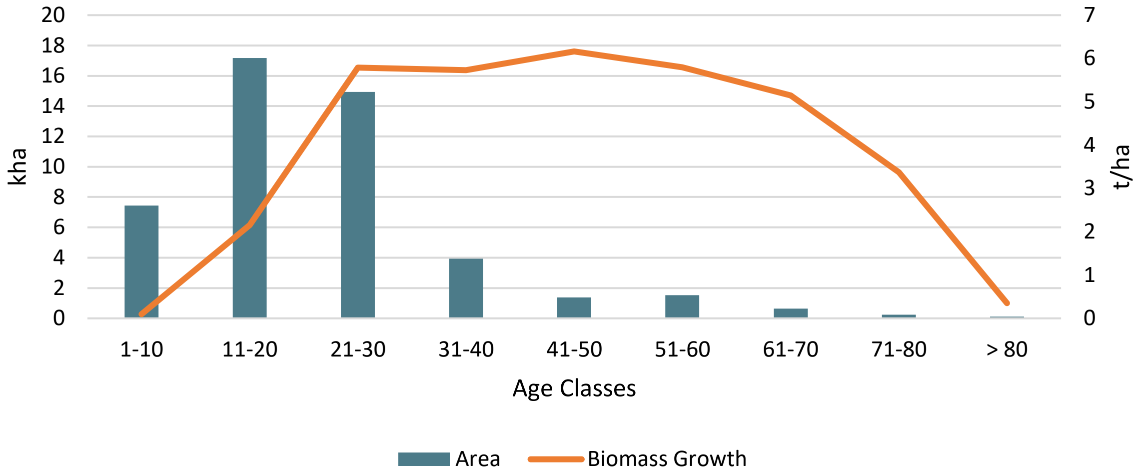


Figure 6.6 Age distribution of Cultivated Forest showing area and current annual biomass growth per hectare of each class.

For the NBF expansion since 1989 a new linear regression between biomass per area unit in trees on measurement plots in Natural Birch Woodland that belongs to the area expansion from 1989 (n=28, P = 0.0002) is used to measure net annual C-stock change (Snorrason et al. in prep.).

In the already mentioned ICEWOODS research project, the carbon stock in vegetation other than trees showed very low increases 50 years after afforestation by the most used tree species, Siberian larch, although the variation inside this period was considerable (Sigurðsson, Magnússon, Elmarsdóttir, & Bjarnadóttir, 2005).

Carbon stock samples of vegetation other than trees are collected on field plots under the field measurement in NFI together with samples of litter and soil. Estimates of carbon stock changes in vegetation other than trees are planned to be available from NFI when sampling plots have been revisited and the samples analysed for C-content.

Annual wood removal is the source of the reporting of C-stock losses using data on activity statistics of commercial round-wood and wood-products production from domestic cuttings in forest (Gunnarsson E., 2010; 2011; 2012; 2013) (Gunnarsson E., 2014; 2015; 2016; Gunnarsson & Brynleifsdóttir, 2017; Gunnarsson & Brynleifsdóttir 2019; Elefsen & Brynleifsdóttir, 2020; Jóhannesdóttir Þ., 2020; Brynleifsdóttir & Jóhannsdóttir, 2021, Snorrason et al. 2022). Most of the cultivated forests in Iceland are relatively young; area weighted average age was only 22 years at the end of 2021, and clear cutting is very rare. As an example, in 2019 only 3 ha of forest were clear cut, 73 ha were commercially thinned, and 87 ha were pre-commercially thinned (Jóhannesdóttir Þ., 2020). Commercial cutting is taking place in some of the older forests and is accounted for as losses in C-stock in living biomass. A very restricted traditional selective cutting is practiced in a few Natural Birch Forests and is managed by the Icelandic Forest Service. As the NBF C-stock change is done by “The Stock-Difference Method,” its wood removal should not be accounted as losses in C-stock, but because the volume of the birch wood from the NBF cannot be distinguished from reported annual birch volume from Cultivated Forest, the birch volume is accounted as C-stock losses in the Cultivated Forest. Estimation of the C-stock losses of biomass has been revised in this year submission in accordance with the biomass losses estimates and calculation done in the Iceland National forestry accounting plan of the Forest Reference Level 2021-2025 (Snorrason, Kjartansson, & Traustason, 2020). To calculate the stem C-stock from commercial reported roundwood C-stock a “left over stem residues” ratio of 30% is used. The ratio between the C-stock of the stem and total C-stock aboveground was calculated from biomass functions of the stem biomass and the total biomass above ground (Snorrason & Einarsson, 2006) for dimensions 22 cm in dbh and 14 m in height of the four main introduced species and 15 cm in $d_{0.5}$ and height 8 m of the native birch, resulting in factor of 0.71. The ratio of the belowground biomass/total biomass used (0.2) is identical to the results of excavation of root systems in Iceland (Snorrason, Sigurðsson, Guðbergsson, Svavarsdóttir, & Jónsson, 2002). Total expansion factor of the commercial roundwood C-stock to the total C-stock of harvested trees is then 2.5 (See calculation steps in Table 6.11).

Estimates of the dead wood stock has also been revised and recalculated using the C-stock of harvested trees as source instead of dead wood measurements on NFI sample plots. The dead wood components of biomass losses due to harvest (Sign H in Table 6.11) are moved to the dead wood C-stock pool. Half-life of the decay of deadwood is set to 30 years with annual decay rate of 0.023 with reference to (Hararuk, Kurz, & Didion, 2020) for annual mean temperature of 5°C and annual precipitation under 1837 mm.

Table 6.11 Calculation of the expansion of commercial roundwood C stock to tree total C-stock.

C-stocks of Various Tree Components	Equation	Sign	Expansion Ratios	% of Total C Stock
Commercial roundwood = 1		A	1.00	40%
Harvested stems and associated stumps above ground	A/(1-0.3)	B	1.43	57%
Leftover of harvested stems including top and stump: 30% of harvested stems	B-A	C	0.43	17%
Above ground stock: Stem/total abg = 0.71	C/0.71	D	2.00	80%
Crown stock	D-C	E	0.57	23%
Below ground 25% of aboveground stock	D*0.25	F	0.50	20%
Root stock and coarse roots > 3 cm 68% of below ground stock	F*0.68	G	0.34	14%
Input to deadwood pool: root stock, stem leftovers	C+G	H	0.77	31%
Crown and other coarse roots combusted or moved into litter pool	E+F-G	J	0.73	29%
Sum all parts			**2.50**	**100%**

All losses from living biomass and the dead wood stock changes are only reported in subcategory Grassland Converted to Forest Land: Afforestation 1-50 years old, which is the biggest category of CF both in area and total C-stock changes. All biomass losses in other CF categories are consequently reported as Included Elsewhere (IE).

As mentioned above, carbon stock samples of litter are collected on field plots under the field measurement in the NFI. Estimates of carbon stock changes in dead organic matter will, as for vegetation other than trees, be available from the NFI data when sampling plots have been revisited and samples analysed.

In the meantime, results from two separate research projects of carbon stock changes are used to estimate carbon stock changes in litter (Snorrason A. , Jónsson, Svavarsdóttir, Guðbergsson, & Traustason, 2000; Snorrason, Sigurðsson, Guðbergsson, Svavarsdóttir, & Jónsson, 2002; Sigurðsson, Magnússon, Elmarsdóttir, & Bjarnadóttir, 2005). In the ICEWOOD research project, carbon removal in the form of woody debris and dead twigs was estimated to 0.083 t C ha^{-1} yr^{-1}. The ICEWOOD project contained chronosequence measurements of Siberian larch, Lodgepole pine, Sitka spruce, and Natural Birch Woodland compared with treeless grazed heathland which is defined as Grassland in IGLUD (Bjarnadóttir, 2009). Snorrason et al. (2000; 2002) found a significant increase in carbon stock of the whole litter layer (woody debris, twigs, and fine litter) for afforestation of plantations and direct seeding of various species (Siberian larch, Downy birch, and Sitka spruce) and ages ranging from 32 to

54 years compared to treeless grazed heathland which is defined as Grassland. The range of the increase was 0.087-1.213 t C ha^{-1} yr^{-1}, with the maximum value in the only thinned forest measured resulting in a rapid increase of the carbon stock of the forest floor. A weighted average for these measurements was 0.199 t C ha^{-1} yr^{-1}. An arithmetic average of the results from these two research projects is used as a factor of annual increase of C-stock in litter, 0.141 t C ha^{-1} yr^{-1}. New research from Southwest Iceland shows higher C accumulation in conifer plantations (0.22 t C ha^{-1} yr^{-1}) compared to native birch plantations (0.049 t C ha^{-1} yr^{-1}) (Owona, 2019), but on average they were at a similar level as the factor used in this submission.

The same research results as mentioned above showed an increase of carbon of soil organic matter (C-SOM) in mineral soils (0.3-0.9 t C ha^{-1} yr^{-1}) due to afforestation (Snorrason, Sigurðsson, Guðbergsson, Svavarsdóttir, & Jónsson, 2002; Sigurðsson, Elmarsdóttir, Bjarnadóttir, & Magnússon, 2008). In the ICEWOODS study, a significant increase in SOC was found in the uppermost 10 cm layer of the soil (Bjarnadóttir, 2009). The average increase in soil carbon detected was 134 g CO_2 m^{-2} yr^{-1} for the three most used tree species. This rate of C-sequestration to soil was applied to estimate changes in soil carbon stocks in mineral soils for Grassland Converted to Forest Land. New research results from Southwest Iceland showed much higher C-stock accumulation in SOC than the factor applied or 309 g CO_2 m^{-2} yr^{-1} for conifer plantations, and 235 g CO_2 m^{-2} yr^{-1} for native birch plantation indicating underestimation of C-stock accumulation in Southwestern Iceland (Owona, 2019).

Research results of carbon stock changes in soil on revegetated and afforested areas show a mean annual increase of soil C-stock between 0.4 to 0.9 t C ha^{-1} yr^{-1} up to 65 years after afforestation. A comparison of a 16-year-old plantation on a poorly vegetated area to a similar open land gave an annual increase of C-SOM of 0.9 t C ha^{-1} (Snorrason, Sigurðsson, Guðbergsson, Svavarsdóttir, & Jónsson, 2002). Newer experimental research results showed removals of 0.4 to 0.65 t C ha^{-1} yr^{-1} of soil seven years after revegetation and afforestation on poorly vegetated land (Arnalds, Orradottir, & Aradottir, 2013). Another chronosequence research project focused on native birch showed a mean annual removal of 0.466 t C ha^{-1} to soil up to 65 years after afforestation in desert areas (Kolka-Jónsson, 2011). All these findings support the use of a country-specific removal factor of the dimension 0.51 t C ha^{-1} yr^{-1}, which is same removal factor as used for revegetation activities.

Drained organic soil reported in the two Forest Land categories results in direct and indirect CO_2, CH_4, and N_2O emissions The methodology and applied emission factors are identical to Forest Land Remaining Forest Land category described in Chapter 6.5.1.2 for Forest Land Remaining Forest Land and in Chapter 6.14 Emissions and Removals from Drainage and Rewetting and Other Management of Organic and Mineral Soils (CRF 4(II)). Area estimations for drained organic soils in Land Converted to Forest Land are identical to Forest Land Remaining Forest Land. The appearance of drained organic soil for the CF is assessed on the measurement plots in field, but for the NBF, the mapping ratio between mineral soil and drained organic soil is used.

Table 6.12 Carbon stock changes and related CO_2 emissions/removals for 6.5.2 Land Converted to Forest Land subcategories in 2021.

Land Category	Soil Type/Biomass	[kha]	EF Type	Tiers	[t C $ha^{-1}yr^{-1}$]	CSC [t C]	Emissions/ Removals [kt CO_2]
Grassland Converted to Forest Land							
Afforestation 1-50 years old – Cultivated Forest	Living Biomass Gains	35.31	OTH	T3	1.85	65.30	-239.43
	Living Biomass Loss		OTH	T3		-1.46	5.35
	Net CSC in Litter	35.31	CS	T2	0.14	4.98	-18.26

Land Category	Soil Type/Biomass	[kha]	EF Type	Tiers	[t C ha-1yr-1]	CSC [t C]	Emissions/ Removals [kt CO_2]
	Mineral Soil	32.13	CS	T2	0.37	11.74	-43.05
	Organic Soil	3.18	D	T1	-0.37	-1.18	4.33
Afforestation Natural Birch Forest 1-50 years old	Living Biomass Gains	6.66	CS	T2	0.19	1.28	-4.69
	Net CSC in Litter	6.66	CS	T2	0.14	0.94	-3.45
	Mineral Soil	5.88	CS	T2	0.37	2.15	-7.88
	Organic Soil	0.77	D	T1	-0.37	-0.29	1.06
Other Land Converted to Forest Land							
Afforestation 1-50 years old	Living Biomass Gains	9.14	OTH	T3	1.22	11.16	-40.92
	Net CSC in Litter	9.14	CS	T2	0.14	1.29	-4.73
	Mineral Soil	8.26	CS	T2	0.51	4.69	-17.20
Afforestation Natural Birch Forest 1-50 years old	Living Biomass Gains	4.82	CS	T2	0.19	0.92	-3.37
	Net CSC in Litter	4.82	CS	T2	0.14	0.68	-2.49
	Mineral Soil	4.82	CS	T2	0.51	2.48	-9.09
Total							**-383.83**

6.5.2.3 *Uncertainties and Time-series Consistency*

Uncertainties in area and biomass C-stock change estimations in Cultivated Forest are 5%; the same as in the Forest Remaining Forest category and described in 6.5.1.3. Biomass C-stock changes in NBW are estimated with a statistical uncertainty of 47%. The country specific removal factor of soil for Grassland Converted to Forest Land has an uncertainty of 23% and for litter removal 24%. Although harvest statistics are rather dependable with uncertainty likely to be below 5%, the biomass loss calculation is built on simplification by using country vice expansion factors. It is therefore an expert judgement to double the harvest statistic uncertainty and use 10% uncertainty for biomass losses. The combined uncertainty for CO_2 emissions of the Land Converted to Forest Land category is 9.89% in this year submission.

6.5.2.4 *Category-specific Recalculations*

As described above, the emission/removal estimate for Forest Land has been revised in comparison to previous submissions. Area-dependent sources, such as removal to litter and soil, and emissions from drained organic soil, have been changed in relation to changes in the area estimate for each category and each year. The C-stock changes in biomass in CF are based on direct stock measurements (Tier 3), as in last year’s submission. They were recalculated for 2020 due to new data from NFI measurements in 2022. Estimates of biomass loss and dead wood CSC are totally revised with more complete estimation of all components of harvested trees. Estimates of the net gain of biomass of the new Natural Birch Forest were revised in last year’s submission according to new data from the newly conducted NFI (2015-2021) of the Natural Birch Woodland already described in Chapter 6.5.1.2 above. The changes in values and relative impacts are shown in Table 6.13.

Table 6.13 Comparison between the 2022 Submission and 2023 Submission on CSC in Land Converted to Forest Land category and subcategories for 2020.

Land Category	Soil type/ biomass	[kha] 2022 subm.	[kha] 2023 subm.	% Change	[t C ha^{-1} yr^{-1}] 2022 subm.	[t C ha^{-1} yr^{-1}] 2023 subm.	% Change	CSC [kt C] 2022 subm.	CSC [kt C] 2023 subm.	% Change
Grassland Converted to Forest Land										
Afforestation 1-50 years old – Cultivated Forest	Living biomass gains	33.88	35.21	3.9%	1.89	1.76	-6.9%	64.09	62.04	-3.2%
	Living biomass loss							-0.74	-1.85	150.0 %
	Dead wood CSC							NO	0.39	
	Net CSC in litter	33.88	35.21	3.9%	0.14	0.14	0.0%	4.78	4.96	3.9%
	Mineral soil	30.71	32.03	4.3%	0.37	0.37	0.0%	11.22	11.70	4.3%
	Organic soil	3.16	3.18	0.6%	-0.37	-0.37	0.0%	-1.17	-1.18	0.6%
Afforestation Natural Birch Forest 1-50 years old	Living Biomass Gains	6.45	6.45	0.0%	0.19	0.19	0.0%	1.24	1.24	0.0%
	Net CSC in litter	6.45	6.45	0.0%	0.14	0.14	0.0%	0.91	0.91	0.0%
	Mineral soil	5.70	5.70	0.0%	0.37	0.37	0.0%	2.08	2.08	0.0%
	Organic soil	0.75	0.75	0.0%	-0.37	-0.37	0.0%	-0.28	-0.28	0.0%
Other Land Converted to Forest Land										
Afforestation 1-50 years old	Living biomass gains	8.26	8.86	7.2%	1.62	1.14	-29.6%	13.38	10.10	-24.5%
	Net CSC in litter	8.26	8.86	7.2%	0.14	0.14	0.0%	1.17	1.25	7.2%
	Mineral soil	8.26	8.86	7.2%	0.51	0.51	0.0%	4.24	4.55	7.2%
Afforestation Natural Birch Forest 1-50 years old	Living biomass gains	4.67	4.67	0.0%	0.19	0.19	0.0%	0.90	0.90	0.0%
	Net CSC in litter	4.67	4.67	0.0%	0.14	0.14	0.0%	0.66	0.66	0.0%
	Mineral soil	4.67	4.67	0.0%	0.51	0.51	0.0%	2.40	2.40	0.0%
Total		**53.26**	**55.19**	**3.6%**	**1.81**	**-8.1%**	**104.87**	**99.87**	**-4.8%**	**1.81**

6.5.2.5 *Category-specific Planned Improvements*

See discussion in Chapter 6.5.1 Forest Land Remaining Forest Land (CRF 4A1)

6.6 Cropland (CRF 4B)

6.6.1 Cropland Remaining Cropland (CRF 4B1)

6.6.1.1 *Category Description*

Carbon dioxide emissions from carbon stock changes in Cropland Remaining Cropland are recognised as key sources/sinks in level (1990 and 2021) as well as in the 1990-2021 trend.

Cropland in Iceland consists mainly of cultivated hayfields (many of which are on drained organic soil), as well as cultivation of potatoes and vegetables. Cultivation of barley is small but increasing part of the category. The new HMI map, introduced as base map for the IGLUD land-use map in the 2019 submission, contains an extended map layer for Cropland. The extension involves adding an area of recently cultivated fields obtained from the IAAC and RI. The IGLUD Cropland map layer was originally digitised from satellite imagery supported by aerial photographs in 2008 by AUI and NLSI in cooperation and revised by AUI in 2009. The total area of Cropland emerging from the 2021 map layer through the IGLUD processing, considering the order of compilation applied, is 147.14 kha compared to 145.20 kha in 2020. This small decrease in map area is not interpreted as decrease in Cropland area but considered to reflect an inaccuracy in mapping indicating a larger area of abandoned Cropland, and as such does not affect the reported Cropland area. The mapped area includes both Cropland in use and abandoned Cropland reported as Grassland. The area reported in CRF as Cropland is 147.14 kha, whereof 65.59 kha is estimated as organic soil. The reported area is a product of the primary time series for new cultivation, drainage of wetland for cultivation, and Cropland abandonment. The time series is prepared by AUI from agricultural statistics, available reports, and unpublished data. The preparation of the time series will be described in detail elsewhere.

The area of Cropland organic soils is estimated through the time series available. In 2021, the submission Cropland Remaining Cropland was reported as two new categories for the first time: "Cropland Active" and "Cropland Inactive (Fallow)." The time series and conversion period applied to these new subcategories are constructed on ratio calculations between the total area of Cropland, Cropland Active, and Cropland Inactive (Fallow) areas emerged from the new map layers through the IGLUD process and then subtracting the ratio of Land Converted to Cropland areas also emerged from the new map layers through the IGLUD process. However, from 2017 Iceland has integrated a payment system based on cultivated areas and that data is now used in IGLUD. The digitisation of cropland has therefore undergone a major transition from being identified with Landsat and SPOT imagery to aerial photography. This data is continuously being improved and future improvements will include better tracking of active and inactive cropland, as well as inactive cropland transitioning to grassland. The two new subcategories are described below.

The geographical identification of Cropland organic soils as appearing on IGLUD maps is still preliminary based on ditches' network density analysis. A special project in IGLUD aiming at identifying cropland organic soils starting in 2011 is now being finalised. The results of this project are expected to improve geographical identification of Cropland organic soils.

No information is available on emissions or removals regarding different cultivation types and subdivisions of areas according to the types of crops cultivated is not attempted.

Cropland Active

This category includes all Cropland that is currently under cultivation, according to RI IAAC. The area reported for this category is the area emerging from the time series and estimated as 102.15 kha whereof 45.00 kha is organic soil (Table 6.15). For the 2022 Submission the total area for Cropland Active has increased *substantially (see* Table 6.14*).* Until 2022 Submission areas of fields of horticulture, green fodder, cereals, oilseeds, lack of crops (see Cropland Other in Table 6.2) were classified as Cropland Inactive. This explains the increase of area for this subcategory and the decrease of areas of inactive Cropland.

Cropland Inactive (Fallow)

This category includes all Cropland currently considered not under cultivation according to RI and IAAC. The area reported for this category is the area emerging from the time series and estimated as 39.72 kha whereof 17.86 kha is organic soil (Table 6.15). Decrease in area for this subcategory is explained in section Cropland Active and in Table 6.14.

Table 6.14 Comparison between the 2022 Submission and 2023 Submission on area in the Cropland remaining Cropland category and subcategories for 2020.

Land Category	Soil Type	[kha] 2022 subm.	[kha] 2023 subm.	% Change
Cropland Active	Mineral Soils	52.22	57.19	9.51%
	Organic Soil	40.82	44.98	10.20%
Total Cropland Active		93.04	102.17	9.82%
Cropland Inactive (Fallow)	Mineral Soils	25.7	21.87	-14.90%
	Organic Soil	21.2	17.86	-15.77%
Total Cropland Inactive (Fallow)		46.9	39.73	-15.29%
Total Cropland Remaining Cropland		**139.94**	**141.9018**	**1.40%**

6.6.1.2 *Methodology*

No perennial woody crops are cultivated in Iceland, and accordingly no changes in living biomass are reported for this category. The AFOLU Guidelines Tier 1 methodology assumes no or insignificant changes in dead organic matter (DOM) in Cropland Remaining Cropland and that no emission/removal factors or activity data are needed. No data is available to estimate the possible changes in DOM in Cropland Remaining Cropland. Most of the land classified as Cropland in Iceland is hayfields with perennial grasses only ploughed or harrowed at decade intervals. A turf layer is formed and depending on the soil horizon definition it can partly be considered as dead organic matter. This is therefore recognised as a possible sink/source.

Annual change of SOC for mineral soil of Cropland Remaining Cropland was estimated for the first time in the 2018 submission, according to Tier 2. The estimate is based on the study of Helgason (1975) on effects of different N fertilisers on soil properties. The experiment site was conducted at four different locations; the one presented here is in Sámsstaðir in Southern Iceland. The site is located on a freely drained, slightly sloping soil, and during the experiment period (1945-1973) the soil had a CEC of 52 m.e/100 g and a BD of 0.7 g/cm^3. The experiment was conducted to estimate the changes in base status and SOM content resulting from long-term use of three different nitrogen fertilisers. Changes were largely restricted to the top of the soil (0-5 cm) and seem to disappear at 10-15 cm soil depth. Compared to the plot where no N was added during the experiment period, the study detected a 15% SOC increase in 0-5 cm soil depth compared to SOC measured in 1945. After reviewing the original paper, the initially calculated factor as 0.17 t C ha^{-1} yr^{-1} was corrected; and from the 2022 Submission, the factor is 0.15 t C ha^{-1} yr^{-1}.

The current data on Cropland is, however, severely limited. As explained above, the C-stock changes factor in mineral soils was estimated only from one study (Helgason 1975). Consequently, aware of the fact that Cropland Inactive is not considered under cultivation, it was decided to use the same EF for CSC in mineral soils for both subcategories, i.e., Cropland Active and Cropland Inactive (Fallow).

There is an ongoing process to correct the issue before 2026.

Changes in SOC of organic soils are calculated according to Tier 1, applying equation 2.3 in the 2013 Wetlands supplement. Total organic soils area of "Cropland Remaining Cropland" is 62.86 kha. These organic soils are estimated to lose 496.56 kt C. Areas and emission factors used for carbon stock changes and comparable CO_2 emissions/removals calculations for Cropland Remaining Cropland subcategories are summarised in Table 6.15.

Table 6.15 Carbon stock changes and related CO_2 emissions/removals for Cropland Remaining Cropland subcategories in 2021.

Land Category	Soil Type/ Biomass	[kha]	EF type	Tiers	[t C ha^{-1} yr^{-1}]	CSC [t C]	Emissions/ Removals [kt CO_2]
Cropland Active	Mineral soil	57.16	CS	T2	0.15	8.72	-31.96
	Organic soil	45.00	D	T1	-7.90	-355.46	1,303.36
Cropland Inactive (Fallow)	Mineral soil	21.86	CS	T2	0.15	3.33	-12.22
	Organic soil	17.86	D	T1	-7.90	-141.10	517.37
Total							**1,776.54**

6.6.1.3 *Uncertainties and Time-series Consistency*

The mapping in IGLUD has been controlled through systematic sampling where land use is recorded at preselected random sampling points. Preliminary results indicate that 91% of land mapped as Cropland is Cropland and that 80% land identified in situ as Cropland is currently mapped as such (AUI unpublished data). A survey of Cropland was conducted in 2010 to control the IGLUD mapping of Cropland and has been ongoing. Randomly selected 500m × 500m squares below (200 m a.s.l. were visited and the mapping of Cropland inside these squares was controlled. Total number of squares visited was 383 with total area of 9,187 ha including mapped Cropland of 998 ha. The results indicated that 216 ha or 21% were not confirmed as Cropland and 38 ha or 4% were identified as Cropland not included in the map layer. Uncertainty in mapped area of Cropland is therefore set as 20%.

The area of drained Cropland is in this year's submission is estimated through preparation of time series of land-use conversion as previously described. The proportion of hayfields on organic soils are estimated as 44% Þorvaldsson (1994), and the time series of Croplands on organic soils has been adjusted to that ratio. In the summer 2011, a survey on Cropland soils was initiated as part of the IGLUD project involving systematic sampling on 50m × 50m grid of randomly selected polygons of the Cropland mapping unit. Preliminary results from this sampling effort show similar ratio of organic soils. The uncertainty for the mapped area of Cropland on organic soil is for this submission assumed to be 20%, or the same as for Cropland total area.

The area of Cropland in use is, as in previous submissions, estimated through the time series of new cultivations and estimated abandonment. There is considerable uncertainty regarding the area of Cropland in use. Preliminary data extracted from the records of land-based payments indicate time series overestimating present area of Cropland in use up to 20-30%.

Uncertainty estimates for C-stock change factors for the period 1990–2021 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). The uncertainty associated to C change factors for Cropland Remaining Cropland in 2021 is 14.71% deriving from combined uncertainty of C-stock change factors in mineral and organic soils. Emissions and removals reported from organic soils are based on default EFs from Table 2.1 in the 2013 Wetlands Supplement to AFOLU (IPCC, 2006). Emissions and removals reported for mineral soils are based on country specific EFs. Country-specific uncertainty is assigned based on expert judgement. The complete uncertainty analysis is shown in Annex 2.

6.6.1.4 *Category-specific QA/QC and Verification*

No specific QA has been performed for this category. The QC procedures are Tier 1 and involve checking the emission calculation processes and data sources during the inventory preparation.

6.6.1.5 *Category-specific Recalculations*

As described in Chapter 6.6.1.2, the C-stock chance factor for mineral soils in Cropland Active and Cropland Inactive (Fallow) was revised and corrected from 0.17 t C $ha^{-1}yr^{-1}$ to 0.15 t C $ha^{-1}yr^{-1}$ for the 2022 Submission. The changed values and relative impact in CSC in mineral soils for these two subcategories are shown in Table 6.16.

Table 6.16 Comparison between the 2022 Submission and 2023 Submission on CSC in the Cropland Remaining Cropland subcategories for 2020.

Land Category	Soil Type/ Biomass	[kha] 2022 subm.	[kha] 2023 subm	% Change	[t C ha^{-1} yr^{-1}] 2022 subm.	[t C ha^{-1} yr^{-1}] 2023 subm.	% Change	CSC [kt C] 2022 subm.	CSC [kt C] 2023 subm.	% Change
Cropland Active	Mineral soil	52.22	57.19	9.5%	0.15	0.15	0.0%	7.96	8.72	+9.5%
	Organic soil	44.82	44.98	10.2%	-7.90	-7.90	0.0%	-322.48	-355.38	+10.2%
Cropland Inactive (Fallow)	Mineral soil	25.70	21.87	-14.9%	0.10	0.15	0.0%	3.92	3.34	-14.9%
	Organic soil	21.20	17.86	-15.8%	-7.90	-7.90	0.0%	-167.48	-141.07	-15.8%
Total		**139.94**	**141.90**	**1.4%**				**-478.09**	**-484.39**	**+1.3%**

6.6.1.6 *Category-specific Planned Improvements*

A new map of cultivated land was prepared by RI for the 2021 Submission. These changes included both recording of total area of harvested land and new and re-cultivated land, as well as spatial identification of this land. This new recording is included in this submission. This change has improved the area estimate for Cropland in use from 2017 and onward. The backward tracking of area of Cropland in use is subject to more uncertainty. This geographically explicit mapping of Cropland enables tracking of land conversion to and from the Cropland category and enables spatially explicit tracking of Cropland in use and abandoned Cropland.

6.6.2 Land Converted to Cropland (CRF 4B2)

6.6.2.1 *Category Description*

Carbon dioxide emissions from carbon stock changes in Land Converted to Cropland are recognised as key sources/sinks in level for 1990 and in trend for 1990-2021.

The category Land Converted to Cropland is in the CRF reported from three sources; Forest Land Converted to Cropland, Grassland Converted to Cropland, and Wetland Converted to Cropland. Only a small area (12 ha) of Forest Land converted to Cropland was detected in 2015 through IFS data sampling. The separation to Land Remaining and Land Converted to Cropland is not presently recognisable in the land-use maps. Grassland and Wetland Converted to Cropland are assumed to be included in the mapping units for Cropland and Cropland on Drained Soils.

Forest Land Converted to Cropland

As described in Chapter 6.5 Forest Land (CRF 4A) , IFR estimates the area of this category as deforestation activity.

Other Land Converted to Cropland

Area of mineral soils of Other Land Converted to Cropland is reported with notation key IE and reported as aggregated values under the subcategory 4.B.2.2 Grassland Converted to Cropland.

6.6.2.2 *Methodology*

Carbon stock changes in living biomass associated with the conversion of land to Cropland are reported. These changes are estimated according to the Tier 1 method and are assumed to occur only at the year of conversion as all biomass is cleared and assumed to be zero immediately after conversion. Changes in living biomass of Land Converted to Cropland are estimated for both losses and gains. Living biomass gains for the area of Grassland Converted to Cropland and Wetlands Converted to Cropland are estimated based on the year before the conversion and assuming biomass after one year of growth using a default emission factor 2.1 t C ha^{-1} yr^{-1} according to Table 5.9 (Temperate (all moisture regimes)) in Chapter 5 – 2006 IPCC Guidelines. Losses are estimated for the area converted in the year. The biomass prior to conversion is estimated from preliminary results from IGLUD field sampling (Guðmundsson, Gísladóttir, Brink, & Óskarsson, 2010). Based on that sampling the average above-ground biomass for Grassland and Wetlands below 200 m height above sea level, including litter and standing dead, was estimated as 1.27 kg C m^{-2}, equivalent to 12.68 t C ha^{-1} yr^{-1}, and 1.80 kg C m^{-2}, equivalent to 17.96 t C ha^{-1} yr^{-1}, respectively. The calculation of the country-specific EF for C-stock change in mineral soils for “Grassland Converted to Cropland” (0.104 t C ha^{-1} yr^{-1}) is based on Equation 2.25 – Annual change in organic carbon stocks in mineral soils – from Chapter 2 – 2006 IPCC Guidelines, where the country-specific SOC_{REF} (9.05 kg C/m^2) was estimated based on the same date set described above, whereas F_{LU}, F_{MG}, and F_I stock change factors are IPCC defaults taken from “Table 5.5 – Relative stock change factors (F_{LU}, F_{MG}, and F_I) (over 20 years) for different management activities on Cropland – from Chapter 5 – 2006 IPCC Guidelines,” with F_{LU} = 0.93 (set aside), F_{MG} = 1.10 (no tillage), F_I = 1.0 (medium input).

Organic soils of Land Converted Cropland are reported in two categories; Forest Land Converted to Cropland, and Wetland Converted to Cropland (Table 6.17). All soils of Wetland Converted to Cropland are assumed to be organic.

The only recent deforestation event of converting Forest Land into Cropland is from 2015 on drained organic soil. For biomass of trees removed, the Tier 2 approach was used and data from a measurement plot of the SSP-NFI of CF situated in this area was used to estimate C-stock removed and instantly oxidised. The same Tier 2 approach was used in KP-LULUCF deforestation when Forest Land is converted to Settlement, it is used for C-stock losses of litter. C-stock emissions from drained organic soil are estimated by the Tier 1 approach with a default emission factor of -7.9 t CO_2-C ha^{-1} yr^{-1} for Cropland, drained in Boreal or Temperate Climate zones from Table 2.1 in the 2013 Wetlands Supplement (IPCC, 2014). On the year after conversion, a Tier 1 default C-stock gain of crop biomass of 5.0 t C ha^{-1} is reported as given for annual Cropland in Table 5.9 in the 2006 AFOLU Guidelines.

With regard to conversion of other land to Cropland, organic soils are reported as “NO,” as Other Land does not contain organic soil. Mineral soils were reported as “IE,” as the emissions are reported under Grassland Converted to Cropland.

Areas and emission factors used for C-stock changes and comparable CO_2 emissions/removals calculations for Land Converted to Cropland subcategories are summarised in Table 6.17.

Table 6.17 Carbon stock changes and related CO_2 emissions/removals for Land Converted to Cropland subcategories in 2021

Land Category	Soil Type/ Biomass	[kha]	EF type	Tiers	[t C ha^{-1} yr^{-1}]	CSC [kt C]	Emissions/ Removals [kt CO_2]
Forest Land Converted to Cropland	Organic Soil	0.01	D,OTH	T1,T3	-7.90	-0.09	0.34
Grassland Converted to Cropland	Mineral Soil	2.53	CS	T2	0.10	0.26	-0.97
	Biomass Gains	2.53	D	T1	0.11	0.27	-0.98
	Biomass Losses	2.53	CS	T2	-0.63	-1.61	5.89
Wetland Converted to Cropland	Organic Soil	2.72	D	T1	-7.90	-21.47	78.72
	Biomass Gains	2.72	D	T1	0.11	0.29	-1.05
	Biomass Losses	2.72	CS	T2	-0.90	-2.45	8.99
Total							**90.95**

6.6.2.3 *Uncertainties and Time-series Consistency*

The official recording of Land Converted to Cropland has been fragmentary until now, but as described above, improvements are on the horizon. The area of land converted is in this year's submission was estimated by applying the same method as in the last submission. The cumulated area of Land Converted to Cropland from 1990-2008 was estimated by Snæbjörnsson et al. (2010). The same rate of new cultivation was assumed to have continued with a fixed ratio of mineral and organic soils. That ratio was adjusted to the estimated proportion of Cropland of wetland origin in a survey conducted during 1990-1993 (Þorvaldsson, 1994). The area of land converted is thus assumed to be highly uncertain on yearly basis.

The area of Forest Land Converted to Cropland is estimated through deforestation reporting of IFR, where each deforestation event is mapped and reported with high spatial accuracy (<4%).

Uncertainty estimates for C-stock change factors for the period 1990-2021 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). The uncertainty associated to C change factors for Land Converted to Cropland in 2021 is 21.12% deriving from combined uncertainty of C-stock change factors in living biomass and in mineral and organic soils. Emissions reported from organic soils are based on the default EF from Table 2.1 in the 2013 Wetlands Supplement to AFOLU (IPCC, 2006). Emissions/removals reported for mineral soils are based on country specific EFs, with uncertainty assigned based on expert judgment. Emissions/removals in C changes in living biomass are based on default EFs from Table 5.9 in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories – Chapter 5 – Cropland (IPCC, 2006). Country-specific uncertainty for living biomass is assigned based on expert judgement. The complete uncertainty analysis is shown in Annex 2.

6.6.2.4 *Category-specific QA/QC and Verification*

No specific QA has been performed for this category. The QC procedures are Tier 1 and involve checking the emission calculation processes and data sources during the inventory preparation.

6.6.2.5 *Category-specific Recalculations*

No specific recalculation was performed for the Land Converted to Cropland subcategories. Changes in values between the 2022 and 2023 Submissions are related to new areas emerged from the new map layers through the IGLUD process. The values relative to C-stock changes in mineral soils, organic soils, living biomass, and dead organic matter for the Grassland Remaining Grassland subcategories for 2022 and 2023 Submissions are shown in Table 6.18.

Table 6.18 Comparison between the 2022 Submission and the 2023 Submission on CSC in Land Converted to Cropland subcategories for 2020.

Land Category	Soil Type/ Biomass	[kha] 2021 subm.	[kha] 2022 subm	% Change	[t C ha^{-1} yr^{-1}] 2021 subm.	[t C ha^{-1} yr^{-1}] 2022 subm.	% Change	CSC [kt C] 2021 subm.	CSC [kt C] 2022 subm.	% Change
Forest Land Converted to Cropland	Organic soil	0.01	0.01	0.0%	-7.90	-7.90	0.0%	-0.09	-0.09	0.0%
Grassland Converted to Cropland	Mineral soil	2.53	2.53	0.0%	0.10	0.10	0.0%	0.26	0.26	0.0%
	Biomass gains	2.53	2.53	0.0%	0.11	0.11	0.0%	0.27	0.27	0.0%
	Biomass losses	2.53	2.53	0.0%	-0.63	-0.63	0.0%	-1.61	-1.61	0.0%
Wetland converted to Cropland	Organic soil	2.72	2.72	0.0%	-7.90	-7.90	0.0%	-21.47	-21.47	0.0%
	Biomass gains	2.72	2.72	0.0%	0.11	0.11	0.0%	0.29	0.29	0.0%
	Biomass losses	2.72	2.72	0.0%	-0.90	-0.90	0.0%	-2.45	-2.45	0.0%
Total		**5.26**	**5.26**	**0.0%**				**-24.98**	**-24.98**	**0.0%**

6.6.2.6 *Category-specific Planned Improvements*

In this submission, as in last year's submission, time series of Cropland categories were used to estimate the area of each category. As described above, improvements in the recording of total area of Cropland in use and new Land Converted to Cropland, as well as the renewing of older hayfields, have been implemented in connection with the reforming of governmental support payments to agriculture. These changes also involve geographically recording all land approved for payments.

Continued field controlling of mapping improved mapping quality, and division of Cropland to soil classes and cultivated crops is planned in coming years. Information on soil carbon of mineral soil under different management and of different origin is important to be able to obtain a better estimate of the effect of land use on the SOC. Establishing reliable estimates of Cropland biomass is also important and is planned.

Considering that the CO_2 emissions from Land Converted to Cropland are recognised as key sources, it is important to move to a higher tier in estimating that factor.

6.7 Grassland (CRF 4C)

Grassland is a diverse category encompassing varying vegetation communities, soil types, erosion forms, and management. This category includes 42 map layers as emerging from the compilation process for the IGLUD land-use map. Of those, 29 originate from the HMI map. From the 2021 Submission, a significant area increase for this category is reported as a large part of Other Land and is added in Grassland. For the 2020 submission, Grassland had an extension of 3,693.65 kha, whereas for this year's submission, this category has extended to 5891.91 kha. The reasons for this change relate to the overlay of the Grazing Areas Map (information regarding the Grazing Areas Map is reported in Chapter 6.1.1) on the IGLUD map which reveals areas of Other Land previously considered unmanaged, where instead grazing activities occur. The Grassland category is divided into 13 subcategories since the 2021 Submission. Three new subcategories are added for this year's submission in Grassland Remaining Grassland: Grazing Areas, Grassland Without Grazing, and Grazing Areas on Other Land. The subcategory Other Grassland was reported until the 2020 submission but has been removed from the CRF inventory navigation tree and replaced with Grassland Without Grazing and Grazing Areas on Other Land. Grazing Areas on Other Land is, however, not classified as Grassland, as Grassland is categorised as land with 20% minimum vascular plant cover. The overlapping of the Grazing areas map on the IGLUD map revealed grazing activities occurring on Other Land areas. Consequently, areas of grazing activities occurring on Other Land are reported as part of Grassland Remaining Grassland.

The Grassland time series reported are prepared from three primary time series of Cropland Converted to Grassland, Wetland Converted to Grassland, and two independent time series for expansion of Birch Shrubland into Other Grassland and Other Land. The time series of Other Grassland was prepared from the Grassland mapping unit when all other mapping units of Grassland subcategories have been considered. The backward tracking of area within that category was done by correcting the area of the year after according to all area within Other Land-use categories considered to originate from Other Grassland, including Forest Land, Cropland, Other Grassland subcategories, Reservoirs, and Settlements. However, in the 2021 Submission, the time series for Other Grassland was disaggregated in two new time series: Grazing Areas and Grassland Without Grazing. This time series disaggregation is obtained by dividing proportionally the time series of the subcategory Other Grassland by the ratio obtained between the total area of Other Grassland, Grazing Areas, and Grassland Without Grazing areas emerged by the overlaying of the Grazing areas map on the IGLUD map.

A similar approach as described above is adopted to obtain time series for Grazing Areas on Other Land. The proportion of areas with grazing activities on Other Land was calculated by multiplying the total area of Other Land by the ratio obtained between the total area of Other Land and areas with grazing activities emerged by the overlaying the Grazing Area's map to the IGLUD map.

6.7.1 Grassland Remaining Grassland (CRF 4C1)

6.7.1.1 *Category Description*

Carbon dioxide emissions from carbon stock changes in "Grassland Remaining Grassland" are recognised as key sources/sinks in level (1990 and 2021) as well as in the 1990-2021 trend.

The time series and conversion period applied enable keeping track of the area of different origin under the category Grassland Remaining Grassland. The subcategories are described below.

Cropland Abandoned for more than 20 Years

This category includes all previous Cropland abandoned for more than 20 years that is still remaining under the Grassland land-use category. The area reported for this category is the area emerging from the time series and estimated as 22.09 kha, whereof 5.45 kha is organic soil.

Natural Birch Shrubland

Natural Birch Shrubland is the part of the Natural Birch Woodland and thus in the NFI, it does not meet the thresholds to be accounted for as Forest Land but is covered with birch (*Betula pubescens*) to a minimum of 10% in vertical cover and at least 0.5 ha in continuous area. Stock changes are estimated by the IFR. The estimates of total area and changes in carbon pools are based on the same methods and data sources as used to estimate the Natural Birch Forest.

Two subcategories of Natural Birch Shrubland are reported as Grassland Remaining Grassland. One is Natural Birch Shrubland – Old, including Shrubland surveyed in the 1987-1991 inventory. As for Natural Birch Forest, the C-stock of Natural Birch Shrubland is estimated to be unchanged between 1987-2006, but new data of the above ground biomass from the second NFI of NBW conducted in 2015-2021 compared to biomass estimates from the first NFI of NBW conducted in 2005-2011 results in new estimates of the mean annual net change of C-stock biomass revised in last year submission (2022). Further information about this revision is to be found in Chapter 6.5.1.2 above. The second subcategory, Grassland Converted to Natural Birch Shrubland, represents Other Grassland Converted to Shrubland. As this change in vegetation cover does not shift the land between categories, this land remains as Grassland. The conversion period is set to 50 years as for Grassland Converted to Natural Birch Forest. Same country specific removal factors as for Natural Birch Forest are used in the case of biomass, dead organic matter and mineral soil and the same IPCC default emission factor for drained organic soil of the category “Forest Land, drained, including Shrubland and drained land that may not be classified as forest” (0.37 t CO_2 – C ha^{-1} yr^{-1} on the basis of the Tier 1 method from the 2013 Wetlands Supplement) (IPCC, 2014). The subcategory Grassland Converted to Natural Birch Shrubland is extracted from the new mapping survey of the Natural Birch Shrubland. Natural Birch Shrubland that did not exist before the 1987-1991 survey expanded into vegetated land defined as Grassland in the period 1989-2012. More exactly, they expanded from zero in 1989 to 2.59 kha in 2012. The mean annual gross area increases of 0.10 kha is interpolated over the 1989-2012 period and extrapolated for 2013-2021.

Grazing Areas

As described in Chapter 6.7, the mapping unit for Grazing Areas obtained by the disaggregation of the subcategory Other Grassland includes all land categorised as Grassland, where vascular plant cover is 20% or more, as compiled from IGLUD. Accordingly, all land within the land-use categories that is ranked higher than Grassland in the hierarchy (Table 6.2) is excluded. The land in this category is, for example, land dominated by grasses, land with grasses and mosses in variable combinations (respecting the 20% minimum vascular plant cover), vegetated lava fields, river plains and costal land, heathlands with dwarf shrubs, shrubs other than birch (*Betula pubescens)*, lichens, and mosses. The area mapped is then adjusted to Other Grassland categories and the time series prepared as described above. The total area reported in this year’s submission for this subcategory is 2642.58 kha.

Grassland Without Grazing

For this subcategory, the description is the same as reported in Grazing Areas. The total area reported in this year’s submission for this subcategory is 326.21 kha.

Revegetated Land Older Than 60 Years

By defining a conversion period of 60 years for revegetation (Other Land Converted to Grassland – Revegetation) which is shorter than the time revegetation has been practiced in Iceland, a small area of revegetated land older than 60 years emerges as this category. The total area in this year’s submission is 8.19 kha. This area is not at present recognised as a separate mapping unit but is assumed to be included in the mapping unit Revegetation before 1990, despite currently limited area of that mapping unit (see Table 6.7). The notation keys for CSC in mineral soils for the period 1990-2015 were updated and changed from NE to NA during the 2020 submission. Current data on Revegetated Land Older than 60 Years is limited. However, it is assumed that changes in C-stock in mineral soils under this subcategory are likely to be sinks rather than sources and is therefore estimated as NA as Tier 1 approach where mineral soils under this subcategory is assumed to be in equilibrium as recommended in 2006 IPCC Guidelines (see page 2.29).

Wetland Drained for More Than 20 Years

This category appears as result of time series and application of default 20 years conversion period for Wetland Converted to Grassland. The time series is prepared from records of excavated ditches (data available until 1993 (Hagstofa Íslands (Statistics Iceland), 1997; Óskarsson, 1998)) and from 1993 to 2008 compiled from personal records of consultant Kristján Bjarndal Jónsson, collected in his local district (personal communication) and upscaled to the whole country. The estimate of the new area drained from 2008 to the present is estimated from preliminary results from re-digitisation of the ditch network. All ditches recognisable on SPOT 4 satellite images were digitised in 2008 in a cooperative effort of the AUI and the NLSI. The new digitisation is based on latest available aerial photographs and comparison to photographs from 2005-2009.

The map layer Grassland on Drained Soils was prepared by SCSI from the AUI/NLSI map of ditches. For the 2020 submission, the previous map layer based on IFD was revised according to the new HMI data and the new Arctic Digital Elevation Model (ADEM). The map layer is still prepared from the 2008 ditch map. The first step, as in previous versions, was to attach a 200 m buffer zone on every ditch. Then, all areas where slope exceeded 10° in the new ADEM or extended below seashore line were excluded. From the remaining area all the areas overlapping with those map layers classified as not potentially drained soils were excluded; this includes the HMI habitat type classes L1, L2, L3, L4, L6, L12, and L13. After these above exclusions, polygons not including a ditch were formed; for example, where the buffer had extended across a river. The next step taken was to remove these polygons. The HMI classes removed are all described as not including organic soils (Ottósson, Sveinsdóttir, & Harðardóttir, 2016). The overlap of the still remaining HMI habitat types not stated to include organic soils was explored. On the basis of that exploration, a habitat type description and expert judgement decision were made for each of the map layers. Through that process, 13 more habitat types (L5.1, L5.2, L5.3, L7.1, L7.2, L7.3, L7.7, L10.1, L10.2, L10.5, L10.7, L10.8, and L14.4) were excluded from the buffer. Of the habitat types remaining, five are not defined as including organic soils. The total overlap of the map layers for these types with the uncut ditch buffer is 59.3 kha. This map layer of Grassland on Drained Soils was used in the IGLUD compilation process and further limited by the map layers ranking higher in compilation order. The Grassland subcategory Drained Grassland is identified in IGLUD on basis of this map.

The time series of drainage ditches is converted to area by applying the ratio of mapped ditches and area estimated as affected. As most of the drained land was drained for at least 20 years, the majority of the drained wetlands are now reported under this category. The total area reported in this year's submission is 253.27 kha and all of it is assumed to be within organic soils. This category is not at present identified as a separate mapping unit, but together with the category Wetland Converted to Grassland is presented as the mapping unit "Grassland on Drained Soils."

Grazing Areas on Other Land

As described in Chapter 6.7, this subcategory is not classified as Grassland. Nevertheless, being subjected to light grazing activities, these areas of the Other Land category become managed, and therefore reported as part of Grassland. The map layers included in the subcategory Grazing Areas on Other Land are areas with vascular vegetation cover <20%.

6.7.1.2 *Methodology*

Carbon stock changes are estimated for all subcategories included under Grassland Remaining Grassland except for Revegetated land older than 60 years, Grazing Areas, and Grassland Without Grazing where available data is limited. However, it is assumed that changes in C-stock in mineral soils under these three subcategories are likely to be sinks rather than sources and are therefore estimated as NA based on the Tier 1 approach.

Carbon stock changes in living biomass of the subcategories Revegetation Older than 60 Years, Wetland Drained for more than 20 Years, Cropland Abandoned for more than 20 Years, Grazing Areas, Grassland Without Grazing, and Grazing Areas on Other Land are also assumed to be sinks and are reported as NA based on the Tier 1 approach.

The changes in carbon stock of the subcategories Natural Birch Shrubland – Old and Natural Birch Shrubland – Recently Expanded into Other Grassland are estimated by IFR based on NFI data. The C-stock changes in living biomass of Natural Birch Shrubland are presented in the NFI by applying Tier 3 methodology of direct estimate of stock changes. As already described in Chapters 6.5.1.2 and 6.7.1.1, the net C-stock changes in biomass of the Natural Birch Woodland for the period 2007-2021 are estimated for the second time with new data of the above-ground biomass from the second NFI of NBW conducted in 2015-2021, compared to biomass estimates from the first NFI of NBW conducted in 2005-2011.

The carbon stock changes in dead organic matter for Natural Birch Shrubland – Recently Expanded into Other Grassland are estimated by the same country-specific EFs as used for Grassland Converted to Forest Land and described above in Chapter 6.5.2.2. The carbon stock changes of dead organic matter in the category Natural Birch Shrubland – Old are, as with Natural Birch Forest older than 50 years, assumed to be a slight sink and reported as NA based on the Tier 1 approach.

The carbon stock changes in the DOC of the mineral soil of subcategory Natural Birch Shrubland – Recently Expanded to Other Grassland are estimated by the same country-specific EFs as used for Grassland Converted to Forest Land and described above in Chapter 6.5.2.2.

Drained organic soils are reported under four subcategories; these are Cropland Abandoned for more than 20 Years, Natural Birch Shrubland – Recently Expanded to Other Grassland, Natural Birch Shrubland – Old, and Wetland Drained for more than 20 Years. In "Natural Birch Shrubland – Recently Expanded to Other Grassland and Natural Birch Shrubland – Old, the emissions are estimated by the same Tier 1 default emission factor as used for drained organic soil on Forest Land, which is 0.37 t C $ha^{-1}yr^{-1}$ for Forest Land, Drained, Including Shrubland and Drained Land that may not be Classified as Forest (see Table 2.1 in the 2013 Wetlands Supplement (IPCC, 2014)). In other categories the emissions are estimated according to Tier 1, and default EF = 5.7 t C $ha^{-1}yr^{-1}$ for Grassland, Drained in Boreal Zone (see Table 2.1 in the 2013 IPCC Wetlands supplement (IPCC, 2014)). The area, C-stock changes and comparable CO_2 emissions are summarised in Table 6.19.

Areas and emission factors used for carbon stock changes and comparable CO_2 emissions and removals calculations for Grassland Remaining Grassland subcategories are summarised in Table 6.20.

Table 6.19. Area of drained soils and estimated C losses and on-site CO_2 emissions of Grassland categories/subcategories in 2021. Subcategories of both "Grassland Remaining Grassland" and "Land Converted to Grassland" are included.

Category/Subcategory	Drained "Organic" Soils [kha]	Carbon Stock Changes in Organic Soils [kt C]	Emission [kt CO_2]
Grassland Remaining Grassland	**259.24**	**-1,474.88**	**5,407.90**
Cropland Abandoned for more than 20 Years	5.45	-31.04	113.81
Natural Birch Shrubland (NBS) – Old	0.26	-0.09	0.35
NBS – Recently Expanded into Other Grassland	0.27	-0.10	0.36
Wetland Drained for more than 20 Years	253.27	-1,443.65	5,293.39
Land Converted to Grassland	**22.48**	**-128.13**	**469.79**
Cropland Converted to Grassland	2.43	-13.88	50.88
Wetland Converted to Grassland	20.04	-114.25	418.92
Total	**281.72**	**-1,603.01**	**5,877.70**

Table 6.20 Carbon stock changes and related CO_2 emissions/removals for the Grassland Remaining Grassland subcategories in 2021

Land Category	Soil Type/ Biomass	[kha]	EF Type	Tiers	[t C ha^{-1} yr^{-1}]	CSC [kt C]	Emissions/ Removals [kt CO_2]
Cropland Abandoned for more than 20 Years	Organic Soil	5.45	D	T1	-5.70	-31.04	113.81
Natural Birch Shrubland – Recently Expanded into Other Grassland	Mineral Soil	2.80	CS	T2	0.37	1.02	-3.75
	Organic Soil	0.27	D	T1	-0.37	-0.10	0.36
	Biomass Gains	3.07	CS	T2	0.19	0.59	-2.16
	Dead Organic Matter	3.07	CS	T2	0.14	0.43	-1.59
Natural Birch Shrubland – Old	Organic Soil	0.26	D	T1	-0.37	-0.09	0.35
	Biomass Gains	49.97	OTH	T3	0.07	3.64	-13.35
Wetland Drained for more than 20 Years	Organic Soil	253.27	D	T1	-5.70	-1,443.65	5,293.39
Total							**5,387.06**

6.7.1.3 *Uncertainties and Time-series Consistency*

The area and changes in biomass of Natural Birch Shrubland are estimated by IFR through NFI and subjected to the same uncertainty as other estimates obtained through NFI.

The size of the drained area is in this year's submission estimated from IGLUD as described above. Improvements in ascertaining the extent of drained organic soils in total and within different land-use categories and soil types has been a priority in the IGLUD data sampling. In summer 2011, a drainage control project aimed at improving the geographical identification of drained organic soils was initiated within the IGLUD. This project involved the testing of plant index and soil characters as proxies to evaluate the effectiveness of drainage. The results of that survey have not yet been fully analysed. Preliminary results indicate that of 966 points included within the area estimated as drained, 492 (51%) are confirmed as drained and 311 (32%) as not drained, with the remaining 163 (17%) points needing further analyses or determined as uncertain. (AUI unpublished results). Of the 210 points outside the area estimated drained, 42 (20%) are confirmed as drained and 102 (49%) as not drained, with the remaining 66 (31%) points needing further analyses or determined as uncertain. The uncertainty is thus higher in the spatial identification of the drained land than in the total area.

Many factors can potentially contribute to the uncertainty of the size of drained area. Among these is the quality of the ditch map. Ongoing surveying on the type of soil drained has already revealed that some features mapped as ditches are not ditches, but are actually tracks or fences. During the summer of 2010, the reliability of the ditch map was evaluated. Randomly selected squares of 500 m x 500 m were controlled for ditches. Preliminary results show that 91% of the ditches mapped were confirmed and 5% of ditches in the squares were not already mapped.

The starting width of the buffer zone, applied on the mapped ditches, is set to be 200 m to each side as determined from an analysis of the Farmland Database (Gísladóttir, Metúsalemsson, & Óskarsson, 2007). The map layers used to exclude certain types of land cover from the buffer zone to estimate area of drained land have their own uncertainty, which is transferred to the estimate of the area of drained land.

As described in Chapter 6.7.1.2, changes in C-stock of living biomass and dead organic matter of the category Grassland Remaining Grassland are reported as NA (Tier 1 approach) except for living biomass of Natural Birch Shrubland. The CO_2 emissions from mineral soils of Grassland Remaining Grassland are also reported as NA based on the Tier 1 approach. Uncertainty estimates for C-stock change factors for the period 1990-2021 have been assessed following Approach 1 of the 2006 IPCC Guidelines (IPCC, 2006). Uncertainty associated with C change factors for Grassland Remaining Grassland in 2021 is 49.63%, deriving from the combined uncertainty of C-stock change factors in living biomass and in mineral and organic soils. Emissions and removals reported from organic soils are based on default EFs from Table 2.1 in 2013 Wetlands Supplement to AFOLU (IPCC, 2006). Emissions and removals reported for mineral soils are based on country-specific EFs with uncertainty assigned based on expert judgment. The complete uncertainty analysis is shown in Annex 2.

6.7.1.4 *Category-specific QA/QC and Verification*

No specific QA has been performed for this category. The QC procedure is T1; involving checking the emission calculation processes and data sources during the inventory preparation.

6.7.1.5 *Category-specific Recalculations*

No specific recalculation was performed for Grassland Remaining Grassland subcategories. Changes in values between the 2022 and 2023 Submissions are related to new areas emerged from the new map layers through the IGLUD process. The values relative to C-stock changes in mineral soils, organic soils, living biomass, and dead organic matter for Grassland Remaining Grassland subcategories for the 2022 and 2023 Submissions are shown in Table 6.21.

Table 6.21 Comparison between the 2022 and 2023 Submissions on CSC in Grassland Remaining Grassland subcategories for 2020.

Land Category	Soil Type/ Biomass	[kha] 2022 subm.	[kha] 2023 subm	% Change	[t C ha^{-1} yr^{-1}] 2022 subm.	[t C ha^{-1} yr^{-1}] 2023 subm.	% Change	CSC [kt C] 2022 subm.	CSC [kt C] 2023 subm.	% Change
Cropland Abandoned for more than 20 Years	Organic Soil	5.60	5.32	-10.3%	-5.70	-5.70	0.0%	-31.90	-30.35	-4.9%
Natural Birch Shrubland –	Mineral Soil	2.71	2.71	0.0%	0.37	0.37	0.0%	0.99	0.99	0.0%

Land Category	Soil Type/ Biomass	[kha] 2022 subm.	[kha] 2023 subm	% Change	[t C ha^{-1} yr^{-1}] 2022 subm.	[t C ha^{-1} yr^{-1}] 2023 subm.	% Change	CSC [kt C] 2022 subm.	CSC [kt C] 2023 subm.	% Change
Recently Expanded into Other Grassland	Organic Soil	0.25	0.26	0.0%	-0.37	-0.37	0.0%	-0.10	-0.10	0.0%
	Biomass Gains	2.97	2.97	0.0%	0.21	0.19	-10.6%	0.57	0.57	0.0%
	Dead OM	2.97	2.97	0.0%	0.14	0.14	0.0%	0.42	0.42	0.0%
Natural Birch Shrubland – Old	Organic Soil	0.26	0.26	0.0%	-0.37	-0.37	0.0%	-0.09	-0.09	0.0%
	Biomass Gains	49.97	49.97	0.0%	0.07	0.07	0.0%	3.64	3.64	0,1%
Wetland Drained for more than 20 Years	Organic Soil	253.25	252.20	0.0%	-5.70	-5.70	0.0%	-1,443.51	-1,437.55	-0.4%
Total		**317.97**	**316.66**	**-0.4%**				**-1,469.99**	**-1,462.46**	**-0.5%**

6.7.1.6 *Category-specific Planned Improvements*

The total emissions related to drainage of Grassland soils are a principal component in the net emissions reported for the land-use category. The total emissions reported from drained soils of Grassland including Grassland Remaining Grassland, Land Converted to Grassland, and N_2O emissions of drained land within these categories is 6524.40 kt CO_2e for this submission, making this component by far the largest identified anthropogenic source of GHG in Iceland. Further revision of the area of drained land is pending, as preparation of a new map of ditches is in progress. The estimation of this component is still based on T1 methodology and basically no disaggregation of the drainage area. Improvements in emission estimates for the Grassland and other categories to adopt higher tiers is planned in future submissions.

The results of the drainage control project are still to be fully analysed and are expected to improve the area estimate of drained land and the effectiveness of drainage.

New map of ditches was released in 2021 and provide new estimates of changes in ditch network. Mapping of ditches is ongoing, now with emphasis on when they were dug. With a time series for ditches, it will be possible to identify and create better and more reliable data on grassland on drained soils. Data for dividing the drained area according to soil type drained has been collected for a part of the country. Continuation of that sampling is planned, and the results used to subdivide the drained area into soil types.

The T1 EF for C-stock changes of drained soils is comparable to newly published Icelandic data (Guðmundsson & Óskarsson, 2014). Considering the amount of emissions from this category, it is important to move to higher tier levels in general and define relevant disaggregation to land-use categories and management regimes. That disaggregation is one of the main objectives of the IGLUD project and it is expected that analyses of the data already sampled will enable some steps in that direction.

The largest subcategory of Grassland, Other Grassland, is, since the 2020 submission, reported as two units: Grazing Areas and Grassland Without Grazing. Severely degraded soils are widespread in Iceland as a result of extensive erosion over a long period of time. Changes in mineral soil carbon stocks of degrading land is a potentially large source of carbon emissions. The importance of this source must be emphasised since Icelandic mineral grassland soils are almost always andosols with a high carbon content (Arnalds, Óskarsson, Gísladóttir, & Grétarsson, 2009; Arnalds & Óskarsson, 2009). Subdivision of those categories according to vegetation coverage and soil erosion is pending. The processing of the IGLUD field data is expected to provide information connecting degradation severity, grazing intensity, and C-stocks. This data is also expected to enable the relative division of the area degradation and grazing intensity categories, including areas where vegetation is improving and degradation decreasing (Magnússon, et al., 2006). Processing of the IGLUD dataset is expected to give results in the next few years.

In a recent report (Guðmundsson J. , 2016), potential emission and removal of greenhouse gasses from the category were identified and their range estimated. This report shows the need to obtain better information on this land-use category and its soils.

One component pinpointed in this report is the effect of soil thickening on C-sequestration. The aeolian deposition of sand and dust on soil of Grassland, as well as other land-use categories, causes soil thickening. On vegetated land, this soil addition will accumulate carbon. The deposition rate of aeolian materials of different regions in Iceland has been estimated by Arnalds (2010). The rate and variability of C-sequestration following this deposition is still not estimated. This potential carbon sink needs to be quantified and its variability mapped. The potential of the soil samples, collected in the IGLUD survey, to estimate this component will be explored.

6.7.2 Land Converted to Grassland (CRF 4C2)

6.7.2.1 *Category Description*

Carbon dioxide emissions from Carbon stock changes in Land Converted to Grassland are recognised as key sources/sinks in level (1990) as well as in the 1990-2021 trend.

Land Converted to Grassland is reported for three main categories: Cropland Converted to Grassland, Wetland Converted to Grassland, and Other Land Converted to Grassland. Conversions of Forest Land and Settlements to Grassland are reported as not occurring.

Cropland Converted to Grassland

The area reported is as emerging from the time series available for Cropland using the default conversion period of 20 years. The category is at present not identified as a specific mapping unit but is included in both the mineral and organic soil part of the Cropland mapping unit. The total area reported for this category is 5.82 kha with 2.43 kha on organic soil (Table 6.22).

Wetland Converted to Grassland

The area included under this subcategory includes the area drained for the last 20 years prior to the inventory year. The total area reported for this subcategory is 20.04 kha and the whole area is assumed to be on organic soil (Table 6.22). The area estimate is based on available time series and applies 20 years as the conversion period. The time series for this category is revised according to new estimate of total area of drained grassland soils.

Other Land Converted to Grassland

This category is divided to four subcategories; three of which originate from revegetation activities: Revegetation Before 1990, Revegetation Since 1990 – (areas) Protected from Grazing, and Revegetation since 1990 – (areas with) Limited Grazing Allowed. The fourth subcategory, Other Land Converted to Natural Birch Shrubland, originates from the ongoing expansion of Birch Shrubland noted in the NFI. The total area reported for these subcategories is shown in Table 6.22.

Revegetation

The revegetation activity where no afforestation is included is reported as Other Land Converted to Grassland. The original vegetation cover is less than 20% for the vast majority of the land before revegetation (Thorsson et al., in prep.). Accordingly, this land does not meet the definition of Grasslands and is all classified as Other Land being converted to Grassland." The SCSI now keeps a National Inventory on Revegetation Areas based on best available data, the NIRA database. Large efforts have been put into improving the NIRA database and all revegetation areas are now expected to be available in draft form by the end of 2022, and formally available for the 2024 submission and it will contain all known revegetation activities since 1907. Preparations are being made to link all data in NIRA to the SCSI's GIS. The geospatial information will have varying accuracy depending on the activity year and available information, but accuracy is constantly being improved; for example, by using GPS tracking in real time. The NIRA database is currently being expanded to include all data from ongoing inventorying field surveys starting in 2007. A conversion period of 60 years has currently been defined on basis of the NIRA database.

Other Land Converted to Natural Birch Shrubland

This subcategory is extracted from the new mapping survey of the NBW as Natural Birch Shrubland that did not exist before 1987-1991. The increment ranges from zero in 1989 to 2.50 kha in 2012. The mean annual area increases of 0.11 kha is interpolated over the 1989-2012 period and extrapolated for 2013-2021. The conversion period is set to 50 years for Other Land Converted to Natural Birch Forest, with the same in-country removal factors for biomass, dead organic matter, and mineral soil.

6.7.2.2 *Methodology*

Carbon stock changes in living biomass are estimated for all categories of Land Converted to Grassland where conversion is reported to occur. Conversions of Forest Land and Settlements to Grassland are reported as not occurring. Changes in living biomass in the category Wetland Converted to Grassland are reported as not occurring; vegetation is mostly undisturbed as no ploughing or harrowing takes place. Changes in living biomass in the category Cropland Converted to Grassland are estimated on basis of default Cropland biomass (Table 5.9. in 2006 IPCC guidelines) and average C stock in living biomass, litter, and standing dead biomass of Grassland as estimated from IGLUD field sampling (see Chapter 6.6.2.2).

The stock changes in living biomass of the subcategories of Other Land Converted to Grassland representing revegetation activities reflect the increase in vegetation coverage and biomass achieved through those activities. The changes in biomass are estimated as relative contribution (10%) of total C-stock increase (Aradóttir, Svavarsdóttir, Jónsson, & Guðbergsson, 2000). The total C-stock increase is estimated on basis of the NIRA sampling. The increase of the carbon stock in living biomass on revegetated land is estimated for four subcategories: Revegetation before 1990, Revegetation since 1990 – Protected from Grazing, and Revegetation Since 1990 – Limited Grazing Allowed, and Other Land Converted to Natural Birch Shrubland (Table 6.22).

Changes in carbon stock of dead organic matter are estimated for the category Other Land Converted to Natural Birch Shrubland by the IFR in the NFI.

The changes in dead organic matter are included in C-stock changes in living biomass for the category Cropland Converted to Grassland, as stated above (Chapter 6.6.2.2). The changes in dead organic matter are also included in living biomass of the three revegetation subcategories under Other Land Converted to Grassland (Aradóttir, Svavarsdóttir, Jónsson, & Guðbergsson, 2000).

Changes in dead organic matter of Wetland Converted to Grassland are reported as NA as it is assumed that changes in C-stock in this C pool is likely to be sinks rather than source based on the Tier 1 approach.

The conversion period for Other Land Converted to Natural Birch Shrubland is set to 50 years, as it is for Other Land Converted to Natural Birch Forest, and with the same in-country removal factors for biomass, dead organic matter, and mineral soil (see Chapter 6.5.2.2 above).

The changes reported in mineral soil of Cropland Converted to Grassland are assumed to be reversed changes estimated for Grassland Converted to Cropland (Chapter 6.6.2.2). No mineral soil is included as Wetland Converted to Grassland.

For the three subcategories of Other Land Converted to Grassland representing revegetation, the changes in carbon stock in mineral soils are estimated by applying Tier 2 and the CS emission (removal) factor. C-stock changes in mineral soils of Other Land Converted to Natural Birch Shrubland are estimated by applying the same CS emission (removal) factor as used for revegetation categories (Table 6.22).

Organic soils are reported under two subcategories: Cropland Converted to Grassland, and Wetland Converted to Grassland. In all categories, the emission is estimated according to Tier 1, and the default EF = 5.70 t C ha^{-1} yr^{-1}.

Areas and emission factors used for carbon stock changes and comparable CO_2 emissions and removal calculations for the Land Converted to Grassland subcategories are summarised in Table 6.22.

Table 6.22 Carbon stock changes and related CO_2 emissions/removals for Land Converted to Grassland subcategories in 2021.

Land Category	Soil Type/ Biomass	[kha]	EF Type	Tiers	[t C ha^{-1} yr^{-1}]	CSC [kt C]	Emissions/ Removals [kt CO_2]
Cropland Converted to Grassland							
	Mineral Soil	3.39	CS	T2	-0.10	-0.35	1.29
	Organic Soil	2.43	D	T1	-5.70	-13.88	50.88
	Biomass Gains	5.82	CS	T2	0.53	3.08	-11.29
Wetlands Converted to Grassland							
	Organic Soil	20.04	D	T1	-5.70	-114.25	418.92
***Other Land* Converted to Grassland**							
Revegetation before 1990	Mineral Soil	157.17	CS	T2	0.51	80.63	-295.63
	Biomass Gains	157.17	CS	T2	0.06	8.96	-32.85
Other Land Converted to Natural Birch Shrubland	Mineral Soil	3.47	CS	T2	0.51	1.78	-6.53
	Biomass Gains	3.47	CS	T2	0.19	0.67	-2.44
	Dead Org. M.	3.47	CS	T2	0.14	0.49	-1.80
Revegetation since 1990 – Protected from Grazing	Mineral Soil	117.45	CS	T2	0.51	60.25	-220.93
	Biomass Gains	117.45	CS	T2	0.06	6.69	-24.55
Revegetation since 1990 – Limited Controlled Grazing Allowed	Mineral Soil	39.15	CS	T2	0.51	20.08	-73.64
	Biomass Gains	39.15	CS	T2	0.06	2.23	-8.18
Total							**-206.76**

6.7.2.3 *Uncertainties and Time-series Consistency*

The area uncertainty of the categories reported is estimated at 20%, except for Revegetation. Uncertainties in the subcategories of Other Land Converted to Grassland involving revegetation have been estimated using data from the KP LULUCF sampling program. It indicates that revegetation areas prior to 2008 are overestimated by a factor of 1.3 (30%), but after 2008 this error is assumed to be 10% due to GPS real-time tracking of activities. Errors in area prior to 1990 remain to be estimated. The NIRA database adjusts automatically for these errors. The area of Other Land Converted to Natural Birch Shrubland is estimated through the IFR effort of remapping birch woodlands and is subjected to same uncertainty as other categories in that mapping effort.

The changes in living biomass of Land Converted to Grassland is estimated for Cropland and Other Land and their subcategories. The C-stock changes in living biomass for the conversion of Cropland to Grassland is based on factors estimated with standard error of 20-30%. The C-stock changes in living biomass in the subcategories of Other Land Converted to Grassland is for the revegetation subcategories based on the estimate of total C-stock changes in all categories and the estimate of average proportion of vegetation in those changes being 10%.

Uncertainty estimates for C-stock change factors for the period 1990-2021 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). Uncertainty associated with C-stock change factors for Land Converted to Grassland is 20.48%, deriving from combined uncertainty of C-stock change factors in living biomass and in mineral and organic soils. Emissions and removals reported from organic soils are based on default EFs from Table 2.1 in 2013 Wetlands Supplement to AFOLU (IPCC, 2006). Emissions and removals reported for mineral soils are based on country-specific EFs with uncertainty assigned based on expert judgment. The complete uncertainty analysis is shown in Annex 2.

6.7.2.4 *Category-specific QA/QC and Verification*

No specific QA has been performed for this category. QC procedures are T1; involving checking the emission calculation processes and data sources during the inventory preparation, except for revegetation (Other Land Converted to Grassland), which is T2.

6.7.2.5 *Category-specific Recalculations*

No specific recalculation was performed for the Land Converted to Grassland subcategories. Changes in values between the 2022 and 2023 Submissions are related to new areas emerged from the new map layers through the IGLUD process. The values relative to C-stock changes in mineral soils, organic soils, living biomass, and dead organic matter for the Land Converted to Grasslands subcategories for the 2022 and 2023 Submissions are shown in Table 6.23.

Table 6.23 Comparison between the 2022 and 2023 Submissions on CSC in the Land Converted to Grassland subcategories for 2020.

Land Category	Soil Type/ Biomass	[kha] 2022 subm.	[kha] 2023 subm	% Change	[t C ha^{-1} yr^{-1}] 2022 subm.	[t C ha^{-1} yr^{-1}] 2023 subm.	% Change	CSC [kt C] 2022 subm.	CSC [kt C] 2023 subm.	% Change
Cropland Converted to Grassland	Mineral soil	4.15	3.39	-18.4%	-0.10	-0.10	0.0%	-0.43	-0.35	-18.4%
	Organic soil	2.98	2.43	-18.4%	-5.70	-5.70	0.0%	-16.99	-13.87	-18.4%
	Biomass gains	7.13	5.82	-18.4%	0.53	0.53	0.0%	3.77	3.08	-18.4%

Land Category	Soil Type/ Biomass	[kha] 2022 subm.	[kha] 2023 subm	% Change	[t C ha^{-1} yr^{-1}] 2022 subm.	[t C ha^{-1} yr^{-1}] 2023 subm.	% Change	CSC [kt C] 2022 subm.	CSC [kt C] 2023 subm.	% Change
Wetlands Converted to Grassland	Organic soil	20.75	20.75	0.0%	-5.70	-5.70	0.0%	-118.29	-118.29	0.0%
Other Land Converted to Grassland										
Revegetation before 1990	Mineral soil	158.33	158.33	0.0%	0.51	0.51	0.0%	81.22	81.22	0.0%
	Biomass gains	158.33	158.33	0.0%	0.06	0.06	0.0%	9.02	9.02	0.0%
Other Land Converted to Natural Birch Shrubland	Mineral soil	3.36	3.36	0.0%	0.51	0.51	0.0%	1.73	1.73	0.0%
	Biomass gains	3.36	3.36	0.0%	0.19	0.19	0.0%	0.64	0.64	0.0%
	Dead OM	3.36	3.36	0.0%	0.14	0.14	0.0%	0.47	0.47	0.0%
Revegetation since 1990 – Protected from Grazing	Mineral soil	103.20	111.92	8.4%	0.51	0.51	0.0%	52.94	57.41	8.4%
	Biomass gains	103.20	111.92	8.4%	0.06	0.06	0.0%	5.88	6.38	8.4%
Revegetation since 1990 – Limited Controlled Grazing Allowed	Mineral soil	46.02	37.31	-18.9%	0.51	0.51	0.0%	23.61	19.14	-18.9%
	Biomass gains	46.02	37.31	-18.9%	0.06	0.06	0.0%	2.62	2.13	-18.9%
Total		**338.80**	**337.49**	**-0.4%**				**46.21**	**48.72**	**5.4%**

6.7.2.6 *Category-specific Planned Improvements*

The planned improvements described above for drained areas of Grassland Remaining Grassland also applies for the drained area of Land Converted to Grassland. The creation of a new map of the drainage network was finished in 2021. It provides a better and improved accuracy of the estimate of Land Converted to Grassland on drained soils.

Maps of Cropland in use have been improved, along with reformation of agricultural support payments. These improvements enable better tracking of abandoned Cropland, such as Cropland Converted to Grassland or other categories.

Improvements in sequestration rate estimates and recordings for other revegetation areas are aimed at establishing a transparent, verifiable inventory of carbon stock changes that are accountable according to the Kyoto Protocol. The corresponding emissions and removal factors, based on the ongoing NIRA update, have been delayed and are now expected to be finished 2022.

When implemented, these improvements will provide more accurate area and removal factor estimates for revegetation, subdivided according to management regime, regions, and age.

6.8 Wetlands (CRF 4D)

6.8.1 Wetlands Remaining Wetlands (CRF 4D1)

6.8.1.1 *Category Description*

Carbon dioxide emissions from Carbon stock changes in Wetlands Remaining Wetlands are recognised as key sources/sinks in level (1990 and 2021) as well as in the 1990-2021 trend.

Wetlands is the third largest land-use category identified by present land-use mapping, as described above. The total area of the Wetlands category is reported as 896.31 kha. Wetlands include lakes and rivers as unmanaged land and reservoirs and intact and rewetted mires and fens as managed land. The mires and fens are included in rangeland grazed by livestock and are grazed to some extent and accordingly included as managed land.

The subdivision of Wetlands Remaining Wetlands is described below. Contrary to Other Land-use categories (except Other Land), this category contains land defined as unmanaged; for example, lakes and rivers which are, according to AFOLU Guidelines, included as unmanaged land. It can be argued that some lakes and rivers should be included as managed land as they are impacted in the sense that their emissions of GHG are affected. Examples of potential impacts on lakes and rivers are urban, agricultural, and industrial inputs of nutrients and organic matter. Channelling of rivers and other alterations of their paths can also potentially affect their GHG profile. There is no attempt made to separate potentially managed lakes and rivers from those that are unmanaged, except for lakes used as reservoirs. For the category Wetland Remaining Wetland, four subcategories are reported: Mires Converted to Reservoirs, Lakes and Rivers, Lakes and Rivers Converted to Reservoirs, and Intact Mires. Mires Converted to Reservoirs is reported as a subcategory under 4.D.1.2 – Flooded Land Remaining Flooded Land, although the land was not flooded before it was inundated by the reservoir. The other categories are reported under 4.D.1.3 – Other Wetlands Remaining Other Wetlands.

Mires Converted to Reservoirs

This subcategory is reported under Flooded Land Remaining Flooded Land. The land included here is inundated land with high soil organic carbon content (high SOC), or higher than 50 kg C m^{-2}. This category includes land with organic soil or complexes of peatland and upland soils. The high SOC soils are, in most cases, organic soils of mires and fens or wetlands previously converted to Grassland or Cropland through drainage. The total area of this category reported is 0.99 kha, as in last year's submission (Table 6.24). The area estimate is based on reservoir mapping and available data on inundated land. As the CRF table does not allow land-use changes within the main category, inundated mires should not be reported as Other Wetlands Converted to Flooded Land. Including them as remaining mires was discussed, but because the inundation changes the functionality of mires through vegetation die-off, it was decided to categorise them as Flooded Land Remaining Flooded Land in order to estimate GHG emissions.

Lakes and Rivers

As described in Chapter 6.2, this applies to all land that is covered or saturated by water for at least part of the year, and does not fall into the Settlements, Forest Land, or Cropland categories. It includes intact mires and reservoirs as managed subdivisions, and natural rivers and lakes as unmanaged subdivisions.

Lakes and Rivers Converted to Reservoirs

This category represents the area of reservoirs previously covered by lakes or rivers. Lakes turned in to reservoirs by building a dam in their outlet without changing the water level are included here.

Intact Mires

In the 2013 Wetlands Supplement (IPCC, 2014), guidelines are provided for estimation of emissions from vegetated wetlands. Intact mires are classified as managed land based on inclusion under land used for livestock grazing. The total area of intact mires is, in this submission, estimated as 617.90 kha, compared to 649.24 kha in 1990 for this year's submission. All the area is included as organic soils.

6.8.1.2 *Methodology*

The CO_2 removal due to carbon stock changes in the category Wetland Remaining Wetland – Other Wetlands is recognised as a key category in level in 1990 and 2021, and in the trend 1990-2021.

No changes of C-stocks in living biomass or dead organic matter are reported for Wetlands Remaining Wetlands. For the land converted to reservoirs, changes in the living biomass and dead organic matter are included in an aggregate number that is reported as changes in C-stocks of soils. For the subcategories of Grassland Converted to Other Wetlands, the changes are not estimated, as no data is available. CO_2 emissions from reservoirs are estimated for three subcategories. However, CO_2 emissions from organic soils are estimated only for Flooded Land Remaining Flooded Land – Mires Converted to Reservoirs, whereas CO_2 emissions from mineral soils are estimated for Grassland Converted to Flooded Land – Medium SOC to Reservoirs, and for Other Land Converted to Flooded Land – Low SOC to Reservoirs.

The CO_2 emissions from Flooded Land are estimated, either on the basis of classification of reservoirs or parts of land flooded to these three categories, or on basis of reservoir-specific emission factors (Óskarsson & Guðmundsson, 2008). For the three new reservoirs established, reservoir-specific emission factors were calculated according to the estimated amount of inundated carbon. The inundated carbon of these reservoirs was estimated by Óskarsson and Guðmundsson (2001). Reservoir classification is based on information from the hydro-power companies using the relevant reservoir on area and type of land flooded.

The CO_2 emission estimates of reservoirs are then converted to C-stock changes of soils and reported as such in CRF tables.

The changes in soils of the category Intact Mires are estimated according to T1 by applying Equation 3.4 and EF = - 0.55 t CO_2-C ha^{-1} yr^{-1}, just as for Boreal Nutrient Rich Soils from Table 3.1 in the 2013 Wetlands Supplement (IPCC, 2014). Areas and emission factors used for carbon stock changes and comparable CO_2 emissions and removal calculations for Wetlands Remaining Wetlands subcategories are summarised in Table 6.24.

Table 6.24 Carbon stock changes and related CO_2 emissions and removals for Wetlands Remaining Wetlands subcategories in 2021.

Land Category	Soil Type/ Biomass	[kha]	EF Type	Tiers	[t C ha^{-1} yr^{-1}]	CSC [kt C]	Emissions/ Removals [kt CO_2]
4.D.1.3 Other Wetlands Remaining Other Wetlands							
Intact Mires	Organic soil	617.90	D	T1	0.55	339.85	-1,246.10
4.D.2.1 Flooded Land Remaining Flooded Land							
Mires Converted to Reservoirs	Organic soil	0.99	CS	T2	-0.76	-0.75	2.75
Total							**-1,243.35**

6.8.1.3 *Uncertainties and Time-series Consistency*

The area of Intact Mires and Lakes and Rivers, the two largest Wetlands Remaining Wetlands subcategories, is not recorded specifically, but rather is estimated through the process of compilation of the land-use map. The increase in extent of drained land is not directly recorded either but is estimated through a time series for drainage ditches. The accuracy of the time series of drainage has not been estimated.

Uncertainty estimates for C-stock change factors for the period 1990-2021 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). Uncertainty associated with C-stock change factors for Wetlands Remaining Wetlands is 39.91% deriving from a combined uncertainty of C-stock change factors in organic soils. Emissions and removals reported from organic soils are based on default EFs from Table 3.1 of the 2013 Wetlands Supplement to AFOLU (IPCC, 2006) and country-specific EFs, with uncertainty assigned based on expert judgment. The complete uncertainty analysis is shown in Annex 2.

6.8.1.4 *Category-specific QA/QC and Verification*

No specific QA has been performed for this category. QC procedures are Tier 1; involving checking the emission calculation processes and data sources during the inventory preparation.

6.8.1.5 *Category-specific Recalculations*

No specific recalculation was performed for the Wetlands Remaining Wetlands subcategories. Changes in values between the 2022 and 2023 Submissions are related to new areas emerged from the new map layers through the IGLUD process. The values relative to C-stock changes in organic soils for the Wetlands Remaining Wetlands subcategories for the 2022 and 2023 Submissions are shown in Table 6.25.

Table 6.25 Comparison between the 2022 and 2023 Submissions on CSC in the Wetlands Remaining Wetlands subcategories for 2020.

Land Category	Soil Type/ Biomass	[kha] 2022 subm.	[kha] 2023 subm	% Change	[t C ha^{-1} yr^{-1}] 2022 subm.	[t C ha^{-1} yr^{-1}] 2023 subm.	% Change	CSC [kt C] 2022 subm.	CSC [kt C] 2023 subm.	% Change
4.D.1.3 Other Wetlands Remaining Other Wetlands										
Intact Mires	Organic Soil	618.76	617.99	-0.1%	0.55	0.55	0.0%	340.32	339.90	-0.1%
4.D.2.1 Flooded Land Remaining Flooded Land										
Mires Converted to Reservoirs	Organic Soil	0.99	0.99	0.0%	-0.76	-0.76	0.0%	-0.75	-0.75	0.0%
Total		**619.75**	**618.98**	**-0.1%**				**339.57**	**339.15**	**-0.1%**

6.8.1.6 *Category-specific Planned Improvements*

Time series for ditches is planned to be completed in 2024-2025. With that data possibilities of analysing, finding patterns and then being able to evaluate age in drained grassland will give us a different geographical stamp on how these areas are affected in terms of emission from these areas. As of today, all drained grassland falls into the same category, no matter how old it is.

6.8.2 Land Converted to Wetlands (CRF 4D2)

6.8.2.1 *Category Description*

Grassland Converted to Flooded Land

This category includes inundated land with mineral soils having medium soil organic carbon content (medium SOC) in a range of 5-50 kg C m^{-2}, and with a vegetation cover in the range of 20-50%.

Other Land Converted to Flooded Land

This category includes inundated land with mineral soils with low soil organic carbon content (low SOC) in a range of 0-5 kg C m^{-2}, and very sparse vegetation cover. The unvegetated part of the surface can be covered with sand, stones, or rock.

Grassland Converted to Other Wetlands

For this category, two subcategories are reported: these are Rewetted Wetland Soils and Refilled Lakes and Ponds. These two subcategories include re-established wetland areas that were previously disturbed. Activity data for mineral soils in the Rewetted Wetland Soils subcategory is reported with the notation key NO from 1990 until 2015, as no rewetting actions on wetland mineral soils have occurred during that period. In the case of Refilled Lakes and Ponds, C-stock changes in soils are reported as “NE,” as 2006 IPCC Guidelines (Vol 4, chap. 7, p. 7.20) do not provide any methodology for estimating C-stock changes in soils due to land conversion to Flooded Land.

6.8.2.2 *Methodology*

Reservoir-specific emission factors are available for one reservoir classified as High SOC, three reservoirs classified as Medium SOC, and six reservoirs classified as Low SOC. For those reservoirs where specific emission factors or data to estimate them are not available, the average of emission factors for the relevant category is applied for the reservoir or part of the flooded land if information on different SOC content of the flooded area is available (Table 6.26).

Reservoir emission factors include diffusion from the surface and degassing through spillways for both CO_2 and CH_4, and bubble emissions for the latter. The emission factors of High SOC are applied for the land-use category Mires Converted to Reservoirs (Chapter 6.8.1.1).

Table 6.26 Emission factors applied to estimate emissions from Flooded Land (Óskarsson and Guðmundsson 2001, Óskarsson and Guðmundsson, 2008).

Emission Factors for Reservoirs in Iceland	Emission Factor [kg GHG ha^{-1} d^{-1}]			
Reservoir Category	CO_2 ice-free	CO_2 ice cover	CH_4 ice-free	CH_4 ice cover
Low SOC				
Reservoir-specific	0.23	0	0.0092	0
Reservoir-specific	0.106	0	0.0042	0
Reservoir-specific	0.076	0	0.003	0
Reservoir-specific	0	0	0	0
Reservoir-specific	0.083	0	0.0033	0

Emission Factors for Reservoirs in Iceland	Emission Factor [kg GHG ha^{-1} d^{-1}]			
Reservoir-specific	0.392	0	0.0157	0
Reservoir-specific	0.2472	0	0.0099	0
Average	0.162	0	0.0065	0
Medium SOC				
Reservoir-specific	4.67	0	0.187	0.004
Reservoir-specific	0.902	0	0.036	0.0008
Reservoir-specific	0.770	0	0.031	0.0007
Average	2.114	0	0.085	0.0018
High SOC				
Reservoir-specific	12.9	0	0.524	0.012

The C-stock changes in soils of the category Rewetted Wetland Soils are estimated according to T1 by applying Equation 3.4 and EF = -0.55 t CO_2-C ha^{-1} yr^{-1}, just as for Boreal Nutrient Rich Soils from Table 3.1 in the 2013 Wetland Supplement (IPCC, 2014). No changes in C-stocks of soils or other pools are estimated for the category Refilled Lakes and Ponds.

Carbon dioxide emissions from mineral soils are estimated for Grassland Converted to Flooded Land – Medium SOC to Reservoirs, Other Land Converted to Flooded Land – Low SOC to Reservoirs, and Rewetted Wetland Soils.

Areas and emission factors used for carbon stock changes and comparable CO_2 emissions, as well as removal calculations for the Land Converted to Wetlands subcategories, are summarised in Table 6.27.

Table 6.27 Carbon stock changes and related CO_2 emissions and removals for the Land Converted to Wetlands subcategories in 2021.

Land Category	Soil Type/ Biomass	[kha]	EF Type	Tiers	[t C ha^{-1} yr^{-1}]	CSC [kt C]	Emissions/ Removals [kt CO_2]
4.D.2.2 Land Converted to Flooded Land							
4.D.2.2.3 Grassland Converted to Flooded Land							
Medium SOC to Reservoirs	Mineral soil	7.19	CS	T2	-0.24	-1.72	6.32
4.D.2.2.5 Other Land Converted to Flooded Land							
Low SOC to Reservoirs	Mineral soil	18.91	CS	T2	-0.01	-0.25	0.92
4.D.2.3 Land Converted to Other Wetlands							
4.D.2.3.3 Grassland Converted to Other Wetlands							
Rewetted Wetland Soils	Mineral soil	0.01	D	T1	0.55	0.00	-0.02
	Organic soil	1.18	D	T1	0.55	0.65	-2.39
Total							**4.83**

6.8.2.3 *Uncertainties and Time-series Consistency*

The area estimates of the category Intact Mires is based on the IGLUD land-use map plus adjustments based on other information. Both the hierarchy of the map layers used, and the quality of the original mapping can affect the accuracy of the area estimate of the IGLUD land-use map. The overall accuracy of the HMI mapping is not estimated. Therefore, the uncertainty of the area estimate of Intact Mires is potentially large.

For the T1 default emission factors used for Intact Mires, comparison to in-country measurements is available for two of them. Two studies have estimated yearly CH_4 emissions from Intact Mires, with one on lowland mires, and the other on highland mires. The annual emission was estimated as 150 kg CH_4-C ha^{-1} yr^{-1} for lowland mires (Guðmundsson J. , 2009) and 63-98 kg CH_4-C ha^{-1} yr^{-1} for highland mires (Óskarsson & Guðmundsson, 2008). The default EF of 137 kg CH_4-C ha^{-1} yr^{-1} is thus in good agreement with those estimates. The comparisons also indicate that uncertainty might decrease by subdividing Intact Mires to emission categories by altitude or regions. The second EF comparison is of N_2O emissions through surfaces of Intact Mires. The default EF is zero emissions, but in Icelandic measurements for lowland mires the emission factor was estimated at 0.04 kg N_2O-N ha^{-1} yr^{-1} (Guðmundsson J. , 2009), but no emission factor was detected for highland mires (Óskarsson & Guðmundsson, 2008). Again, there is a good agreement and subdivision according to altitude or regions might decrease uncertainty of the estimate.

The uncertainty associated with the reservoir emission factors includes uniformity of emissions from reservoirs of different ages, and how different qualities of the decomposing carbon affects the emissions. The emission factors for CH_4 are estimated from measurements on freshly flooded soils. The CO_2 emission factors are based on measurements on a reservoir flooded 15 years earlier. The information on the area of flooded land is not complete and some reservoirs are still unaccounted. This applies to reservoirs in all reported categories. The same number of days for the ice-free period is applied for all reservoirs and all years. This is a source of error in the estimate.

Uncertainty estimates for C-stock change factors for the period 1990-2020 have been assessed following Approach 1 of 2006 IPCC Guidelines (IPCC, 2006). Uncertainty associated to C-stock change factors for Land Converted to Wetlands is 113.02% deriving from combined uncertainty of C-stock change factors in mineral and organic soils. Emissions and removals reported from organic soils are based on default EFs from Table 3.1 in 2013 Wetlands Supplement to AFOLU (IPCC, 2006) and country-specific EFs with uncertainty assigned based on expert judgment. The complete uncertainty analysis is shown in Annex 2.

6.8.2.4 *Category-specific QA/QC and Verification*

No specific QA has been performed for this category. QC procedures are T1, involving checking the emission calculation processes and data sources during the inventory preparation.

6.8.2.5 *Category-specific Recalculations*

No specific recalculation was performed for the Land Converted to Wetlands subcategories. Changes in values between the 2022 and 2023 Submissions are related to new areas emerged from the new map layers through the IGLUD process. The values relative to C-stock changes in mineral and organic soils for the Land Converted to Wetlands subcategories for the 2022 and 2023 Submissions are shown in Table 6.28.

Table 6.28 Comparison between the 2022 and 2023 Submissions on CSC in the Land Converted to Wetlands subcategories for 2020.

Land Category	Soil Type/ Biomass	[kha] 2022 subm.	[kha] 2023 subm	% Change	[t C ha^{-1} yr^{-1}] 2022 subm.	[t C ha^{-1} yr^{-1}] 2023 subm.	% Change	CSC [kt C] 2022 subm.	CSC [kt C] 2023 subm.	% Change
4.D.2.2 Land Converted to Flooded Land										
4.D.2.2.3 Grassland Converted to Flooded Land										
Medium SOC to Reservoirs	Mineral soil	7.19	7.19	0.0%	-0.24	-0.24	0.0%	-1.72	-1.72	0.0%
4.D2.2.5 Other Land Converted to Flooded Land										
Low SOC to Reservoirs	Mineral soil	18.91	18.91	0.0%	-0.01	-0.01	0.0%	-0.25	-0.25	0.0%
4.D.2.3 Land Converted to Other Wetlands										
4.D.2.3.3 Grassland Converted to Other Wetlands										

Land Category	Soil Type/ Biomass	[kha] 2022 subm.	[kha] 2023 subm	% Change	[t C ha^{-1} yr^{-1}] 2022 subm.	[t C ha^{-1} yr^{-1}] 2023 subm.	% Change	CSC [kt C] 2022 subm.	CSC [kt C] 2023 subm.	% Change
Rewetted Wetland Soils	Mineral soil	0.01	0.01	0.0%	0.55	0.55	0.0%	0.00	0.00	0.0%
	Organic soil	1.12	1.18	6.1%	0.55	0.55	0.0%	0.61	0.65	6.1%
Total		**27.23**	**27.29**	**0.3%**				**-1.36**	**-1.32**	**-2.8%**

6.8.2.6 *Category-specific Planned Improvements*

Improvements regarding information on reservoir area and type of land flooded are planned. Efforts will be made to map existing reservoirs but many of them are not included in the present inventory. Introduction of reservoir-specific emission factors for more reservoirs is to be expected as information on land flooded is improved. Compiling information on the ice-free period for individual reservoirs or regions is planned. Applying reservoir specific ice-free periods will decrease the uncertainty of emission estimates. Information on how emission factors change with the age of reservoirs is needed, but no plans have been made at present to conduct this research.

The planned revisions of the map of drainage ditches and deducted map layer of drained soils are especially likely to affect the estimate of wetland area.

Mapping of wetland restoration activities is available in printed form, but digitisation of those maps is pending and will be included in the compilation of the IGLUD land-use map, when available.

Separation of Intact Mires to altitude, regions, soil classes, and drainage categories, as well as adoption of different emission factors is planned.

6.9 Settlements (4E)

6.9.1 Settlements Remaining Settlements (CRF 4E1)

6.9.1.1 *Category Description*

As already mentioned in Chapter 6.1.1, significant changes have been made for this category. For the first time, area estimation of Settlements has been constructed adopting Approach 3, which is characterised by using spatially explicit observations of land-use categories and land-use conversions. The SCSI created four new urban area maps in certain time resolutions: 1990, 2000, 2010, 2020, and 2021. Maxar Satellite Images, aerial images from NLSI, and *Loftmyndir ehf*,[29] were used for this purpose. The HMI layer L14.1 “Constructed, Industrial, and Other Artificial Habitats” was deleted from the habitat mapping. However, since new urban maps produced by the SCSI could not entirely fit the replaced HMI layer, the Icelandic Farmland Database (IFD) was used for this purpose, which appeared to have a comparable IGLUD/LULUCF classification of the land surface for the IGLUD database and mapping. The new Settlements map layer included towns and villages with a required minimum of 200 inhabitants. The roads map layer has a buffer zone ranging from 2.5-15.0 m from the central line. No subdivision of this category is reported, but the estimated total area consists of two components represented in IGLUD land-use map; these are Towns and Villages and Other Settlements (Roads). Time series for these two components are now constructed on interpolation of the new four map areas. The total area reported in this submission is 41.78 kha, whereas areas for Towns and Villages and Other Settlements (Roads) are 12.01 kha and 29.77 kha, respectively. No maps are available for these time

[29] https://loftmyndir.is

series. The area of Settlements Remaining Settlements is set as the total area of Settlements the year before, subtracting the recorded conversions from Forest and Natural Birch Shrubland.

6.9.1.2 *Methodology*

No emissions are estimated for Settlements Remaining Settlements.

6.9.1.3 *Uncertainties and Time-series Consistency*

Despite updated records of the area of Settlements as described in Chapter 6.9.1.1, uncertainties for this category have been estimated assuming expert judgement for the 2023 Submission. The activity data uncertainty for these areas is 5%. Emission uncertainties for Settlements Remaining Settlements are not estimated, as no emissions are reported from this subcategory (see Chapter 6.9.1.2).

6.9.1.4 *Category-specific QA/QC and Verification*

No specific QA has been performed for this category. QC procedures are Tier 1, involving checking the emission calculation processes and data sources during the inventory preparation.

6.9.1.5 *Category-specific Recalculations*

Except for the recalculations made for the activity data for areas of Settlements (see Chapter 6.9.1.1), there are no other recalculations, as emissions from this subcategory are not reported.

6.9.1.6 *Category-specific Planned Improvements*

There are no category-specific planned improvements for this category.

6.9.2 Land Converted to Settlements (CRF 4E2)

6.9.2.1 *Category Description*

Two time series of Land Converted to Settlements area available; these are Forest Land Converted to Settlements and Natural Birch Shrubland Converted to Settlements. These time series explain only a small portion of the increase in Settlement’s area. The area of both categories is estimated through the deforestation recording of IFR, where each deforestation event is mapped and reported with high spatial accuracy.

The remaining increase in the area of Settlements is, for the time being, assumed to be converted from the Grassland subcategory Other Grassland and reported as such. No maps are available for this time series.

Forest Land Converted to Settlements

As already described in Chapter 6.5, IFR estimates the area, of this category, as deforestation activity. Permanent deforestation resulting from building activities as road construction, house building and construction of power lines is reported to the Icelandic Forest Service and defined as conversion to Settlements. It is assumed that this deforestation is included in Settlements maps, although a comparison of maps has not been carried out.

Cropland, Wetlands, and Other Land Converted to Settlements

These areas are reported with the notation key IE and included as aggregated areas under the subcategory 4.E.2.3.1 All Other Grassland Subcategories Converted to Settlements.

6.9.2.2 *Methodology*

Carbon stock changes are estimated for three categories of Land Converted to Settlements; these are Forest Land Converted to Settlements, Natural Birch Shrubland Converted to Settlements, and All Other Grassland Subcategories Converted to Settlements (Table 6.29).

Forest Land Converted to Settlements and Natural Birch Shrubland Converted to Settlements are estimated with same methodology described below.

Biomass is either measured on the site prior to deforestation or built on measurement plots in the neighbourhood of the deforestation site. In few cases with deforestation of Natural Birch Woodland Country Specific value for biomass C-stock is used. According to the 2006 AFOLU Guidelines Tier 1 methodology biomass is reported as instant oxidation in the year of deforestation.

According to the 2006 AFOLU Guidelines Tier 1 method for dead organic matter of Forest Land Converted to Settlements (Chapter 8.3.2), all carbon contained in litter is assumed to be lost during conversion and subsequent accumulation not accounted for. Carbon stock in litter has been measured outside of Forest areas as control data in measuring the change in the C-stock with afforestation. Its value varies depending on the condition of the vegetation cover. On treeless medium to fertile sites, a mean litter C-stock of 1.04 t ha^{-1} was measured (n=40, SE=0.15; data from research described in Snorrason et al., (2002)). Given the annual increase of 0.141 t C ha^{-1} as used in this year’s submission, the estimated C-stock in litter of afforested areas of 10 years of age on medium to fertile land is 2.45 t C ha^{-1}. Treeless, poorly vegetated land has a much sparser litter layer. Data from the research cited above showed a C-stock of 0.10 t ha^{-1} (n=5, SE: 0.03). A litter C-stock of a 10-year-old afforestation site would be 1.51 t C ha^{-1}. Using the similar ratio between poorly and fully vegetated land as in this year’s submission (17% and 83%, respectively), will give 2.29 t C ha^{-1} as weighted C-stock of the 10-year-old afforestation site. As with carbon in litter, soil organic carbon (SOC) has been measured in research projects. SOC in the same research plots that were mentioned above for poorly vegetated areas was 14.9 t C ha^{-1}, for fully vegetated areas with thick developed andosol layers it was 72.9 t C ha^{-1} (n=40; down to 30 cm soil depth). The annual increase in poor soil according to this year’s submission is 0.513 t C ha^{-1} yr^{-1} for poorly vegetated sites and 0.365 t C ha^{-1} yr^{-1} for fully vegetated sites. Accordingly, 10 years old forests will then have a C-stock of 20 t ha^{-1} and 76.6 t ha^{-1} on poorly and fully vegetated sites, respectively. Weighted C-stock of treeless land is then 66.9 t ha^{-1}. According to the 2006 IPCC guidelines Tier 1 method for mineral soil stock change of Land Converted to Settlements that is paved over is attributed a soil stock change factor of 0.8. Using a 20-year conversion period, this means an estimated carbon stock loss of 1% during the year of conversion; the annual emissions from SOC will be 0.67 t C ha^{-1}. These factors were used to estimate emissions from litter and soil in this first type of deforestation.

The second type of deforestation leading to Forest Land Converted to Settlements are two one events in 2006 and 2020 where trees in an afforested area were cut down under new power line. Bigger trees were removed. In this case, litter and soil were not removed, so only the biomass of the trees is supposed to cause emissions instantly on the year of the action taken and reported as such.

The carbon stock changes in above ground biomass of the category Other Grassland Converted to Settlements is based on average carbon stock of IGLUD field sampling points on land below 200 m a.s.l. categorised to the Grassland category, and the assumption that 70% of the original vegetation cover is removed in the conversion. The estimation of the ratio of vegetation cover removed is based on correspondence with planning authorities of several towns in Iceland. The changes of above ground carbon stock are reported as aggregate number of changes in living biomass.

Areas and emission factors used for carbon stock changes and comparable CO_2 emissions and removal calculations for Land Converted to Settlements subcategories are summarised in Table 6.29.

Table 6.29 Carbon stock changes and related CO_2 emissions and removals for the Land Converted to Settlements subcategories in 2021.

Land Category	Soil Type/Biomass	kha (2021)	EF Type (2021)	Tiers (2021)	t C ha^{-1}yr^{-1} (2021)	CSC kt C (2021)	Emissions/ Removals kt CO_2 (2021)
Forest Land Converted to Settlement	Mineral Soil	0.08	D	T1	-0.63	-0.05	0.18
	Living Biomass Losses	0.08	OTH	T3	-3.93	-0.31	1.13
	Dead Organic Matter	0.08	OTH	T3	-0.70	-0.06	0.21
Grassland Converted to Settlement							
All Other Subcategories Converted to Settlements	Living Biomass Losses	0.22	CS	T2	-8.88	-1.95	7.16
NBS Converted to Settlements	Mineral Soil	0.01	CS	T2	-0.37	0.00	0.02
	Living Biomass Losses	0.01	CS	T2	-2.52	-0.03	0.11
	Dead Organic Matter	0.01	CS	T2	-0.14	0.00	0.01
Total							**8.79**

6.9.2.3 *Uncertainties and Time-series Consistency*

For activity data uncertainty, see text for Settlements Remaining Settlements. Uncertainty estimates for C-stock change factors for the period 1990-2021 have been assessed following Approach 1 of 2006 AFOLU Guidelines (IPCC, 2006). Emissions and removals reported for Land Converted to Settlements mineral soils are based on country-specific EFs. Uncertainty associated with C-stock change factors for this category is 150% and assigned based on expert judgment.

6.9.2.4 *Category-specific QA/QC and Verification*

No specific QA has been performed for this category. QC procedures are Tier 1, involving checking the emission calculation processes and data sources during the inventory preparation.

6.9.2.5 *Category-specific Recalculations*

As described in Chapter 6.9.1.1, significant changes have occurred in activity data for areas in the Settlements category. Changes in values between the 2022 and 2023 Submissions are related to new areas emerged from the new map layers through the IGLUD process. For the 2023 Submission the area for the subcategory 4.E.2.3 All Other Grassland subcategories converted to Settlements increases significantly with the creation of the 2021 urban map area (see section 6.9.1.1). Consequently, the significant increase in carbon losses related to biomass losses detected in this subcategory for 2020 according to the 2023 Submission compared to the 2022 Submission (Table 6.30), is to be attributed to the increase in urban area described here above (see also 10.3.4). The values relative to C-stock changes in mineral soils for the Land Converted to Settlements subcategories for the 2022 and 2023 Submissions are shown in Table 6.30.

Table 6.30 Comparison between the 2022 and 2023 Submissions on CSC in the Land Converted to Settlements subcategories for 2020.

Land Category	Soil Type/ Biomass	[kha] 2022 subm.	[kha] 2023 subm	% Change	[t C ha^{-1} yr^{-1}] 2022 subm.	[t C ha^{-1} yr^{-1}] 2023 subm.	% Change	CSC [kt C] 2022 subm.	CSC [kt C] 2023 subm.	% Change
Forest Land Converted to Settlement	Mineral Soil	0.05	0.05	0.0%	-0.62	-0.62	0.0%	-0.03	-0.03	0.0%
Grassland Converted to Settlement										
All Other Subcategories Converted to Settlements	Biomass Losses	0.11	0.42	283.5%	-8.88	-8.88	0.0%	-0.97	-3.71	283.5%
NBS Converted to Settlements	Biomass Losses	0.01	0.01	0.0%	-1.16	-1.16	0.0%	-0.01	-0.01	0.0%
Total		**0.17**	**0.48**	**182.5%**				**-1.01**	**-3.75**	**272.2%**

6.9.2.6 *Category-specific Planned Improvements*

There are no category specific planned improvements for this category.

6.10 Other Land (4F)

6.10.1 *Other Land Remaining Other Land* (CRF 4F1)

6.10.1.1 *Category Description*

No changes in carbon stocks of Other Land Remaining Other Land are reported in accordance with AFOLU Guidelines. Conversion of land into the category Other Land is not recorded. Direct human induced conversion is not known to occur. Potential processes capable of converting land to Other Land are, however, recognised. Among these are soil erosion, soil avalanches, floods in glacial and other rivers, changes in river pathways, and volcanic eruptions.

The area reported for Other Land is the area estimated in IGLUD. Other Land in IGLUD is recognised as the area of the map layer included in the category remaining after the compilation process. The map layers included in the category Other Land are areas with vascular vegetation cover <20%. During the 2020 submission, the Other Land area decreases significantly. In 2020, Other Land was reported with an area of 5,314.54 kha, whereas for this submission Other Land covers an area of 3113.86 kha as large part of this category is reported as Grassland Remaining Grassland (see Chapter 6.7).

6.10.1.2 *Methodology*

No emissions reported as occurring.

6.10.1.3 *Uncertainties and Time-series Consistency*

Time series of Other Land Remaining Other Land derive from changes in conversion to other categories.

6.10.1.4 *Category-specific QA/QC and Verification*

No specific QA has been performed for this category. QC procedures are Tier 1, involving checking the emission calculation processes and data sources during the inventory preparation.

6.10.1.5 *Category-specific Recalculations*

No emissions reported, and thus no recalculations were performed for this category.

6.10.1.6 *Category-specific Planned Improvements*

There are no category-specific planned improvements for this category.

6.10.2 *Other Land Converted to Other Land* (CRF 4F2)

No anthropogenic conversion of land to this category is recorded.

6.11 Harvested Wood Products (CRF 4G)

6.11.1 Category Description

Emissions and removals related to Harvested Wood Products (HWP) are estimated for the sixth time in this year's submission. Although data on domestic wood utilisation and production of wood products from domestic wood are not official and the official statistical agency in Iceland (Statistics Iceland) has fragmented, unverified, and incomplete reporting of these data[30], the annual unofficial report of the Iceland Forest Association contains data about sawnwood production from domestic harvested wood for 1996 to 2021 (see Table 6.31); (Gunnarsson E. , 2010; 2011; 2012; 2013) (Gunnarsson E. , 2014; 2015; 2016; Gunnarsson & Brynleifsdóttir, 2017; Gunnarsson & Brynleifsdóttir, Skógræktarárið 2017, 2019) (Elefsen & Brynleifsdóttir, 2020; Jóhannesdóttir Þ., 2020; Brynleifsdóttir & Jóhannsdóttir, 2021) (Snorrason, Brynleifsdóttir, & Jóhannsdóttir, 2022).

Table 6.31 Annual wood production (in m^3 on bark) and sawnwood production (in m^3) in 1996 to 2021.

Year	Wood	Sawnwood
1996	403	9
1997	314	18
1998	308	5
1999	309	9
2000	326	6
2001	286	7
2002	458	11
2003	620	9
2004	537	10
2005	961	6
2006	884	6
2007	642	27
2008	1,444	21
2009	1,528	46
2010	4,185	50
2011	3,845	112
2012	3,459	93
2013	5,511	93
2014	5,923	165
2015	4,744	64
2016	4,182	133
2017	4,333	202
2018	3,131	118
2019	2,702	76
2020	3,537	77

[30] http://faostat3.fao.org/download/F/FO/E

Year	Wood	Sawnwood
2021	2,726	46

These data were used to estimate C-stock changes in HWP. Sawnwood is only a small fragment of commercial wood removal. Other HWP than sawnwood are not produced from domestic wood. To convert sawnwood volume (m^3) to C-stock, a conversion factor of 0.229 from Table 2.8.1 in 2013 Revised Supplementary Methods and GPG Arising from the KP (IPCC, 2014) is used. Equation 2.8.5 with a default half-life of 35 years for sawnwood given in Table 2.8.2 are used to estimate CSC of the HWP pool. Methods and activity data of HWP are unchanged from last year submission. Uncertainty is assumed to be 5%. HWP C-stock changes were recalculated in this year submission as a calculation error was found in previous estimates.

6.12 Other (CRF 4H)

6.12.1 Category Description

In response to the UNFCCC expert review team request, as well as by the review team during the 2019 EU step 2, the N_2O emissions form drained Grassland soils are no longer reported under the LULUCF sector as three subcategories, Grassland Remaining Grassland, Cropland Converted to Grassland, and Wetland Converted to Grassland under 4.H Other. From the 2020 submission, these emissions are reported under the Agriculture sector under the subcategory Cultivation of Organic Soils (3.D.1.6).

6.13 Direct N_2O Emissions from N Inputs to Managed Soils (CRF 4(I))

6.13.1 Category Description

The N_2O emissions from fertilisers used in revegetation are reported under agricultural soil (Chapter 5.7).

In response to the comment from the UNFCCC ERT about the completeness of 4(IV) Indirect N_2O emissions from managed soils – N_2O (L 22, ARR 2017) under the LULUCF chapter, it was decided to include the fertilisers used in Forestry under the total synthetic fertiliser under 3D1 (see Chapter 5.7. above). According to this decision, use of inorganic fertiliser previously reported under Land Converted to Forest Land (CRF 4.A.2) / Grassland Converted to Forest Land / Afforestation 1-50 years old – Cultivated Forest, has been removed and replaced with Included Elsewhere (IE) in the CRF 4.A.2. Activity data are still reported in CRF 4.A.2 Inorganic Fertilisers.

6.14 Emissions and Removals from Drainage and Rewetting and Other Management of Organic and Mineral Soils (CRF 4(II))

6.14.1 Category Description

Emissions of both CO_2 and CH_4 of this category are key categories in level 1990 and 2021, and CH_4 in trend 1990-2021.

Forest Land

As described in the Chapter 6.5, Forest Land on drained organic soil is reported with direct and indirect CO_2 emissions and CH_4 and N_2O emissions.

Cropland

The 2013 Supplement to the 2006 Guidelines: Wetlands (IPCC, 2014), provides guidelines for estimation of emissions related to two factors reported here. These factors are the off-site decomposition of dissolved organic carbon (DOC) and emissions and removal of CH_4 from drained soils. No rewetting of soils in land included as Cropland and no other source or sink of GHG related to drainage or rewetting of Cropland soils is recognised, and the relevant categories of 4(II) are reported with notation key NO.

Grassland

Two sources of emissions are reported here; these are off-site CO_2 emissions via waterborne losses from drained inland soils, and CH_4 emissions and removal from drained inland soils. The third source described here is N_2O emission from drained soils of the Grassland category.

The rewetting of Grassland is reported as Grassland Converted to Wetland. No other source or sink of GHG related to drainage or rewetting of Grassland soils is recognised, and the relevant categories of 4(II) reported with notation key NO.

From the 2020 submission, the emissions of N_2O from drained Grassland soil are no longer reported under the LULUCF sector, but are moved into the Agriculture sector under the subcategory “Cultivation of Organic Soils” (3.D.1.6) (see also Chapter6.12) in response to the UNFCCC expert review team request, as well as by the review team during the 2019 EU step 2.

Wetlands

Included in this category is off-site CO_2 emissions and CH_4 emissions from wet organic soils.

Settlements

No emission from this component is reported for Settlements in this submission. There is no data on extent of organic soils or drainage within the Settlements category.

6.14.2 Methodology

Forest Land

Indirect CO_2 emissions from drained organic soils (which are off-site emissions via waterborne carbon losses) is estimated by default emission factor of 0.12 t C ha^{-1} yr^{-1} for Boreal climate zone (see Table 2.2 in the 2013 Wetlands Supplement (IPCC, 2014). In newly published research in which Eddy Covariance technic was used to estimate CO_2 fluxes in 23-25-year-old Black Cottonwood plantation on drained peatland in South Iceland, offsite CO_2 was measured simultaneously (Bjarnadóttir B., 2021). Waterborne carbon losses were measured at 0.04 t C ha^{-1} yr^{-1}, which is ⅓ of the default value. Nevertheless, the default value will be used in this submission.

Methane emissions from drained organic soil are also estimated by default emission factors using Equation 2.6 in the 2013 Wetlands Supplement, assuming an average ditch width of 2.5 m and average distance between ditches of 50 m. The drained area is thus divided between ditches (2.5%) and drained land (97.5%). Emission factors used are for drained land (2.0 kg CH_4 ha^{-1} yr^{-1} for 'Forest Land, Drained, Nutrient-rich, Boreal' in Table 2.3 and 217 kg CH_4 ha^{-1} yr^{-1} for ditches in 'Boreal/Temperate-Drained Forest Land/Drained Wetlands' in Table 2.4 in the 2013 Wetlands Supplement. Combined emission factor is 7.375 kg CH_4 ha^{-1} yr^{-1}.

Nitrous oxide emissions from drained organic soils are estimated with country-specific emission factors; the same as used for drained organic soils of Grassland, which is 0.44 kg N_2O-N ha^{-1} yr^{-1} (see further description in Chapter 5.7.2.6).

Area, implied emission factors, and estimated off-site CO_2 and CH_4 emissions for Forest Land are shown in Table 6.32 and Table 6.33.

Cropland

Off-site CO_2 emissions via waterborne losses from drained inland soils for Cropland are calculated according to Tier 1 by applying Equation 2.4 in the 2013 Wetlands Supplement. Area, implied emission factors, and estimated off-site CO_2 for Cropland are shown in Table 6.32.

Methane Emissions and Removals from Drained Inland Soils (Cropland): The CH_4 emission from drained land is calculated according to Tier 1 by applying Equation 2.6 in 2013 Wetlands supplement. The equations separate the emissions into two components; these are emissions from the drained land, and emissions from ditches. The Tier 1 default EF for drained land under Cropland is zero, and consequently the emissions reported are only from the ditches. The CH_4 emissions and removals from drained cropland is calculated according to Tier 1 by applying EFCH4_laNd = 0 and EFCH4_ditCH = 1,165 kg CH_4 ha^{-1} yr^{-1} from Tables 2.3 and 2.4 in the 2013 Wetlands Supplement, respectively. Area, implied emission factors, and estimated CH_4 emissions for Cropland are shown in Table 6.33.

Grassland

Off-site CO_2 emission via waterborne losses from drained inland soils: The off-site emission of CO_2 waterborne organic matters from drained soils is estimated according to equation 2.4 in 2013 Wetlands Supplement applying Tier 1 methodology. The off-site emission is reported for all Grassland subcategories with drained soils. The off-site CO_2 emission via waterborne losses from drained Grassland soils is calculated according to Tier 1 using EF = 0.12 t C ha^{-1} yr^{-1} from table 2.2 in 2013 Wetlands Supplement. Area, implied emission factors and estimated off- site CO_2 for Grassland are shown in Table 6.32.

Methane Emissions and Removals from Drained Inland Soils (Grassland): The CH_4 emissions from drained land are calculated according to Tier 1 by applying Equation 2.6 from the 2013 Wetlands Supplement. The equations separate the emissions into two components; these are emissions from drained land and emissions from ditches. No estimate on the fraction of area covered by ditches is available and the indicated value from Table 2.4 in the 2013 Wetlands Supplement is applied. In general, drainage ditches in Iceland are deep (1.5-4.0 m) and EF for Grassland ditches selected accordingly. The CH_4 emissions and removals from drained Grassland is calculated according to Tier 1 by applying EFCH4_land = 1.4 and EFCH4_ditCH = 1,165 kg CH_4 ha^{-1} yr^{-1} from Tables 2.3 and 2.4 in the 2013 Wetlands Supplement, respectively. The emissions of CH_4 are reported for all the Grassland subcategories including drained soils. Area, implied emission factors, and estimated CH_4 for Grassland are shown in Table 6.33.

Wetlands

Off-site CO_2 emissions via waterborne losses from wet organic soils are reported for four wetland subcategories; these are Mires Converted to Reservoirs, Intact Mires (of Wetland Remaining Wetland), Refilled Lakes and Ponds, and Rewetted Wetland Soils (of Land Converted to Wetlands). In all cases, the emissions are estimated according to Tier 1 by applying Equation 3.5 in the 2013 Wetlands Supplement. The off-site CO_2 emissions via waterborne losses from Mires Converted to Reservoirs, Intact Mires, Refilled Lakes and Ponds, and Rewetted Wetland Soils are calculated according to Tier 1 using EF = 0.08 t CO_2-C ha^{-1} yr^{-1} from Table 3.2 in the 2013 Wetlands Supplement. Area, implied emission factors, and estimated off-site CO_2 emissions for Wetlands are shown in Table 6.32.

Methane Emissions and Removals from Wetlands: The CH_4 emissions from reservoirs are estimated for reservoirs as in previous submissions. Emissions of CH_4 from reservoirs were estimated by applying a comparative method for CO_2 emissions using either reservoir classification or a reservoir-specific emission factor (Óskarsson & Guðmundsson, 2008). In cases where information was available, the emissions were calculated from inundated carbon.

CH_4 emissions from wet soils in the Intact Mires, Refilled Lakes and Ponds, and Rewetted Organic Soils categories are estimated according to Tier 1 by applying Equation 3.8 in the 2013 Wetlands Supplement.

The CH_4 emissions and removals from Intact Mires, Refilled Lakes and Ponds, and Rewetted Wetland Soils are calculated according to Tier 1 by applying EF = 137 kg CH_4-C ha^{-1} yr^{-1} from Table 3.3 in 2013 Wetlands Supplement. Area, implied emission factors, and estimated CH_4 are shown in Table 6.34.

Nitrous Oxide Emissions from Wetland Soils: Emissions of N_2O from reservoirs are considered as not occurring. Zero emissions were measured in a recent Icelandic study on which the emission estimates of CO_2 and CH_4 for reservoirs were based (Óskarsson & Guðmundsson, 2008).

The Tier 1 approach of the 2013 Wetlands Supplement for emissions of N_2O is considered negligible for Rewetted Wetland Soils and the same is assumed here to apply to Intact Mires.

Other Land

By definition, this category is unmanaged, and no drainage or rewetting is occurring.

Table 6.32 Drained soils: Area, implied emission factors, and estimated off-site CO_2 emissions of categories and subcategories which include drained soils.

Category/Subcategory	Drained “Organic” Soils [kha]	EF CO_2 per area [kg CO_2/ha]	Off-site CO_2 emission [kt CO_2]
Forest Land Remaining Forest Land	**0.19**		**0.08**
Afforestation more than 50 Years Old	0.10	440.0	0.05
Forest Land Remaining Forest Land – Natural Birch Forest older than 50 Years	0.08	440.0	0.04
Land Converted to Forest Land	**3.95**		**1.74**
Grassland Converted to Forest Land – Natural Birch Forest 1 to 50 Years Old	0.77	440.0	0.34
Grassland Converted to Forest Land – Afforestation 1 to 50 Years Old	3.18	440.0	1.40
Cropland Remaining Cropland	**62.86**		**27.66**
Cropland Active	45.00	440.0	19.8
Cropland Inactive	17.86	440.0	7.9
Land Converted to Cropland	**2.73**		**1.21**
Wetlands Converted to Cropland	2.72	440.0	1.2
Forest Land Converted to Cropland	0.01	440.0	0.01
Grassland Remaining Grassland	**259.24**		**114.07**
Cropland Abandoned for more than 20 Years	5.45	440.0	2.40
Natural Birch Shrubland (NBS) – Old	0.26	440.0	0.11
NBS – Recently Expanded into Other Grassland	0.27	440.0	0.12
Wetlands Drained for more than 20 Years	253.27	440.0	111.44
Land Converted to Grassland	**22.48**		**9.89**

Category/Subcategory	Drained "Organic" Soils [kha]	EF CO_2 per area [kg CO_2/ha]	Off-site CO_2 emission [kt CO_2]
Cropland Converted to Grassland	2.43	440.0	1.07
Wetlands Converted to Grassland	20.04	440.0	8.82
Wetlands Remaining Wetlands	**618.89**		**181.54**
Intact Mires	617.90	293.3	181.25
Mires Converted to Reservoirs	0.99	293.3	0.29
Land Converted to Wetlands	**1.24**		**0.36**
Refilled Lakes and Ponds	0.01	293.3	0.00
Rewetted Wetland Soils	1.18	293.3	0.35
Total	**971.53**		**336.53**

Table 6.33 Drained soils: area, implied emission factors and estimated CH_4 emissions of categories/subcategories which include drained soils.

Category/Subcategory	Drained "Organic" Soils [kha]	EF Land [kg CH_4/ha/yr]	EF Ditches [kg CH_4/ha/yr]	CH_4 Total [kt CH_4]	[kt CO_2e]
Forest Land Remaining Forest Land	**0.19**			**0.001**	**0.039**
Afforestation more than 50 Years Old	0.103	2.00	217.0	0.001	0.021
Forest Land Remaining Forest Land - Natural Birch Forest older than 50 Years	0.080	2.00	217.0	0.001	0.017
Land Converted to Forest Land	**3.910**			**0.029**	**0.721**
Grassland Converted to Forest Land Natural Birch Forest 1 to 50 Years Old	0.773	2.00	217.0	0.006	0.160
Grassland Converted to Forest Land Afforestation 1 to 50 Years Old	3.181	2.00	217.0	0.023	0.657
Cropland Remaining Cropland	**62.86**			**3.66**	**102.518**
Cropland Active	44.995	-	1,165.0	2.621	73.387
Cropland Inactive	17.861	-	1,165.0	1.040	29.131
Land Converted to Cropland	**2.730**			**0.159**	**4.452**
Wetlands Converted to Cropland	2.720	-	1,165.0	0.158	4.433
Forest Land Converted to Cropland	0.012	-	1,165.0	0.001	0.019
Grassland Remaining Grassland	**259.24**			**15.418**	**431.711**
Cropland Abandoned for more than 20 Years	5.445	1.40	1,165.0	0.324	9.084
Natural Birch Shrubland (NBS) – Old	0.256	2.00	217.0	0.002	0.053
NBS – Recently Expanded into Other Grassland	0.268	2.00	217.0	0.002	0.055
Wetlands Drained for more than 20 Years	253.272	1.40	1,165.0	15.090	422.519
Land Converted to Grassland	**22.48**				**35.350**
Cropland Converted to Grassland	2.434	1.40	1,165.0	0.145	4.061
Wetland Converted to Grassland	20.044	1.40	1,165.0	1.194	33.438
Total	**351.45**			**20.61**	**577.89**

Table 6.34 Area, implied emission factors and estimated CH_4 emissions of Wetland

Category/Subcategory	Drained "Organic" Soils [kha]	EF Land CH_4 per Area [kg CH_4/h]	CH_4 Total [kt CH_4]	[kt CO_2e]
Wetlands Remaining Wetlands	**618.891**		**112.983**	**3,163.531**
Intact Mires	617.901	182.667	112.870	3,160.358
Mires Converted to Reservoirs	0.990	114.440	0.113	3.172
Land Converted to Wetlands	**1.195**		**0.218**	**6.112**
Rewetted Wetland Soils	1.184	182.667	0.216	6.056
Refilled Lakes and Ponds	0.011	182.667	0.002	0.056
Total	**620.086**		**113.20**	**3,169.64**

6.14.3 Uncertainties and Time-series Consistency

The uncertainties and time-series consistency are as described for the relevant land-use category. Activity data uncertainties are based on expert judgement and are estimated to be 20% for the categories Cropland, Grassland, and Wetlands.

Emission factor uncertainties for CO_2 and CH_4 are calculated from the default range given in the IPCC guidelines by using Equation 3.2 of the 2006 IPCC Guidelines.

Uncertainties for Forest Land are 58.33% CO_2 emissions, 175.51% CH_4 emissions, and 20% N_2O, as estimated in Chapter 5.7.6 above.

Uncertainties for Cropland are 43.13% for CO_2 emissions and 51.37% for CH_4 emissions. Uncertainties for Grassland are 52.62% for CO_2 emissions and 65.23% for CH_4 emissions. Uncertainties for Wetlands are 37.37% for CO_2 emissions and 258.43% for CH_4 emissions.

6.14.4 Category-specific QA/QC and Verification

No specific QA has been performed for this category. QC procedures are Tier 1 and involve checking the emission calculation processes and data sources during the inventory preparation.

6.14.5 Category-specific Recalculations

A calculation error was found in the estimation of CO_2 emission in Forest Land and Natural Birch Woodland. These estimates were recalculated and increased by the factor of expansion from Carbon (C) to CO_2 (44/12). Other changes in values between the 2022 and 2023 Submissions are related to new areas emerged from the new map layers through the IGLUD process and new area results from NFI data sampled in 2022.

6.14.6 Category-specific Planned Improvements

There are no specific improvements planned for this category.

6.15 Direct N_2O Emissions from N Mineralisation and Immobilisation (CRF 4(III))

6.15.1 Category Description

Direct N_2O emissions from N mineralisation and immobilisation are reported for Cropland Converted to Grassland and Forest Land Converted to Settlements. As for the subcategories Grassland converted to Wetlands, Other Land converted to Wetlands and Grassland converted to Settlements, N2O emissions are reported as NE because despite activity data the emissions are not yet estimated since the Party has prioritized the estimation of emissions from other land uses.

6.15.2 Methodology

Conversion of Cropland on mineral soils to Grassland, and Forest Land Converted to Settlements result in loss of SOC. Emissions of associated mineralisation of N are calculated by assuming C:N of 15. The resulting N_2O emissions are estimated at 0.10 kt CO_2e and 0.01 kt CO_2e for these categories, respectively.

6.15.3 Uncertainties and Time-series Consistency

The uncertainties of this category involve uncertainties of estimated area and changes in C-stock of mineral soils already described for relevant land-use categories. Additional uncertainty for these emissions is the assumption of a fixed C:N ratio of 15.

Uncertainties for Cropland converted to Grassland are 200.00% for the N_2O emission factor. Uncertainties for Forest Land converted to Settlements are 100.00% for the N_2O emission factor.

6.15.4 Category-specific QA/QC and Verification

No specific QA has been performed for this category. QC procedures are Tier 1 and involve checking the emission calculation processes and data sources during the inventory preparation.

6.15.5 Category-specific Recalculations

No category specific recalculations are performed.

6.15.6 Category-specific Planned Improvements

No category specific improvements are planned for this category.

6.16 Indirect N_2O Emissions from Managed Soils (CRF 4(IV))

These emissions include emissions related to Atmospheric deposition and Nitrogen leaching and run-off. The component matches completely to 3.D.2 in the Agricultural sector and is reported there (Chapter 5.8).

Although moderate scarification is partially practiced when land is afforested or reforested, research such as ICEWOOD did not show net C-stock losses from mineral soil of afforestation with scarification, but on the contrary, net C-stock gains 11 years after afforestation (Bjarnadóttir, 2009), so indirect N_2O emissions from management of forest soils are reported as not occurring.

For further information on this sector, including the methodology, recalculations, and improvements see the Agriculture chapter.

6.17 Biomass Burning (CRF 4(V))

6.17.1 Category Description

Accounting for biomass burning in all land-use categories is addressed commonly in this section. The IINH has, in cooperation with regional natural history institutes, started recently to record incidences of biomass burning categorised as wildfire. This recording includes mapping the area burned. These maps are used to classify the burned area according to IGLUD land-use map. Based on this classification, biomass burning is reported for the land-use categories; Forest Land Remaining Forest Land, Cropland Remaining Cropland, Grassland Remaining Grassland, Wetlands Remaining Wetlands, and Other Land.

Biomass estimates are based on biomass sampling in the IGLUD project from the relevant land-use category as identified in land-use map. Emissions of CH_4 and N_2O are calculated according to Equation 2.27 from AFOLU guidelines (IPCC 2006).

$$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$$

L_{fire} = tons of GHG emitted, A = area burned [ha], M_B = mass of fuel available [tons/ha], C_f = combustion factor, G_{ef} = emission factor [g GHG/kg DM].

Emissions from woodland wildfires are reported for the second time. One fire was reported in 2021 and burned on 4 May 2021 in Southwest Iceland. As reported by the specialist of IINH, that mapped and examined the burned area of Natural Birch Forest of 4 ha and cultivated forest of 40.0 ha and 12.5 ha of a *Lupinus nootkatensis* field in an area of land reported under the land category Grassland remaining grassland[31]. Only some of the trees died and most of the biomass of trees that died was turned into necromass (litter or deadwood).

Tier 1 methodology using Equation 2.27 from the 2006 AFOLU Guidelines, Volume 4, Chapter 2 is applied. Natural Birch Forest reaching 2-5 m height at maturity has 11.9 $Mgha^{-1}$ in above-ground biomass on average (Snorrason et. al. 2019) and was used as an estimate of M_B of burned NBF. In the case of cultivated forest, the average above-ground biomass measured on five surrounding NFI plots with similar age and species composition was used (24.0 $Mgha^{-1}$). Emission factors given for Extra tropical forest were chosen together with combustion factor of All boreal forest.

Available biomass is for each land-use category is calculated from the average of IGLUD biomass samples of each mapping category weighted against the area of the relevant mapping category. The value of the Cf constant is assumed to be 0.5 for all land-use categories as no applicable constants are found in Table 2.6 of AFOLU guidelines. Gef = is as default values of Savanna and Grassland in Table 2.5 in AFOLU guidelines. No emissions of CO_2 are reported as biomass is assumed to reach its pre-burning values within a few years of the burning. Available biomass ranges from 18.7 ±3.8 to 29.9 ±1.9 tons of organic matter Dw ha^{-1}; the standard error for individual categories from 6-29%. In Table 6.35 a summary of area, CO_2, CH_4, and N_2O emissions and their corresponding value in CO_2e.

Biomass burning due wildfires on areas under the land category Other Land remaining Other Land have occurred during the eruption of Fagradalsfjall volcano which started on 19 March 2021. The eruption ended six months later on 27 September 2021. The IINH detected that the wildfires caused by the volcano eruption have burned 33.5 ha of land. Non-CO_2 emissions regarding this eruption event are not estimated in accordance with the 2006 AFOLU Guidelines, Volume 4, Chapter 9 where is stated that Other Land is often unmanaged, and in that case changes in carbon stocks and non-CO_2 emissions and removals are not estimated."

Wildfires reported for 2006, 2008, 2009, 2012, 2015, 2017, and 2020 occurred in areas reported as Other Land Remaining Other Land. However, these wildfires were incorrectly reported in Land Converted to Other Land. The Party has corrected this error in the 2023 Submission. In any case, the

[31] Web link for information on the burned area (in Icelandic) (https://www.ni.is).

emissions will not be reported in Other Land remaining Other Land in accordance with the 2006 AFOLU Guidelines, Volume 4, Chapter 9.

Table 6.35 Biomass burning due to wildfires. Area, CO_2, CH_4, and N_2O emissions and their corresponding values in CO_2e.

Land Category	[kha]	kt CO_2 Emissions	kt CH_4 Emissions	kt CH_4 Emissions [kt CO_2e]	kt N_2O Emissions	N_2O Emissions [kt CO_2e]	Total Emissions [kt CO_2e]
Forest Land	0.0440	0.4357	0.0013	0.0365	0.0001	0.0191	0.3334
Cropland	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000
Grassland	0.0125	NA	0.0004	0.0103	0.0000	0.0089	0.0193
Wetlands	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000
Other Land	0.0000	NA	0.0000	0.0000	0.0000	0.0000	0.0000
Total							**0.3527**

Controlled burning of Forest Land is not occurring. Controlled burning on grazing land near the farm was common practice in sheep farming in the past. This management regime of Grassland and Wetlands is becoming less common and is now subjected to official licensing. The recording of the activity is minimal, although formal approval of the local police authority is needed for safety and for birdlife protection purposes. Controlled burning of Grassland and Wetlands is reported as NE because there is not enough data to report biomass burning as NO. For all other land-use categories, controlled burning is reported as NO.

6.17.2 Uncertainties

Uncertainties related to biomass combustion from wildfires for Grassland are 41.51% for the CH_4 emission factor and 33.06% for the N_2O emission factor. Uncertainties related to biomass combustion from wildfires for Forest Land are 33.96% for the CO_2 emission factor, 42.99% for the CH_4 emission factor and 38.00% for the N_2O emission factor.

6.17.3 Planned Improvements on Biomass Burning

Recording of the area where controlled biomass burning is licensed is still not practiced. General awareness on the risk of controlled burning getting out of hand is presently rising and concerns are frequently expressed by municipal fire departments regarding this matter. Prohibition or stricter licenses on controlled burning can be expected in near future. This development might involve better recordkeeping on biomass burning.

Planned special sample plot measurements of forest fire areas is considered in the future.

7 Waste (CRF sector 5)

7.1 Overview

This sector includes emissions from Solid Waste Disposal (5A), Biological Treatment of Solid Waste (5B), Incineration and Open Burning of Waste (5C), and Wastewater Treatment and Discharge (5D). The category Other (5E) is currently reported as NO.

Table 7.1 shows an overview of the emissions from the waste sector. From 1990, emissions from the waste sector increased by 10%. The main contributor to the waste sector is CH_4 emissions from Solid Waste Disposal (5A), contributing 69% (1990) and 77% (2021) to the total emissions from this sector. From 1990, emissions from Solid Waste Disposal) increased by 24%.

Composting (5B1) started in Iceland in 1995 and was the only category reported under Biological Treatment of Solid Waste until the first anaerobic gas and composting plant was opened in 2020. The emissions from the biogas production at the plant are reported under Anaerobic Digestion at Biogas Facilities (5B2). The plant is currently only running at a fraction of its operating capacity, but the future aim is for the plant to greatly reduce the amount of biodegradable waste going to landfill in the capital area. The CH_4 and N_2O emissions generated by Biological Treatment of Solid Waste (5B) contributed 0.12% to total emissions from the waste sector in 1995 and reached 2.1% in 2021 and have increased by 1473% in that time period.

Incineration and Open Burning of Waste (5C) contributed 6.4% to the total emissions in 1990, decreasing to 2.6% in 2021. Under Waste Incineration (5C1) the only active incinerator in the country, active since 2004, is reported. Open Burning of Waste (5C2) includes combustion in nature, on dumpsites and in open containers as well as in uncontrolled incinerators which were installed in Iceland during the period 1990-2010. Once the main pathway in the subcategory 5C, nowadays only New Year's Eve and Twelfth Night bonfires are reported within the Open Burning of Waste category. In 2020 and 2021, there were only a handful of bonfires due to the COVID-19 pandemic and, consequently, 5C2 emissions are significantly lower than in previous years.

The category Wastewater Handling and Discharge (5D) contributed 25% to total waste emissions in 1990 and 18% in 2021 and has decreased by 19% in that time period. Overall, the emission from the waste sector increased by 10% between 1990 and 2021 and by 1.3% between 2020 and 2021.

Table 7.1 Emissions from the waste sector [kt CO_2e], calculated using GWP from AR5.

CRF			1990	1995	2000	2005	2010	2015	2020	2021
5A	Solid Waste Disposal	CH_4	167.7	225.2	254.4	262.5	271.8	224.2	207.5	207.2
5B	Biological Treatment of Solid Waste	CH_4	NO	0.2	0.2	0.6	1.7	2.4	3.6	3.7
		N_2O	NO	0.1	0.1	0.3	1.0	1.4	2.0	1.8
5C	Incineration and Open Burning	CH_4	6.8	4.7	2.9	0.5	0.4	0.4	0.1	0.1
		N_2O	1.5	1.0	0.6	0.3	0.2	0.3	0.2	0.2
		CO_2	7.3	4.9	2.7	4.8	6.1	6.9	6.6	6.6
5D	Wastewater Treatment and Discharge	CH_4	56	60.3	70.5	66.4	48.5	49.1	40.1	43.3
		N_2O	4.3	4.5	4.7	4.4	4.8	4.9	5.5	5.5
5E			NO	NO	NO	NO	NO	NO	NO	NO
5	**Waste**	**Total**	**243.6**	**301.0**	**336.3**	**339.8**	**334.5**	**289.5**	**265.7**	**268.5**

7.1.1 Waste Management in Iceland

The following paragraphs describe the evolution of waste management in Iceland. Characteristic and relevant for Iceland's early waste management practices are its remote location in the middle of the North Atlantic Ocean, the low population density (ranging from 2.0 to 3.6 people per square kilometres in 1970 and 2020 respectively)[32], and the rather difficult road transportation network, especially during the first half of the 20th century. Further information can be found in the National Plan on Waste Treatment 2004-2016 (2004)[33], the National Plan on Waste Treatment 2013-2024 (2013)[34] and Towards a Circular Economy (2021)[35], all in Icelandic. Figure 7.1 shows a summary of the most important developments from 1970-2021.

From 1970 to 1990, little or no waste management practices were common in Iceland. The waste was disposed in landfills, which did not have to meet specific requirements regarding location, management, and aftercare before 1990 and were often just holes in the ground. Another practice involved the open burning of waste which mostly occurred at the same sites as the landfills, in the vicinity of settlements. Transport ways were short, and the waste was disposed of where it was produced. To prevent that the waste was blown away by the Icelandic weather, open concrete containers were used to burn the waste at relatively low temperature and in an uncontrolled way. In Reykjavík, the capital of Iceland and the area with the highest population, a landfill site, Gufunes, was opened in 1967 and stayed operative until 1990. Akureyri and Selfoss, two of the biggest municipalities outside the capital area, opened municipal solid waste disposal sites (SWDS) in the 1970s and 1980s.

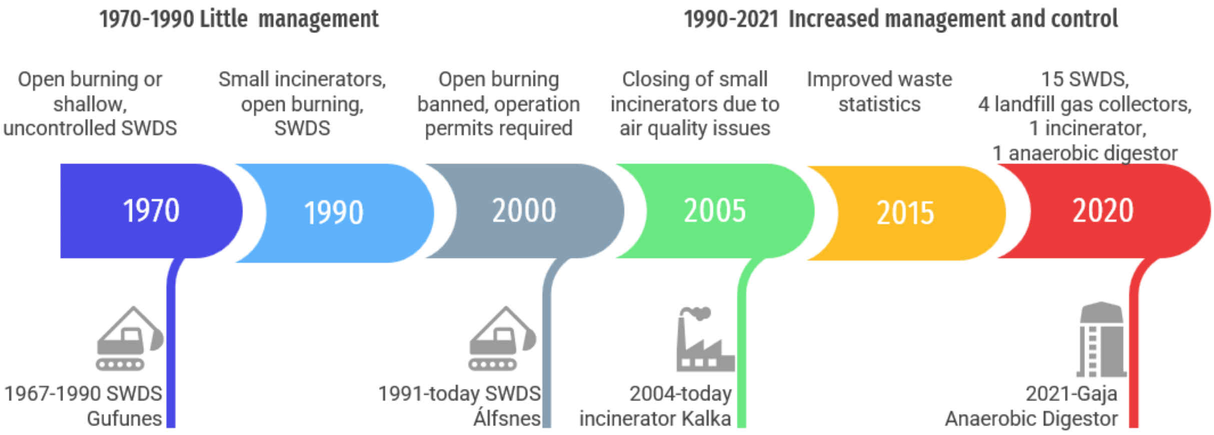


Figure 7.1 Timeline of the most important developments in waste management in Iceland from 1970.

From 1990 onwards, the number of landfills in the country increased, the practise of open burning decreased, and incinerators were built which, however, did not comply with modern air quality regulations. In 1991 a new SWDS site, Álfsnes, was opened in the capital area, which is still in use today. From 1993 onwards, a number of municipalities established regional associations for waste treatment

[32] The Worldbank, population density, accessed 04/11/2021 https://data.worldbank.org/indicator/EN.POP.DNST?end=2020&locations=IS&start=1970

[33] The National Plan on Waste Treatment 2004-2016, available at https://ust.is/library/Skrar/Atvinnulif/urgangur/Landsaatlun_2004-2016_VEF.pdf

[34] The National Plan on Waste Treatment 2013-2024, available at https://www.stjornarradid.is/media/umhverfisraduneyti-media/media/PDF_skrar/Landsaaetlun-2013-2024-(utgafa).pdf

[35] Towards a Circular Economy, available at https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/UAR_stefnal_att_ad_hringrasarhagkerfi.pdf.

to achieve operational efficiency, creating fewer, but larger disposal sites. Composting, as a waste management practise, began in 1995, although the amounts composted were small in the beginning. During the period 1990-2010 several smaller incinerators were built but then closed due to air quality and dioxin pollution issues. The only incinerator operative today in Iceland is Kalka, which opened in 2004. Open burning of waste was banned in 1999 and is non-existent today. The last place to burn waste openly was the rather remote island of Grímsey, which stopped doing so in 2010. Only traditional New Year's Eve and Twelfth Night bonfires are regarded as open burning of waste nowadays and reported as such.

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 on waste composition of landfilled waste since 1999. Since 2014, all waste operators in Iceland are required to report data on the amount of waste landfilled, incinerated, and recycled.

Furthermore, obligations and criteria in waste matters are stipulated in detail in Act No 55/2003, on waste treatment, more specifically on regulated waste management practices, landfilling and waste incineration.

Icelandic legislation on management of solid waste is at large based on and in accordance with EU legislation. As stipulated in the abovementioned Act on waste treatment, all activities connected to waste management are subject to environmental permits and special requirements are required for waste operators regarding the collection, handling, and disposal of waste. The Environment Agency of Iceland (EAI) is responsible for issuing operating permits and supervising them, as well as checking that the permits are fulfilled and collecting waste statistics.

7.1.2 Methodology

The emission estimates of GHGs from the waste sector in Iceland are based on methodologies suggested by the 2006 IPCC Guidelines. The following Table 7.2 gives an overview of the reported emissions, calculation methods and type of emissions factors for the sector waste. The methodologies are described under each of the CRF categories in the respective chapters.

Table 7.2 Reported emissions, calculation methods and type of emission factors used in the Icelandic inventory (CS: country specific, PS: plant specific, D: default).

CRF		Reported Emissions	Method	Emission Factor
5A	**Solid Waste Disposal**	CH_4	Tier 2	CS, D
5B	**Biological Treatment of Solid Waste**			
5B1	Composting	CH_4	Tier 1	D
5B1	Composting	N_2O	Tier 1	D
5B2	Anaerobic Digestion at Biogas Facilities	CH_4	Tier 3	PS
5C	**Incineration and Open Burning of Waste**			
5C1	Waste Incineration	CH_4	Tier 1	D
5C1	Waste Incineration	N_2O	Tier 1	D
5C1	Waste Incineration	CO_2	Tier 2a	D
5C2	Open Burning of Waste	CH_4	Tier 1	D
5C2	Open Burning of Waste	N_2O	Tier 1	D
5C2	Open Burning of Waste	CO_2	Tier 2	D
5D	**Wastewater Treatment and Discharge**			
5D1	Domestic Wastewater	CH_4	Tier 1	D
5D1	Domestic Wastewater	N_2O	Tier 1	D
5D2	Industrial Wastewater	CH_4	Tier 1	D

CRF		Reported Emissions	Method	Emission Factor
5D2	Industrial Wastewater	N_2O	Tier 1	D
5E	**Other**	**/**	**/**	**/**

7.1.3 Activity Data

In recent years data has been received from waste operators with weighted waste amounts landfilled, incinerated, composted, or recycled. For some CRF categories there can be a time lag between reassessment of waste generation data and its publication and, therefore, inconsistencies between older published data and newer data used in the GHG inventory are possible. When surrogate data is used, especially for the first half of the reporting period, explanations can be found in the respective chapters.

The data is collected by the EAI and the waste operators use the categories of the European Waste Statistics Regulation (WStatR) to communicate the waste amounts. The communicated waste amounts are then transposed to the waste categories as outlined in the 2006 IPCC Guidelines. Data about the recovery of CH_4 is collected from the single operators running CH_4 collection systems at the landfills. For the calculation of the emissions deriving from domestic wastewater treatment the population data is retrieved from Statistics Iceland, the protein consumption is periodically collected from the Icelandic Directorate of Health, which conducts semi-regular surveys, and the treatment systems utilisation is collected by the EAI. For industrial wastewater the amount of domestically processed fish is also retrieved from Statistics Iceland.

7.1.4 Key Category Analysis

The key sources for 1990, 2021 and the 1990-2021 trend in the Waste sector are as follows (compared to total emissions excluding LULUCF):

Table 7.3 Key source categories for Waste (excluding LULUCF).

CRF		Gas	Level 1990	Level 2021	Trend
5A1	Managed Waste Disposal	CH_4		✓	✓
5A2	Unmanaged Waste Disposal	CH_4	✓		✓
5D2	Industrial Wastewater Treatment	CH_4	✓		✓

7.1.5 Completeness

Table 7.4 gives an overview of the IPCC source categories included in this chapter and presents the status of emission estimates from all GHG emission sources in the waste sector.

Table 7.4 Completeness in Waste (NA: not applicable, E: estimated, NE: not estimated, NO: not occurring, IE: included elsewhere).

CRF		Direct GHG			Indirect GHG		
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC
5A	**Solid Waste Disposal**						
5A1	Managed Waste Disposal Sites[1]	NA	E	NA	NA	NA	E
5A2	Unmanaged Waste Disposal Sites	NA	E	NA	NA	NA	E
5A3	Uncategorised Waste Disposal Sites	NOT OCCURRING					
5B	**Biological Treatment of Solid Waste**						
5B1	Composting[2]	NA	E	E	NA	E	NA
5B2	Anaerobic Digestion at Biogas Facilities[3]	NA	E	NA	NA,NO	NA,NO	NA,NO
5C	**Waste Incineration and Open Burning of Waste**						

CRF		Direct GHG			Indirect GHG		
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC
5C1	Waste Incineration[4]	E	E	E	E[5]	E[5]	E[5]
5C2	Open Burning	E	E	E	E[5]	E[5]	E[5]
5D	**Wastewater Treatment and Discharge**						
5D1	Domestic Wastewater	NA	E	E	NA[6]	NA[6]	NA[6]
5D2	Industrial Wastewater	NA	E	IE[7]	NA[6]	NA[6]	NA[6]
5E	**Other**	NOT OCCURRING					

[1] These notation keys apply to Managed Waste Disposal Sites – Anaerobic (CRF 5A1a). Semi-aerobic Managed Waste Disposal Sites (CRF 5A1b) are altogether NO in Iceland.

[2] These notation keys apply to Composting of Municipal Solid Waste (CRF 5B1a) from 1995. Composting of Municipal Solid Waste was NO in Iceland between 1990-1994. Composting of Other (CRF 5B1b) is NO in Iceland.

[3] These notation keys apply to Anaerobic Digestion at Biogas Facilities of Municipal Waste (CRF 5B2a) from 2020. Anaerobic Digestion at Biogas Facilities of Municipal Waste was NO in Iceland between 1990-2019. Anaerobic Digestion of Other (CRF 5B2b) is NO in Iceland.

[4] These notation keys apply to Waste Incineration from 2001. Waste Incineration was NO in Iceland between 1990-2000.

[5] Data also submitted under CLRTAP.

[6] Indirect GHG for Wastewater treatment and discharge: NA because there is no EF available in 2019 EMEP EEA GB, NE because currently used activity data does not allow to apply EF from the 2019 EMEP EEA GB.

[7] Included in Domestic Wastewater (CRF 5D1).

N_2O emissions from Solid Waste Disposal Sites (5A1 and 5A2) are not applicable since the 2006 IPCC Guidelines consider N_2O emissions to be insignificant. CO_2 emissions from the same categories are also not applicable, because CO_2 emissions from the decomposition of organic material, derived from biomass sources, are of biogenic origin and, therefore, accounted for under the AFOLU sector. CO_2 emissions from Composting (5B1) are also not applicable since the 2006 IPCC Guidelines do not require their reporting. For the category Wastewater Treatment and Discharge (5D), both for Domestic and Industrial Wastewater, the calculation of NO_x and CO is not applicable (NA), as there is no emission factor available in the 2019 EMEP EEA GB. There is, however, an emission factor to calculate NMVOCs, but the activity data needed is different from that used to calculate the greenhouse gases (Tier 1). The activity data required to calculate NMVOCs, mg/m^3 of wastewater handled, has not been accessible and, therefore, these emissions are not estimated (NE).

7.1.6 Source-specific QA/QC Procedures

The GHG inventory for Waste was presented to and criticised by waste experts from the Circular Economy team and the team of Sea and Water, within the EAI, before the 2023 Submission.

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, estimating uncertainties, archiving information and reporting. The data collection and emission estimation are carried out by one inventory compiler and a second one performs the quality checks on activity data, emission factors and emission calculations. Further information can be found in Chapter 1.5 on Quality Assurance and Quality Control.

7.2 Solid Waste Disposal (CRF 5A)

7.2.1 Methodology

The calculation of CH_4 emissions deriving from solid waste disposal on land follows the Tier 2 method of the 2006 IPCC Guidelines, and Iceland uses the First Order Decay (FOD) model provided by the IPCC for these estimates. The method assumes that the degradable organic carbon (DOC) in waste decays slowly throughout the years or decades following its deposition thus producing CH_4 and (biogenic) CO_2 emissions.

No methodology is given in the 2006 IPCC guidelines for the estimation of N_2O emissions from Solid Waste Disposal Sites and these have not been estimated. CO_2 emissions from this category are also not applicable, because CO_2 emissions from the decomposition of organic material derived from biomass sources are of biogenic origin and, therefore, accounted for under the AFOLU sector.

7.2.2 Activity Data

7.2.2.1 *Waste Generation*

The EAI compiles data on total amounts of waste generated since 1995. This data is published by Statistics Iceland (2020). The data for the time-period from 1995 to 2004 relies on assumptions and estimation and is less reliable than the data generated since 2005. Data from 2005-2014 was received from most operators according to the 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 WStatR categorisation from all waste operators in Iceland. Data on CH_4 recovery and flaring is based on data provided by operators to the European Pollutant Release and Transfer Register (E-PRTR).

As a precise data collection is not available prior to 1995 in Iceland, the indications from the 2006 IPCC Guidelines, Volume 5 Chapter 3, section 3.2.2 Choice of activity data, especially regarding the AD from 1950-1990 were followed: "*When production data are not available, historical disposal of industrial waste can be estimated proportional to GDP or other economic indicators [..] For those years data are not available interpolation or extrapolation can be used.*"

Waste generation before 1995 was therefore estimated using gross domestic product (GDP) as surrogate data. Linear regression analysis for the time period from 1995-2007 resulted in a coefficient of determination of 0.54. A polynomial regression of the 2nd order had more explanation power (R^2 = 0.8) and predicted waste for GDPs closer to the reference period (1990-1994) more realistically (Figure 7.2). Therefore, the polynomial regression was chosen. More recent data were not used because the economic crisis that began in 2008 had an immediate impact on GDP whereas the impact on MSW generation was delayed, therefore, reducing the correlation between the two. Information on GDP dates back to 1945 and is reported relative to the 2005 GDP. It was therefore used to estimate waste generation since 1950. The formula the regression analysis provided is:

$$\text{Waste amount generated (t)} = -22.045 * \text{GDP index}^2 + 7367 * \text{GDP index}$$

The combination of these different datasets was carried out with the help of an external consultant company, Aether Ltd. The waste amount generated was calculated for total waste and not separately for municipal and industrial waste as was done in Iceland's 2011 and 2012 submissions to the UNFCCC. The reason behind this is that the existing data on waste amounts does not support this distinction. Waste amounts are reported to the EAI as either mixed or separated waste. Though the questionnaires sent to the waste industry contain the two categories mixed household and mixed production waste, the differentiation between the two on site is often neglected. Therefore, they can be assumed to have similar content. The fact that all other household and production waste is reported in separate categories makes the use of the umbrella category industrial waste obsolete.

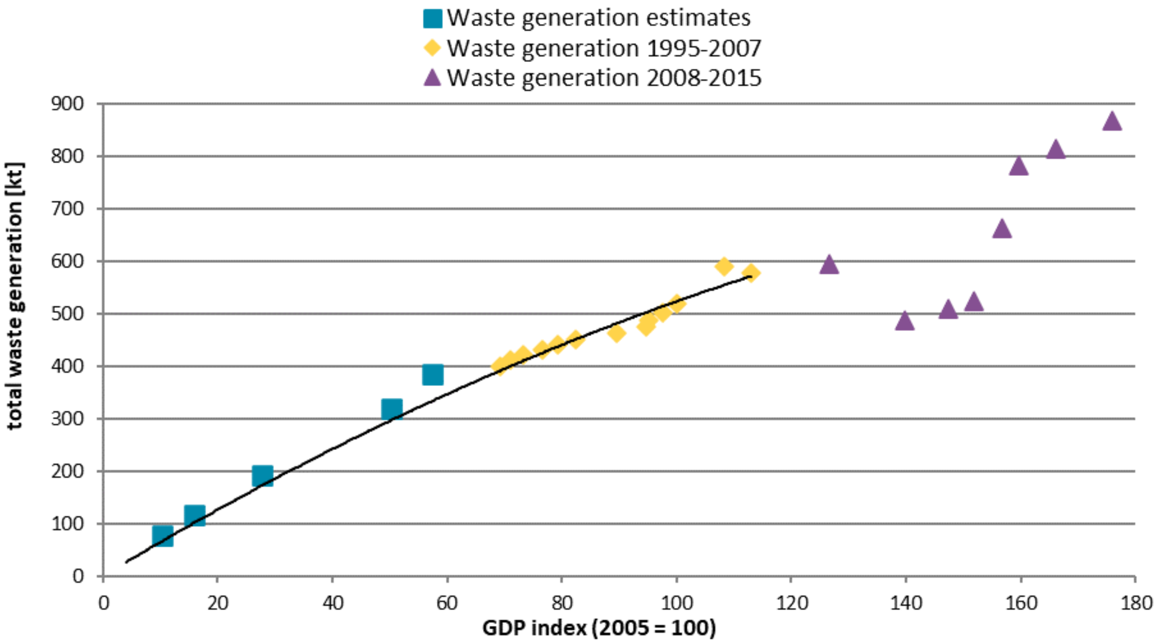


Figure 7.2 Correlation between waste generation and GDP index in Iceland used for waste generation estimates before 1995.

7.2.2.2 *Waste Allocation*

The data since 1995 as described above allocates fractions of waste generated to SWDS, incineration, recycling, and composting. Recycling and composting began in 1995. Before 1995, the generated waste has to be allocated to either SWDS or incineration/open burning of waste. In a second step the waste landfilled has to be allocated to SWDS types and the waste incinerated to incineration forms. To this end, population was used as surrogate data. It was determined that all waste in the Capital Area (Reykjavík and surrounding municipalities) was landfilled since at least 1950 (expert judgement), whereas only 50% of the waste generated in the rest of the country was landfilled. The remaining 50% were burned in open pits. Calculated annual waste generation was multiplied with the respective population fractions. It is not improbable that more than half of the waste generated in the countryside was burned openly. Nevertheless, in order to not underestimate the emissions from SWDS this assumption was used until 1972. That year the SWDS in Akureyri, the biggest town in North Iceland, opened and all waste generated in the town and, since 1990 in the neighbouring countryside, was landfilled there. In response to this, the fraction of the population burning its waste was reduced accordingly, i.e., the 50% of waste that was burned in Akureyri before the opening of the new landfill were instead allocated to SWDS. The same was done in response to the opening of another big SWDS in Selfoss, in South Iceland, in 1981. The waste management system fractions from 1950-1989 and 1990-2021 are shown in Figure 7.3 and Figure 7.4.

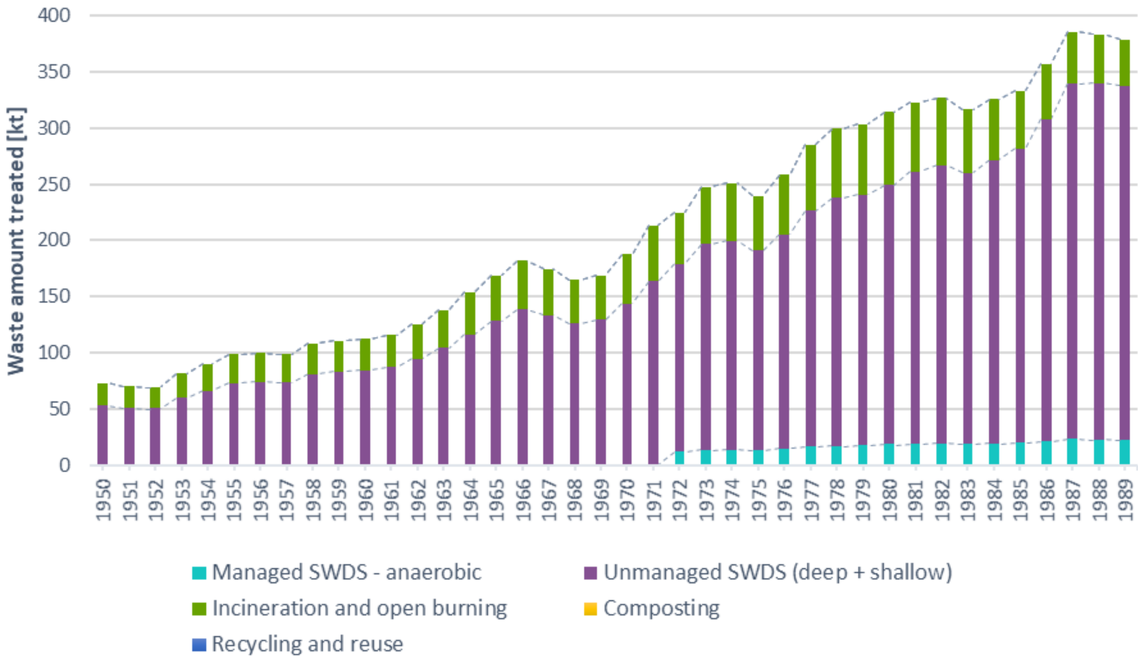


Figure 7.3 Waste amount and allocation to incineration/open burning, solid waste disposal, recycling, and composting 1950-1989.

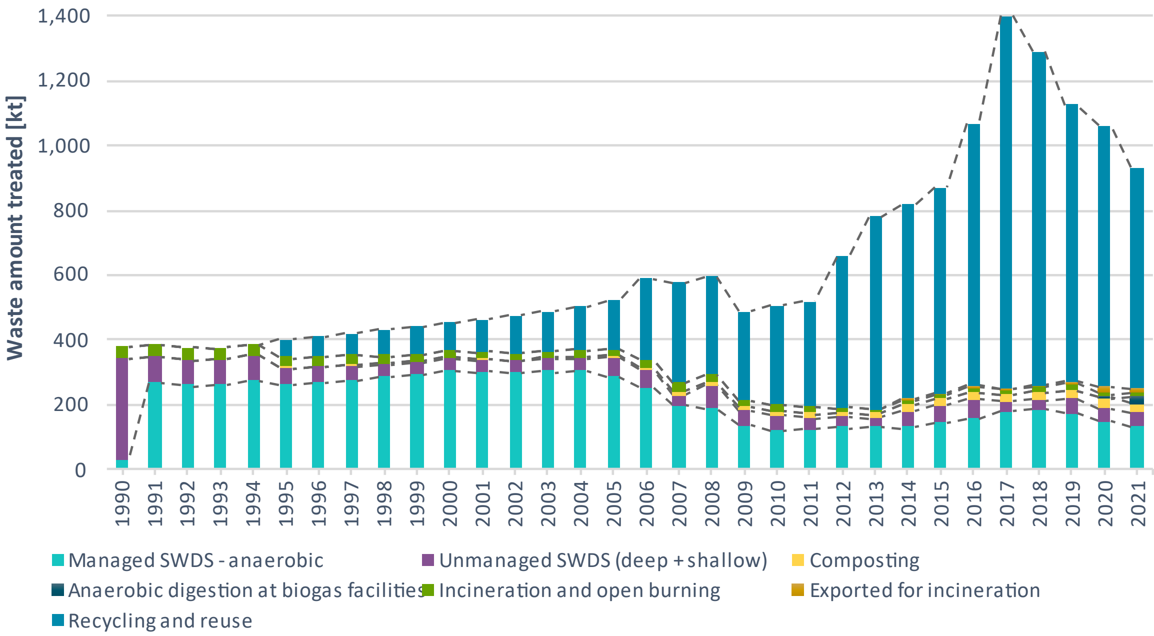


Figure 7.4 Waste amount and allocation to incineration/open burning, solid waste disposal, recycling, and composting, since 1990.

In accordance with the 2006 IPCC Guidelines the amount of waste landfilled was allocated to one of three SWDS types:

- Managed – anaerobic (from here on referred to as just “managed”).
- Unmanaged – deep (>5 m waste, from here on sometimes referred to as just “deep”).
- Unmanaged – shallow (<5 m waste, from here on sometimes referred to as just “shallow”).

Waste allocation to the different SWDS types is mainly based on the following events. The geographical location of the cited sites is shown in Figure 7.5:

- From 1950 to 1966, all waste landfilled went to shallow sites. The fraction of total waste landfilled that went to shallow sites was reduced by the following events.
- In 1967, the SWDS Gufunes classified as deep SWDS was commissioned to serve Reykjavík.
- In 1972, the aforementioned SWDS in Akureyri was commissioned. Based on two landfill gas formation studies conducted there (Kamsma & Meyles, 2003; Júlíusson, 2011) it was classified as managed SWDS.
- In 1981, a SWDS in Selfoss was commissioned and was classified as deep SWDS.
- In 1991, Gufunes was closed and in its place the *SWDS Álfsnes* was opened, now serving the capital and all surrounding municipalities. *Álfsnes* is the biggest SWDS in Iceland today and was classified as managed SWDS (thus reducing both shallow and deep SWDS fractions).
- In 1995, a new SWDS in South Iceland was opened. It received the waste that previously had gone to the *SWDS Selfoss*, plus waste from surrounding municipalities. Based on 2006 Guidelines criteria it was classified as managed SWDS (thus reducing both shallow and deep SWDS fractions).
- In 1996, the *SWDS Þernunes* in Eastern Iceland was opened. Based on 2006 Guidelines criteria it was classified as managed SWDS.
- In 1998, the *SWDS Fíflholt* in Western Iceland was opened. It was classified as managed SWDS based on 2006 Guidelines criteria and landfill gas measurements (Kamsma & Meyles, 2003); (Júlíusson, 2011).
- In 2001, the *SWDS Tjarnarland* in Eastern Iceland was opened. Based on 2006 Guidelines criteria it was classified as managed SWDS.
- Until 2004, the fractions of landfilled waste allocated to the different SWDS types are based on surrogate data (population). From 2005 and onwards, actual waste amounts going to the five sites classified as managed, as well as going to the remaining shallow sites, have been recorded by the EAI.
- In 2011, the *SWDS Stekkjarvík* in Northern Iceland was opened. It was classified as managed SWDS based on 2006 Guidelines criteria and landfill gas measurements.

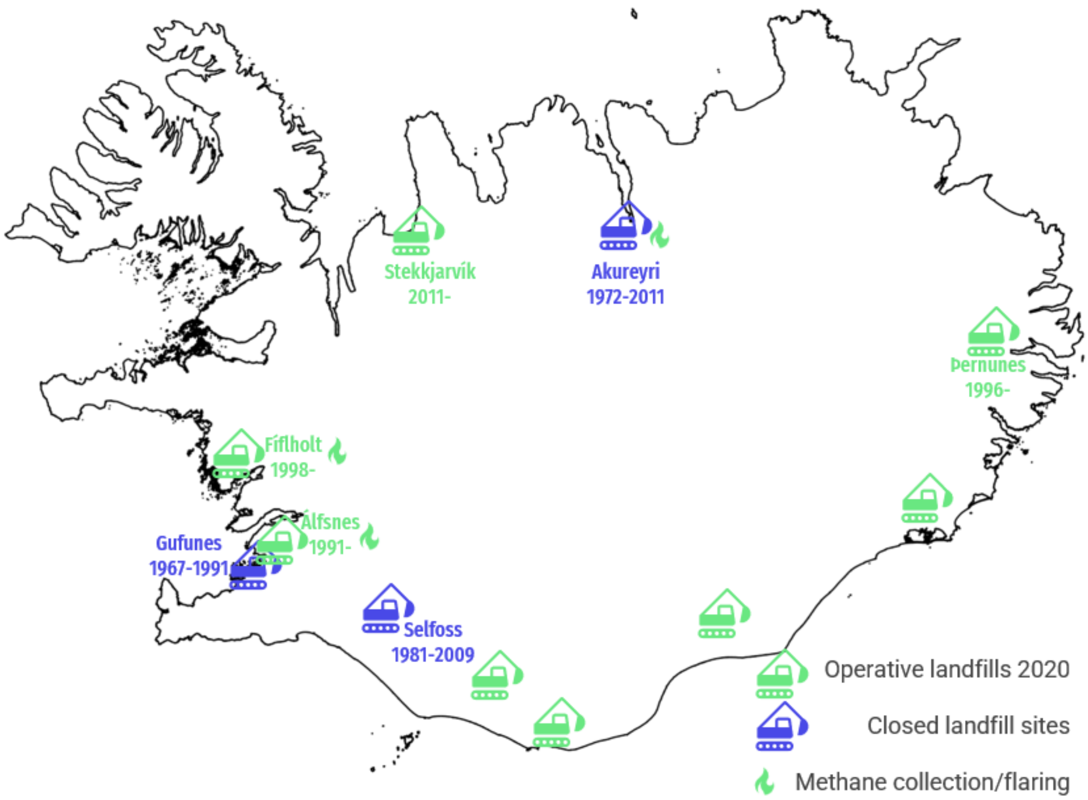


Figure 7.5 Main SWD sites in Iceland, operative in 2020 (green) and closed sites (blue). There are several other smaller sites which are still operative or dismissed.

Figure 7.6 shows the development of landfill waste management practice shares since 1950. From 2004-2020 on average, 20% of waste was declared landfilled in unmanaged SWDS, with a maximum of 27.8% and a minimum of 10.5%. Between 1990-2003 on average 21% was declared landfilled in unmanaged SWDS, with a maximum of 91% (in 1990) and a minimum of 10.6% (in 2003). Until 2004 the fractions of waste allocated to different SWDS types, managed and unmanaged are based on surrogate data, e.g., population. Between 2005 and 2007, actual waste amounts going to the six landfill sites classified as managed (*Álfsnes*, *Akureyri*, *Selfoss*, *Fíflholt*, *Þernunes*, *Tjarnarland*) were reported to the EAI and the waste amount going to unmanaged landfills is estimated by subtraction from the total amount of waste landfilled, estimated with population data. Since 2008, all SWDS data has been based on real reported data from each SWDS and not on surrogate data. The classification between managed and unmanaged landfills is accurate for the early years, as the unmanaged landfills were the ones without operation permit and the managed landfills were the ones with operation permits. Nowadays, however, all landfills are running with operation permits and follow daily managing requirements. Therefore, this method of classification needs to be revised. The 2019 refinements contain updated SWDS classifications and the updated version of Managed Well – Semi-aerobic would probably fit well for the sites with operation permits that are currently classified as unmanaged. There are, however, still outstanding questions such as whether the fraction of degradable organic carbon (DOC_f) for industrial waste is accurate for Icelandic circumstances. Furthermore, the country specific CH_4 correction factor (MCF) for these sites needs to be revisited prior to changing the classification.

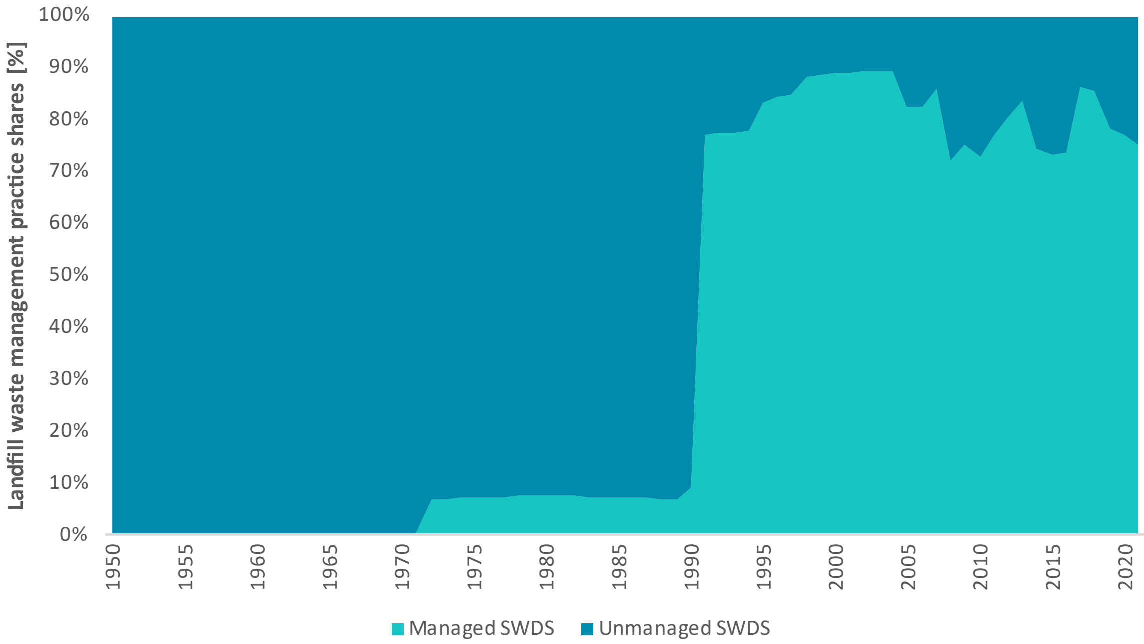


Figure 7.6 Waste management practice shares of total waste disposed of in managed and unmanaged SWDS.

7.2.2.3 *Waste Categories*

From 2005, the EAI has gathered information on waste quantities and composition from waste operators. From 2005-2013 data was received from most operators according to the EWC categorisation. Smaller operators generally did not submit data during that period, so some estimations had to be done by experts at the EAI.

From 2014 the EAI has received data according to the WStatR categorisation from all waste operators in Iceland. This information includes:

- Amount of waste composted
- Amount of waste recovered and recycled
- Amount of waste incinerated with energy recovery
- Amount of waste incinerated without energy recovery
- Amount of waste landfilled

Since this data is received on the WStatR categorisation level, the EAI is required to transform the data so that it matches the IPCC categorisation.

Current waste composition used for the emission estimates (i.e., used in the IPCC FOD models) are shown in Annex 7: Input data for Managed and Unmanaged Solid Waste Disposal Sites for the IPCC First Order Decay Model (5A1, 5A2) for Managed Solid Waste Disposal Sites and for Unmanaged Waste Disposal Sites, together with the parameters used in the First Order Decay model. The composition amounts are regularly subject to updates as streamlining of the WStatR to IPCC categorisation is a continuous process that requires regular reviewing and improvement.

Assumptions and Explanations for Specific Waste Category Amount Estimates

Since 2005, the EAI has gathered information about annual composition of waste landfilled, burned, composted, and recycled. This data consists of separated and mixed waste categories. The separated waste categories could be allocated to one of the following waste categories:

- Food waste
- Food industry waste
- Paper/cardboard
- Textiles
- Wood
- Garden and park waste
- Nappies (disposable diapers)
- Construction and demolition waste
- Sludge
- Inert waste

The last category comprises plastics, metal, glass, and hazardous waste. The pooling of these waste categories is done in the context of CH_4 emissions from SWDS only. For purposes other than GHG emission estimation, the EAI keeps these categories separated. The mixed waste categories were allocated to the categories above with the help of a study conducted by *Sorpa Ltd.*, the waste management company servicing the capital area and operating the SWDS *Álfsnes*. *Sorpa Ltd.* takes random samples from the waste landfilled in Álfsnes each year, classifies, and weighs them. This data is used to attribute the mixed waste categories to the ten waste categories listed above. This is done for both mixed household and mixed production waste. As mentioned above, there is no real distinction between the two. A third mixed category was used up until 2014, mixed waste from waste reception centres. There is no reason for people to bring food waste to these reception centres since it can be thrown in the bin at home, and mixed waste from collection points located in summer house areas is put in the mixed household waste category. Hence, it is reasonable to assume that this third category does not contain food waste. Therefore, the studies' fractions without the food waste fractions were used to attribute this category to the waste categories from the list, up until 2014. Thus, all waste landfilled could be attributed to one of the ten waste categories listed above with changing fractions from 2005 to the current reporting year. The average fractions from 2005-2011 were used as starting point to estimate waste composition of the years and decades before.

Although the data gathered by *Sorpa Ltd.* dates back to 1999, the data from 1999-2004 could not be used to represent mixed waste categories. That is because the mixed waste categories in the data gathered by the EAI underwent changes during the same time period: many categories that were recorded separately during the five-year period (1999-2004) had been included in the mixed waste category before 2005 as well, thus doubling the amount recorded as mixed waste. Also, for the period from 1995-2004, the EAI data did not permit the exact allocation of waste categories to waste management systems.

Therefore, the average waste composition from 1990-2004 is assumed to be the same as the average waste composition from 2005-2011. Before 1990, the waste composition fractions were adjusted based on expert judgement and a trend deductible from the *Sorpa Ltd.* study data, namely that the fraction of food waste is increasing back in time. The adjustments that were made are shown in Table 7.5.

Table 7.5 Manipulations of waste category fractions for the time-period 1950-1990.

Waste Category	Adjustment	Rationale
Nappies/ Disposable Diapers	Linear reduction by 100% between 1990 and 1980	Disposable diapers were introduced to Iceland around 1980 and were not widely used until the 1990s
Paper/Cardboard	Linear reduction by 50% between 1990 and 1950	The fraction of paper in waste was assumed to be much smaller decades ago. Also, paper was rather burned than landfilled (expert judgement)
Inert Waste	Linear reduction by 25% between 1990 and 1980 and linear reduction by 25% between 1980 and 1950	Plastic and glass comprise around 50% of inert waste. Glass was reused during the beginning of the period. Plastic was much rarer during the beginning of the period. The amount of plastic in circulation increased in the 1980s (data from Norway), therefore the steeper decrease during that decade.
Food Waste	Increase of fraction by the amount that other categories were reduced by.	Expert judgement and trend in data from study by *Sorpa Ltd.*

Waste Data Adjustments

The EAI receives data from all Icelandic waste operators that have a permit to accept waste for treatment or treat their own waste. This data is the basis for the EAI's waste datasets. Corrections that are made to the data are the following:

- Amounts of waste metals, paper, plastics, and rubber that have been exported for treatment by other entities than waste operators are added.
- Data from the Icelandic Recycling Fund, which imposes a recycling fee on various goods (e.g., selected hazardous materials, plastic and paper packaging, tires, EEE, batteries and accumulators and vehicles), are added to the datasets and the datasets are corrected accordingly.
- Amount of waste wood that was burned on bonfires is estimated separately (not annually).

7.2.3 Emission Factors

CH_4 emissions from SWDS are calculated with equation 3.1 of the 2006 IPCC Guidelines:

Equation 3.1

$$CH_4\ Emissions = \left[\sum_x CH_4generated_{x,T} - R_T\right] * (1 - OX_T)$$

Where:

- CH_4 Emissions = CH_4 emitted in year T, kt
- T = inventory year
- x = waste category or type/material
- R_T = recovered CH_4 in year T, kt
- OX_T = oxidation factor in year T, (fraction)

According to Icelandic Regulation No 738/2003 on waste management practices, it is a requirement that managed landfills are covered to prevent air and smell pollution and access by birds and vermin. In Iceland, most landfills use a combination of soil and wood chips as cover material, except for a few exceptions which use sand and gravel. Therefore, the value of 0.1 is chosen for the oxidation factor (OX) as suggested in Table 3.2 of the 2006 IPCC Guidelines (Volume 5).

The amount of CH_4 recovered is discussed in chapter 7.2.4.1. In order to calculate CH_4 generated, the FOD method uses the emission factors and parameters shown in Table 7.6.

Table 7.6 Emission factors and parameters used to calculate CH_4 generated.

Emission Factors/Parameters	Values
Degradable organic carbon in the year of deposition (DOC)	Table 7.7
Fraction of DOC that can decompose (DOC_f)	0.5
CH_4 correction factor for anaerobic decomposition (MCF)	Table 7.8
Oxidation factor (OX) for SWDS	0.1
Fraction of CH_4 in generated landfill gas (F)	0.5
Molecular weight ratio CH_4/C	16/12 (=1.33)
CH_4 generation rate (k)	Table 7.7
Half-life time of waste in years ($t_{1/2}$)	Table 7.7
Delay time in months	6

DOC, k, and $t_{1/2}$ (which is a function of k) are defined for individual waste categories. The values are from the 2006 IPCC guidelines and are shown in Table 7.7.

Table 7.7 Degradable organic carbon (fraction) (DOC), CH_4 generation rate (k) and half-life time in years ($t_{1/2}$) for each waste category (M: Managed, UM: Unmanaged).

Waste Category	Food	Paper	Textiles	Wood	Garden	Nappies	Industrial	Sludge	Inert
DOC	0.15	0.4	0.24	0.43	0.2	0.24	0.1195 (M) 0.04 (UM)	0.05	NA
k	0.185	0.06	0.06	0.03	0.2	0.1	0.09	0.185	NA
$t_{1/2}$	3.7	12	12	23	7	7	8	4	NA

The DOC of waste going to SWDS each year was weighted by multiplying individual waste category fractions with the corresponding DOC values. The multiplication of annual values for mass of waste deposited (W), with DOC and the fraction of DOC that can decompose (DOC_f), as well as the CH_4 correction factor, results in the mass of decomposable DOC deposited annually (DDOCm).

The default MCFs for types of SWDS account for the fact that unmanaged and semi-aerobic SWDS produce less CH_4 from a given amount of waste than managed, anaerobic SWDS. The default values suggested by the 2006 IPCC Guidelines for the three SWDS types used are shown in Table 7.8. Based on two landfill gas studies (Kamsma & Meyles, 2003) and (Júlíusson, 2011), no CH_4 production was reported for several of the SWDS contained in the category unmanaged, shallow. Therefore, their MCF was reduced from 0.4 to 0.2. Multiplication of MCF with respective SWDS type fractions results in a fluctuating MCF for solid waste disposal.

Table 7.8 IPCC default MCFs and MCFs used in the emission estimates.

SWDS Type	Managed, Anaerobic	Unmanaged, Deep	Unmanaged, Shallow
MCF (IPCC default)	1	0.8	0.4
MCF used	1	0.8	0.2

The FOD method is then used in order to establish both the mass of decomposable DOC accumulated and decomposed at the end of each year. To this end the k values of waste categories are used. A delay time of six months takes into account that decomposition is aerobic at first and production of CH_4 does not start immediately after the waste deposition. Equations 3.4 and 3.5 from the 2006 Guidelines, used to calculate DDOC accumulated and decomposed, are shown below. Finally, generated CH_4 is calculated by multiplying decomposed DDOC with the volume fraction of CH_4 in landfill gas (= 0.5) and the molecular weight ratio of CH_4 and carbon $(16/12 = 1.33)$.

Equation 3.4

DDOC accumulated in SWDS at the end of year T

$$DDOCma_T = DDOCmd_T + (DDOCma_{T-1} * e^{-k})$$

Equation 3.5

DDOC decomposed at the end of year T

$$DDOCm\ decomp_T = DDOCma_{T-1} * (1 - e^{-k})$$

Where:

T = inventory year

- $DDOCma_T$ = DDOCm accumulated in the SWDS at the end of year T, kt
- $DDOCma_{T-1}$ = DDOCm accumulated in the SWDS at the end of year (T^{-1}), kt
- $DDOCmd_T$ = DDOCm deposited into the SWDS in year T, kt
- DDOCm $decomp_T$ = DDOCm decomposed in the SWDS in year T, kt
- k = reaction constant, k = ln(2)/$t_{1/2}$ (y^{-1})
- $t_{1/2}$ = half-life time (y)

7.2.4 Emissions

7.2.4.1 *Methane Recovery*

Recovery of landfill gas occurs currently at four sites in Iceland: *Álfsnes*, the biggest landfill in Iceland, serving the capital area since 1996, *Glerárdalur* (Akureyri), a SWDS situated in the north of Iceland, which is not used for landfilling anymore, *Fíflholt* and *Stekkjarvík*, SWDS serving the Western and Northern part of the country, respectively, both collecting CH_4 since 2019. Figure 7.5 shows the location of the SWDS with CH_4 collection.

Data on the amount of landfill gas recovered from *Álfsnes* stems from the operator *Sorpa Ltd.*, either through e-mail request or though the environmental reporting obligations, such as for the E-PRTR. For the earlier time period landfill gas recovery from *Álfsnes* is estimated using the known capability of the burner and the time it was in operation as proxies. For the later time period, measurements exist on the amount of landfill gas recovered and the amount of CH_4 sold. Recovery of landfill gas from *Glerárdalur* began in 2014 and data on the amount of gas recovered is directly collected from the operator, *Norðurorka*. CH_4 has been collected at *Fíflholt* and *Stekkjarvík* since 2019 and all the gas is burned in a burner on site. Information about the amount of CH_4 collected and burnt is retrieved from the companies, *Sorpurðun Vesturlands* and *Norðurá*, through their environmental reporting obligations.

Where the landfill gas volume is obtained instead of the CH_4 volume, a CH_4 fraction, based on regularly performed measurements, is used to estimate the CH_4 volume. CH_4 volume is converted to CH_4 mass assuming standard conditions (0.717 kg at 0°C and 101.325 kPa) and 95% purity.

Between 1996 and 2001, recovered CH_4 was combusted only. The main use between 2002 and 2006 was electricity production (reported in CRF category 1A1a in chapter 3.2.1). The bulk of CH_4 recovered since 2007 is sold as fuel for vehicles, e.g., cars and urban buses (reported in CRF category 1A3b in chapter 3.3.3). Figure 7.7 Methane recovery (5A1a) at Álfsnes, Glerárdalur, Stekkjarvík, and Fíflholt (the last two started CH_4 recovery in 2019) SWDSs [kg CH_4]. gives an overview of the annual CH_4 amounts by utilisation. There is currently a discrepancy between the values reported under the Energy sector, retrieved from the National Energy Authority (*Orkustofnun*) (NEA), and the values reported within this sector, based on numbers reported from the waste management company. This was pointed out during the 2021 UNFCCC review. It is planned to harmonise these numbers for future submissions and check which version is correct.

As can be seen in Figure 7.7, CH_4 recovery peaked in 2019. This can be explained by an increased collection of landfill gas at the *Álfsnes* landfill, from the end of 2018 to the summer of 2019. Due to the increased collection the quality of the CH_4 decreased, and the collection amount was reduced again in 2020 (information from *Sorpa Ltd.*, e-mail).

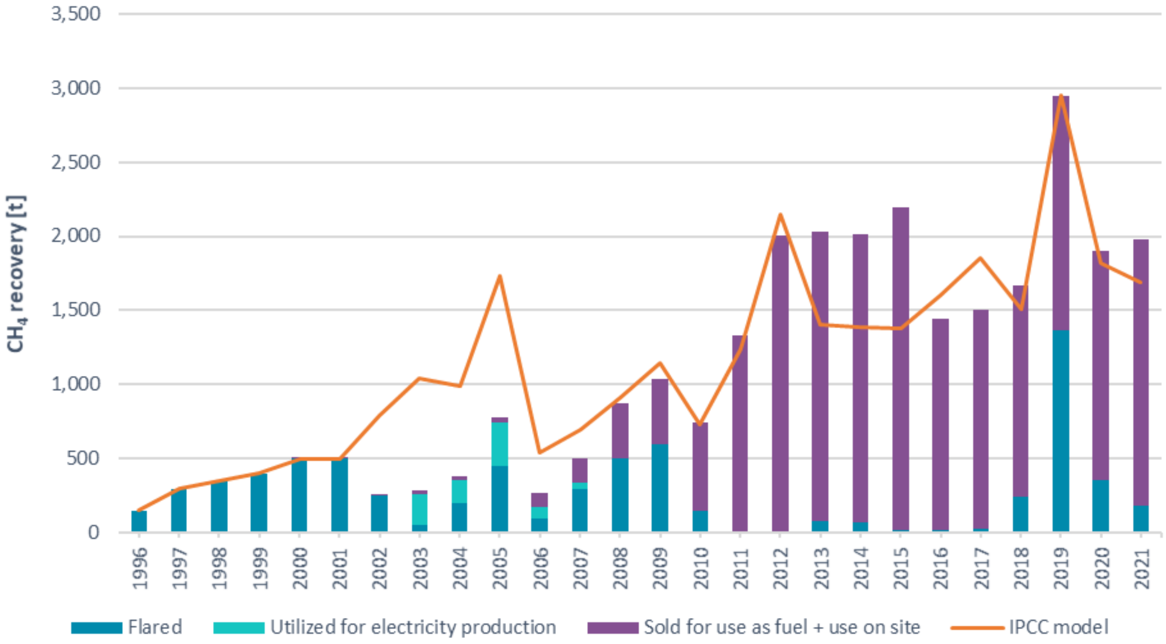


Figure 7.7 Methane recovery (5A1a) at Álfsnes, Glerárdalur, Stekkjarvík, and Fíflholt (the last two started CH_4 recovery in 2019) SWDSs [kg CH_4].

7.2.4.2 *Methane Emissions*

In 1990, CH_4 emissions from SWDS amounted to 6 kt CH_4 and increased to 10.6 kt in 2006. Since 2006 they decreased again, reaching 7.4 kt CH_4 in 2021. This equals an increase of 24% between 1990 and 2021, as can be seen in Table 7.9.

The main reason behind the increase until 2006 is a rather stable, high amount of waste disposed of in SWDS in connection with an increase of the CH_4 correction factor caused by the closing down of unmanaged SWDS in favour of managed SWDS. The shift in emissions from unmanaged to managed SWDS can be seen in Figure 7.8. In 1990, the CH_4 emissions from managed SWDS was only 11% of all SWDS emissions, whereas the emissions from unmanaged SWDS accounted for 89%. This trend has been reversed since then and in 2021, 89% of SWDS emissions originated from managed SWDS. The main event underlying this development is the closing down of the unmanaged *SWDS Gufunes* accompanied by the simultaneous opening of the managed SWDS *Álfsnes*, which services more than half the population of Iceland and receives corresponding waste amounts.

The reason for the decrease since 2006 is due to changes in waste management where the amount of waste landfilled is rapidly decreasing and the amount of recycled waste is increasing. Because of the relatively high fraction of rapidly decreasing waste, the relatively new trend away from landfilling can already be seen in emissions. Increasing recovery amounts add to this trend. The decrease of emissions in 2019 is due to the increased landfill gas collection at the *Álfsnes* site during 2019, which had to be stopped in order to assure a satisfying quality of the CH_4.

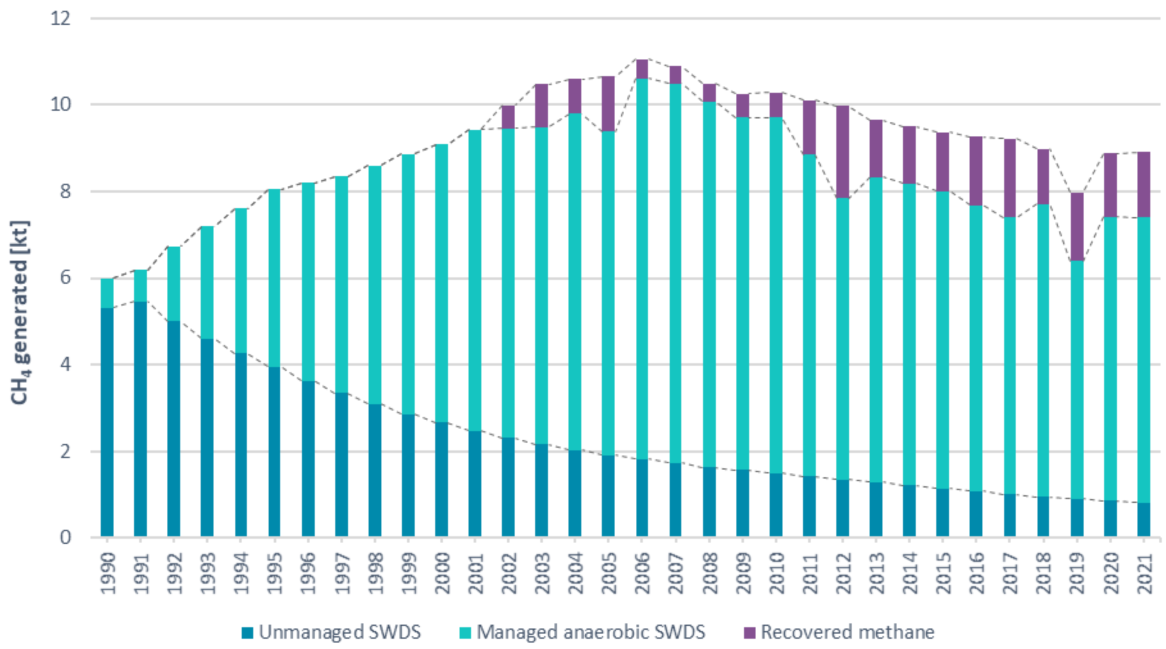


Figure 7.8 Methane generation estimates and recovery from SWDs since 1990.

Table 7.9 Methane emission estimates and recovery from SWDS since 1990.

Emissions	1990	1995	2000	2005	2010	2015	2020	2021
CH_4 from Unmanaged SWDS [kt CO_2e]	148.9	110.7	74.4	53.4	41.9	32.0	23.9	22.7
CH_4 from Managed Anaerobic SWDS [kt CO_2e].	18.8	114.5	180.0	209.1	229.9	192.1	183.6	184.4
Total CH_4 emissions [kt CO_2e]	167.7	225.2	254.4	262.5	271.8	224.2	207.5	207.2
Relative change from 1990		34%	52%	57%	62%	34%	24%	24%
Recovered CH_4 [kt CO_2e]	NO	NO	NO	35.9	16.3	38.3	41.0	42.2

7.2.5 Uncertainties

Activity data uncertainty for managed and unmanaged SWDS was calculated based on Table 3.5, chapter 3, volume 5 of the 2006 IPCC Guidelines and is 52%. The emission factor uncertainty is based on the uncertainty values from Table 3.5 of the 2006 IPCC Guidelines. It was calculated using Equation 3.1 of the same guidelines (vol. 1, chapter 3) and is 42.7% and 41.2%, respectively for managed and unmanaged SWDS.

The combined uncertainty between activity data and emission factor is 67.3% for managed SWDS (5A1) and 66.5% for unmanaged SWDS (5A2). The complete uncertainty analysis is shown in Annex 2: Assessment of Uncertainty.

7.2.6 Recalculations

7.2.6.1 *Recalculations for the 2023 Submission*

For the current submission, there was a recalculation for 2019 and 2020; CH_4 collection at the *SWDS Stekkjarvík* in Northern Iceland was added. This led to an increase of flared CH_4 by 6.4% in 2019 and 29% in 2020. The change in CH_4 emissions can be seen in Table 7.10.

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Table 7.10 Recalculation of emissions in sector 5A1 due to the addition of CH_4 collection at one SWDS site (Stekkjarvík).

CRF 5A1a, Managed Anaerobic SWDS	2019	2020
2022 v4 Submission [kt CO_2e]	156	186
2023 Submission [kt CO_2e]	154	184
Change relative to the 2022 Submission	-1.3%	-1.1%

7.2.6.2 *Recalculations from the 2022 Submission*

For the last submission, there was a recalculation for 2019 as the CH_4 collection on the SWDS *Fíflholt* in Western Iceland was added. This led to a decrease of CH_4 emissions for 2019 of 0.04 kt, or by 0.75%.

7.2.7 Planned Improvements

The 2019 refinements contain updated SWDS classifications and the updated version of Managed Well – Semi-aerobic would probably fit well for the sites with operation permits that are currently classified as unmanaged. There are, however, still outstanding questions such as whether the DOC_f for industrial waste is accurate for Icelandic circumstances. Furthermore, the country specific MCF for these sites needs to be revisited prior to changing the classification. For future emissions, the plan is to answer these questions and change to using the 2019 refinements to the 2006 IPCC Guidelines for Solid Waste Disposal.

Additionally, it is planned to increase the detail of information on landfill gas utilisation. A request to the data provider for the Energy sector, the NEA, has been sent out since more research is necessary to confirm which datasets are correct. Thereafter, the inconsistency between the reporting of landfill gas between the Energy and the Waste sectors can be corrected.

7.3 Biological Treatment of Solid Waste: Composting and Anaerobic Digestion (CRF 5B)

Composting on a noteworthy scale has been practiced in Iceland since the mid-1990s. Composted waste mainly includes organic household waste, waste from slaughterhouses, garden and park waste, timber, and manure. Garden and park waste has been collected from the Reykjavík capital area and composted using windrow composting, where grass, tree crush, and horse manure are mixed. In some municipalities there is an active composting program where most organic waste is collected and composted. Increased emphasis is placed on composting as an option in waste treatment in opposition to landfilling this kind of waste.

A new anaerobic digestion facility (gas and composting plant), GAJA, started operating at a small scale in the second half of 2020. It is the first plant of its kind in Iceland, and it will process municipal solid waste from households from the entire capital area, which contains around two thirds of Iceland's population. It is planned to process 30 to 40 kt of organic waste every year and produce 10 to 12 kt of compost and 3 million Nm^3 of CH_4 each year, which will be utilised for downstream energy/heat.

7.3.1 Methodology

Estimation of CH_4 and N_2O emissions from composting are calculated using the Tier 1 method of the 2006 IPCC Guidelines according to Equation 4.1 below. CO_2 emissions from composting are biogenic and do not need to be included according to the 2006 IPCC Guidelines.

Equation 4.1

CH_4 emissions from biological treatment

$$CH_4\ Emissions = \sum_i (M_i \times EF_i) \times 10^{-3} - R$$

Where:

- $CH_4\ Emissions$ = total CH_4 emissions in inventory year, [t CH_4]
- M_i = mass of organic waste treated by biological treatment type i, [t]
- EF = emission factor for treatment i, [g CH_4/kg waste treated]
- i = composting or anaerobic digestion
- R = total amount of CH_4 recovered in inventory year, [t CH_4]

Country specific data is used to quantify emissions from the anaerobic digestor, despite the very limited amount of data (5 months of operations) available. Emissions estimated based on the country specific data were significantly different from emissions estimated based on the Tier 1 method of the IPCC guidelines described in Equation 4.1 above. The methodology will be reviewed in the next few years as more activity data becomes available.

According to the 2006 IPCC Guidelines, emissions of CH_4 from biogas plants (anaerobic digestion) due to unintentional leakages during process disturbances or other unexpected events will generally be between 0 and 10% of the amount of CH_4 generated. In the absence of further information, use 5% as a default value for the CH_4 emissions (IPCC, 2006). Based on this information, emissions from the anaerobic digestion facility were estimated based on the following equation:

Equation

Emissions from anaerobic *digestion* at biogas facilities

$$CH_{4,\mathrm{leakage}} = CH_{4,\mathrm{production}} \times C \times Frac_{\mathrm{leakage}}$$

Where:

- $CH_{4,\mathrm{leakage}}$= emissions from anaerobic digestion, [Nm^3]
- $CH_{4,\mathrm{production}}$ = CH_4 production at the biogas plant, [Nm^3]
- C = CH_4 density conversion factor, [0.716 kg/Nm^3]
- $Frac_{leakage}$= fraction of unintentional leakages, [5%]

7.3.2 Activity Data

Composting started in 1995 but activity data for the amount of waste composted has been reported only since 2005 to the EAI. The amounts composted in 1995-2004 are estimated to be between 0.8 and 1.2 kt of dry matter. Since 2005, this amount has increased steadily, as can be seen in Table 7.11.

Table 7.11 Waste amounts composted since 1990 as dry matter weight.

	1990	1995	2000	2005	2010	2015	2020	2021
Waste amount composted [kt DM]	NO	0.80	0.80	2.0	6.1	8.5	12.7	11.1

Anaerobic digestion at biogas facilities started in the second half of 2020 at a small scale in the capital region of Iceland. Biogas production in this sector covers emissions from the handling of biological waste including garden waste, household waste, sludge, and manure. Biogas production is received directly from facility data (Table 7.12).

Table 7.12 Activity data for anaerobic digestion of organic waste since 2020.

	2020	2021
Waste amount sent to anaerobic digestion at biogas facilities [kt DM]	2.62	19.24
Biogas production [Nm^3]	55,400	982,233
CH_4 production [Nm^3]	35,000	641,036

7.3.3 Emission Factors

Both CH_4 and N_2O emissions from composting are calculated by multiplying the mass of organic waste composted with the respective emission factors. The 2006 Guidelines default emission factors from Table 4.1 are used, shown in Table 7.13.

Table 7.13 Tier 1 emission factors for CH_4 and N_2O from the 2006 IPCC Guidelines.

	Gas	Emission Factors [g/kg waste treated]
Dry weight	CH_4	10
	N_2O	0.6
Wet weight	CH_4	4
	N_2O	0.24

CH_4 emissions from anaerobic digestion at biogas facilities are calculated by multiplying the volume of CH_4 produced at the biogas facility with the CH_4 density conversion factor [0.716 kg/Nm^3] and the fraction of leakage expected, which is 5% (IPCC Guidelines, 2006), see the Equation above.

7.3.4 Emissions

Emissions from Composting are shown in Figure 7.9, as well as the mass of waste composted. Emissions, both from Composting and Anaerobic Digestion at Biogas Facilities, are shown in Table 7.14

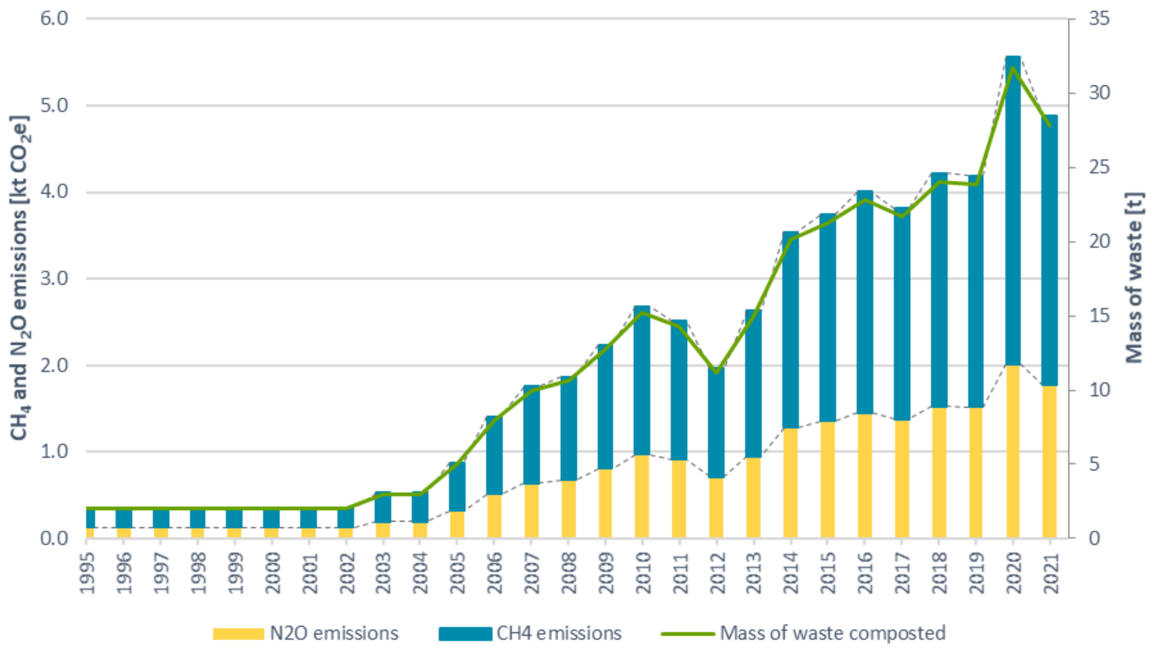


Figure 7.9 Mass of waste composted and estimated CH_4 and N_2O emissions, calculated using GWP from AR5.

CH_4 emissions from Anaerobic Digestion at Biogas Facilities can also be seen in Table 7.14. Emissions reported here are the estimated CH_4 leakage from the facility ($FRAC_{leakage}$). Any emissions that result downstream, due to the use of the produced biogas for energy generation, are accounted for in the energy sector. In this sense, the biogas / CH_4 produced (Table 7.12) acts as activity data for the energy sector where it is utilised rather than being released directly.

Table 7.14 Emissions from composting and anaerobic digestion at biogas facilities since 1990, calculated using GWP from AR5.

Emissions	1990	1995	2000	2005	2010	2015	2020	2021
Composting CH_4 [kt CO_2e]	NO	0.22	0.22	0.56	1.71	2.39	3.55	3.09
Composting N_2O [kt CO_2e]	NO	0.13	0.13	0.32	0.97	1.35	2.02	1.76
Composting Total [kt CO_2e]	**NO**	**0.35**	**0.35**	**0.88**	**2.68**	**3.74**	**5.57**	**4.85**
Anaerobic digestion CH_4 [kt CO_2e]	NO	NO	NO	NO	NO	NO	0.04	0.64

7.3.5 Uncertainties

Uncertainty for emissions from composting was calculated using value ranges from Table 4 in the 2006 Guidelines. The uncertainty of CH_4 emissions from composting is 113% (with an activity data uncertainty of 52% and emission factor uncertainty of 100%). The N_2O uncertainty for emissions from composting is 159% (with activity data uncertainty of 52% and emission factor uncertainty of 150%). The complete uncertainty analysis is shown in Annex 2: Assessment of Uncertainty.

7.3.6 Recalculations

7.3.6.1 *Recalculations for the 2023 Submission*

For the current submission, a recalculation was made for 2020 in Sector 5B1 Composting (Table 7.15 Recalculations in the Sector 5B1 Composting due to a change in activity data.). The activity data previously used in 2020 was incorrect due to a human error in the emission estimation file.

Table 7.15 Recalculations in the Sector 5B1 Composting due to a change in activity data.

CRF 5B1, Composting	2020
2022 v4 Submission [kt CO_2e]	5.45
2023 Submission [kt CO_2e]	5.57
Change relative to the 2022 Submission	2.1%

The notation key for N_2O emissions from Anaerobic Digestion at Biogas Facilities was changed from NE to NA for this submission as there is no EF provided for these emissions in the 2006 IPCC Guidelines.

7.3.6.2 *Recalculations from the 2022 Submission*

No recalculations were done for the 2022 Submission for biological treatment of solid waste.

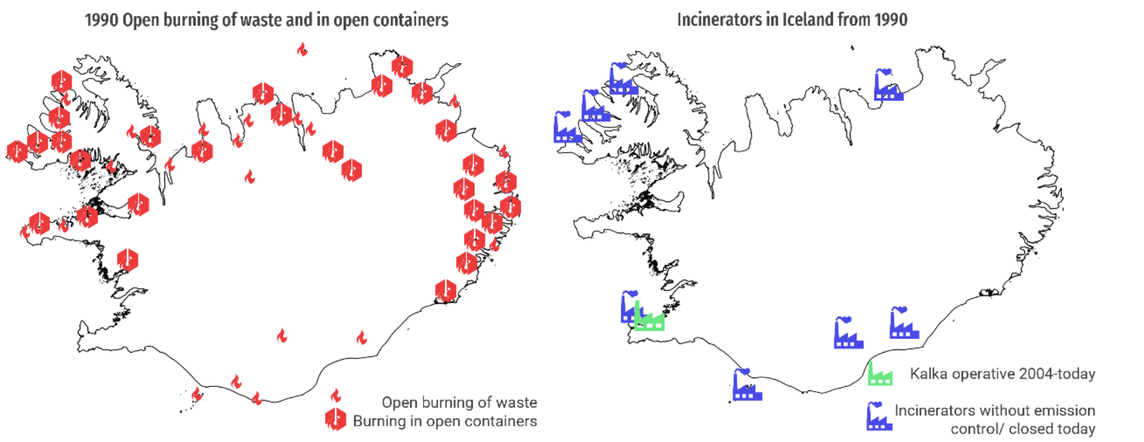
7.3.7 Planned Improvements

Emissions from the new anaerobic facility, GAJA, have been estimated for the second time in this submission. Facility level data has been used to understand the CH_4 output from the plant. The biogas is used for energy/heat and the emissions reported under the waste sector therefore represents only CH_4 from unintentional leakage (at 5%, following the IPCC 2006 approach). This estimate is considered conservative, as the facility is new, and leakage might be expected to be negligible. Iceland intends to refine this estimate with the data provider and facility experts in the coming years.

7.4 Waste Incineration and Open Burning of Waste (CRF 5C)

From 1970 to 1990, there were no special laws or recommendations regarding handling of waste in Iceland. The waste was mostly openly burned in designated areas, or dumps, outside inhabited areas. It can be assumed that in 1970, 55 of these open burning sites were to be found around the country. From 1973 onwards, concrete containers (4-6m^3-20m^3) were installed with one open side for adding the waste to avoid its dispersal due to wind. The incineration occurred without controls and at slightly higher temperatures than at the previous open fires in the dumps, but still too low to allow for complete combustion.

Example of a concrete container, Patreksfjörður, 2000, archives EA



Maps of Iceland with the location of open burning of waste in Iceland in 1990 (left) and the incinerators built from 1990. Nowadays only one, Kalka, in the Southwest of the island is still operative.

In 1990, there were still 19 places around the country practising open burning of waste. 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 due to the lack of emission controls. The incinerator Kalka was built in 2004 and is now the only incinerator still running in the country. It complies with air pollution control requirements.

This category calculates emissions from incineration and open burning of waste for CH_4, N_2O and CO_2. Consistent with the 2006 IPCC Guidelines, only CO_2 emissions deriving from the burning of waste from fossil origin are taken into consideration. Burning of biomass materials (paper, food, wood) leads to biogenic CO_2 emissions which should not be included in the national totals. Other waste categories such as textiles, diapers, and rubber contain both fossil and biogenic carbon and are therefore included in CO_2 emission totals proportionally to their fossil carbon content.

While open burning of waste was a widespread waste management option in Iceland in the past, it is banned nowadays and currently only the New Year's Eve and Twelfth Night bonfires are allocated to this subcategory (5C2). During these bonfires only wood can be burned, generating biogenic CO_2, which is not included in the national totals.

Incineration of waste is subdivided into incineration with energy recovery and incineration without energy recovery. Emissions from incineration with ER are reported under the Energy sector (1A1a and 1A4a) whereas emissions from incineration without ER are reported under the Waste sector (5C1). Despite having had several incinerators in Iceland, only one is currently operative and reported under the Subcategory 5C1, as no energy recovery is occurring.

Total GHG emissions from waste incineration and open burning of waste decreased from 15.1 kt CO_2e in 1990 to 6.9 kt CO_2e in 2021.

7.4.1 Methodology

The methodology for calculating CO_2 emissions from waste incineration follows the Tier 2a method from the 2006 Guidelines. Country-specific data regarding waste generation, composition and management practices is used, while default data for other parameters for municipal solid waste is applied.

CH_4 and N_2O emissions are calculated using the Tier 1 method of the 2006 IPCC Guidelines.

NO_x, CO, NMVOC, and SO_2 emissions are estimated in accordance with the 2019 EMEP/EEA Guidebook (EEA, 2019).

Kalka performs continuous measurements for NO_x, CO and SO_2. As of the 2023 Submission, the measured values at *Kalka* will be used instead of calculated values for these three pollutants, for the whole timeline since *Kalka* opened in 2004.

7.4.2 Activity Data

7.4.2.1 *Waste Incineration (5C1)*

Currently, Kalka is the only active incinerator in Iceland, operative since 2004. The amount of waste incinerated there is reported yearly to the EAI by the operator. The incineration occurs without energy recovery. In the past, several other incinerators were operative in Iceland, but due to their low combustion temperature or discontinuous usage, the burning was judged to be incomplete and better allocated in the category Open Burning of Waste (CRF 5C2). The exception is one incinerator operative from 2001-2004, included in this category. The amounts burned in that incinerator are based on expert judgement, as no reporting was required at that time. Therefore, from 1990-2000, the notation key "NO" is appropriate for this activity.

The amounts of waste incinerated in open pits and in incinerators with and without energy recovery, as well as the amount of wood incinerated at the yearly New Year's Eve and 6 January bonfires, are shown in Figure 7.10.

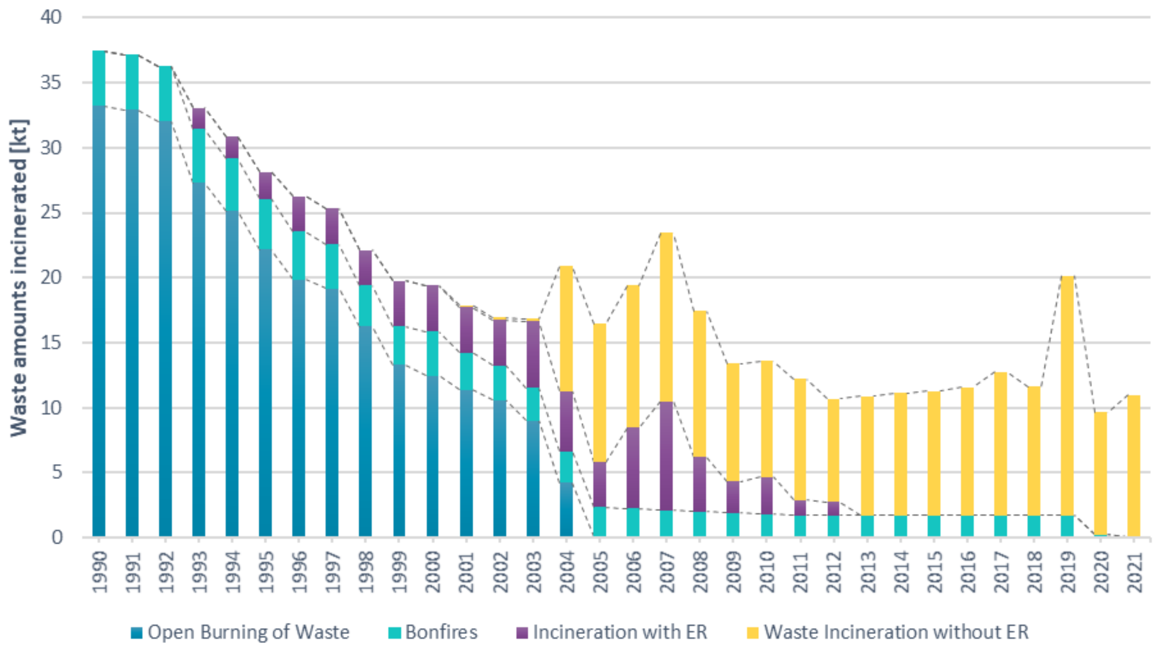


Figure 7.10 Amounts of MSW waste incinerated with and without energy recovery, burned openly and amount of wood burned in bonfires 1990-2021.

7.4.2.2 *Open Burning of Waste (5C2)*

The following types of incineration are accounted for under this category:

- Open Burning of Waste in open pits and concrete containers (see information box above)
- Waste burned in incinerators without satisfactory air pollution and temperature control
- New Year's Eve and Twelfth Night bonfires

The amount of waste burned openly is estimated using information on population in municipalities that were known to utilise open burning of waste and an assumed waste amount burned of 500 kg per head. The amount of waste burned in open pits decreased rapidly since the early 1990s, at which time more than 30 kt of waste were burned per year. Between 2005 and 2010, there was only one place still burning waste in open pits, on the remote island of Grímsey. It is assumed that around 45 tonnes of waste were burned there annually. Incineration of waste in incineration plants without energy recovery started in 2001 and incinerated waste amounts have been oscillating between 9 and 17 kt since 2004.

The only emissions currently arising from 5C2 are from New Year's Eve and Twelfth Night bonfires which are celebrated all around the country. After stricter regulations and inspections of bonfires were adopted around 2000, their number has significantly decreased, the bonfires have become smaller, and only unpainted wood is allowed to be used. In 2010, the EAI estimated the amount and type of material burnt at these bonfires by accurately weighing the total amount of material going into one representative bonfire and measuring its volume. This resulted in an estimate of the density of such bonfires. Consequently, all the Public Health Authorities in Iceland, who give permits for such bonfires and are responsible for inspecting them, were contacted and asked to provide information on all the bonfires occurring in their region/operational area. They were asked to provide the number of bonfires as well as their diameter and height. With that information and using the density estimate made by the EAI, the total amount of material burnt in bonfires was estimated. There is not a significant correlation between bonfires or population and strict regulations have been in place for some years requiring permits for bonfires. Therefore, this estimate is still expected to be accurate and has been used for the past years. The amount of material burned in bonfires has also decreased from around 4.3 kt in 1990 to 1.7 kt in 2019. In 2020 and 2021, the occurrence of bonfires was almost none, due to COVID-19 gathering restrictions, leading to only 0.2 and 0.1 kt of materials being burned respectively (see Figure 7.10).

7.4.2.3 *Composition of Waste Incinerated*

Data on the composition of waste incinerated has been available since 2005. The waste reported as mixed waste is divided into separate categories using the same studies carried out by *Sorpa Ltd*. used to define the mixed waste landfilled at the SWDS. The mixed share of waste incinerated is deemed to contain the same waste components as mixed waste landfilled, since incineration plants often took over the function of SWDS at their locations. In addition, the special function of incinerators, such as destruction of clinical and hazardous waste, is considered. From 2005 onwards, the incinerated waste is allocated to the following categories: paper, diapers, hazardous, industrial solid waste, textiles, food, clinical, wood, inert, rubber, garden, plastics, and sludge plus manure. The category inert waste is defined differently here than it is defined for the SWDS chapter. In this context it excludes plastics, rubber, and hazardous waste. As the data is only reliable from 2005 onwards, the weighted average fractions from 2005-2011 is applied to the period before 2005 to both incineration and open burning of waste. Although the standard of living in Iceland has increased during the last two decades thus affecting waste composition, this method was deemed to yield better results than the Tier 1 method (with IPCC default waste composition).

The calculation of the amount of unpainted wood burned in the annual bonfires follows these steps: first the material that went into one of the country's largest bonfires was weighted and its mass correlated with the height and diameter of the timber pile. Then the height and diameter for most of the country's bonfires were used to calculate their weight. As a result, the amount of timber burned in bonfires was estimated at 1,700 tonnes. The result was projected back in time using expert judgement. This calculation shows a decrease of the amount of wood burned, from 4.25 kt in 1990 to 1.7 kt in 2011. From that year onwards, 1.7 kt is kept constant as there are no indications of a decrease and/or increase of these bonfires. In 2020 and 2021, the occurrence of bonfires was almost none, due to COVID-19 gathering restrictions.

7.4.3 Emission Factors

7.4.3.1 *CO_2 Emission Factors*

CO_2 emissions were calculated using Equation 5.2 from the 2006 IPCC Guidelines. As described for SWDS, there is no distinction between municipal solid and industrial waste. Therefore, total waste incinerated was entered into the calculation instead of municipal solid waste.

Equation 5.2

$$CO_2Emissions = MSW * \sum_j (WF_j * dm_j * CF_j * FCF_j * OF_j) * 44/12$$

Where:

- CO_2 emissions = CO_2 emissions in inventory year, t/yr
- MSW = total amount of municipal solid waste as wet weight incinerated or open-burned, t/yr
- WF_j = fraction of waste type/material of component j in the MSW (as wet weight incinerated or open-burned)
- dm_j = dry matter content in the component j of the MSW incinerated or open-burned, (fraction)

- CF_j = fraction of carbon in the dry matter (i.e., carbon content) of component j
- FCF_j = fraction of fossil carbon in the total carbon of component j
- OF_j = oxidation factor, (fraction)
- 44/12 = conversion factor from C to CO_2
- with: $\Sigma_j WF_j = 1$
- j = component of the MSW incinerated/open-burned such as paper/cardboard, textiles, food waste, wood, garden (yard) and park waste, disposable nappies, rubber and leather, plastics, metal, glass, other inert waste.

As oxidation factors, the 2006 IPCC Guidelines' defaults of 1 for waste incineration (1 = complete oxidation) and 0.58 for open burning, were used. The equation first calculates the amount of fossil carbon incinerated and then converts it to CO_2. This is shown for 2021 in Table 7.16.

Table 7.16 Calculation of non-biogenic CO_2 emissions from incineration in 2021 (for all incineration subcategories under 5C1).

	Mass of Incinerated Waste [t]	Fraction of Incinerated Waste	(f) Dry Matter	(f) Carbon in Dry Matter	(f) Fossil Carbon in Total Carbon	Fossil Carbon [t]	CO_2 Emissions [t/yr]
Paper	1,689	0.13	0.90	0.46	0.01	6.99	25.6
Textiles	360	0.03	0.80	0.50	0.20	28.8	105.5
Wood	2,481	0.19	0.85	0.50	0	0	0
Garden	NO	NO	0.40	0.49	0	0	0
Diapers	665	0.05	0.40	0.70	0.10	18.6	68.2
Food	3,345	0.26	0.40	0.38	0	0	0
Inert	621	0.05	0.90	0.03	1.00	16.8	61.5
Plastics	2,005	0.15	1.00	0.75	1.00	1,504	5,514
Hazardous	467	0.04	0.50	NA	0.275	129[1]	471[2]
Clinical	402	0.03	0.65	NA	0.25	101[1]	369[2]
Rubber	NO	NO	0.84	0.67	0.20	0	0
Sludge plus manure	NO	NO	0.40	0.45	0	0	0
Industrial solid waste	1,002	0.08	0.40	0.38	0	0	0
Sum	**13,038**					**1,804**	**6,614**

[1] These numbers are the fraction of fossil carbon in wet waste produced, which for clinical and hazardous waste, is used instead of carbon in dry matter and fossil carbon in total carbon.

[2] These numbers are obtained by multiplying together the mass of waste and the fraction of fossil carbon in waste and converting from C to CO_2.

Between 1990 and 2004, the weighted average waste category fractions from 2005-2011 were combined with annual amounts incinerated. The same fractions were used for open burning of waste. In bonfires, only timber (packaging, pallets, etc.), which does not contain fossil carbon, is burned. Therefore, no CO_2 emissions from bonfires are reported.

7.4.3.2 *CH_4, N_2O, NO_x, CO, NMVOC, and SO_x Emission Factors*

In contrast to CO_2 emission factors, which are applied to the fossil carbon content of waste incinerated, the emission factors for CH_4, N_2O, NO_x, CO, NMVOC, and SO_2 are applied to the total waste amount incinerated. Emission factors for CH_4 and N_2O are taken from the 2006 IPCC Guidelines. They differ between incineration and open burning of waste. Since continuous measurements are performed for NO_x, CO and SO_2 at Kalka, those values are used directly in the Icelandic inventory. For NMVOC and emissions from the older incineration plants and open burning, emission factors are taken from the 2019 EMEP/EEA Guidebook (EEA, 2019), chapter 5C1a: Municipal Waste Incineration, 5C1b: Industrial Waste Incineration Including Hazardous Waste & Sewage Sludge, 5Cbiii: Clinical Waste Incineration and 5C2: Open Burning of Waste. The emission factors used are shown in Table 7.17.

Table 7.17 Emission factors (EF) for Incineration and Open Burning of Waste. All values are in g/tonne wet waste except were indicated otherwise.

	CH_4	N_2O		NO_x	CO	NMVOC	SO_2
Incineration (MSW) EF	237	60	Kalka	/	/	5.9	/
			Little or no abatement	1,800	700	20	1,700
Incineration (Industrial) EF	237	100	Kalka	/	/	7,400	/
			Little or no abatement	NA	NA	NA	NA
Incineration (Hazardous) EF	237	100	Kalka	/	/	7,400	/
			Little or no abatement	NA	NA	NA	NA
Incineration (Clinical) EF	237	100	Kalka	/	/	700	/
			Little or no abatement	1,800	1,500	700	1,100
Open Burning EF	6500	150		3,180	55,830	1,230	110

7.4.4 Emissions

GHG emissions from Incineration and Open Burning of Waste are shown in Figure 7.11 and Table 7.18. Generally, the emission trend from Waste Incineration correlates with the waste amounts incinerated, with an exception to this from 2014 and 2015 where the share of plastics in waste incinerated is considerably higher in 2015 than in 2014, leading to increased fossil CO_2 emissions despite a reduction in waste amounts incinerated in Iceland. CH_4 and N_2O emissions have been reduced significantly from 1990 due to a transition from open burning facilities towards waste incineration in waste incineration plants.

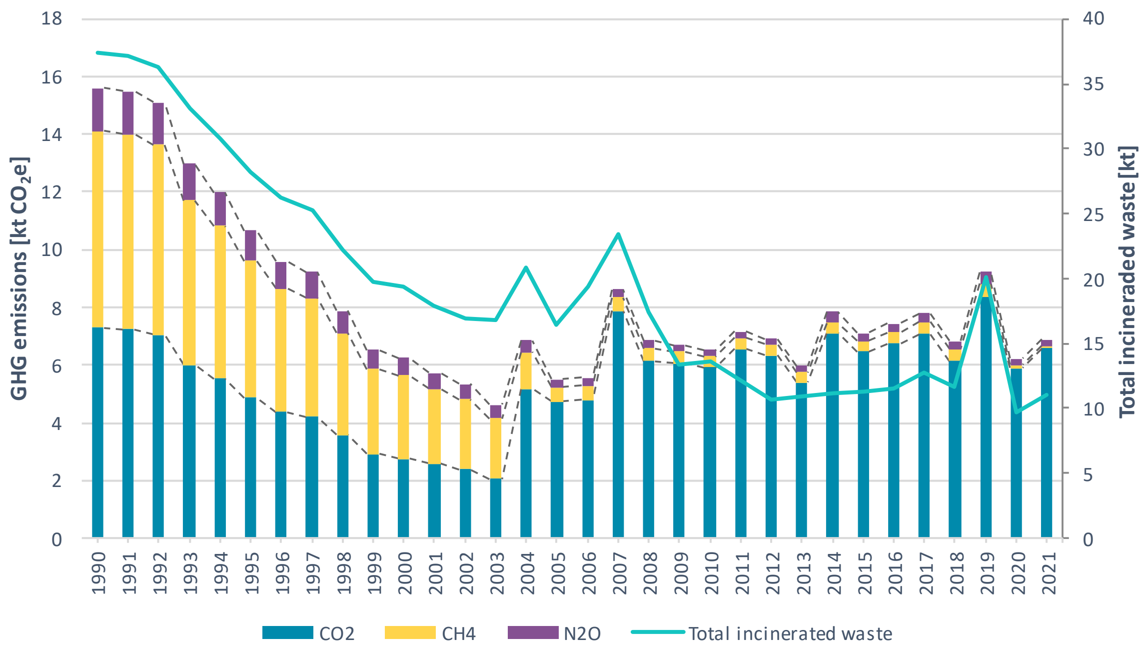


Figure 7.11 Emission estimates from incineration and open burning of waste since 1990.

Table 7.18 Emissions from Incineration and Open Burning of Waste since 1990.

Emissions	1990	1995	2000	2005	2010	2015	2020	2021
Incineration and open burning of waste CO_2 [kt CO_2e]	7.30	4.87	2.74	4.73	5.91	6.46	5.89	6.57
Incineration and open burning of waste CH_4 [kt CO_2e]	6.82	4.74	2.89	0.50	0.39	0.38	0.12	0.10
Incineration and open burning of waste N_2O [kt CO_2e]	1.49	1.04	0.63	0.27	0.22	0.27	0.23	0.23
Total [kt CO_2e]	**15.60**	**10.65**	**6.26**	**5.49**	**6.53**	**7.11**	**6.24**	**6.90**
Relative change since 1990	/	-32%	-60%	-65%	-58%	-54%	-60%	-56%

7.4.5 Uncertainties

Uncertainties associated with CO_2 emission factors for open burning depend on uncertainties related to fraction of dry matter in waste open-burned, fraction of carbon in the dry matter, fraction of fossil carbon in the total carbon, combustion efficiency, and fraction of carbon oxidised and emitted as CO_2. A default value of ± 40% was used to estimate the emission factor uncertainty for CO_2 emissions from incineration and open burning of waste as proposed in the 2006 IPCC Guidelines (Volume 5, chapter 5, paragraph 5.7.1). This value is proposed for countries relying on default data on the composition in their calculations. The activity data uncertainty of CO_2 emissions from incineration and open burning of waste was also estimated by using IPCC default values and is 52%. The combined uncertainty for CO_2 emissions from incineration and open burning of waste is therefore 66%.

Default values were also used to estimate the uncertainties associated with N_2O and CH_4 emissions. The total combined uncertainty for N_2O and CH_4 emissions was estimated to be ±113% (100% for emission factor and 52% for the activity data). The complete uncertainty analysis is shown in Annex 2: Assessment of Uncertainty.

7.4.6 Recalculations

7.4.6.1 *Recalculations for the 2023 Submission*

Final numbers for waste amounts incinerated in 2020 did not arrive until after the 2022 Submission and with it came corrections to the 2019 waste amounts. Because of it, a 1.3% reduction is observed for 2019 and a 2.7% increase in emissions for 2020 from Waste Incineration, compared to the 2022 Submission. Additionally, a computational error was found in the calculation of fossil carbon emissions from hazardous and clinical waste. Total recalculations are shown in Table 7.19.

Table 7.19 Recalculation in the Sector 5C1 due to changes in activity data and corrected calculations for fossil carbon emission for Hazardous and Clinical waste.

CRF 5C1, Waste Incineration	2019	2020
2022 v4 Submission [kt CO_2e]	8.97	6.03
2023 Submission [kt CO_2e]	9.62	6.93
Change relative to 2022 Submission	7.1%	15.1%

The EAI had assumed no bonfires were held in 2020 because of COVID, but COVID started after the annual Twelfth Night bonfires. Hence, a recalculation was made resulting in a slight increase of emissions, as shown in Table 7.20.

Table 7.20 Recalculation in the Sector 5C2 due to a change in activity data.

CRF 5C2, Open Burning of Waste	2020
2022 v4 Submission [kt CO_2e]	0
2023 Submission [kt CO_2e]	0.045

7.4.6.2 *Recalculations from the 2022 Submission*

No recalculations were done for the 2022 Submission for Incineration and Open Burning of Waste.

7.4.7 Planned Improvements

No specific improvements are planned for Incineration and Open Burning of Waste.

7.5 Wastewater Treatment and Discharge (CRF 5D)

In the 1990s, almost all wastewater was discharged directly into rivers or the sea. A small percentage was collected in septic systems. The share of septic systems, which are mostly used in remote places such as summer houses and building sites in the highlands such as the *Kárahnjúkar* hydropower plant, has increased slightly. Since 2002, the share of direct discharge of wastewater into rivers and the sea has diminished, mainly in favour of collection in closed underground sewers systems with basic treatment. Basic or primary treatment includes, e.g., removal of suspended solids by settlement and pumping of wastewater up to 4 km away from the coastline (capital area). Also, since 2002, some smaller municipalities have taken up secondary treatment of wastewater. This involves aerobic treatment, secondary settlement, and removal of sludge. A few municipalities in Iceland have started using sewage sludge as fertiliser for land reclamation purposes. Emissions from sludge, which is removed and used a fertiliser, are accounted for in the Agriculture sector.

The foremost industry causing organic waste in wastewater is fish processing. Other major industries contributing organic waste are meat and dairy industries. Industrial wastewater is either discharged directly into the sea or by means of closed underground sewers and basic treatment.

Several site factors reduce CH_4 emissions from wastewater in Iceland, such as:

- a cold climate with mild summers;
- a steep terrain with fast running streams and rivers;
- an open sea with strong currents surrounding the island, and;
- scarcity of population.

Icelanders have a high protein intake which affects N_2O emissions from the wastewater.

Total CH_4 and N_2O emissions from wastewater amounted to 49 kt CO_2e in 2021. Compared to 1990 emissions of 60 kt CO_2e, this is a decrease of 19%.

7.5.1 Methodology

The calculation of GHG emissions from wastewater treatment in Iceland is based on the methodologies suggested by the 2006 IPCC Guidelines. Country-specific emissions factors are not available for key pathways and therefore the Tier 1 method was used when estimating CH_4 emissions from wastewater. To estimate the N_2O emissions from wastewater handling, the default method given by the 2006 IPCC Guidelines was used.

7.5.2 Activity Data

7.5.2.1 *Activity Data – Methane Emissions from Wastewater*

Domestic Wastewater

Activity data for emissions from domestic wastewater treatment and discharge consists of the annual amount of total organics in wastewater. Total organics in wastewater (TOW) are calculated using Equation 6.3 of the 2006 IPCC Guidelines. In the equation, the annual amount of TOW is a product of population, amount of biochemical oxygen demand (BOD) (in kg per head and year) and a correction factor for additional industrial BOD discharged into sewers. The correction factor I is set to 1 for the pathways "not known, septic tanks urban, and septic tanks rural," while for "not known into sea, river, lake, no treatment, primary, secondary, and tertiary treatment," I is set to 1.25 to account for industrial wastewater discharge such as commercial activities, accommodation services, restaurants, shops which are commonly discharged in the same sewer system. The default BOD_5 value for Canada, Europe, Russia, and Oceania was used, 60 g per person per day (Table 6.4).

Equation 6.3

$$TOW = P * BOD * 0.001 * I * 365$$

Where:

- TOW = total organics in wastewater in inventory year, kg BOD/yr
- P = country population in inventory year, (person)
- BOD = country- specific per capita BOD_5 in inventory year, g/person/day (60 g/person/day)
- 0.001 = conversion from grams BOD to kg BOD
- I = correction factor for additional industrial BOD discharge into sewers (1.25 for "not known into sea, river, lake, no treatment, primary, secondary, and tertiary treatment," otherwise 1)

Table 7.21 provides information on activity data used to estimate CH_4 emissions from Wastewater Treatment and Discharge in Iceland.

Table 7.21 Information on population and total organic matter in Domestic Wastewater since 1990.

	1990	1995	2000	2005	2010	2015	2020	2021
Population [n]	253,785	266,978	279,049	293,577	317,630	329,100	364,134	368,792
Total organic matter[2] [kt BOD/yr]	5.6	5.8	6.1	6.4	7.0	7.2	8.0	8.1

[1] Used to estimate N_2O emissions from Wastewater Discharge and Treatment.

[2] This is TOW divided by I, i.e., excluding the correction factor for additional industrial BOD discharge into sewers.

Industrial Wastewater

The biggest industry in Iceland, which produces organic wastewater, is fish processing. Emissions from Industrial Wastewater are calculated from total organics in wastewater (TOW_i), found using Equation 6.6 in the 2006 IPCC Guidelines. In the equation, the annual amount of TOW_i is a product of the total industrial product for industrial sector i, wastewater generated and chemical oxygen demand (COD_i) in the wastewater.

Equation 6.6

$$TOW_i = P_i * W_i * COD_i$$

Where:

- TOW_i = total organics in wastewater for industry i in inventory year, kg COD/yr
- i = industrial sector
- P_i = total industrial product for industrial sector i, t/yr
- W_i = wastewater generated, $m^3/t_{product}$

- COD_i = chemical oxygen demand, kg COD/m^3

The default COD_i and W_i values for fish processing were used; 2.5 kg/m^3 and 13 m^3/t product, respectively (2006 IPCC Guidelines, Vol. 5, Table 6.9). Activity data on the amount of processed fish was only available from 1992 and onwards. Therefore, the number for 1990-1991 was estimated based on the average of 1992-1995, see Table 7.22.

Table 7.22 Information on fish processing and organic matter in industrial wastewater since 1990.

	1990	1995	2000	2005	2010	2015	2020	2021
Processed Fish [kt]	1,371	1,376	1,705	1,254	729	1,105	859	1,001
TOW_i [kt COD/yr]	44.6	44.7	55.4	40.7	23.7	35.9	27.9	32.5

7.5.2.2 *Activity Data – Nitrous Oxide Emissions from Wastewater*

The activity data needed to estimate N_2O emissions is the total amount of nitrogen in the wastewater effluent ($N_{EFFLUENT}$). $N_{EFFLUENT}$ was calculated using Equation 6.8 from the 2006 IPCC Guidelines:

Equation 6.8

$$N_{EFFLUENT} = (P * Protein * F_{NPR} * F_{NON-CON} * N_{IND-COM}) - N_{SLUDGE}$$

Where:

- $N_{EFFLUENT}$ = total annual amount of nitrogen in the wastewater effluent, kg N/yr
- P = human population
- Protein = annual per capita protein consumption, kg/person/yr
- F_{NPR} = fraction of nitrogen in protein, default = 0.16, kg N/kg protein
- $F_{NON-CON}$ = factor for non-consumed protein added to the wastewater
- $F_{IND-COM}$ = factor for industrial and commercial co-discharged protein into the sewer system
- N_{SLUDGE} = nitrogen removed with sludge, kg N/yr

Default values from the 2006 IPCC Guidelines are used for the fraction of nitrogen in protein, factor for non-consumed protein added to wastewater, and factor for industrial and commercial co-discharged protein, and are shown in Table 7.23.

Table 7.23 Default parameters used to calculate the amount of nitrogen in the wastewater effluent.

Parameter	Default value	Range	Remark
F_{NPR}	0.16	0.15-0.17	Default value used
$F_{NON-CON}$	1.1	1-1.5	The default value of 1.1 for countries with no garbage disposal was selected.
$F_{IND-COM}$	1.25	1-1.5	Default value used

Other parameters influencing the nitrogen amount in wastewater are country specific. The Icelandic Directorate of Health has conducted a number of dietary surveys both for adults (Embætti landlæknis, 2022; 2011; 2002; 1990), and for children of different ages (Þórsdóttir & Gunnarsdóttir, 2006; Gunnarsdóttir, Eysteindsdóttir, & Þórsdóttir, 2008). The studies showed a high protein intake of Icelanders of all age classes. Adults and adolescents consumed on average 90 g, 9-year-olds 78 g and 5-year-olds 50 g per day. These values, as well as values for infants, were integrated over the whole population resulting in an average intake of 90 g per day and per Icelander regardless of age.

The amount of sludge removed for landfilling and incineration, or to use as a fertiliser for land reclamation is used alongside the protein consumption to obtain the amount of nitrogen in effluent. The default value from the 2019 refinements to the 2006 IPCC Guidelines, for the nitrogen amount in domestic sewage treated sludge, is used (4.2% N/dry matter sludge).

Table 7.24 provides information on activity data used to estimate nitrous oxide emissions from Wastewater Treatment and Discharge in Iceland.

Table 7.24 Activity data used to estimate N_2O emissions from Wastewater Treatment and Discharge in Iceland; Protein consumption, amount of sludge removed and N in effluent.

	1990	1995	2000	2005	2010	2015	2020	2021
Protein consumption [kg/person/yr]	37.2	37.2	37.2	32.9	32.9	32.9	33.0	33.0
Sludge removed [kt DC]	6.0	5.5	6.0	4.9	3.9	3.3	3.3	3.9
N in effluent [kt N/year]	2.1	2.2	2.3	2.1	2.3	2.4	2.6	2.7

7.5.3 Emission Factors

Domestic Wastewater

The CH_4 emission factor for domestic wastewater treatment and discharge pathway and system is a function of the maximum CH_4 producing potential (B_O) and the MCF, see Equation 6.2 of the 2006 IPCC Guidelines.

Equation 6.2

$$EF_j = B_O * MCF_j$$

Where:

- EF_j = emission factor, kg CH_4 /kg BOD
- j = each treatment/discharge pathway or system
- B_O = maximum CH_4 production capacity, kg CH_4/kg BOD
- MCF_j = CH_4 correction factor (fraction)

The default B_o for domestic wastewater, 0.6 kg CH_4/kg BOD, was applied (Table 6.2 of the 2006 IPCC Guidelines). Seven known wastewater discharge pathways exist in Iceland. In addition, some wastewater goes to unknown pathways. These are shown in Table 7.25 along with respective shares of total wastewater discharge and MCFs.

Table 7.25 Domestic Wastewater discharge pathways fractions of MSW and population of Iceland since 1990.

		MCF	I-factor	1990	1995	2000	2005	2010	2015	2020	2021
Not known		0.5	1.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Collected – untreated systems	Not known into sea, river, lake	0.1	1.25	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00
	No treatment	0.1	1.25	0.75	0.72	0.49	0.28	0.24	0.21	0.10	0.10
Collected – treated systems	Primary treatment	0.1	1.25	0.02	0.03	0.26	0.41	0.45	0.55	0.76	0.76
	Secondary treatment	0.0	1.25	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02
	Tertiary treatment	0.0	1.25	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
Uncollected	Septic tank urban	0.5	1.00	0.03	0.05	0.05	0.07	0.04	0.00	0.00	0.00
	Septic tank rural	0.5	1.00	0.20	0.20	0.20	0.23	0.25	0.20	0.12	0.12
Population				253,785	266,978	279,049	293,577	317,630	329,100	364,134	368,792

Total CH_4 emissions from domestic wastewater were calculated with Equation 6.1 from the 2006 IPCC Guidelines.

Equation 6.1

$$CH_4\ Emissions = \left[\sum_{ij}(U_i * T_{i,j} * EF_j\right](TOW - S) - R$$

Where:

- CH_4 emissions = CH_4 emissions in inventory year, kg CH_4/yr
- TOW = total organics in wastewater in inventory year, kg BOD/yr
- S = organic component removed as sludge in inventory year, kg BOD/yr
- $T_{i,j}$ = degree of utilisation of treatment/discharge pathway or system, j, for each income group fraction i in inventory year
- i = income group: rural, urban high income and urban low income
- j = each treatment/discharge pathway or system
- EF_j = emission factor, kg CH_4 / kg BOD
- R = amount of CH_4 recovered in inventory year, kg CH_4/y

The parameter S has not been estimated for Iceland and is set to 0. The parameter R is set to 0 as well because no CH_4 from wastewater is recovered in Iceland.

Industrial Wastewater

The CH_4 EF for industrial wastewater is a function of Bo and the MCF, see Equation 6.5 of the 2006 IPCC Guidelines.

Equation 6.5

$$EF_j = B_O * MCF_j$$

Where:

- EF_j = emission factor, kg CH_4 /kg BOD
- j = each treatment/discharge pathway or system
- B_O = maximum CH_4 production capacity, kg CH_4/kg COD
- MCF_j = CH_4 correction factor (fraction)

The default B_O for industrial wastewater, 0.25 kg CH_4/kg COD, was applied (2006 IPCC Guidelines). Seven wastewater discharge pathways exist in Iceland. They are shown for industrial wastewater in Table 7.26 along with the respective shares of total wastewater discharge and MCFs.

Table 7.26 Industrial wastewater discharge pathways fractions for industrial wastewater since 1990.

		MCF	1990	1995	2000	2005	2010	2015	2020	2021
Not known		0.5	0	0	0	0	0.01	0	0	0
Collected – untreated systems	Not known into sea, river, lake	0.1	0	0	0	0	0	0.06	0	0
	No treatment	0.1	0.94	0.90	0.61	0.39	0.25	0.22	0.35	0.35
Collected – treated systems	Primary treatment	0.1	0.02	0.04	0.33	0.49	0.65	0.70	0.57	0.57
	Secondary treatment	0	0	0	0	0.01	0.01	0.01	0.09	0.09
	Tertiary treatment	0	0	0	0	0	0.01	0.01	0	0
Uncollected	Septic tank urban	0.5	0.04	0.06	0.06	0.11	0.07	0	0	0

Total CH_4 emissions from industrial wastewater were calculated with Equation 6.4 from the 2006 IPCC Guidelines.

Equation 6.4

$$CH_4\ Emissions = \sum_i [(TOW_i - S_i)\ EF_i - R_i]$$

Where:

- CH_4 emissions = CH_4 emissions in inventory year, kg CH_4/yr
- TOW_i = total organics in wastewater from industry i in inventory year, kg COD/yr
- i = industrial sector
- S_i = organic component removed as sludge in inventory year, kg COD/yr
- EF_i = emission factor for industry i, kg CH_4 / kg COD
- R_i = amount of CH_4 recovered in inventory year, kg CH_4/y

The amount of sludge (S_i) removed from septic systems cannot be distinguished from sludge removed during secondary treatment and was therefore set to zero. Since there is no recovery of wastewater CH_4, R_i was set to zero. The 2006 Guidelines emission factor for N_2O emissions from Domestic Wastewater is 0.005 kg N_2O-N/kg N.

7.5.4 Emissions

Total GHG emission estimates from Wastewater Treatment and Discharge have decreased compared to 1990. An overview of the emissions is shown in Table 7.27

Table 7.27 Emissions from wastewater treatment and discharge since 1990, calculated using GWP from AR5].

Emissions	1990	1995	2000	2005	2010	2015	2020	2021
Domestic Wastewater CH_4 [kt CO_2e]	19.8	21.4	22.4	25.6	27.0	24.3	22.2	22.5
Industrial Wastewater CH_4 [kt CO_2e]	36.2	38.8	48.1	40.8	21.6	24.8	17.8	20.8
Domestic and Industrial Wastewater N_2O [kt CO_2e]	4.30	4.53	4.73	4.40	4.77	4.94	5.48	5.55
Total [kt CO_2e]	**60.3**	**64.8**	**75.2**	**70.8**	**53.3**	**54.0**	**45.6**	**48.9**
Relative Change from 1990		7%	25%	17%	-12%	-10%	-24%	-19%

7.5.4.1 *Methane Emissions*

The various wastewater treatment systems in Iceland are attributed with different emission factors, ranging from 0 to 0.3 kg CH_4/kg BOD. Therefore, the share of the various wastewater treatment systems of the total wastewater discharge determines the amount of CH_4 emissions.

Domestic Wastewater

The correlation between biochemical oxygen demand and CH_4 emissions from domestic wastewater can be seen in Figure 7.12. CH_4 emissions from domestic wastewater were at their highest in 2008, when they reached 1.00 kt. The significant drop in emissions after 2008 was due to the construction of the *Kárahnjúkar* power plant being finished. The share of septic tank systems in the country was reduced when the construction site was closed after the power plant was completed.

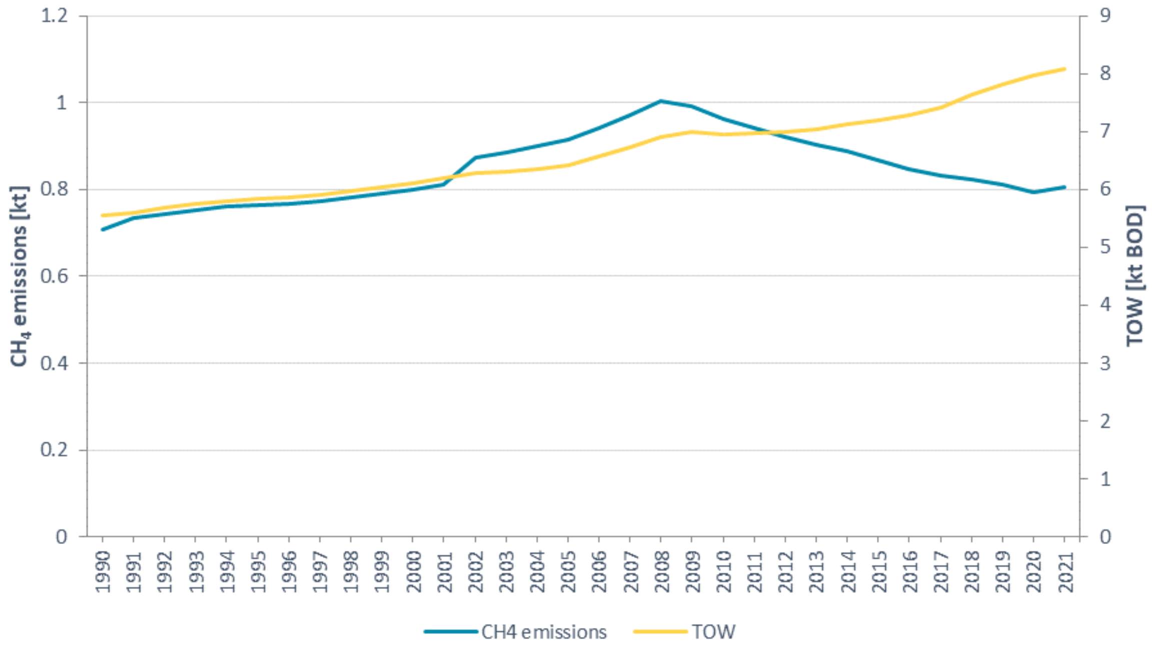


Figure 7.12 Methane emissions and total organics in domestic wastewater in Iceland since 1990.

Industrial Wastewater

The correlation between chemical oxygen demand and CH_4 emissions from industrial wastewater can be seen in Figure 7.13. CH_4 emissions from industrial wastewater were at their highest in 2002, when they reached 2.1 kt, and have been showing a downward trend since then due to less fish being processed domestically.

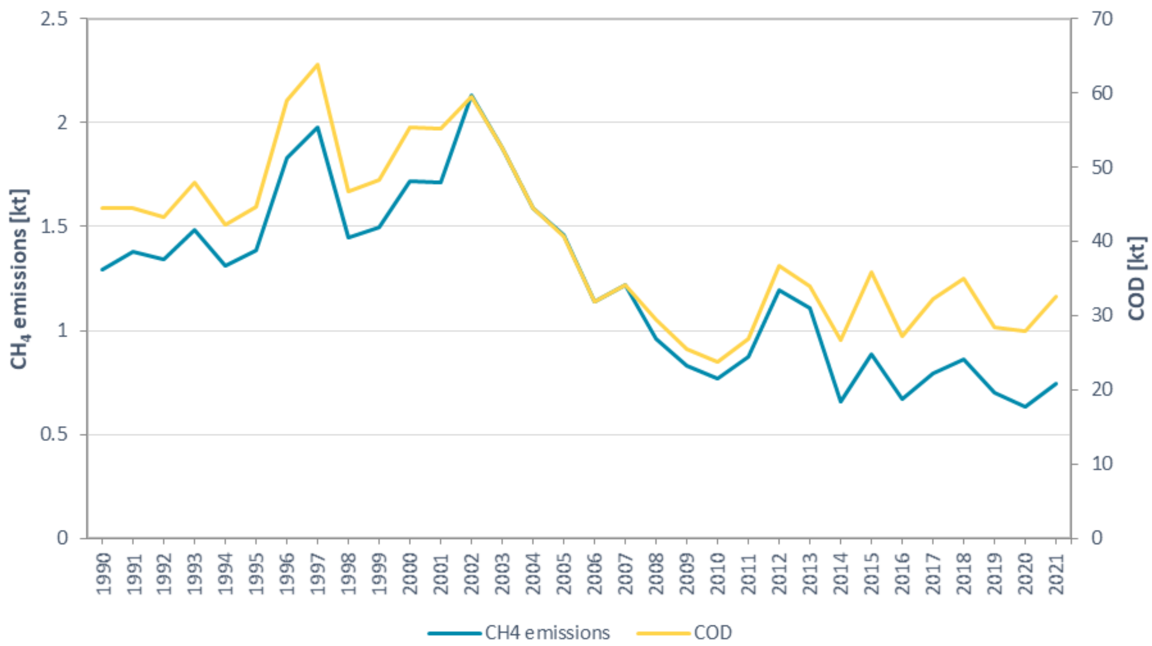


Figure 7.13 Methane emissions and total organics in industrial wastewater in Iceland since 1990.

7.5.4.2 *Nitrous Oxide Emissions*

In order to estimate N_2O emissions from wastewater effluent, $N_{EFFLUENT}$ was calculated using Equation 6.8 from the 2006 Guidelines. The nitrogen in the effluent is then multiplied with the EF and converted from N_2O-N to N_2O by multiplying it with 44/28 (molecular weight of N_2O/molecular weight of N_2). Emissions from sludge removed are accounted for in CRF categories 5A1a Managed Waste Disposal Sites and 5C11biv Waste Incineration - Biogenic - Other - Sewage Sludge, and under the Agriculture sector, CRF category 3D12b Organic Fertilisers Applied to Soils - Sewage Sludge.

The resulting emissions are shown in Table 7.27 and Figure 7.14. Emissions rose by 29% in 1990-2021. The main driver behind this development was a 45% increase in the population over the same time. The drop in emissions in 2002 was due to a new dietary survey which showed a decrease in protein intake (Steingrímsdóttir, Þorgeirsdóttir, & Ólafsdóttir, 2002).

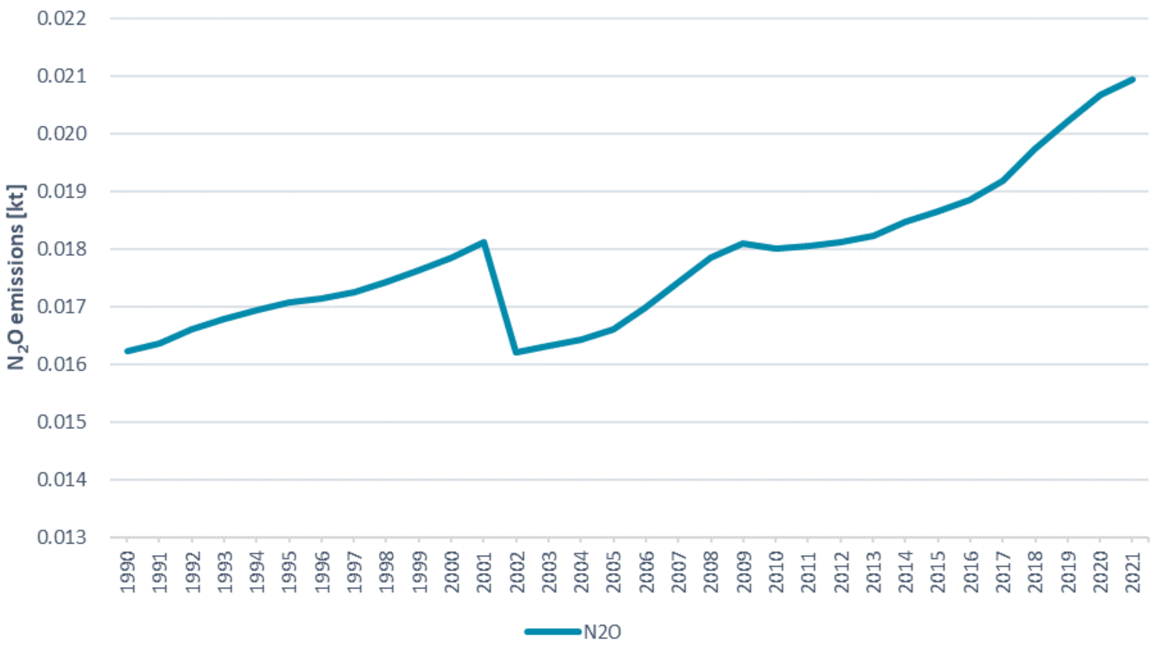


Figure 7.14 Emission estimates for N_2O from wastewater effluent since 1990.

7.5.5 Uncertainties

The activity data uncertainty of Domestic Wastewater was calculated to be 39% for CH_4 emissions and the EF uncertainty is 58% based on values from Table 6.7 of the 2006 IPCC Guidelines (Volume 5, chapter 6). The combined uncertainty for CH_4 emissions from Domestic Wastewater is, therefore, 70%. The activity data uncertainty of Industrial Wastewater was calculated to be 39% for CH_4 emissions and the emission factor uncertainty is 58% based on values from Table 6.7 of the 2006 IPCC Guidelines (Volume 5, chapter 6). The combined uncertainty is, therefore, 70%.

The activity data uncertainty of domestic wastewater for N_2O emissions is based on values from the 2006 IPCC Guidelines and is 44% while the emission factor uncertainty is calculated using the ranges given in Table 6.11 of the 2006 IPCC Guidelines and amounts to 2495%, giving a combined uncertainty of 2495%. The N_2O emissions from industrial are included in the domestic wastewater emissions and present therefore the same uncertainties mentioned above. The complete uncertainty analysis is shown in Annex 2: Assessment of Uncertainty.

7.5.6 Recalculations

7.5.6.1 *Recalculations for the 2023 Submission*

For the current submission, a recalculation was made in Sector 5D1 Domestic Wastewater due to changes in factors and in activity data (see Table 7.28). The fraction of nitrogen content in sludge was changed from 2% to 4.2%, i.e., the default value from IPCC 2019 Refinement, Table 2.4A, since the references behind the default value were considered better. Another recalculation was made in the fraction of treatment system in Iceland, so the fraction is interpolated between years where data is available. Before data was kept constant between input data. At the same time a human error in the calculations was discovered; the nitrogen content in sludge had been calculated as a fraction of the total weight of sludge instead of the dry weight. That has been fixed now. This update affects the whole timeline.

Furthermore, changes in activity data were made for 2019 and 2020. Following the publication of the 2019-2021 dietary surveys (Embætti landlæknis, 2022), the 2019 and 2020 values for protein consumption were updated from 32.9 to 33 kg/person/year.

Similarly, but impacting the CH_4 emissions in 2020, all fractions for treatment systems were updated following the publication of the 2020 status report on wastewater treatment in Iceland (EAI, 2022).

Table 7.28 Recalculation in 5D1 Domestic Wastewater due to changes in factors and in activity data.

CRF 5D1	1990	1995	2000	2005	2010	2015	2020
2022 v4 Submission [kt CO_2e]	23.89	25.75	26.91	29.30	27.21	29.97	33.20
2023 Submission [kt CO_2e]	24.11	25.96	27.13	30.03	31.73	29.25	27.72
Change relative to the 2022 Submission	0.9%	0.8%	0.8%	2.5%	16.6%	2.4%	-16.5%

A recalculation was also made in 5D2 Industrial Wastewater for 2020 (Table 7.29) due to updates in fractions for treatment systems (the same updates that were made in 5D1).

Table 7.29 Recalculation in 5D2 Industrial Wastewater due to changes in activity data.

CRF 5D2	2020
2022 v4 Submission [kt CO_2e]	19.25
2023 Submission [kt CO_2e]	17.83
Change relative to the 2022 Submission	-7.4%

7.5.6.2 *Recalculations from the 2022 Submission*

For the 2022 Submission, the sewage sludge used in Agriculture for land restoration purposes (CRF 3D12b) has been added to the amount of sludge removed in response to a question raised during the 2021 Centralised UNFCCC review (2021ISLQA115). This implies recalculations for the amount of sewage sludge removed and consequently for the N_2O emissions from 2012-2019. N_2O emissions are reduced on average by 0.15%.

7.5.7 Planned Improvements

The Industrial Wastewater category is currently only calculated for fish processing on land. For future submissions it is planned to add more industries and upgrade the methodology to Tier 2 for CH_4 emissions from Industrial Wastewater. Preliminary work on mapping the missing data has begun and completing the data set for various industries for the whole timeseries is a considerable project that will take a few years.

It is also planned for future emissions to include the additional emissions from Wastewater Treatment and Discharge from overnight stays associated with foreign visitors to Iceland.

8 Other (CRF Sector 6)

Iceland has no activities and emissions to report under the CRF Sector 6. Reporting of activities at *Climeworks*, an experimental Direct Air Capture (DAC) plant at the site of the *CarbFix* reinjection site (see also Chapter 3.4.1.2) is currently being investigated. The *Climeworks* project captures CO_2 from the atmosphere; the captured CO_2 is then injected into the subsurface in the *CarbFix* well, where CO_2 mineralises to form calcite ($CaCO_3$). More about *Climeworks* can be found here: www.climeworks.com.

9 Indirect CO_2 and N_2O Emissions

9.1 Indirect CO_2 Emissions

The only indirect CO_2 emissions estimated in Iceland's GHG Inventory are those occurring from atmospheric oxidation of NMVOC from road paving with asphalt and solvent use (CRF category 2D3). However, in order to comply with the reporting guidance provided in 2006 IPPC Guidelines related to the tracking of the non-energy use of fuels and in line with the reporting of other EU countries, EAI followed recommendations outlined in a Guidance document related to the reporting indirect emissions, distributed by Working Group 1 under the EU Climate Change Committee. Thus, CO_2 emissions from the oxidation of NMVOC in Category 2D3 are reported in CRF Tables 2(I)s2 and 2(I).A-Hs2, and not as indirect emissions in CRF Table 6, and the CO_2 emissions related to this are included in the national totals.

9.2 Indirect N_2O Emissions

Indirect N_2O emissions are calculated and reported in the Agriculture and LULUCF chapters. These emissions all count towards the national total and are discussed in the relevant sectoral chapters. No other indirect N_2O emissions are estimated.

Methodology, Recalculations, and Planned Improvements

For more information on these topics the reader is referred to the appropriate sections in the sectoral chapters.

10 Recalculations and Improvements

10.1 Explanations and Justifications for Recalculations, Including in Response to the Review Process

The Icelandic 2023 greenhouse gas emission inventory was recalculated for several sources. Detailed information on the recalculations can be seen below, as well as in the respective sectoral chapters. Recalculations are mostly due to reviewers' comments, changes in activity data or emission factors, tier upgrade or issues detected by the sectoral experts.

Table 10.1 and Table 10.2 show the difference between the total emissions in the 2023 Submission and the 2022 Submission, without and with emissions from the LULUCF sector, calculated with GWP from AR4. **Note:** Tables 10.1 and 10.2 are in kt CO_2e calculated using GPW values from **AR4**, to ensure consistency with the reporting tables and to be able to compare total numbers between last year's and this year's submission. Explanations for the differences are given in Chapter 10.3 Sector-specific Recalculations.

*Table 10.1 Total emissions according to the 2023 Submission compared to the 2022 Submission, [kt CO_2e] - without LULUCF. **Emissions calculated with GWP from AR4.***

Inventory Year	2022 Submission	2023 Submission	Change [kt]	Change [%]
1990	3,674	3,692	18	0.49
1995	3,506	3,519	13	0.37
2000	4,119	4,125	6	0.13
2005	4,019	4,017	-2	-0.04
2010	4,865	4,876	11	0.22
2015	4,746	4,741	-5	-0.11
2019	4,713	4,699	-14	-0.29
2020	4,510	4,493	-17	-0.38

*Table 10.2 Total emissions according to the 2023 Submission compared to the 2022 resubmission, [kt CO_2e] - with LULUCF. **Emissions calculated with GWP from AR4.***

Inventory Year	2022 Submission	2023 Submission	Change [kt]	Change [%]
1990	12,873	12,889	16	0.12
1995	12,681	12,694	13	0.10
2000	13,314	13,318	4	0.04
2005	13,251	13,244	-6	-0.05
2010	14,061	14,067	6	0.05
2015	13,853	13,843	-10	-0.07
2019	13,733	13,706	-27	-0.19
2020	13,519	13,511	-8	-0.05

10.2 Most Recent Reviews

10.2.1 EU Review 2023

In February 2023, the inventory underwent the yearly EU step 1 review checks ("initial checks"). All questions were answered and addressed, and appropriate changes were made for the 15 March submission.

10.2.2 UNFCCC Review 2022

Iceland's inventory submitted to UNFCCC in April 2022 was subjected to a UNFCCC centralised review during the week from 19 to 24 September 2022. The expert review team (ERT) raised some issues that were solved during the review week and led to recalculations of Iceland's inventory. Iceland therefore resubmitted the 2022 inventory data (CRF) to the UNFCCC on 23rd of September 2022. Iceland's 2022 National Inventory Report (NIR) was updated in accordance with the latest submission of 2022 (v4). Therefore, Iceland's official 2022 Submission is that of September 2022. The recalculations which led to the resubmission were linked to KP-LULUCF accounting quantities for Art. 3.4 Activity "Revegetation," and changed the available removal units for use for the second commitment period of the Kyoto Protocol.

10.2.3 EU Review 2022

In February 2022, the inventory underwent the yearly EU step 1 review checks ("initial checks"). All questions were answered and addressed, and appropriate changes were made for the 15 March submission.

10.2.4 UNFCCC Review 2021

Iceland's inventory submitted to UNFCCC in April 2021 was subjected to a UNFCCC centralised review conducted remotely during the week from 4 to 9 October 2021. The Provisional Main findings did not identify potential significant issues leading to technical corrections and Iceland did not need to resubmit the inventory following the review. Therefore, Iceland's official 2021 Submission is that of April 2021.

10.2.5 EU Review 2021

In 2021, the Icelandic inventory underwent the yearly "EU step 1 review checks."[36]

The review report was received by Iceland in April 2021 and the conclusions state that the checks performed did not identify any significant issue. Therefore, the GHG emissions data officially reported by Iceland by 15 March 2021 under the Monitoring Mechanism Regulation (Regulation (EU) 525/2013) will form the basis for the determination of the ESD emissions (Effort Sharing Decision No 406/2009/EC).

10.3 Sector-specific Recalculations

10.3.1 Energy (CRF Sector 1)

Recalculations were performed for the Energy sector for this submission, leading to a difference in GHG emissions between the 2022 and the 2023 Submissions amounting to +6.5 kt CO_2e for 2020, +7.8 kt CO_2e for 2005, and +6.9 kt CO_2e for 1990. A summary of the changes made are presented here, and further details are documented under the specific "recalculations" sections in each individual subcategory of Chapter 3 (Energy). There are various reasons that caused these recalculations:

- Iceland is now for the first time using a country-specific carbon content for gas/diesel oil, which affected CO_2 emissions for most Energy subcategories.

[36] cf. Art. 29, Commission Implementing Regulation (EU) 749/2014

- Version 5.6 of COPERT is now available and was used for this submission; the new version uses updated emission factors for certain fuels, causing recalculations in Road Transport.
- In 1A3b Road Transport, some diesel oil had been wrongly allocated to motorcycles, which do not use diesel oil. This fuel was reallocated properly to the other subsectors under 1A3b Road Transport, causing recalculations.
- In previous years, activity data for 1A2gvii Construction and 1A4cii Agricultural Machinery were reported as IE under 1A3eii Other Mobile Machinery. Activity data is now reported under 1A2gvii Construction and 1A4cii Agricultural Machinery as far back as 1990. The change in the subsector under which this activity data was reported caused recalculations.
- Small errors were made in how fuel sales were reported in 1A4ai Commercial/Industrial Stationary and 1A4bi Residential Stationary; diesel oil was wrongly reported under 1A4ai in 2019 and 2020 when it should instead have been reported under 1A4bi. This caused recalculations for these subsectors for 2019 and 2020.

10.3.2 Industrial Processes and Products Use (CRF Sector 2)

Recalculations were performed for the IPPU sector for this submission, leading to a difference in GHG emissions between the 2022 and the 2023 Submission amounting to 0.084 kt CO_2e for 2020, 0.079 kt CO_2e for 2005, and 0.081 kt CO_2e for 1990. A summary of the changes made are presented here, and further details are documented under the specific “recalculations” sections in each individual subcategory of Chapter 4 (IPPU). These recalculations were in the following subsectors:

- 2C2 Ferroalloys Production, recalculations were done for 2013, 2014, and 2015. Data on C-content of coke and amount of limestone was rounded before used in the emission calculations. Now the data with more significant figures is used. Also, the production amount used for CH_4 calculations for 2015 was updated for consistency within the inventory (rounding issue as well).
- 2C3 Aluminium Production, recalculations were done for 2013, 2014 and 2015. Activity data (anode consumption, C-content of anodes and emissions of CF_4 and C_2F_6) was rounded when used from the aluminium plants, through electronic reporting forms in accordance with the EU ETS. Now the data with more significant figures is used.
- 2D1 Lubricant use, recalculations were done for 2002, 2004-2006, 2011, 2012, and 2019 due to updated import/export data from Statistics Iceland (*Hagstofa Íslands*) (SI).
- 2D2 Paraffin was use, recalculations were done for 2012 and 2019 due to updated import/export data of candles from SI.
- 2D3 Other non-energy products from fuels and solvent use, recalculation were done for 1999-2000, 2009-2010, 2012-2015, and 2019 due to updated import/export data from SI.
- 2D3i De-icing was added for the first time for the 2022 Submission. Applies to the whole timeseries.
- 2F4a Metered Dose Inhalers, recalculations were done for 1990-2002 due to an update in population data. For 1990-2001, the emissions are based on population data, this data has been updated to ensure consistency within the inventory. The emissions from 2002 are also affected due to methodology used in the calculations.
- 2G4 Tobacco, recalculations were done for 2003, 2005, 2013, and 2019 due to updated import data from SI.
- 2G4 Fireworks, recalculations were done for 2012-2013 and 2019 due to updated import data from SI.
- 2H2, Food and Beverages, recalculations were done for 2013-2020 due to updated activity data which is based on a new survey on food consumption.

10.3.3 Agriculture (CRF Sector 3)

Recalculations were performed in the Agriculture sector for this submission, leading to a difference in GHG emissions between the 2022 and 2023 Submission amounting to -12.9 kt CO_2e for 2020, -6.9 kt CO_2e for 2005, and +16.4 kt CO_2e for 1990. A summary of the changes made is presented here and further details are documented under the specific “recalculations” sections in each individual subcategory of Chapter 5 (Agriculture). There are various reasons that caused these recalculations:

- Livestock parameters for all Cattle and Sheep subcategories were updated for the whole timeseries, from 1990-2020. These parameters include feed digestibility, animal weights, pregnancy rates, and time spent in various feeding situations. For Cattle subcategories the fractions of manure going to different manure storage pathways were also updated. For Sheep subcategories the ratios for how many lambs each ewe and female animal for replacement carried with them in pasture over the summer, were updated. The updated livestock parameters led to changes in emissions in CRF categories 3A1, 3A2, 3B11, 3B12, 3B21, 3B22, 3B25, 3D12, 3D13, and 3D2.
- The lamb population activity data was updated for 1990-2020. Due to a human error, incorrect AAP for lambs was used previously and updated pregnancy ratios also affect the population numbers. The updated livestock numbers led to changes in emissions in CRF categories 3A2, 3B12, 3B22, 3D12, 3D13, and 3D2.
- The methodology used to calculate horse population in Iceland was updated, resulting in recalculations for 2012-2020, affecting CRF categories 3A4, 3B14, 3B24, 3B25, 3D12, 3D13, and 3D2.
- Poultry population activity data was updated for 1990-2020. The number of pullets was adjusted according to their AAP, since chickens are only categorised as pullets until they are five months old. The number of turkey chickens and turkey hens were gap filled where activity data had been lacking. The recalculations affected CRF Categories 3A4, 3B14, 3B24, 3B25, 3D12, and 3D2.
- Recalculations were performed for Category 3D14 because of updated methodology for calculations of emissions from crop residues for 1990-2020.
- Shellsand application for liming purposes was moved from Category 3I to 3G, causing recalculations.
- Recalculations were done for Urea because of a data provider change from SI to the Icelandic Food and Veterinary Authority for 1990-2020. The new data is certain to include only Urea for fertiliser use. Category 3H is affected.
- CO_2 emission estimates, from the use of calcium ammonium nitrate fertilisers, where added for the whole timeline resulting in recalculations for Category 3I.

10.3.4 LULUCF (CRF sector 4)

Recalculations have been done to the LULUCF sector between the 2022 and 2023 Submissions, mostly due to revised area estimations. The effect of the recalculations on the emissions from the sector are shown in Table 10.3. A significant increase in total emissions is detected for 2020 according to the 2023 Submission compared to the 2022 Submission related to revised area for Settlements (see Section Settlements (4E)). Further explanations for the subsectors are also explained below.

Table 10.3 Total emissions from LULUCF according to the 2023 Submission compared to the 2022 Submission, [kt CO_2e]. (Emissions are calculated using global warming potentials (GWP) from the IPCC's 5th Assessment Report [AR5]).

Inventory Year	2022 Submission [AR5]	2023 Submission [AR5]	Difference [kt CO_2e]	Difference [%]
1990	9,612	9,610	-2	-0.02%
1995	9,588	9,587	-1	-0.01%
2000	9,605	9,604	-1	-0.01%
2005	9,640	9,635	-5	-0.05%
2010	9,601	9,596	-5	-0.05%
2015	9,511	9,506	-5	-0.05%
2020	9,413	9,421	8	0.08%

Forest Land (4A)

The emission/removal estimate for forest land has been revised in comparison to previous submissions. Area dependent sources as removal to litter and soil and emission from drained organic soil have been changed in relation to changes in the area estimate for each category and each year. The C-stock change of the biomass of the Cultivated Forest are as always revised for the last year of last submission in accordance with new data from the NFI sampled last summer.

Major revision of the C-stock change of biomass losses and dead wood CSC was conducted to make the reporting more complete.

Cropland (4B)

The area for this category was revised according to the revised estimate of the total area of the map layer of Cropland. The time series for the area of this category was subsequently revised in relation to the new total area for this category. Emissions of all pools depending on that area were recalculated accordingly. Emission/removal factors used for this category are unchanged except for C-Stock change factor in Cropland active and Cropland inactive (Fallow) which was corrected from 0.17 t C ha^{-1} yr^{-1} to 0.15 t C ha^{-1} yr^{-1} for 2022 Submission (see methodology in Chapter 6.6.1.2)

Grassland (4C)

The areas of Cropland abandoned for more than 20 years, and Cropland converted to Grassland were revised in relation to the revised estimate of the total area of the map layer of Cropland. The time series for the areas of these two sub-categories were revised according to the revised estimate of the total area of map layer Cropland. Emissions of all pools depending on those areas were recalculated accordingly. Emission/removal factors used for this category are unchanged.

Wetland (4D)

No specific recalculations have been made for this category.

Settlements (4E)

For the first time area estimation of Settlements has been constructed adopting Approach 3. The SCSI created four new urban areas maps in a certain time resolution (1990, 2000, 2010,2020, and 2021). Maxar Satellite Images, aerial images from National Land Survey of Iceland and *Loftmyndir ehf* were used for the purpose. The total area of Settlements has been revised, therefore, due to the revised estimate of the total area of the map layer. The time series for the area was subsequently revised in relation to the new total area for this category. Emissions of all pools depending on that area were recalculated accordingly. Emission/removal factors used for this category are unchanged (see methodology in Chapter 6.1.1 and category description in Chapter 6.9.1.1). The creation of the new 2021 urban area resulted in a significant increase of the land category Settlements. For the 2023 Submission, the area for the subcategory 4.E.2.3 All Other Grassland subcategories converted to Settlements, increases significantly resulted from the revised estimate of the total area of the map layer explained above. Consequently, the significant increase of net emissions detected for 2020 according to the 2023 Submission compared to the 2022 Submission (Table 10.3), is to be attributed to the increased urban area and consequently to the increased carbon losses related to biomass losses from this subcategory.

Other Land (4F)

No emissions are reported under this category.

Harvested Wood Products (4G)

C-stock changes were recalculated in this year submission as a calculation error was found in previous estimates.

Other (please specify) (4H)

N_2O emissions/removals estimate for “Other (please specify) 4H” and reported in CRF table 4(II) until 2019 submission, is moved from LULUCF sector to the Agriculture sector under the subcategory “Cultivation of organic soils” (3.D.a.6) in CRF table 3.D.

Emissions and Removals from Drainage and Rewetting and Other Management of Organic and Mineral Soils (4(II))

Recalculation of offsite CO_2 emission from drained organic soil of Forest Land was conducted as errors in former calculation was found and corrected. No other recalculations were done in this category.

Direct N_2O Emissions from N Mineralisation and Immobilisation (CRF 4(III))

No recalculations were done in this category.

Indirect N_2O Emissions from Managed Soils (CRF 4(IV))

See Agriculture.

Biomass burning (4(V))

No recalculations were done in this category.

10.3.5 Waste (CRF sector 5)

Recalculations were performed in the waste sector for this submission, leading to a difference in GHG emissions between the 2022 and 2023 Submissions amounting to -8.6 kt CO_2e for 2020, +0.18 kt CO_2e for 2005, and +0.22 kt CO_2e for 1990. A summary of the changes made is presented here and further details are documented under the specific “recalculations” sections in each individual subcategory of Chapter 7 (Waste). There are various reasons that caused these recalculations:

- 5A1a Managed Waste Disposal Sites, recalculations were done for the years 2019 and 2020 as CH_4 collection at the SWDS *Stekkjarvík* in northern Iceland was added.
- 5B1 Composting, recalculations were done because of a human error in the emission estimate file for the year 2020.

- 5C1 Waste Incineration, recalculations were done for 2020 and 2019 because final numbers for waste amounts incinerated in 2020 did not arrive until after the 2022 Submission and with it came corrections to the 2019 waste amounts.
- 5C2 Open Burning of Waste, recalculations were done for 2020 to account for the Twelfth Night bonfires held on 6 January that year. Previously emissions from 5C2 were considered zero because of COVID, but these bonfires were held before COVID reached Iceland.
- 5D1 Domestic Wastewater, recalculations were done due to changes in factors and activity data. The method for calculating the nitrogen amount in sludge was updated and an error fixed. This update affects the whole timeline, 1990-2020. Furthermore, changes in activity data were made for 2019 and 2020, following the publication of the 2019-2021 dietary surveys, changing slightly the value for protein consumption in Iceland. Also, all fractions for treatment systems were updated following the publication of the 2020 status report on wastewater treatment in Iceland.
- 5D2 Industrial Wastewater, recalculations were made for 2020 due to updated fractions for treatment systems, following the publication of the 2020 Status Report on Wastewater Treatment in Iceland.

10.4 Implications for Emission Levels and Trends, Including Time-series Consistency

The total emissions of GHG have changed for all inventory years due to the recalculations. Where applicable, all the years of the time series were recalculated. Changes are though within 1% of the totals, therefore the recalculations do not have a significant impact on emission levels and trends.

10.5 Overview of Implemented and Planned Improvements, Including in Response to the Review Process

Iceland’s 2022 Submission was reviewed during the UNFCCC centralised review conducted remotely.

Table 10.4 - Table 10.9 show the status of implementation of each general recommendation for each sector listed in the 2022 Provisional Main Findings received in October 2022 after the review week (according to paragraph 84 of the annex to decision 13/CP.20)

The following table shows the status of implementation of each general recommendation listed in Tables 1 and 2 of the 2022 Provisional Main Findings Report.

Table 10.4 Status of implementation of general recommendations in response to UNFCCC's review process.

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-impleme ntation	Chapter/ Section in the NIR
Article 3.14 (G.1, 2021) (G.10, 2019) KP reporting adherence	Report any changes in its information provided under Article 3, paragraph 14, of the Kyoto Protocol in accordance with decision 15/CMP.1 in conjunction with decision 3/CMP.11. Iceland reported in its NIR (p. 375) information under on minimization of adverse impacts in accordance with article 3, paragraph 14 of the Kyoto Protocol with the explanation that no changes have occurred since last submission.	FCCC/ARR/2022/ISL/G.1	Done.		
National registry (G.2, 2021) (G.2, 2019) (G.3, 2017) (G.4, 2016) KP reporting adherence	Include in the national registry disaster recovery plan information on the roles and responsibilities of primary and alternate registry personnel in disaster recovery; a communication procedure for the contingency plan; documentation for registry operation in a crisis situation; a periodic testing strategy based on procedures agreed with the registry host; and the time frame in which the registry could resume operations following a disaster. Party clarified during the review that the responsibility of the management of the registry rests with the European Union under the terms of the Agreement between the EU and its Member States, on the one part, and Iceland, on the other part, concerning Iceland's participation in the Joint Fulfilment of the commitments of the EU, its Member States and Iceland for the second commitment period of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (Brussels 11 November 2014). The original uptake of EU ETS Directive no. 2003/87/EC, which provides far all the obligations and commitments of Iceland regarding the EU registry, was done with Decision of the EEA Joint Committee No 146/2007, whereby the EU ETS directive was formally added to the EEA Agreement. The bilateral agreement on the joint fulfilment, from 11 November 2014, only refers briefly to the fact that Iceland is already part of the EU ETS; the main goal of the agreement is to set conditions for the emissions that do not fall under the EU ETS directive.	FCCC/ARR/2022/ISL/G.2	Solved during review.		

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-impleme ntation	Chapter/ Section in the NIR
QA/QC and verification (G.6, 2021) (G.6, 2019) (G.7, 2017) Convention reporting adherence	Report in the NIR complete information on the tools and spreadsheets used for QA/QC and present a summary of the revised QA/QC plan and manual once they are finalized. Iceland added more information on QA/QC tools and spreadsheets in the NIR (section 1.5) and an ongoing improvement plan (section 1.5.5, p. 18). During the review, the Party clarified that the full QA/QC Plan and manual will not be completed until the 2023 Submission.	FCCC/ARR/2022/ISL/G.3	The QA/QC procedures have been revisited and are now described in chapter 1.5, as well as in individual sectoral chapters.		Chapter 1.5 and sectoral chapters
QA/QC and verification (G.7, 2021) (G.11, 2019) Convention reporting adherence	Use the 2006 IPCC Guidelines as the only guidelines for QA/QC procedures and for assessing completeness and remove all outdated references to earlier IPCC guidelines from the NIR in order to improve its transparency and comparability. Iceland removed outdated references to earlier IPCC Guidelines in NIR sections 1.3.2, 1.6 and 1.7 and confirmed that it uses only the 2006 IPCC Guidelines for QA/QC procedures and assessing of completeness.	FCCC/ARR/2022/ISL/G.4	Done.		
Recalculations (G.9, 2021) (G.12, 2019) Convention reporting adherence	Improve the QC for the NIR to ensure that all changes affecting the recalculation of a given category are included in the description of the recalculations in the NIR and to ensure consistent reporting of the recalculations between the NIR and the CRF tables. Iceland clarified during the review that it has established a new procedure for documenting recalculations for the Energy, IPPU, Agriculture and Waste sectors, but that the new procedure is still to be implemented for the LULUCF sector.	FCCC/ARR/2022/ISL/G.5	In progress		
Inventory management	The Party reported in its NIR (p.5 chapter 1.2.3) that the Environment Agency’s ability to collect data is intended to be clarified through a revision to the Regulation No 520/2017. The NIR states that the Regulation will be revised to “include clearer definitions of responsibilities of the various institutions and other data providers involved, clearer deadlines and clearer provisions on what can be done if data providers fail to provide the data required as per the regulation.“ During the review, the Party advised that the planned revision to this Regulation had been delayed. Report in its next NIR on whether there have been any difficulties for the National Inventory	FCCC/ARR/2022/ISL/G.6	Done.		Chapter 1.2.3 and 12.

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-impleme ntation	Chapter/ Section in the NIR
	Compiler in obtaining data from data providers and to provide an update on progress with the planned revision to Regulation 520/2017.				
Inventory management	The Party reported in its NIR (p.5 chapter 1.2.2) that the Environment Agency is responsible for compilation of the inventory but that other agencies prepare estimates for certain categories in the inventory preparation. In certain cases, there has been insufficient co-ordination among agencies and/or quality control checks by the coordinating agency resulting in double counting, or omission, or a lack of transparency about the allocation of emissions (see #A.8/#L.29 where it was not clear from the submission whether emissions from biomass burning of field residues were reported in the Agriculture or LULUCF sector or #L.32 where a case of double counting of emissions from nitrogen fertilizer application was identified across the Agriculture sector and the Revegetation activity). Take specific measures to improve co-ordination among agencies and improve the quality control cross checks across the Agriculture and LULUCF reporting categories for future submissions.	FCCC/ARR/2022/ISL/G.7	In progress.		
Annual submission	Iceland did not report national total emission estimates with and without indirect CO_2 in the CRF 1ables 10.1-10.6. The ERT notes that Decision 24/CP.19, paragraph 29 states that “for Parties that decide to report indirect CO_2 the national totals shall be presented with and without indirect CO_2”. During the review, the Party provided a spreadsheet with tthe total national emissions with and without indirect CO_2 The ERT noted that emissions are estimated in line with 2006 IPCC and UNFCCC Annex I reporting guidelines. Report national total emission with and without indirect CO_2 in CRF tables 10.1-10.6. The ERT notes that this can be done by including the indirect CO_2 emissions either under the sectoral level or the national level in the CRF Reporter (that uses this information to automatically update the CRF tables 10.1-10.6).	FCCC/ARR/2022/ISL/G.8	Solved during review, where Iceland submitted Table 10s1 with totals including indirect CO_2 emissions.		Chapter 9 in the NIR.

10.5.1 Energy (CRF Sector 1)

Various improvements were planned and implemented in this most recent submission in the Energy sector. Iceland has now implemented a country-specific emission factor for CO_2 emissions for gas/diesel oil in most sectors which addresses various review recommendations. Charcoal usage is now being properly reported.

Issues regarding the Reference Approach (RA) have been a point of focus in this past submission. The EAI has worked closely with the NEA to improve the data reported in the RA, as well as identify the reasons for discrepancies between the RA and the Sectoral Approach (SA).

Table 10.5 Status of implementation in the Energy sector in response to UNFCCC's review process.

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
1. General (energy sector) – (E.3, 2021) (E.5, 2019) (E.18, 2017) Convention reporting adherence	Correct the errors and omissions in the national inventory, such as: (f) Missing use of charcoal. This issue is being considered under ID# E.17 below.	FCCC/ARR/2022/ISL/E.1	Addressed by ID# E.17		
Fuel combustion – reference approach – electrodes – CO_2 (E.4, 2021) (E.22, 2019) Convention reporting adherence	Remove the separate entries for electrodes from the reference approach and report the correct apparent consumption for the reference approach, allowing for meaningful comparison between the estimated CO2 emissions resulting from the two approaches across the time series and explain the planned recalculation for the reference approach in the next NIR. Iceland continues to report in CRF table 1.A(b) "NO" for electrodes for the entire time series under the rationale that all electrodes are used and reported in the IPPU sector. The Party reported in section 3.5.2 (p.79) of its NIR information reiterating this interpretation. However, in accordance with the UNFCCC Annex I reporting guidelines, data on the consumption of feedstock and non-energy use of fuels requires to be reported in CRF table 1.A(b), with the amount of C excluded entered in cell P37 of CRF table 1.A(b), and reported in CRF table 1.A(d) together with an indication of under which category these emissions have been reported (see also ID#E.4 below).	FCCC/ARR/2022/ISL/E.2	Implemented. Electrodes are now included under non-energy use of fuels and all Carbon is excluded. This ensure transparency whole also allowing for meaningful comparison between the reference approach and saectoral approach.		
Fuel combustion – reference approach – CO_2 (E.5, 2021) (E.26, 2019) Accuracy	Report the results of the data analysis by NEA in the NIR and ensure the use of consistent AD for the inventory estimates across the time series. Iceland reported the results of the data analysis in the NIR section 3.1.6 (p.46). According to the Party a comprehensive review was performed on how the fuels sales data from the NEA is attributed to IPCC sectors. The Party performed this analysis for the entire time series and harmonised methodologies from 1990 onwards.	FCCC/ARR/2022/ISL/E.3	Implemented		

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
Fuel combustion – reference approach – peat – CO_2 (E.7, 2021) (E.28, 2019) Convention reporting adherence	Report on peat consistently between the sectoral and reference approach. Iceland continues to report in CRF table 1.A(b) "NO" for peat consumption for the entire time series under the rationale that all peat is used for non-energy purposes (mostly gardening purposes), with no associated GHG emissions, and reported in its NIR (p.302) that this issue has been implemented. However, in accordance with the UNFCCC Annex I reporting guidelines, data on the consumption of peat used for non-energy purposes requires to be reported in CRF table 1.A(b), with the amount of C excluded, entered in the column "Carbon fraction excluded from reference approach" of CRF table 1.A(b), and reported in CRF table 1.A(d) together with an indication of under which category these emissions have been reported.	FCCC/ARR/2022/ISL/E.4	Implemented		
Fuel combustion – reference approach – solid, liquid and other fossil fuels – CO_2 (E.8, 2021) (E.29, 2019) Convention reporting adherence	Enhance the collaboration among NEA, IEA and relevant national authorities to resolve the errors detected in the data and report correctly in CRF table 1.A(b) the stock changes for coke oven/gas coke between 2007 and 2012 and make corrections to the emission estimates. Stock change values reported in the CRF table 1.A(b) for coke oven/gas coke between 2007-2012 is related only for sub-bituminous coal while for IEA it includes sub-bituminous coal and coke oven/gas coke. Therefore, AD is not disaggregated between sub-bituminous coal and coke oven/gas coke for these years in the CRF table1.A(b). The Party clarified that it will investigate this issue and will check if the numbers for stocks under coke oven/gas coke reported in the inventory are correct.	FCCC/ARR/2022/ISL/E.5	In progress		
Feedstocks, reductants and other non-energy use of fuels – liquid fuels – CO_2 (E.9, 2021) (E.30, 2019) Convention reporting adherence	(a) Correctly fill in CRF table 1.A(d) for lubricants. (b) Correctly estimate and consistently report the use of petroleum coke across the time series. (a) Iceland continues to report "IE" for CO_2 emissions under "CO_2 emissions from the NEU reported in the inventory" in CRF table 1.A(d) in cells I22 and I23 for lubricants and petroleum coke rather than specifying a value for these emissions in kt CO2. (b) Iceland improved the consistency of the reporting for petroleum coke in order to resolve the double counting of emissions between the energy and IPPU sector. The Party recalculated emissions under category 1.A.2.f (non-metallic minerals) for the years 2013-2019 by excluding petroleum coke from this category. Total emissions under category 1.A.2.f reduced by 0.07 – 0.13 kt CO_2e for 2013-2019. During the review, the Party clarified that petroleum coke was	FCCC/ARR/2022/ISL/E.6	Implemented		

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	only accounted in the energy sector for 2004-2007, when it was used by a cement factory, but since that factory closed in 2007 it has not been used in the energy sector since then.				
1.A Fuel combustion – sectoral approach – all fuels – CO_2 (E.10, 2021) (E.10, 2019) (E.21, 2017) Accuracy	Develop country-specific fuel properties (NCVs and carbon content of fuels) that would allow the tier 2 approach for key categories to be used in line with the 2006 IPCC Guidelines. Iceland reported in the NIR table 3.1 (p.43) the key categories for the Energy Sector and in table 3.2 (p.44) the used methodologies for each of the categories within the Energy Sector. The ERT acknowledges that the Party has developed country-specific NCV and c-content measurements for gasoline and diesel oil and applied a tier 2/tier 3 approach for key category 1.A.3.b (road transport) and a combined tier 1/tier 2 approach for key category 1.A.3.d (domestic navigation) and 1A4c (agriculture/forestry/fishing). However, the Party estimated emissions from key categories 1.A.2 (manufacturing industries and construction), 1.A.3.a (domestic aviation), 1.A.3.e (other mobile machinery), and 1.A.4.b (residential combustion) using a tier 1 approach with default NCVs and carbon content of fuels and has not provided an explanation in the NIR why it was unable to use a higher tier method. The ERT noted that this is not in accordance with paragraph 11 of the UNFCCC Annex I reporting guidelines, which states that Parties should make every effort to use a recommended method, in accordance with the corresponding decision trees in the 2006 IPCC Guidelines and explain in the NIR why it was unable to implement a recommended method in accordance with the decision trees in the 2006 IPCC Guidelines. In addition, the ERT acknowledges that the Party has included more information on how the EFs of CO_2 were derived by including section 3.3.3.2 on EFs in its NIR (p.66). However, this does not address the increase in the CO_2 EF for gasoline between 1990-2016, considering constant values of the c-content and NCV.	FCCC/ARR/2022/ISL/E.7	Partially implemented. Still need to investigate further he increase in the CO_2 EF for gasoline between 1990-2016.		
1.A Fuel combustion – sectoral approach – liquid fuels – CO_2 (E.11, 2021)	Report information on AD and emissions for the information item waste incineration with energy recovery in CRF table 1.A(a)s4. Iceland included in CRF table 1.A(a)s4 AD and emissions for the information item waste incineration with energy recovery for 1993-2013, biomass and fossil fuel. The Party reported in NIR section 3.2.1 (p.48) that from 2013 onward., no solid waste or fossil fuels were used for the production of heat because the district heating stations stopped burning waste for energy	FCCC/ARR/2022/ISL/E.8	Implemented		

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
(E.31, 2019) Convention reporting adherence	recovery. The Party accordingly reports NO after 2013 for both biomass and fossil fuels in CRF table 1.A(a)s4.				
1.A.2 Manufacturing industries and construction – solid and liquid fuels – CO_2, CH_4 and N_2O (E.12, 2021) (E.1, 2019) (E.2, 2017) (E.2, 2016) (E.2, 2015) (21, 2014) Transparency	Report information on (b) steam coal consumption and (c) petroleum coke consumption that provides justification for significant inter-annual changes and gaps in the time series of fuel consumption and associated emissions under category 1.A.2.f (non-metallic minerals). Iceland reported in the NIR (p. 46) the methodology used to harmonize AD (fuel consumption) from sales statistics and why zero consumption is used in some years of the times series for some fuels or why the inter-annual variation occurs. Further information is added in NIR (p. 52), where the Party explains that sales statistics do not fully specify by which type of industry the fuel is being purchased and that to address this issue, the major industries report their fuel use to the Iceland environmental agency along with other relevant information for industrial processes. The difference between the given total for the sector and the sum of the fuel use as reported by industrial facilities is categorized as category 1.A.2.g.viii (other non-specified industry). In addition, the Party also updated some estimates since the original recommendation that improved estimates for other bituminous coal and petroleum coke. For other bituminous coal (that due to a translation error was reported as steam coal in the 2014 NIR (p.54)), the Party applied NCV (25.8 TJ/kt) and carbon content (25.8 kg C/GJ) from the 2006 IPCC Guidelines as presented in NIR table 3.11 (p.52). For petroleum coke, the Party clarified that it is accounted in the energy sector only for 2004-2007, when it was used by a cement factory that closed since then. In the 2022 Submission the Party recalculated emissions under category 1.A.2.f (non-metallic minerals) because petroleum coke was accounted in the energy sector for the other years of the time series and doubled counted with the IPPU sector (see also ID# E.6).	FCCC/ARR/2022/ISL/E.9	Implemented		
1.A.3.a Domestic aviation – jet kerosene – CO_2, CH_4 and N_2O	Correct the allocation of the AD reported for jet kerosene in 2014 between category 1.A.3.a (domestic aviation) and 1.D.1.a (international aviation). Iceland corrected the allocation of jet kerosene for 2014 between categories 1.A.3.a (domestic aviation) and 1.D.1.a (international aviation). The Party reported in NIR section 3.3.2.4 (p.64) explanation on the recalculation performed and AD for 2014 in CRF table 1.A(a)s3 changed	FCCC/ARR/2022/ISL/E.10	Implemented		

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
(E.25, 2021) Comparability	from 542.43 TJ to 251.72 TJ and is consistent with the time series. Reallocation reduced AD in 2014 for category 1.A.3.a by 6.7 kt as indicated by the Party in the previous submission.				
1.A.3.b Road transportation – diesel oil – CH_4 and N_2O (E.15, 2021) (E.15, 2019) (E.25, 2017) Transparency	Update the NIR with the CH4 and N2O EFs used for estimating emissions from diesel oil in road transportation. Original issue asked the Party to recalculate CH4 and N2O emissions using default EFs from the 2006 IPCC Guidelines (3.9 kg CH4/TJ and 3.9 kg N2O/TJ respectively) and resubmit emissions estimates (in response to a Saturday paper), what was implemented by the Party in subsequent submissions. In 2020 submission the Party changed the reporting for road transport by using COPERT model, which uses a tier 3 methodology to estimate N2O and CH4 emissions. The range of the CH4 and N2O IEF are in accordance with what is being used by other European countries using COPERT. Further information on the methodology applied are in NIR p.65.	FCCC/ARR/2022/ISL/E.11	Implemented by using COPERT		
1.A.3.b Road transportation – gasoline – CO_2 (E.26, 2021) Accuracy	Verify the measured carbon content for gasoline and apply the correct value, based on the pure fossil fuel, for estimate CO_2 emissions. Explain in the NIR how the CO_2 EF was derived, including values and assumption for NCVs and carbon content and how the bioethanol is considered in the calculation of the CO2 EF. Iceland did not verify the measured carbon content for gasoline to ensure that the correct value (based on pure fossil fuel) is applied in inventory to estimate CO2 emissions for road transportation. The Party applied constant NCVs and constant measured carbon content for 1990–2016 and the CO2 EF varied in this period from 69,96–70,15 t CO2/TJ. The Party reports in NIR section 3.3.3 (p.65) that measurements of carbon content in gasoline used in road transport were done from fuel samples from 2019, with new measurements conducted in 2020. However, during the 2021 review, the Party clarified that the measured carbon content for gasoline was for the fossil fuel blended with bioethanol. For CO_2, emission factors mainly depend upon the carbon content of the fuel, and it is therefore important to measure the correct carbon content for gasoline, which can be different considering the inclusion of bioethanol. The ERT notes that when the Party calculate CO_2 EF from gasoline considering the blended bioethanol, there is probably an overestimation in the CO_2 emissions in the energy sector. This should be clarified by the Party.	FCCC/ARR/2022/ISL/E.12	Implemented.		3.3.3.4 Road transport Recalculations

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
1.A.3.b.i Cars – gasoline – CH4 and N2O (E.17, 2021) (E.32, 2019) Transparency	Explain in the NIR any significant inter-annual and trend changes in the AD, emissions and IEFs for CH_4 and N_2O emissions related to the use of gasoline for passenger cars. Iceland implemented the COPERT model for road transport for the whole time series since 2020 submission and explained in NIR section 3.3.3 (p.65) the methodology used in the estimations. For the CH4 EF no significant inter-annual and trend changes are observed. However, the N2O EF shows a considerable inter-annual variation between 2005 and 2006, during which it drops from 5.16 t N2O/TJ to 2.37 t N2O/TJ, respectively, and the related emissions drop from 0.034 kt N2O in 2005 to 0.016 kt N2O in 2006, which is not addressed and explained in the NIR.	FCCC/ARR/2022/ISL/E.13	Implemented.		
1.A.3.b.i Cars – biomass – CO_2, CH_4 and N_2O (E.18, 2021) (E.33, 2019) Transparency	Explain any significant inter-annual changes in the AD used for biomass and provide information on the EFs used for biofuels to justify any significant inter-annual changes in the biomass IEFs. Iceland recalculated emissions under this sector using COPERT model since 2020 submission. The CO_2, CH_4 and N_2O EFs for biomass in the 2022 Submission still present some inter-annual variation between 2012-2015, however, the ERT could not identify in the NIR explanation on the reasons for the annual changes or trends in AD and EFs or how EF was derived. The ERT notes that sales data from NEA is used as AD (NIR table 3.17. p.56). During the review the Party clarified that this issue will be addressed in next submission.	FCCC/ARR/2022/ISL/E.14	Implemented		
1.A.3.e Other transportation – liquid fuels – CO_2, CH_4 and N_2O (E.20, 2021) (E.35, 2019) Comparability	Investigate the possibility of separately estimating and reporting fuel consumption by splitting it between ground activities at airports and harbours (category 1.A.3.e.ii), agriculture and forestry (category 1.A.4.c.ii) and manufacturing industries and construction (category 1.A.2) by developing institutional cooperation or by extending the reporting obligations included in Icelandic regulation 520/2017, which is expected to be updated soon. Iceland performed recalculations (NIR, p. 62) to correct the allocation of fuels used for off-road vehicles for 2019 and 2020 on categories 1.A.3.e.ii (off-road vehicles and other machinery), 1.A.4.c.ii (agriculture/forestry/fishing: off-road vehicles and other machinery) and 1.A.2.g.vii (off-road vehicles and other machinery in construction), as follow: (a) Fuels used in ground activities in airports and harbours that were previously reported under category 1.A.2.g.vii are now reported under category 1.A.3.e.ii. (b) Fuels consumed under category 1.A.2 (manufacture industry and construction), that were previously reported under category 1.A.2.g.v are now reported under category 1.A.2.g.vii. (c) Fuels consumed under category 1.A.4.c.ii were revised due to a change in activity data reported by the NEA.	FCCC/ARR/2022/ISL/E.15	Implemented		

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	For 1990-2018, categories 1.A.2.g.v.ii and 1.A.4.c.ii are reported as IE and emissions included in 1.A.3.e.ii. During the review the Party explained that there is no sufficient data to make a distinction among the categories on the fuels consumed and that will extrapolate data back to 1990 in the next submission.				
1.A.4 Other sectors – liquid fuels – CO_2, CH_4 and N_2O (E.27, 2021) Comparability	Change the notation key from “NO” to “IE” in CRF table 1.A(a) (sheet 4) for other machinery used in the category 1.A.4.a.ii (off-road vehicles and other machinery under commercial/institutional) and include in the NIR where AD and emissions related to other machinery are reported. Iceland changed the notation key in CRF table 1.A(a)s4 and is now reporting “IE” for category 1.A.4.a.ii (off-road vehicles and other machinery under commercial/institutional) for the entire time series. The Party did not include information in the NIR regarding where AD and emissions related to other machinery are reported or indicated in CRF table 9 where the emissions have been included. However, the ERT considers that to provide information in CRF table 9 is sufficient to be in accordance with paragraph 37(d) of the UNFCCC Annex I reporting guidelines, which states that “Parties should indicate, in the CRF completeness table (table 9), where in the inventory the emissions or removals for the displaced source/sink category that are reported as “IE” have been included”.	FCCC/ARR/2022/ISL/E.16	Implemented		
1.A.4 Other sectors – biomass – CO_2, CH_4 and N_2O (E.21, 2021) (E.18, 2019) (E.27, 2017) Completeness	Collect AD on the consumption of charcoal, estimate emissions from charcoal consumption, report the corresponding CO_2 emissions as a memo item and include the non- CO_2 emissions in the corresponding CRF table and national totals. Iceland explained during the review that data on imports of charcoal for 2019-2021 was collected from Statistics Iceland with the amount of charcoal used in industry excluded from this data. Based on the emissions calculations for the charcoal imported and not used in industry, the GHG emissions are considered insignificant by the Party in terms of the overall level and trend in national emissions as it is approximately 0.03 kt CO_2eq per year, which is well below the significance threshold of around 2.35 kt CO_2eq. The ERT recognizes that emissions are insignificant and does not have impact on accounting for the second commitment period of the Kyoto Protocol, but these emissions should be included in the estimates because justification for exclusion based on the likely level of emissions should be applied at category level and not to parts of a category or subcategory in accordance with footnote 7 of the UNFCCC Annex I reporting guidelines.	FCCC/ARR/2022/ISL/E.17	Implemented		3.2.3 Commercial / Institutional, Residential, and Agricultural Stationary Fuel Combustion

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
1.A.4.c.ii Off-road vehicles and other machinery – (E.28, 2021) Transparency	Create a separate section in its NIR for providing information regarding off-road vehicles used in the category 1A.4.c.ii (off-road vehicles and other machinery in agriculture/forestry/fishing). Iceland created a separated section 3.3.1 in its NIR (p.60) that provides information on all categories related to mobile machinery, including 1.A.4.c.ii (agriculture/forestry/fishing: off-road vehicles and other machinery). The section covers mobile sources under categories 1.A.2 (manufacturing industries and construction), 1.A.3 (transport), and 1.A.4 (other sectors), which for the Party constitutes to categories 1.A.g.v.ii (off-road vehicles and other machinery in construction), 1.A.3.e.ii (off-road vehicles and other machinery), and 1.A.4.c.ii (agriculture/forestry/fishing: off-road vehicles and other machinery). The section describes the activity data, emission factors, emissions, recalculations, planned improvements, and uncertainties for these categories.	FCCC/ARR/2022/ISL/E.18	Implemented		
1.B.2.d Other (oil, natural gas and other emissions from energy production) – CO_2 and CH_4 (E.22, 2021) (E.19, 2019) (E.28, 2017) Transparency	Improve the description provided in the NIR of the methodology used to estimate the emissions from geothermal power plants, as this is a key category accounting for 11.1 per cent of the GHG emissions of the energy sector, by providing the necessary details in order to facilitate the replication and assessment of the inventory. Iceland included in the 2022 NIR more information related to the “Icelandic report on the emissions of geothermal power plants in Iceland in 1970–2009” on direct measurements used to estimate CO_2 and CH_4 emissions (see NIR section 3.4.2.3, p.77).	FCCC/ARR/2022/ISL/E.19	Implemented		
1.A Fuel combustion – sectoral approach – diesel oil – CO_2	Iceland reported in table 3.3 of its NIR (p.47) the emission factors used for calculations emissions from stationary combustion which shows that only for gas/diesel oil country specific NCVs were used from 2017, based on annual measurements. Furthermore, table 3.29 of its NIR (p.61), which shows the emission factors from mobile combustion reported under 1.A.2.g.vii (off-road vehicles and other machinery in construction), 1.A.3.eii (off-road vehicles and other machinery) and 1.A.4.cii (agriculture/forestry/fishing: off-road vehicles and other machinery), also indicates that only for diesel oil country specific NCVs were used from 2017, based on annual measurements. However, Iceland performed a country-specific measurement of carbon content for diesel oil in 2019, with a new measurement performed in 2020. The ERT noted that Iceland is only using the country-specific carbon content measurement value for category 1.A.3.b (road transportation) and does not apply this country-specific value to	FCCC/ARR/2022/ISL/E.20	Implemented		

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	estimate CO_2 emissions from diesel oil in other categories such as in stationary combustion and categories 1.A.2.g.vii, 1.A.3.e.ii and 1.A.4.cii. During the review, Iceland clarified that this was an error, and that the country-specific carbon content should have been applied to 1.A.2.g.vii, 1.A.3.eii, and 1.A.4.cii. Iceland recalculated the emissions for these categories for 2017, 2018, 2019, and 2020 as they should have been reported, and despite the error, the Party noted that the total change in emissions does not meet the threshold of significance in any of these years and will thus be fixed in the next submission. In 2017 and 2018, 1.A.2.g.vii and 1.A.4.cii were reported as IE, and were included as part of 1.A.3.e.ii The corrected emissions in 1.A.3.e.ii were 1.01 kt CO_2e and 1.04 kt CO2e lower than the originally reported values for 2017 and 2018, respectively. In 2019, the corrected emissions were 0.64 kt CO_2e lower than the originally reported value, as totaled for all three referenced categories. In 2020, the corrected emissions were 0.17 kt CO_2e higher than the originally reported value, as totaled for all three referenced categories. The ERT noted that the change in emissions is below the significance threshold of around 2.35 kt CO_2eq and that Iceland has therefore not included the emissions in the inventory at this time. Apply the country-specific carbon content value for diesel oil to estimate CO_2 emissions in stationary combustion categories and in 1.A.2.g.vii, 1.A.3.eii and 1.A.4.cii, which could allow Iceland to apply a tier 2/tier 3 approach.				
1.A.3 Transport – all fuels– CH4, N2O	Iceland reported in section 3.3.3 of its NIR (p.65) the use of COPERT 5.5.1. model to estimate the CH4 and N2O emissions from road transport and the country-specific activity data that was used for COPERT. The ERT noted that considerable inter-annual variations can be observed in the CH4 and N2O IEFs for gasoline and diesel oil during the 1990-2020 period. This is mainly observed for CH4 EFs, that reduces along the time series. The ERT acknowledges that CH4 and N2O emissions depend on vehicle technology, fuel, and operating characteristics, which differ for each vehicle and noted that the range of the IEFs is in accordance with what is being used by other European countries using COPERT, however, the ERT notes that no justification is provided in the NIR for explaining the trends and the reasons for the inter-annual variation of CH4 and N2O IEFs for gasoline and diesel oil during the 1990-2020 period. During the review the Party clarified that all emission factors in the COPERT model are based on the 2019 EEA/EMEP guidebook, which shows increased Euro standards for pollution control in 2020 compared to conventional technologies in 1990, and which influence the emission trends significantly. Provide sufficient verification information for the activity data in the COPERT model in section	FCCC/ARR/2022/ISL/E.21	Partially implemented		

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	3.3.3 of its NIR (p.65), such as technological improvements, changes in the fleet, or regulatory changes, to justify and verify the inter-annual changes in CH_4 and N_2O emissions as per paragraph 41 of the UNFCCC Annex I reporting guidelines that states that “Annex I Parties that prepare their estimates of emissions and/or removals using higher-tier (tier 3) methods and/or models shall provide in the NIR verification information consistent with the 2006 IPCC Guidelines”. The ERT notes that once the Party further clarifies the COPERT model parameters and the activity data used in section 3.3.3 of its NIR to justify and verify the inter-annual diesel oil and gasoline EFs variations for CH_4, and N_2O issues on ID#s E.11, E.13, and E.14 in table 3 could be resolved.				

10.5.2 Industrial Processes and Products Use (CRF Sector 2)

For this submission, the main improvement has been the addition of de-icing of airplanes to the inventory. Implemented recommendations from the latest UNFCCC review can be seen in the table below. For future submissions, it is planned to continue updating the 2F sector with ongoing efforts to obtain more information about pre-charged amounts and data on recovery. EAI also plans to further investigate the usage of PFCs which is not within 2F1 and the usage of SF_6 which is not within electrical equipment.

Table 10.6 Status of implementation in the IPPU sector in response to UNFCCC's review process.

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter / Section in the NIR
2. General (IPPU) – CO_2, HFCs, PFCs, SF_6 and NF_3 (I.1, 2021) (I.1, 2019) (I.1, 2017) (I.3, 2016) Transparency	Report in the CRF tables emission estimates or the relevant notation keys, as appropriate, for the subcategories glass production (2.A.3), ammonia production (2.B.1), adipic acid production (2.B.3), soda ash production (2.B.7) and electronic industry (2.E), and for foam blowing agents (2.F.2), fire protection (2.F.3), solvents (2.F.5) and other applications (2.F.6). Iceland reported in its CRF Table2(I).A-Hs1 notation keys for the subcategories glass production (2.A.3), ammonia production (2.B.1), adipic acid production (2.B.3) and soda ash production (2.B.7). In CRF table 2(II) there were still blank cells for subcategories 2.E.1 to 2.E.4 (under electronic industry (2.E)) and for foam blowing agents (2.F.2), fire protection (2.F.3), solvents (2.F.5) and other applications (2.F.6). During the review, the Party acknowledged the existence of these blank cells and clarified that notations keys in CRF table 2(II) were not uploaded due to a technical problem with CRF Reporter.	FCCC/ARR/2022/ISL/I.1	Clarified during review.		
2.C.2 Ferroalloys production – CO2 (I.9, 2021) Convention reporting adherence	Correct the NIR table 4.4 (p.78) to reflect the correct emission as reported in CRF table 2(I)A-H (sheet 2). Iceland corrected the NIR table 4.4 (p.89) to reflect the correct emissions as reported in CRF table 2(I).A-Hs2 for selected years of the time series. For example, for 2020, emissions in the CRF table for ferroalloys production was 415.30 kt of CO2 and 0.12 kt for CH4 totalizing 418.35 kt CO2eq. Emission reported in the NIR in table 4.4 is 418 kt CO2 eq and these number are consistent.	FCCC/ARR/2022/ISL/I.2	Implemented.		
2.D.2 Paraffin wax use – CO2 (I.10, 2021) Transparency	Include in the NIR more detailed information on the methodology and assumptions used to estimate emissions from paraffin wax, as explained during the review. Iceland included in the NIR section 4.5.2 (p.96) the required information i.e. that paraffin wax consumption is calculated from the AD in tones multiplied by the NCV value of 40,2 TJ/k and that since the AD is twofold, it calculates the emissions considering both from candles and other paraffin as follow: (a) emissions from paraffin from candles based on net consumption of candles; (b) emissions from paraffin (without candles) based on net consumption of paraffin (without candles). To be able to add the two, the net consumption of candles is multiplied by the factor 0.66 since not all of the candle activity data is made of paraffin	FCCC/ARR/2022/ISL/I.3	Implemented.		Paraffin Wax Use (4.5.2)

10.5.3 Agriculture (CRF Sector 3)

It is planned to adapt and check the Icelandic inventory against the 2019 IPCC Refinements to be fully consistent with emission factors and methodologies. Transparency of the inventory will continue to be improved and sector specific QA/QC procedures will be developed further.

Iceland improved the livestock characterisation data for all Cattle and Sheep categories for the 2023 Submission by working with the Icelandic Agricultural Advisory Centre (*Ráðgjafamiðstöð landbúnarðarins*) (IAAC). New data was obtained for 1990, 1999, 2005, 2010, and 2019-2021 and the IAAC advised on how best to interpolate between the data points. Previously, similar data had been obtained for 2018 for Mature Dairy Cattle and Lambs.

Iceland is continuing to work on improving the quality of the animal characterisation data by working with the Ministry of Food, Agriculture, and Fisheries (*Matvælaráðuneytið*) (MFAF) and the IAAC with the aim of updating animal characterisation parameters regularly for all livestock categories.

Other planned improvements that were implemented for this submission are crosschecking the value used for the amount of bedding material for Cattle with national expertise in Iceland, research of the use of other organic fertilisers in Iceland and research on emissions from the use of calcium ammonium nitrates (CAN) as fertiliser to assure the completeness of the inventory. The bedding material amounts were updated and emissions from CAN were added to the inventory. An effort was made for this submission to ensure that no underreporting of organic fertiliser use is taking place in the Icelandic inventory, but the results were inconclusive.

For future submissions, it is planned to obtain measurements of emissions from manure storage on sheep farms. First steps regarding this cooperation have been undertaken and the plan is for these measurements to be available within the next few years.

Preliminary steps will be undertaken to look into defining a country specific FracLeachMS based on a 2021 UNFCCC review recommendation.

Table 10.7 Status of implementation in the Agriculture sector in response to UNFCCC's review process.

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-impleme ntation	Chapter/ Section in the NIR
3. General (agriculture) – CH4 and N2O (A.3, 2021) (A.3, 2019) (A.9, 2017) Accuracy	Update productivity data, in particular the weight categories for cattle, poultry productivity (live weight and living age) and swine productivity (piglets per sow) and include in the improvement plan activities to update the productivity data at regular intervals. Iceland updated since the previous review animal characterization data for mature dairy cattle for 2018-2020, for lambs for the years 2003-2020, and for mature ewes in 2018-2020. The weights for mature dairy cattle and lambs were also updated since the last review and are increasing over time. NIR tables 5.9 and 5.10 (pp. 135 and 137) show the characterisation of cattle and sheep. During the review the Party explained that another update of this data is planned for the 2023 Submission. The Party also explained that weights of other animal categories are stable for the whole period. Regarding poultry, the Party explained during the review that living age is used to estimate annual average populations from production data. The living age was mostly constant over time but it was updated in 2021 with new information from an expert. The living age were updated and changed slightly from 2018-2020. The live weights of poultry are constant over time. Based on the expert information, the categorization of poultry was updated in the 2022 Submission (see NIR sections 5.2.1, pp.132-133 and 5.2.4.1, p.143). For sows, the productivity (piglets per sow) is not presented in the NIR but, according to the Party, it was also updated in 2021 submission with new information from an expert. The age of slaughter for pigs changes over time (5.4-7.1 months) given in table 5.5 on p.133. The Party included in its improvement plan that it will update animal characterization parameters regularly for all livestock categories (p. 143). Upon an additional question, Iceland responded that the average lifetime of piglets was 215 days in the year 1990, then 180 days from 1991-1994. The lifetime of piglets has stayed the same, 165 days, since 1995. This has been confirmed by experts in 2005, 2012 and 2020. The number of piglets per sow has increased from 15 on average in 1990 to 26.5 on average in 2020. The number of piglets per sow was most recently changed from 25 to 26.5 on average in 2020. These numbers are received from expert farmers who have many years of experience in this field. Also, a spreadsheet with the productivity data for piglets was	FCCC/ARR/2022/ISL/A.1	Implemented. Information on animal population data has been expanded in the NIR to include separate descriptions and tables for all animals with a lifespan shorter than one year, including lambs, piglets, kids, foals and poultry.		Animals with a lifespan shorter than one year (5.2.1.1)

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	presented to the ERT for transparency for the years 1990-2020 in 5 year intervals. The ERT considers that the recommendation has not been fully addressed because sows data was not presented in the NIR, however, during the review, the Party submitted it to the ERT				
3. General (agriculture) – (A.28, 2021) Transparency	Clarify in the NIR how the population for horses is estimated by adding some explanations on the methodology applied for the inclusion of foals. Iceland did not include in the NIR explanation to clarify the reasons for the difference in the population of horses between NIR table 5.8 (p. 135) (e.g. 71,747 for 2020) and the CRF tables 3.As1 and 3.B(a)s1 (e.g 73,583 for 2020). During the review, the Party clarified that the horse population numbers in NIR table 5.8 only include mature horses (e.g. the number reported as the population number for 2020), not the total population including foals. The population numbers reported in CRF tables 3.As.1, 3.B(a)s1, 3.B(b), are the total number of horses (mature horses and foals). The ERT considers that a footnote to NIR table 5.8 could resolve this issue.	FCCC/ARR/2022/ISL/A.2	Implemented. Explanations of horse population numbers have been improved in chapter 5.2.1 and a footnote has been added to Table 5.8. Furthermore, a detailed explanation on the calculation of of the foal population has been added to chapter 5.2.1.1.		Animal population data (5.2.1), Animals with a lifespan shorter than one year (5.2.1.1)
3. General (agriculture) – (A.29, 2021) Transparency	Present in the NIR additional explanations on the calculations implemented to estimate the population of young animals by indicating for each species the productivity (number of births per year), the rate of pregnancy and the early mortality considered. Iceland provided additional explanation on the calculations implemented to estimate the population of young animals by the addition of table 5.6 (p.133) in the NIR. However, the data in the table does not transparently described how calculations to estimate the population of young animals were implemented. It was also not clear how productivity (number of births per year), rate of pregnancy and early mortality is considered.	FCCC/ARR/2022/ISL/A.3	Implemented. Explanations of the calculations to estimate the population of young animals have been expanded in chapter 5.2.1.1.		Animals with a lifespan shorter than one year (5.2.1.1)

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-impleme ntation	Chapter/ Section in the NIR
3.A.1 Cattle – CH4 (A.8, 2021) (A.30, 2019) Accuracy	Justify the appropriateness of the current parameters and/or update the input parameters and consequently the CH4 EF for future submissions, as planned. Iceland did not provide a justification of the parameters nor updated the input parameters. During the review, the Party indicated that there were no updates available regarding the livestock parametrization of other mature cattle. These parameters will be updated when such data will become available. The Party further explained that the Agricultural Advisory Centre is currently collaborating with the Environment Agency to update the parameters for future submissions.	FCCC/ARR/2022/ISL/A.4	Implemented. Parameters for cattle have been updated for this submission.		Livestock Population Characterisation (5.2.2), CH4 Emissions from Enteric Fermentation (CRF 3A) (5.3)
3.A.1 Cattle – CH4 (A.11, 2021) (A.33, 2019) Transparency	Revise the explanation of CH4 estimates for mature dairy cattle in the NIR by indicating the use of the Cfi value from the 2006 IPCC Guidelines and ensure that the approach is used consistently across the time series. Iceland revised the explanation of CH4 estimates for mature dairy cattle and indicated in the NIR table 5.11 (p. 138) the current Cfi value used in the calculations (0.3755) in accordance with the 2006 IPCC Guidelines. The CH4 IEF is between the default IPCC Range (90-128 kg CH4/head/year) for the entire time series.	FCCC/ARR/2022/ISL/A.5	Implemented. The Cfi value is included in Table 5.16.		Livestock Population Characterisation (5.2.2)
3.D Direct and indirect N2O emissions from agricultural soils – N2O (A.30, 2021) Convention reporting adherence	Correct the reported value for FracGASM for the entire time series (e.g. for 2019 from 0.158 to 0.132 by adding NH3 and NOx from other organic fertilizers, animal manure applied to soils and urine and dung deposited from grazing animals). Iceland corrected the value for FracGASM, for the entire time series, by adding NH3 and NOx from other organic fertilizers, animal manure applied to soils and urine and dung deposited from grazing animals (see NIR section 5.8.5.1, p.172).	FCCC/ARR/2022/ISL/A.6	Implemented.		Recalculations (5.8.5)
3.D.b.1 Atmospheric deposition – N2O (A.24, 2021) (A.23 2019) (A.24, 2017) Accuracy	Make a thorough examination of N flow to estimate emissions from N volatilized from atmospheric deposition reported in CRF table 3.D and consider including in the NIR a table with the overall mass balance of N, including information on N volatilized as NOX, nitric oxide and N2O. Iceland provided Figure 5.3 (p. 155) with the complete N flow applied to the categories 3B Manure Management and 3D Agricultural soils for the year 2020 (mass balance including information on N volatised as NOX, nitric oxide and N2O). Regarding N volatilization from	FCCC/ARR/2022/ISL/A.7	Implemented. The Nitrogen fluxes are demonstated in Figure 5.3.		Activity Data (5.2.2)

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	atmospheric deposition (category 3.D.b.1), the Party included the overall N volatilised, that included synthetic and other types of organic fertilizers.				
3.F Field burning of agricultural residues – CH_4 and N_2O (A.25, 2021) (A.24, 2019) (A.7, 2017) (A.5, 2016) (A.5, 2015) (54, 2014) Transparency	Include in the NIR additional information on the non-occurrence of the field burning of agricultural crop residues. Iceland reported in its CRF table 3.F that field burning from agricultural residues does not occur and used the notation key "NO". But, the text in the NIR (pp.173-174) does not provide any justification in this regard. Based on the information provided in the text (p.173-4) and the table 5.43 (p.174), it seemed that field burning of agricultural residues occurred in the country. During the review, the Party clarified in detail that hay is too valuable for bedding & feeding to be burned in Iceland and it searched from a variety of sources information on field burning which led to the conclusion that field burning of agricultural residues does not occur in Iceland. The Party explained in detail that field burning was banned with strict laws in 1992 (Act No 61/1992 – Law about the burning of straws and use of fire in open areas). Later laws almost closed the possibility to gain a permit, i.e. Act No 40/2015 (Law about the treatment of fire and fire prevention) and Regulation No 325/2016 about the treatment of fire and fire prevention. The ERT considers that the recommendation has not been fully addressed because the Party has not included the detailed information regarding the non-occurrence of field burning.	FCCC/ARR/2022/ISL/A.8	Implemented. Detailed information on the non-occurrence has been included in the NIR.		Field burning of agricultural residues (CRF 3F) (5.10)
3.G Liming – CO_2 (A.26, 2021) (A.39, 2019) Consistency	Implement the planned checks of the AD for the category and update them as planned and report CO_2 emissions from liming following the UNFCCC Annex I inventory reporting guidelines in future submissions, ensuring consistent reporting of the emissions across the entire time series under category 3.G. If the change is not made in the next submission, justify this in the NIR and include explanation of the allocation in CRF table 9. Iceland reported in CRF table 3.G-I, complete time series since 1990 for limestone thanks to an update in data collection from Statistics Iceland. Data for dolomite is however not available before 2002 and reported in the CRF tables as NE. During the review Iceland indicated that they contacted experts of the Agricultural University of Iceland and they clarified that dolomite has not been used in agriculture at that time, that is from 1990–	FCCC/ARR/2022/ISL/A.9	Implemented. The notation key has been corrected.		CO_2 Emissions from Limingm, Urea Application, Other Carbon Containing Fertilisers

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-impleme ntation	Chapter/ Section in the NIR
	2002. Just when one company started to import dolomite its use became more widespread. So, for dolomite the appropriate notation key for the period 1990–2002 is "NO" instead of NE. The trend of recent years, the low value of dolomites used for known years and the expert judgement presented by Iceland can justify the use of NO in this category for the period 1990–2002. The ERT considers that the recommendation has not yet been fully addressed because the Party has not yet corrected the notation key from NE to NO for dolomite for 1990-2002 in CRF table 3.G-I.				and Other (CRF 3G, 3H, 3I, 3J) (5.11)
3.I Other carbon-containing fertilizers – CO2 (A.27, 2021) (A.40, 2019) Consistency	Report CO2 emissions from other carbon-containing fertilizers consistently across the time series under category 3.I. If the change is not made in the next submission, justify this in the NIR and include explanation of the allocation in CRF table 9. Iceland reported in its CRF table 3.G-I, AD for other carbon-containing fertilisers since 2003. For 1990-2002 the notation key not occurring "NO" is reported. The Party reported in its NIR (p.176) that based on expert judgement from specialists at the Agricultural University and the Icelandic Agricultural Advisory Centre received in 2021, there was no- or very little shell sand used during these years. Therefore, it is now estimated as not occurring for the period 1990-2002. The ERT considers that the expert judgement presented by Iceland can justify the use of NO in this category for the period 1990–2002.	FCCC/ARR/2022/ISL/A.10	Implemented.		CO2 Emissions from Limingm, Urea Application, Other Carbon Containing Fertilisers and Other (CRF 3G, 3H, 3I, 3J) (5.11)
3.D.a.6 Cultivation of organic soils (i.e. histosols) – N2O	Iceland reported the area of cultivated organic soils (i.e. histosols) in CRF table 3.D. as 323,583.75 ha in 2020. The ERT noted that the sum of the areas of organic soils under cropland in CRF table 4.B (64,750.69 ha) and areas of organic soils under grassland in CRF table 4.C (283,093.49 ha), totalizing 347,844.18 ha, is 7.5 % more than those reported in CRF table 3.D. During the review, the Party clarified that in CRF table 3.D it is not included area of organic soils related to natural birch shrubland (recently expanded into other grassland) and natural birch shrubland (old) because these areas are neither considered as cultivated/managed cropland nor as cultivated/managed grassland. Indicate in the NIR the difference in the areas reported for cultivated organic soils under category 3.D.a.6 and the sum of the areas of organic soils under cropland and grassland in CRF table 4.B and 4.C and explain that the reasons for the difference in the area reported is because area of natural birch (old and recently expanded) are not considered in the	FCCC/ARR/2022/ISL/A.11	Implemented. An explanation of the difference in areas has been added to the NIR.		Cultivation of Organic Soils (5.7.2.6)

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-impleme ntation	Chapter/ Section in the NIR
	agriculture sector as these areas are neither considered as cultivated/managed cropland nor as cultivated/managed grassland.				
3.G Liming – CO2	Iceland reported “NE” for AD and CO2 emissions for category 3.G.2 (dolomite) in the CRF Table 3.G-I for 1990-2002. During the review, The Party clarified that it is an error and that the correct notation key should be NO. The Party also explained that for the 2021 submission it was confirmed by experts from the Agricultural University of Iceland and from the Agricultural Advisory Centre that no dolomite use was occurring in Iceland over those years. Correct the notation key from NE to NO for category 3.G.2 (dolomite) in CRF table 3.G-I for 1990-2002.	FCCC/ARR/2022/ISL/A.12	Implemented. The notation key has been corrected.		CO2 Emissions from Limingm, Urea Application, Other Carbon Containing Fertilisers and Other (CRF 3G, 3H, 3I, 3J) (5.11)

10.5.4 LULUCF and KP-LULUCF (CRF Sectors 4 and 7)

10.5.4.1 *Forest Land (4A)*

Data from NFI are used for the 14th time to estimate main sources of carbon stock changes in the cultivated forest where changes in carbon stock are most rapid.

Sampling of soil, litter, and other vegetation than trees, is included as part of NFI and higher tier estimates of changes in the carbon stock in soil, dead organic matter, and other vegetation than trees are expected in future reporting when data from re-measurement of the permanent sample plot will be available and analysed for C-content.

One can therefore expect gradually improved estimates of carbon stock and carbon stock changes regarding forest and forestry in Iceland. As mentioned before improvements in forest inventories will also improve uncertainty estimates both on area and stock changes.

10.5.4.2 *Cropland (4B)*

Cropland Remaining Cropland:

As indicated above improvements in the recording of Cropland in use is pending in relation to changes in payments of governmental support to agriculture. These changes include both recording of total area of harvested land and new and re-cultivated land, as well as spatial identification of this land. This new recording will be included in future submission, hopefully both as total area and as new map layers. This change is assumed to considerable improve the area estimate for cropland in use from 2017 and onward. The backward tracking of area of cropland in use is subjected to more uncertainty. This pending geographically explicit mapping of Cropland in use, will enable tracking of land conversion to and from the category Cropland. Additionally, the Registers Iceland (*Þjóðskrá Íslands*) (RI) is presently preparing map of cultivated land. These efforts will hopefully enable spatially explicit tracking of cropland in use and abandoned cropland.

The geographical separation of organic and mineral soils of the category is pending.

Land Converted to Cropland:

In this submission as in last year's submissions, time series of Cropland categories were used to estimate the area of each category. As described above improvements in recording of total area of cropland in use and new land converted to cropland as well as renewing of older hayfield have been implemented in connection with reforming of governmental support payments to agriculture. These changes also involve geographically recording of all land approved for payments. This new mapping is expected to be available for next submissions, considerable improving the area estimate of the category in future submission. The backward tracking of land converted to and from Cropland is also considered to be improved by this new data at least back to 2012.

Continued field controlling of mapping, improved mapping quality and division of cropland to soil classes and cultivated crops is planned in coming years. Information on soil carbon of mineral soil under different management and of different origin is important to be able to obtain a better estimate of the effect of land use on the SOC. Establishing reliable estimate of cropland biomass is also important and is planned.

Considering that the CO_2 emission from "Land Converted to Cropland" are recognised as key sources, it is important to move to a higher tier in estimating that factor.

10.5.4.3 *Grassland (5C)*

Grassland Remaining Grassland:

The total emission related to drainage of Grassland soils is a principal component in the net emission reported for the land use category. The total emission reported from drained soils of Grassland including “Grassland remaining Grassland,” “Land Converted to Grassland,” and N_2O emissions of drained land within these categories, is in this submission 6524.40 kt CO_2e making that component the far largest identified anthropogenic source of GHG in Iceland. Revision of area of drained land is pending, as new map of ditches is in progress. The estimation of this component is still based on T1 methodology and basically no disaggregation of the drainage area. Improvements in emission estimates for the grassland and other categories to adopt higher tiers is being prepared.

The results of the drainage control project are still to be fully analysed and are expected to improve the area estimate of drained land and the effectiveness of drainage.

SCSI now uses new mapping of the network of drainage ditches utilizing new satellite images and aerial photographs of much higher resolution and quality than used to create present map layer of drainage ditches. The plan is to finish this new mapping in mid-year 2018 and to utilise the new map in next submission. This new map of ditches will provide updated map of ditches and also, through comparison with aerial photographs from 2005-2008 now available for limited area, provide new estimate of changes in ditches network for the period 2005 to 2016.

Data for dividing the drained area according to soil type drained has been collected for a part of the country. Continuation of that sampling is planned, and the results used to subdivide the drained area into soil types.

The T1 EF for C-stock changes of drained soils is comparable to new data from in country studies (Guðmundsson & Óskarsson, 2014). Considering the amount of the emission from this category it is important to move to higher tier levels in general and define relevant disaggregation to land use categories and management regimes. That disaggregation is one of the main objectives of the IGLUD project and it is expected that analyses of the data already sampled will enable some steps in that direction.

The largest subcategory of Grassland, “Other Grassland,” is reported since 2021 Submission as two units: “Grazing areas” and “Grassland without grazing” (see Chapter 6.7). Severely degraded soils are widespread in Iceland as a result of extensive erosion over a long period of time. Changes in mineral soil carbon stocks of degrading land is potentially large source of carbon emissions. The importance of this source must be emphasised since Icelandic mineral grassland soils are almost always Andosols with high carbon content (Arnalds, Óskarsson, Gísladóttir, & Grétarsson, 2009; Arnalds & Óskarsson, 2009). Subdivision of that category according to management, vegetation coverage and soil erosion is pending. The processing of the IGLUD field data is expected to provide information connecting degradation severity, grazing intensity and C-stocks. This data is also expected to enable relative division of area degradation and grazing intensity categories. Including areas where vegetation is improving and degradation decreasing (Magnússon, et al., 2006).

In a recent report (Guðmundsson J. , 2016) potential emission and removal of greenhouse gasses from the category were identified and its range estimated. This report clearly shows the need to obtain better information on this land-use category and its soils.

One component pinpointed in this report is the effects of soil thickening on C-sequestration. The aeolian deposition of sand and dust on soil of grassland, as well as other land use categories, causes soil thickening. On vegetated land this soil addition will accumulate, carbon in the end. The deposition rate of aeolian materials of different regions in Iceland has been estimated by Arnalds (2010). The rate and variability of C-sequestration following this deposition is still not estimated. This potential carbon sink needs to be quantified and its variability mapped. The potential of the soil samples, collected in the IGLUD survey, to estimate this component will be explored.

Land Converted to Grassland:

The planned improvements described above for drained areas of "Grassland remaining Grassland" also applies for drained area of this "Land Converted to Grassland." The creation of a new map of the drainage network is presently in progress and expected to be finished in 2022; it is expected to provide a better estimate of recent changes in the ditches network, and thereby improved accuracy of the estimate of Land Converted to Grassland on drained soils.

Maps of Cropland in use are currently improving along with reformation of agricultural support payments. This improvement will enable better tracking of abandoned Cropland, i.e., Cropland Converted to Grassland or eventually to other categories.

Improvements in both the sequestration rate estimates and area recording for revegetation, aim at establishing a transparent, verifiable inventory of carbon stock changes accountable according to the Kyoto Protocol. It is expected that in the 2024 submission, all reclamation areas, both prior to and after 1990, will be revised, as well as the corresponding emission/removal factors, based on the ongoing NIRA update.

When implemented, these improvements will provide more accurate area and removal factor estimates for revegetation, subdivided according to management regime, regions, and age.

10.5.4.4 *Wetlands (4D)*

Wetlands Remaining Wetlands:

New digitisation of drainage ditches is ongoing, also including evaluation of excavation of new ditches in the period 2005-2016. Survey of extent of drainage in ditches surrounding was completed in 2014 and analysis of the data is pending. A new ditch map and re-evaluation of ditches effect is expected in next two years to lead to revision of area of drained wetlands, also likely to affect the estimate of intact mires.

Land Converted to Wetlands:

Improvements regarding information on reservoir area and type of land flooded are planned. Effort will be made to map existing reservoirs but many of them are not included in the present inventory. Introduction of reservoir specific emission factors for more reservoirs is to be expected as information on land flooded is improved. Compiling information on the ice-free period for individual reservoirs or regions is planned. Applying reservoir specific ice-free periods will decrease the uncertainty of emission estimates. Information on how emission factors change with the age of reservoirs is needed but no plans have been made at present to carry out this research.

The planned revision of the map of drainage ditches and deducted map layer of drained soils are especially likely to affect the estimate of wetland area.

Mapping of wetland restoration activity is available in printed form, but digitisation of those maps, is pending and will be included in the compilation of IGLUD land use map, when available.

Separation of intact mires to altitude, regions, soil classes, and drainage categories, and adoption of different emission factors is planned.

10.5.4.5 *Settlements (4E)*

There are no category-specific planned improvements for this category.

10.5.4.6 *Other Land (4F)*

No emissions are reported under this category.

10.5.4.7 *Harvested Wood Products (4G)*

There are no category-specific planned improvements for this category.

10.5.4.8 *Other (4H)*

There are no category-specific planned improvements for this category.

10.5.4.9 *Direct N_2O Emissions from N Inputs to Managed Soils (4(I))*

There are no category-specific planned improvements for this category.

10.5.4.10 *Emissions and Removals from Drainage and Rewetting and Other Management of Organic and Mineral Soils (4(II)*

There are no category-specific planned improvements for this category.

10.5.4.11 *Direct N_2O Emissions from N Mineralisation and Immobilisation (CRF 4(III))*

There are no category-specific planned improvements for this category.

10.5.4.12 *Indirect N_2O Emissions from Managed Soils (CRF 4(IV))*

There are no category-specific planned improvements for this category

10.5.4.13 *Biomass Burning (4(V))*

Recording of the area where controlled biomass burning is licensed is still not practiced. General awareness on the risk of controlled burning getting out of hand is presently rising and concerns are frequently expressed by municipal fire departments regarding this matter. Prohibition or stricter licenses on controlled burning can be expected in near future. This development might involve better recordkeeping on biomass burning.

Table 10.8 Status of implementation in the LULUCF and KP LULUCF sectors in response to UNFCCC's review process.

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
4. General (LULUCF) – (L.1, 2021) (L.1, 2019) (L.1, 2017) (L.2, 2016) (L.2, 2015) (67, 2014) Transparency	Enhance the transparency of the information in the NIR on the uncertainty analysis. Iceland reported in its NIR the additional information about uncertainty assessment related to forest land (pp.200, 205 and 243), and land converted to cropland (p. 212).	FCCC/ARR/ 2022/ISL/L .1	Implemented		
4. General (LULUCF) – CO2, CH4 and N2O (L.2, 2021) (L.2, 2019) (L.14, 2017) Convention reporting adherence	Conduct an uncertainty assessment of all carbon pools and gases in the LULUCF sector in accordance with decision 24/CP.19, annex I, paragraph 15. Iceland reported in its NIR information about the uncertainty assessment related to forest land (pp. 200, 205, 243) and for all carbon pools and gases (p. 243).	FCCC/ARR/ 2022/ISL/L .2	Implemented		
4. General (LULUCF) – (L.4, 2021) (L.30, 2019) Convention reporting adherence	Improve the QA/QC plan to avoid discrepancies in cross references between NIR sections and to ensure that section numbering is correct. Iceland improved cross references between the NIR sections. However, the ERT noted that there are still some discrepancies. During the review, the Party clarified that cross references are being checked by the NIR coordinator upon completion of the report. This is to be included in the QA/QC plan that should be ready for the 2023 Submission.	FCCC/ARR/ 2022/ISL/L .3	Resolved in 2022 Submission		
4. General (LULUCF) – (L.5, 2021) (L.31, 2019) Transparency	Provide transparent information in the NIR section discussing the land transition matrix on the use of the notation key "IE" where areas have been accounted for elsewhere. Iceland did not provide information in the NIR explaining about the land transition matrix and the use of the notation key "IE". The ERT noted that the Party reported IE for some land uses in CRF table 4.1 (cropland and wetlands (managed) converted to settlements, other land converted to cropland, other land converted to settlements). During the review, the Party clarified that the	FCCC/ARR/ 2022/ISL/L .4	Resolved in 2023 Submission		

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	information regarding the use of the notation key “IE” was added in the documentation box in CRF Table 4.1, and that the Party will improve the transparency regarding the use of the notation key “IE” where areas have been accounted for elsewhere in the 2023 Submission.				
Land representation – (L.6, 2021) (L.4, 2019) (L.2, 2017) (L.3, 2016) (L.3, 2015) (68, 2014) Transparency	Select the required information and organize it in a manner that enables the reader to clearly understand the data sources and their quality and the methodology used to derive the land representation. Iceland added the section 6.1.1 (p.181) to the NIR with description of the data sources, their quality and the methodology used to derive the land representation. However, the Party has not reorganized the information of land representation. The ERT considers that Iceland could improve the transparency of its reporting by providing the following information on land representation in an appropriate format (such as tabular) for each category: (1) the data sources; (2) the time series of raw data; (3) the methodology applied for filling in gaps in the raw data, if any; (4) the methodology applied, including assumptions and inferences, to derive the land category areas from the raw data; (5) the methodology applied for filling in gaps in the time series of areas, if any; (6) the transition time of the land category (for land in conversion categories); and (7) any other relevant information. During the review, the Party clarified that the organization of information in an appropriate format will be considered in future submissions.	FCCC/ARR/ 2022/ISL/L .5	Not resolved. The Party is working to improve this issue in future submissions.		
Land representation – (L.7, 2021) (L.5, 2019) (L.16, 2017) Accuracy	Improve the land representation data used to report LULUCF emissions and removals under the Convention by reconciling all data on areas contained in databases and land-use maps, as well as data collected from observations, including an estimation of uncertainties related to AD once land matrices are improved and updated. Iceland improved some inconsistencies of land areas detected between the land transition matrix (CRF table 4.1) and the corresponding CRF tables on carbon stocks (4.A, 4.B, 4.C and 4.E). The ERT observed that for CRF tables 4.D and 4.F the inconsistencies have remained. The ERT considers that the information provided by Iceland in sections 6.3 (p.192) and 11.2.2 (p.355) of the NIR has not been improved according to the previous recommendations. During the review, the Party clarified that very small inconsistencies between final areas in CRF table 4.1 and the corresponding total areas in CRF tables on carbon stocks for 4.C (Grassland) and 4.F (Other Land) still occur in the NIR. In the case of “Grassland” the inconsistency is only for the year 2007 where the final area in table 4.1 is 0.50 kha larger than the total area in CRF Table 4.C for the same year. In the case of “Other Land” inconsistencies are from the year 1991 to 2020 within a range from a maximum value of 0.03 kha (final area in Table 4.1 larger than CRF Table 4.F) to a minimal value of -0.80 kha (final area in Table 4.1 smaller than CRF Table 4.F). This can also be found in section 6.3 (p. 192). The party	FCCC/ARR/ 2022/ISL/L .6	Resolved in 2023 Submission. The information for inconsistencies of land areas detected between the land transition matrix (CRF table 4.1) and the corresponding CRF tables on carbon stocks are included in chapter 6.3 in section "Inconsistencies detected between CRF Table 4.1 and corresponding total areas in CRF tables"		Chapter 6.3 - section "Inconsistencies detected between CRF Table 4.1 and corresponding total areas in CRF tables" - NIR 2023

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	informed that it is working to improve the transparency of the land representation in future annual submissions.				
Land representation – CO_2 (L.8, 2021) (L.25, 2019) Transparency	Improve the transparency of the AD reporting by providing information on the uncertainties related to habitat type classification, especially in relation to separating wetlands from grassland and other land. Iceland did not provide uncertainties related to habitat type. The ERT noted that the Party indicated in its NIR (p.185) increasing areas of grassland corresponding to areas of other land previously considered unmanaged, where instead grazing activities occur. The ERT noted that habitat type map is updated regularly, and the last update was in 2020. During the review, the Party clarified that it is working to improve this issue in future annual submissions.	FCCC/ARR/ 2022/ISL/L .7	Not resolved. The Party is working to improve this issue in future submissions. See information in chapter 6.1.1 in NIR 2023		Chapter 6.1.1 - NIR 2023
4.A Forest land – CO_2 (L.10, 2021) (L.7, 2019) (L.3, 2017) (L.4, 2016) (L.4, 2015) (69, 2014) Transparency	Provide an additional description of the processes by which CSC and associated emissions and removals are estimated, including tables with raw data and intermediate outputs stratified by year and forest type. Iceland added in its NIR new tables showing areas, CSC per area unit (ha) and total CSC of biomass, litter and soil separately (see table 6.8 and 6.10, pp. 200 and 205). Additionally, graphs showing change in age of CSC or carbon stocks in the two main forest categories, cultivated forest and natural birch forest and the area of age classes were added (see figure 6.7 and 6.8, pp. 197 and 203).	FCCC/ARR/ 2022/ISL/L .8	Resolved in 2022 Submission		Chapter 6.5.1.2 and 6.5.2.2 -NIR 2023
4.A Forest land – CO_2 (L.11, 2021) (L.8, 2019) (L.17, 2017) Completeness	Improve the estimates of CSC under forest land, particularly by including estimates for the deadwood and litter carbon pools or provide an explanation in the NIR and in CRF table 9 of why these pools could not be estimated. Iceland reported net CSC of litter as notation key "NA" in CRF table 4.A including an explanation in its NIR (p. 173) about the use of tier 1 and the ERT considered CSC for litter During the review, the Party clarified that in cultivated forest CSC in deadwood, measured as lying deadwood on NFI plots, is reported in Grassland converted to Forest land. Dead wood CSC in other categories of cultivated forest is included in this estimate and reported as IE. For natural birch forest "The Stock-Difference Method" as described in Chapter 2.3.1.1. with Equation 2.8 in AFOLU (IPCC, 2006) was used to measure changes in carbon pools. Deadwood, meeting the definition of lying deadwood (minimum diameter 10 cm and minimum length 1 m) was not found on NFI plots in both the first (2005-2011) and the second (2015-2021) inventory. CSC in the Dead wood pool of natural birch woodland is therefore considered not occurring. The Party also clarifies that this information will be added to	FCCC/ARR/ 2022/ISL/L .9	Resolved in 2022 and 2023 Submission		Chapter 6.5.1.2 and 6.5.2.2 -NIR 2023

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	the NIR in future annual submissions together with information on IE in CRF table 9 and NO in natural birch forest categories.				
4.A Forest land – CO2 (L.12, 2021) (L.33, 2019) Convention reporting adherence	Provide transparent information in CRF table 9 for reporting "IE" where GHG emissions have been accounted for elsewhere and correct the notation key from "NE" to "NA" for litter carbon stock in the forest land remaining forest land categories. Iceland has corrected the notation key from "NE" to "NA" for litter carbon stock in the forest land remaining forest land category. The ERT noted that the Party has not provided transparent information in CRF table 9 and documentation box in CRF table 4.A about the use of the notation key "IE" for CSC in deadwood for forest land remaining forest land (category 4.A.1) and for other land converted to forest land (category 4.A.2.5). During the review, the Party clarified that the main source of deadwood is cutting activities and harvest activities that cannot be separated between forest land remaining forest land and land converted to forest land. The Party informed that for this reason, all CSC in deadwood is included in grassland converted to forest land. The Party clarified that the issue related to CRF table 9 would be provided in future annual submissions.	FCCC/ARR/ 2022/ISL/L .10	Resolved in 2022 and 2023 Submission		Chapter 6.5.1.2 and 6.5.2.2 -NIR 2023
4.A.2 Land converted to forest land – CO2 (L.13, 2021) (L.10, 2019) (L.18, 2017) Transparency	Include transparent information in the NIR on carbon stock for the land-use categories occurring in Iceland. Iceland has added new tables showing area, CSC per area unit (ha) and total CSC of biomass, litter and soil separately (see NIR table 6.8 and 6.10, pp. 200 and 205).	FCCC/ARR/ 2022/ISL/L .11	Resolved in 2022 Submission		Chapter 6.5.1.2 and 6.5.2.2 -NIR 2023
4.A.2 Land converted to forest land – CO2 (L.14, 2021) (L.11, 2019) (L.18, 2017) Accuracy	Implement the calculation methods in line with equations 2.15 and 2.16 of volume 4 of the 2006 IPCC Guidelines with instant oxidation of all amounts of living biomass and litter when making land-use conversions, unless Iceland can document that the carbon stock before land-use conversion is maintained in the land converted. The ERT noted that there is no additional information about the calculation methods in line with equations 2.15 and 2.16 of volume 4 of the 2006 IPCC Guidelines in section land converted to forest land in the NIR or documentation to prove that the carbon stock before land-use conversion is maintained in the land converted.	FCCC/ARR/ 2022/ISL/L .12	Resolved in 2022 Submission		Chapter 6.5.1.2 and 6.5.2.2 -NIR 2023

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
4.B.1 Cropland remaining cropland – CO2 (L.15, 2021) (L.34, 2019) Transparency	Provide information to justify the high EF for mineral soils in the next annual submission. Iceland provided more information in it NIR (section, 6.6.1.2, p. 208) for justifying the high EF for mineral soils. The Party also corrected the annual change of SOC for mineral soil of Cropland remaining Cropland from 0.1708 to 0.1525 tC/ha/year, after reviewing the original study on effects of different N fertilizers on soil properties	FCCC/ARR/ 2022/ISL/L .13	Resolved in 2022 Submission		Section 6.6.1.2 Methodology (NIR 2023)
4.B.1 Cropland remaining cropland – CO2 (L.35, 2021) Accuracy	Apply the correct CSC for mineral soils for active cropland (0.1525 tC/ha/year) and revise the CSC for mineral soils for inactive cropland, because cropland inactive is not under cultivation and the content of carbon in mineral soils should be different from cropland active. Iceland explained during the review that the EF factor for CSC in mineral soils was estimated for the first time in 2018 submission. It is only based on one study (Helgason 1975) and consequently the current data on Cropland is severely limited. Therefore, it was decided to use the same EF for CSC in mineral soils both for cropland active and for cropland inactive. The ERT noted that the Party reported in its NIR (p. 208) an explanation as to why it used the same value of SOC and so CSC for active and inactive cropland. The Party clarified that will consider this issue in future submissions.	FCCC/ARR/ 2022/ISL/L .14	Not resolved. The EF is only based on one study (Helgason 1975) and consequently the current data on Cropland is severely limited. Therefore, it was decided to use the same EF for CSC in mineral soils both for Cropland active and for Cropland inactive until we have data on which to calculate the appropriate EFs.		Section 6.6.1.2 Methodology (NIR 2023)
4.B.2 Land converted to cropland – (L.16, 2021) (L.13, 2019) (L.7, 2017) (L.11, 2016) (L.11, 2015) Accuracy	Estimate the area of forest land and other land that was converted to cropland before 1990 and report these values under the appropriate categories. Iceland has not reported new information in its NIR about the estimation of the area of forest land and other land that was converted to cropland before 1990. With regard to notation key "IE" for other land converted to cropland, the Party has included an explanation in the CRF table 9. During the review, the Party clarified that an analysis of the conversion of forest land to cropland in the period 1970 – 1989 has not been done but is planned to be conducted in coming years.	FCCC/ARR/ 2022/ISL/L .15	Not resolved. Lack of data. The Party will improve this issue in future submissions		

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
4.B.2.2 Grassland converted to cropland – CO_2 (L.18, 2021) (L.14, 2019) (L.8, 2017) (L.6, 2016) (L.6, 2015) (71, 2014) Accuracy	Ensure the equivalence of climatic, historical and edaphic conditions when analysing pairs of samples (i.e. in cropland and grassland) to determine the dynamic of the soil carbon stocks associated with conversion among the two land uses. Iceland has not made improvements to ensure the equivalence of climatic, historical and edaphic conditions when analysing pairs of samples (i.e. in cropland and grassland) to determine the dynamic of the soil carbon stocks associated with conversion among the two land uses. During the review, the Party explained that it is planning to improve this issue in future submissions.	FCCC/ARR/ 2022/ISL/L .16	Not resolved. Current data is very limited. The Party is working to improve this issue for future submissions.		
4.C Grassland – CO_2 (L.19, 2021) (L.15, 2019) (L.9, 2017) (L.7, 2016) (L.7, 2015) (72, 2014) (67, 2013) Completeness	Prepare estimates for the emissions from degraded areas of grassland. Iceland did not provide estimates for the emissions from degraded areas of grassland. During the review, the Party clarified that measurements and data collection from degraded grassland areas commenced in 2021 and that estimates of the emissions from these areas will be included in future submissions.	FCCC/ARR/ 2022/ISL/L .17	Not resolved		
4.C.1 Grassland remaining grassland – CO_2 (L.21, 2021) (L.16, 2019) (L.10, 2017) (L.12, 2016) (L.12, 2015) Accuracy	(a) Estimate and report CSC in mineral soils under grassland remaining grassland for “Natural birch shrubland – old” (b) Estimate and report CSC in mineral soils under grassland remaining grassland for “Revegetated land older than 60 years”. (a) Iceland reports the notation key “NA” for “natural birch shrubland – old” in the CRF table 4.C for CSC in mineral soils under grassland remaining grassland (and not more NE). The Party justified the use of NA explaining that CSC in mineral soils for natural birch shrubland is in equilibrium and it used a tier 1 approach, since “Natural birch shrubland – old” has more in common with natural birch forest than grassland, based on the survey results presented in the Iceland NFI and results	FCCC/ARR/ 2022/ISL/L .18	(a) Resolved regarding "Natural birch shrubland old" in the 2022 Submission. (b) Resolved regarding "Revegetated land older than 60 years"		Section "Revegetated Land Older Than 60 Years" and section "Naturar Birch Shrubland" in chapter 6.7.1.1

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	from various researches showing that cold temperate forests in general are adding C to soil. (b) Iceland reports the notation key "NA" for "revegetated land older than 60 years" in the CRF table 4.C for CSC in mineral soils under grassland remaining grassland (and not more NE). The Party explained that it assumed this pool also as in equilibrium and applied a tier 1 approach, however clarified that current data is very limited and the extent is small. The Party explained that it has set up monitoring plots at selected sites within this land category with the aim at improving the reporting and when the results are available it will evaluate and update estimates.				Category Description (NIR 2023)
4.C.1 Grassland remaining grassland – CO_2 (L.23, 2021) (L.37, 2019) Transparency	Improve the transparency of the reporting of CSC under grassland mineral soils for revegetated land older than 60 years by providing an explanation in the NIR and in CRF table 9 as to why estimates could not be produced for this pool for 1990–2015 and by reporting "NA" where CSC is assumed to be in equilibrium (i.e. zero). Iceland has used notation key "NA" for CSC under grassland mineral soils for revegetated land older than 60 years for complete time series in the CRF table 4.C. The Party provided additional information for revegetated land older than 60 years in NIR section 6.7.1.1 (215). The Party has also provided information in the "Documentation box" and in the relevant cells of the CRF tables for CSC mineral soils for revegetated land older than 60 years	FCCC/ARR/ 2022/ISL/L .19	Resolved in 2022 Submission		Section "Revegetated Land Older Than 60 Years" in chapter 6.7.1.1 Category Description (NIR 2023).
4.C.2 Land converted to grassland – CO_2 (L.24, 2021) (L.17, 2019) (L.19, 2017) Accuracy	Revise the CO_2 estimates for land converted to grassland using updated data on carbon sequestration in soils, especially for other land converted to grassland, and include in the NIR, in tabular format, the total estimates of CSC in living biomass, litter and soil, and the average CSC per area for the whole time series, in land converted to grassland and land converted to forest land. Iceland has not included new information about the review of the CO_2 estimates for land converted to grassland using updated data on carbon sequestration in soils, especially for other land converted to grassland or information on the total estimates of CSC in living biomass, litter and soil, and the average CSC per area for the whole time series, in land converted to grassland and land converted to forest land. The Party included in its NIR new tables showing area, CSC per area unit (ha) and total CSC of biomass, litter and soil for all land categories (p. 200, 205, 209, 212, 218, 224, 228, 230 and 235).	FCCC/ARR/ 2022/ISL/L .20	Resolved in 2022 Submission		Chapter 6.5.2.2 and 6.7.1.1.
4.D.1 Wetlands remaining wetlands – CO_2	Develop a country-specific methodology for managed wetlands that would allow it to use the tier 2 approach for key categories in line with the 2006 IPCC Guidelines. Iceland did not develop the CS methodology as required. During the review, the Party clarified that the it is working to improve this issue for future submissions.	FCCC/ARR/ 2022/ISL/L .21	Not resolved		

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
(L.26, 2021) (L.38, 2019) Accuracy					
4.D.1.2 Flooded land remaining flooded land – CO2 and CH4 (L.36, 2021) Accuracy	If reservoirs are defined as flooded land, use the methodology of the 2006 IPCC guidelines for flooded land (vol. 4, chap. 7.3, p.7.19). If reservoirs are considered as rewetted organic soils, then use the methodology of the wetlands Supplement (chap. 3). For the transparency of the report, include more information about the characteristic of the reservoirs in the NIR. The Party included additional text in its NIR section 6.8.1.1 (p 226) with more information about the characteristic of these specific reservoirs that improved transparency.	FCCC/ARR/ 2022/ISL/L .22	Resolved in 2022 Submission		Section "Mires converted to Reservoirs" in chapter 6.8.11 Category Description (NIR 2023)
4.D.2 Land converted to wetlands – CO2 (L.25, 2021) (L.18, 2019) (L.11, 2017) (L.13, 2016) (L.13, 2015) Transparency	Estimate and report CSC in mineral soils under land converted to wetlands. During the review, the Party clarified that it continues to report CSC in mineral soils under land converted to wetlands as “NE” because the 2006 IPCC Guidelines do not provide any methodology for estimating CSC in mineral soils under land converted to wetlands or flooded land, as noted already by the previous ERT. Additionally, the Party informed that it will continue to report CSC in mineral soils as “NE” under land converted to other wetlands and refilled lakes and ponds for future annual submissions. For the “Rewetted wetland soils” subcategory, the Party has provided additional information in the NIR 2022, section 6.8.2.1.	FCCC/ARR/ 2022/ISL/L .23	Not resolved. The Party will also continue to report CSC in mineral soils as “NE” under land converted to other wetlands refilled lakes and ponds (see nk explanation in Cell comments) for future annual submissions because the 2006 IPCC Guidelines do not provide any methodology for estimating CSC in mineral soils under land converted to wetlands or flooded land, as noted already by the previous		Chapter 6.8.2.1 Category Description (NIR 2023).

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
			ERT. For the “Rewetted wetland soils” subcategory, the Party has provided additional information in the NIR 2022 and 2023 in chapter 6.8.2.1.		
4.E.2 Land converted to settlements – CO2 (L.28, 2021) (L.20, 2019) (L.12, 2017) (L.14, 2016) (L.14, 2015) Completeness	Estimate and report CSC in mineral soils under land converted to settlements. During the review, the Party clarified that the Party is working to improve this issue for future submissions.	FCCC/ARR/ 2022/ISL/L .24	Not resolved		
4(I) Direct N2O emissions from N input to managed soils – N2O (L.37, 2021) Convention reporting adherence	Report the correct AD for inorganic fertilizer in CRF table 3.D for the entire time series and apply the correct notation key IE in CRF table 4(I) for AD explaining in the documentation box and in CRF table 9 where emissions are reported. Iceland reported in CRF table 3.D the correct AD for inorganic fertilizer for the entire time series and applied the notation key IE in CRF table 4(I) for inorganic fertilizer under category 4.A.2.1. In the documentation box the Party clarify that “under the LULUCF chapter it was decided to include the fertilizers used in Forestry under the total synthetic fertilizer in category 3.D.1. According to this decision use of inorganic fertilizers previously reported under land converted to forest land (grassland converted to forest land) have been replaced with IE”. However, the ERT could not find explanation in the CRF table 9.	FCCC/ARR/ 2022/ISL/L .25	Resolved in the 2023 Submission		
4(II) Emissions/removals from drainage and rewetting and other	Correct in the NIR the proportion of ditches for drained organic soils (the correct value is 2.5 per cent) Iceland corrected in the NIR the proportion of ditches for drained organic soils by indicating the correct value (2.5 per cent) in its NIR (p. 239)	FCCC/ARR/ 2022/ISL/L .26	Resolved in the 2022 Submission		

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
management of organic/mineral soils – CH4 (L.38, 2021) Convention reporting adherence					
4(III) Direct N2O emissions from N mineralization /immobilization – N2O (L.31, 2021) (L.40, 2019) Transparency	Report in the NIR the reasons for carbon accumulation on cropland soils, especially on mineral soils converted to cropland. Iceland explained in the NIR the reasons for carbon accumulation on cropland soils, especially on mineral soils converted to cropland. The Party provided additional information regarding the EF used for mineral soils in Cropland remaining Cropland in NIR section 6.6.1.2 (pp. 208-211). The Party indicated that the CSC factor for mineral soils in Cropland active and Cropland inactive (Fallow) has been corrected from 0.1708 tC/ha/year to 0.1525 tC/ha/year.	FCCC/ARR/ 2022/ISL/L .27	Resolved in the 2022 Submission. Additional information were added in NIR 2022 in section 6.6.1.2 for Cropland remaining Cropland and in section 6.6.2.2 for Land converted to Cropland.		Sections 6.6.1.2 and 6.6.2.2 in NIR 2022 and 2023
4(V) Biomass burning – CO2, CH4 and N2O (L.33, 2021) (L.24, 2019) (L.23, 2017) Convention reporting adherence	Correct the use of notation keys to report on emissions from biomass burning in CRF table 4(V). Iceland corrected the notation key for reporting the emissions from biomass burning. in its CRF table 4(V)	FCCC/ARR/ 2022/ISL/L .28	Resolved in the 2023 Submission		
4(V) Biomass burning – CO2, CH4 and N2O (L.34, 2021)	Include estimates of the emissions from biomass burning on cropland and grassland for the entire time series, or, if not, include information on the reporting of “NE” (both in the NIR and the CRF tables) and provide an explanation as to why these pools could not be estimated. The Party reported in its NIR detailed information on the use of key notation “NE” in NIR (pp. 246) and CRF table 4(V). Also, the Party provided a documentation box in CRF table 4(V) for Controlled	FCCC/ARR/ 2022/ISL/L .29	Resolved in 2022 Submission. The Party added detailed information regarding the use of nk "NE" for		Section 6.17.1 Category Description in NIR 2022

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
(L.41, 2019) Convention reporting adherence	burning activity data in Grassland remaining Grassland, Land converted to Grassland, Wetlands remaining wetlands and Land converted to Wetlands. For all other land use categories, Controlled burning is reported as NO and none "NE" notation key is used for biomass burning in Cropland.		Grassland and Wetlands in section 6.17.1 Category Description in NIR 2022. Additionally, information of the use of nk "NE" are reported in the documentation box and in Cell comments for Grassland and Wetlands		and NIR 2023
4.A.2 Land converted to forest land – CO_2	Iceland reported in its NIR section 6.5.2.2 (pp. 203-204) a description of the estimation of litter removals in land converted to forest and afforestation/reforestation.. Two separate research projects were used to estimate a country specific EF including both introduced tree species and the native Betula pubescens which is the main tree species of the natural birch forest (see also #KL.7). In the same section of the NIR the Party also informed about new research that will increase the understanding of CSC in litter and that information related to these ongoing projects will be added to the next submission (2023). Update the estimates of CSC litter as soon as new information is available.	FCCC/ARR/ 2022/ISL/L .30	Will be implemented in later submissions when research results ar available		Chapter 6.5.2.2.
4.A.1 Forest land remaining forest land – CO_2	Iceland reported in its CRF table 4.A.1 net carbon stock change in living biomass separately for "Natural Birch forest older than 50 years", "Afforestations older than 50 years" and "Plantations in natural birch forest." The ERT noted that losses of carbon from below-ground biomass for cultivated forest was reported as "NE" in table CRF 4(KP-I)B.1 (See #KL.10) for the entire time series. During the review the Party resubmitted updated values of losses from this carbon pool to complete the reporting under the second commitment period under the Kyoto protocol, e.g. values reported in CRF table 4(KP-I)B.1 for losses from below-ground biomass for "Cultivated forests" which were previously reported as "NE" is now -0.185 kt C for 2020. The ERT noted that this could lead also to a recalculation of the net changes in carbon stock changes reported under forest land remaining forest land (category 4.A.1) and ask the Party to explore whether these updated calculations should be reflected in the net carbon stock changes under forest land remaining forest land and if so report updated net carbon stock changes under forest land remaining forest land in its next annual submission.	FCCC/ARR/ 2022/ISL/L .31	Partiallly resolved in the 2022 resubmission. Resolved in the 2023 Submission		Chapter 6.5.2.2. 2023 Submission.

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
General (KP-LULUCF) – CO2, CH4 and N2O (KL.1, 2021) (KL.2, 2019) (KL.2, 2017) (KL.4, 2016) (KL.4, 2015) Transparency	Include in the NIR country-specific information on the associated FM and AR and background levels of emissions associated with annual disturbances, as well as information on a margin and how to avoid the expectation of net credits or net debits during the commitment period, including through the use of a margin. Iceland reported in its NIR (p.363) country-specific information on the associated AR and FM and background levels of emissions associated with annual disturbances. As the associated emissions are so small that a background level and a margin cannot be established, Iceland now report "NO" for these parameters under AR and FM in CRF tables 4(KP-I)A.1.1 and. 4(KP-I)B.1.3. The ERT notes that no events qualifying for the natural disturbance mechanism occurred in Iceland during the second commitment period 2013-2020.	FCCC/ARR/ 2022/ISL/K L.1	Resolved in the 2022 Submission		Chapter 11.4.4 in 2022 Submission
General (KP-LULUCF) – CO2, CH4 and N2O (KL.2, 2021) (KL.3, 2019) (KL.3, 2017) (KL.5, 2016) (KL.5, 2015) Transparency	Report information clearly demonstrating that emissions by sources and removals by sinks resulting from FM under Article 3, paragraph 4, and any elected activities under Article 3, paragraph 4, are not accounted for under activities under Article 3, paragraph 3. Iceland included in its NIR (p. 363) section 11.5.5 information that demonstrates that emissions and removals resulting from elected Article 3.4 are not accounted for under activities under Article 3.3. The section (11.5.5) has been updated with the required information described in the 2021 ARR (ID# KL.2, 2021).	FCCC/ARR/ 2022/ISL/K L.2	Resolved in the 2022 Submission		Chapter 11.5.5 in 2022 Submission
General (KP-LULUCF) – CO2, CH4 and N2O (KL.3, 2021) (KL.4, 2019) (KL.7, 2017) Transparency	Provide in the NIR a description of the methodologies used for conducting an uncertainty analysis for KP-LULUCF activities (AR, deforestation, FM and HWP), including the methodology used in the uncertainty analysis of AD, EFs and emissions for each carbon pool. Iceland reported uncertainty estimates for HWP in section 11.6 (p. 364) and for AR and FM in section 11.3.2.5 (p. 358). During the review, the Party provided additional information related to the uncertainty estimate for deforestation, i.e. the Party explained that deforestation reporting in Iceland is built on data sampling of every deforestation event. The combined uncertainty of the area estimate and the CSC is judged to be 20 % of the reported net emissions. With this information provided during the review the ERT consider the issue	FCCC/ARR/ 2022/ISL/K L.3	Resolved in the 2022 Submission		
General (KP-LULUCF) – CO2, CH4 and N2O	Provide information in the NIR on the approach used to develop background level and margin values for FM and AR and demonstrate how the approach taken avoids the expectation of net credits or net debits, in accordance with decision 2/CMP.7, annex, paragraph 33. See #KL.1 above.	FCCC/ARR/ 2022/ISL/K L.4	Resolved in the 2022 Submission		Chapter 11.4.4 in 2022 Submission

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
(KL.4, 2021) (KL.5, 2019) (KL.8, 2017) Transparency					
AR – CO2, CH4 and N2O (KL.5, 2021) (KL.6, 2019) (KL.4, 2017) (KL.1, 2016) (KL.1, 2015) (86, 2014) Transparency	Provide an additional description of the process by which CSC and associated emissions and removals are estimated, including tables with raw data and intermediate outputs stratified by year and forest type. Iceland provided additional description of the process by which CSC and associated emissions and removals are estimated. The Party reported in its NIR (table 6.8, p. 200 and table 6.10, p. 205) the CSC per area unit and total CSC of biomass, litter and soil separated. Additionally, the Party in its NIR (figure. 6.7 p. 197 and figure 6.8 p. 203) included graphs showing area as well as CSC and carbon stocks related to age for the two main forest categories, cultivated forest and natural birch forest.	FCCC/ARR/ 2022/ISL/KL.5	Resolved in the 2022 Submission		Chapter 6.5.1.2 and 6.5.2.2 -NIR 2022 and 2023
AR – CO2 (KL.6, 2021) (KL.7, 2019) (KL.9, 2017) Transparency	Correct the use of notation keys by reporting CSC in the HWP pool under AR using the notation key "NO" for the whole time series and provide an explanation in the NIR that harvesting from afforestation lands has not yet occurred. Iceland reported in the NIR section 11.4.5 (p. 359) the use of the notation key "NO" by explaining that "afforestation since 1990 has not yet yielded wood removals as these forests are still too young for commercial thinning and therefore harvested wood products are reported as not occurring". However, in CRF table 4(KP-I)A.1 and CRF table 4(KP-I)C the Party still reports "NA" for CSC in the HWP pool under AR..	FCCC/ARR/ 2022/ISL/KL.6	Resolved in the 2022 Submission		
AR – CO2 (KL.8, 2021) (KL.17, 2019) Transparency	Indicate in the NIR that the average EF obtained from the data from two research projects for litter on AR includes both natural birch forests and cultivated forests. Iceland did not include in the NIR the required information. In response to the previous review the Party clarified that EF for litter in cultivated forest under FM compared to EF for litter in cultivated forest under AR can be explained by the age of afforestation in FM. Part of the forest in FM was afforested more than 50 years ago and reported with no removal to litter. The part FM younger than 51 years were estimated with the same EF as in AR. The average for these two groups yields consequently lower EF than the country wise EF of 0.14 t C/ha. The ERT noted that the NIR section 6.5.2.2 (p. 203) mentioned the two research projects. During the review, the Party explained that the separate research projects used to estimate the CS average EF include both introduced tree species and the native Betula pubescens which is the main tree species of the natural birch forest	FCCC/ARR/ 2022/ISL/KL.7	Resolved in the 2022 Submission		Chapter 6.5.1.2 and 6.5.2.2 -NIR 2022 and 2023

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	and that more information will be added in the next NIR. The ERT recognize that this issue has no impact in accounting and considered this issue as resolved.				
Deforestation – CO_2, CH_4 and N_2O (KL.9, 2021) (KL.8, 2019) (KL.5, 2017) (KL.2, 2016) (KL.2, 2015) (87, 2014) Accuracy	Recalculate CSC in soil organic matter by ensuring symmetry among the pairs of land-use conversions (e.g. grassland converted to forest land, and forest land converted to grassland). Iceland did not recalculate CSC in soil organic matter. The Party reported in its CRF table 4(KP-I)A.1 and 4(KP-I)A.2 the same CSC for soil organic carbon from previous submissions. During the review, the Party clarified that a recalculation using symmetrical emission factors for deforestation and for afforestation to estimate annual CSC in soil organic carbon would have a minimal effect on accounting. The annual loss of carbon would change from -0.03 kt C, to -0.02 kt C in 2020. The ERT acknowledge that this is the final year to report under the Kyoto protocol and that any issues related to the accounting needs to be resolved. However, the ERT also noted that the current estimate is conservative, i.e. it does not create any additional credits, and therefore accepted the current estimate.	FCCC/ARR/ 2022/ISL/K L.8	Resolved in the 2023 Submission. Forest land converted to grassland has never been reported.		
Deforestation – CO_2 and N_2O (KL.10, 2021) (KL.18, 2019) Completeness	Report the AD, CSC and related N_2O emissions for this category to avoid underestimating the emissions. If this is not possible, provide information that justifies the reporting of "NE" for AD and CSC related to N_2O emissions from mineralization and immobilization due to carbon loss or gain associated with land-use conversion and management change in mineral soils on land subject to deforestation in the NIR in the next annual submission and consider providing information in the documentation box to CRF table 4(KP-II)3. Iceland reported in its CRF table 4(KP-II)3, N_2O emissions from mineralization and immobilization due to carbon loss after deforestation for the first time by using default tier 1 methods. However, the ERT noted that there is no description of the methods in the NIR except in table 10.8 (p. 345) where the Party reports the status of implementation in the LULUCF and KP LULUCF sectors in response to UNFCCC's review process. The ERT considers, however, that the completeness issue is resolved and considering the clarification provided by the Party in NIR table 10.8, consider this issue as resolved.	FCCC/ARR/ 2022/ISL/K L.9	Resolved in the 2022 Submission		
FM – CO_2 (KL.11, 2021) (KL.10, 2019) (KL.10, 2017) Completeness	Report information on CSC in below-ground biomass for FM or provide justification that the carbon pool is not a net source in accordance with decision 2/CMP.8, annex II, paragraph 2(e). Iceland did not include an estimate of losses from below-ground biomass for cultivated forests for the years 2013-2020 although losses from above ground biomass was reported. In CRF table 4(KP-I)B.1 losses of carbon from below ground biomass for cultivated forests under FM is reported as	FCCC/ARR/ 2022/ISL/K L.10	Partiallly resolved in the 2022 resubmission. Resolved in the 2023 Submission		Chapter 6.5.2.2. 2023 Submission.

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	"NE". The ERT listed this issue as a potential problem and in response, the Party provided revised estimates and a revised NIR during the review week. The revised estimates for the losses of carbon from below ground biomass for cultivated forests reported under FM. covered the entire time series (2013-2020), making the reporting of FM complete. The revised estimates resulted in a decrease in net removals reported and accounted for FM during the commitment period (2013-2020) of 6.634 kt CO2 eq. The ERT checked the resubmitted values in CRF table 4(KP-I)B.1 and concluded that the issue is now resolved.				
FM – CO2 (KL.12, 2021) (KL.13, 2019) Transparency	Report transparently in the NIR any recalculations for FM (including changes in CSC factors for the pools, e.g. mineral and organic soils). Iceland reported transparently in the NIR recalculation made for FM. The Party reported in its NIR section 11.2.3.4 (p. 358), information on changes in data and methods since the previous submissions including all activities and pools reported (see also ID#KL.12).	FCCC/ARR/ 2022/ISL/K L.11	Resolved in the 2022 Submission		
FM – CO2 (KL.13, 2021) (KL.14, 2019) Transparency	Provide information on any changes in data and methods from previous submissions, including those resulting from a detected error, in future annual submissions Iceland reported in its NIR (pp. 360-364) detailed description on the changes in data and methods used in the recalculations for FM. See also ID#KL.11.	FCCC/ARR/ 2022/ISL/K L.12	Resolved in the 2022 Submission		
FM – CO2 (KL.14, 2021) (KL.19, 2019) Completeness	Report estimates for CSC in the litter of natural birch forests under FM or justify why the carbon pool is not a net source, in accordance with decision 2/CMP.8, annex II, paragraph 2(e). Iceland changed the notation key from NE to NA in its CRF table 4(KP-I)B.1 for CSC in litter in natural birch forests under FM for 2013–2020 and provided justification in the NIR (section 11.5.5, p. 364) why the pool is not a net source of emissions. According to the Party, forest management includes natural birch forests as estimated in the end of 1989. They are all defined as forest land remaining forest land and are not in a transitional state". In section 11.3.1.1 (p. 356), it is highlighted that the reporting of CSC for litter and mineral soil for the part of FM that is defined as forest land remaining forest land is not occurring leading to the reporting of NA rfor the subcategory of natural birch forest. The Party further explain in the NIR that CSC in litter in FM follow the same pattern of variation as CSC in mineral soil (because CSC in litter are only reported for forests of 50 years old or younger under FM). Therefore, considering that all FM is defined as older than 50 years CSC in litter and mineral soil is likely to be a sink rather than a source . As Tier 1 approach these pools are assumed to be 0 (zero) as recommended in 2006 AFOLU Guidelines (see page 2.21)."	FCCC/ARR/ 2022/ISL/K L.13	Resolved in the 2022 Submission		

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
FM – CO2 (KL.16, 2021) (KL.21, 2019) Accuracy	Provide the revised technical correction to the FMRL, as planned, before the end of the commitment period. Iceland reported in its NIR, section 11.5.3 (pp. 360-363) an updated technical correction with the calculations of a corrected FMRL and with explanation of the elements that changed in relation to the originally submitted FMRL (changes in area estimates, in carbon stock calculations and in emission factors). However, the ERT noted that the Party made a post-calibration of the projected removals in living biomass using the reported numbers for the period 2013-2020. During the review, in interaction with the Party, it was clarified that only updates to the historical data (2009) as well as the updated model for projection could be used to revise the estimate on living biomass in the FMRL. The ERT listed this issue as a potential problem and in response, the Party provided revised estimates and a revised NIR during the review week. The revised estimates consisted of an updated technical correction following the advice from the current ERT to not calibrate the FMRL using the reported removals for cultivated forests during the commitment period. The updated FMRLcorr reported during the review was -156.107 kt CO2e/year and the updated technical correction was estimated to -1.755 kt CO2e/year which have now been included in the CRF-tables 4(KP-I)B.1.1. The update of the FMRLcorr led to an increase in accounted net removals for FM of 146.240 kt CO2 eq for the second commitment period. The ERT checked the values resubmitted in the CRF table 4(KP-I)B.1.1 and concluded that the issue is now resolved.	FCCC/ARR/ 2022/ISL/K L.14	Resolved in the 2022 resubmission		Chapter 11.5.3 in 2022 Submission
RV – CO2 (KL.18, 2021) (KL.11, 2019) (KL.11, 2017) Accuracy	Revise estimates of carbon stock in living and dead biomass as well as carbon stock in soils in revegetated areas and revise estimates of carbon sequestration in revegetated land for the whole time series. Iceland did not revise the estimates as requested in the recommendation. However, the Party reported in its NIR, section 11.3.1.2 (p. 357) that the changes in carbon stocks at revegetation sites were estimated based on a country specific EF covering all carbon pools and clarified during the review, that the current estimates for CSC in living biomass and dead wood as well as CSC in soils are based on three peer-reviewed publications. The Party provided a full explanation on the studies used to estimate the CSC in living biomass and soil organic carbon, as follow: (a) Biomass: for 2013-2020 Iceland has been using for the category: 4(KP).B.4 (revegetation) an implied carbon stock changes factor of 0.057 t C/ha/yr for Gains in above ground biomass. According to one of the studies, “the annual rate of sequestration in aboveground biomass ranged from 0.01 to 0.5 t C/ha/yr the amount depending on the reclamation method used and site conditions”. (b) Mineral soils: for 2013-2020 Iceland has been using for the Category: 4(KP).B.4 (revegetation) an	FCCC/ARR/ 2022/ISL/K L.15	Resolved in the 2022 resubmission		

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	implied carbon stock changes factor of 0.513 t C ha-1 yr-1 for mineral soils. According to one of the studies “reclamation of Icelandic deserts results in an average sequestration rate in soils of 0.6 t C ha–1 yr–1, which is maintained >50 yrs”. In addition, it is considered “sequestration in aboveground or belowground biomass of 0.01–0.5 t/ha/yr”. Moreover, another study estimated that “barren desert soils were sandy with unstable surface conditions subjected to intense cryoturbation and wind erosion are, the initial carbon stocks in soils of eroded, untreated areas were 0.1–0.3 kg m−2, largely consisting of inert metal–humus and/or clay–humus complex characteristic of Andosols. Carbon content in the 5 cm surface layer increased from <0.3% up to >0.7% in some treated plots. Annual carbon accumulation of 0.04–0.063 kg C m−2 yr−1 was observed over the first seven years after initiation of restoration efforts, highest in treatments seeded with grasses and fertilized but no accumulation was observed in untreated controls. Carbon accumulation rate of >0.05 kg C m−2 yr−1 can potentially be maintained over >100 yr due to the nature of Andosols and a steady burial by an influx of eolian materials”. The Party ensured that these estimates are conservative and there is no underestimate of emissions. The ERT recognize that this issue has no impact in accounting and considered this issue as resolved.				
HWP – CO2 (KL.19, 2021) (KL.12, 2019) (KL.12, 2017) Transparency	Provide in the NIR information on the calculation of emissions from HWP, including the AD and methodology used, including information on HWP from FM and deforestation, as well as information on how Iceland distinguishes between domestic and imported HWP, in accordance with the requirements in decision 2/CMP.8, annex II, paragraph 2(g)(i). Iceland reported in its NIR, section 11.6 (pp. 364-365) new and improved information on the calculations of emissions from HWP including information on how HWP from FM and deforestation are distinguished, as well as information on how domestic and imported HWP are distinguished. Most of the deforestation event are either deforestation of young afforestation areas or of natural birch forest that do not yield harvested wood to be utilised as HWP. In two deforestation events (2006 – 4.3 ha and 2015 – 3.0 ha) harvested wood was partially removed from the area and used to make wood chips and firewood.	FCCC/ARR/ 2022/ISL/K L.16	Resolved in the 2022 Submission		Chapter 11.6 in 2022 Submission
Direct and indirect N2O emissions from N fertilization – N2O	During the review the ERT observed some problems related to the reporting and accounting under the Kyoto protocol. All these issues were resolved during the review, including the issues already included in table 3. Since this is the last review under the Kyoto protocol the issues not covered by table 3 are documented below. During the review it was observed that N2O-emissions related to the application of organic fertilizers on land reported under Revegetation was missing for the years 2013, 2014 and 2015. To complete the reporting under the Kyoto protocol, the Party provided updated estimates through a	FCCC/ARR/ 2022/ISL/K L.17	Resolved in the 2022 resubmission		

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	resubmission of the CRF-tables during the review week. The resubmission included revised estimates of the entire time series as errors were detected by the Party during the recalculation process. However, the ERT also noted that the area reported and accounted for under Revegetation are also part of the area reported under grassland (CRF 4.C) and that N2O-emissions related to the application of organic fertilizers to grassland are reported in the Agriculture sector (CRF table 3.D.a.1 and 3.D.a.2). After correspondence with the Party the Party detected that the reporting of N2O-emissions related to the application of fertilizers under Revegetation (CRF table 4[KP-II]1) was considered to be a double counting of the emissions already reported in the Agriculture sector (CRF table 3.D.a.1 and 3.D.a.2). Therefore, the Party provided updated estimates through a second resubmission of the CRF-tables during the review week, i.e. by reporting N2O-emissions related to the application of organic fertilizers using the notation key “IE” under RV. The resubmission led to a reduction of the accounted amount for the second commitment period of 284.218 kt CO2e. The Party also provided background information and evidence on how the calculations have been made, that all N2O-emissions related to the application of fertilizers was reported in the agricultural sector (CRF table 3.D) and why parts of the emissions was allocated to RV to demonstrate that there actually is a double counting of emissions. The calculations for the estimate of fertilization of RV were based on the quantities of inorganic and organic fertilizers recorded in the Soils Conservation Service of Iceland‘s database which records fertilizers used for all revegetation projects although these quantities were already captured in the estimate reported in the agricultural sector (CRF table 3.D).				
FM – CO2, N2O, CH4	It is good practice (see page 2.97 of the 2013 IPCC KP Supplement) to provide information in the NIR on the main factors generating the accounted quantity (i.e. the difference in net emissions between reporting of FM during CP2 and the FMRL) and whether the accounting quantity (AQ = FM - FMRL) is consistent with those factors, with the aim to show that AQ can be explained as deviations in actual policies compared to those historical policies included in the FMRL, rather than as differences in the methodological elements as factors/parameters, including increments, used in the FMRL and in the actual GHG emissions and removals. During the review, Iceland provided information that explained that the accounted quantity (-19.941 kt CO2e/ year), i.e. difference between FM and FMRLcorr where to due with (i) a higher net removal in HWP due to an increase in harvest level since 2010 (the FMRLcorr considered the same harvest level as in 2010) (ii) an increase in forest growth during the commitment period compared to the growth in the FMRL. However, the causes for the increase in growth was not specifically explained by the Party.	FCCC/ARR/ 2022/ISL/KL.18	Resolved in the 2022 resubmission		

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
General (KP-LULUCF) –	The ERT observed that some of the information required according to decision 2/CMP.8 Annex II paragraph 2 was not provided in the NIR, i.e. information related to (i) The geographical location of the boundaries of the areas that encompass article 3.3 and 3.4 activities and (ii) The spatial assessment unit used for determining the area of accounting for afforestation, reforestation and deforestation. During the review the Party informed that boundaries encompassing activities under article 3.3 and 3.34 are the national boundaries of Iceland. The Party also informed that chapter 6.5 (page 195) in the NIR describes the systematic sampling grid of the NFI of cultivated forest and natural birch forest and that the sampling grid is used to separate ARD from FM. The spatial assessment unit is 50 ha in the case of Cultivated forest and 450 ha in the case of Natural birch forest.	FCCC/ARR/ 2022/ISL/KL.19	Resolved in the 2022 resubmission		

10.5.5 Waste (CRF Sector 5)

For future emissions it is planned to update the solid waste disposal site classification used. The 2019 refinements contain updated SWDS classifications and the updated version of Managed Well – Semi-aerobic would probably fit well for the sites with operation permits that are currently classified as unmanaged. There are, however, still outstanding questions that need to be answered before the new classification can be implemented.

Additionally, it is planned to fix the inconsistency between the reporting of landfill gas, between the Energy and the Waste sectors.

Regarding emissions from Anaerobic Digestion the 5% value for unintentional leakage, suggested in the 2006 IPCC Guidelines, is currently used in the inventory. This estimate is considered conservative, as the facility is new, and leakage might be expected to be negligible. EAI intends to refine this estimate with the data provider and facility experts in the coming years.

The Industrial Wastewater category is currently only calculated for fish processing on land. For future submissions it is planned to add more industries and upgrade the methodology for CH_4 emissions from Industrial Wastewater to Tier 2.

Comments and suggestions received during the 2022 reviews which could not be addressed during the current submission will be tackled in future submissions.

Table 10.9 Status of implementation in the Waste sector in response to UNFCCC's review process.

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
5.A Solid waste disposal on land – CH4 (W.1, 2021) (W.12, 2019) Transparency	Document and provide in the NIR all the parameters used in the estimation of CH4 emissions from solid waste disposal and include the population data and waste generation rates used as input data in the IPCC solid waste disposal model. Iceland included in the 2022 NIR a new annex (Annex 9 in 2022 Submission, Annex 6 in this submissions) with input data for managed and unmanaged SWDS, i.e. a table with the parameters applied (e.g.DOC, MCF, etc), and two tables with population and the types of waste assigned to managed and unmanaged SWDS for the entire time series. Further tables on waste generation and allocation data can be found in NIR tables 7.5 – 7.8 (pp. 258-260).	FCCC/ARR /2022/ISL /W.1	Implemented.		Chapter 7.2. Annex 6
5.A Solid waste disposal on land – CH4 (W.2, 2021) (W.13, 2019) Accuracy	Investigate the composition of both municipal solid waste and industrial waste and reconsider estimating separately emissions from industrial waste. Iceland still assumes a similar composition of waste between municipal solid waste and industrial waste. The Party explained that the reason behind this is that the existing data on waste amounts does not support this distinction. Waste amounts are reported to the EA as either mixed or separated waste. The Party clarified that though the questionnaires sent to the waste industry contain the two categories mixed household and mixed production waste, the differentiation between the two on site is often neglected, and therefore, they are assumed to have similar content (see NIR section 7.22, p. 252). In addition, the Party explained that data received according to the European Waste Statistic Regulation (WStatR) (EC 2150/2002) does not exactly match IPCC categorization and that streamlining of the WStatR to IPCC categorization is in progress and those composition amounts may be revised in future submissions.	FCCC/ARR /2022/ISL /W.2	Implemented.		Chapter 7.2.2
5.A Solid waste disposal on land – CH4 (W.3, 2021) (W.13, 2019) Transparency	Report information on waste composition for municipal solid waste and industrial waste separately in order to enhance the transparency of the NIR. Iceland did not report information on waste composition separated by domestic and industrial waste (see ID# W.2 above).	FCCC/ARR /2022/ISL /W.3	Partially resolved. Iceland still assumes a similar composition of waste between municipal solid waste and industrial waste. The reason behind this is that the existing data on waste amounts does not support this distinction. Waste amounts are reported to the EA as either mixed or separated waste. Though the questionnaires		Chapter 7.2.2

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
			sent to the waste industry contain the two categories mixed household and mixed production waste, the differentiation between the two on site is often neglected, and therefore, they are assumed to have similar content (see NIR section 7.2.2). In addition, data received according to the European Waste Statistic Regulation (WStatR) (EC 2150/2002) does not exactly match IPCC categorization. Streamlining of the WStatR to IPCC categorization is in progress and those composition amounts may be revised in future submissions.		
5.A.1 Managed waste disposal sites – CO2, CH4 and N2O (W.4, 2021) (W.11, 2019) Completeness	Estimate emissions from the combustion of landfill gas for energy and transparently allocate them under the relevant categories in the energy sector (e.g. for electricity production in 2002–2009); Improve the explanation of the allocation of emissions from landfill gas in the inventory (NIR section 7.2.4.1). Iceland improved the explanation regarding landfill gas recovery in NIR section 7.2.4.1 (p. 261). However, it has not provided enough information on the allocation of emissions from landfill gas between categories 1.A.1.a (electricity generation) and 1.A.3.b (road transport). During the review, the Party clarified that there is still a discrepancy between the values reported under the Energy sector, retrieved from the National Energy Authority, and the values reported within the waste sector, based on numbers reported from the waste management company. The Party reported in its NIR (page 261) that it will investigating the differences with the aim of harmonizing the values. The ERT notes the differences between the values are low and cannot lead to an underestimation of emissions.	FCCC/ARR /2022/ISL /W.4	Partially resolved. The investigation has started, but not yet been concluded. Therefore, there is still a slight discrepancy between the values reported under the Energy sector and the values reported under the Waste sector.		Chapter 7.2.4
5.B.1 Composting – CH4 and N2O (W.8, 2021) Convention	(a) Report the amount of waste composted consistently between its NIR table 7.13 and CRF table 5.B., (b) Correctly reports in the NIR text the basis for the estimation, whether by dry weight or wet weight. (a) Iceland did not report consistently the amount of waste composted between the NIR table 7.10 (p.266) and the CRF table 5.B. In CRF table 5.B, the amount of	FCCC/ARR /2022/ISL /W.5	Resolved in the 2023 Submission.		Chapter 7.3.2

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
reporting adherence	composted waste is 12.42 kt dm and in NIR table 7.10, 14 kt dm. The party also continues to report the CH4 and N2O EFs in wet weight in the NIR table 7.12 (p. 266), i.e 4 g CH4/kg waste and 0.24 g N2O/kg. During the review, the Party explained that the correct waste amount composted was reported in CRF table 5.B and that it will correct the typo in Table 7.10 for the amount of waste composted in dry weight. (b) Iceland included in NIR table 7.10 (p. 266) a row with the amount of waste composted in dry weight and therefore this table presents AD in dry and wet weight. The Party added to the NIR information that “the basis for the estimation of emissions from composting is wet weight”.				
5.D Wastewater treatment and discharge – CH4 and N2O (W.6, 2021) (W.6, 2019) (W.8, 2017) (W.5, 2016) (W.5, 2015) (81, 2014) (74, 2013) Transparency	Include in the NIR more background data on sludge removal (e.g. amount and N content), clearly indicating in which category the resulting emissions are accounted for. Iceland reported in NIR the amount of sewage sludge removed and the N effluent for relevant years of the time series. For 2020, sludge removed accounted for 3.3 kt DC and N effluent 2.6 kt N (see NIR section 7.5.4.2 and table 7.21, p.282). The Party also indicated that emissions from sludge removed are accounted for in categories 5. A.1.a (managed waste disposal sites, anaerobic) and 5.C.1.1.b.iv (waste incineration, biogenic, sewage sludge). However, the ERT noted that the Party reported sludge applied to soil (as fertilizer) in the agriculture sector. NIR table 5.34 (p.164) indicates that in 2020 the N content of sewage sludge applied to soil as fertilizer was 6.56 t N. During the review, the Party clarified that the amount of sewage sludge reported in the agriculture sector as organic fertilizer was not deducted from the calculations of N2O emissions under category 5.D.1 (domestic wastewater) and clarified that it will correct these data in the next submission (see Section, 7.5.4.2, p. 282).	FCCC/ARR/2022/ISL/W.6	Resolved in the 2023 Submission.		Chapter 7.5.4.2
5.D Wastewater treatment and discharge – CH4 and N2O (W.9, 2021) Transparency	Update the NIR to explain that correction factor 1 is applied for the pathways “not known, septic tanks urban and septic tank rural” and that correction factor 1.25 is applied for the pathways in which commercial activities are likely to occur as “not known into sea, river, lake, primary, secondary and tertiary treatment”. Iceland updated the NIR and included on section 7.5.2.1 (p. 276) the required information, explaining that “the correction factor is set to 1 for the pathways “not known, septic tanks urban and septic tanks rural”, while for “not known into sea, river, lake, no treatment, primary, secondary and tertiary treatment” it is set	FCCC/ARR/2022/ISL/W.7	Implemented.		Chapter 7.5.2.1

CRF Category/Issue	Review Recommendation	Review Report/ Paragraph	MS Response / Status of Implementation	Reason for Non-implementation	Chapter/ Section in the NIR
	to 1.25 to account for industrial wastewater discharge such as commercial activities, accommodation services, restaurants, shops which are commonly discharged in the same sewer system.”				
5.D Wastewater treatment and discharge – CH4 and N2O (W.9, 2021) Completeness	Verify if emissions from “overnight stays associated with foreign visitors to Iceland” are included in the inventory (in the pathways using correction factor 1.25), and if not, include the emissions estimates in the inventory, because justification for exclusion based on the likely level of emissions should be applied at category level and not to parts of a category or subcategory in accordance with footnote 7 of the UNFCCC Annex I reporting guidelines.	FCCC/ARR /2022/ISL /W.8	Partially resolved. This is on the improvement plan to revisit for future submissions.		
5.D Wastewater treatment and discharge – NOX, CO, NMVOCs (W.10, 2021) Transparency	Update the notation key to “NA” for NOX and CO. Continue to use “NE” for NMVOC until the Party is able to change AD and obtain the volume of wastewater handled, for calculating the GHG emissions based on tier 1 and using BOD from population. Provide in CRF table 9 the reasons for reporting “NE” for NMVOCs under domestic and industrial wastewater. Iceland updated the notation keys in CRF table 5. For category 5.D.1, the reported NA for NOX and CO and continued to report NE for NMVOCs. For category 5.D.2, the Party reported correctly NE for NMVOCs, but continued to report NE (instead of NO) for NOx and CO. During the review, the Party clarified that it was an error in updating the CRF table 5 and that it will address this issue in next submission. The arty did not provide in CRF table 9 the reasons for reporting “NE” for NMVOCs under domestic and industrial wastewater.	FCCC/ARR /2022/ISL /W.9	Implemented. Explanations for the reasons for reporting "NE" for NMVOCs under domestic and industrial wastewater have been added to CRF.		

11 Information on Accounting of Kyoto Units

11.1 Background Information

The Environment Agency of Iceland (*Umhverfisstofnun*) (EAI) maintains the national registry. The registry holds as of 31 December 2022: 57 EU ETS accounts, thereof 9 Operator holding accounts, 37 Aircraft operator holding accounts, 11 Verifier accounts, in addition to 1 National holding account and 1 Party holding account. Iceland's AAUs were 15,327,217 tonnes of CO_2e, on December 31, 2022.

Iceland acquired 5,087 ERUs from AAUs Kyoto Protocol units in December 2013. These additional units came from Joint Implementation projects. Article 6 of the Kyoto Protocol allows an Annex I Party, with a commitment inscribed in Annex B to the Kyoto Protocol to transfer to or acquire from another Annex I Party emission reduction units (ERUs) resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks for the purpose of meeting its commitments under Article 3 of the Protocol. In addition to that, Iceland acquired 6,986 CERs from the EU in March 2014 on the basis of Ineligible CER units transferred to a national KP account in accordance with Article 58(3) of the Registry Regulation (EU) No 389/2013.

No transactions on any units took place in 2022. Iceland's Standard Electronic Format (SEF) reports for 2022, for the second commitment period, are reported with the CRF data and NIR, and will be made available at the UNFCCC website[37].

11.1.1 First Commitment Period - CP1

Decision 14/CP.7 "Impact of single projects on emissions in the commitment period" set a threshold for significant proportional impact of single projects at 5% of total CO_2 emissions of a party in 1990. Projects exceeding this threshold were to be reported separately and CO_2 emissions from them were not included in national totals to the extent that they would have cause the party to exceed its assigned amount. The Government of Iceland notified the Conference of the Parties with a letter dated 17 October 2002 of its intention to avail itself of the provisions of Decision 14/CP.7. In small economies such as Iceland, a single project can dominate the changes in emissions from year to year, as can be seen in Iceland's GHG emission profile where for instance clear increases in national totals occurred around 1998 and 2006-2007, where two new aluminium smelters started their operations. When the impact of such projects becomes several times larger than the combined effects of available GHG abatement measures, it becomes very difficult for the party involved to adopt quantified emissions limitations. It does not take a large source to strongly influence the total emissions from Iceland. A single aluminium plant can add more than 15% to the country's total GHG emissions. A plant of the same size would have negligible effect on emissions in most industrialised countries.

The total amount that could be reported separately under Decision 14/CP.7 was set at 8 million tonnes of CO_2. The scope of this was explicitly limited to small economies, defined as economies emitting less than 0.05% of total Annex I CO_2 emissions in 1990. In addition to the criteria above, which relate to the fundamental problem of scale, additional criteria were included that relate to the nature of the project and the emission savings resulting from it. Only projects using renewable energy were eligible, and only where this use of renewable energy resulted in a reduction in GHG emissions per unit of production. The use of best environmental practice (BEP) and best available technology (BAT) was also

[37] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/10116.php

required. It should be underlined that the decision only applied to CO_2 emissions from industrial processes. Other emissions, such as energy emissions or process emissions of other gases, such as PFCs, were not affected.

The industrial process CO_2 emissions falling under Decision 14/CP.7 could not be transferred by Iceland or acquired by another Party under Articles 6 and 17 of the Kyoto Protocol. If CO_2 emissions were to be reported separately according to the Decision, it would have implied that Iceland would not have been able to transfer assigned amount units to other Parties through international emissions trading.

Iceland fulfilled its commitments under the first commitment period of the Kyoto Protocol by retiring the number of units equal to its accountable emissions.

Iceland's initial assigned amount for CP1 were 18,523,847 AAUs. Added to that are a total of 1,542,761 RMUs from Art. 3.3 and Art. 3.4 activities and 33,125 AAUs, CERs and ERUs from Joint Implementation Projects, resulting in an available assigned amount of 20,098,931 AAUs.

Emissions from Annex A sources during CP1 were 23,356,066 tonnes CO_2e. This means that Annex A emissions were 3,257,140 tonnes CO_2 in excess of Iceland's available assigned amount.

Two projects fulfilled the provisions of Decision 14/CP.7 in 2008, 2009, 2010, 2011, and 2012 total CO_2 emissions fulfilling the provisions of Decision 14/CP.7 for the first commitment period under the Kyoto Protocol therefore were 5,913 kt Emissions from Annex A sources during CP1 were 23,356,066 tonnes CO_2e. Emissions with the exception of Decision 14/CP.7 were 17,443,107 tonnes CO_2e.

That means that 3,257,140 tonnes were reported separately under decision 14/CP.7 in December 2015 and not included in national totals. However, Emissions falling under Decision 14/CP.7 were not excluded from national totals in the current report (2018), as Iceland undertook the accounting with respect to the Decision at the end of the commitment period, and the accompanying CRF tables contain Iceland's Annex A emissions in their entirety.

Table 11.1 and Figure 11.1 show all Kyoto units accounting relevant to the CP1, as well as the emissions for the period.

Table 11.1. Summary of Kyoto accounting for CP1.

		2008	2009	2010	2011	2012	CP1
Initial assigned amount	AAUs	3,704,769	3,704,769	3,704,769	3,704,769	3,704,769	18,523,847
Activity Deforestation Cancelation (Art.3.3)	AAUs					-802	-802
JI Projects	AAUs CERs ERUs					33,125	33,125
Art. 73a international credits	CERs ERUs					102,346	102,346
Art. 73a credits returned	AAUs					-102,346	-102,346
KP-LULUCF Art. 3.3	RMUs	103,428	115,625	135,586	153,426	172,966	681,031
KP-LULUCF Art. 3.4	RMUs	152,293	159,608	171,719	184,453	193,658	861,730
Total RMUs from KP-LULUCF	RMUs	255,721	275,233	307,305	337,879	366,624	1,542,761
Available assigned amount	AAUs	3,960,490	3,980,002	4,012,074	4,042,648	4,103,716	20,098,931
Emissions from Annex A sources	t CO_2e	5,021,786	4,779,267	4,646,161	4,441,127	4,467,730	23,356,071

		2008	2009	2010	2011	2012	CP1
Difference AAU - Annex A emissions	t CO_2e	1,061,296	799,265	634,087	398,479	364,014	3,257,140
Emissions falling under Decision 14/CP.7	t CO_2e	1,134,704	1,178,389	1,197,398	1,184,753	1,217,720	5,912,964
Emissions falling under Decision 14/CP.7 reported under national totals	t CO_2e	73,408	379,124	563,311	786,274	853,706	2,655,824
Emissions falling under Decision 14/CP.7 not reported under national totals	t CO_2e	1,061,296	799,265	634,087	398,479	364,014	3,257,140

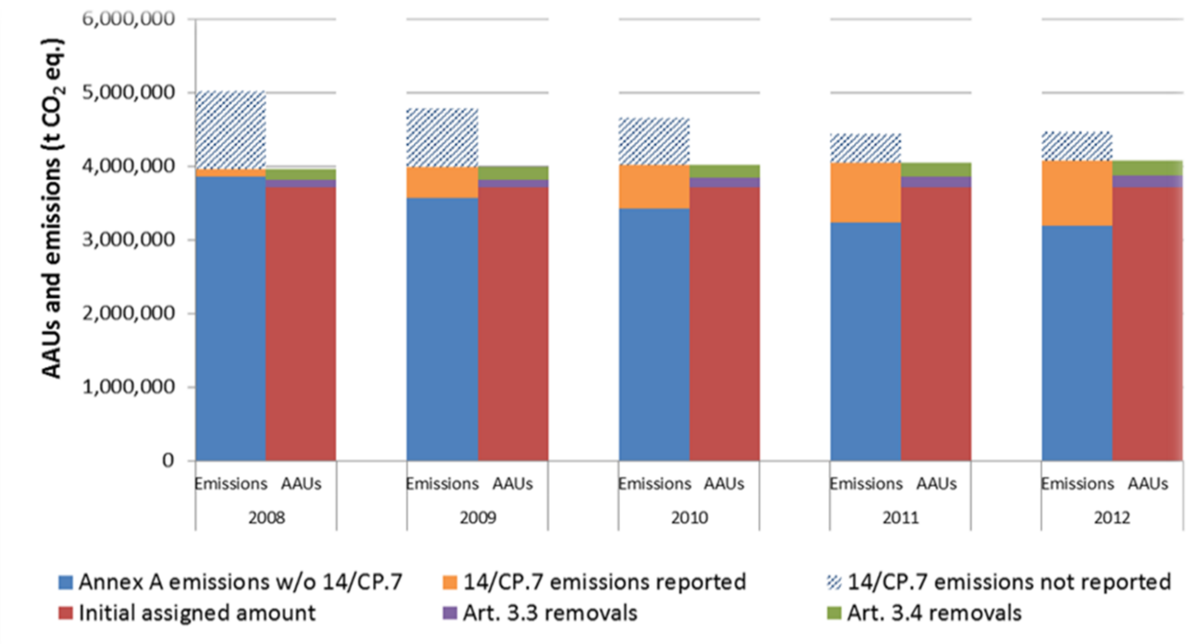


Figure 11.1 Summary of Kyoto accounting for CP1

11.1.2 Second Commitment Period – CP2

The second Commitment Period started 1 January 2013 and ended 31 December 2020. The EU, its Member States and Iceland agreed to the immediate implementation of the Doha Amendment as of 1 January 2013, and to fulfil the commitments under the second commitment period of the Kyoto Protocol jointly (see Chapter 1.1, as well as Council Decision (EU) 2015/1339[38]). Iceland did not account for Decision 14/CP.7 on the “Impact of single project on emissions in the commitment period.” No Kyoto Protocol units were requested to be carried over to the second commitment period in accordance with paragraph 49(c) of the annex to decision 13/CMP.1. Calculation of the Commitment Period Reserve (CPR) can be found in chapter 12.5 of this report.

According to the joint fulfilment agreement between the EU, its Member States and Iceland, the joint fulfilment was to be achieved, on one hand, by accounting for emissions falling under the scope of

[38] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015D1339&from=EN

Directive 2003/87/EC (the ETS Directive) as a whole for all EU member states and Iceland; and, on the other hand, by accounting for emissions falling under Directive No 406/2009/EC (The Effort Sharing Directive) for non-LULUCF emissions not falling under the scope of the ETS Directive. As noted in Iceland's initial report to the Kyoto Protocol[39], Iceland's individual assigned amount was established at 15 327 217 assigned amount units (AAUs), in accordance with the notification of the terms of the agreement to fulfil the commitment jointly by the EU, its Member States, and Iceland. These units were to cover Iceland's emissions falling under the scope of the Effort Sharing Decision, for the 8 years of the commitment period; Effort Sharing emissions are calculated by subtracting CO_2 emissions from domestic aviation and verified EU ETS emissions from stationary installations, from total emissions without LULUCF. In addition, Iceland can use removal units (RMUs) from land-use and forestry as per Art. 3.3 and 3.4 of the Kyoto Protocol and as described in Chapter 11.6.2 below. Table 11.2 below shows the yearly and total ESD emissions, the yearly and total RMUs, as well as the total of units to be acquired to fulfil Iceland's obligations towards the EU.

Table 11.2 Summary of Kyoto accounting for CP2. ESD = Effort Sharing Decision, and RMUs as per Art. 3.3 and 3.4 of the Kyoto protocol. In the case of RMUs, positive numbers indicate removals. All numbers in t CO_2e.

	2013	2014	2015	2016
Annual ESD emissions	2,861,533	2,886,968	2,913,985	2,888,941
Annual RMUs[1]	417,634	448,019	479,597	512,497
	2017	**2018**	**2019**	**2020**
Annual ESD emissions	2,922,340	2,967,820	2,872,545	2,716,429
Annual RMUs[1]	566,458	609,252	618,391	647,279
Total CP2 (2013-2020)				
Total ESD emissions: 23,030,562				
Total RMUs[1]: 4,299,128				
Total AAUs: 15,327,217				
Units to be acquired to fulfil JFA[2]: 3,404,217				

[1] *see details of RMUs in Table 11.6 below.*

[2] *JFA: Joint Fulfilment Agreement between EU member states and Iceland*

11.2 Summary of Information Reported in the SEF Tables

Article 3 in part I 'General reporting instruction' of the annex to decision 14/CMP.1 says: "…each Annex I Party shall submit the SEF in the year following the calendar year in which the Party first transferred or acquired Kyoto Protocol units."

There were 18,420,881 AAUs from CP1 in Iceland's national registry at the end of 2022, all of them in the CP1 Retirement Account. 802 AAUs were in the CP1 Cancellation Account, all of them ineligible. Furthermore, at the end of 2022, the following units were recorded in Iceland's national registry (all of which in the CP1 Retirement Account):

- 93,161 CERs
- 42,128 ERUs from AAU
- 1,542,761 RMUs

[39] https://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/zip/isl-2016-ir-19sep16.zip

There were 15,327,217 AAUs for CP2 in Iceland's party holding account at the end of 2022. The Voluntary cancellation account CP1 in the registry did not contain any units.

11.3 Discrepancies and Notifications

No discrepancies or notifications have occurred in relation to Iceland's accounting of Kyoto units in 2021.

Table 11.3 Discrepancies and notifications in 2022.

Annual Submission Item	Reporting Information
15/CMP.1 Annex 1.E paragraph 12: List of discrepant transactions	No discrepant transaction occurred in 2022
15/CMP.1 Annex 1.E paragraph 13 & 14: List of CDM notifications	No CDM notifications occurred in 2022
15/CMP.1 Annex 1.E paragraph 15: List of non-replacements	No non-replacements occurred in 2022
15/CMP.1 Annex 1.E paragraph 16: List of invalid units	No invalid units exist as of 31 December 2022
15/CMP.1 Annex 1.E paragraph 17: Actions and changes to address discrepancies	No discrepant transactions occurred in 2022

Iceland has not submitted the R2- R5 reports since none of these events have occurred in the registry, and these reports would thus be empty.

11.4 Publicly Accessible Information

A set of information regarding the registry and guidance on accessing registry accounts has been updated on the homepage of the EAI, both in Icelandic (https://ust.is/atvinnulif/ets/skraningarkerfi/) and in English (aimed at foreign account holders in the EU ETS - https://ust.is/english/air-climate/eu-ets/registry/).

The website of the EU Transaction Log allows for the general public to access information, as referred to in decision 13/CMP.1, annex, paragraphs 44-48, about Iceland's national registry, as relevant. This link can be accessed on the homepage of EA: https://ust.is/english/air-climate/eu-ets/registry/public-information/

It can also be accessed from the website of the Union Registry: https://ets-registry.webgate.ec.europa.eu/euregistry/IS/index.xhtml

11.5 Calculation of the Commitment Period Reserve (CPR)

The Annex to Decision 11/CMP.1 specifies that: "each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90% of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8 of the Kyoto Protocol, or 100% of eight times its most recently reviewed inventory, whichever is lowest." It was noted by the ERT during the 2022 UNFCCC review that "most recently reviewed inventory" should be understood as "the inventory being reviewed that year." Therefore, in the calculations below the national total is taken as the total from the latest submission of 2022 (version 4, as submitted to the UNFCCC on 23 September 2022).

Iceland's commitment period reserve is calculated as, either:

$$
\begin{aligned}
&90\% \text{ of Iceland's assigned amount}\\
&= 0.9 \times 15{,}327{,}217 \text{ tonnes } CO_2 \text{ equivalent}\\
&= 13{,}794{,}496 \text{ tonnes } CO_2 \text{ equivalent.}
\end{aligned}
$$

or,

$$
\begin{aligned}
&100\% \text{ of } 8 \times (\text{the national total in the most recently reviewed inventory})\\
&= 8 \times 4{,}509{,}640 \text{ tonnes } CO_2 \text{ equivalent}\\
&= 36{,}077{,}116 \text{ tonnes } CO_2 \text{ equivalent}
\end{aligned}
$$

This means Iceland's Commitment Period Reserve is **13,794,496 tonnes CO_2e**, calculated as 90% of Iceland's assigned amount and rounded up to the next integer.

The Icelandic registry did not violate the CPR during 2022.

11.6 KP-LULUCF Accounting

11.6.1 First Commitment Period - CP1

Iceland accounted for Article 3.3 and 3.4 LULUCF activities for the entire first commitment period. Iceland elected Revegetation under Article 3.4. Table 12.3 shows the RMUs from KP-LULUCF for the first commitment period.

Table 11.4. Removals from activities under Article 3.3 and 3.4 and resulting RMUs (t CO_2e).

	2008	2009	2010	2011	2012	CP1
KP-LULUCF Art. 3.3	103,428	115,625	135,586	153,426	172,966	681,031
KP-LULUCF Art. 3.4	152,293	159,608	171,719	184,453	193,658	861,730
RMUs	255,721	275,233	307,305	337,879	366,624	1,542,761

11.6.2 Second Commitment Period - CP2

In the second commitment period, Iceland reports RMUs from Afforestation/Reforestation and Deforestation (obligatory activities under Article 3.3 of the Kyoto Protocol), Forest Management (obligatory activity under Article 3.4), as well as Revegetation (elected activity under Article 3.4).

RMUs from Afforestation/Reforestation and Deforestation are the net emissions/removals as calculated under CRF sectors KP.A.1 and KP.A.2. RMUs from Forest management are calculated by subtracting the Forest Management Reference Level (-154,000 t CO_2e, as per the Appendix of Annex of Decision 2/CMP.7) and a technical correction (amounting to -1,755 t CO_2e) from the net emissions/removals reported under Forest Management (CRF sector KP.B.1). RMUs from Revegetation are calculated by subtracting the 1990 emissions/removals from the emissions/removals from a given year (CRF sector KP.B.4). Table 11.5 below shows the calculated RMUs for the second commitment period.

Table 11.5 Calculated RMUs (in t CO_2e) from Art. 3.3 and Art. 3.4 activities for CP2. In contrary to conventional inventory notations, in the case of removal units positive numbers indicate removals and negative emissions indicate emissions.

	2013	2014	2015	2016	2017	2018	2019	2020
Article 3.3								
A.1 Afforestation/ Reforestation	183,735	204,312	225,038	244,617	281,363	309,239	310,075	337,379
A.2 Deforestation	-163	-119	-655	-256	-475	-470	-470	-607
Article 3.4								
B.1 Forest Management	11,293	14,536	18,471	22,288	23,873	24,405	24,167	16,891
B.4 Revegetation	222,769	229,290	236,743	245,849	261,697	276,078	284,620	293,616
Total RMUs	**417,634**	**448,019**	**479,597**	**512,497**	**566,458**	**609,252**	**618,391**	**647,279**
Total RMUs for entire CP2: 4,299,126								

12 Information on Changes in National Registry

The following changes to the National Registry of Iceland occurred in 2022.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32. (a) Change of name or contact	None
15/CMP.1 annex II.E paragraph 32. (b) Change regarding cooperation arrangement	No changes.
15/CMP.1 annex II.E paragraph 32. **(c)** Change to database structure or the capacity of national registry	There has been 3 new EUCR releases (versions 13.6.1, 13.7.1 and 13.8.2) after version 13.5.2 (the production version at the time of the last Chapter 14 submission). No changes were applied to the database, whose model is provided in Annex A. No change was required to the application backup plan or to the disaster recovery plan. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32. **(d)** Change regarding conformance to technical standards	The changes that have been introduced with versions 13.6.1, 13.7.1 and 13.8.2 compared with version 13.5.2 of the national registry are presented in Annex B. It is to be noted that each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and are carried out prior to the relevant major release of the version to Production (see Annex B). No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32. (e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32. (f) Change regarding security	No changes regarding security were introduced.
15/CMP.1 annex II.E paragraph 32. (g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reported period.
15/CMP.1 annex II.E paragraph 32. (h) Change of Internet address	No change to the registry internet address during the reported period.
15/CMP.1 annex II.E paragraph 32. (i) Change regarding data integrity measures	No change of data integrity measures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32. **(j)** Change regarding test results	No change during the reported period.

13 References

Legislation

European

Council Decision (EU) 2015/1339 of 13 July 2015 on the conclusion, on behalf of the European Union, of the Doha Amendment to the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfilment of commitments thereunder OJ L 207, 4.8.2015, p. 1–5

Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC Text with EEA relevance OJ L 165, 18.6.2013, p. 13–40

Commission Implementing Regulation (EU) No 749/2014 of 30 June 2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council OJ L 203, 11.7.2014, p. 23–90

Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC OJ L 275, 25.10.2003, p. 32–46

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives OJ L 312, 22.11.2008, p. 3–30

Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 Text with EEA relevance OJ L 150, 20.5.2014, p. 195–230

Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases OJ L 161, 14.6.2006, p. 1–11

National (all in Icelandic)

3/1955 Lög um skógrækt – “Forestry Act”

70/2012 Lög um loftslagsmál – “Climate Act”

62/2015 Lög um breytingu á lögum um loftslagsmál, nr. 70/2012, með síðari breytingum (EES-reglur, geymsla koldíoxíðs, vistvæn ökutæki, Kyoto-bókunin). – “Act amending the Climate Act, no. 70/2012, with subsequent amendments (EEA regulations, storage of carbon dioxide, eco-friendly vehicles, Kyoto Protocol”

48/2007 Lög um breytingu á lögum nr. 87/2003, um Orkustofnun. – “Act amending Act no. 87/2003, on the National Energy Authority”

230/1998 Reglugerð um tiltekin efni sem stuðla að auknum gróðurhúsaáhrifum. – “Regulation on certain substances that contribute to increased greenhouse effect”

851/2002 Reglugerð um grænt bókhald. – “Regulation about Green Accounting”

244/2009 Reglugerð um skil atvinnurekstrar á upplýsingum um losun gróðurhúsalofttegunda. – “Regulation on the provision of information on greenhouse gas emissions to business operators”

834/2010 Reglugerð um flúoraðar gróðurhúsalofttegundir – "Regulation on fluorinated greenhouse gases"

520/2017 Reglugerð um gagnasöfnun og upplýsingagjöf stofnana vegna bókhalds Íslands yfir losun gróðurhúsalofttegunda og bindingu kolefnis úr andrúmslofti. – "Regulation of data collection and reporting of agencies for Icelands accounting of greenhouse gas emissions and carbon sequestration from the atmosphere"

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Annexes to the National Inventory Report

Annex 1: Key Category Analysis

According to the IPCC definition, key categories are those that add up to 95% of the total inventory in level and/or in trend. In the Icelandic Emission Inventory key categories are identified by means of Approach 1 described in Volume 1, Chapter 4 of the 2006 IPCC Guidelines.

Table 1.1 and Table 1.2 list identified key categories. Tables A1.1, A1.2, and A1.3 show the 1990 level, 2021 level and 1990-2021 trend assessment without LULUCF, and Table A1.4, A1.5, and A1.6 show the 1990 level, 2021 level and 1990-2021 trend assessment with LULUCF. All categories are listed in decreasing order of level or trend % contribution. All emission figures are reported in kt CO_2e, with CO_2 equivalents calculated using GWPs from the 5th assessment report of the IPCC (AR5).

Table A1.1 Key Category analysis approach 1 level assessment for 1990 excluding LULUCF, [kt CO_2e, GWP AR5].

IPCC Code	IPCC Category	Gas	1990 Emissions [kt CO_2e]	Level Assessment [%]	Cumulative Total of Level [%]
1A4c	Agriculture/Forestry/Fishing	CO_2	794.1	21.6%	21.6%
1A3b	Road Transport	CO_2	519.8	14.1%	35.7%
2C3	Metal Production: Aluminium	PFC	444.8	12.1%	47.8%
1A2	Manufacturing and Construction	CO_2	294.9	8.0%	55.8%
3A2	Enteric Fermentation: Sheep	CH_4	208.8	5.7%	61.5%
2C2	Metal Production: Ferroalloys	CO_2	208.8	5.7%	67.1%
3D1	Agricultural Soils	N_2O	170.5	4.6%	71.8%
5A2	Unmanaged Waste Disposal Sites	CH_4	148.9	4.0%	75.8%
3A1	Enteric Fermentation: Cattle	CH_4	143.1	3.9%	79.7%
2C3	Metal Production: Aluminium	CO_2	139.2	3.8%	83.5%
1B2d	Fugitive Emissions	CO_2	61.4	1.7%	85.1%
2A1	Mineral Products: Cement	CO_2	51.6	1.4%	86.5%
3B1	Manure Management: Cattle	CH_4	48.2	1.3%	87.8%
2B10	Other	N_2O	41.3	1.1%	89.0%
3A4	Enteric Fermentation: Other	CH_4	37.8	1.0%	90.0%
5D2	Wastewater Treatment and Discharge: Industrial Wastewater	CH_4	36.2	0.98%	91.0%
3D2	Agricultural Soils: Indirect	N_2O	34.9	0.95%	91.9%
1A3a	Domestic Aviation	CO_2	33.3	0.91%	92.8%
1A3d	Navigation	CO_2	32.6	0.89%	93.7%
1A4b	Residential Stationary	CO_2	27.9	0.76%	94.4%
1A3e	Other Mobile Machinery	CO_2	21.6	0.59%	95.0%

Table A1.2 Key category analysis approach 1 level for 2021, excluding LULUCF, [kt CO_2].

IPCC code	IPCC category	Gas	2021 Emissions [kt CO_2e]	Level Assessment [%]	Cumulative Total of Level [%]
2C3	Metal Production: Aluminium	CO_2	1,272.2	27.3%	27.3%
1A3b	Road Transport	CO_2	851.7	18.3%	45.6%
1A4c	Agriculture/Forestry/Fishing	CO_2	589.1	12.6%	58.2%
2C2	Metal Production: Ferroalloys	CO_2	472.0	10.1%	68.3%
5A1	Managed Waste Disposal Sites	CH_4	184.4	3.96%	72.3%
3D1	Agricultural Soils	N_2O	179.0	3.8%	76.1%
1B2d	Fugitive Emissions	CO_2	175.8	3.8%	79.9%
2F1	Refrigeration and Air Conditioning	HFC	156.4	3.4%	83.2%
3A1	Enteric Fermentation: Cattle	CH_4	144.3	3.1%	86.3%
3A2	Enteric Fermentation: Sheep	CH_4	141.1	3.0%	89.4%
2C3	Metal Production: Aluminium	PFC	88.9	1.9%	91.3%
1A2	Manufacturing and Construction	CO_2	73.1	1.6%	92.8%
3B1	Manure Management: Cattle	CH_4	39.6	0.85%	93.7%
3A4	Enteric Fermentation: Other	CH_4	36.4	0.78%	94.4%
3D2	Agricultural Soils: Indirect	N_2O	31.7	0.68%	95.1%

Table A1. 3 Key category analysis approach 1 1990-2021 trend assessment, excluding LULUCF, [kt CO_2e].

IPCC code	IPCC Category	Gas	Base Year (1990) Estimate $E_{x,0}$ [kt CO_2e]	Current Year (2021) Estimate $E_{x,t}$ [kt CO_2e]	Trend Assessment $T_{x,t}$	Contribution to Trend [%]	Cumulative Total of trend [%]
2C3	Metal Production: Aluminium	CO_2	139.2	1,272.2	29.8%	28.3%	28.3%
2C3	Metal Production: Aluminium	PFC	444.8	88.9	12.9%	12.2%	40.5%
1A4c	Agriculture/Forestry/Fishing	CO_2	794.1	589.1	11.3%	10.7%	51.2%
1A2	Manufacturing and Construction	CO_2	294.9	73.1	8.2%	7.7%	59.0%
2C2	Metal Production: Ferroalloys	CO_2	208.8	472.0	5.6%	5.4%	64.3%
1A3b	Road Transport	CO_2	519.8	851.7	5.3%	5.0%	69.3%
5A2	Unmanaged waste disposal sites	CH_4	148.9	22.7	4.5%	4.28%	73.6%
5A1	Managed waste disposal sites	CH_4	18.8	184.4	4.4%	4.14%	77.8%
2F1	Refrigeration and Air Conditioning	HFC	0.0	156.4	4.2%	4.0%	81.8%
3A2	Enteric Fermentation: Sheep	CH_4	208.8	141.1	3.4%	3.2%	85.0%
1B2d	Fugitive Emissions	CO_2	61.4	175.8	2.7%	2.5%	87.5%
2A1	Mineral Products: Cement	CO_2	51.6	0.0	1.8%	1.7%	89.2%
2B10	Other	N_2O	41.3	0.0	1.4%	1.4%	90.5%
3A1	Enteric Fermentation: Cattle	CH_4	143.1	144.3	1.0%	0.95%	91.5%
3D1	Agricultural Soils	N_2O	169.7	178.5	1.0%	0.94%	92.4%
1A4b	Residential Stationary	CO_2	27.9	5.2	0.82%	0.78%	93.2%
5D2	Wastewater Treatment and Discharge: Industrial wastewater	CH_4	36.2	20.8	0.68%	0.65%	93.8%
1A3e	Other Mobile Machinery	CO_2	21.6	2.8	0.67%	0.63%	94.5%
1A3d	Navigation	CO_2	32.6	17.3	0.65%	0.62%	95.1%

Table A1. 4 Key Category analysis approach 1 Level Assessment for 1990, including LULUCF, [kt CO_2e].

IPCC code	IPCC Category	Gas	1990 Emissions /Removals [kt CO_2e]	Level Assessment (%)	Cumulative Total of Level [%]
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	3,322.8	20.8%	20.8%
4C1	Grassland	CO_2	3,133.9	19.6%	40.4%
4C2	Grassland	CO_2	1,757.0	11.0%	51.4%
4D1	Wetlands	CO_2	1,308.0	8.2%	59.6%
4B1	Cropland	CO_2	1,220.9	7.6%	67.3%
1A4c	Agriculture/Forestry/Fishing	CO_2	794.1	5.0%	72.3%
4B2	Cropland	CO_2	634.8	4.0%	76.2%
1A3b	Road Transport	CO_2	519.8	3.3%	79.5%
2C3	Metal Production: Aluminium	PFC	444.8	2.8%	82.3%
4(II) - Grasslands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	418.9	2.6%	84.9%
1A2	Manufacturing and Construction	CO_2	294.9	1.8%	86.7%
3A2	Enteric Fermentation: Sheep	CH_4	208.8	1.3%	88.1%
2C2	Metal Production: Ferroalloys	CO_2	208.8	1.3%	89.4%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	190.6	1.2%	90.6%
3D1	Agricultural Soils	N_2O	169.7	1.1%	91.6%
5A2	Unmanaged waste disposal sites	CH_4	148.9	0.93%	92.5%
3A1	Enteric Fermentation: Cattle	CH_4	143.1	0.90%	93.4%
2C3	Metal Production: Aluminium	CO_2	139.2	0.87%	94.3%
4(II) - Grasslands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	110.6	0.69%	95.0%

Table A1. 5 Key category analysis approach 1 level for 2021, including LULUCF, [kt CO_2e].

IPCC Code	IPCC Category	Gas	2021 Emissions/ Removals [kt CO_2e]	Level Assessment [%]	Cumulative Total of Level [%]
4C1	Grassland	CO_2	5,387.1	30.0%	30.0%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	3,177.7	17.7%	47.6%
4B1	Cropland	CO_2	1,776.5	9.9%	57.5%
2C3	Metal Production: Aluminium	CO_2	1,272.2	7.1%	64.6%
4D1	Wetlands	CO_2	1,243.4	6.9%	71.5%
1A3b	Road Transport	CO_2	851.7	4.7%	76.2%
1A4c	Agriculture/Forestry/Fishing	CO_2	589.1	3.3%	79.5%
2C2	Metal Production: Ferroalloys	CO_2	472.0	2.6%	82.1%
4(II) - Grasslands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	469.2	2.6%	84.7%
4A2	Forest Land	CO_2	384.8	2.1%	86.9%
4C2	Grassland	CO_2	206.8	1.1%	88.0%
5A1	Managed Waste Disposal Sites	CH_4	184.4	1.0%	89.0%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	181.9	1.0%	90.1%
3D1	Agricultural Soils	N_2O	178.5	1.0%	91.0%
1B2d	Fugitive Emissions	CO_2	175.8	1.0%	92.0%
2F1	Refrigeration and Air Conditioning	HFC	156.4	0.87%	92.9%
3A1	Enteric Fermentation: Cattle	CH_4	144.3	0.80%	93.7%
3A2	Enteric Fermentation: Sheep	CH_4	141.1	0.78%	94.5%
4A1	Forest Land	CO_2	128.1	0.71%	95.2%

Table A1. 6 Key category analysis approach 1 - 1990-2021 trend assessment, including LULUCF, [kt CO_2e].

IPCC Code	IPCC Category	Gas	Base Year (1990) Estimate $E_{x,0}$ [kt CO_2e]	Current Year (2020) Estimate $E_{x,t}$ [kt CO_2e]	Trend Assessment $T_{x,t}$	Contribution to Trend [%]	Cumulative Total of trend [%]
4C1	Grassland	CO_2	3,133.9	5,387.1	11.6%	19.3%	19.3%
4C2	Grassland	CO_2	1,757.0	206.8	11.1%	18.4%	37.6%
2C3	Metal Production: Aluminium	CO_2	139.2	1,272.2	7.0%	11.6%	49.2%
4B2	Cropland	CO_2	634.8	90.9	3.9%	6.5%	55.7%
4(II) - Wetlands	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	3,322.8	3,177.7	3.5%	5.9%	61.6%
2C3	Metal Production: Aluminium	PFC	444.8	88.9	2.6%	4.3%	65.8%
4B1	Cropland	CO_2	1,220.9	1,776.5	2.5%	4.2%	70.0%
4A2	Forest Land	CO_2	27.7	384.8	2.2%	3.7%	73.7%
1A4c	Agriculture/Forestry /Fishing	CO_2	794.1	589.1	1.9%	3.2%	76.8%
1A3b	Road Transport	CO_2	519.8	851.7	1.7%	2.8%	79.6%
1A2	Manufacturing and Construction	CO_2	294.9	73.1	1.6%	2.7%	82.3%
2C2	Metal Production: Ferroalloys	CO_2	208.8	472.0	1.5%	2.5%	84.7%
4D1	Wetlands	CO_2	1,308.0	1,243.4	1.4%	2.39%	87.1%
5A1	Managed waste disposal sites	CH_4	18.8	184.4	1.0%	1.69%	88.8%
2F1	Refrigeration and Air Conditioning	HFC	0.0	156.4	1.0%	1.62%	90.4%
5A2	Unmanaged waste disposal sites	CH_4	148.9	22.7	0.91%	1.50%	91.9%
4A1	Forest land	CO_2	2.1	128.1	0.79%	1.3%	93.2%
1B2d	Fugitive Emissions	CO_2	61.4	175.8	0.67%	1.1%	94.4%
3A2	Enteric Fermentation: Sheep	CH_4	208.8	141.1	0.59%	1.0%	95.3%

Annex 2: Assessment of Uncertainty

The methodology for this assessment of uncertainty is discussed in Section 1.6 of this report. The assessment of uncertainty takes into account activity data and emission factor uncertainties, and their relationship to national totals.

Because emissions from the LULUCF sector represent such a large part of Iceland's inventory, the assessment of uncertainty changes considerably depending on whether it includes or excludes LULUCF. When including LULUCF, the overall trend uncertainty estimate for this submission is 18%, whereas the uncertainty in total inventory is 62%. When looking at the uncertainty analysis without LULUCF, the trend uncertainty is 6.4%, and the uncertainty in total inventory is 6.7%.

Table A2.1 and Table A2.2 show the complete uncertainty assessment, with and without LULUCF, respectively. All emission figures are reported in kt CO_2e, with CO_2 equivalents calculated using GWPs from the 5th assessment report of the IPCC (AR5).

Table A2.1 Uncertainty Analysis including LULUCF

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
1A1ai	Public Electricity and Heat Production (Electricity Generation)	CO_2	4.12	2.37	5%	5%	7%	1.4E-10	0.0007%	0.0013%	0.0000%
1A1aiii	Public Electricity and Heat Production (Heat Plants)	CO_2	9.34	0.19	5%	5%	7%	9.4E-13	0.0036%	0.0001%	0.0000%
1A2a	Iron and Steel	CO_2	0.35	1.18	2%	5%	5%	1.9E-11	0.0003%	0.0002%	0.0000%
1A2b	Non-Ferrous Metals	CO_2	13.50	9.17	2%	5%	5%	1.2E-9	0.0019%	0.0015%	0.0000%
1A2c	Chemicals	CO_2	7.43	0.00	5%	5%	7%	0.0E+00	0.0030%	0.0000%	0.0000%
1A2e	Food Processing, Beverages, and Tobacco	CO_2	128.24	22.24	5%	5%	7%	1.3E-8	0.0427%	0.0118%	0.0000%
1A2f	Non-metallic Minerals	CO_2	47.42	0.41	5%	5%	7%	4.2E-12	0.0187%	0.0002%	0.0000%
1A2g	Other Manufacturing Industries and Constructions	CO_2	97.96	40.10	5%	5%	7%	4.1E-8	0.0239%	0.0213%	0.0000%
1A3a	Domestic Aviation	CO_2	33.34	20.74	5%	5%	7%	1.1E-8	0.0055%	0.0110%	0.0000%
1A3b	Road Transport	CO_2	519.80	851.69	5%	3%	6%	1.2E-5	0.0636%	0.4531%	0.0021%
1A3d	Domestic Water-borne Navigation	CO_2	32.59	17.34	5%	5%	7%	7.6E-9	0.0064%	0.0092%	0.0000%
1A3e	Mobile Machinery – Other	CO_2	21.62	2.82	5%	5%	7%	2.0E-10	0.0075%	0.0015%	0.0000%
1A4a	Commercial/Institutional	CO_2	8.02	1.74	5%	5%	7%	7.6E-11	0.0025%	0.0009%	0.0000%
1A4b	Residential	CO_2	27.94	5.16	5%	5%	7%	6.7E-10	0.0092%	0.0027%	0.0000%
1A4c	Agriculture/Fishing	CO_2	794.06	589.07	5%	5%	7%	8.8E-6	0.0943%	0.3134%	0.0011%
1A5a	Other – Stationary	CO_2	0.12	2.53	5%	5%	7%	1.6E-10	0.0009%	0.0013%	0.0000%
1B2a5	Oil – Distribution of Oil Products	CO_2	0.00	0.00	5%	5%	7%	3.5E-16	0.0000%	0.0000%	0.0000%
1B2d	Other Emissions from Energy Production	CO_2	61.36	175.76	10%	10%	14%	3.1E-06	0.0834%	0.1870%	0.0004%
2A1	Cement Production	CO_2	51.56	0.00	2%	30%	30%	0.0E+00	0.1231%	0.0000%	0.0002%
2A4d	Other: Mineral Wool Production	CO_2	0.70	0.93	2%	2%	3%	3.2E-12	0.0000%	0.0002%	0.0000%
2B10a	Other: Silica Production	CO_2	0.36	0.00	5%	10%	11%	0.0E+00	0.0003%	0.0000%	0.0000%
2C1a	Metal Production – Iron and steel	CO_2	0.00	0.00	10%	25%	27%	0.0E+00	0.0000%	0.0000%	0.0000%

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
2C2	Metal Production – Ferroalloys	CO_2	208.80	472.05	2%	2%	2%	5.1E-7	0.0283%	0.0753%	0.0001%
2C3	Metal Production – Aluminium Production	CO_2	139.21	1,272.20	2%	2%	2%	3.7E-6	0.1269%	0.2030%	0.0006%
2D1	Lubricants	CO_2	4.06	2.09	5%	50%	50%	5.6E-9	0.0083%	0.0011%	0.0000%
2D2	Paraffin Wax Use	CO_2	0.17	0.34	5%	100%	100%	5.8E-10	0.0012%	0.0002%	0.0000%
2D3a	Domestic Solvent Use Including Fungicide	CO_2	1.37	2.00	2%	11%	11%	2.4E-10	0.0004%	0.0004%	0.0000%
2D3b	Other (please specify) Road Paving with Asphalt	CO_2	0.01	0.01	2%	303%	303%	3.0E-12	0.0001%	0.0000%	0.0000%
2D3d	Coating Applications	CO_2	1.12	0.90	2%	43%	44%	7.8E-10	0.0009%	0.0002%	0.0000%
2D3e	Degreasing	CO_2	0.17	0.11	2%	74%	74%	3.6E-11	0.0004%	0.0000%	0.0000%
2D3f	Dry Cleaning	CO_2	0.00	0.00	2%	496%	496%	2.8E-12	0.0000%	0.0000%	0.0000%
2D3g	Chemical Products	CO_2	0.03	0.01	2%	36%	36%	5.1E-14	0.0001%	0.0000%	0.0000%
2D3h	Printing	CO_2	0.17	0.19	2%	207%	207%	7.7E-10	0.0001%	0.0000%	0.0000%
2D3ia	Creosotes	CO_2	0.00	0.00	2%	43%	43%	0.0E+00	0.0000%	0.0000%	0.0000%
2D3ib	Organic Preservative	CO_2	0.02	0.09	2%	5%	6%	1.3E-13	0.0000%	0.0000%	0.0000%
2D3ic	De-icing	CO_2	0.08	0.05	30%	75%	80%	8.6E-12	0.0002%	0.0002%	0.0000%
2D3urea	Urea-based Catalysts	CO_2	0.00	0.75	2%	5%	5%	8.2E-12	0.0003%	0.0002%	0.0000%
2G4fw	Other: Fireworks	CO_2	0.00	0.02	2%	50%	50%	6.6E-13	0.0001%	0.0000%	0.0000%
3G	Liming	CO_2	0.46	5.77	50%	0%	50%	4.2E-8	0.0000%	0.0307%	0.0000%
3H	Urea Application	CO_2	0.00	1.48	50%	0%	50%	2.8E-9	0.0000%	0.0079%	0.0000%
3I	Other Carbon Containing Fertilisers	CO_2	0.00	1.94	50%	0%	50%	4.8E-9	0.0000%	0.0103%	0.0000%
4(II)	Cropland	CO_2	28.65	28.86	20%	43%	48%	9.5E-7	0.0047%	0.0614%	0.0000%
4(II)	Forest Land	CO_2	0.28	1.82	5%	58%	59%	5.8E-9	0.0067%	0.0010%	0.0000%
4(II)	Grasslands	CO_2	110.6	124.0	20%	53%	56%	2.5E-5	0.0276%	0.2638%	0.0007%
4(II)	Wetlands	CO_2	190.6	181.9	20%	37%	42%	3.0E-5	0.0554%	0.3871%	0.0015%
4(V)	Forest Land	CO_2	0.00	0.44	5%	34%	34%	1.1E-10	0.0011%	0.0002%	0.0000%

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
4A1	Forest Land Remaining Forest Land	CO_2	-2.14	-128.10	5%	25%	26%	5.4E-6	0.2369%	0.0681%	0.0006%
4A2	Land Converted to Forest Land	CO_2	-27.66	-384.79	5%	10%	11%	9.2E-6	0.2645%	0.2047%	0.0011%
4B1	Cropland Remaining Cropland	CO_2	1,220.9	1,776.5	20%	15%	25%	9.8E-4	0.5364%	3.7804%	0.1458%
4B2	Land Converted to Cropland	CO_2	634.8	90.9	20%	21%	29%	3.5E-6	0.9220%	0.1935%	0.0089%
4C1	Grassland Remaining Grassland	CO_2	3,133.9	5,387.1	20%	50%	54%	4.2E-2	7.7191%	11.4635%	1.9100%
4C2	Land Converted to Grassland	CO_2	1,757.0	-206.8	20%	20%	29%	1.8E-5	3.1786%	0.4400%	0.1030%
4D1	Wetlands Remaining Wetlands	CO_2	-1,308.0	-1,243.4	20%	40%	45%	1.6E-3	0.4215%	2.6458%	0.0718%
4D2	Land Converted to Wetlands	CO_2	0.51	4.83	20%	113%	115%	1.6E-7	0.0365%	0.0103%	0.0000%
4E2	Land Converted to Settlements	CO_2	21.84	8.80	5%	150%	150%	8.8E-7	0.1614%	0.0047%	0.0003%
4G	Harvested Wood Products	CO_2	0.00	-0.01	10%	50%	51%	2.6E-13	0.00005%	0.0000%	0.0000%
5C	Incineration and Open Burning of waste	CO_2	7.30	6.61	52%	40%	66%	9.5E-8	0.0033%	0.0366%	0.0000%
1A1ai	Public electricity and heat production (electricity generation)	CH_4	0.005	0.003	5%	100%	100%	3.7E-14	0.0000%	0.0000%	0.0000%
1A1aiii	Public electricity and heat production (heat plants)	CH_4	0.010	0.000	5%	100%	100%	2.4E-16	0.0001%	0.0000%	0.0000%
1A2a	Iron and Steel	CH_4	0.000	0.001	2%	100%	100%	5.7E-15	0.0000%	0.0000%	0.0000%
1A2b	Non-Ferrous Metals	CH_4	0.014	0.010	2%	100%	100%	5.1E-13	0.0000%	0.0000%	0.0000%
1A2c	Chemicals	CH_4	0.008	0.000	5%	100%	100%	0.0E+00	0.0001%	0.0000%	0.0000%
1A2e	Food Processing, Beverages, and Tobacco	CH_4	0.139	0.096	5%	100%	100%	4.7E-11	0.0004%	0.0001%	0.0000%
1A2f	Non-metallic Minerals	CH_4	0.137	0.000	5%	100%	100%	1.1E-15	0.0011%	0.0000%	0.0000%
1A2g	Other Manufacturing Industries and Constructions	CH_4	0.136	0.059	5%	100%	100%	1.8E-11	0.0006%	0.0000%	0.0000%
1A3a	Domestic Aviation	CH_4	0.007	0.004	5%	100%	100%	8.4E-14	0.0000%	0.0000%	0.0000%
1A3b	Road Transport	CH_4	6.237	1.124	5%	219%	219%	3.1E-8	0.0902%	0.0006%	0.0001%
1A3d	Domestic Water-borne Navigation	CH_4	0.085	0.046	5%	50%	50%	2.7E-12	0.0002%	0.0000%	0.0000%
1A3e	Mobile machinery – Other	CH_4	0.034	0.004	5%	100%	100%	1.0E-13	0.0002%	0.0000%	0.0000%

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
1A4a	Commercial/Institutional	CH_4	0.027	0.004	5%	100%	100%	1.0E-13	0.0002%	0.0000%	0.0000%
1A4b	Residential	CH_4	0.106	0.052	5%	100%	100%	1.4E-11	0.0005%	0.0000%	0.0000%
1A4c	Agriculture/Fishing	CH_4	2.055	1.544	5%	50%	50%	3.0E-9	0.0024%	0.0008%	0.0000%
1A5a	Other – Stationary	CH_4	0.000	0.006	5%	100%	100%	1.5E-13	0.0000%	0.0000%	0.0000%
1B2a5	Oil – Distribution of Oil Products	CH_4	0.545	0.539	5%	100%	100%	1.5E-9	0.0003%	0.0003%	0.0000%
1B2d	Other emission from Energy Production	CH_4	0.219	3.951	10%	25%	27%	5.7E-9	0.0070%	0.0042%	0.0000%
2C2	Metal Production – Ferroalloys	CH_4	1.758	3.979	2%	10%	10%	8.2E-10	0.0016%	0.0006%	0.0000%
2G4tob	Other – Tobacco	CH_4	0.050	0.019	2%	50%	50%	4.7E-13	0.0001%	0.0000%	0.0000%
2G4fw	Other – Fireworks use	CH_4	0.003	0.012	2%	50%	50%	1.9E-13	0.0000%	0.0000%	0.0000%
3A1	Enteric Fermentation – Cattle	CH_4	143.1	144.3	5%	40%	40%	1.7E-5	0.0213%	0.0768%	0.0001%
3A2	Enteric Fermentation – Sheep	CH_4	208.8	141.1	5%	40%	40%	1.6E-5	0.2402%	0.0750%	0.0006%
3A3	Enteric Fermentation – Swine	CH_4	1.250	1.612	5%	40%	40%	2.1E-9	0.0009%	0.0009%	0.0000%
3A4 rabbit	Enteric Fermentation – Rabbit	CH_4	0.005	0.000	5%	40%	40%	3.3E-17	0.0000%	0.0000%	0.0000%
3A4 fur-bearing	Enteric Fermentation – Fur-bearing	CH_4	0.134	0.046	5%	40%	40%	1.8E-12	0.0003%	0.0000%	0.0000%
3A4 poultry	Enteric Fermentation – Poultry	CH_4	0.372	0.446	5%	40%	40%	1.6E-10	0.0002%	0.0002%	0.0000%
3A4 horses	Enteric Fermentation – Horses	CH_4	37.229	35.535	10%	40%	41%	1.1E-6	0.0116%	0.0378%	0.0000%
3A4 goats	Enteric Fermentation – Goats	CH_4	0.068	0.342	5%	40%	40%	9.6E-11	0.0008%	0.0002%	0.0000%
3B11	Manure Management – Cattle	CH_4	48.222	39.557	11%	20%	23%	4.2E-7	0.0172%	0.0471%	0.0000%
3B12	Manure Management – Sheep	CH_4	18.596	11.201	50%	20%	54%	1.9E-7	0.0127%	0.0599%	0.0000%
3B13	Manure Management – Swine	CH_4	5.001	6.448	11%	30%	32%	2.2E-8	0.0026%	0.0077%	0.0000%
3B14 rabbit	Manure Management – Rabbit	CH_4	0.004	0.000	11%	30%	32%	1.3E-17	0.0000%	0.0000%	0.0000%

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
3B14 fur-bearing	Manure Management – Fur-bearing	CH_4	0.910	0.316	11%	30%	32%	5.2E-11	0.0015%	0.0004%	0.0000%
3B14 poultry	Manure Management – Poultry	CH_4	8.812	4.306	11%	30%	32%	9.6E-9	0.0113%	0.0051%	0.0000%
3B14 horses	Manure Management – Horses	CH_4	3.268	3.119	14%	30%	33%	5.4E-9	0.0008%	0.0047%	0.0000%
3B14 goats	Manure Management – Goats	CH_4	0.002	0.009	11%	30%	32%	4.1E-14	0.0000%	0.0000%	0.0000%
4(II)	Cropland	CH_4	106.2	107.0	20%	51%	55%	1.8E-5	0.0208%	0.2276%	0.0005%
4(II)	Forest Land	CH_4	0.131	0.855	5%	176%	176%	1.1E-8	0.0095%	0.0005%	0.0000%
4(II)	Grassland	CH_4	418.9	469.2	20%	65%	68%	5.2E-4	0.1280%	0.9985%	0.0101%
4(II)	Wetlands	CH_4	3,322.8	3,177.7	20%	258%	259%	3.4E-1	6.5397%	6.7621%	0.8849%
4(V)	Forest Land	CH_4	0.000	0.037	5%	43%	43%	1.3E-12	0.0001%	0.0000%	0.0000%
4(V)	Grassland	CH_4	0.000	0.010	20%	42%	46%	1.1E-13	0.0000%	0.0000%	0.0000%
5A1	Managed Waste Disposal Sites	CH_4	18.8	184.4	52%	43%	67%	7.8E-5	0.5288%	1.0197%	0.0132%
5A2	Unmanaged Waste Disposal Sites	CH_4	148.9	22.7	52%	41%	67%	1.2E-6	0.4180%	0.1263%	0.0019%
5B	Biological Treatment of Solid Waste	CH_4	0.000	3.737	52%	100%	113%	9.0E-8	0.0281%	0.0207%	0.0000%
5C	Incineration and Open Burning of Waste	CH_4	6.816	0.102	52%	100%	113%	6.7E-11	0.0535%	0.0006%	0.0000%
5D1	Wastewater Treatment and Discharge Domestic Wastewater	CH_4	19.813	22.528	39%	58%	70%	1.3E-6	0.0069%	0.0928%	0.0001%
5D2	Wastewater Treatment and Discharge Industrial Wastewater	CH_4	36.182	20.781	39%	58%	70%	1.1E-6	0.0767%	0.0856%	0.0001%
1A1ai	Public electricity and heat production (electricity generation)	N_2O	0.009	0.005	5%	100%	100%	1.3E-13	0.0000%	0.0000%	0.0000%
1A1aiii	Public electricity and heat production (heat plants)	N_2O	0.019	0.000	5%	100%	100%	8.8E-16	0.0001%	0.0000%	0.0000%
1A2a	Iron and Steel	N_2O	0.001	0.002	2%	100%	100%	1.7E-14	0.0000%	0.0000%	0.0000%

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
1A2b	Non-ferrous Metals	N_2O	0.026	0.019	2%	100%	100%	1.8E-12	0.0001%	0.0000%	0.0000%
1A2c	Chemicals	N_2O	0.015	0.000	5%	100%	100%	0.0E+00	0.0001%	0.0000%	0.0000%
1A2e	Food Processing, Beverages, and Tobacco	N_2O	0.264	0.132	5%	100%	100%	8.9E-11	0.0011%	0.0001%	0.0000%
1A2f	Non-metallic Minerals	N_2O	0.195	0.001	5%	100%	100%	3.9E-15	0.0015%	0.0000%	0.0000%
1A2g	Other Manufacturing Industries and Construction	N_2O	6.012	3.227	5%	100%	100%	5.3E-8	0.0236%	0.0017%	0.0000%
1A3a	Domestic Aviation	N_2O	0.248	0.154	5%	150%	150%	2.7E-10	0.0012%	0.0001%	0.0000%
1A3b	Road Transport	N_2O	4.653	6.789	5%	188%	188%	8.2E-7	0.0264%	0.0036%	0.0000%
1A3d	Domestic Water-borne Navigation	N_2O	0.230	0.125	5%	140%	140%	1.5E-10	0.0013%	0.0001%	0.0000%
1A3e	Mobile Machinery – Other	N_2O	2.227	0.289	5%	250%	250%	2.6E-9	0.0389%	0.0002%	0.0000%
1A4a	Commercial/Institutional	N_2O	0.013	0.001	5%	100%	100%	9.5E-15	0.0001%	0.0000%	0.0000%
1A4b	Residential	N_2O	0.060	0.007	5%	100%	100%	2.8E-13	0.0004%	0.0000%	0.0000%
1A4c	Agriculture/Fishing	N_2O	9.605	6.183	5%	140%	140%	3.8E-7	0.0419%	0.0033%	0.0000%
1A5a	Other – Stationary	N_2O	0.000	0.006	5%	100%	100%	1.7E-13	0.0000%	0.0000%	0.0000%
1B2a5	Oil – Distribution of Oil Products	N_2O	0.000	0.000	5%	0%	5%	8.9E-23	0.0000%	0.0000%	0.0000%
2B10b	Other – Fertiliser Production	N_2O	41.340	0.000	5%	40%	40%	0.0E+00	0.1316%	0.0000%	0.0002%
2G3a	N_2O from Product Uses: Medical Applications	N_2O	4.711	1.216	6%	5%	8%	4.6E-11	0.0014%	0.0008%	0.0000%
2G3b	N_2O from Product Uses: Other	N_2O	0.639	0.386	6%	5%	8%	4.6E-12	0.0001%	0.0002%	0.0000%
2G4tob	Other – Tobacco	N_2O	0.010	0.004	2%	50%	50%	1.7E-14	0.0000%	0.0000%	0.0000%
2G4fw	Other – Fireworks	N_2O	0.058	0.270	2%	50%	50%	9.2E-11	0.0008%	0.0001%	0.0000%
3B21	Manure Management – Cattle	N_2O	0.866	1.736	55%	100%	114%	2.0E-8	0.0062%	0.0102%	0.0000%
3B22	Manure Management: – Sheep	N_2O	4.556	3.039	68%	100%	121%	6.9E-8	0.0134%	0.0221%	0.0000%
3B24 rabbit	Manure Management – Rabbit	N_2O	0.005	0.000	47%	100%	110%	2.8E-16	0.0000%	0.0000%	0.0000%

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
3B24 fur-bearing	Manure Management – Fur-bearing	N_2O	0.094	0.028	47%	100%	110%	4.8E-12	0.0005%	0.0001%	0.0000%
3B24 poultry	Manure Management – Poultry	N_2O	0.351	0.213	57%	100%	115%	3.0E-10	0.0012%	0.0013%	0.0000%
3B24 horses	Manure Management – Horses	N_2O	0.544	0.533	51%	100%	112%	1.8E-9	0.0003%	0.0029%	0.0000%
3B24 goats	Manure Management – Goats	N_2O	0.014	0.070	47%	100%	111%	3.1E-11	0.0004%	0.0004%	0.0000%
3B25	Manure Management – Indirect	N_2O	7.995	6.755	100%	400%	412%	3.9E-6	0.0512%	0.0719%	0.0001%
3D1.1	Inorganic N Fertilisers	N_2O	51.945	50.992	5%	233%	233%	7.2E-5	0.0695%	0.0271%	0.0001%
3D1.2a	Organic N Fertilisers	N_2O	26.777	22.166	71%	233%	244%	1.5E-5	0.1081%	0.1672%	0.0004%
3D1.2b	Organic N Fertilisers	N_2O	0.000	0.029	20%	233%	234%	2.3E-11	0.0005%	0.0001%	0.0000%
3D1.2c	Organic N Fertilisers	N_2O	0.000	0.727	20%	233%	234%	1.5E-8	0.0128%	0.0015%	0.0000%
3D1.3	Urine and Dung Deposited by Grazing Animals	N_2O	36.353	29.739	71%	233%	244%	2.7E-5	0.1530%	0.2260%	0.0007%
3D1.4	Crop Residues	N_2O	0.259	0.423	100%	233%	254%	5.8E-9	0.0026%	0.0045%	0.0000%
3D1.6	Cultivation of Organic Soils	N_2O	54.320	74.438	20%	200%	201%	1.1E-4	0.2555%	0.1584%	0.0009%
3D2.1	Indirect N_2O Emissions	N_2O	9.946	9.194	100%	400%	412%	7.3E-6	0.0399%	0.0978%	0.0001%
3D2.2	Nitrogen Leaching and Run-off	N_2O	24.958	22.504	100%	500%	510%	6.7E-5	0.1466%	0.2394%	0.0008%
4(II)	Forest Land	N_2O	0.116	0.759	5%	200%	200%	1.2E-8	0.0096%	0.0004%	0.0000%
4(V)	Forest Land	N_2O	0.000	0.019	5%	38%	38%	2.7E-13	0.0001%	0.0000%	0.0000%
4(III)	Grassland	N_2O	0.066	0.098	20%	200%	201%	2.0E-10	0.0004%	0.0002%	0.0000%
4(V)	Grassland	N_2O	0.000	0.009	20%	33%	39%	6.0E-14	0.0000%	0.0000%	0.0000%
4(III)	Settlements	N_2O	0.000	0.012	5%	100%	100%	7.0E-13	0.0001%	0.0000%	0.0000%
5B	Biological Treatment of Solid Waste	N_2O	0.000	1.757	52%	150%	159%	3.9E-8	0.0198%	0.0097%	0.0000%
5C	Incineration and Open Burning of Waste	N_2O	1.489	0.231	52%	100%	113%	3.4E-10	0.0101%	0.0013%	0.0000%

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertaint y	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
5D1	Wastewater Treatment and Discharge Domestic Wastewater	N_2O	4.298	5.547	39%	0%	39%	2.3E-8	0.0000%	0.0229%	0.0000%
2F1	Refrigeration and Air Conditioning	HFC	0.000	156.428			57%	4.1E-5			
2F4	Aerosols	HFC	0.314	0.820	5%	5%	7%	1.7E-11	0.0002%	0.0004%	0.0000%
2C3	Metal Production – Aluminium Production	PFC	444.816	88.886	2%	15%	15%	9.1E-7	0.4306%	0.0142%	0.0019%
2F1	Refrigeration and Air Conditioning	PFC	0.000	0.063			57%	6.6E-12			
2G1	Electrical Equipment	SF_6	1.130	2.975	30%	30%	42%	8.1E-9	0.0040%	0.0095%	0.0000%
Total Emissions			**13,291.6**	**14,060.0**							
Total Uncertainties				**% Uncertainty in total inventory (including LULUCF):**				**62.4%**		**Trend uncertainty:**	**17.8%**

Table A2.2 Uncertainty Analysis excluding LULUCF.

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
1A1ai	Public Electricity and Heat Production (Electricity Generation)	CO_2	4.1166	2.3662	5%	5%	7%	1.3E-9	0.0039%	0.0045%	0.0000%
1A1aiii	Public Electricity and Heat Production (Heat Plants)	CO_2	9.3425	0.1930	5%	5%	7%	8.6E-12	0.0158%	0.0004%	0.0000%
1A2a	Iron and Steel	CO_2	0.3533	1.1800	2%	5%	5%	1.7E-10	0.0010%	0.0007%	0.0000%
1A2b	Non-Ferrous Metals	CO_2	13.5006	9.1695	2%	5%	5%	1.1E-8	0.0108%	0.0053%	0.0000%
1A2c	Chemicals	CO_2	7.4296	0.0000	5%	5%	7%	0.0E+00	0.0128%	0.0000%	0.0000%
1A2e	Food Processing, Beverages, and Tobacco	CO_2	128.2408	22.2399	5%	5%	7%	1.1E-7	0.1902%	0.0427%	0.0004%
1A2f	Non-metallic Minerals	CO_2	47.4154	0.4059	5%	5%	7%	3.8E-11	0.0810%	0.0008%	0.0001%
1A2g	Other Manufacturing Industries and Constructions	CO_2	97.9584	40.0973	5%	5%	7%	3.7E-7	0.1140%	0.0770%	0.0002%
1A3a	Domestic Aviation	CO_2	33.3382	20.7354	5%	5%	7%	9.9E-8	0.0292%	0.0398%	0.0000%
1A3b	Road Transport	CO_2	519.7973	851.6911	5%	3%	6%	1.1E-4	0.1471%	1.6356%	0.0270%
1A3d	Domestic Water-borne Navigation	CO_2	32.5906	17.3444	5%	5%	7%	6.9E-8	0.0325%	0.0333%	0.0000%
1A3e	Mobile Machinery – Other	CO_2	21.6182	2.8196	5%	5%	7%	1.8E-9	0.0333%	0.0054%	0.0000%
1A4a	Commercial/Institutional	CO_2	8.0177	1.7363	5%	5%	7%	6.9E-10	0.0114%	0.0033%	0.0000%
1A4b	Residential	CO_2	27.9390	5.1584	5%	5%	7%	6.1E-9	0.0410%	0.0099%	0.0000%
1A4c	Agriculture/Fishing	CO_2	794.0561	589.0731	5%	5%	7%	8.0E-5	0.5642%	1.1313%	0.0160%
1A5a	Other – Stationary	CO_2	0.1219	2.5294	5%	5%	7%	1.5E-9	0.0032%	0.0049%	0.0000%
1B2a5	Oil – Distribution of Oil Products	CO_2	0.0028	0.0037	5%	5%	7%	3.2E-15	0.0000%	0.0000%	0.0000%
1B2d	Other Emissions from Energy Production	CO_2	61.3554	175.7570	10%	10%	14%	2.8E-5	0.2663%	0.6751%	0.0053%
2A1	Cement Production	CO_2	51.5612	0.0000	2%	30%	30%	0.0E+00	0.5319%	0.0000%	0.0028%
2A4d	Other: Mineral Wool Production	CO_2	0.6951	0.9307	2%	2%	3%	2.9E-11	0.0000%	0.0008%	0.0000%
2B10a	Other: Silica Production	CO_2	0.3603	0.0000	5%	10%	11%	0.0E+00	0.0012%	0.0000%	0.0000%
2C1a	Metal Production – Iron and steel	CO_2	0.0000	0.0000	10%	25%	27%	0.0E+00	0.0000%	0.0000%	0.0000%
2C2	Metal Production – Ferroalloys	CO_2	208.7966	472.0452	2%	2%	2%	4.6E-6	0.0846%	0.2720%	0.0008%

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
2C3	Metal Production – Aluminium Production	CO_2	139.2106	1,272.2035	2%	2%	2%	3.4E-5	0.4463%	0.7329%	0.0074%
2D1	Lubricants	CO_2	4.0597	2.0921	5%	50%	50%	5.1E-8	0.0415%	0.0040%	0.0000%
2D2	Paraffin Wax Use	CO_2	0.1732	0.3389	5%	100%	100%	5.3E-9	0.0033%	0.0007%	0.0000%
2D3a	Domestic Solvent Use Including fungicide	CO_2	1.3746	1.9975	2%	11%	11%	2.2E-9	0.0007%	0.0015%	0.0000%
2D3b	Other (please specify) Road Paving with Asphalt	CO_2	0.0051	0.0080	2%	303%	303%	2.7E-11	0.0001%	0.0000%	0.0000%
2D3d	Coating Applications	CO_2	1.1190	0.9013	2%	43%	44%	7.1E-9	0.0061%	0.0007%	0.0000%
2D3e	Degreasing	CO_2	0.1677	0.1139	2%	74%	74%	3.3E-10	0.0020%	0.0001%	0.0000%
2D3f	Dry cleaning	CO_2	0.0033	0.0047	2%	496%	496%	2.5E-11	0.0001%	0.0000%	0.0000%
2D3g	Chemical Products	CO_2	0.0343	0.0087	2%	36%	36%	4.7E-13	0.0003%	0.0000%	0.0000%
2D3h	Printing	CO_2	0.1705	0.1882	2%	207%	207%	7.0E-9	0.0016%	0.0001%	0.0000%
2D3ia	Creosotes	CO_2	0.0029	0.0000	2%	43%	43%	0.0E+00	0.0000%	0.0000%	0.0000%
2D3ib	Organic preservative	CO_2	0.0162	0.0907	2%	5%	6%	1.2E-12	0.0001%	0.0001%	0.0000%
2D3ic	De-icing	CO_2	0.0805	0.0514	30%	75%	80%	7.8E-11	0.0010%	0.0006%	0.0000%
2D3urea	Urea-based Catalysts	CO_2	0.0000	0.7481	2%	5%	5%	7.5E-11	0.0010%	0.0006%	0.0000%
2G4fw	Other – Fireworks	CO_2	0.0049	0.0228	2%	50%	50%	6.0E-12	0.0002%	0.0000%	0.0000%
3G	Liming	CO_2	0.4620	5.7689	50%	0%	50%	3.8E-7	0.0000%	0.1108%	0.0001%
3H	Urea Application	CO_2	0.0000	1.4765	50%	0%	50%	2.5E-8	0.0000%	0.0284%	0.0000%
3I	Other Carbon Containing Fertilisers	CO_2	0.0000	1.9448	50%	0%	50%	4.3E-8	0.0000%	0.0373%	0.0000%
5C	Incineration and Open Burning of Waste	CO_2	7.2956	6.6143	52%	40%	66%	8.7E-7	0.0285%	0.1320%	0.0002%
1A1ai	Public Electricity and Heat Production (Electricity Generation)	CH_4	0.0047	0.0027	5%	100%	100%	3.3E-13	0.0001%	0.0000%	0.0000%
1A1aiii	Public Electricity and Heat Production (Heat Plants)	CH_4	0.0101	0.0002	5%	100%	100%	2.2E-15	0.0003%	0.0000%	0.0000%
1A2a	Iron and Steel	CH_4	0.0004	0.0011	2%	100%	100%	5.1E-14	0.0000%	0.0000%	0.0000%
1A2b	Non-ferrous Metals	CH_4	0.0139	0.0100	2%	100%	100%	4.6E-12	0.0002%	0.0000%	0.0000%
1A2c	Chemicals	CH_4	0.0081	0.0000	5%	100%	100%	0.0E+00	0.0003%	0.0000%	0.0000%

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
1A2e	Food Processing, Beverages, and Tobacco	CH_4	0.1392	0.0963	5%	100%	100%	4.3E-10	0.0022%	0.0002%	0.0000%
1A2f	Non-metallic Minerals	CH_4	0.1365	0.0005	5%	100%	100%	9.9E-15	0.0047%	0.0000%	0.0000%
1A2g	Other Manufacturing Industries and Construction	CH_4	0.1356	0.0588	5%	100%	100%	1.6E-10	0.0031%	0.0001%	0.0000%
1A3a	Domestic Aviation	CH_4	0.0065	0.0041	5%	100%	100%	7.6E-13	0.0001%	0.0000%	0.0000%
1A3b	Road Transport	CH_4	6.2369	1.1239	5%	219%	219%	2.8E-7	0.4030%	0.0022%	0.0016%
1A3d	Domestic Water-borne Navigation	CH_4	0.0852	0.0461	5%	50%	50%	2.5E-11	0.0008%	0.0001%	0.0000%
1A3e	Mobile machinery – Other	CH_4	0.0342	0.0044	5%	100%	100%	9.1E-13	0.0011%	0.0000%	0.0000%
1A4a	Commercial/Institutional	CH_4	0.0268	0.0044	5%	100%	100%	9.1E-13	0.0008%	0.0000%	0.0000%
1A4b	Residential	CH_4	0.1062	0.0518	5%	100%	100%	1.2E-10	0.0022%	0.0001%	0.0000%
1A4c	Agriculture/Fishing	CH_4	2.0548	1.5437	5%	50%	50%	2.8E-8	0.0144%	0.0030%	0.0000%
1A5a	Other – Stationary	CH_4	0.0001	0.0055	5%	100%	100%	1.4E-12	0.0001%	0.0000%	0.0000%
1B2a5	Oil – Distribution of Oil Products	CH_4	0.5453	0.5393	5%	100%	100%	1.3E-8	0.0041%	0.0010%	0.0000%
1B2d	Other emissions from Energy Production	CH_4	0.2189	3.9508	10%	25%	27%	5.2E-8	0.0249%	0.0152%	0.0000%
2C2	Metal Production – Ferroalloys	CH_4	1.7582	3.9794	2%	10%	10%	7.4E-9	0.0048%	0.0023%	0.0000%
2G4tob	Other – Tobacco	CH_4	0.0501	0.0192	2%	50%	50%	4.3E-12	0.0006%	0.0000%	0.0000%
2G4fw	Other – Fireworks	CH_4	0.0026	0.0122	2%	50%	50%	1.7E-12	0.0001%	0.0000%	0.0000%
3A1	Enteric Fermentation – Cattle	CH_4	143.1129	144.3006	5%	40%	40%	1.6E-4	0.4008%	0.2771%	0.0024%
3A2	Enteric Fermentation – Sheep	CH_4	208.8202	141.0571	5%	40%	40%	1.5E-4	1.3393%	0.2709%	0.0187%
3A3	Enteric Fermentation – Swine	CH_4	1.2503	1.6120	5%	40%	40%	1.9E-8	0.0003%	0.0031%	0.0000%
3A4 rabbit	Enteric Fermentation – Rabbit	CH_4	0.0051	0.0002	5%	40%	40%	3.0E-16	0.0001%	0.0000%	0.0000%
3A4 fur-bearing	Enteric Fermentation – Fur-bearing	CH_4	0.1338	0.0464	5%	40%	40%	1.6E-11	0.0013%	0.0001%	0.0000%
3A4 poultry	Enteric Fermentation – Poultry	CH_4	0.3722	0.4456	5%	40%	40%	1.5E-9	0.0003%	0.0009%	0.0000%

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
3A4 horses	Enteric Fermentation – Horses	CH_4	37.2290	35.5353	10%	40%	41%	9.9E-6	0.1261%	0.1365%	0.0003%
3A4 goats	Enteric Fermentation – Goats	CH_4	0.0679	0.3419	5%	40%	40%	8.7E-10	0.0028%	0.0007%	0.0000%
3B11	Manure Management – Cattle	CH_4	48.2217	39.5575	11%	20%	23%	3.8E-6	0.1168%	0.1699%	0.0004%
3B12	Manure Management – Sheep	CH_4	18.5964	11.2006	50%	20%	54%	1.7E-6	0.0671%	0.2162%	0.0005%
3B13	Manure Management – Swine	CH_4	5.0010	6.4481	11%	30%	32%	2.0E-7	0.0009%	0.0277%	0.0000%
3B14 rabbit	Manure Management – Rabbit	CH_4	0.0041	0.0002	11%	30%	32%	1.2E-16	0.0000%	0.0000%	0.0000%
3B14 fur-bearing	Manure Management – Fur-bearing	CH_4	0.9097	0.3158	11%	30%	32%	4.7E-10	0.0068%	0.0014%	0.0000%
3B14 poultry	Manure Management – Poultry	CH_4	8.8118	4.3062	11%	30%	32%	8.7E-8	0.0558%	0.0185%	0.0000%
3B14 horses	Manure Management – Horses	CH_4	3.2679	3.1192	14%	30%	33%	4.9E-8	0.0083%	0.0169%	0.0000%
3B14 goats	Manure Management – Goats	CH_4	0.0018	0.0089	11%	30%	32%	3.7E-13	0.0001%	0.0000%	0.0000%
5A1	Managed waste disposal sites	CH_4	18.8102	184.4380	52%	43%	67%	7.1E-4	1.8635%	3.6809%	0.1702%
5A2	Unmanaged waste disposal sites	CH_4	148.8899	22.7430	52%	41%	67%	1.1E-5	1.8557%	0.4560%	0.0365%
5B	Biological treatment of solid waste	CH_4	0.0000	3.7373	52%	100%	113%	8.2E-7	0.1015%	0.0746%	0.0002%
5C	Incineration and Open Burning of waste	CH_4	6.8159	0.1020	52%	100%	113%	6.1E-10	0.2316%	0.0020%	0.0005%
5D1	Wastewater Treatment and Discharge Domestic Wastewater	CH_4	19.8129	22.5283	39%	58%	70%	1.1E-5	0.0405%	0.3351%	0.0011%
5D2	Wastewater Treatment and Discharge Industrial Wastewater	CH_4	36.1823	20.7807	39%	58%	70%	9.7E-6	0.3964%	0.3091%	0.0025%
1A1ai	Public Electricity and Heat Production (Electricity Generation)	N_2O	0.0089	0.0051	5%	100%	100%	1.2E-12	0.0002%	0.0000%	0.0000%
1A1aiii	Public Electricity and Heat Production (Heat Plants)	N_2O	0.0192	0.0004	5%	100%	100%	8.0E-15	0.0006%	0.0000%	0.0000%
1A2a	Iron and Steel	N_2O	0.0008	0.0018	2%	100%	100%	1.5E-13	0.0000%	0.0000%	0.0000%
1A2b	Non-ferrous Metals	N_2O	0.0258	0.0187	2%	100%	100%	1.6E-11	0.0004%	0.0000%	0.0000%

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
1A2c	Chemicals	N_2O	0.0153	0.0000	5%	100%	100%	0.0E+00	0.0005%	0.0000%	0.0000%
1A2e	Food Processing, Beverages, and Tobacco	N_2O	0.2636	0.1325	5%	100%	100%	8.1E-10	0.0055%	0.0003%	0.0000%
1A2f	Non-metallic Minerals	N_2O	0.1949	0.0009	5%	100%	100%	3.5E-14	0.0067%	0.0000%	0.0000%
1A2g	Other Manufacturing Industries and Construction	N_2O	6.0118	3.2272	5%	100%	100%	4.8E-7	0.1191%	0.0062%	0.0001%
1A3a	Domestic Aviation	N_2O	0.2479	0.1538	5%	150%	150%	2.5E-9	0.0065%	0.0003%	0.0000%
1A3b	Road Transport	N_2O	4.6532	6.7894	5%	188%	188%	7.5E-6	0.0458%	0.0130%	0.0000%
1A3d	Domestic Water-borne Navigation	N_2O	0.2303	0.1246	5%	140%	140%	1.4E-9	0.0063%	0.0002%	0.0000%
1A3e	Mobile Machinery – Other	N_2O	2.2274	0.2893	5%	250%	250%	2.4E-8	0.1719%	0.0006%	0.0003%
1A4a	Commercial/Institutional	N_2O	0.0133	0.0014	5%	100%	100%	8.7E-14	0.0004%	0.0000%	0.0000%
1A4b	Residential	N_2O	0.0603	0.0074	5%	100%	100%	2.5E-12	0.0019%	0.0000%	0.0000%
1A4c	Agriculture/Fishing	N_2O	9.6046	6.1835	5%	140%	140%	3.5E-6	0.2273%	0.0119%	0.0005%
1A5a	Other – Stationary	N_2O	0.0003	0.0057	5%	100%	100%	1.5E-12	0.0001%	0.0000%	0.0000%
1B2a5	Oil – Distribution of Oil Products	N_2O	0.0000	0.0000	5%	0%	5%	8.1E-22	0.0000%	0.0000%	0.0000%
2B10b	Other – Fertiliser Production	N_2O	41.3400	0.0000	5%	40%	40%	0.0E+00	0.5686%	0.0000%	0.0032%
2G3a	N_2O from Product Uses – Medical Applications	N_2O	4.7110	1.2155	6%	5%	8%	4.2E-10	0.0064%	0.0028%	0.0000%
2G3b	N_2O from Product Uses – Other	N_2O	0.6387	0.3865	6%	5%	8%	4.2E-11	0.0006%	0.0009%	0.0000%
2G4tob	Other – Tobacco	N_2O	0.0095	0.0037	2%	50%	50%	1.5E-13	0.0001%	0.0000%	0.0000%
2G4fw	Other – Fireworks	N_2O	0.0584	0.2698	2%	50%	50%	8.4E-10	0.0027%	0.0002%	0.0000%
3B21	Manure Management – Cattle	N_2O	0.8664	1.7360	55%	100%	114%	1.8E-7	0.0174%	0.0370%	0.0000%
3B22	Manure Management – Sheep	N_2O	4.5565	3.0390	68%	100%	121%	6.2E-7	0.0742%	0.0798%	0.0001%
3B24 rabbit	Manure Management – Rabbit	N_2O	0.0054	0.0002	47%	100%	110%	2.5E-15	0.0002%	0.0000%	0.0000%
3B24 fur-bearing	Manure Management – Fur-bearing	N_2O	0.0936	0.0278	47%	100%	110%	4.3E-11	0.0025%	0.0005%	0.0000%
3B24 poultry	Manure Management – Poultry	N_2O	0.3513	0.2128	57%	100%	115%	2.8E-9	0.0063%	0.0046%	0.0000%

IPCC Category		Gas	1990 Emissions [kt CO_2e]	2021 Emissions [kt CO_2e]	Activity Data Uncertainty	Emission Factor Uncertainty	Combined Uncertainty	Contribution to Variance by Category in Year x	Uncertainty in Trend Introduced by Emission Factor [%]	Uncertainty Introduced by Activity Data Uncertainty [%]	Uncertainty Introduced into the Trend in Total National Emissions [%]
3B24 horses	Manure Management – Horses	N_2O	0.5441	0.5327	51%	100%	112%	1.6E-8	0.0042%	0.0104%	0.0000%
3B24 goats	Manure Management – Goats	N_2O	0.0139	0.0702	47%	100%	111%	2.8E-10	0.0014%	0.0013%	0.0000%
3B25	Manure Management – Indirect	N_2O	7.9951	6.7554	100%	400%	412%	3.6E-5	0.3659%	0.2595%	0.0020%
3D1.1	Inorganic N fertilisers	N_2O	51.9453	50.9917	5%	233%	233%	6.5E-4	0.9366%	0.0979%	0.0089%
3D1.2a	Animal Manure Applied to Soils	N_2O	26.7769	22.1663	71%	233%	244%	1.3E-4	0.7438%	0.6035%	0.0092%
3D1.2b	Animal Manure Applied to Soils	N_2O	0.0000	0.0291	20%	233%	234%	2.1E-10	0.0018%	0.0002%	0.0000%
3D1.2c	Animal Manure Applied to Soils	N_2O	0.0000	0.7269	20%	233%	234%	1.3E-7	0.0461%	0.0056%	0.0000%
3D1.3	Urine and Dung Deposited by Grazing Animals	N_2O	36.3534	29.7391	71%	233%	244%	2.4E-4	1.0323%	0.8157%	0.0173%
3D1.4	Crop Residues	N_2O	0.2590	0.4227	100%	233%	254%	5.3E-8	0.0060%	0.0162%	0.0000%
3D1.6	Cultivation of Organic Soils (e.g., histosols)	N_2O	54.3204	74.4381	20%	200%	201%	1.0E-3	0.3072%	0.5718%	0.0042%
3D2.1	Atmospheric Deposition	N_2O	9.9455	9.1937	100%	400%	412%	6.6E-5	0.3693%	0.3531%	0.0026%
3D2.2	Nitrogen Leaching and Run-off	N_2O	24.9582	22.5040	100%	500%	510%	6.1E-4	1.2354%	0.8643%	0.0227%
5B	Biological Treatment of Solid Waste	N_2O	0.0000	1.7573	52%	150%	159%	3.6E-7	0.0716%	0.0351%	0.0001%
5C	Incineration and Open Burning of Waste	N_2O	1.4886	0.2305	52%	100%	113%	3.1E-9	0.0449%	0.0046%	0.0000%
5D1	Wastewater Treatment and Discharge Domestic Wastewater	N_2O	4.2983	5.5468	39%	0%	39%	2.1E-7	0.0000%	0.0825%	0.0001%
2F1	Refrigeration and Air Conditioning	HFC	0.0000	156.4277			57%	3.7E-4			
2F4	Aerosols	HFC	0.3136	0.8205	5%	5%	7%	1.5E-10	0.00057%	0.00158%	0.00000%
2C3	Metal Production – Aluminium Production	PFC	444.8159	88.8864	2%	15%	15%	8.3E-6	1.93006%	0.05121%	0.03728%
2F1	Refrigeration and Air Conditioning	PFC	0.0000	0.0628			57%	6.0E-11			
2G1	Electrical Equipment	SF_6	1.1301	2.9746	30%	30%	42%	7.3E-8	0.01258%	0.03428%	0.00001%
Total Emissions			**3,682.0**	**4,662.24**							
Total Uncertainties			**% Uncertainty in total inventory (excluding LULUCF):**					**6.7%**		**Trend uncertainty:**	**6.4%**

Annex 3: National Energy Balance for 2021

The Icelandic energy balance is compiled by the Environment Agency of Iceland (*Umhverfisstofnun*) (EAI) using data from the National Energy Authority (*Orkustofnun*) (NEA) and Statistics Iceland (*Hagstofa*) (SI). Work has begun in collaboration with the agencies that provide the data to improve the energy balance for Iceland.

The energy balance can be seen in Table A3.1. The available final energy consumption is based on the Reference Approach for this submission. That data is received from the NEA and SI. Data for final energy consumption is received from the NEA, disaggregated by CRF subsector, and is used for the Sectoral Approach.

The total absolute difference between the Sectoral and Reference approaches is 4,667 TJ, which is 20.8% of the total energy consumption in Iceland in 2021. The biggest discrepancies in fuel use are in gas/diesel oil. This discrepancy will be further analysed with the agencies that provide the data.

Table A3. 1 National Energy Balance for 2021

2021 Unit = TJ	Gasoline	Jet Kerosene	Gas Diesel Oil	Residual Fuel Oil	LPG	Bitumen	Lubricants	Petroleum Coke	Other Oil	Anthracite	Coke oven Gas	Liquid Biomass	Landfill Gas	Total
Indigenous Production	-	-	-	-	-	-	-	-	-	-	-	-	80.0	80.0
Imports	3,902	6,109	19,752	156	117	430	144	254	47.4	4,784	415	963	-	37,072
Exports	-	-	-		-	-	-	-	-	-	-	-	-	0.00
International Bunkers	-	5,765	1,514	141	-	-	-	-	-	-	-	-	-	7,420
Stock Change	207	29.8	1,278	-101	-1.61	-	-	-	-	-	-	-	-	1,412
Primary Energy Supply	3,695	314	16,960	116	118	430	144	254	47.4	4,784	415	963	80.0	28,320
Non-Energy Use of Fuels						430	144	254	47.4	4,784	415	0.00		6,074
Available Final Energy Consumption	**3,695**	**314**	**16,960**	**116**	**118**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**963**	**80.0**	**22,247**
1A1ai – Electricity Generation	-	-	32.1	-	-	-	-	-	-	-	-	-	-	32.1
1A1aiii – Heat Plants	-	-	2.62	-	-	-	-	-	-	-	-	-	-	2.62
1A2a – Iron and Steel	-	-	10.4	-	6.5	-	-	-	-	-	-	-	-	16.9
1A2b – Non-ferrous Metals	-	-	116	-	9.8	-	-	-	-	-	-	-	-	126
1A2e – Food processing, Beverages, and Tobacco	-	-	185	116	-	-	-	-	-	-	-	-	-	301
1A2f – Non-metallic Minerals (Mineral Wool)	-	-	5.50	-	-	-	-	-	-	-	-	-	-	5.50
1A2gvii – Off-road Vehicles & Mobile Machinery	-	-	423	-	-	-	-	-	-	-	-	-	-	423
1A2gviii – Other Industry	-	-	110	-	10.0	-	-	-	-	-	-	-	-	120
1A3a – Domestic Aviation	10.7	279	-	-	-	-	-	-	-	-	-	-	-	290
1A3b – Road Transport	3,730	-	7,857	-	-	-	-	-	-	-	-	1,012	90.7	12,689
1A3d – Domestic Navigation	-	-	235	-	-	-	-	-	-	-	-	-	-	235
1A3eii – Other Mobile Machinery	-	7.01	31.4	-	-	-	-	-	-	-	-	-	-	38.4
1A4ai – Commercial/Institutional - Stationary Combustion	-	-	5.02	-	21.7	-	-	-	-	-	-	-	-	26.7
1A4bi – Residential - Stationary Combustion	-	-	27.1	-	50.0	-	-	-	-	-	-	-	-	77.2
1A4ci – Stationary Agriculture	-	-	-	-	0.331	-	-	-	-	-	-	-	-	0.331
1A4cii – Off-road in Agriculture	-	-	277	-	-	-	-	-	-	-	-	-	-	277
1A4ciii – Fishing	-	-	7,709	-	-	-	-	-	-	-	-	2.03	-	7,711
1A5 – Other	-	12.5	22.2	-	-	-	-	-	-	-	-	1.22	5.60	41.5
Final Energy Consumption	**3,740**	**299**	**17,049**	**116**	**98.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1,015**	**96.3**	**22,415**
Statistical Differences	45.3	-14.9	89.1	0.0	-19.7	0.0	0.0	0.0	0.0	0.0	0.0	52.4	16.29	185
Difference (%)	1.23%	-4.75%	0.53%	0.00%	-16.7%							5.44%	20.4%	0.83%

Annex 4: ETS vs. Non-ETS

Information on consistency of reported emissions with data from the EU Emission Trading System according to Article 10 in the Implementing Regulation No 749/2014. According to Art.10 shall report the information referred to in Article 7(1)(k) of Regulation (EU) No 525/2013 in accordance with the tabular format set out in Annex V to the same Regulation. All emission figures are reported in kt CO_2e, with CO_2 equivalents calculated using GWPs from the 5th assessment report of the IPCC (AR5).

Table A4. 1 Total GHG inventory emissions vs. emissions verified under the EU ETS.

Total Emissions (CO_2e)					
Category(1)	**Gas**	**GHG inventory emissions [kt CO_2e]**(3)	**Verified emissions under Directive 2003/87/EC [kt CO_2e]**(3)	**Ratio in % (Verified emissions/ inventory emissions)**(3)	**Comment**(2)
Greenhouse gas emissions (for GHG inventory: total GHG emissions, including indirect CO_2 emissions if reported, without LULUCF, and excluding emissions from domestic aviation; for Directive 2003/87/EC: GHG emissions from stationary installations under Article 2(1) of Directive 2003/87/EC)	Total GHG	4,641.5	1,843.6	39.7%	
CO_2 emissions (for GHG inventory: total CO2 emissions, including indirect CO_2 emissions if reported, without LULUCF, and excluding CO_2 emissions from domestic aviation; for Directive 2003/87/EC: CO_2 emissions from stationary installations under Article 2(1) of Directive 2003/87/EC)	CO_2	3,489.3	1,754.7	50.3%	

For footnotes, see under Table A4. 4 below.

Table A4. 2 Total GHG inventory CO_2 emissions vs. emissions verified under the EU ETS, by CRF sector.

CO_2 emissions					
Category[(1)]	Gas	GHG inventory emissions [kt CO_2][(3)]	Verified emissions under Directive 2003/87/EC [kt CO_2][(3)]	Ratio in % (Verified emissions/ inventory emissions)[(3)]	Comment[(2)]
1.A Fuel combustion activities, total	CO_2	1,566.7	10.5	0.7%	
1.A Fuel combustion activities, stationary combustion	CO_2	77.4	10.5	13.5%	
1.A.1 Energy industries	CO_2	2.6	NO		Not verified emissions under Directive 2003/87/EC
1.A.1.a Public electricity and heat production	CO_2	2.6	NO		Not verified emissions under Directive 2003/87/EC
1.A.1.b Petroleum refining	CO_2	NO	NO		Does not occur in Iceland
1.A.1.c Manufacture of solid fuels and other energy industries	CO_2	NO	NO		Does not occur in Iceland
Iron and steel total (1.A.2, 1.B, 2.C.1)[(4)]	CO_2	473.23	473.23	100.0%	
1.A.2. Manufacturing industries and construction	CO_2	73.1	10.5	14.3%	
1.A.2.a Iron and steel	CO_2	1.2	1.2	100.5%	Differences due to slightly different NCV values used by ETS companies vs. inventory
1.A.2.b Non-ferrous metals	CO_2	9.2	9.2	100.7%	Differences due to slightly different NCV values used by ETS companies vs. inventory
1.A.2.c Chemicals	CO_2	NO	NO		Does not occur in Iceland
1.A.2.d Pulp, paper, and print	CO_2	NO	NO		Does not occur in Iceland
1.A.2.e Food processing, beverages, and tobacco	CO_2	22.2	NO		Not verified emissions under Directive 2003/87/EC
1.A.2.f Non-metallic minerals	CO_2	0.41	NO		Not verified emissions under Directive 2003/87/EC
1.A.2.g Other	CO_2	40.1	0.030	0.1%	One company is included in ETS, others are not
1.A.3. Transport	CO_2	892.6	NO		Not verified emissions under Directive 2003/87/EC
1.A.3.e Other transportation (pipeline transport)	CO_2	NO	NO		Does not occur in Iceland
1.A.4 Other sectors	CO_2	596.0	NO		Not verified emissions under Directive 2003/87/EC
1.A.4.a Commercial / Institutional	CO_2	1.7	NO		Not verified emissions under Directive 2003/87/EC
1.A.4.c Agriculture/ Forestry / Fisheries	CO_2	589.1	NO		Not verified emissions under Directive 2003/87/EC
1.B Fugitive Emissions from Fuels	CO_2	175.8	NO		Not verified emissions under Directive 2003/87/EC

CO_2 emissions					
Category[(1)]	**Gas**	**GHG inventory emissions [kt CO_2][(3)]**	**Verified emissions under Directive 2003/87/EC [kt CO_2][(3)]**	**Ratio in % (Verified emissions/ inventory emissions)[(3)]**	**Comment[(2)]**
1.C CO_2 Transport and Storage	CO_2	NO	NO		Does not occur in Iceland
1.C.1 Transport of CO_2	CO_2	NO	NO		Does not occur in Iceland
1.C.2 Injection and Storage	CO_2	NO	NO		Does not occur in Iceland
1.C:3 Other 2.A Mineral Products	CO_2	NO	NO		Does not occur in Iceland
2.A Mineral Products	CO_2	0.9	NO		Not verified emissions under Directive 2003/87/EC
2.A.1 Cement Production	CO_2	NO	NO		Does not occur in Iceland
2.A.2. Lime Production	CO_2	NO	NO		Does not occur in Iceland
2.A.3. Glass Production	CO_2	NO	NO		Does not occur in Iceland
2.A.4. Other Process Uses of Carbonates	CO_2	0.9	NO		Not verified emissions under Directive 2003/87/EC
2.B Chemical Industry	CO_2	NO	NO		Does not occur in Iceland
2.B.1. Ammonia Production	CO_2	NO	NO		Does not occur in Iceland
2.B.3. Adipic Acid Production (CO_2)	CO_2	NO	NO		Does not occur in Iceland
2.B.4. Caprolactam, Glyoxal, and Glyoxylic Acid Production	CO_2	NO	NO		Does not occur in Iceland
2.B.5. Carbide Production	CO_2	NO	NO		Does not occur in Iceland
2.B.6 Titanium Dioxide Production	CO_2	NO	NO		Does not occur in Iceland
2.B.7 Soda Ash Production	CO_2	NO	NO		Does not occur in Iceland
2.B.8 Petrochemical and Carbon Black Production	CO_2	NO	NO		Does not occur in Iceland
2.C Metal Production	CO_2	1,744.2	1,744.2	100.0%	
2.C.1. Iron and Steel Production	CO_2	NO	NO		Does not occur in Iceland
2.C.2 Ferroalloys Production	CO_2	472.0	472.0	100.0%	
2.C.3 Aluminium Production	CO_2	1,272.2	1,272.2	100.0%	
2.C.4 Magnesium Production	CO_2	NO	NO		Does not occur in Iceland
2.C.5 Lead Production	CO_2	NO	NO		Does not occur in Iceland
2.C.6 Zinc Production	CO_2	NO	NO		Does not occur in Iceland
2.C.7 Other Metal Production	CO_2	NO	NO		Does not occur in Iceland

For footnotes, see under Table A4. 4 below.

Table A4. 3 GHG inventory N_2O emissions vs. emissions verified under the EU ETS, by CRF sector [kt CO_2e].

N_2O Emissions					
Category[1]	Gas	GHG inventory emissions [kt CO_2e][3]	Verified emissions under Directive 2003/87/EC [kt CO_2e][3]	Ratio in % (Verified emissions/ inventory emissions)[3]	Comment[2]
2.B.2. Nitric Acid Production	N_2O	NO	NO		Does not occur in Iceland
2.B.3. Adipic Acid Production	N_2O	NO	NO		Does not occur in Iceland
2.B.4. Caprolactam, Glyoxal, and Glyoxylic Acid Production	N_2O	NO	NO		Does not occur in Iceland

For footnotes, see under Table A4.4 below.

Table A4. 4 GHG inventory PFC emissions vs. emissions verified under the EU ETS, by CRF sector [kt CO_2e].

PFC Emissions					
Category[1]	Gas	GHG inventory emissions [kt CO_2e][3]	Verified emissions under Directive 2003/87/EC [kt CO_2e][3]	Ratio in % (Verified emissions/ inventory emissions)[3]	Comment[2]
2.C.3 Aluminium Production	PFC	88.9	88.9	100.0%	

(1) The allocation of verified emissions to disaggregated inventory categories at four-digit level must be reported where such allocation of verified emissions is possible and emissions occur. The following notation keys should be used:
NO = not occurring; IE = included elsewhere; C = confidential
Negligible = small amount of verified emissions may occur in respective CRT category, but amount is < 5 % of the category.
(2) The column comment should be used to give a brief summary of the checks performed and if a Member State wants to provide additional explanations with regard to the allocation reported.
(3) Data to be reported up to one decimal point for kt and % values.
(4) The be filled on the basis of combined CRT categories pertaining to 'Iron and Steel', to be determined individually by each Member State; the stated formula is for illustration purposes only.

Annex 5: Values used in Calculation of Digestible Energy of Cattle and Sheep Feed

Table A5.1 Values used in Calculation of Digestible Energy of Feed: Mature Dairy Cattle.

1. Dairy cattle, stallfed, lactation period		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Hay	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Feed intake [kg/day]	Barley	0.00	0.17	0.30	0.30	0.30	0.30	0.30	0.30
Feed intake [kg/day]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed intake [kg/day]	Concentrate	2.00	2.11	2.45	3.70	4.20	4.76	5.20	5.20
Dry matter digestibility [%]	Hay	68.00	69.25	71.20	72.00	71.00	74.13	76.00	74.00
Dry matter digestibility [%]	Barley	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00
Dry matter digestibility [%]	Pulp	67.00	67.00	67.00	67.00	67.00	67.00	65.00	65.00
Dry matter digestibility [%]	Concentrate	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
Ash content [%]	Hay	7.00	7.00	7.00	7.00	7.00	7.25	7.40	7.80
Ash content [%]	Barley	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Ash content [%]	Pulp	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Ash content [%]	Concentrate	8.00	8.00	8.00	8.00	8.00	8.63	9.00	9.00
Crude protein content (of dry matter) [%]	Hay	14.10	14.85	15.94	16.00	15.80	15.93	15.50	15.70
Crude protein content (of dry matter) [%]	Barley	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Crude protein content (of dry matter) [%]	Pulp	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50
Crude protein content (of dry matter) [%]	Concentrate	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
Weighted average dry matter digestibility [%]		70.83	72.19	74.20	75.74	75.37	77.80	79.21	77.92
Weighted average ash content [%]		7.17	7.12	7.10	7.18	7.21	7.60	7.85	8.11
Weighted average CP [%]		14.58	15.18	16.05	16.18	16.07	16.19	15.94	16.06
Time in feeding situation [days]		230.00	232.74	235.48	238.23	240.97	243.71	246.45	247.00
2. Dairy cattle, stallfed, non-lactation		**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**
Feed intake [kg/day]	Hay	10.00	10.00	10.00	10.00	10.00	9.38	9.00	9.00
Feed intake [kg/day]	Concentrate	0.20	0.20	0.21	0.25	0.30	0.43	0.50	0.50
Dry matter digestibility [%]	Hay	67.00	68.11	69.17	70.00	70.00	70.00	70.00	70.00
Dry matter digestibility [%]	Concentrate	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00

2. Dairy cattle, stallfed, non-lactation		1990	1995	2000	2005	2010	2015	2020	2021
Ash content [%]	Hay	7.00	7.00	7.00	7.00	7.00	7.31	7.50	7.20
Ash content [%]	Concentrate	8.00	8.00	8.00	8.00	8.00	8.63	9.00	9.00
Crude protein content (of dry matter) [%]	Hay	14.10	14.93	15.67	16.00	15.80	14.49	13.70	12.80
Crude protein content (of dry matter) [%]	Concentrate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weighted average dry matter digestibility [%]		67.00	68.11	69.17	70.00	70.00	70.00	70.00	70.00
Weighted average ash content [%]		7.00	7.00	7.00	7.00	7.00	7.31	7.50	7.20
Weighted average CP [%]		14.10	14.93	15.67	16.00	15.80	14.49	13.70	12.80
Time in feeding situation [days]		35.00	37.74	40.48	43.23	45.97	48.71	51.45	52.00

3. Dairy cattle, pasture, lactation period		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Hay	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50
Feed intake [kg/day]	Concentrate	2.00	2.11	2.45	3.70	4.20	4.39	4.50	4.50
Dry matter digestibility [%]	Hay	72.00	72.00	72.00	72.00	72.00	75.13	77.00	77.00
Dry matter digestibility [%]	Concentrate	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
Ash content [%]	Hay	7.40	7.40	7.40	7.40	7.40	7.40	7.40	7.40
Ash content [%]	Concentrate	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Crude protein content (of dry matter) [%]	Hay	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00
Crude protein content (of dry matter) [%]	Concentrate	17.00	17.00	17.00	17.00	17.00	17.63	18.00	18.00
Weighted average dry matter digestibility [%]		73.93	74.02	74.28	75.16	75.48	77.85	79.25	79.25
Weighted average ash content [%]		7.64	7.65	7.68	7.79	7.83	7.84	7.85	7.85
Weighted average CP [%]		17.85	17.84	17.82	17.76	17.73	17.90	18.00	18.00
Time in feeding situation [days]		65.00	62.26	59.52	56.77	54.03	51.29	48.55	48.00

4. Dairy cattle, pasture, non-lactation		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Hay	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Dry matter digestibility [%]	Hay	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00
Ash content [%]	Hay	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
Crude protein content (of dry matter) [%]	Hay	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70
Weighted average dry matter digestibility [%]		72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00

4. Dairy cattle, pasture, non-lactation	1990	1995	2000	2005	2010	2015	2020	2021
Weighted average ash content [%]	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
Weighted average CP [%]	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70
Time in feeding situation [days]	25.00	22.26	19.52	16.77	14.03	11.29	8.55	8.00
Conversion of dry matter digestibility to digestible energy % of gross energy intake[40]	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**
Digestible organic matter per kg of dry matter	629.73	638.86	652.75	664.67	662.62	681.66	692.68	684.10
Metabolizable energy per gram dry matter	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Metabolizable energy per kg dry matter	9,446	9,583	9,791	9,970	9,939	10,225	10,390	10,261
Ratio of metabolizable to digestible energy	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Digestible energy per kg dry matter	11,662	11,831	12,088	12,309	12,271	12,623	12,827	12,668
Gross energy per kg dry matter	18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,500
Digestible % of gross energy intake	63.04	63.95	65.34	66.53	66.33	68.21	69.34	68.48

Table A5.2 Values used in Calculation of Digestible Energy of Feed: Other Mature Cattle.

1. Other Mature Cattle, stallfed		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Hay	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Feed intake [kg/day]	Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed intake [kg/day]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed intake [kg/day]	Concentrate	0.10	0.10	0.10	0.10	0.20	0.26	0.30	0.30
Dry matter digestibility [%]	Hay	66.00	67.56	68.80	70.00	69.00	69.56	70.00	70.00
Dry matter digestibility [%]	Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry matter digestibility [%]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry matter digestibility [%]	Concentrate	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
Ash content [%]	Hay	7.00	7.00	7.00	7.00	7.00	7.31	7.50	7.20
Ash content [%]	Barley	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Ash content [%]	Pulp	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Ash content [%]	Concentrate	8.00	8.00	8.00	8.00	8.00	8.56	9.00	9.00

[40] Breyting á orkumatskerfi fyrir jórturdýr (Guðmundsson & Eiríksson, 1995)

1. Other Mature Cattle, stallfed		1990	1995	2000	2005	2010	2015	2020	2021
Crude protein content (of dry matter) [%]	Hay	14.00	14.63	15.30	16.00	15.50	14.67	14.00	13.00
Crude protein content (of dry matter) [%]	Barley	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Crude protein content (of dry matter) [%]	Pulp	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50
Crude protein content (of dry matter) [%]	Concentrate	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
Weighted average dry matter digestibility [%]		66.19	67.74	68.96	70.15	69.31	69.94	70.44	70.44
Weighted average ash content [%]		7.01	7.01	7.01	7.01	7.02	7.34	7.54	7.25
Weighted average CP [%]		14.03	14.65	15.32	16.01	15.53	14.72	14.09	13.12
Time in feeding situation [days]		30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00

2. Other Mature Cattle, pasture		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Hay	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Feed intake [kg/day]	Concentrate	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Dry matter digestibility [%]	Hay	66.00	67.56	68.80	70.00	69.00	69.56	70.00	70.00
Dry matter digestibility [%]	Concentrate	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
Ash content [%]	Hay	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Ash content [%]	Concentrate	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Crude protein content (of dry matter) [%]	Hay	14.00	14.63	15.30	16.00	15.50	14.67	14.00	13.00
Crude protein content (of dry matter) [%]	Concentrate	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Weighted average dry matter digestibility [%]		74.40	75.03	75.52	76.00	75.60	75.82	76.00	76.00
Weighted average ash content [%]		7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Weighted average CP [%]		15.47	15.72	15.99	16.27	16.07	15.74	15.47	15.07
Time in feeding situation [days]		335.00	335.00	335.00	335.00	335.00	335.00	335.00	335.00

Conversion of dry matter digestibility to digestible energy % of gross energy intake[41]	1990	1995	2000	2005	2010	2015	2020	2021
Digestible organic matter per kg of dry matter	674.51	681.37	686.81	692.09	687.82	690.32	692.32	692.32
Metabolizable energy per gram dry matter	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Metabolizable energy per kg dry matter	10,118	10,221	10,302	10,381	10,317	10,355	10,385	10,385
Ratio of metabolizable to digestible energy	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81

[41] Breyting á orkumatskerfi fyrir jórturdýr (Guðmundsson & Eiríksson, 1995)

Conversion of dry matter digestibility to digestible energy % of gross energy intake[41]	1990	1995	2000	2005	2010	2015	2020	2021
Digestible energy per kg dry matter	12,491	12,618	12,719	12,816	12,737	12,784	12,821	12,821
Gross energy per kg dry matter	18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,500
Digestible % of gross energy intake	67.52	68.21	68.75	69.28	68.85	69.10	69.30	69.30

Table A5.3 Values used in Calculation of Digestible Energy of Feed: Pregnant Heifers.

1. Pregnant, stallfed		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Hay	5.00	5.00	5.00	5.00	5.00	5.00	6.00	6.00
Feed intake [kg/day]	Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed intake [kg/day]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed intake [kg/day]	Concentrate	0.20	0.20	0.21	0.25	0.30	0.41	0.50	0.50
Dry matter digestibility [%]	Hay	66.00	67.56	68.80	70.00	69.00	70.67	72.00	72.00
Dry matter digestibility [%]	Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry matter digestibility [%]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry matter digestibility [%]	Concentrate	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
Ash content [%]	Hay	7.00	7.00	7.00	7.00	7.00	7.31	7.50	7.50
Ash content [%]	Barley	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Ash content [%]	Pulp	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Ash content [%]	Concentrate	8.00	8.00	8.00	8.00	8.00	8.56	9.00	9.00
Crude protein content (of dry matter) [%]	Hay	14.00	14.63	15.30	16.00	15.50	15.22	15.00	15.00
Crude protein content (of dry matter) [%]	Barley	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Crude protein content (of dry matter) [%]	Pulp	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50
Crude protein content (of dry matter) [%]	Concentrate	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
Weighted average dry matter digestibility [%]		66.73	68.23	69.45	70.73	69.91	71.76	73.00	73.00
Weighted average ash content [%]		7.04	7.04	7.04	7.05	7.06	7.41	7.62	7.62
Weighted average CP [%]		14.12	14.72	15.37	16.05	15.58	15.36	15.15	15.15
Time in feeding situation [days]		245.00	245.00	245.00	245.00	245.00	245.00	245.00	245.00
2. Pregnant Heifers, pasture		**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**
Feed intake [kg/day]	Hay	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

2. Pregnant Heifers, pasture		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Concentrate	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
Dry matter digestibility [%]	Hay	66.00	67.56	68.80	70.00	69.00	70.67	72.00	72.00
Dry matter digestibility [%]	Concentrate	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
Ash content [%]	Hay	7.00	7.00	7.00	7.00	7.00	7.31	7.50	7.50
Ash content [%]	Concentrate	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Crude protein content (of dry matter) [%]	Hay	14.00	14.63	15.30	16.00	15.50	15.22	15.00	15.00
Crude protein content (of dry matter) [%]	Concentrate	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Weighted average dry matter digestibility [%]		77.85	78.09	78.28	78.46	78.31	78.56	78.77	78.77
Weighted average ash content [%]		7.00	7.00	7.00	7.00	7.00	7.05	7.08	7.08
Weighted average CP [%]		16.08	16.18	16.28	16.39	16.31	16.27	16.23	16.23
Time in feeding situation [days]		120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
Conversion of dry matter digestibility to digestible energy % of gross energy intake[42]		**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**
Digestible organic matter per kg of dry matter		641.77	652.43	661.05	670.04	664.15	677.14	685.99	685.99
Metabolizable energy per gram dry matter		15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Metabolizable energy per kg dry matter		9,627	9,786	9,916	10,051	9,962	10,157	10,290	10,290
Ratio of metabolizable to digestible energy		0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Digestible energy per kg dry matter		11,885	12,082	12,242	12,408	12,299	12,540	12,703	12,703
Gross energy per kg dry matter		18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,500
Digestible % of gross energy intake		64.24	65.31	66.17	67.07	66.48	67.78	68.67	68.67

Table A5.4 Values used in Calculation of Digestible Energy of Feed: Steers and Uninseminated Heifers.

1. Steers and Uninseminated Heifers, stallfed		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Hay	5.00	5.00	5.00	5.00	5.00	5.00	5.50	5.50
Feed intake [kg/day]	Barley	0.00	0.19	0.50	0.50	0.50	0.50	0.50	0.50
Feed intake [kg/day]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed intake [kg/day]	Concentrate	0.50	0.55	0.60	0.65	0.70	0.70	0.70	0.70

[42] Breyting á orkumatskerfi fyrir jórturdýr (Guðmundsson & Eiríksson, 1995)

1. Steers and Uninseminated Heifers, stallfed		1990	1995	2000	2005	2010	2015	2020	2021
Dry matter digestibility [%]	Hay	66.00	67.56	68.80	70.00	69.00	71.22	73.00	73.00
Dry matter digestibility [%]	Barley	86.00	86.00	86.00	86.00	86.00	86.00	86.00	86.00
Dry matter digestibility [%]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry matter digestibility [%]	Concentrate	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
Ash content [%]	Hay	7.00	7.00	7.00	7.00	7.00	7.31	7.50	7.20
Ash content [%]	Barley	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Ash content [%]	Pulp	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Ash content [%]	Concentrate	8.00	8.00	8.00	8.00	8.00	8.56	9.00	9.00
Crude protein content (of dry matter) [%]	Hay	14.00	14.63	15.30	16.00	15.50	15.22	15.00	15.00
Crude protein content (of dry matter) [%]	Barley	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Crude protein content (of dry matter) [%]	Pulp	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50
Crude protein content (of dry matter) [%]	Concentrate	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Weighted average dry matter digestibility [%]		67.73	69.84	71.80	72.89	72.18	73.97	75.22	75.22
Weighted average ash content [%]		7.09	6.97	6.77	6.78	6.79	7.11	7.32	7.07
Weighted average CP [%]		14.00	14.48	14.90	15.46	15.05	14.82	14.67	14.67
Time in feeding situation [days]		307.00	307.00	307.00	307.00	307.00	307.00	307.00	307.00

2. Steers and Uninseminated Heifers, pasture		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Hay	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Feed intake [kg/day]	Concentrate	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50
Dry matter digestibility [%]	Hay	66.00	67.56	68.80	70.00	69.00	70.88	72.00	72.00
Dry matter digestibility [%]	Concentrate	78.00	78.00	78.00	78.00	78.00	77.38	77.00	77.00
Ash content [%]	Hay	7.00	7.00	7.00	7.00	7.00	7.31	7.50	7.20
Ash content [%]	Concentrate	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Crude protein content (of dry matter) [%]	Hay	14.00	14.63	15.30	16.00	15.00	15.44	15.00	15.00
Crude protein content (of dry matter) [%]	Concentrate	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Weighted average dry matter digestibility [%]		75.82	76.10	76.33	76.55	76.36	76.19	76.09	76.09
Weighted average ash content [%]		7.00	7.00	7.00	7.00	7.00	7.06	7.09	7.04

2. Steers and Uninseminated Heifers, pasture	1990	1995	2000	2005	2010	2015	2020	2021
Weighted average CP [%]	16.01	16.12	16.25	16.37	16.19	16.27	16.19	16.19
Time in feeding situation [days]	58.00	58.00	58.00	58.00	58.00	58.00	58.00	58.00
Conversion of dry matter digestibility to digestible energy % of gross energy intake[43]	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**
Digestible organic matter per kg of dry matter	628.33	646.16	662.72	671.98	665.86	680.36	690.54	690.54
Metabolizable energy per gram dry matter	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Metabolizable energy per kg dry matter	9,425	9,692	9,941	10,080	9,988	10,205	10,358	10,358
Ratio of metabolizable to digestible energy	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Digestible energy per kg dry matter	11,636	11,966	12,273	12,444	12,331	12,599	12,788	12,788
Gross energy per kg dry matter	18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,500
Digestible % of gross energy intake	62.90	64.68	66.34	67.27	66.65	68.10	69.12	69.12

Table A5.5 Values used in Calculation of Digestible Energy of Feed: Calves

1. Calves, first 90 days		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Milk/formula	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Feed intake [kg/day]	Hay	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Feed intake [kg/day]	Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed intake [kg/day]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed intake [kg/day]	Concentrate	0.20	0.20	0.20	0.26	0.31	0.37	0.40	0.40
Dry matter digestibility [%]	Milk/formula	93.00	93.00	93.00	93.00	93.00	93.00	93.00	93.00
Dry matter digestibility [%]	Hay	68.00	69.56	70.80	72.00	71.00	73.22	75.00	75.00
Dry matter digestibility [%]	Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry matter digestibility [%]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry matter digestibility [%]	Concentrate	82.00	82.00	82.00	82.00	82.00	82.00	85.00	85.00
Ash content [%]	Milk/formula	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Ash content [%]	Hay	7.00	7.00	7.00	7.00	7.00	7.31	7.50	7.50
Ash content [%]	Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[43] Breyting á orkumatskerfi fyrir jórturdýr (Guðmundsson & Eiríksson, 1995)

1. Calves, first 90 days		1990	1995	2000	2005	2010	2015	2020	2021
Ash content [%]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ash content [%]	Concentrate	8.00	8.00	8.00	8.00	8.00	8.56	9.00	9.00
Crude protein content (of dry matter) [%]	Hay	14.10	14.94	15.81	16.00	15.80	15.54	15.50	15.50
Crude protein content (of dry matter) [%]	Barley	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Crude protein content (of dry matter) [%]	Pulp	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50
Crude protein content (of dry matter) [%]	Concentrate	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Weighted average dry matter digestibility [%]		89.38	89.50	89.60	89.38	89.02	88.90	89.67	89.67
Weighted average ash content [%]		8.69	8.69	8.69	8.66	8.64	8.77	8.90	8.90
Weighted average CP [%]		18.03	18.31	18.60	18.88	18.98	19.05	19.10	19.10
Time in feeding situation [days]		90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00
2. Calves, days 91-365		**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**
Feed intake [kg/day]	Hay	2.00	2.16	2.35	2.58	2.91	3.42	2.90	2.90
Feed intake [kg/day]	Concentrate	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Dry matter digestibility [%]	Hay	68.00	69.56	70.80	72.00	71.00	72.11	73.00	73.00
Dry matter digestibility [%]	Concentrate	82.00	82.00	82.00	82.00	82.00	82.00	85.00	85.00
Ash content [%]	Hay	7.00	7.00	7.00	7.00	7.00	7.31	7.50	7.50
Ash content [%]	Concentrate	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Crude protein content (of dry matter) [%]	Hay	14.10	14.94	15.81	16.00	15.80	15.54	15.50	15.50
Crude protein content (of dry matter) [%]	Concentrate	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00
Weighted average dry matter digestibility [%]		70.80	71.90	72.77	73.62	72.61	73.37	74.76	74.76
Weighted average ash content [%]		7.20	7.19	7.18	7.16	7.15	7.40	7.57	7.57
Weighted average CP [%]		15.08	15.71	16.37	16.49	16.27	15.98	16.01	16.01
Time in feeding situation [days]		275.00	275.00	275.00	275.00	275.00	275.00	275.00	275.00
Conversion of dry matter digestibility to digestible energy % of gross energy intake[44]		**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**
Digestible organic matter per kg of dry matter		690.75	699.17	705.79	711.56	703.24	708.57	720.70	720.70
Metabolizable energy per gram dry matter		15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00

[44] Breyting á orkumatskerfi fyrir jórturdýr (Guðmundsson & Eiríksson, 1995)

Conversion of dry matter digestibility to digestible energy % of gross energy intake[44]	1990	1995	2000	2005	2010	2015	2020	2021
Metabolizable energy per kg dry matter	10,361	10,488	10,587	10,673	10,549	10,629	10,811	10,811
Ratio of metabolizable to digestible energy	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Digestible energy per kg dry matter	12,792	12,948	13,070	13,177	13,023	13,122	13,346	13,346
Gross energy per kg dry matter	18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,500
Digestible % of gross energy intake	69.14	69.99	70.65	71.23	70.39	70.93	72.14	72.14

Table A5.6 Values used in Calculation of Digestible Energy of Feed: Sheep

1. Sheep, stallfed		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Hay	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Feed intake [kg/day]	Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed intake [kg/day]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed intake [kg/day]	Concentrate	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Dry matter digestibility [%]	Hay	65.00	66.56	67.80	69.00	68.00	70.78	73.00	71.00
Dry matter digestibility [%]	Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry matter digestibility [%]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry matter digestibility [%]	Concentrate	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
Ash content [%]	Hay	7.00	7.00	7.00	7.00	7.00	7.22	7.40	7.80
Ash content [%]	Barley	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ash content [%]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ash content [%]	Concentrate	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Crude protein content (of dry matter) [%]	Hay	13.30	14.14	14.89	15.20	15.00	14.66	14.58	14.62
Crude protein content (of dry matter) [%]	Barley	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Crude protein content (of dry matter) [%]	Pulp	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Crude protein content (of dry matter) [%]	Concentrate	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00
Weighted average dry matter digestibility [%]		65.12	66.68	67.91	69.10	68.11	70.87	73.07	71.09
Weighted average ash content [%]		7.01	7.01	7.01	7.01	7.01	7.23	7.41	7.81
Weighted average CP [%]		13.33	14.17	14.91	15.22	15.02	14.68	14.60	14.64

1. Sheep, stallfed		1990	1995	2000	2005	2010	2015	2020	2021
Time in feeding situation [days]		200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
2. Sheep, pasture		**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**
Feed intake [kg/day]	Hay	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Feed intake [kg/day]	Pasture	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Dry matter digestibility [%]	Hay	68.00	69.56	70.80	72.00	71.00	73.22	75.00	75.00
Dry matter digestibility [%]	Pasture	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
Ash content [%]	Hay	7.00	7.00	7.00	7.00	7.00	7.22	7.40	7.80
Ash content [%]	Pasture	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Crude protein content (of dry matter) [%]	Hay	14.10	14.94	15.69	16.00	15.80	15.49	15.50	15.70
Crude protein content (of dry matter) [%]	Pasture	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Weighted average dry matter digestibility [%]		77.00	77.39	77.70	78.00	77.75	78.31	78.75	78.75
Weighted average ash content [%]		7.00	7.00	7.00	7.00	7.00	7.06	7.10	7.20
Weighted average CP [%]		15.87	16.08	16.27	16.34	16.29	16.22	16.22	16.27
Time in feeding situation [days]		60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
3. Sheep, range		**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**
Feed intake [kg/day]	Gras/vegetation	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
Dry matter digestibility [%]	Gras/vegetation	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Ash content [%]	Gras/vegetation	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Crude protein content (of dry matter) [%]	Gras/vegetation	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Weighted average dry matter digestibility [%]		70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Weighted average ash content [%]		7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Weighted average CP [%]		16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Time in feeding situation [days]		105.00	105.00	105.00	105.00	105.00	105.00	105.00	105.00
Conversion of dry matter digestibility to digestible energy % of gross energy intake[45]		**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**
Digestible organic matter per kg of dry matter		623.09	632.06	639.16	646.05	640.31	656.03	668.61	657.93

[45] Breyting á orkumatskerfi fyrir jórturdýr (Guðmundsson & Eiríksson, 1995)

Conversion of dry matter digestibility to digestible energy % of gross energy intake[45]	1990	1995	2000	2005	2010	2015	2020	2021
Metabolizable energy per gram dry matter	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Metabolizable energy per kg dry matter	9,346	9,481	9,587	9,691	9,605	9,840	10,029	9,869
Ratio of metabolizable to digestible energy	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Digestible energy per kg dry matter	11,539	11,705	11,836	11,964	11,858	12,149	12,382	12,184
Gross energy per kg dry matter	18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,500
Digestible % of gross energy intake	62.37	63.27	63.98	64.67	64.10	65.67	66.93	65.86

Table A5.7 Values used in Calculation of Digestible Energy of Feed: Lambs

1. Lambs, pre-weaning		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Gras/vegetation	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Feed intake [kg/day]	Milk	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Feed intake [kg/day]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed intake [kg/day]	Concentrate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry matter digestibility [%]	Gras/vegetation	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Dry matter digestibility [%]	Milk	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00
Dry matter digestibility [%]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dry matter digestibility [%]	Concentrate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ash content [%]	Gras/vegetation	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Ash content [%]	Milk	5.10	5.10	5.10	5.10	5.10	5.10	5.10	5.10
Ash content [%]	Pulp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ash content [%]	Concentrate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crude protein content (of dry matter) [%]	Gras/vegetation	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Crude protein content (of dry matter) [%]	Milk	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Crude protein content (of dry matter) [%]	Pulp	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Crude protein content (of dry matter) [%]	Concentrate	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Weighted average dry matter digestibility [%]		79.91	79.91	79.91	79.91	79.91	79.91	79.91	79.91
Weighted average ash content [%]		6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25

1. Lambs, pre-weaning	1990	1995	2000	2005	2010	2015	2020	2021
Weighted average CP [%]	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Time in feeding situation [days]	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00

2. Lambs, after-weaning		1990	1995	2000	2005	2010	2015	2020	2021
Feed intake [kg/day]	Gras/vegetation	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Feed intake [kg/day]	Rape/rye grass etc.	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Feed intake [kg/day]	Milk	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Dry matter digestibility [%]	Gras/vegetation	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Dry matter digestibility [%]	Rape/rye grass etc.	83.00	83.00	83.00	83.00	83.00	83.00	83.00	83.00
Dry matter digestibility [%]	Milk	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00
Ash content [%]	Gras/vegetation	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Ash content [%]	Rape/rye grass etc.	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Ash content [%]	Milk	5.10	5.10	5.10	5.10	5.10	5.10	5.10	5.10
Crude protein content (of dry matter) [%]	Gras/vegetation	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Crude protein content (of dry matter) [%]	Rape/rye grass etc.	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Crude protein content (of dry matter) [%]	Milk	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Weighted average dry matter digestibility [%]		79.41	79.41	79.41	79.41	79.41	79.41	79.41	79.41
Weighted average ash content [%]		7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58
Weighted average CP [%]		16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
Time in feeding situation [days]		70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00

Conversion of dry matter digestibility to digestible energy % of gross energy intake[46]	1990	1995	2000	2005	2010	2015	2020	2021
Digestible organic matter per kg of dry matter	703.56	703.56	703.56	703.56	703.56	703.56	703.56	703.56
Metabolizable energy per gram dry matter	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Metabolizable energy per kg dry matter	10,553	10,553	10,553	10,553	10,553	10,553	10,553	10,553
Ratio of metabolizable to digestible energy	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
Digestible energy per kg dry matter	13,029	13,029	13,029	13,029	13,029	13,029	13,029	13,029
Gross energy per kg dry matter	18,500	18,500	18,500	18,500	18,500	18,500	18,500	18,500
Digestible % of gross energy intake	70.43	70.43	70.43	70.43	70.43	70.43	70.43	70.43

Table A6. 8 Conversion of DMD into DE

2021	Dry matter digestibility	Organic matter digestibility	Metabolizable energy	Metabolisality	Net energy for lactation	Net energy/ 1 kg barley	Digestible energy
	DMD [%]	OMD [g/kg]	BO [kJ/kg dm]	q	NOm [kj/kg]	FEm	DE [%]
Calculations	cf. A-G	$(0.98 \cdot \mathrm{DMD} - 4.8) \cdot 10$	$15 \cdot \mathrm{OMD}$	$\frac{\mathrm{BO} \cdot 100}{18500}$	$0.6 \cdot (1+0.004 \cdot (q-57)) \cdot 0.9752 \cdot \mathrm{BO}$	$\frac{\mathrm{NOm}}{6900}$	$\frac{\mathrm{OMD} \cdot 15}{0.81 \cdot 18.5 \cdot 10}$
Mature dairy cows	74.70	684.10	10,261	55.47	5,967	0.86	**68.48**
Cows used for producing meat	75.54	692.32	10,385	56.13	6,055	0.88	**69.30**
Heifers	74.90	685.99	10,290	55.62	5,988	0.87	**68.67**
Steers used for producing meat	75.36	690.54	10,358	55.99	6,036	0.87	**69.12**
Young cattle	78.44	720.70	10,811	58.44	6,362	0.92	**72.14**
Sheep	72.03	657.93	9,869	53.35	5,690	0.82	**65.86**
Lambs	76.69	703.56	10,553	57.05	6,176	0.90	**70.43**

[46] Breyting á orkumatskerfi fyrir jórturdýr (Guðmundsson & Eiríksson, 1995)

Annex 6: Justification of Use of Country-specific N_2O Emission Factor for Cultivation of Organic Soils (Histosols)

As mentioned in Chapter 5.7.3 and in response to a potential problem flagged at the end of Iceland's 2019 UNFCCC desk review, Iceland produced a document explaining the rationale for using a country-specific emission factor for N_2O emission from cultivation of organic soils (e.g., histosols). The explanations were accepted by the ERT at the end of the review and the document is reproduced here in its integrity.

The Icelandic Soil Classification System

Iceland is a volcanic island of about 103,000 km^2, located at the plate boundary between the Eurasian and the American tectonic plates and above an active hotspot, which explains over 30 active volcanic systems. The main area of active volcanism is the axial volcanic zone, stretching from the southwest to the northeast, crossing the whole island and being the only exposed section of the Mid-Atlantic Ridge (Thordarson & Höskuldsson, 2002; Thordarson & Larsen, 2007). Volcanic eruptions defined as the ejection of magma, gas, or rocks, are frequent and occur approximately every five years in Iceland (Thordarson & Larsen, 2007).

The active volcanism plays an important role in the soil formation of Iceland, as volcanic material acts as the main parent material (Arnalds O. , 2015).

The Icelandic soil classification system distinguishes three main soil types: **Vitrisols, Andosols**, and **Histosols** (Arnalds O. , 2015). The parent material of **Vitrisols** is of volcanic origin, but these soils are mainly non-vegetated and are also called "desert soils." More than 40% of the area of Iceland is classified as a desert (Arnalds O. , 2015). However, Vitrosols are not relevant for the present purpose and are not further discussed.

The other main soil type found in Iceland are **Andosols** or Andisols (soil order) under the US Soil Taxonomy (Arnalds O. , 2015). Andosols in Iceland are characterised by a silt-sized aggregation, a thixotropic nature, a bulk density lower than 0.9 g/cm^3, a water content of more than 60% (per dry weight of soil), high hydraulic conductivity, high frost susceptibility, a pH dependent charge and a high accumulated organic matter at depths (Arnalds O. , 2015). The volcanic parent material, tephra, is very often of basic nature and weathers very quickly resulting in high concentrations of Al, Fe and Si. Mainly amorphous or non-crystalline clay minerals are formed such as allophane ($(Al_2O_3)(SiO_2)_{1.3} \cdot 2.5(H_2O)$) , imogolite ($Al_2SiO_3(OH)_4$), ferrihydrite ($Fe^{3+}{}_2O_3 \cdot 0.5(H_2O)$) and halloysite ($Al_2Si_2O_5(OH)_4$)[47]. These clay minerals form relatively stable bonds with the organic matter leading to the accumulation of organic matter in the soil (>6% C in both A and B horizon). These bonds can be allophane organic matter complexes or metal-humus complexes (Al^{3+} and Fe^{3+} form stable bonds with the organic matter by ligand exchange) (Arnalds O. , 2015). In addition, environmental factors such as poor drainage and cold climate can result in organic matter accumulation resulting in OC of 12-20% in Iceland (Arnalds O. , 2015). The clay minerals all have large reactive surface areas, and the cation exchange capacity rises with increasing pH (Arnalds O. , 2015).

Andosols are subdivided into three subcategories based on two main factors: (1) the **amount of aeolian input** and (2) the **drainage category**. The aeolian input plays an important role in the soil formation as it is influencing carbon content, clay content, hydraulic properties, soil reaction, grain size

[47] All empirical formulas from http://webmineral.com

and other overall properties (Arnalds O. , 2015). The aeolian input in Iceland is not only given by the episodical volcanic eruptions providing material in the form of ash but also due to the desertic conditions and highly eroded areas acting as source areas for dust which then is transported by the wind. These two factors, together with the carbon content are the basis for the Icelandic soil classification system (Figure A8.1). The three subcategories of Andosols include **Histic Andosols, Gleyic Andosols** and **Brown Andosols**. Histic Andosols mostly comprised wetlands with some drylands covered with rich heathlands, birch forests and grasslands far from aeolian sources. Gleyic Andosols can also be found in wetlands but are characterised by a carbon level below 12% due to increased aeolian deposition and by strong andic properties with 10-20% of allophane and ferrihydrite content. Brown Andosols are the soils of vegetated drylands and show many tephra layers and intermediate amounts of aeolian addition (Arnalds O. , 2015).

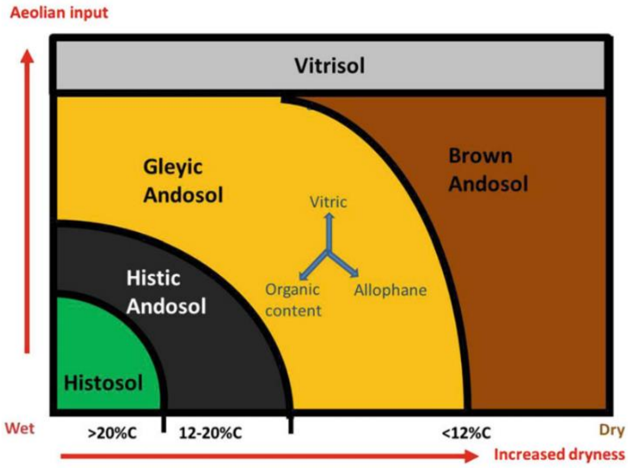

Figure A6. 1 Classification of Icelandic Andosols together with Vitrisols (soils of the desert) and Histosols (wetland soils), determined by the aeolian input and the drainage conditions. The amount of soil carbon is also given, separating Histosols (20%) from Andosols, (Arnalds O. , 2015).

The third main soil type in the Icelandic classification system is **Histosol**, characterised by a carbon content of more than 20% in the surface horizon (Arnalds O. , 2015). Organic histosols are only found in Iceland where the aeolian input is low, and which is mainly in the westernmost and northernmost part of Iceland, and the total extent is rather limited. The organic matter is poorly decomposed and would classify under the Soil Taxonomy classification as Fibrists (Borofibrists and Cryofibrists). These soils do not contain an appreciable amount of allophane, but the volcanic ash content in the matrix leads to a limited or very slow shrinkage when drained. The pH is generally low, but the soils still present some andic properties with a considerable amount of aluminium-humus complexes (Arnalds O. , 2015).

For a better understanding of the Icelandic Soil Classification System, a comparison with Soil Taxonomy and WRB is given in Table A6.1.

Table A6.1 Icelandic soil classification system and corresponding terms in Soil Taxonomy and WRB, (Arnalds O. , 2015)

Soil class	Symbol	Identification	S.T.	WRB (2006)
Histosol	H	>20 % C	Histosol	Histosol
Histic Andosol	HA	12–20 % C	Aquand	Histic and Vitric Andosol
Gleyic Andosol	GA	<12 % C; gleying/mottles	Aquand	Gleyic, Histic and Vitric Andosol
Brown Andosol	BA	<12 % C, dry; >6 % allophane	Cryand	Vtiric, Silandic Andosol and more
Cambic Vitrisol	MV/GV	<1.5 % C; <6 % allophane	Cryand	Vitric Andosol/Regosol/Leptosol
Arenic Vitrisol	SV	Sand, <1.5 % C	Cryand	Vitric Andosol/Arenosol/Leptosol
Pumice Vitrisol	PV	Pumice >2 mm	Cryand/Entisol	Regosol/Vitric Andosol
Leptosol	L	Rock/scree	Entisol	Leptosol
Cryosol	C	Permafrost	Gelisol	Cryosol

Identification criteria also shown. Table slightly modified from Arnalds and Oskarsson (2009)

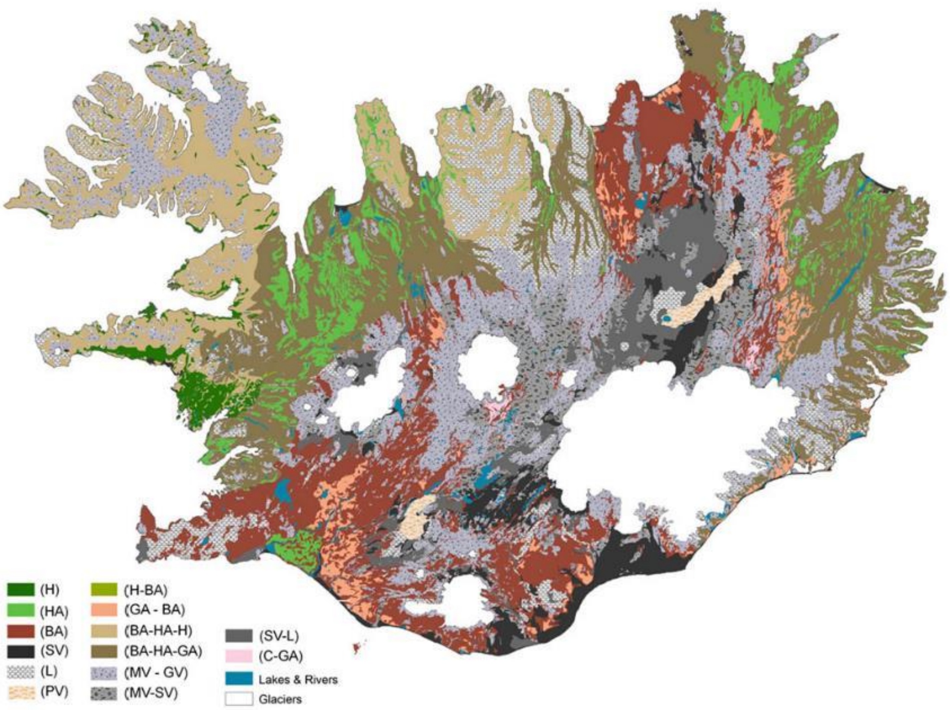

Figure A6.2 General soil map of Iceland (Arnalds O. , 2015), based on (Arnalds & Óskarsson, 2009). H: Histosol, HA: Histic Andosol, GA: Gleyic Andosol, BA: Brown Andosol, MV: Cambic Vitrisol, GV: Gravelly Vitrisol, SV: Sandy Vitrisol, PV: Pumice Vitrisol, L: Leptosol, C: Cryosol.

Cultivation of Organic Soils in Iceland

According to the IPCC 2006 Guidelines, Volume 4 (AFOLU), Chapter 11[48], soils are organic if they fulfil the requirements 1 and 2 or 1 and 3 defined by FAO. The minimum soil organic carbon is 12% by weight among other conditions. As can be seen from Figure A8.1, the Icelandic soil types containing 12% of soil carbon or more are **Histic Andosols** and **Histosols**. The former is part of the Andosols and presents andic properties. Histosols, on the other hand, can be distinguished from Andosols by their high carbon content of 20% which in depth can even reach up to 40% in certain horizons (Arnalds O. , 2015). Both soil types are mainly found in wetland areas in Iceland and their extension is relatively small as can be seen from Figure A6.2

[48] IPCC 2006 Guidelines, Volume 4, Agriculture, Forestry and Other Land Use.

Icelandic inland wetlands cover an area of about 9000 km^2 and represent around 19.4% of vegetated surfaces (Arnalds, Gudmundsson, Oskarsson, Brink, & Gísladóttir, 2016). Figure A8.3 shows the extent of Icelandic wetlands with the predominant soil types: Histosols, Histic Andosols and Gleyic Andosols. The soil is mainly thick (1-3 m) and stores 33 to more than 100 kg of carbon per square meter (Arnalds, Gudmundsson, Oskarsson, Brink, & Gísladóttir, 2016).

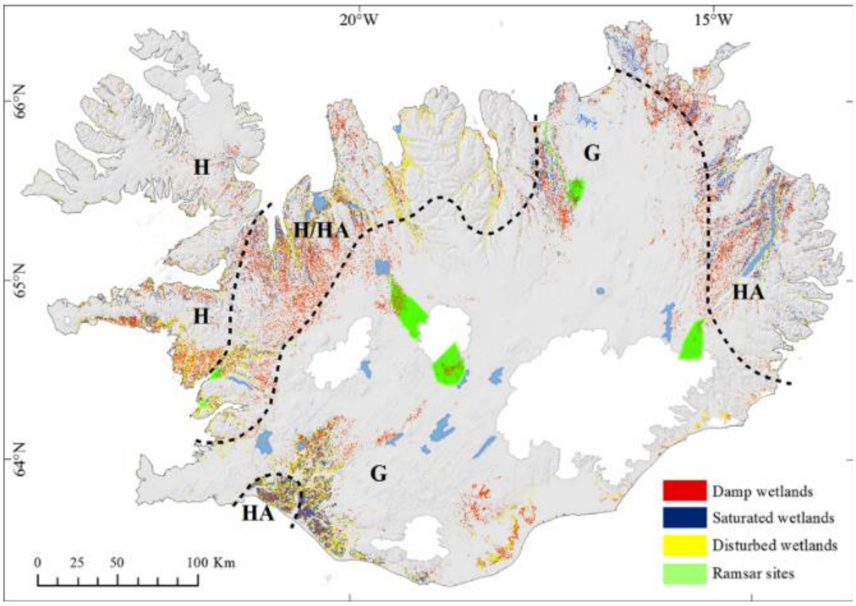

Figure A6.3 Inland wetlands in Iceland. H: Histosols, HA: Histic Andosols, G: Gleyic Andosols. In green the Ramsar sites are shown. Large water bodies are light blue, in white are the main glaciers (Arnalds, Gudmundsson, Oskarsson, Brink, & Gísladóttir, 2016).

Due to a system of governmental subsidies applied mainly during the 20th century, about 47% of Icelandic inland wetlands are drained, but only less than 15% of the drained areas are used for agricultural purposes such as haymaking or growing grains, or low impact grazing (Arnalds, Gudmundsson, Oskarsson, Brink, & Gísladóttir, 2016; Arnalds O. , 2015). Figure A8.4 shows a close-up of such system of ditches and drained wetlands, as well as the amount of cultivated drained wetland areas.

Similar to the other soil types in Iceland, wetlands are also impacted by aeolian input of volcanic products which provide nutrients and a relatively high pH to the wetland soils (Arnalds, Gudmundsson, Oskarsson, Brink, & Gísladóttir, 2016). Compared to other countries, the Icelandic wetland soils are dominated by a mixture of poorly crystalline basaltic volcanic materials and peat which makes them quite unique: their lower content of metal-humus complexes and higher proportion of vitric materials deriving from volcanic ash inputs makes them different from Histic Andosols in Ecuador and the Azores (Arnalds, Gudmundsson, Oskarsson, Brink, & Gísladóttir, 2016). The Aquic Andosols of Japan are usually more developed and do not present as many volcanic additions as the Icelandic ones, which are younger and show a higher frequency of aeolian input of vitric material (Arnalds, Gudmundsson, Oskarsson, Brink, & Gísladóttir, 2016). Compared to soils in the other northern circumpolar countries which present mostly peat soils (Histosols) and/or permafrost (Cryosols), the Icelandic wetland soils are characterised by Andosols and small areas of Histosols which are also influenced by volcanic input through aeolian deposition (Arnalds, Gudmundsson, Oskarsson, Brink, & Gísladóttir, 2016).

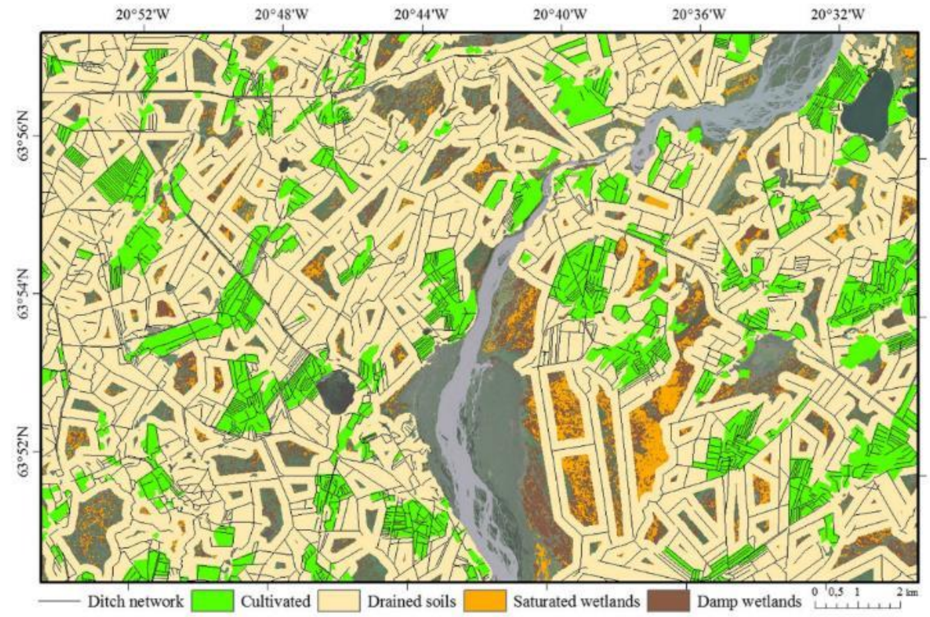

Figure A6.4 South Iceland, close to the river Þjórsá. The black lines show the system of ditches created to drain the wetlands. Of the drained soils, only the green patches are cultivated as hay fields (Arnalds, Gudmundsson, Oskarsson, Brink, & Gísladóttir, 2016).

N_2O Emissions from Drained Wetlands in Iceland

Drained peatlands are a major source of N_2O through soil microbial processes due to nitrification and denitrification. In general, cultivated peatlands show the highest N_2O emissions among drained peatlands. The IPCC 2006 Guidelines propose in Table 11.1 of Chapter 11 of AFOLU[49] different emission factors for managed soils. In particular, the EF2CG, Temp for temperate organic cropland and grassland soils is 8 kg N_2O-N $ha^{-1}yr^{-1}$. The emission factor for managed peatlands with nutrient-rich organic soils is 1.8 kg N_2O-N ha^{-1} yr^{-1} as of Table 7.6 from Chapter 7 AFOLU. While these values have been derived from boreal areas of mostly Northern Europe (Klemedtsson et al., (1999); Alm et al., (1999); Laine et al., (1996); Martikainen et al., (1995); Minkkinen et al., (2002); Regina et al., (1996)), these emission factors do not reflect the peculiarity of Icelandic soils.

The measurements of N_2O fluxes in Iceland were carried out by Jón Guðmundsson, a biologist researcher from the Agricultural University of Iceland, over a period of three years comprising nine measurement sites with three different land management types of organic soils: undrained land, drained but not cultivated land and drained, cultivated, and fertilised (hayfield). In addition to these sites, some measurements were done in freshly tilled drained land. In total, 861 measurements on plots with different land use were carried out (Guðmundsson J. , 2009).

The measurements were carried out using a static chamber and a gas chromatograph measuring the gas flux from the gas concentration in the headspace of the chamber with time.

The results (Table A6.2 and Table A6.3) clearly show how the land use is influencing the N_2O fluxes: the drained cultivated area (hayfield) emits more than the drained uncultivated areas with the non-drained wetlands emitting the lowest. The freshly tilled, drained area emits around 10 times more than the cultivated hay fields which are not tilled regularly. The field measurements did not occur evenly

[49] IPCC 2006 Guidelines, Volume 4, Agriculture, Forestry, and Other Land Use.

over the year with more measurements carried out during the summertime. Therefore, the measurements have been weighted considering the number of measurements per month.

Table A6.2 Average of all N_2O measurements in the different land-use categories, transcribed and translated from (Guðmundsson J. , 2009).

Land Use	µg N_2O m^{-1} hr^{-1}	StDev	n	SE	CV	g N_2O ha^{-1} day^{-1}	kg N_2O_N ha^{-1} yr^{-1}
Undrained	0.45	10.34	209	0.72	23.18	0.11	0.02
Drained, Not cultivated	7.82	34.21	381	1.75	4.38	1.88	0.44
Drained hayfield	17.80	42.35	231	2.79	2.38	4.27	0.99
Drained tilled	149.98	335.74	40	53.08	2.24	36.00	8.36

Table A6.3 All N_2O measurements in the different land-use categories over 12 months and weighted average: transcribed and translated from (Guðmundsson J. , 2009). Methane, N_2O-N and CO_2e in kg ha^{-1} yr^{-1}.

													Monthly average	CO_2e
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**		
							Undrained							
n	10	5	11	25	25	30	30	44	15	4	10	0		
N_2O_N	0	0	0	-0.02	0.12	0	0	-0.08	0.41	0	0		0.04	19.08
CH_4	60.29	13.46	124.44	114.16	237.83	626.80	304.06	366.94	192.69	76.03	87.01		200.34	4,207.10
							Drained Not Cultivated							
n	20	25	15	45	30	45	50	65	20	26	30	10		
N_2O_N	0.62	0.36	0.24	0.11	1.23	0.10	0.13	0.32	2.58	0.51	0.00	0.25	0.54	262.03
CH_4	1.09	4.62	1.32	2.19	-0.21	11.46	3.81	5.58	10.21	3.85	4.09	2.54	4.21	88.49
							Drained Hayfield							
n	10	5	14	30	25	30	30	44	15	8	15	5		
N_2O_N	0.82	2.93	0.29	1.04	1.95	1.32	0.09	1.06	2.66	-0.39	-0.22	0	0.96	468.49
CH_4	0	-3.77	0	0.76	-0.45	-1.82	-1.42	-1.66	-0.75	0	1.36	0	-0.65	-13.57

The variations of the measured N_2O flux are great both in time and space, as can be seen on the drained, cultivated (hayfield), where the measurements in October and November even show uptake of N_2O.

Considering the weighted measurements over all months the emission factor for drained **uncultivated land is 0.54 kg ha^{-1} yr^{-1}**, and the one for **drained cultivated land (hayfield)** is **0.96 kg ha^{-1} yr^{-1}**. On the other hand, considering the average over all measurements, independently from the single months, the emission factor for **drained uncultivated land** is **0.44 kg ha^{-1} yr^{-1}** and the one for **drained cultivated land (hayfield)** is **0.99 kg ha^{-1} yr^{-1}**.

Comparison with Measurements from Other Countries

A recent study compares the characteristics across 11 peatland sites in Finland, Sweden, and Iceland; all sites have available in situ N_2O fluxes and show different management histories (Liimatainen, et al., 2018). Among the investigated sites with different management options are peatlands with forested, cultivated or only drained peatlands, afforested or abandoned agricultural peatlands. According to (Klemedtsson, Von Arnold, Weslien, & Gundersen, 2005), low C:N ratios can be used to predict high N_2O emissions, and all sites in the Liimataien et al. (2018) study display low C:N ratios (15-27). The two Icelandic peatland areas with N_2O flux measurements included in the study are one cultivated peat area (hayfield) and one drained site in Iceland, not used for agriculture or forestry. The study shows that the correlation between low C/N ratio and high N_2O emissions (Klemedtsson et al., 2005) cannot be used and that the N_2O emissions are linked to the amount of peat P and Cu content; if both are low, they can limit N_2O production even though there is sufficient N available in the soil (Liimatainen, et al., 2018). This is clearly visible from the Icelandic soil samples which present the lowest P content (Figure A8.5), an intermediate Cu content and a high Na content when compared to the soil sites of Finland and Sweden. The lowest N_2O flux data are from Icelandic soils (CI – cultivated hayfield, DI - drained) ranging between 0.03 and 0.04 g N $m^{-2}yr^{-1}$ (Liimatainen, et al., 2018)[50]. These numbers derive directly from the experiments of (Guðmundsson J. , 2009) and are compared to measurements carried out in other Nordic Countries, Finland, and Sweden.

The analysed data are summarised in Table 1 of the study and reported here in Table A6.4. (Liimatainen, et al., 2018) explain the lowest N_2O fluxes from Icelandic soils by the different soil characteristics due to the presence of volcanic ash from aeolian deposition which favours the formation of stable aluminium-humus complexes. From the other Nordic Country-sites, Icelandic soils also differ in nutrient composition, isotopic composition, being 13C enriched and 15N depleted showing a low P content, low gross nitrification rates, and microbial biomass C which explain their low N_2O emissions (Liimatainen, et al., 2018).

The reason of low P content and intermediate Cu content in Icelandic soils can be found in the mineralogic composition of Icelandic soils strongly influenced by mostly basic volcanic parent material, tephra, which weathers easily releasing Al, Fe and Si (Arnalds O. , 2015). One of the formed minerals is ferrihydrite and recent geochemical modelling has shown that this predominant Fe phase within Icelandic peat soils affects the heavy metal and nutrient retention upon oxidation (Linke & Gislason, 2018) showing high retention of phosphate by ferrihydrite.

Wang et al. (2016) show in a flooding experiment how the oxidation of Fe(II) is coupled to denitrification and therefore low N_2O emissions from paddy soils. The presence of ferrihydrite in Icelandic soils is clearly a sign of the oxidation process of Fe, a consequence of the aeolian input of volcanic parent material.

[50] 0.03 g N $m^{-2}yr^{-1}$*44/28*10000 = 471 g N_2O-N ha^{-1} yr^{-1} = 0.471 kg N_2O-N ha^{-1} yr^{-1}
0.04 g N $m^{-2}yr^{-1}$*44/28*10000 = 628 g N_2O-N ha^{-1} yr^{-1} = 0.628 kg N_2O-N ha^{-1} yr^{-1}

Table A6.4 Table 1 from (Liimatainen, et al., 2018) showing the soil properties of the investigated study sites. In yellow the Icelandic study sites are highlighted, comprising a cultivated field (hayfield) -C_I- and a drained field (not used for agriculture or forestry)-D_I.

Table 1

The study sites and their soil characteristics: degree of peat humification (*H*), C/N ratio, N_2O flux, water table level (WT), field bulk density (BD) and soil phosphorus (P) concentration. L1 refers to the surface layer of 0–10 cm and L2 to the deeper layer of 10–20 cm. The first letter of the site code refers to land-use type: F = forest, C = cultivated, A = afforested field, D = drained but not used for agriculture or forestry, B = abandoned field. The letter in subscript defines the site. The N_2O values are annual averages and in all cases ± denotes standard deviation.

Land-use	Site	Location	Country	Soil sampling	*H**		C/N ratio		N_2O flux	WT	BD	P (mg kg^{-1})	
					L1	L2	L1	L2	(g N m^{-2} y^{-1})	(cm)	0-20 cm	L1	L2
Forests	F_S	63°54′N, 23°56′E	Finland	18/06/2012	7–8	8	23 ± 0.0	22 ± 0.4	1.43 ± 0.59[a]	−41[a]	0.20[a]	943	1260
	F_J	63°52′N, 23°44′E	Finland	18/07/2011	6–7	7–8	19 ± 0.1	18 ± 0.1	0.07 ± 0.03[a]	−36[a]	0.17[a]	861	1340
Cultivated fields	C_S	63°54′N, 23°56′E	Finland	22/09/2011	8–9	8–9	17 ± 0.0	17 ± 0.0	2.38 ± 1.49[b]	−60[b]	0.22[b]	3280	3060
	C_I	64°34′N, 21°46′W	Iceland	12/07/2011	7–8	7–8	15 ± 0.1	16 ± 0.1	0.03[c]		0.23[g]	1660	964
	C_K	60°54′N, 23°31′E	Finland	23/04/2012	9	9	23 ± 0.2	22 ± 0.1	0.73 ± 0.12[d]	−82[d]	0.48[h]	1470	1560
Afforested fields	A_L	64°06′N, 24°21′E	Finland	23/08/2011	7	7–8	17 ± 0.1	18 ± 0.2	2.14 ± 0.60[e]	−52[e]	0.25[e]	2870	1760
	A_R	64°06′N, 24°21′E	Finland	23/08/2011	8–9	8–9	24 ± 0.2	27 ± 0.1	0.07 ± 0.07[e]	−25[e]	0.25[e]	1640	1190
	A_G	58°23′N, 12°09′E	Sweden	09/05/2011	7–8	9–10	25 ± 0.2	27 ± 0.0	0.26 ± 0.08[f]	−80[f]	0.20[i]	1000	862
Drained	D_I	64°34′N, 21°46′W	Iceland	12/07/2011	5–6	6–7	15 ± 0.0	16 ± 0.1	0.04[c]		0.34[g]	956	801
Abandoned fields	B_A	63°54′N, 23°56′E	Finland	25/04/2012	8–9	8–9	20 ± 0.2	23 ± 0.0	0.41 ± 0.17[e]	−35[e]	0.30[e]	1460	1270
	B_B	63°54′N, 23°56′E	Finland	25/04/2012	9–10	9–10	25 ± 0.5	26 ± 1.3	1.42 ± 0.68[e]	−51[e]	0.42[e]	944	1010

* Degree of humification was estimated according to von Post (1922).
[a]Maljanen et al. (2014), [b]Maljanen et al. (2009), [c]Maljanen et al. (2010a,b), [d]Regina et al. (2004), [e]Maljanen et al. (2012), [f]Klemedtsson et al. (2010), [g]Hlynur Óskarsson; personal communication, [h]Lohila et al. (2003), [i]Björk et al. (2010).

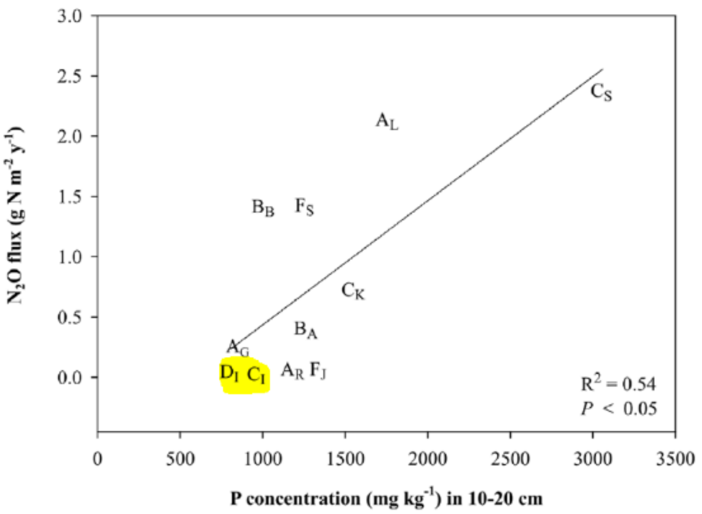

Fig. 4. Correlation between N_2O emissions (g N m^{-2} y^{-1}) *in situ* and the content of total P (mg kg^{-1}) in soil at the depth of 10–20 cm.

Figure A6.5 Correlation between N_2O emissions in situ and total P content. Icelandic study sites are highlighted, comprising a cultivated field (hayfield) -C_I- and a drained field (not used for agriculture or forestry) – D_I. (Liimatainen, et al., 2018).

Annex 7: Input data for Managed and Unmanaged Solid Waste Disposal Sites for the IPCC First Order Decay Model (5A1, 5A2)

Table A.7 1 Parameters used in the IPCC First Order Decay Model for Iceland, Managed and Unmanaged SWDS.

	Managed SWDS (5A1)		Unmanaged SWDS (5A2)	
	DOC	CH_4 Generation Rate Constant (k)	DOC	CH_4 Generation Rate Constant (k)
	Weight fraction, wet basis	$years^{-1}$	Weight fraction, wet basis	$years^{-1}$
Food Waste	0.15	0.185	0.15	0.185
Garden	0.2	0.1	0.2	0.1
Paper	0.4	0.06	0.4	0.06
Wood and Straw	0.43	0.03	0.43	0.03
Textiles	0.24	0.06	0.24	0.06
Disposable Nappies	0.24	0.1	0.24	0.1
Sewage Sludge	0.05	0.185	0.05	0.185
Industrial Waste	0.12	0.09	0.04	0.09
	DOC_f	0.5	DOC_f	0.5
	Delay time	6	Delay time	6
	Fraction of CH_4 (F) in developed gas	0.5	Fraction of CH_4 (F) in developed gas	0.5
	Oxidation factor (OX)	0.1	Oxidation factor (OX)	0
	MCF Managed	1	MCF Unmanaged Shallow	0.2
			MCF Unmanaged Deep	1
	Starting year	1950	Starting year	1950

Table A.8 2 Amounts Deposited in Managed SWDS (CRF 5A1a).

Year	Population [millions]	Food [kt]	Garden [kt]	Paper [kt]	Wood [kt]	Textile [kt]	Nappies [kt]	Sludge [kt]	Inert [kt]	Industrial [kt]	Recovery [kt]	Total [kt]
1950	0.141	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1951	0.144	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1952	0.147	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1953	0.149	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1954	0.153	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1955	0.156	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1956	0.159	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1957	0.163	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1958	0.167	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1959	0.170	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1960	0.174	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1961	0.177	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1962	0.181	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1963	0.184	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1964	0.187	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1965	0.191	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1966	0.194	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1967	0.197	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**

Year	Population [millions]	Food [kt]	Garden [kt]	Paper [kt]	Wood [kt]	Textile [kt]	Nappies [kt]	Sludge [kt]	Inert [kt]	Industrial [kt]	Recovery [kt]	Total [kt]
1968	0.200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1969	0.203	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1970	0.204	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1971	0.205	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	**0.0**
1972	0.207	5.2	0.4	1.7	0.4	0.3	0.0	0.2	3.0	0.7	NO	**11.9**
1973	0.211	5.7	0.5	2.0	0.4	0.3	0.0	0.2	3.4	0.8	NO	**13.3**
1974	0.214	5.7	0.5	2.0	0.5	0.3	0.0	0.2	3.5	0.8	NO	**13.5**
1975	0.217	5.5	0.4	2.0	0.4	0.3	0.0	0.2	3.5	0.8	NO	**13.1**
1976	0.219	5.9	0.5	2.2	0.5	0.4	0.0	0.3	3.8	0.8	NO	**14.4**
1977	0.221	6.6	0.5	2.5	0.5	0.4	0.0	0.3	4.4	0.9	NO	**16.2**
1978	0.223	6.9	0.6	2.7	0.6	0.4	0.0	0.3	4.7	1.0	NO	**17.2**
1979	0.225	6.9	0.6	2.8	0.6	0.4	0.0	0.3	4.8	1.0	NO	**17.6**
1980	0.227	7.2	0.6	3.0	0.6	0.5	0.0	0.3	5.1	1.1	NO	**18.4**
1981	0.229	7.1	0.6	3.1	0.6	0.5	0.1	0.3	5.4	1.1	NO	**18.9**
1982	0.232	6.9	0.6	3.2	0.6	0.5	0.2	0.3	5.7	1.1	NO	**19.2**
1983	0.236	6.3	0.6	3.2	0.6	0.5	0.2	0.3	5.7	1.1	NO	**18.4**
1984	0.238	6.2	0.6	3.3	0.6	0.5	0.3	0.3	6.0	1.1	NO	**19.0**
1985	0.241	6.1	0.7	3.4	0.7	0.5	0.4	0.3	6.4	1.1	NO	**19.6**
1986	0.242	6.3	0.7	3.8	0.7	0.5	0.5	0.4	7.1	1.2	NO	**21.2**
1987	0.244	6.5	0.8	4.2	0.8	0.6	0.7	0.4	7.9	1.3	NO	**23.1**
1988	0.248	6.0	0.8	4.2	0.8	0.6	0.8	0.4	8.1	1.3	NO	**22.8**
1989	0.252	5.6	0.8	4.2	0.8	0.6	0.8	0.4	8.2	1.3	NO	**22.7**
1990	0.254	7.2	1.0	5.8	1.0	0.8	1.3	0.5	11.5	1.8	NO	**30.9**
1991	0.256	62.2	9.0	50.2	8.9	6.8	11.1	4.7	99.4	15.4	NO	**267.6**
1992	0.260	60.9	8.9	49.1	8.8	6.6	10.8	4.6	97.3	15.0	NO	**262.0**
1993	0.262	61.2	8.9	49.4	8.8	6.6	10.9	4.6	97.8	15.1	NO	**263.3**
1994	0.265	63.4	9.2	51.1	9.1	6.9	11.3	4.8	101.3	15.6	NO	**272.7**
1995	0.267	60.8	8.8	49.1	8.7	6.6	10.8	4.6	97.1	15.0	NO	**261.6**
1996	0.268	62.0	9.0	50.1	8.9	6.7	11.0	4.7	99.1	15.3	0.2	**267.0**
1997	0.270	63.5	9.2	51.2	9.1	6.9	11.3	4.8	101.4	15.7	0.3	**273.1**
1998	0.272	66.8	9.7	53.9	9.6	7.3	11.9	5.1	106.7	16.5	0.4	**287.4**
1999	0.276	68.0	9.9	54.9	9.8	7.4	12.1	5.1	108.7	16.8	0.4	**292.8**
2000	0.279	70.7	10.3	57.0	10.2	7.7	12.6	5.3	112.9	17.4	0.5	**304.0**
2001	0.283	70.2	10.2	56.7	10.1	7.6	12.5	5.3	112.3	17.3	0.5	**302.3**
2002	0.287	69.5	10.1	56.1	10.0	7.6	12.4	5.3	111.1	17.2	0.8	**299.2**
2003	0.288	71.1	10.3	57.4	10.2	7.7	12.6	5.4	113.6	17.5	1.0	**305.8**
2004	0.291	71.1	10.3	57.4	10.2	7.7	12.6	5.4	113.7	17.6	1.0	**306.1**
2005	0.294	66.4	9.7	53.6	9.5	7.2	11.8	5.0	106.1	16.4	1.7	**285.8**
2006	0.300	58.9	8.6	47.6	8.5	6.4	10.5	4.5	94.2	14.5	0.5	**253.6**
2007	0.308	32.7	12.1	39.8	13.1	5.8	7.1	5.0	61.8	19.5	0.7	**197.0**
2008	0.315	43.1	2.7	44.6	6.5	7.1	8.2	3.1	69.3	1.6	0.9	**186.4**
2009	0.319	40.1	2.0	17.2	4.8	7.1	9.0	2.8	52.4	1.2	1.1	**136.5**
2010	0.318	32.1	1.2	25.6	1.5	2.5	8.6	1.8	46.6	0.2	0.7	**120.2**
2011	0.318	46.5	1.6	25.7	2.3	3.1	8.7	1.9	29.7	4.1	1.2	**123.7**
2012	0.320	51.4	4.5	23.1	2.7	2.8	7.3	1.6	36.4	2.2	2.1	**132.1**
2013	0.322	63.6	4.5	9.3	3.6	3.7	9.5	2.0	36.1	0.8	1.4	**133.2**
2014	0.326	62.2	0.8	13.5	1.2	3.3	8.2	2.2	37.6	4.1	1.4	**133.0**

Year	Population [millions]	Food [kt]	Garden [kt]	Paper [kt]	Wood [kt]	Textile [kt]	Nappies [kt]	Sludge [kt]	Inert [kt]	Industrial [kt]	Recovery [kt]	Total [kt]
2015	0.329	66.2	2.4	13.6	3.5	4.5	8.2	2.9	39.4	2.4	1.4	**143.2**
2016	0.333	68.7	2.4	17.3	5.1	5.8	8.6	2.5	44.4	3.7	1.6	**158.4**
2017	0.338	61.6	0.0	36.9	17.9	5.5	3.3	2.4	47.9	4.5	1.8	**180.0**
2018	0.348	52.0	0.0	40.8	19.9	5.1	4.3	2.4	54.3	6.3	1.5	**185.1**
2019	0.357	54.2	0.7	28.5	31.6	4.1	6.8	1.3	38.6	5.2	3.0	**170.9**
2020	0.364	49.2	0.0	15.9	36.3	3.4	6.2	2.0	30.4	2.8	1.8	**146.1**
2021	0.369	40.2	0.0	11.8	25.0	6.5	9.1	2.8	29.9	6.1	1.7	**131.4**

Table A.8 3 Amounts Deposited in Unmanaged SWDS (CRF 5A2).

Year	Population [millions]	Food [kt]	Garden [kt]	Paper [kt]	Wood [kt]	Textile [kt]	Nappies [kt]	Sludge [kt]	Inert [kt]	Industrial [kt]	Recovery [kt]	Total [kt]
1950	0.141	29.2	1.8	5.0	1.8	1.3	0.0	0.9	9.9	3.0	0.0	**52.8**
1951	0.144	27.8	1.7	4.9	1.7	1.3	0.0	0.9	9.6	2.9	0.0	**50.8**
1952	0.147	27.4	1.7	5.0	1.7	1.3	0.0	0.9	9.8	2.9	0.0	**50.6**
1953	0.149	31.9	2.0	6.0	2.0	1.5	0.0	1.0	11.7	3.4	0.0	**59.6**
1954	0.153	35.0	2.2	6.8	2.2	1.7	0.0	1.2	13.1	3.8	0.0	**66.0**
1955	0.156	38.2	2.5	7.7	2.4	1.8	0.0	1.3	14.7	4.2	0.0	**72.8**
1956	0.159	38.4	2.5	8.0	2.5	1.9	0.0	1.3	15.2	4.2	0.0	**73.9**
1957	0.163	37.7	2.5	8.1	2.5	1.9	0.0	1.3	15.3	4.2	0.0	**73.4**
1958	0.167	41.2	2.7	9.1	2.7	2.0	0.0	1.4	17.1	4.6	0.0	**80.9**
1959	0.170	41.8	2.8	9.5	2.8	2.1	0.0	1.5	17.8	4.8	0.0	**82.9**
1960	0.174	41.9	2.8	9.9	2.8	2.1	0.0	1.5	18.3	4.8	0.0	**84.2**
1961	0.177	42.9	2.9	10.4	2.9	2.2	0.0	1.5	19.2	5.0	0.0	**87.0**
1962	0.181	46.1	3.2	11.5	3.2	2.4	0.0	1.7	21.2	5.4	0.0	**94.7**
1963	0.184	50.2	3.5	12.9	3.5	2.6	0.0	1.8	23.6	6.0	0.0	**104.2**
1964	0.187	55.4	3.9	14.7	3.9	2.9	0.0	2.0	26.7	6.7	0.0	**116.3**
1965	0.191	60.3	4.3	16.5	4.3	3.2	0.0	2.3	29.8	7.3	0.0	**128.1**
1966	0.194	64.5	4.7	18.2	4.6	3.5	0.0	2.4	32.7	8.0	0.0	**138.6**
1967	0.197	61.3	4.5	17.8	4.5	3.4	0.0	2.3	31.8	7.6	0.0	**133.2**
1968	0.200	57.2	4.3	17.1	4.2	3.2	0.0	2.2	30.5	7.2	0.0	**125.9**
1969	0.203	58.0	4.4	17.9	4.3	3.3	0.0	2.3	31.6	7.4	0.0	**129.1**
1970	0.204	63.7	4.9	20.2	4.8	3.6	0.0	2.5	35.6	8.2	0.0	**143.5**
1971	0.205	71.8	5.5	23.4	5.5	4.1	0.0	2.9	41.2	9.4	0.0	**163.8**
1972	0.207	72.2	5.6	24.3	5.6	4.2	0.0	2.9	42.4	9.6	0.0	**166.9**
1973	0.211	78.4	6.2	27.1	6.1	4.6	0.0	3.2	47.2	10.5	0.0	**183.5**
1974	0.214	78.5	6.3	27.9	6.2	4.7	0.0	3.3	48.5	10.7	0.0	**186.1**
1975	0.217	74.0	6.0	27.1	5.9	4.5	0.0	3.1	46.8	10.2	0.0	**177.7**
1976	0.219	78.6	6.5	29.6	6.4	4.8	0.0	3.4	51.0	11.0	0.0	**191.2**
1977	0.221	85.3	7.1	33.0	7.0	5.3	0.0	3.7	56.7	12.1	0.0	**210.3**
1978	0.223	88.3	7.5	35.2	7.4	5.6	0.0	3.9	60.2	12.7	0.0	**220.7**
1979	0.225	88.2	7.5	36.1	7.5	5.6	0.0	3.9	61.6	12.8	0.0	**223.2**
1980	0.227	90.0	7.8	37.9	7.7	5.8	0.0	4.1	64.4	13.3	0.0	**231.0**
1981	0.229	90.5	8.2	40.3	8.1	6.1	1.0	4.3	69.8	13.9	0.0	**242.1**
1982	0.232	88.8	8.4	41.9	8.3	6.3	2.0	4.4	73.8	14.2	0.0	**248.0**
1983	0.236	82.7	8.2	41.4	8.1	6.1	3.0	4.2	74.1	13.9	0.0	**241.6**
1984	0.238	82.5	8.5	43.8	8.4	6.4	4.2	4.4	79.8	14.5	0.0	**252.6**
1985	0.241	81.6	8.9	46.1	8.8	6.6	5.4	4.6	85.3	15.1	0.0	**262.3**

Year	Population [millions]	Food [kt]	Garden [kt]	Paper [kt]	Wood [kt]	Textile [kt]	Nappies [kt]	Sludge [kt]	Inert [kt]	Industrial [kt]	Recovery [kt]	Total [kt]
1986	0.242	84.7	9.7	51.1	9.6	7.2	7.1	5.0	96.0	16.5	0.0	**286.9**
1987	0.244	88.5	10.7	57.2	10.6	8.0	9.2	5.6	108.8	18.2	0.0	**316.7**
1988	0.248	83.6	10.7	58.0	10.6	8.0	10.5	5.6	111.9	18.2	0.0	**317.0**
1989	0.252	78.2	10.6	58.4	10.5	8.0	11.7	5.5	114.1	18.1	0.0	**315.1**
1990	0.254	72.3	10.5	58.4	10.4	7.9	12.9	5.5	115.6	17.9	0.0	**311.2**
1991	0.256	18.5	2.7	14.9	2.7	2.0	3.3	1.4	29.5	4.6	0.0	**79.4**
1992	0.260	17.8	2.6	14.4	2.6	1.9	3.2	1.3	28.5	4.4	0.0	**76.7**
1993	0.262	17.7	2.6	14.3	2.5	1.9	3.1	1.3	28.3	4.4	0.0	**76.1**
1994	0.265	18.0	2.6	14.5	2.6	2.0	3.2	1.4	28.8	4.5	0.0	**77.6**
1995	0.267	12.2	1.8	9.8	1.8	1.3	2.2	0.9	19.5	3.0	0.0	**52.4**
1996	0.268	11.4	1.7	9.2	1.6	1.2	2.0	0.9	18.2	2.8	0.0	**49.0**
1997	0.270	11.4	1.7	9.2	1.6	1.2	2.0	0.9	18.2	2.8	0.0	**48.9**
1998	0.272	8.7	1.3	7.0	1.3	0.9	1.6	0.7	13.9	2.2	0.0	**37.6**
1999	0.276	8.7	1.3	7.0	1.2	0.9	1.5	0.7	13.8	2.1	0.0	**37.2**
2000	0.279	8.8	1.3	7.1	1.3	1.0	1.6	0.7	14.1	2.2	0.0	**38.0**
2001	0.283	8.5	1.2	6.9	1.2	0.9	1.5	0.6	13.6	2.1	0.0	**36.7**
2002	0.287	8.3	1.2	6.7	1.2	0.9	1.5	0.6	13.3	2.1	0.0	**35.8**
2003	0.288	8.4	1.2	6.8	1.2	0.9	1.5	0.6	13.4	2.1	0.0	**36.2**
2004	0.291	8.3	1.2	6.7	1.2	0.9	1.5	0.6	13.3	2.1	0.0	**35.9**
2005	0.294	14.0	2.0	11.3	2.0	1.5	2.5	1.1	22.4	3.5	0.0	**60.2**
2006	0.300	12.4	1.8	10.0	1.8	1.3	2.2	0.9	19.8	3.1	0.0	**53.4**
2007	0.308	11.9	0.7	3.3	0.3	0.3	0.6	0.1	13.5	1.3	0.0	**32.0**
2008	0.315	16.0	10.0	5.8	1.1	0.8	1.0	3.5	28.5	4.9	0.0	**71.7**
2009	0.319	14.2	4.6	2.1	0.5	0.7	1.1	1.2	16.9	3.7	0.0	**45.0**
2010	0.318	11.7	2.3	2.9	0.9	0.5	1.0	0.5	21.9	2.9	0.0	**44.6**
2011	0.318	14.2	2.7	3.2	0.8	0.5	1.1	0.7	9.3	3.8	0.0	**36.4**
2012	0.320	13.0	0.2	2.4	1.7	0.4	0.8	0.9	10.7	1.6	0.0	**31.7**
2013	0.322	11.4	0.8	1.0	1.2	0.5	1.0	1.0	6.9	2.1	0.0	**25.9**
2014	0.326	5.6	0.1	0.8	0.3	0.2	0.5	0.4	37.0	0.9	0.0	**45.8**
2015	0.329	5.0	0.3	1.0	0.3	0.3	0.6	0.3	43.9	1.1	0.0	**52.6**
2016	0.333	3.9	0.1	1.0	0.5	0.3	0.5	0.2	48.9	1.3	0.0	**56.8**
2017	0.338	3.1	0.0	1.6	0.9	0.2	0.1	0.4	20.5	1.5	0.0	**28.3**
2018	0.348	3.1	0.0	2.0	1.1	0.2	0.2	1.1	22.6	1.2	0.0	**31.5**
2019	0.357	3.3	0.1	1.6	9.4	0.2	0.4	1.0	29.4	2.3	0.0	**47.7**
2020	0.364	4.5	0.2	1.2	2.7	0.3	0.5	0.5	30.9	2.4	0.0	**43.1**
2021	0.369	3.8	0.2	0.9	2.3	0.5	0.7	0.3	33.5	1.0	0.0	**43.3**

Annex 8: CRF (Common Reporting Format) Summary 2 Tables for 1990-2021 (GWP from AR4)

1990

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1990
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	7984.14	4565.95	295.29	0.31	444.82	1.13	NO,NA	NO,NA	13291.65
1. Energy	1807.19	9.76	23.58						1840.54
A. Fuel combustion (sectoral approach)	1745.84	9.00	23.58						1778.41
1. Energy industries	13.46	0.01	0.03						13.50
2. Manufacturing industries and construction	294.90	0.43	6.51						301.84
3. Transport	607.34	6.36	7.36						621.07
4. Other sectors	830.01	2.19	9.68						841.88
5. Other	0.12	0.00	0.00						0.12
B. Fugitive emissions from fuels	61.36	0.76	NO,NA						62.12
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	61.36	0.76	NA,NO						62.12
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	407.84	1.81	46.76	0.31	444.82	1.13	NO,NA	NO,NA	902.66
A. Mineral industry	52.26								52.26
B. Chemical industry	0.36	NO,NA	41.34	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	41.70
C. Metal industry	348.01	1.76	NO	NO	444.82	NO	NO	NO	794.58
D. Non-energy products from fuels and solvent use	7.21	NA	NA						7.21
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				0.31	NO	NO	NO	NO	0.31
G. Other product manufacture and use	0.00	0.05	5.42		NO	1.13			6.61
H. Other	NA	NA	NA						NA
3. Agriculture	0.46	475.81	218.98						695.25
A. Enteric fermentation		390.99							390.99
B. Manure management		84.81	14.43						99.24
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	204.56						204.56
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.46								0.46
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5761.36	3848.06	0.18						9609.60
A. Forest land	-29.52	0.13	0.12						-29.28
B. Cropland	1884.40	106.21	NO,NA						1990.61
C. Grassland	5001.49	418.90	0.07						5420.46
D. Wetlands	-1116.85	3322.82	NO,NE,NA						2205.97
E. Settlements	21.84	NE,NA	NO,NE,IE,NA						21.84
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	7.30	230.51	5.79						243.59
A. Solid waste disposal	NO,NA	167.70							167.70
B. Biological treatment of solid waste		NO	NO						NO
C. Incineration and open burning of waste	7.30	6.82	1.49						15.60
D. Waste water treatment and discharge		56.00	4.30						60.29
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	247.24	0.12	1.83						249.19
Aviation	219.44	0.04	1.63						221.11
Navigation	27.81	0.07	0.20						28.08
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NE,NA								NO,NE,NA
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3682.04
Total CO_2 equivalent emissions with land use, land-use change and forestry									13291.65
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for
(2) See footnote 7 to table Summary 1.A.
(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

1991

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1991
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	7869.72	4563.24	289.11	0.63	369.25	1.28	NO,NA	NO,NA	13093.23
1. Energy	1722.76	9.64	22.93						1755.34
A. Fuel combustion (sectoral approach)	1652.81	8.98	22.93						1684.72
1. Energy industries	15.05	0.02	0.03						15.10
2. Manufacturing industries and construction	221.30	0.34	6.08						227.73
3. Transport	613.24	6.51	7.51						627.26
4. Other sectors	803.07	2.11	9.30						814.48
5. Other	0.14	0.00	0.00						0.14
B. Fugitive emissions from fuels	69.95	0.67	NO,NA						70.62
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	69.95	0.67	NA,NO						70.62
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	373.43	1.46	44.94	0.63	369.25	1.28	NO,NA	NO,NA	790.99
A. Mineral industry	48.63								48.63
B. Chemical industry	0.31	NO,NA	40.02	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	40.33
C. Metal industry	317.42	1.41	NO	NO	369.25	NO	NO	NO	688.08
D. Non-energy products from fuels and solvent use	7.06	NA	NA						7.06
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				0.63	NO	NO	NO	NO	0.63
G. Other product manufacture and use	0.00	0.05	4.92		NO	1.28			6.27
H. Other	NA	NA	NA						NA
3. Agriculture	0.18	461.72	215.20						677.11
A. Enteric fermentation		379.64							379.64
B. Manure management		82.09	13.64						95.73
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	201.56						201.56
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.18								0.18
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5766.11	3851.10	0.23						9617.44
A. Forest land	-30.87	0.18	0.16						-30.53
B. Cropland	1885.25	106.24	NO,NA						1991.49
C. Grassland	4999.86	419.26	0.07						5419.18
D. Wetlands	-1109.96	3325.42	NO,NE,NA						2215.46
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	7.24	239.31	5.81						252.36
A. Solid waste disposal	NO,NA	173.32							173.32
B. Biological treatment of solid waste		NO	NO						NO
C. Incineration and open burning of waste	7.24	6.77	1.48						15.48
D. Waste water treatment and discharge		59.22	4.33						63.55
E. Other	NA	NO	NO						NO,NA
6. Other ***(as specified in summary 1.A)***	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	235.64	0.08	1.74						237.46
Aviation	221.77	0.04	1.64						223.46
Navigation	13.87	0.04	0.10						14.00
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NE,NA								NO,NE,NA
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3475.79
Total CO_2 equivalent emissions with land use, land-use change and forestry									13093.23
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1992

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1992
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	8008.98	4564.96	278.15	0.64	164.60	1.28	NO,NA	NO,NA	13018.60
1. Energy	1865.93	9.97	23.20						1899.10
A. Fuel combustion (sectoral approach)	1798.31	9.24	23.20						1830.76
1. Energy industries	14.06	0.02	0.03						14.10
2. Manufacturing industries and construction	280.71	0.38	5.80						286.90
3. Transport	623.98	6.53	7.78						638.29
4. Other sectors	878.77	2.31	9.59						890.67
5. Other	0.79	0.00	0.00						0.80
B. Fugitive emissions from fuels	67.62	0.73	NO,NA						68.34
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	67.62	0.73	NA,NO						68.34
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	376.69	1.58	40.21	0.64	164.60	1.28	NO,NA	NO,NA	585.01
A. Mineral industry	45.67								45.67
B. Chemical industry	0.25	NO,NA	35.78	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	36.03
C. Metal industry	323.55	1.52	NO	NO	164.60	NO	NO	NO	489.67
D. Non-energy products from fuels and solvent use	7.22	NA	NA						7.22
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				0.64	NO	NO	NO	NO	0.64
G. Other product manufacture and use	0.01	0.06	4.44		NO	1.28			5.78
H. Other	NA	NA	NA						NA
3. Agriculture	0.50	449.63	208.61						658.73
A. Enteric fermentation		372.53							372.53
B. Manure management		77.09	13.08						90.17
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	195.53						195.53
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.50								0.50
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5758.81	3850.39	0.28						9609.48
A. Forest land	-35.52	0.24	0.22						-35.06
B. Cropland	1885.48	106.26	NO,NA						1991.74
C. Grassland	4996.59	419.62	0.07						5416.28
D. Wetlands	-1109.57	3324.27	NO,NE,NA						2214.70
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	7.04	253.40	5.84						266.28
A. Solid waste disposal	NO,NA	188.33							188.33
B. Biological treatment of solid waste		NO	NO						NO
C. Incineration and open burning of waste	7.04	6.61	1.44						15.09
D. Waste water treatment and discharge		58.47	4.40						62.87
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	223.70	0.09	1.65						225.44
Aviation	203.42	0.04	1.51						204.97
Navigation	20.28	0.05	0.15						20.48
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	NO,NE,NA								NO,NE,NA
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3409.12
Total CO_2 equivalent emissions with land use, land-use change and forestry									13018.60
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1993

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1993
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) (1)	8153.68	4577.79	285.56	1.44	79.35	1.28	NO,NA	NO,NA	13099.09
1. Energy	1968.86	9.94	25.01						2003.81
A. Fuel combustion (sectoral approach)	1883.48	9.20	25.01						1917.69
1. Energy industries	14.42	0.04	0.08						14.54
2. Manufacturing industries and construction	303.49	0.42	6.27						310.18
3. Transport	627.17	6.28	8.35						641.80
4. Other sectors	936.96	2.46	10.30						949.73
5. Other	1.44	0.00	0.00						1.44
B. Fugitive emissions from fuels	85.38	0.74	NO,NA						86.12
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	85.38	0.74	NA,NO						86.12
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	425.64	1.94	42.00	1.44	79.35	1.28	NO,NA	NO,NA	551.64
A. Mineral industry	39.65								39.65
B. Chemical industry	0.24	NO,NA	37.63	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	37.87
C. Metal industry	378.27	1.89	NO	NO	79.35	NO	NO	NO	459.51
D. Non-energy products from fuels and solvent use	7.47	NA	NA						7.47
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				1.44	NO	NO	NO	NO	1.44
G. Other product manufacture and use	0.01	0.05	4.37		NO	1.28			5.70
H. Other	NA	NA	NA						NA
3. Agriculture	0.44	446.63	212.56						659.64
A. Enteric fermentation		370.36							370.36
B. Manure management		76.28	13.12						89.40
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	199.44						199.44
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.44								0.44
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry (1)	5752.74	3849.64	0.30						9602.68
A. Forest land	-40.62	0.26	0.23						-40.13
B. Cropland	1885.73	106.29	NO,NA						1992.01
C. Grassland	4994.98	419.97	0.07						5415.02
D. Wetlands	-1109.18	3323.12	NO,NE,NA						2213.95
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	6.00	269.64	5.70						281.33
A. Solid waste disposal	NO,NA	201.25							201.25
B. Biological treatment of solid waste		NO	NO						NO
C. Incineration and open burning of waste	6.00	5.72	1.25						12.97
D. Waste water treatment and discharge		62.66	4.45						67.11
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: (2)									
International bunkers	225.02	0.12	1.66						226.80
Aviation	195.45	0.04	1.45						196.94
Navigation	29.57	0.08	0.21						29.86
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	3.14								3.14
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3496.42
Total CO_2 equivalent emissions with land use, land-use change and forestry									13099.09
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

1994

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1994
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	8098.96	4582.45	290.61	1.85	47.24	1.28	NO,NA	NO,NA	13022.39
1. Energy	1917.39	9.70	25.56						1952.65
A. Fuel combustion (sectoral approach)	1847.27	8.95	25.56						1881.78
1. Energy industries	14.28	0.04	0.08						14.40
2. Manufacturing industries and construction	284.05	0.40	6.34						290.78
3. Transport	628.31	6.10	8.88						643.29
4. Other sectors	920.52	2.42	10.26						933.20
5. Other	0.10	0.00	0.00						0.10
B. Fugitive emissions from fuels	70.12	0.75	NO,NA						70.87
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	70.12	0.75	NA,NO						70.87
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	426.74	1.90	41.87	1.85	47.24	1.28	NO,NA	NO,NA	520.89
A. Mineral industry	37.35								37.35
B. Chemical industry	0.35	NO,NA	37.90	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	38.25
C. Metal industry	381.64	1.85	NO	NO	47.24	NO	NO	NO	430.73
D. Non-energy products from fuels and solvent use	7.39	NA	NA						7.39
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				1.85	NO	NO	NO	NO	1.85
G. Other product manufacture and use	0.01	0.05	3.98		NO	1.28			5.32
H. Other	NA	NA	NA						NA
3. Agriculture	0.01	446.05	217.20						663.26
A. Enteric fermentation		371.05							371.05
B. Manure management		74.99	13.17						88.16
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	204.03						204.03
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.01								0.01
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	NO								NO
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5749.29	3848.37	0.32						9597.98
A. Forest land	-43.49	0.27	0.24						-42.98
B. Cropland	1885.99	106.31	NO,NA						1992.30
C. Grassland	4993.49	420.60	0.07						5414.16
D. Wetlands	-1108.52	3321.19	NO,NE,NA						2212.67
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	5.53	276.44	5.65						287.62
A. Solid waste disposal	NO,NA	213.18							213.18
B. Biological treatment of solid waste		NO	NO						NO
C. Incineration and open burning of waste	5.53	5.31	1.16						12.00
D. Waste water treatment and discharge		57.95	4.49						62.44
E. Other	NA	NO	NO						NO,NA
6. Other ***(as specified in summary 1.A)***	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	247.06	0.13	1.82						249.01
Aviation	213.41	0.04	1.58						215.03
Navigation	33.65	0.09	0.24						33.98
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	3.14								3.14
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3424.41
Total CO_2 equivalent emissions with land use, land-use change and forestry									13022.39
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

1995

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1995
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) (1)	8209.55	4578.21	287.29	3.15	62.38	1.28	NO,NA	NO,NA	13141.85
1. Energy	2017.88	9.60	29.71						2057.20
A. Fuel combustion (sectoral approach)	1935.65	8.82	29.71						1974.18
1. Energy industries	15.10	0.05	0.10						15.24
2. Manufacturing industries and construction	286.66	0.39	7.78						294.83
3. Transport	639.45	5.79	10.05						655.30
4. Other sectors	992.82	2.60	11.77						1007.19
5. Other	1.61	0.00	0.00						1.62
B. Fugitive emissions from fuels	82.24	0.78	NO,NA						83.02
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	82.24	0.78	NA,NO						83.02
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	444.14	2.05	40.03	3.15	62.38	1.28	NO,NA	NO,NA	553.02
A. Mineral industry	37.84								37.84
B. Chemical industry	0.46	NO,NA	36.04	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	36.50
C. Metal industry	397.93	2.00	NO	NO	62.38	NO	NO	NO	462.31
D. Non-energy products from fuels and solvent use	7.91	NA	NA						7.91
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				3.15	NO	NO	NO	NO	3.15
G. Other product manufacture and use	0.01	0.05	3.99		NO	1.28			5.32
H. Other	NA	NA	NA						NA
3. Agriculture	2.44	429.51	211.50						643.45
A. Enteric fermentation		356.23							356.23
B. Manure management		73.28	12.70						85.98
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	198.81						198.81
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.00								0.00
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.44								2.44
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry (1)	5740.21	3846.59	0.36						9587.16
A. Forest land	-53.48	0.32	0.28						-52.88
B. Cropland	1886.23	106.34	NO,NA						1992.57
C. Grassland	4993.24	421.47	0.07						5414.78
D. Wetlands	-1107.60	3318.46	NO,NE,NA						2210.86
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	NO,NA								NO,NA
H. Other	IE	IE	IE						IE
5. Waste	4.87	290.45	5.69						301.01
A. Solid waste disposal	NO,NA	225.23							225.23
B. Biological treatment of solid waste		0.22	0.13						0.35
C. Incineration and open burning of waste	4.87	4.74	1.04						10.65
D. Waste water treatment and discharge		60.26	4.53						64.78
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: (2)									
International bunkers	239.25	0.06	1.77						241.08
Aviation	235.92	0.05	1.75						237.71
Navigation	3.33	0.01	0.02						3.37
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	3.90								3.90
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3554.69
Total CO_2 equivalent emissions with land use, land-use change and forestry									13141.85
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

1996

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1996
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	8260.52	4599.38	302.06	10.09	26.66	1.28	NO,NA	NO,NA	13199.99
1. Energy	2072.87	9.50	30.27						2112.64
A. Fuel combustion (sectoral approach)	1991.60	8.63	30.27						2030.50
1. Energy industries	12.11	0.05	0.12						12.28
2. Manufacturing industries and construction	331.49	0.42	7.65						339.56
3. Transport	629.62	5.47	10.72						645.81
4. Other sectors	1018.00	2.68	11.78						1032.46
5. Other	0.38	0.00	0.00						0.39
B. Fugitive emissions from fuels	81.27	0.87	NO,NA						82.14
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	81.27	0.87	NA,NO						82.14
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	443.50	2.08	46.50	10.09	26.66	1.28	NO,NA	NO,NA	530.11
A. Mineral industry	41.76								41.76
B. Chemical industry	0.40	NO,NA	42.14	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	42.54
C. Metal industry	393.47	2.03	NO	NO	26.66	NO	NO	NO	422.16
D. Non-energy products from fuels and solvent use	7.86	NA	NA						7.86
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				10.09	NO	NO	NO	NO	10.09
G. Other product manufacture and use	0.01	0.05	4.36		NO	1.28			5.71
H. Other	NA	NA	NA						NA
3. Agriculture	2.98	434.03	219.31						656.32
A. Enteric fermentation		360.46							360.46
B. Manure management		73.56	12.98						86.54
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	206.33						206.33
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.35								0.35
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.63								2.63
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5736.80	3847.00	0.37						9584.18
A. Forest land	-57.58	0.34	0.30						-56.95
B. Cropland	1886.46	106.36	NO,NA						1992.83
C. Grassland	4991.34	422.16	0.08						5413.58
D. Wetlands	-1105.25	3318.14	NO,NE,NA						2212.89
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	4.37	306.77	5.61						316.74
A. Solid waste disposal	NO,NA	229.55							229.55
B. Biological treatment of solid waste		0.22	0.13						0.35
C. Incineration and open burning of waste	4.37	4.29	0.94						9.59
D. Waste water treatment and discharge		72.71	4.54						77.25
E. Other	NA	NO	NO						NA,NO
6. Other ***(as specified in summary 1.A)***	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	290.26	0.10	2.15						292.51
Aviation	271.24	0.05	2.01						273.30
Navigation	19.02	0.05	0.14						19.20
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	4.97								4.97
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3615.81
Total CO_2 equivalent emissions with land use, land-use change and forestry									13199.99
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

1997

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1997
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2[(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	8357.13	4598.40	296.44	16.14	87.30	1.28	NO,NA	NO,NA	13356.68
1. Energy	2109.29	9.24	34.01						2152.55
A. Fuel combustion (sectoral approach)	2042.44	8.35	34.01						2084.80
1. Energy industries	7.00	0.05	0.11						7.15
2. Manufacturing industries and construction	383.68	0.51	9.20						393.39
3. Transport	646.26	5.17	12.01						663.44
4. Other sectors	1005.46	2.62	12.71						1020.80
5. Other	0.04	0.00	0.00						0.04
B. Fugitive emissions from fuels	66.85	0.89	NO,NA						67.75
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	66.85	0.89	NA,NO						67.75
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	502.71	2.05	39.52	16.14	87.30	1.28	NO,NA	NO,NA	649.01
A. Mineral industry	46.52								46.52
B. Chemical industry	0.44	NO,NA	35.14	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	35.57
C. Metal industry	448.00	2.00	NO	NO	87.30	NO	NO	NO	537.30
D. Non-energy products from fuels and solvent use	7.75	NA	NA						7.75
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				16.14	NO	NO	NO	NO	16.14
G. Other product manufacture and use	0.01	0.05	4.38		NO	1.28			5.73
H. Other	NA	NA	NA						NA
3. Agriculture	3.22	427.71	216.91						647.85
A. Enteric fermentation		356.35							356.35
B. Manure management		71.37	13.19						84.55
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	203.73						203.73
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.69								0.69
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.52								2.52
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5737.70	3844.13	0.39						9582.22
A. Forest land	-64.48	0.35	0.31						-63.81
B. Cropland	1886.72	106.39	NO,NA						1993.11
C. Grassland	4997.39	423.60	0.08						5421.06
D. Wetlands	-1103.76	3313.79	NO,NE,NA						2210.04
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.01								-0.01
H. Other	IE	IE	IE						IE
5. Waste	4.21	315.25	5.60						325.06
A. Solid waste disposal	NO,NA	233.81							233.81
B. Biological treatment of solid waste		0.22	0.13						0.35
C. Incineration and open burning of waste	4.21	4.11	0.90						9.22
D. Waste water treatment and discharge		77.11	4.57						81.69
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items:[(2)]									
International bunkers	329.95	0.16	2.43						332.54
Aviation	291.83	0.06	2.16						294.05
Navigation	38.12	0.10	0.27						38.49
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	4.97								4.97
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2[(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3774.47
Total CO_2 equivalent emissions with land use, land-use change and forestry									13356.68
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

1998

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1998
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)(1)	8383.09	4594.40	297.00	25.47	190.94	1.28	NO,NA	NO,NA	13492.19
1. Energy	2102.00	9.15	35.00						2146.15
A. Fuel combustion (sectoral approach)	2018.29	8.01	35.00						2061.30
1. Energy industries	9.03	0.05	0.11						9.19
2. Manufacturing industries and construction	355.40	0.49	9.25						365.14
3. Transport	649.98	4.85	12.94						667.78
4. Other sectors	998.90	2.62	12.69						1014.21
5. Other	4.97	0.01	0.01						4.99
B. Fugitive emissions from fuels	83.72	1.14	NO,NA						84.85
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	83.72	1.14	NA,NO						84.85
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	530.56	1.80	35.15	25.47	190.94	1.28	NO,NA	NO,NA	785.20
A. Mineral industry	54.36								54.36
B. Chemical industry	0.40	NO,NA	30.63	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	31.03
C. Metal industry	467.90	1.75	NO	NO	190.94	NO	NO	NO	660.59
D. Non-energy products from fuels and solvent use	7.89	NA	NA						7.89
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				25.47	NO	NO	NO	NO	25.47
G. Other product manufacture and use	0.01	0.05	4.52		NO	1.28			5.86
H. Other	NA	NA	NA						NA
3. Agriculture	2.55	436.66	220.90						660.10
A. Enteric fermentation		363.63							363.63
B. Manure management		73.02	13.63						86.65
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	207.27						207.27
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.00								0.00
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.55								2.55
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5744.41	3839.98	0.43						9584.82
A. Forest land	-72.91	0.40	0.35						-72.16
B. Cropland	1886.98	106.41	NO,NA						1993.39
C. Grassland	5009.94	425.73	0.08						5435.75
D. Wetlands	-1101.42	3307.43	NO,NE,NA						2206.01
E. Settlements	21.83	NE,NA	NO,NE,IE,NA						21.83
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	3.57	306.83	5.52						315.91
A. Solid waste disposal	NO,NA	240.67							240.67
B. Biological treatment of solid waste		0.22	0.13						0.35
C. Incineration and open burning of waste	3.57	3.53	0.77						7.87
D. Waste water treatment and discharge		62.40	4.62						67.02
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items:(2)									
International bunkers	389.32	0.20	2.87						392.40
Aviation	337.80	0.07	2.50						340.37
Navigation	51.52	0.14	0.37						52.03
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	4.97								4.97
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									3907.36
Total CO_2 equivalent emissions with land use, land-use change and forestry									13492.19
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

1999

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1999
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)(1)	8598.97	4591.44	304.02	37.00	183.61	1.28	NO,NA	NO,NA	13716.31
1. Energy	2156.23	9.33	37.00						2202.56
A. Fuel combustion (sectoral approach)	2044.96	7.79	37.00						2089.75
1. Energy industries	6.68	0.04	0.10						6.83
2. Manufacturing industries and construction	370.58	0.51	10.09						381.18
3. Transport	674.53	4.64	13.61						692.79
4. Other sectors	988.80	2.59	13.19						1004.58
5. Other	4.36	0.00	0.01						4.38
B. Fugitive emissions from fuels	111.27	1.54	NO,NA						112.81
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	111.27	1.54	NA,NO						112.81
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	679.44	2.08	35.58	37.00	183.61	1.28	NO,NA	NO,NA	938.98
A. Mineral industry	61.41								61.41
B. Chemical industry	0.43	NO,NA	30.93	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	31.36
C. Metal industry	610.13	2.03	NO	NO	183.61	NO	NO	NO	795.76
D. Non-energy products from fuels and solvent use	7.45	NA	NA						7.45
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				37.00	NO	NO	NO	NO	37.00
G. Other product manufacture and use	0.02	0.06	4.65		NO	1.28			6.02
H. Other	NA	NA	NA						NA
3. Agriculture	2.78	429.38	225.54						657.71
A. Enteric fermentation		358.63							358.63
B. Manure management		70.75	13.50						84.25
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	212.04						212.04
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.02								0.02
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.76								2.76
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5757.60	3835.12	0.45						9593.18
A. Forest land	-79.14	0.42	0.37						-78.34
B. Cropland	1887.27	106.44	NO,NA						1993.71
C. Grassland	5026.61	428.11	0.08						5454.81
D. Wetlands	-1098.97	3300.15	NO,NE,NA						2201.18
E. Settlements	21.82	NE,NA	NO,NE,IE,NA						21.82
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.92	315.52	5.45						323.88
A. Solid waste disposal	NO,NA	248.24							248.24
B. Biological treatment of solid waste		0.22	0.13						0.35
C. Incineration and open burning of waste	2.92	2.95	0.65						6.52
D. Waste water treatment and discharge		64.10	4.67						68.77
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items:(2)									
International bunkers	401.93	0.17	2.97						405.07
Aviation	363.01	0.07	2.69						365.77
Navigation	38.92	0.10	0.28						39.30
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	5.07								5.07
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4123.13
Total CO_2 equivalent emissions with land use, land-use change and forestry									13716.31
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2000

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2000
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	8707.90	4583.84	287.16	42.99	134.79	1.35	NO,NA	NO,NA	13758.04
1. Energy	2138.39	9.07	37.31						2184.77
A. Fuel combustion (sectoral approach)	1985.24	7.37	37.31						2029.93
1. Energy industries	6.38	0.04	0.10						6.53
2. Manufacturing industries and construction	318.92	0.45	10.19						329.56
3. Transport	677.70	4.32	13.73						695.75
4. Other sectors	977.65	2.55	13.27						993.48
5. Other	4.60	0.01	0.01						4.61
B. Fugitive emissions from fuels	153.15	1.69	NO,NA						154.84
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	153.15	1.69	NA,NO						154.84
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	789.25	3.09	20.31	42.99	134.79	1.35	NO,NA	NO,NA	991.79
A. Mineral industry	65.45								65.45
B. Chemical industry	0.41	NO,NA	15.93	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	16.33
C. Metal industry	715.56	3.04	NO	NO	134.79	NO	NO	NO	853.40
D. Non-energy products from fuels and solvent use	7.82	NA	NA						7.82
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				42.99	NO	NO	NO	NO	42.99
G. Other product manufacture and use	0.02	0.05	4.38		NO	1.35			5.80
H. Other	NA	NA	NA						NA
3. Agriculture	2.80	415.05	223.54						641.40
A. Enteric fermentation		344.96							344.96
B. Manure management		70.09	13.25						83.34
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	210.30						210.30
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.04								0.04
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.76								2.76
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5774.71	3828.59	0.51						9603.81
A. Forest land	-90.27	0.48	0.43						-89.35
B. Cropland	1887.55	106.46	NO,NA						1994.02
C. Grassland	5054.87	431.34	0.08						5486.29
D. Wetlands	-1095.65	3290.30	NO,NE,NA						2194.65
E. Settlements	18.21	NE,NA	NO,NE,IE,NA						18.21
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.74	328.04	5.49						336.27
A. Solid waste disposal	NO,NA	254.44							254.44
B. Biological treatment of solid waste		0.22	0.13						0.35
C. Incineration and open burning of waste	2.74	2.89	0.63						6.26
D. Waste water treatment and discharge		70.49	4.73						75.22
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	461.20	0.22	3.40						464.83
Aviation	407.33	0.08	3.02						410.43
Navigation	53.86	0.14	0.39						54.39
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	5.07								5.07
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4154.23
Total CO_2 equivalent emissions with land use, land-use change and forestry									13758.04
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2001

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2001
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2[1]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[1]	8656.87	4587.79	283.20	39.83	97.16	1.35	NO,NA	NO,NA	13666.20
1. Energy	2028.65	8.51	36.40						2073.56
A. Fuel combustion (sectoral approach)	1884.88	6.80	36.40						1928.07
1. Energy industries	5.97	0.04	0.10						6.12
2. Manufacturing industries and construction	353.76	0.51	10.08						364.35
3. Transport	687.73	4.10	14.17						706.00
4. Other sectors	817.67	2.12	12.00						831.79
5. Other	19.75	0.02	0.04						19.81
B. Fugitive emissions from fuels	143.77	1.72	NO,NA						145.49
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	143.77	1.72	NA,NO						145.49
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	831.48	3.21	17.97	39.83	97.16	1.35	NO,NA	NO,NA	990.99
A. Mineral industry	58.66								58.66
B. Chemical industry	0.49	NO,NA	13.81	NA,NO	NA,NO	NA,NO	NO,NA	NO,NA	14.30
C. Metal industry	765.37	3.16	NO	NO	97.16	NO	NO	NO	865.69
D. Non-energy products from fuels and solvent use	6.93	NA	NA						6.93
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				39.83	0.00	NO	NO	NO	39.83
G. Other product manufacture and use	0.02	0.05	4.16		NO	1.35			5.58
H. Other	NA	NA	NA						NA
3. Agriculture	2.72	414.33	222.79						639.84
A. Enteric fermentation		345.26							345.26
B. Manure management		69.07	13.24						82.31
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	209.55						209.55
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.02								0.02
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.69								2.69
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[1]	5791.44	3824.47	0.55						9616.46
A. Forest land	-95.74	0.52	0.47						-94.75
B. Cropland	1887.89	106.49	NO,NA						1994.37
C. Grassland	5074.43	433.56	0.08						5508.08
D. Wetlands	-1093.34	3283.90	NO,NE,NA						2190.56
E. Settlements	18.20	NE,NA	NO,NE,IE,NA						18.20
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.58	337.26	5.50						345.34
A. Solid waste disposal	NO,NA	263.72							263.72
B. Biological treatment of solid waste		0.22	0.13						0.35
C. Incineration and open burning of waste	2.58	2.59	0.57						5.74
D. Waste water treatment and discharge		70.73	4.80						75.53
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items:[2]									
International bunkers	407.79	0.22	3.01						411.02
Aviation	348.78	0.07	2.59						351.43
Navigation	59.01	0.16	0.42						59.59
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	5.07								5.07
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [3]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4049.73
Total CO_2 equivalent emissions with land use, land-use change and forestry									13666.20
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2002

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2002
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	8807.17	4586.31	261.36	44.65	76.90	1.35	NA,NO	NA,NO	13777.74
1. Energy	2138.81	8.49	36.20						2183.49
A. Fuel combustion (sectoral approach)	1991.39	6.77	36.20						2034.36
1. Energy industries	6.85	0.04	0.11						7.00
2. Manufacturing industries and construction	364.03	0.50	9.49						374.02
3. Transport	689.22	3.83	14.28						707.33
4. Other sectors	908.69	2.37	12.28						923.34
5. Other	22.60	0.02	0.05						22.67
B. Fugitive emissions from fuels	147.41	1.73	NO,NA						149.14
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	147.41	1.73	NA,NO						149.14
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	848.79	3.38	3.88	44.65	76.90	1.35	NA,NO	NA,NO	978.95
A. Mineral industry	39.31								39.31
B. Chemical industry	0.45	NO,NA	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.45
C. Metal industry	801.83	3.33	NO	NO	76.89	NO	NO	NO	882.05
D. Non-energy products from fuels and solvent use	7.18	NA	NA						7.18
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				44.65	0.01	NO	NO	NO	44.66
G. Other product manufacture and use	0.01	0.06	3.88		NO	1.35			5.30
H. Other	NA	NA	NA						NA
3. Agriculture	2.47	404.52	215.75						622.73
A. Enteric fermentation		337.44							337.44
B. Manure management		67.07	13.10						80.17
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	202.65						202.65
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	0.06								0.06
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.41								2.41
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5814.71	3818.54	0.58						9633.83
A. Forest land	-104.85	0.56	0.50						-103.79
B. Cropland	1888.22	106.51	NO,NA						1994.74
C. Grassland	5103.47	436.49	0.09						5540.04
D. Wetlands	-1090.33	3274.98	NO,NE,NA						2184.65
E. Settlements	18.20	NE,NA	NO,NE,IE,NA						18.20
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.40	351.39	4.95						358.74
A. Solid waste disposal	NO,NA	264.65							264.65
B. Biological treatment of solid waste		0.22	0.13						0.35
C. Incineration and open burning of waste	2.40	2.41	0.53						5.34
D. Waste water treatment and discharge		84.10	4.29						88.40
E. Other	NA	NO	NO						NA,NO
6. Other ***(as specified in summary 1.A)***	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	394.53	0.29	2.90						397.72
Aviation	309.54	0.06	2.29						311.90
Navigation	84.99	0.23	0.61						85.83
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	5.07								5.07
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4143.91
Total CO_2 equivalent emissions with land use, land-use change and forestry									13777.74
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

2003

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2003
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	8803.87	4569.70	256.87	45.14	63.38	1.35	NA,NO	NA,NO	13740.31
1. Energy	2129.47	8.21	34.96						2172.64
A. Fuel combustion (sectoral approach)	1993.12	6.54	34.96						2034.62
1. Energy industries	4.99	0.04	0.10						5.14
2. Manufacturing industries and construction	335.36	0.46	8.70						344.52
3. Transport	780.64	3.78	14.64						799.05
4. Other sectors	864.85	2.25	11.51						878.61
5. Other	7.28	0.01	0.02						7.31
B. Fugitive emissions from fuels	136.34	1.67	NO,NA						138.02
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	136.34	1.67	NA,NO						138.02
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	849.66	3.38	3.84	45.14	63.38	1.35	NA,NO	NA,NO	966.75
A. Mineral industry	32.98								32.98
B. Chemical industry	0.48	NO,NA	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.48
C. Metal industry	809.34	3.33	NO	NO	63.37	NO	NO	NO	876.04
D. Non-energy products from fuels and solvent use	6.85	NA	NA						6.85
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				45.14	0.01	NO	NO	NO	45.14
G. Other product manufacture and use	0.02	0.05	3.84		NO	1.35			5.26
H. Other	NA	NA	NA						NA
3. Agriculture	4.77	397.72	212.48						614.97
A. Enteric fermentation		332.51							332.51
B. Manure management		65.21	13.10						78.31
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	199.37						199.37
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.52								2.52
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.25								2.25
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5817.92	3814.90	0.62						9633.45
A. Forest land	-115.39	0.61	0.54						-114.25
B. Cropland	1888.57	106.54	NO,NA						1995.10
C. Grassland	5115.02	438.28	0.09						5553.38
D. Wetlands	-1088.48	3269.48	NO,NE,NA						2181.00
E. Settlements	18.20	NE,NA	NO,NE,IE,NA						18.20
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	2.05	345.48	4.97						352.51
A. Solid waste disposal	NO,NA	265.54							265.54
B. Biological treatment of solid waste		0.34	0.19						0.53
C. Incineration and open burning of waste	2.05	2.10	0.46						4.61
D. Waste water treatment and discharge		77.51	4.32						81.83
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	351.89	0.12	2.60						354.61
Aviation	332.67	0.07	2.47						335.20
Navigation	19.22	0.05	0.14						19.41
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	5.87								5.87
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4106.87
Total CO_2 equivalent emissions with land use, land-use change and forestry									13740.31
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

2004

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	8933.03	4558.21	260.08	52.17	40.90	1.36	NA,NO	NA,NO	13845.75
1. Energy	2224.18	8.41	38.90						2271.49
A. Fuel combustion (sectoral approach)	2101.28	6.59	38.90						2146.77
1. Energy industries	3.16	0.04	0.10						3.30
2. Manufacturing industries and construction	333.06	0.49	10.32						343.87
3. Transport	838.84	3.68	15.61						858.13
4. Other sectors	900.03	2.33	12.82						915.19
5. Other	26.20	0.03	0.06						26.29
B. Fugitive emissions from fuels	122.90	1.82	NO,NA						124.72
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	122.90	1.82	NA,NO						124.72
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	873.40	3.37	3.60	52.17	40.90	1.36	NA,NO	NA,NO	974.79
A. Mineral industry	50.81								50.81
B. Chemical industry	0.39	NO,NA	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.39
C. Metal industry	814.54	3.32	NO	NO	40.89	NO	NO	NO	858.75
D. Non-energy products from fuels and solvent use	7.63	NA	NA						7.63
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				52.17	0.00	NO	NO	NO	52.18
G. Other product manufacture and use	0.02	0.05	3.60		NO	1.36			5.03
H. Other	NA	NA	NA						NA
3. Agriculture	6.98	390.01	211.98						608.97
A. Enteric fermentation		326.56							326.56
B. Manure management		63.45	13.30						76.76
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	198.67						198.67
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	4.83								4.83
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.15								2.15
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5823.24	3810.95	0.64						9634.83
A. Forest land	-121.60	0.62	0.55						-120.42
B. Cropland	1888.88	106.56	NO,NA						1995.44
C. Grassland	5124.35	440.21	0.09						5564.65
D. Wetlands	-1086.48	3263.55	NO,NE,NA						2177.07
E. Settlements	18.09	NE,NA	0.00						18.09
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	5.23	345.47	4.96						355.66
A. Solid waste disposal	NO,NA	274.21							274.21
B. Biological treatment of solid waste		0.34	0.19						0.53
C. Incineration and open burning of waste	5.23	1.27	0.42						6.92
D. Waste water treatment and discharge		69.66	4.35						74.01
E. Other	NA	NO	NO						NA,NO
6. Other ***(as specified in summary 1.A)***	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	400.47	0.13	2.96						403.56
Aviation	379.62	0.07	2.81						382.51
Navigation	20.84	0.06	0.15						21.05
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	5.74								5.74
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4210.92
Total CO_2 equivalent emissions with land use, land-use change and forestry									13845.75
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

2005

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2005
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	8807.75	4540.06	259.38	57.24	27.66	2.59	NO	NO	13694.68
1. Energy	2111.12	7.99	39.24						2158.35
A. Fuel combustion (sectoral approach)	1992.96	6.04	39.24						2038.25
1. Energy industries	3.26	0.04	0.10						3.40
2. Manufacturing industries and construction	287.03	0.40	11.00						298.44
3. Transport	847.76	3.44	15.25						866.46
4. Other sectors	826.16	2.12	12.83						841.12
5. Other	28.75	0.03	0.06						28.84
B. Fugitive emissions from fuels	118.16	1.95	NO,NA						120.11
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	118.16	1.95	NA,NO						120.11
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	856.35	3.16	3.45	57.24	27.66	2.59	NO	NO	950.45
A. Mineral industry	54.98								54.98
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	793.98	3.11	NO	NO	27.66	NO	NO	NO	824.75
D. Non-energy products from fuels and solvent use	7.35	NA	NA						7.35
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				57.24	0.00	NO	NO	NO	57.24
G. Other product manufacture and use	0.03	0.05	3.45		NO	2.59			6.12
H. Other	NA	NA	NA						NA
3. Agriculture	6.22	393.54	211.02						610.78
A. Enteric fermentation		328.90							328.90
B. Manure management		64.64	12.86						77.50
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	198.16						198.16
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	4.09								4.09
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.13								2.13
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5829.27	3805.40	0.67						9635.34
A. Forest land	-140.76	0.65	0.58						-139.53
B. Cropland	1889.24	106.59	NO,NA						1995.83
C. Grassland	5146.35	442.94	0.09						5589.37
D. Wetlands	-1083.68	3255.23	NO,NE,NA						2171.55
E. Settlements	18.11	NE,NA	0.00						18.12
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	4.79	329.98	4.99						339.76
A. Solid waste disposal	NO,NA	262.50							262.50
B. Biological treatment of solid waste		0.56	0.32						0.88
C. Incineration and open burning of waste	4.79	0.50	0.27						5.56
D. Waste water treatment and discharge		66.41	4.40						70.82
E. Other	NA	NO	NO						NA,NO
6. Other ***(as specified in summary 1.A)***	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	422.96	0.09	3.13						426.18
Aviation	421.23	0.08	3.12						424.43
Navigation	1.74	0.00	0.01						1.75
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	5.91								5.91
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4059.34
Total CO_2 equivalent emissions with land use, land-use change and forestry									13694.68
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

2006

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2006
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	9046.31	4574.59	274.59	66.31	353.22	2.69	NO	NO	14317.71
1. Energy	2180.03	8.69	32.99						2221.71
A. Fuel combustion (sectoral approach)	2052.61	5.98	32.99						2091.58
1. Energy industries	9.03	0.08	0.18						9.29
2. Manufacturing industries and construction	281.39	0.41	10.02						291.82
3. Transport	987.24	3.55	11.11						1001.90
4. Other sectors	748.29	1.91	11.63						761.83
5. Other	26.65	0.03	0.06						26.74
B. Fugitive emissions from fuels	127.43	2.71	NO,NA						130.13
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	127.43	2.71	NA,NO						130.13
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	965.37	3.10	3.67	66.31	353.22	2.69	NO	NO	1394.36
A. Mineral industry	62.17								62.17
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	895.02	3.05	NO	NO	353.22	NO	NO	NO	1251.29
D. Non-energy products from fuels and solvent use	8.13	NA	NA						8.13
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				66.31	0.00	NO	NO	NO	66.31
G. Other product manufacture and use	0.04	0.06	3.67		NO	2.69			6.46
H. Other	NA	NA	NA						NA
3. Agriculture	5.45	403.82	227.06						636.33
A. Enteric fermentation		336.25							336.25
B. Manure management		67.57	13.60						81.17
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	213.46						213.46
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.77								2.77
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.69								2.69
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5890.47	3802.24	5.58						9698.29
A. Forest land	-147.30	0.68	0.60						-146.03
B. Cropland	1889.63	106.63	0.01						1996.27
C. Grassland	5207.98	453.23	3.96						5665.17
D. Wetlands	-1078.73	3241.70	1.00						2163.98
E. Settlements	18.89	NE,NA	0.00						18.89
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	0.00								0.00
H. Other	IE	IE	IE						IE
5. Waste	4.99	356.74	5.28						367.02
A. Solid waste disposal	NO,NA	297.16							297.16
B. Biological treatment of solid waste		0.90	0.51						1.40
C. Incineration and open burning of waste	4.99	0.48	0.28						5.75
D. Waste water treatment and discharge		58.21	4.50						62.70
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items:[(2)]									
International bunkers	516.57	0.14	3.82						520.53
Aviation	499.40	0.10	3.70						503.20
Navigation	17.16	0.04	0.12						17.33
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	9.01								9.01
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4619.42
Total CO_2 equivalent emissions with land use, land-use change and forestry									14317.71
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2007

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2007
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	9310.26	4567.73	280.37	66.98	298.01	2.98	NO	NO	14526.33
1. Energy	2319.58	9.60	33.83						2363.00
A. Fuel combustion (sectoral approach)	2172.20	6.14	33.83						2212.17
1. Energy industries	24.94	0.10	0.23						25.27
2. Manufacturing industries and construction	276.32	0.53	10.20						287.05
3. Transport	1023.29	3.35	11.09						1037.73
4. Other sectors	840.85	2.15	12.29						855.30
5. Other	6.80	0.01	0.01						6.82
B. Fugitive emissions from fuels	147.37	3.46	NO,NA						150.84
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	147.37	3.46	NA,NO						150.84
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1163.17	3.26	4.08	66.98	298.01	2.98	NO	NO	1538.48
A. Mineral industry	64.33								64.33
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1091.13	3.20	NO	NO	298.00	NO	NO	NO	1392.33
D. Non-energy products from fuels and solvent use	7.66	NA	NA						7.66
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				66.98	0.00	NO	NO	NO	66.99
G. Other product manufacture and use	0.05	0.06	4.08		NO	2.98			7.17
H. Other	NA	NA	NA						NA
3. Agriculture	4.43	411.76	236.19						652.38
A. Enteric fermentation		342.26							342.26
B. Manure management		69.50	13.74						83.24
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	222.46						222.46
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	1.40								1.40
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	3.02								3.02
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5815.13	3786.17	0.72						9602.01
A. Forest land	-255.68	0.69	0.61						-254.38
B. Cropland	1890.04	106.64	NO,NA						1996.67
C. Grassland	5235.84	452.68	0.10						5688.62
D. Wetlands	-1073.20	3226.16	NO,NE,NA						2152.96
E. Settlements	18.15	NE,NA	0.01						18.16
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.01								-0.01
H. Other	IE	IE	IE						IE
5. Waste	7.96	356.94	5.55						370.45
A. Solid waste disposal	NO,NA	293.90							293.90
B. Biological treatment of solid waste		1.12	0.64						1.76
C. Incineration and open burning of waste	7.96	0.47	0.30						8.73
D. Waste water treatment and discharge		61.44	4.62						66.06
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	522.97	0.13	3.87						526.98
Aviation	511.03	0.10	3.79						514.92
Navigation	11.94	0.03	0.08						12.06
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	10.69								10.69
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4924.32
Total CO_2 equivalent emissions with land use, land-use change and forestry									14526.33
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

2008

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2008
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	9677.46	4544.55	286.76	68.57	369.94	3.10	NO	NO	14950.39
1. Energy	2193.79	9.03	32.06						2234.88
A. Fuel combustion (sectoral approach)	2007.85	5.53	32.06						2045.45
1. Energy industries	10.16	0.07	0.17						10.40
2. Manufacturing industries and construction	249.17	0.48	9.72						259.37
3. Transport	969.25	3.00	10.60						982.85
4. Other sectors	772.19	1.97	11.56						785.71
5. Other	7.09	0.01	0.02						7.11
B. Fugitive emissions from fuels	185.94	3.49	NO,NA						189.43
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	185.94	3.49	NA,NO						189.43
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1604.83	2.75	3.64	68.57	369.94	3.10	NO	NO	2052.84
A. Mineral industry	61.80								61.80
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1536.09	2.70	NO	NO	369.94	NO	NO	NO	1908.73
D. Non-energy products from fuels and solvent use	6.92	NA	NA						6.92
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				68.57	0.00	NO	NO	NO	68.57
G. Other product manufacture and use	0.02	0.05	3.64		NO	3.10			6.81
H. Other	NA	NA	NA						NA
3. Agriculture	7.89	416.73	244.57						669.18
A. Enteric fermentation		346.57							346.57
B. Manure management		70.16	13.70						83.85
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	230.87						230.87
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	4.54								4.54
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	3.35								3.35
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5864.64	3777.12	0.82						9642.59
A. Forest land	-259.31	0.72	0.64						-257.96
B. Cropland	1890.47	106.66	NO,NA						1997.13
C. Grassland	5283.81	457.23	0.16						5741.20
D. Wetlands	-1068.60	3212.52	0.02						2143.94
E. Settlements	18.28	NE,NA	0.01						18.29
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.01								-0.01
H. Other	IE	IE	IE						IE
5. Waste	6.31	338.92	5.67						350.90
A. Solid waste disposal	NO,NA	282.33							282.33
B. Biological treatment of solid waste		1.19	0.67						1.86
C. Incineration and open burning of waste	6.31	0.44	0.27						7.02
D. Waste water treatment and discharge		54.96	4.73						59.69
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	474.94	0.21	3.50						478.64
Aviation	427.40	0.08	3.17						430.65
Navigation	47.53	0.12	0.33						47.98
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	8.83								8.83
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									5307.80
Total CO_2 equivalent emissions with land use, land-use change and forestry									14950.39
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

2009

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2009
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	9587.92	4534.84	264.80	81.82	161.91	3.13	NO	NO	14634.43
1. Energy	2102.67	8.43	25.90						2137.00
A. Fuel combustion (sectoral approach)	1932.56	5.24	25.90						1963.69
1. Energy industries	7.75	0.06	0.13						7.94
2. Manufacturing industries and construction	177.78	0.29	6.66						184.74
3. Transport	932.75	2.80	9.19						944.73
4. Other sectors	809.47	2.09	9.90						821.46
5. Other	4.81	0.01	0.01						4.83
B. Fugitive emissions from fuels	170.11	3.19	NO,NA						173.30
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	170.11	3.19	NA,NO						173.30
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1616.26	2.79	3.20	81.82	161.91	3.13	NO	NO	1869.12
A. Mineral industry	28.69								28.69
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1582.10	2.75	NO	NO	161.91	NO	NO	NO	1746.76
D. Non-energy products from fuels and solvent use	5.46	NA	NA						5.46
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				81.82	0.00	NO	NO	NO	81.83
G. Other product manufacture and use	0.02	0.04	3.20		NO	3.13			6.39
H. Other	NA	NA	NA						NA
3. Agriculture	5.89	423.50	229.10						658.49
A. Enteric fermentation		352.36							352.36
B. Manure management		71.14	13.80						84.94
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	215.30						215.30
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	3.24								3.24
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.65								2.65
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5856.84	3775.32	0.76						9632.93
A. Forest land	-272.19	0.74	0.66						-270.79
B. Cropland	1890.92	106.68	NO,NA						1997.61
C. Grassland	5287.40	458.06	0.10						5745.56
D. Wetlands	-1067.53	3209.83	NO,NE,NA						2142.30
E. Settlements	18.28	NE,NA	0.01						18.28
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.03								-0.03
H. Other	IE	IE	IE						IE
5. Waste	6.26	324.81	5.84						336.90
A. Solid waste disposal	NO,NA	271.93							271.93
B. Biological treatment of solid waste		1.43	0.81						2.24
C. Incineration and open burning of waste	6.26	0.41	0.23						6.90
D. Waste water treatment and discharge		51.04	4.79						55.84
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	351.15	0.09	2.60						353.84
Aviation	343.01	0.07	2.54						345.61
Navigation	8.15	0.02	0.06						8.22
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	6.57								6.57
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									5001.50
Total CO_2 equivalent emissions with land use, land-use change and forestry									14634.43
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

2010

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2010
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	9449.55	4528.77	255.17	109.92	154.37	4.81	NO	NO	14502.59
1. Energy	1993.77	10.42	22.51						2026.70
A. Fuel combustion (sectoral approach)	1804.13	4.74	22.51						1831.38
1. Energy industries	8.36	0.06	0.14						8.55
2. Manufacturing industries and construction	132.83	0.23	5.27						138.32
3. Transport	884.56	2.47	8.37						895.39
4. Other sectors	764.51	1.97	8.71						775.19
5. Other	13.88	0.02	0.03						13.92
B. Fugitive emissions from fuels	189.64	5.67	NO,NA						195.32
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	189.64	5.67	NA,NO						195.32
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1623.35	2.90	3.45	109.92	154.37	4.81	NO	NO	1898.80
A. Mineral industry	10.40								10.40
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1607.25	2.86	NO	NO	154.37	NO	NO	NO	1764.48
D. Non-energy products from fuels and solvent use	5.67	NA	NA						5.67
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				109.92	0.00	NO	NO	NO	109.92
G. Other product manufacture and use	0.02	0.04	3.45		NO	4.81			8.32
H. Other	NA	NA	NA						NA
3. Agriculture	4.22	419.68	222.47						646.37
A. Enteric fermentation		351.96							351.96
B. Manure management		67.71	13.78						81.49
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	208.69						208.69
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	1.93								1.93
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.29								2.29
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5822.14	3773.32	0.78						9596.24
A. Forest land	-294.72	0.76	0.68						-293.28
B. Cropland	1891.38	106.71	NO,NA						1998.09
C. Grassland	5288.34	459.04	0.10						5747.49
D. Wetlands	-1066.51	3206.80	0.00						2140.29
E. Settlements	3.68	NE,NA	0.01						3.68
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.03								-0.03
H. Other	IE	IE	IE						IE
5. Waste	6.07	322.45	5.96						334.49
A. Solid waste disposal	NO,NA	271.81							271.81
B. Biological treatment of solid waste		1.71	0.97						2.68
C. Incineration and open burning of waste	6.07	0.39	0.22						6.69
D. Waste water treatment and discharge		48.54	4.77						53.31
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	377.14	0.07	2.80						380.01
Aviation	376.89	0.07	2.79						379.75
Navigation	0.25	0.00	0.00						0.25
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	7.31								7.31
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4906.35
Total CO_2 equivalent emissions with land use, land-use change and forestry									14502.59
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2011

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2011
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)(1)	9301.96	4503.30	251.52	134.72	67.01	3.14	NO	NO	14261.66
1. Energy	1875.52	8.80	20.71						1905.03
A. Fuel combustion (sectoral approach)	1696.01	4.31	20.71						1721.03
1. Energy industries	6.42	0.04	0.11						6.57
2. Manufacturing industries and construction	140.15	0.24	4.59						144.98
3. Transport	852.16	2.23	8.29						862.68
4. Other sectors	690.40	1.79	7.71						699.90
5. Other	6.88	0.01	0.01						6.90
B. Fugitive emissions from fuels	179.51	4.49	NO,NA						184.00
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	179.51	4.49	NA,NO						184.00
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1617.84	2.99	3.55	134.72	67.01	3.14	NO	NO	1829.25
A. Mineral industry	20.14								20.14
B. Chemical industry	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal industry	1591.77	2.95	NO	NO	67.01	NO	NO	NO	1661.73
D. Non-energy products from fuels and solvent use	5.90	NO,NA	NO,NA						5.90
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				134.72	0.01	NO	NO	NO	134.73
G. Other product manufacture and use	0.02	0.04	3.55		NO	3.14			6.75
H. Other	NA	NA	NA						NA
3. Agriculture	4.56	419.36	220.54						644.46
A. Enteric fermentation		350.48							350.48
B. Manure management		68.88	13.69						82.57
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	206.85						206.85
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.42								2.42
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.14								2.14
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5797.26	3771.35	0.80						9569.41
A. Forest land	-321.94	0.78	0.69						-320.47
B. Cropland	1891.84	106.73	NO,NA						1998.57
C. Grassland	5289.23	460.02	0.10						5749.34
D. Wetlands	-1065.48	3203.82	NO,NE,NA						2138.34
E. Settlements	3.68	NE,NA	0.01						3.69
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.06								-0.06
H. Other	IE	IE	IE						IE
5. Waste	6.78	300.80	5.92						313.50
A. Solid waste disposal	NO,NA	247.94							247.94
B. Biological treatment of solid waste		1.60	0.91						2.51
C. Incineration and open burning of waste	6.78	0.37	0.23						7.39
D. Waste water treatment and discharge		50.89	4.78						55.67
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items:(2)									
International bunkers	471.13	0.21	3.47						474.81
Aviation	421.51	0.08	3.12						424.72
Navigation	49.62	0.13	0.35						50.10
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	8.65								8.65
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4692.25
Total CO_2 equivalent emissions with land use, land-use change and forestry									14261.66
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2012

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2012
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	9294.33	4468.51	256.95	140.16	84.53	5.51	NO	NO	14250.00
1. Energy	1828.14	7.76	19.99						1855.89
A. Fuel combustion (sectoral approach)	1656.09	4.09	19.99						1680.17
1. Energy industries	7.71	0.04	0.10						7.85
2. Manufacturing industries and construction	127.68	0.20	4.79						132.66
3. Transport	834.91	2.07	7.24						844.23
4. Other sectors	685.70	1.77	7.86						695.33
5. Other	0.09	0.00	0.00						0.09
B. Fugitive emissions from fuels	172.05	3.67	NO,NA						175.72
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	172.05	3.67	NA,NO						175.72
C. CO_2 transport and storage	NO,IE								NO,IE
2. Industrial processes and product use	1660.71	3.36	3.47	140.16	84.53	5.51	NO	NO	1897.74
A. Mineral industry	0.51								0.51
B. Chemical industry	NO,NA	NO,NA	NO	NO	NO	NO	NO	NO	NO,NA
C. Metal industry	1654.33	3.31	NO	NO	84.53	NO	NO	NO	1742.17
D. Non-energy products from fuels and solvent use	5.85	NO,NA	NO,NA						5.85
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				140.16	0.00	NO	NO	NO	140.17
G. Other product manufacture and use	0.03	0.04	3.47		NO	5.51			9.05
H. Other	NA	NA	NA						NA
3. Agriculture	5.90	407.85	226.97						640.72
A. Enteric fermentation		342.96							342.96
B. Manure management		64.89	13.32						78.21
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	213.64						213.64
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	3.52								3.52
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.39								2.39
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5793.03	3769.25	0.82						9563.10
A. Forest land	-332.93	0.80	0.71						-331.43
B. Cropland	1892.30	106.76	NO,NA						1999.05
C. Grassland	5294.45	461.05	0.11						5755.61
D. Wetlands	-1064.42	3200.65	NO,NE,NA						2136.23
E. Settlements	3.70	NE,NA	0.01						3.71
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.07								-0.07
H. Other	IE	IE	IE						IE
5. Waste	6.54	280.30	5.71						292.56
A. Solid waste disposal	NO,NA	219.44							219.44
B. Biological treatment of solid waste		1.25	0.71						1.96
C. Incineration and open burning of waste	6.54	0.37	0.21						7.11
D. Waste water treatment and discharge		59.25	4.80						64.04
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	465.47	0.15	3.44						469.05
Aviation	441.72	0.09	3.27						445.08
Navigation	23.75	0.06	0.16						23.97
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	9.94								9.94
CO_2 captured	0.06								0.06
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4686.90
Total CO_2 equivalent emissions with land use, land-use change and forestry									14250.00
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

2013

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2013
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)(1)	9271.57	4468.01	251.44	170.54	79.28	3.32	NO	NO	14244.18
1. Energy	1792.88	8.37	19.27						1820.52
A. Fuel combustion (sectoral approach)	1619.74	3.91	19.27						1642.91
1. Energy industries	4.37	0.01	0.02						4.41
2. Manufacturing industries and construction	117.05	0.21	4.63						121.89
3. Transport	849.55	2.01	7.15						858.71
4. Other sectors	648.01	1.67	7.47						657.14
5. Other	0.76	0.00	0.00						0.76
B. Fugitive emissions from fuels	173.14	4.47	NO,NA						177.61
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	173.14	4.47	NA,NO						177.61
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	1686.72	3.38	3.06	170.54	79.28	3.32	NO	NO	1946.31
A. Mineral industry	0.55								0.55
B. Chemical industry	NO,NA	NO,NA	NO	NO	NO	NO	NO	NO	NO,NA
C. Metal industry	1680.35	3.35	NO	NO	79.28	NO	NO	NO	1762.98
D. Non-energy products from fuels and solvent use	5.80	NO,NA	NO,NA						5.80
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				170.54	0.00	NO	NO	NO	170.54
G. Other product manufacture and use	0.02	0.04	3.06		NO	3.32			6.44
H. Other	NA	NA	NA						NA
3. Agriculture	5.01	397.69	222.27						624.97
A. Enteric fermentation		335.40							335.40
B. Manure management		62.29	13.01						75.30
C. Rice cultivation		NO							NO
D. Agricultural soils		NE,NA,NO	209.25						209.25
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.80								2.80
H. Urea application	NO								NO
I. Other carbon-containing fertilizers	2.21								2.21
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5781.47	3767.19	0.84						9549.50
A. Forest land	-350.62	0.80	0.71						-349.11
B. Cropland	1892.75	106.78	NO,NA						1999.53
C. Grassland	5298.95	462.07	0.13						5761.15
D. Wetlands	-1063.38	3197.53	NO,NE,NA						2134.15
E. Settlements	3.84	NE,NA	0.01						3.85
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.07								-0.07
H. Other	IE	IE	IE						IE
5. Waste	5.50	291.37	6.00						302.87
A. Solid waste disposal	NO,NA	233.08							233.08
B. Biological treatment of solid waste		1.68	0.95						2.63
C. Incineration and open burning of waste	5.50	0.37	0.22						6.09
D. Waste water treatment and discharge		56.24	4.83						61.08
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items:(2)									
International bunkers	576.65	0.30	4.24						581.19
Aviation	498.57	0.10	3.70						502.36
Navigation	78.08	0.20	0.55						78.83
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	13.19								13.19
CO_2 captured	NO,NA								NO,NA
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4694.67
Total CO_2 equivalent emissions with land use, land-use change and forestry									14244.18
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

2014

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2014
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) (1)	9209.72	4474.22	272.57	168.56	89.05	2.46	NO	NO	14216.59
1. Energy	1779.34	8.88	20.69						1808.91
A. Fuel combustion (sectoral approach)	1596.39	3.79	20.69						1620.87
1. Energy industries	5.10	0.01	0.01						5.12
2. Manufacturing industries and construction	82.42	0.14	5.31						87.87
3. Transport	856.54	1.96	7.36						865.86
4. Other sectors	649.68	1.67	7.99						659.35
5. Other	2.65	0.01	0.01						2.67
B. Fugitive emissions from fuels	182.95	5.09	NA,NO						188.04
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	182.95	5.09	NA,NO						188.04
C. CO_2 transport and storage	NO,IE								NO,IE
2. Industrial processes and product use	1655.20	3.06	2.84	168.56	89.05	2.46	NO	NO	1921.17
A. Mineral industry	0.55								0.55
B. Chemical industry	NO,NA	NO,NA	NO	NO	NO	NO	NO	NO	NO,NA
C. Metal industry	1648.76	3.02	NO	NO	89.05	NO	NO	NO	1740.83
D. Non-energy products from fuels and solvent use	5.87	NO,NA	NO,NA						5.87
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				168.56	0.00	NO	NO	NO	168.57
G. Other product manufacture and use	0.02	0.04	2.84		NO	2.46			5.35
H. Other	NA	NA	NA						NA
3. Agriculture	4.68	421.97	241.63						668.28
A. Enteric fermentation		354.41							354.41
B. Manure management		67.56	13.83						81.40
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	227.80						227.80
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.05								2.05
H. Urea application	0.01								0.01
I. Other carbon-containing fertilizers	2.63								2.63
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry (1)	5763.01	3765.20	0.87						9529.07
A. Forest land	-374.24	0.81	0.72						-372.71
B. Cropland	1893.21	106.80	NO,NA						2000.01
C. Grassland	5302.67	463.12	0.14						5765.93
D. Wetlands	-1062.05	3194.46	0.01						2132.41
E. Settlements	3.54	NE,NA	0.01						3.55
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.12								-0.12
H. Other	IE	IE	IE						IE
5. Waste	7.49	275.12	6.54						289.15
A. Solid waste disposal	NO,NA	229.14							229.14
B. Biological treatment of solid waste		2.26	1.28						3.54
C. Incineration and open burning of waste	7.49	0.38	0.37						8.23
D. Waste water treatment and discharge		43.35	4.89						48.24
E. Other	NA	NO	NO						NA,NO
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO

Memo items: (2)									
International bunkers	650.91	0.30	4.80						656.01
Aviation	580.37	0.11	4.30						584.79
Navigation	70.53	0.18	0.50						71.22
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	18.11								18.11
CO_2 captured	2.38								2.38
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4687.52
Total CO_2 equivalent emissions with land use, land-use change and forestry									14216.59
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2015

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2015
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	9285.09	4478.07	259.14	161.37	93.25	1.63	NO	NO	14278.56
1. Energy	1823.67	9.02	21.06						1853.75
A. Fuel combustion (sectoral approach)	1660.54	3.92	21.06						1685.51
1. Energy industries	4.18	0.00	0.01						4.19
2. Manufacturing industries and construction	111.55	0.19	5.35						117.09
3. Transport	885.71	2.02	7.64						895.37
4. Other sectors	658.91	1.70	8.06						668.67
5. Other	0.19	0.00	0.00						0.19
B. Fugitive emissions from fuels	163.14	5.10	NA,NO						168.24
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	163.14	5.10	NA,NO						168.24
C. CO_2 transport and storage	NO,IE								NO,IE
2. Industrial processes and product use	1707.77	3.34	2.87	161.37	93.25	1.63	NO	NO	1970.24
A. Mineral industry	0.72								0.72
B. Chemical industry	NO,NA	NO,NA	NO	NO	NO	NO	NO	NO	NO,NA
C. Metal industry	1700.82	3.30	NO	NO	93.24	NO	NO	NO	1797.37
D. Non-energy products from fuels and solvent use	6.21	NO,NA	NO,NA						6.21
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				161.37	0.01	NO	NO	NO	161.38
G. Other product manufacture and use	0.03	0.04	2.87		NO	1.63			4.57
H. Other	NA	NA	NA						NA
3. Agriculture	5.35	426.26	227.62						659.23
A. Enteric fermentation		357.50							357.50
B. Manure management		68.77	13.81						82.58
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	213.80						213.80
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	3.28								3.28
H. Urea application	0.01								0.01
I. Other carbon-containing fertilizers	2.05								2.05
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5741.38	3763.44	1.03						9505.85
A. Forest land	-399.17	0.82	0.72						-397.63
B. Cropland	1893.77	106.83	NO,NA						2000.59
C. Grassland	5304.14	464.28	0.25						5768.67
D. Wetlands	-1061.05	3191.52	0.04						2130.51
E. Settlements	3.73	NE,NA	0.01						3.74
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.04								-0.04
H. Other	IE	IE	IE						IE
5. Waste	6.92	276.00	6.56						289.49
A. Solid waste disposal	NO,NA	224.17							224.17
B. Biological treatment of solid waste		2.39	1.35						3.74
C. Incineration and open burning of waste	6.92	0.38	0.27						7.57
D. Waste water treatment and discharge		49.07	4.94						54.01
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	821.66	0.52	6.04						828.22
Aviation	673.99	0.13	5.00						679.12
Navigation	147.66	0.39	1.05						149.10
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	43.16								43.16
CO_2 captured	3.91								3.91
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4772.71
Total CO_2 equivalent emissions with land use, land-use change and forestry									14278.56
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

2016

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2016
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	9210.05	4462.01	256.77	179.21	82.56	1.39	NO	NO	14191.99
1. Energy	1798.74	7.54	22.63						1828.91
A. Fuel combustion (sectoral approach)	1649.78	3.58	22.63						1675.99
1. Energy industries	2.36	0.00	0.01						2.37
2. Manufacturing industries and construction	118.12	0.18	6.17						124.47
3. Transport	966.37	1.96	8.48						976.81
4. Other sectors	562.78	1.44	7.96						572.19
5. Other	0.16	0.00	0.00						0.16
B. Fugitive emissions from fuels	148.96	3.95	NO,NA						152.91
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	148.96	3.95	NO,NA						152.91
C. CO_2 transport and storage	NO,IE								NO,IE
2. Industrial processes and product use	1684.41	3.39	2.32	179.21	82.56	1.39	NO	NO	1953.28
A. Mineral industry	0.77								0.77
B. Chemical industry	NO,NA	NO,NA	NO	NO	NO	NO	NO	NO	NO,NA
C. Metal industry	1677.31	3.35	NO	NO	82.54	NO	NO	NO	1763.21
D. Non-energy products from fuels and solvent use	6.30	NO,NA	NO,NA						6.30
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				179.21	0.02	NO	NO	NO	179.23
G. Other product manufacture and use	0.03	0.04	2.32		NO	1.39			3.77
H. Other	NA	NA	NA						NA
3. Agriculture	4.90	429.58	224.25						658.73
A. Enteric fermentation		359.86							359.86
B. Manure management		69.72	13.88						83.59
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	210.37						210.37
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.82								2.82
H. Urea application	0.24								0.24
I. Other carbon-containing fertilizers	1.84								1.84
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5714.53	3761.09	0.83						9476.45
A. Forest land	-422.92	0.82	0.73						-421.37
B. Cropland	1893.90	106.85	NO,NA						2000.75
C. Grassland	5299.98	465.02	0.10						5765.10
D. Wetlands	-1060.06	3188.40	NO,NE,NA						2128.34
E. Settlements	3.72	NE,NA	0.01						3.73
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.09								-0.09
H. Other	IE	IE	IE						IE
5. Waste	7.47	260.41	6.74						274.62
A. Solid waste disposal	NO,NA	215.01							215.01
B. Biological treatment of solid waste		2.55	1.45						4.01
C. Incineration and open burning of waste	7.47	0.39	0.29						8.15
D. Waste water treatment and discharge		42.46	5.00						47.46
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	1101.38	0.66	8.10						1110.14
Aviation	916.88	0.18	6.80						923.86
Navigation	184.50	0.48	1.30						186.28
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	45.18								45.18
CO_2 captured	6.64								6.64
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4715.54
Total CO_2 equivalent emissions with land use, land-use change and forestry									14191.99
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2017

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2017
Submission 2023 v1
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GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	9288.61	4445.76	267.22	170.45	61.12	2.81	NO	NO	14235.97
1. Energy	1839.53	7.18	23.53						1870.24
A. Fuel combustion (sectoral approach)	1693.05	3.47	23.53						1720.06
1. Energy industries	2.31	0.00	0.01						2.32
2. Manufacturing industries and construction	90.91	0.16	6.28						97.35
3. Transport	1020.39	1.82	9.09						1031.29
4. Other sectors	579.28	1.49	8.16						588.93
5. Other	0.17	0.00	0.00						0.17
B. Fugitive emissions from fuels	146.48	3.71	NO,NA						150.18
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	146.48	3.71	NO,NA						150.18
C. CO_2 transport and storage	NO,IE								NO,IE
2. Industrial processes and product use	1759.83	3.54	2.15	170.45	61.12	2.81	NO	NO	1999.90
A. Mineral industry	0.90								0.90
B. Chemical industry	NO,NA	NO,NA	NO	NO	NO	NO	NO	NO	NO,NA
C. Metal industry	1752.78	3.50	NO	NO	61.10	NO	NO	NO	1817.38
D. Non-energy products from fuels and solvent use	6.13	NO,NA	NO,NA						6.13
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				170.45	0.01	NO	NO	NO	170.46
G. Other product manufacture and use	0.03	0.03	2.15		NO	2.81			5.02
H. Other	NA	NA	NA						NA
3. Agriculture	4.98	420.73	233.87						659.58
A. Enteric fermentation		352.21							352.21
B. Manure management		68.52	13.64						82.16
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	220.23						220.23
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	2.32								2.32
H. Urea application	0.54								0.54
I. Other carbon-containing fertilizers	2.13								2.13
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5676.42	3758.97	0.88						9436.27
A. Forest land	-461.02	0.83	0.73						-459.46
B. Cropland	1894.56	106.88	NO,NA						2001.44
C. Grassland	5298.32	466.04	0.13						5764.48
D. Wetlands	-1059.00	3185.24	0.01						2126.24
E. Settlements	3.72	NE,NA	0.01						3.72
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.15								-0.15
H. Other	IE	IE	IE						IE
5. Waste	7.84	255.35	6.78						269.98
A. Solid waste disposal	NO,NA	206.98							206.98
B. Biological treatment of solid waste		2.43	1.38						3.81
C. Incineration and open burning of waste	7.84	0.40	0.32						8.56
D. Waste water treatment and discharge		45.54	5.08						50.62
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	1357.98	0.77	9.99						1368.74
Aviation	1146.71	0.22	8.50						1155.44
Navigation	211.27	0.55	1.49						213.30
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	49.53								49.53
CO_2 captured	10.17								10.17
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4799.70
Total CO_2 equivalent emissions with land use, land-use change and forestry									14235.97
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2018

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2018
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	9321.01	4441.89	255.97	188.53	68.70	4.03	NO	NO	14280.12
1. Energy	1882.55	7.13	21.49						1911.17
A. Fuel combustion (sectoral approach)	1726.09	3.42	21.49						1750.99
1. Energy industries	2.35	0.00	0.01						2.36
2. Manufacturing industries and construction	85.28	0.15	5.05						90.48
3. Transport	1054.39	1.75	9.04						1065.18
4. Other sectors	583.54	1.51	7.39						592.45
5. Other	0.52	0.00	0.00						0.53
B. Fugitive emissions from fuels	156.46	3.71	NO,NA						160.17
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	156.46	3.71	NO,NA						160.17
C. CO_2 transport and storage	NO,IE								NO,IE
2. Industrial processes and product use	1773.83	3.57	2.61	188.53	68.70	4.03	NO	NO	2041.27
A. Mineral industry	0.91								0.91
B. Chemical industry	NO,NA	NO,NA	NO	NO	NO	NO	NO	NO	NO,NA
C. Metal industry	1766.12	3.54	NO	NO	68.66	NO	NO	NO	1838.31
D. Non-energy products from fuels and solvent use	6.77	NO,NA	NO,NA						6.77
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				188.53	0.04	NO	NO	NO	188.57
G. Other product manufacture and use	0.03	0.04	2.61		NO	4.03			6.71
H. Other	NA	NA	NA						NA
3. Agriculture	5.70	408.10	223.98						637.77
A. Enteric fermentation		341.11							341.11
B. Manure management		66.98	13.21						80.20
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	210.77						210.77
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	3.15								3.15
H. Urea application	0.72								0.72
I. Other carbon-containing fertilizers	1.83								1.83
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry[(1)]	5652.05	3756.82	0.84						9409.71
A. Forest land	-490.28	0.83	0.74						-488.71
B. Cropland	1895.01	106.90	NO,NA						2001.91
C. Grassland	5301.61	467.00	0.10						5768.71
D. Wetlands	-1057.94	3182.09	NO,NE,NA						2124.14
E. Settlements	3.73	NE,NA	0.01						3.73
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.08								-0.08
H. Other	IE	IE	IE						IE
5. Waste	6.89	266.27	7.05						280.20
A. Solid waste disposal	NO,NA	215.97							215.97
B. Biological treatment of solid waste		2.69	1.53						4.22
C. Incineration and open burning of waste	6.89	0.39	0.29						7.57
D. Waste water treatment and discharge		47.22	5.23						52.45
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items:[(2)]									
International bunkers	1525.25	0.88	11.22						1537.35
Aviation	1285.04	0.25	9.53						1294.82
Navigation	240.21	0.63	1.70						242.53
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	58.47								58.47
CO_2 captured	12.20								12.20
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4870.41
Total CO_2 equivalent emissions with land use, land-use change and forestry									14280.12
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2019

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(Sheet 1 of 1)

Inventory 2019
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	9214.28	4386.34	244.40	199.64	87.22	2.34	NO	NO	14134.23
1. Energy	1827.29	7.34	19.36						1853.99
A. Fuel combustion (sectoral approach)	1664.19	3.10	19.36						1686.65
1. Energy industries	4.95	0.01	0.01						4.97
2. Manufacturing industries and construction	67.41	0.11	4.10						71.62
3. Transport	1051.57	1.54	9.79						1062.89
4. Other sectors	538.58	1.44	5.45						545.48
5. Other	1.68	0.00	0.00						1.68
B. Fugitive emissions from fuels	163.11	4.24	NO,NA						167.34
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	163.11	4.24	NO,NA						167.34
C. CO_2 transport and storage	NO,IE								NO,IE
2. Industrial processes and product use	1711.99	3.64	2.49	199.64	87.22	2.34	NO	NO	2007.33
A. Mineral industry	0.96								0.96
B. Chemical industry	NO,NA	NO,NA	NO	NO	NO	NO	NO	NO	NO,NA
C. Metal industry	1704.85	3.61	NO	NO	87.18	NO	NO	NO	1795.64
D. Non-energy products from fuels and solvent use	6.16	NO,NA	NO,NA						6.16
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				199.64	0.05	NO	NO	NO	199.69
G. Other product manufacture and use	0.02	0.03	2.49		NO	2.34			4.89
H. Other	NA	NA	NA						NA
3. Agriculture	10.34	396.72	214.40						621.47
A. Enteric fermentation		330.67							330.67
B. Manure management		66.05	12.71						78.76
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	201.69						201.69
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	5.61								5.61
H. Urea application	3.19								3.19
I. Other carbon-containing fertilizers	1.55								1.55
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry [(1)]	5655.54	3753.94	0.85						9410.33
A. Forest land	-491.27	0.84	0.74						-489.69
B. Cropland	1895.46	106.92	NO,NA						2002.38
C. Grassland	5304.36	467.80	0.10						5772.26
D. Wetlands	-1056.70	3178.38	NO,NE,NA						2121.69
E. Settlements	3.73	NE,NA	0.01						3.74
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.04								-0.04
H. Other	IE	IE	IE						IE
5. Waste	9.12	224.70	7.30						241.11
A. Solid waste disposal	NO,NA	179.19							179.19
B. Biological treatment of solid waste		2.67	1.52						4.19
C. Incineration and open burning of waste	9.12	0.45	0.43						9.99
D. Waste water treatment and discharge		42.39	5.35						47.74
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items: [(2)]									
International bunkers	1159.90	0.72	8.54						1169.16
Aviation	956.38	0.19	7.09						963.65
Navigation	203.52	0.53	1.45						205.51
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	60.45								60.45
CO_2 captured	9.70								9.70
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 [(3)]	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4723.90
Total CO_2 equivalent emissions with land use, land-use change and forestry									14134.23
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

2020

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2020
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)(1)	9005.71	4405.64	245.67	195.61	85.96	3.25	NO	NO	13941.84
1. Energy	1640.27	7.50	16.01						1663.79
A. Fuel combustion (sectoral approach)	1465.40	2.68	16.01						1484.10
1. Energy industries	1.78	0.00	0.00						1.79
2. Manufacturing industries and construction	52.23	0.08	2.15						54.46
3. Transport	874.16	1.18	7.79						883.13
4. Other sectors	536.87	1.42	6.07						544.36
5. Other	0.36	0.00	0.00						0.36
B. Fugitive emissions from fuels	174.87	4.82	NO,NA						179.69
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	174.87	4.82	NO,NA						179.69
C. CO_2 transport and storage	NO,IE								NO,IE
2. Industrial processes and product use	1683.83	3.44	2.51	195.61	85.96	3.25	NO	NO	1974.61
A. Mineral industry	0.89								0.89
B. Chemical industry	NO,NA	NO,NA	NO	NO	NO	NO	NO	NO	NO,NA
C. Metal industry	1676.61	3.41	NO	NO	85.90	NO	NO	NO	1765.92
D. Non-energy products from fuels and solvent use	6.31	NO,NA	NO,NA						6.31
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				195.61	0.06	NO	NO	NO	195.67
G. Other product manufacture and use	0.02	0.03	2.51		NO	3.25			5.82
H. Other	NA	NA	NA						NA
3. Agriculture	8.82	389.67	218.51						617.01
A. Enteric fermentation		325.14							325.14
B. Manure management		64.54	12.42						76.95
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	206.10						206.10
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	5.27								5.27
H. Urea application	1.67								1.67
I. Other carbon-containing fertilizers	1.89								1.89
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5666.15	3753.73	0.90						9420.78
A. Forest land	-494.52	0.86	0.76						-492.91
B. Cropland	1895.91	106.97	0.02						2002.90
C. Grassland	5307.46	468.42	0.11						5775.99
D. Wetlands	-1056.55	3177.48	0.00						2120.94
E. Settlements	13.90	NE,NA	0.01						13.91
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.04								-0.04
H. Other	IE	IE	IE						IE
5. Waste	6.63	251.29	7.72						265.65
A. Solid waste disposal	NO,NA	207.52							207.52
B. Biological treatment of solid waste		3.58	2.02						5.60
C. Incineration and open burning of waste	6.63	0.12	0.23						6.98
D. Waste water treatment and discharge		40.07	5.48						45.55
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO

Memo items:(2)									
International bunkers	338.55	0.25	2.49						341.30
Aviation	261.36	0.05	1.94						263.35
Navigation	77.19	0.20	0.55						77.95
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	64.10								64.10
CO_2 captured	11.70								11.70
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4521.06
Total CO_2 equivalent emissions with land use, land-use change and forestry									13941.84
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2 the national totals shall be provided with and without indirect CO_2.

2021

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2021
Submission 2023 v1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)(1)	9152.18	4408.89	249.83	157.25	88.95	2.97	NO	NO	14060.07
1. Energy	1742.50	7.44	16.94						1766.89
A. Fuel combustion (sectoral approach)	1566.74	2.95	16.94						1586.63
1. Energy industries	2.56	0.00	0.01						2.57
2. Manufacturing industries and construction	73.09	0.17	3.38						76.64
3. Transport	892.59	1.18	7.36						901.13
4. Other sectors	595.97	1.60	6.19						603.76
5. Other	2.53	0.01	0.01						2.54
B. Fugitive emissions from fuels	175.76	4.49	NO,NA						180.25
1. Solid fuels	NO	NO	NO						NO
2. Oil and natural gas	175.76	4.49	NO,NA						180.25
C. CO_2 transport and storage	NO,IE								NO,IE
2. Industrial processes and product use	1751.75	4.01	1.88	157.25	88.95	2.97	NO	NO	2006.80
A. Mineral industry	0.93								0.93
B. Chemical industry	NO,NA	NO,NA	NO	NO	NO	NO	NO	NO	NO,NA
C. Metal industry	1744.25	3.98	NO	NO	88.89	NO	NO	NO	1837.11
D. Non-energy products from fuels and solvent use	6.54	NO,NA	NO,NA						6.54
E. Electronic Industry				NO	NO	NO	NO	NO	NO
F. Product uses as ODS substitutes				157.25	0.06	NO	NO	NO	157.31
G. Other product manufacture and use	0.02	0.03	1.88		NO	2.97			4.90
H. Other	NA	NA	NA						NA
3. Agriculture	9.19	388.30	222.59						620.07
A. Enteric fermentation		323.34							323.34
B. Manure management		64.96	12.37						77.33
C. Rice cultivation		NO							NO
D. Agricultural soils		NA,NE,NO	210.21						210.21
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO,NA	NO,NA						NO,NA
G. Liming	5.77								5.77
H. Urea application	1.48								1.48
I. Other carbon-containing fertilizers	1.94								1.94
J. Other	NO	NO	NO						NO
4. Land use, land-use change and forestry(1)	5642.13	3754.81	0.90						9397.83
A. Forest land	-510.63	0.89	0.78						-508.96
B. Cropland	1896.35	106.97	NO,NA						2003.32
C. Grassland	5304.25	469.22	0.11						5773.58
D. Wetlands	-1056.63	3177.73	NO,NE,NA						2121.10
E. Settlements	8.80	NE,NA	0.01						8.81
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-0.01								-0.01
H. Other	IE	IE	IE						IE
5. Waste	6.61	254.33	7.53						268.48
A. Solid waste disposal	NO,NA	207.18							207.18
B. Biological treatment of solid waste		3.74	1.76						5.49
C. Incineration and open burning of waste	6.61	0.10	0.23						6.95
D. Waste water treatment and discharge		43.31	5.55						48.86
E. Other	NA	NO	NO						NO,NA
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo items:(2)									
International bunkers	534.77	0.41	3.93						539.10
Aviation	412.22	0.08	3.06						415.35
Navigation	122.55	0.32	0.88						123.75
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	89.25								89.25
CO_2 captured	7.54								7.54
Long-term storage of C in waste disposal sites	NO								NO
Indirect N_2O			NO,NE,NA						
Indirect CO_2 (3)	NO,NE,NA								
Total CO_2 equivalent emissions without land use, land-use change and forestry									4662.24
Total CO_2 equivalent emissions with land use, land-use change and forestry									14060.07
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.